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DEMONSTRATION OF INNOVATIVE APPLICATIONS OF TECHNOLOGY FOR THE CT-121 FGD PROCESS

Plant Yates

Environmental Monitoring Program
Period 1 Report
(Testing at Low-Particulate Loading—With ESP In Service)

(Final)

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EXECUTIVE SUMMARY

This report summarizes the results obtained during Environmental Monitoring Program (EMP) activities conducted during Period 1 testing of an Innovative Clean Coal Technology (ICCT) demonstration of the Chiyoda Thoroughbred 121 (CT-121) flue gas desulfurization process. This test period demonstrates the performance of the CT-121 process at low particulate loading (i.e., with the ESP in service). The project is being conducted at Georgia Power Company's Plant Yates Unit 1 located near Newnan, Georgia.

The primary goal of this project is to demonstrate the cost and technical benefits of the CT-121 process compared to other flue gas desulfurization technologies. The demonstration features the use of fiberglass-reinforced plastic (FRP) in the construction of the scrubber, the elimination of the prescrubber, and, potentially, the elimination of the electrostatic precipitator (ESP) as means of reducing the costs of this FGD process. The project at Plant Yates consists of four distinct environmental test periods:

- Period 0: Site Preparation, Construction, and Startup of the Demonstration Project;
- Period 1: Testing at Low-Particulate Loading—With ESP In Service;
- Period 2: Testing at High-Particulate Loading—ESP Detuned or Out of Service; and
- Period 3: Post Demonstration Groundwater Testing and Gypsum By-Product Evaluation.

EMP activities include supplemental sampling and analysis of a number of process and emission streams during each phase's testing periods, together with compliance monitoring of gaseous and aqueous streams. Radian Corporation is responsible for the preparation of all EMP reports.

Period 1 consisted of parametric, long-term, and auxiliary tests. All parametric and long-term tests were performed using the program coal, which contains approximately 2.5% sulfur. The auxiliary tests investigated the impacts of using an alternate limestone as well as a higher sulfur coal. With few exceptions, the analytical methods specified and approved in the project's Environmental Monitoring Plan[1] were used for the environmental monitoring. In a few cases, alternative methods were used to improve detection limits.

EMP monitoring conducted during Period 1 testing periods showed the following:

- The CT-121 demonstration scrubber was capable of removing well over 90% of the flue gas SO_2 during parametric tests conducted using the 2.5% sulfur program coal. As expected, SO_2 removal was found to be directly proportional to scrubber slurry pH and jet bubbling reactor (JBR) deck pressure drop and inversely proportional to unit load and inlet flue gas SO_2 concentration.

- The average SO_2 removal during the long-term load-following tests was nearly 94%, although it was necessary to operate at somewhat higher pH and pressure drop than expected from model predictions. The causes of this discrepancy were found to be (1) scrubber deck and tube fouling and (2) flue gas bypassing due to erosion of scrubber internals.

- SO_2 removals during operation with the alternate limestone were similar to those obtained with the initial program limestone. However, a decision was made to use the alternate limestone for all future tests based on improvements in gypsum properties.

- Even when the boiler was fired using a 4.3% sulfur coal, over 90% SO_2 removal could be achieved by the scrubber at most test conditions.

- The particulate matter loading in the JBR outlet flue gas was relatively consistent and low (i.e., less than 0.015 lb/MMBtu) for all test conditions. Particulate matter removal across the JBR was about 90% except for some 50 MW load tests; in these cases the apparently lower removal was actually due to decreased JBR inlet gas loadings.

- The scrubber was found to be relatively inefficient in removing particles with a diameter smaller than 1 micrometer. The particle-size distribution measured in the JBR outlet gas was relatively unaffected by changes in load at a constant pressure drop.

- The SO_3 concentration in the JBR inlet and outlet gas streams was typically 2-3 ppmv (at 3% O_2). There was little or no change in concentration across the JBR.

- As expected, the JBR outlet gas was typically saturated with water vapor.

- The limestone slurry solids concentration to the scrubber averaged about 30% solids by weight. The limestone consisted primarily of calcium carbonate, with a small amount of magnesium carbonate; about 2% inerts were also present. The alternate limestone contained slightly more magnesium and correspondingly less inerts.

- The concentrations of chloride and sulfate ions in the gypsum stack return liquor were consistent with a scrubber system operating with a relatively closed water balance. The sulfate concentration was relatively consistent over time, while it appeared that the chloride concentration was continuing to increase throughout the Period 1 test period. The results for the JBR underflow liquor were consistent with those for the gypsum stack return liquor.

- The JBR overflow and underflow slurry solids concentrations averaged 21% solids by weight. The solids were found to consist primarily of calcium sulfate; the sulfite concentration was typically very low, consistent with the high level of oxidation expected for this scrubber. Low carbonate concentrations were typically found, indicative of the high limestone utilization achieved at most test conditions.

- There is no evidence that the liner installed under the gypsum stacking area has developed any leaks based on the groundwater monitoring results obtained both prior to and after gypsum stacking area construction.

- There were no exceedances of Plant Yates' NPDES permit limitations in the monitored aqueous discharge streams.

- The main program coal composition was found to be consistent during all test blocks. The alternate coal composition was found to be similar to the program coal except for its higher sulfur content (i.e., 4.3% compared to 2.4%).

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1.0 INTRODUCTION

As an Innovative Clean Coal Technology demonstration, this project, entitled "Demonstration of Innovative Applications of Technology to the CT-121 FGD Process," is required to develop and implement an approved Environmental Monitoring Plan (EMP). The EMP for this project was prepared by Radian Corporation for Southern Company Services, Inc. (SCS) and submitted to DOE on December 18, 1990. [The EMP is now being revised.] The EMP includes supplemental and compliance monitoring of several gaseous, aqueous, and solid streams.

This report presents the results of EMP activities conducted during Period 1 of the project (Testing at Low Particulate Loading—With ESP in Service).

1.1 Project Description

Southern Company Services signed a Cooperative Agreement for this ICCT Round II project in January 1990. The project is demonstrating the performance of the Chiyoda Thoroughbred 121 (CT-121) flue gas desulfurization process. The demonstration is being conducted using flue gas from Unit 1 at Georgia Power Company's Plant Yates near Newnan, Georgia. The demonstration features the use of fiberglass-reinforced plastic (FRP) in the construction of the scrubber, the elimination of the prescrubber, and, potentially, the elimination of the electrostatic precipitator (ESP) as means of reducing the costs of this FGD process. The project at Plant Yates consists of four distinct environmental test phases:

- Period 0: Site Preparation, Construction, and Startup of the Demonstration Project;
- Period 1: Testing at Low Particulate Loading—With ESP In Service;
- Period 2: Testing at High Particulate Loading—ESP Detuned or Out of Service; and

- Period 3: Post Demonstration Groundwater Testing and Gypsum By-Product Evaluation.

Groundwater monitoring was initiated in Period 0 and will continue through Period 3. During each of the two operational periods (Periods 1 and 2), short-term parametric tests and long-term load-following tests will be conducted to determine how different operating conditions, such as Jet Bubbling Reactor (JBR) pressure drop, scrubbing slurry pH, gas flow rate, limestone type and grind, and coal sulfur content, affect emissions and performance of the CT–121 process.

EMP activities consist of sampling and analyses performed during each period's testing blocks, together with compliance monitoring performed on gaseous and aqueous streams. Test block reports are prepared by Radian Corporation for SCS. Radian also prepares EMP reports presenting the data obtained in fulfillment of the monitoring requirements outlined in the EMP.

1.2 Plant Yates CT-121 Scrubber Facility Description

The CT-121 flue gas desulfurization project treats the entire flue gas stream from Plant Yates Unit 1, which has a nominal capacity of 100 MW; this represents approximately 12% of the total flue gas generated at Plant Yates. A separate 258-foot stack has been constructed to vent emissions from the CT-121 demonstration unit. A simplified process flow diagram of the FGD process is shown in Figure 1-1. The key features of the process are described below.

Reactant (Limestone) Feed System

Limestone from available suppliers is transported into Plant Yates by truck, and delivered to a 30-day storage pile. The limestone storage area runoff is collected and piped to the waste gypsum tank. As limestone is needed in the process, it is loaded into an above-grade,

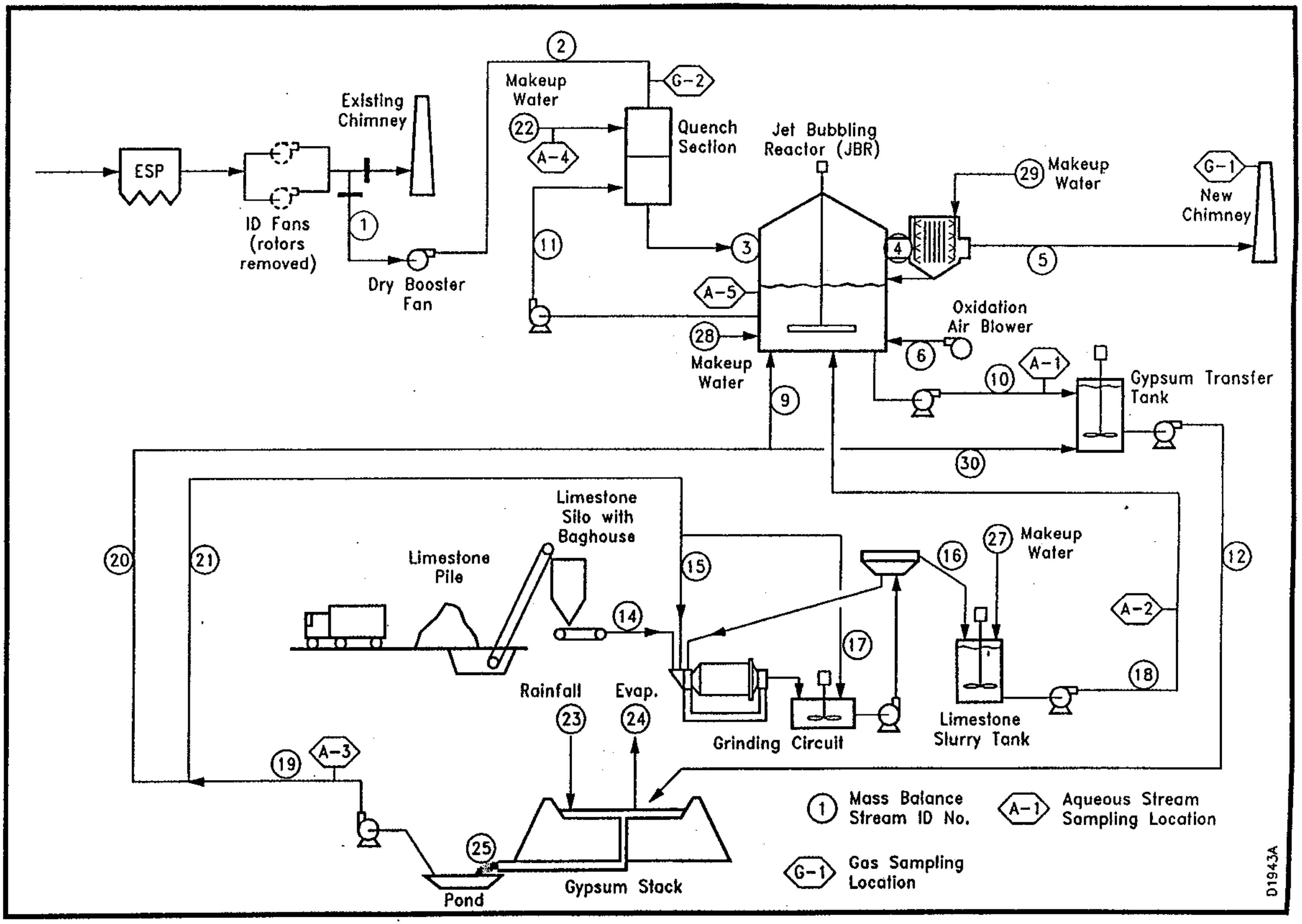


Figure 1-1. Plant Yates 100 MW CT-121 Process Flow Diagram

20-ton capacity carbon steel load hopper. The hopper feeds limestone to a 365-foot long inclined and covered conveyor belt, which delivers the material to a 50-foot tall carbon steel day storage silo. From the silo, limestone is conveyed in a covered conveyor to a wet ball mill. The limestone is typically ground to 90% less than 200 mesh.

The ground limestone is then pumped to hydroclones, located on top of a 50,000 gallon FRP slurry feed tank, for classification. The hydroclone underflow, containing larger limestone particles, is recycled to the ball mill while the overflow is routed to the slurry tank. The slurry is then pumped from the slurry tank into the JBR as required to maintain the desired pH. Spills and runoff are routed to the gypsum stacking area via the waste gypsum tank.

Sulfur Dioxide Removal

The JBR is the key element of the CT-121 process. The JBR used in the demonstration project is approximately 40 feet in diameter and is constructed of FRP. The JBR slurry is mixed by a center-mounted agitator. A schematic of the JBR is shown in Figure 1-2.

Precooled flue gas from Unit 1 enters the JBR in a plenum chamber. The gas is then forced into the jet bubbling (froth) zone of the tank. Air is injected below the slurry to oxidize the absorbed SO_2 from sulfite to sulfate, After bubbling through the limestone slurry, the gas flows upward through risers. Most of the entrained liquid is disengaged in a second plenum, and the cleaned gas exits the JBR through a mist eliminator to the stack. Slurry density in the tank is controlled by pumping slurry from the bottom of the JBR to a remote gypsum slurry (surge) station and then to the gypsum stacking area.

Flue Gas Handling System

The Plant Yates Unit 1 flue gas handling system has been modified to allow several different modes of operation. Tests are planned with the ESP in service (low-

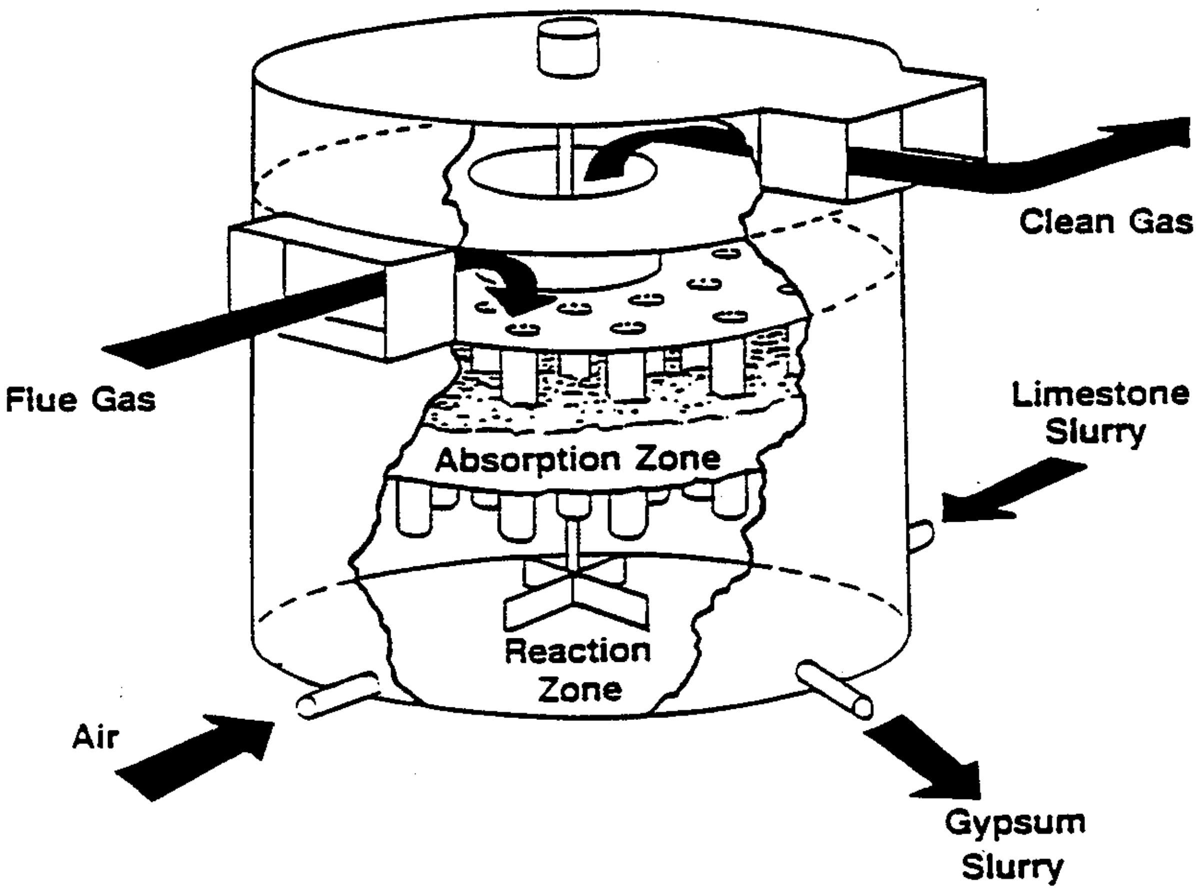


Figure 1-2. Schematic of Jet Bubbling Reactor

particulate loading tests) and with the ESP either detuned or out of service (high-particulate loading tests). The purpose of the high particulate loading tests will be to assess the efficiency of the JBR as a particulate control device.

Solids Disposal

As the JBR slurry exceeds a prescribed density, the underflow is pumped approximately 2,540 feet via pipeline to an eight-acre gypsum stacking area. Within the stacking area the high quality gypsum produced during the low particulate loading tests will be managed separately from the gypsum/fly ash solids produced during the high particulate loading tests. The gypsum slurry is pumped to a central location in the stack area. Supernatant liquor and accumulated rainfall in the disposal area are collected for reuse in the process. After the inner area is filled with solids, a dragline is used to stack the dewatered material and to elevate the perimeter dike. This process is repeated as additional gypsum is added to the stacking area.

The gypsum and gypsum/fly ash stacking areas are lined with synthetic liners to minimize the potential for adverse impacts on the groundwater. Requirements for the liner, leachate collection system, and groundwater monitoring are specified in the permit issued by the Georgia Department of Natural Resources (DNR).

1.3 Report Organization

The remainder of this report is organized as follows:

- Section 2 discusses the EMP monitoring planned for each of the test blocks during Period 1;
- Section 3 briefly summarizes the sampling and analytical methods;
- Section 4 presents and discusses the gas stream monitoring results;
- Section 5 presents and discusses the aqueous stream monitoring results;

- Section 6 presents and discusses the solid stream monitoring results;
- Section 7 discusses EMP-related quality assurance/quality control activities performed during Period 1;
- Section 8 provides a summary of the reports of compliance monitoring activities; and
- Section 9 presents conclusions based on the EMP monitoring results.

Tables containing detailed monitoring results for each of the streams monitored as part of the EMP are provided in Appendix A. Appendix B contains figures showing the results of JBR inlet and stack gas particle size distribution determinations.

2.0 PERIOD 1 EMP MONITORING

Period 1 consisted of short-term parametric and long-term load-following tests for a number of test blocks, including:

- Parametric tests using the main program coal and limestone;
- Long-term load-following tests using the main program coal and limestone; and
- Auxiliary tests consisting of high removal, alternate limestone, and alternate coal tests.

The purpose of the short-term parametric tests was to determine the relationships between JBR SO_2 removal efficiency and operating parameters such as JBR pressure drop, slurry pH, and flue gas flow rate (i.e., boiler load). The long-term load-following tests were performed at JBR operating conditions selected to provide a desired level of SO_2 removal; the operating conditions were determined from the results of the parametric tests. The long-term tests were conducted with Unit 1 under normal system dispatch control, so the unit load (and therefore the amount of flue gas to be scrubbed) was expected to vary appreciably. The auxiliary tests were designed to measure system impacts of high SO_2 removal conditions, alternate limestone, and alternate coal feed. The auxiliary test block included both short-term parametric and load-following tests.

Table 2-1 is a summary of the tests performed during Period 1. For each series of tests, the table gives the test numbers and dates. This information was used in conjunction with the EMP monitoring schedules to determine the total number of "planned" samples to be collected for each parameter during each block of tests.

Tables 2-2, 2-3, and 2-4 present the EMP integrated monitoring schedules for gaseous, aqueous, and solid streams, respectively, for Period 1.

Table 2-1

Summary of Period 1 (Low-Particulate Loading) Tests

Test Block	Test Numbers	Dates
Parametric Tests	P1-1 - P1-36	01/17/93 - 03/31/93
Long-Term Load-Following Tests	L1-1 - L1-3	04/01/93 - 09/10/93
Auxiliary Tests		
• High SO_2 Removal		
—Parametric	HR1-1 - HR1-3	09/14/93 - 09/16/93
—Load-Following	HR1-4	09/17/93 - 10/22/93
• Alternate Limestone		
—"Clean" JBR Parametric	P1B-1 - P1B-13	12/03/93 - 12/21/93
—Load-Following	AL1-1 - AL1-2	12/22/93 - 01/25/94
• Alternate Coal		
—Parametric	AC1-1 - AC1-12	01/26/94 - 02/21/94

Table 2-2

Gaseous Streams: Integrated Monitoring Schedule for Each Testing Phase[a]

Parameter	Monitoring Schedule			
	Stack Gas Stream (G-1)		Flue Gas Inlet to JBR (G-2)	
	Parametric	Long-Term	Parametric	Long-Term
Opacity	None	None	C [c][b]	C [c]
SO_2	C [s]	C [s]	C [s]	C [s]
O_2	C [s]	C [s]	C [s]	C [s]
Moisture Content	9 [s][c]		9 [s]	
SO_3	36 [s]		36 [s]	
Particulate Matter				
Loading	9 [s][d] A [c]		9 [s]	
Particle Size Distribution	9 [s]		9 [s]	

Abbreviations:

A = Annual monitoring
C = Continuous monitoring
[c] = Compliance monitoring
[s] = Supplemental monitoring

Notes:

[a] Each of the two testing periods (low particulate and high particulate) will consist of parametric and long-term tests.

[b] Opacity monitoring will be conducted using a continuous monitor in the JBR inlet gas stream.

[c] The numbers shown refer to the number of samples planned for EMP monitoring.

[d] Particulate loading measurements will be made in triplicate for each of three load levels at three JBR liquid levels.

Stream identifiers G-1 and G-2 are used in Figure 1-1.

Table 2-3

Aqueous Streams: Integrated Monitoring Schedule for Each Testing Phase

Parameter	Ash Transport Water	Final Plant Discharge	JBR Overflow (A-5)		JBR Underflow (A-1)	
			Parametric	Long-Term	Parametric	Long-Term
Liquid Phase						
pH		2/M [c]	7/M [s]	4/M [s]	7/M [s]	4/M [s]
Total Suspended Solids	2/M [c]					
Oil & Grease	2/M [c]					
Specific Conductance						
Temperature						
Eh						
Alkalinity						
Total Dissolved Solids						
Bromide						
Chloride			7/M [s]	4/M [s]		
Total Organic Carbon						
Fluoride						
Nitrate						
Sulfite			7/M [s]	4/M [s]		
Sulfate			7/M [s]	4/M [s]		
Carbonate			7/M [s]	4/M [s]		
Radium 226 and 228						
Gross Alpha						
Gross Beta						
Gross Gamma						
Trace Elements				1/M [s]		

Table 2-3 (Continued)

Parameter	Ash Transport Water	Final Plant Discharge	JBR Overflow (A-5)		JBR Underflow (A-1)	
			Parametric	Long-Term	Parametric	Long-Term
Solid Phase						
Solids Content			7/M [s]	4/M [s]	7/M [s]	4/M [s]
Inert Content			7/M [s]	4/M [s]	7/M [s]	4/M [s]
Calcium			7/M [s]	4/M [s]	7/M [s]	4/M [s]
Magnesium					7/M [s]	4/M [s]
Sulfite					7/M [s]	4/M [s]
Sulfate			7/M [s]	4/M [s]	7/M [s]	4/M [s]
Carbonate			7/M [s]	4/M [s]	7/M [s]	4/M [s]
Trace Elements						1/M [s]
TCLP						1/P [s]

Table 2-3 (Continued)

Parameter	Limestone Slurry Feed (A-2)		Gypsum Stack Return (A-3)		Makeup Water (A-4)		Groundwater Post-Construction
	Parametric	Long-Term	Parametric	Long-Term	Parametric	Long-Term	
Liquid Phase							
pH			7/M [s]	4/M [s]	1/M [s]	1/M [s]	1/Q [s]
Total Suspended Solids							
Oil & Grease							
Specific Conductance							1/Q [s]
Temperature							1/Q [s]
Eh							1/Q [s]
Alkalinity							1/Q [s]
Total Dissolved Solids							1/Q [s]
Bromide							1/Q [s]
Chloride			7/M [s]	4/M [s]	1/M [s]	1/M [s]	1/Q [s]
Total Organic Carbon							1/Q [s]
Fluoride							1/Q [s]
Nitrate							1/Q [s]
Sulfite					1/M [s]	1/M [s]	
Sulfate			7/M [s]	4/M [s]	1/M [s]	1/M [s]	1/Q [s]
Carbonate			7/M [s]	4/M [s]	1/M [s]	1/M [s]	
Radium 226 and 228							1/Q [s]
Gross Alpha							1/Q [s]
Gross Beta							1/Q [s]
Gross Gamma							1/Q [s]
Trace Elements			1/M [s]	1/M [s]			1/Q [s]
Solid Phase							
Solids Content	7/M [s]	4/M [s]					
Inert Content	7/M [s]	4/M [s]					
Calcium	7/M [s]	4/M [s]					
Magnesium	7/M [s]	4/M [s]					
Sulfite							
Sulfate							

Table 2-3 (Continued)

Parameter	Limestone Slurry Feed (A-2)		Gypsum Stack Return (A-3)		Makeup Water (A-4)		Groundwater Post-Construction
	Parametric	Long-Term	Parametric	Long-Term	Parametric	Long-Term	
Carbonate	7/M [s]	4/M [s]					
Trace Elements							
TCLP							

Abbreviations:

n/D = n times per day
n/W = n times per week
n/M = n times per month
n/Q = n times per quarter
1/nM = once per n months
[c] = compliance monitoring
[s] = supplemental monitoring

Notes:

Each of the two testing phases (low particulate and high particulate) will consist of parametric and long-term tests.

Trace elements that are measured in these tests include the following:

Aluminum	Cadmium	Manganese	Silicon
Antimony	Copper	Mercury	Sodium
Arsenic	Chromium	Molybdenum	Sulfur
Barium	Cobalt	Nickel	Titanium
Beryllium	Iron	Phosphorus	Uranium
Boron	Lead	Potassium	Vanadium
Calcium	Magnesium	Selenium	

Stream identifiers A-1, A-2, A-3, A-4, and A-5 are used in Figure 1-1.

Table 2-4

Solid Streams: Integrated Monitoring Schedule for Each Testing Phase

Parameter			Monitoring Schedule Coal Feed	
			Parametric	Long-Term
Proximate Analysis, Sulfur, and HHV			1/D	1/D
Ultimate Analysis, Chlorine, and Fluorine			1/6M	1/6M
Trace Elements:			1/6M	1/6M
Aluminum Antimony Arsenic Barium Beryllium Boron Cadmium Calcium Chromium	Cobalt Copper Iron Lead Magnesium Manganese Mercury Molybdenum Nickel	Phosphorus Potassium Selenium Silicon Sodium Sulfur Titanium Uranium Vanadium		

Abbreviations:

1/D = Once per day
1/6M = Once every six months
HHV = Higher heating value

Notes:

All monitoring shown is supplemental.

In addition to the monitoring shown, analysis of the coal feed for sulfur, moisture, heating value, and ash content once per week is a regulatory compliance requirement.

Each testing period will consist of parametric and long-term tests.

Gypsum solids are monitored in the JBR underflow (Stream A-1). The results of the monitoring will be reported under the JBR underflow solids. See Table 2-3.

3.0 SAMPLING AND ANALYTICAL METHODS

The sampling and analytical methods specified in the Environmental Monitoring Plan (EMP) are summarized in Tables 3-1 through 3-3. Additional details are available in the test block reports and the QA/QC Plan appended to the project's EMP.

For the most part, the methods specified in the EMP were followed during Period 1 testing. Deviations from the EMP-specified methods are briefly discussed below:

- Aqueous stream nitrates: EPA method 353.1, the colorimetric method for nitrates-nitrites is being used instead of the specified ion chromatographic method (EPA 300). The alternate method provides an improved detection limit as well as a longer sample holding time.

- Coal trace elements: Rather than analyze trace metals by inductively coupled argon plasma emission spectroscopy (ICP-AES - EPA Method 200.7), the Georgia Power Company laboratory is using ASTM methods that use atomic absorption spectrophotometry, which give improved detection limits (i.e., ASTM D3682, D3683, and D3684).

In addition, the EPA methods being used by Radian to measure trace elements in groundwater are described in more detail in Table 3-2 than is provided in the EMP.

Table 3-1

Sampling and Analytical Methods: Gaseous Streams

Parameter	Sampling Method	Analytical Method/Instrument	Streams Included[a]
Opacity	--	Continuous Opacity Monitor	G-2
SO_2	GAS[b]	UV Spectrophotometer	G-1,G-2
O_2	GAS[b]	O_2 Analyzer	G-1,G-2
Moisture	EPA Method 4	Gravimetric	G-1,G-2
SO_3	Controlled Condensation	Titration	G-1,G-2
Particulate Matter:			
Loading	EPA Method 5B	Gravimetric	G-1,G-2
Particle Size Distribution	Isokinetic, Cascade Impactor	Gravimetric	G-1,G-2

[a] Stream identification:

G-1 = treated stack gas stream; and

G-2 = flue gas inlet to JBR.

[b] GAS = Continuous extractive gas analysis system.

Table 3-2

Sampling and Analytical Methods: Aqueous Streams

Stream/Type & Parameter	Sampling Method	Analytical Method/Instrument[a,b]	Analytical Reference[c]	Streams Included[d]
Aqueous Discharge	Grab			
pH		Potentiometric[b]	EPA 150.1	f
Total Suspended Solids		Filtration/Drying/Gravimetric[b]	EPA 160.2	a
Oil and Grease		Freon Extraction/Gravimetric[b]	EPA 413.1	a
Process Streams - Liquid Phase	Positive Pressure Filtration[e] & Preservation			
pH[f]		Potentiometric	EPRI C1	A-1,A-3,A-4,A-5
Chloride		Ion Chromatography	EPRI I3	A-3,A-4,A-5
Sulfite		Indirect I_2 Titration	EPRI M2	A-4,A-5
Sulfate		Ion Chromatography	EPRI I3	A-3,A-4,A-5
Carbonate		Nondispersive IR	ASTM 2579	A-3,A-4,A-5
Trace Elements		AA and ICP-AES	EPA 200.2/200.7	A-3, A-5
Process Streams - Solid Phase	Positive Pressure Filtration			
Solids Content		Gravimetric	EPRI F1	A-1,A-2,A-5
Inerts		Acid Dissolution/Gravimetric	--	A-1,A-2,A-5
Calcium		AA	EPRI H1	A-1,A-2,A-5
Magnesium		AA	EPRI H1	A-1,A-2

Table 3-2 (Continued)

Stream/Type & Parameter	Sampling Method	Analytical Method/Instrument[a,b]	Analytical Reference[c]	Streams Included[d]
Sulfite		Indirect I_2 Titration	EPRI M2	A-1
Sulfate		Ion Chromatography	EPRI I3	A-1,A-5
Carbonate		Nondispersive IR or Acid-Base Titration	EPRI N2 or N3	A-1,A-2, A-5
Trace Metals		Dissolution/AA and ICP-AES	EPA 200.0/200.7	A-1
TCLP		Leaching/GC,AA	40 CFR 261; Appendices II and III	A-1
Groundwater Wells	Well Pumps			
pH		Potentiometric	EPA 150.1	g
Specific Conductance		Conductivity Meter	EPA 120.1	g
Temperature		Temperature Probe	EPA 170.1	g
Eh		Electrometry	ASTM D1498	g
Alkalinity		Colorimetry or Titration	EPA 310.1/310.2	g
Bromide		Ion Chromatography	EPA 300.0	g
Chloride		Ion Chromatography	EPA 300.0	g
Total Organic Carbon		Combustion/IR	EPA 415.1	g
Fluoride		Distillation/SIE	EPA 340.2	g
Nitrate-Nitrite (as N)		Colorimetry	EPA 353.1	g
Sulfate		Ion Chromatography	EPA 300.0	g
Total Dissolved Solids		Filtration/Evaporation/Gravimetric	EPA 160.2	g
Mercury		Cold Vapor AA	SW 7470	g
Trace Elements		AA and ICP-AES	Note g	g

Table 3-2 (Continued)

Stream/Type & Parameter	Sampling Method	Analytical Method/Instrument[a,b]	Analytical Reference[c]	Streams Included[d]
Radium 226 and 228		Proportional Counter	ASTM D2460	g
Gross Alpha		Proportional Counter	ASTM D1943	g
Gross Beta		Proportional Counter	ASTM D1890	g
Gross Gamma		Gamma Ray Spectrometer	ASTM D2459	g

[a] Analytical methods: AA = atomic absorption; SIE = specific ion electrode; ICP-AES = inductively coupled plasma argon emission spectroscopy; and IR = infrared.

[b] All analytical methods for NPDES compliance will follow 40 CFR 136 approved procedures.

[c] EPRI No: EPRI method number specified in "FGD Chemistry and Analytical Methods Handbook" (Ref. 4). EPA No: EPA Methods for Chemical Analysis of Water and Wastes (Ref 7). SW No: Test Methods for Evaluation of Solid Wastes, EPA SW-846, 3rd ed. (November 1986).

[d] Stream identification:

a =	Ash transport water;	A-2 =	Limestone slurry feed;
f =	Final plant discharge;	A-3 =	Gypsum stack return;
g =	Groundwater from wells;	A-4 =	Makeup water; and
A-1 =	JBR underflow;	A-4 =	JBR overflow.

[e] Positive pressure filtration will be used to collect samples of all reactive slurry streams. Vacuum filtration will be used for sampling and separation of all other aqueous/slurry streams. The liquid phase of reactive slurries will be preserved to prevent loss of reactive compounds.

[f] The pH of the slurry measured before the sample filtration.

[g] Methods for groundwater trace elements include SW 6010 (metals by ICP-AES); SW 7041 (Sb); SW 7060 (As); SW 7421 (Pb); SW 7740 (Se); and SW 7841 (Tl).

Table 3-3

Sampling and Analytical Methods: Solid Streams

Parameter	Sampling Method	Analytical Method	Analytical Reference[b]	Streams Included
Ultimate Analysis	Grab/Composite	--	ASTM D3176	Coal Feed
Proximate Analysis	Grab/Composite	Thermogravimetric	ASTM D3172	Coal Feed
Higher Heating Value	Grab/Composite	Calorimetry	ASTM D2015	Coal Feed
Total Chlorine	Grab/Composite	Fusion/IC or Titration	ASTM D2361/4208	Coal Feed
Total Fluorine	Grab/Composite	Fusion Combustion/SIE	ASTM D3761	Coal Feed
Trace Elements	Grab/Composite	Fusion and/or Dissolution/AA	ASTM D3682, D3683, D3684	Coal Feed

[a] Analytical methods: AA = atomic absorption; SIE = specific ion electrode; and IC = ion chromatography.

[b] Analytical reference: ASTM Number = American Society for Testing and Materials Method Number.

4.0 GASEOUS STREAM MONITORING RESULTS

Two gas streams were monitored as specified in the EMP: the flue gas inlet to the JBR and the stack gas. Table 4-1 summarizes the actual and planned Period 1 gaseous stream monitoring. The planned EMP monitoring was essentially all performed during Phase 1. Although the results are not presented in this report, continuous monitoring of the oxygen content of the two gas streams was performed as planned. This was done so that the measured SO_2 concentrations could be presented on a consistent basis (i.e., 3% O_2).

Supplemental and compliance monitoring results are discussed separately (Sections 4.1 and 4.2, respectively).

4.1 <u>Supplemental Monitoring</u>

This section presents the results of Period 1 EMP monitoring for sulfur dioxide, particulate matter loading and size distribution, sulfur trioxide, and water vapor.

4.1.1 Sulfur Dioxide

Defining the sulfur dioxide removal efficiency of the CT-121 scrubber is one of the major thrusts of this demonstration project. SO_2 concentrations in the JBR inlet gas and stack gas streams were monitored continuously during each of the Period 1 test blocks. The measured SO_2 concentrations in both streams were adjusted to a consistent basis of 3% O_2 to allow direct computation of the scrubber removal efficiency. This section discusses the results obtained during each of the three test blocks comprising Period 1: parametric, long-term, and auxiliary tests.

Table 4-1

Gaseous Streams: Actual and Planned Monitoring

Parameter	Stack Gas	Flue Gas Inlet to JBR
Opacity	0/0	C/C[b]
SO_2	C/C	C/C
O_2	C/C	C/C
Moisture Content	9/9	9/9
SO_3	34/36	34/36
Particulate Loading	9/9	9/9
PSD	9/9	9/9

[a] 34/36 = 34 actual/36 planned.

[b] C = Continuous monitoring.

Parametric Test Results

The purpose of the parametric tests was to determine the impact of several scrubber operating variables [scrubber slurry pH, Unit 1 load (i.e., flue gas flow rate), and JBR deck pressure drop (i.e., depth of scrubber slurry in the JBR absorption zone)] on SO_2 removal. Because of variations in feed coal sulfur content during some of the Parametric tests, it was also possible to determine the impact of inlet SO_2 concentration on removal efficiency. Based on the results of the parametric tests, an equation was developed for predicting SO_2 removal as a function of scrubber operating parameters. The details are beyond the scope of the EMP, but they are provided in the test block reports.

Figures 4-1 through 4-3 present the SO_2 removal data from the parametric tests plotted against scrubber pressure drop and pH for loads of 100, 75, and 50 MW, respectively. These figures show that in general SO_2 removal increases with increasing JBR deck pressure drop and slurry pH. However, the increase in SO_2 removal obtained when the slurry pH increased from 4.5 to 5.0 was typically very small, indicating that there is little incentive to operate at the higher pH level. Higher pH operation was also found to be undesirable because of operating problems such as scaling and diminished limestone utilization. SO_2 removals above 90% generally required a JBR deck pressure drop of more than 12 inches of water (in. WC).

Figures 4-4 through 4-6 show the impact of load and JBR deck pressure drop on SO_2 removal at slurry pH levels of 4.0, 4.5, and 5.0. In general, SO_2 removal tended to decrease with increasing load, although the impact was greatest at low pressure drop and became insignificant at the highest pressure drop of 16 in. WC for pH levels of 4.5 and 5.0.

Natural variations in the coal sulfur content lead to increased SO_2 concentrations in the JBR inlet flue gas and allowed for a comparison of SO_2 removal efficiency as a function of coal sulfur. As shown in Figure 4-7, an increase in JBR inlet gas SO_2 concentration lead to a decrease in removal efficiency at a given set of scrubber operating conditions.

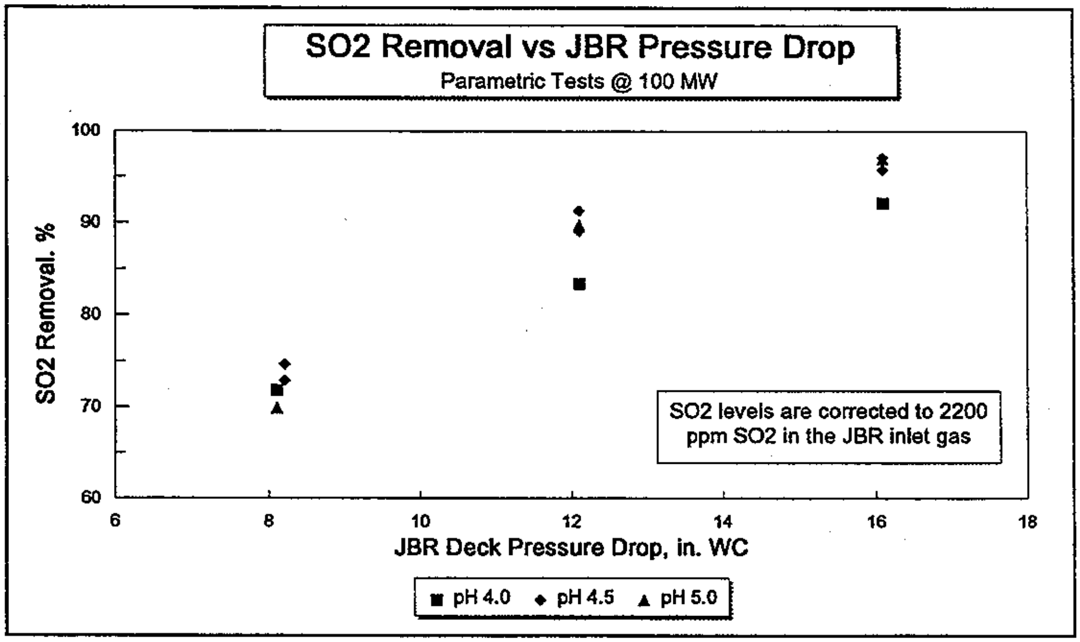


Figure 4-1. Parametric Test Results at 100 MW

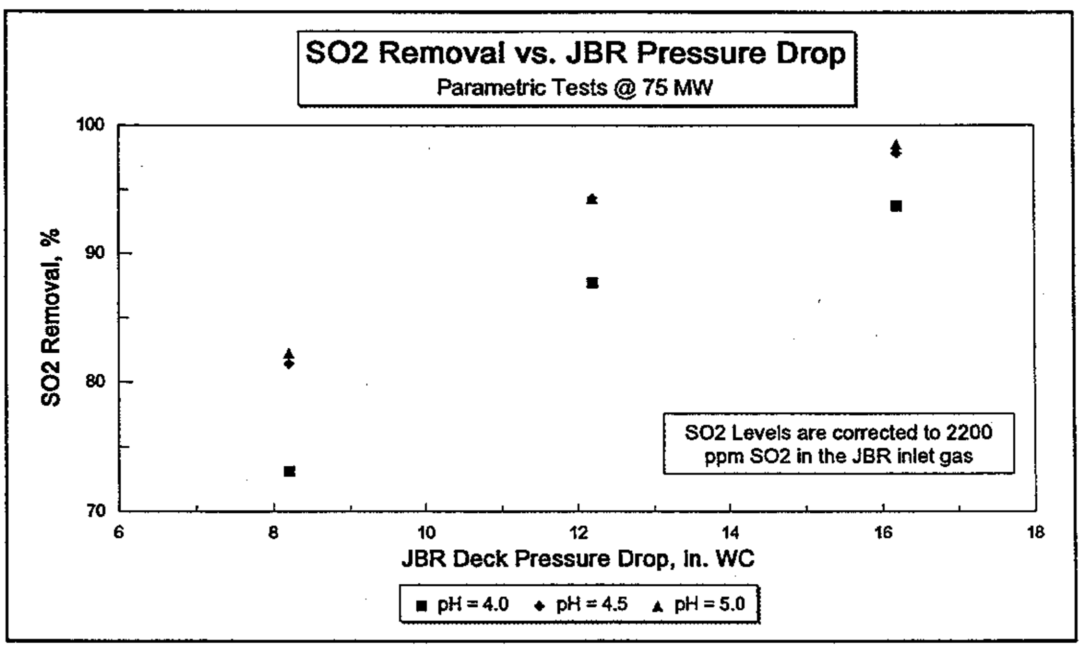


Figure 4-2. Parametric Test Results at 75 MW

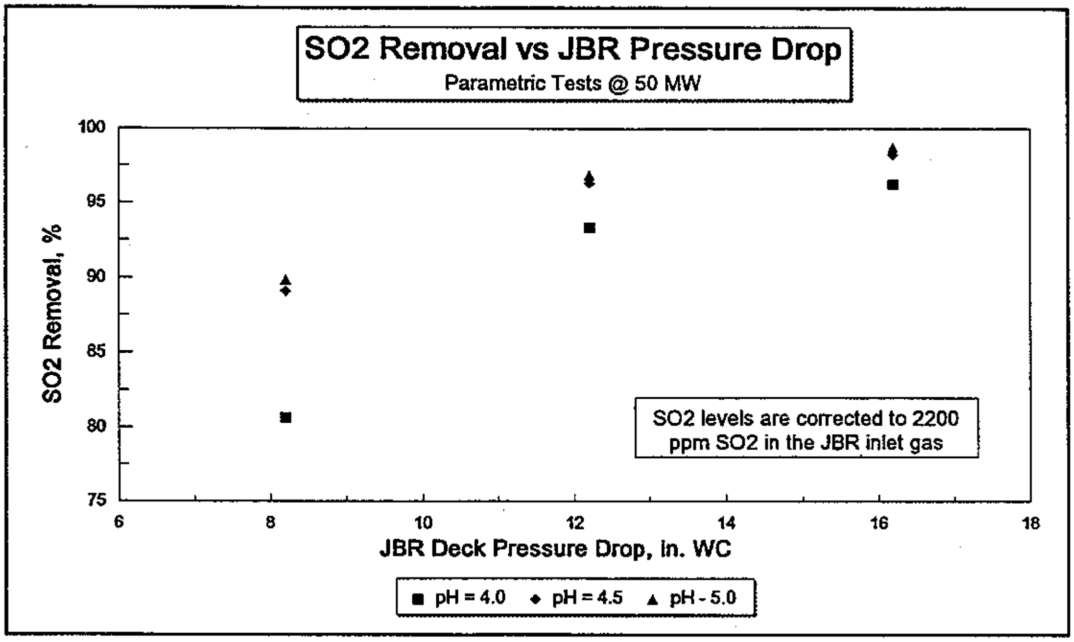


Figure 4-3. Parametric Test Results at 50 MW

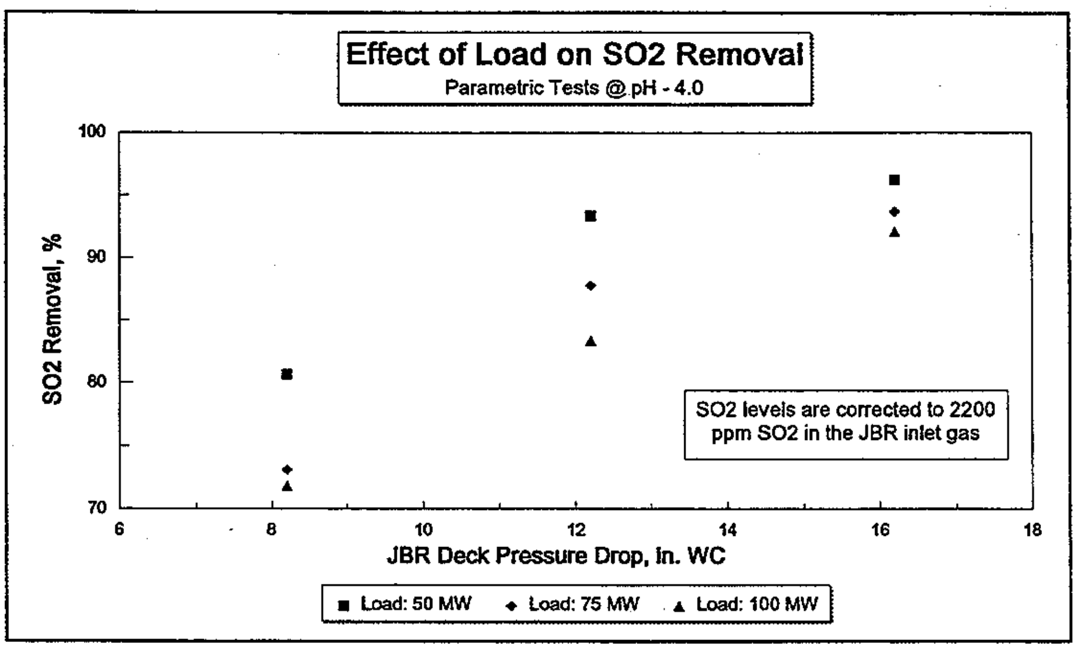


Figure 4-4. Effect of Load on SO_2 Removal: pH = 4.0

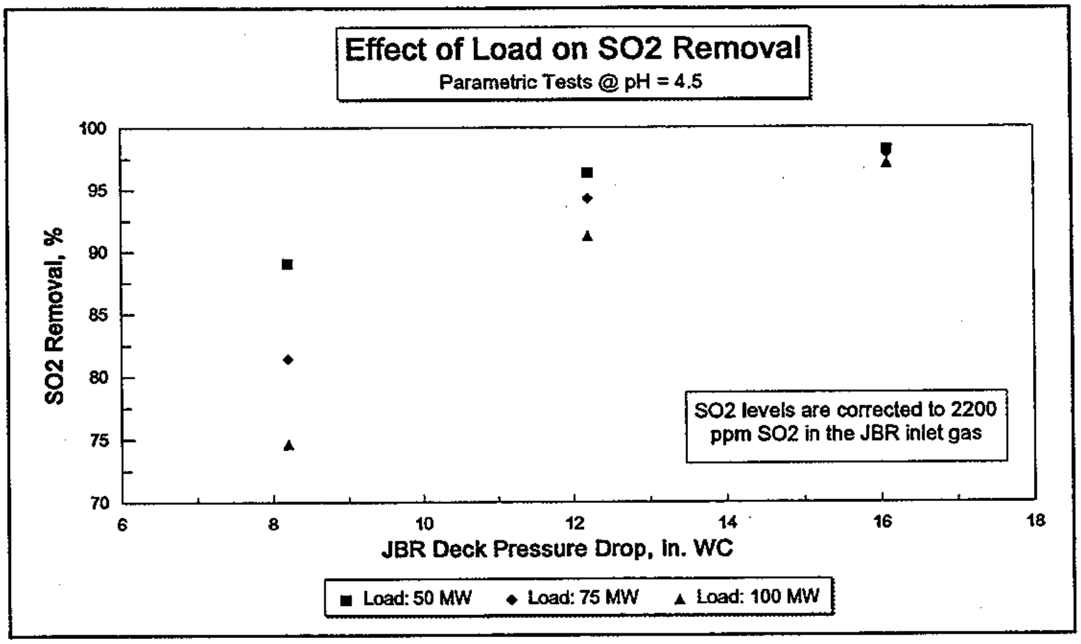


Figure 4-5. Effect of Load on SO_2 Removal: pH = 4.5

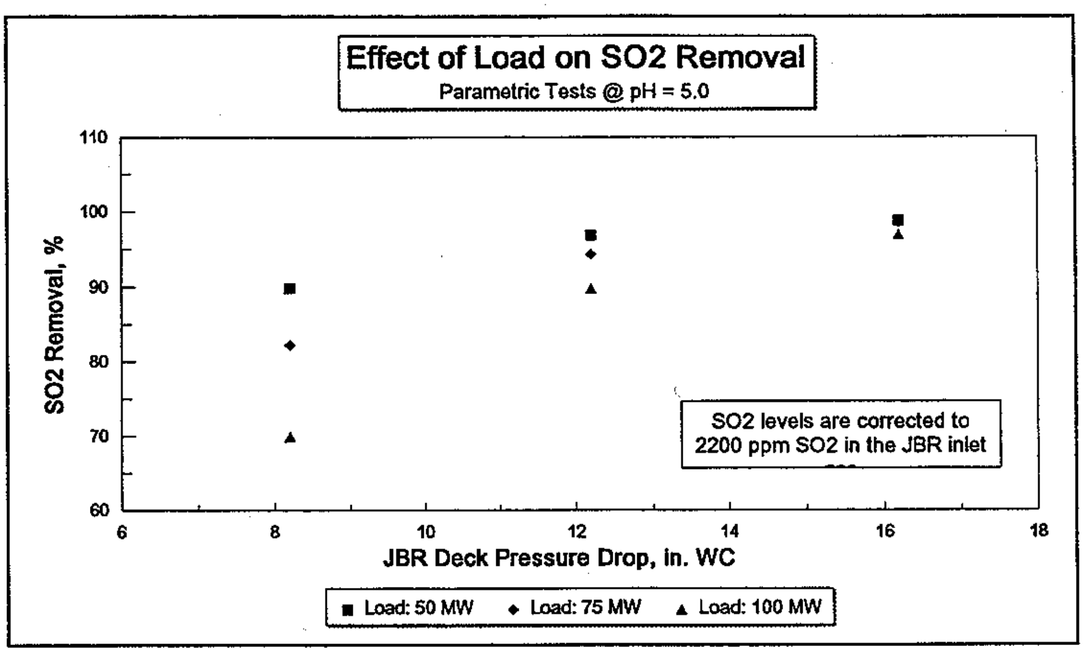


Figure 4-6. Effect of Load on SO_2 Removal: pH = 5.0

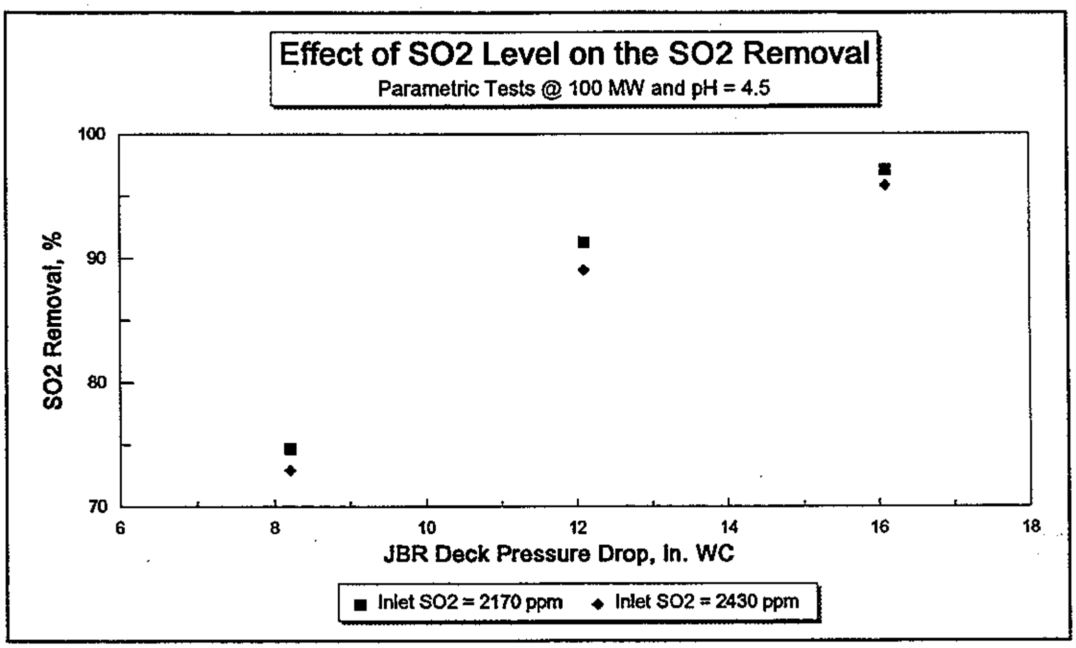


Figure 4-7. Effect of JBR Inlet Gas SO_2 Concentration on SO_2 Removal

Long-Term Tests

The long-term tests were conducted over an extended period of time during which the operating load for Unit 1 was allowed to vary in response to power demand. Scrubber operating conditions were selected to achieve a goal of 95% SO_2 removal. These conditions were selected from preliminary results of the Parametric tests.

Figure 4-8 presents the daily average SO_2 concentrations in the JBR inlet gas and stack gas streams over the long-term test period from April to September 1993. Figure 4-9 shows the SO_2 removal efficiency over this same period. As shown, the inlet SO_2 concentration was relatively consistent over the test period, while the outlet concentration varied in response to changing removal efficiencies. When the initial operating conditions [pH = 4.0, JBR pressure drop (ΔP) = 12 in. WC] provided lower removals than desired, the operating conditions were changed (pH = 5.0, JBR Δ = 14 inches). Once a more thorough examination of the parametric test data was available, the slurry pH operating level was reduced to 4.5. At these conditions, the average long-term SO_2 removal was nearly 94 percent. Compared to model predictions, the removal during this test block averaged about 2.6% low, possibly due to fouling of the JBR lower deck and sparger tubes, flue gas bypass through broken sparger tube(s), or erosion damage to the inlet plenum.

Auxiliary Tests

The Period 1 auxiliary test block included high removal tests, alternate limestone tests, and alternate coal tests.

The high SO_2 removal tests were conducted at a scrubber slurry pH of 4.8 and JBR ΔP of 18 inches WC. Short-term parametric tests were conducted at loads of 50, 75, and 88 MW, followed by a load-following test while Unit 1 was operated on load dispatch (the average load during this period was 90.6 MW). Figure 4-10 presents the results of these tests. As shown,

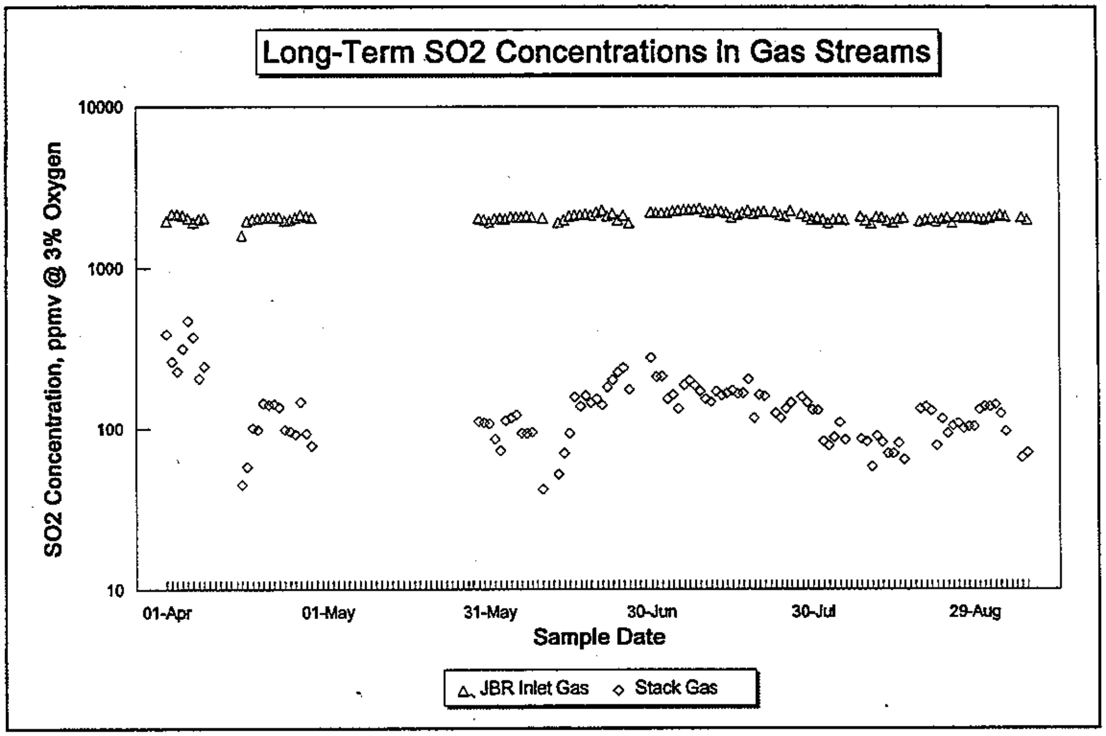


Figure 4-8. Long-Term Gas Stream Daily Average SO_2 Concentrations

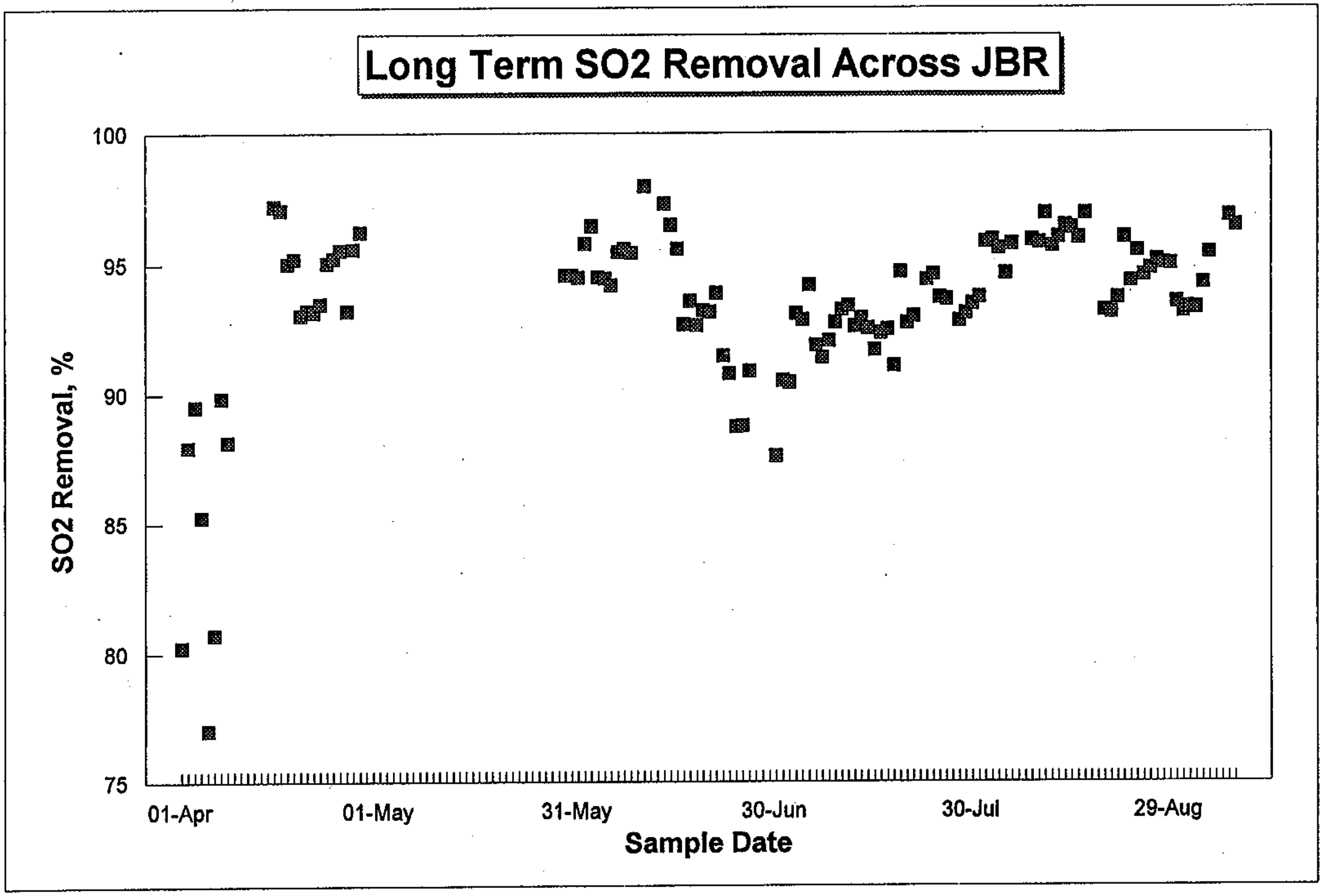


Figure 4-9. Long-Term Daily Average SO_2 Removal

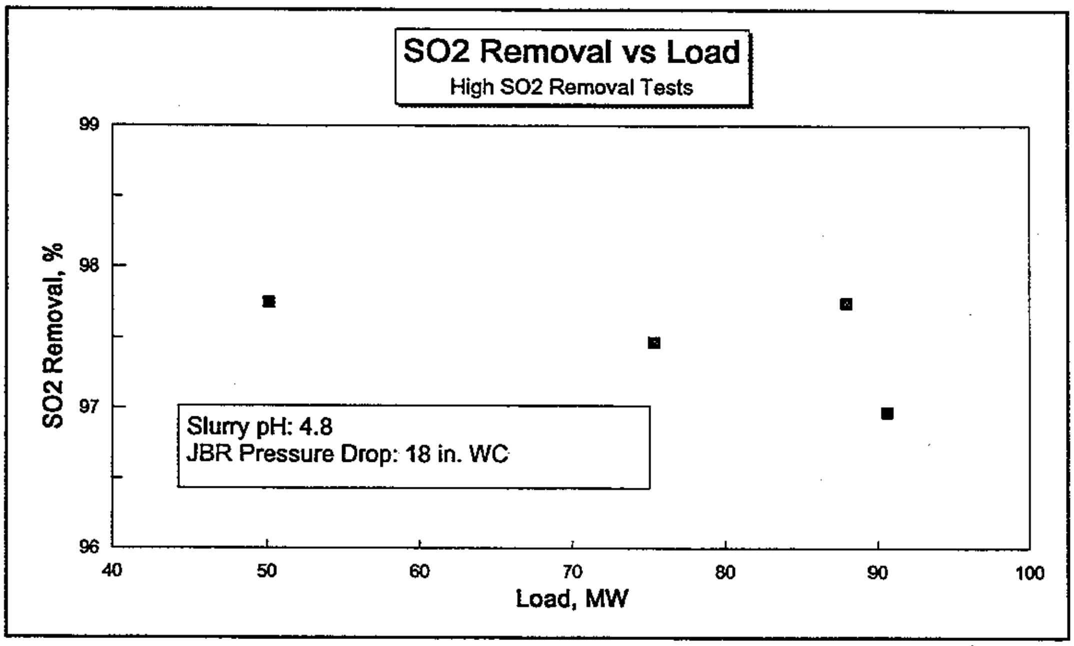


Figure 4-10. SO_2 Removal During High-Removal Tests

SO_2 removals were essentially independent of load during these tests, varying from 97.0 to 97.7 percent.

Tests were conducted to provide a comparison between the limestone originally selected for use in this project, from Martin Marietta Aggregates, and an alternative limestone supplied by Dravo. Test conditions allowed for direct comparisons of scrubber performance using the two limestones at two load levels (50 and 100 MW), JBR deck ΔP of 16 in. WC, and three pH levels. The results are presented in Figures 4-11 and 4-12. In general, SO_2 removals when using the alternative limestone were similar to or slightly lower than those obtained using the initial program limestone. Based on improvements in the properties of the gypsum produced, a decision was made to switch to the alternate limestone for the remainder of the demonstration program. The details are not within the scope of the EMP but are discussed in the auxiliary test block report.[2]

The final set of tests in the auxiliary test block investigated the ability of the CT–121 unit to treat flue gas produced by burning coal with significantly higher sulfur content compared to the program coal (4.3% versus about 2.5%). This level of coal sulfur was also above the level used in the design of the unit (3.0%). The complete results for all tests in this block are given in Appendix A, Table A-1. Figures 4-13 and 4-14 present the results for tests corresponding to parametric tests (50 and 75 MW, JBR ΔP = 16 in. WC) for three pH levels. As with the higher sulfur coal, reductions in SO_2 removal efficiency were observed at both load levels, although the scrubber was able to produce removals of more than 90% for all test conditions shown, with a single exception (75 MW, pH = 4.0).

4.1.2 Particulate Matter Loading and Size Distribution

Particulate matter (PM) samples were obtained from the JBR inlet and stack gas streams during the first nine parametric tests conducted in January 1993. The operating conditions for these tests are summarized in Table 4-2. Southern Research Institute (SRI)

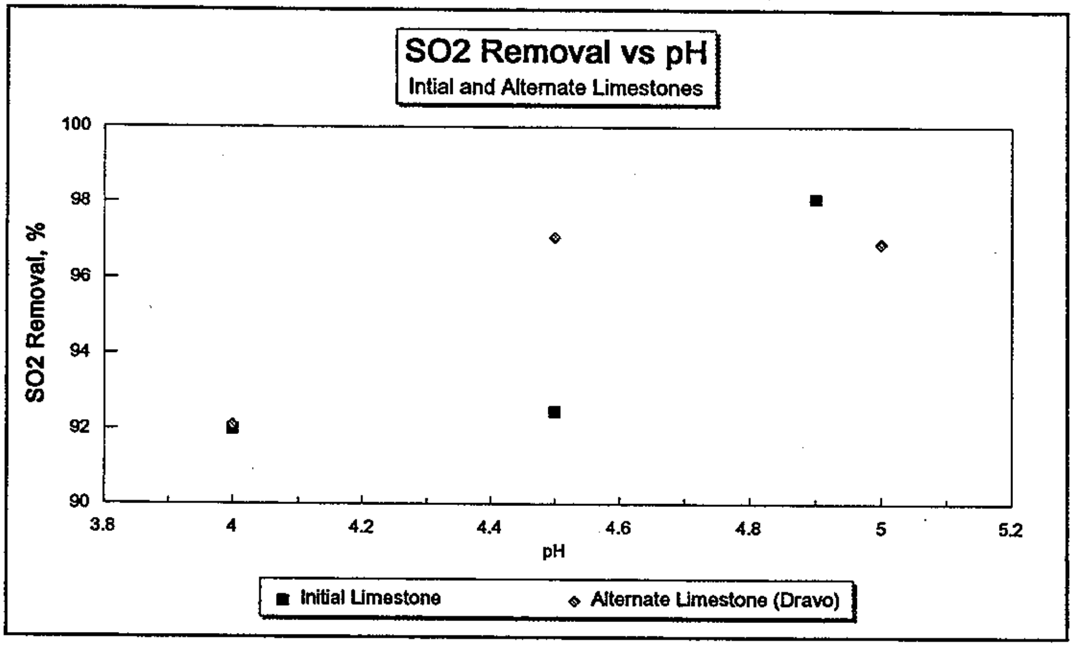


Figure 4-11. Effect of Limestone on SO_2 Removal: 100 MW Tests

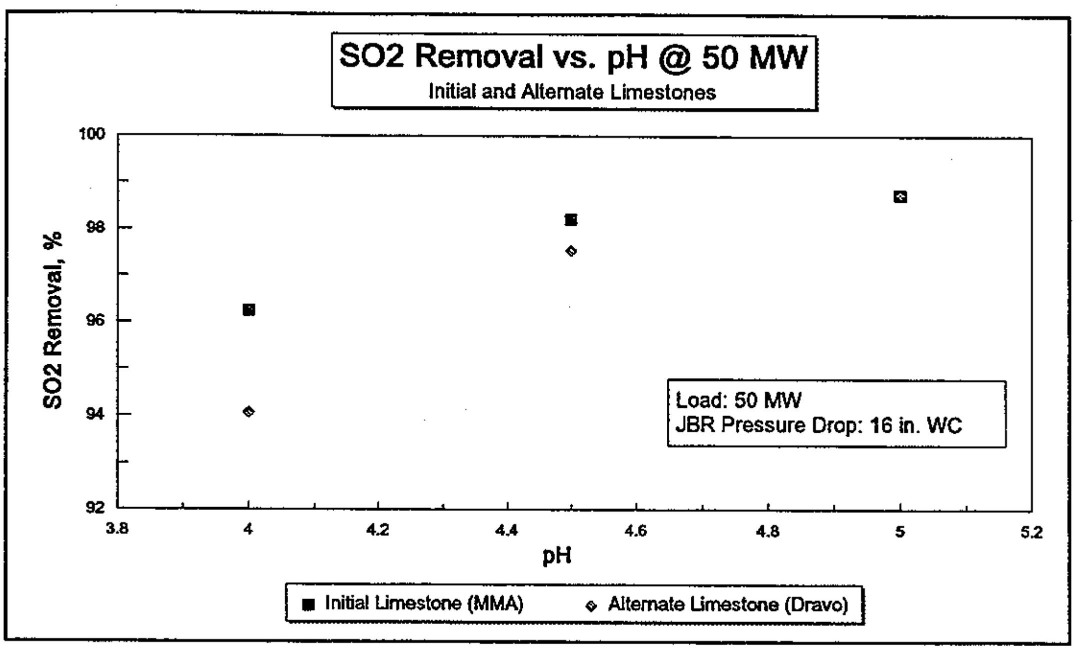


Figure 4-12. Effect of Limestone on SO_2 Removal: 50 MW Tests

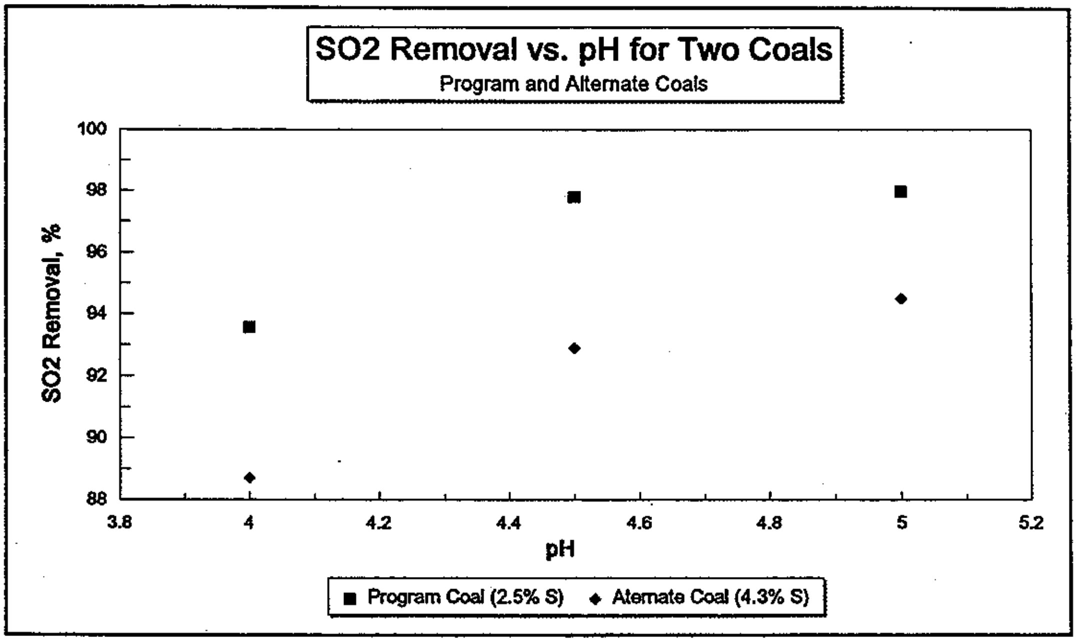


Figure 4-13. Comparison of SO_2 Removals for Program and Alternate Coals: 75 MW

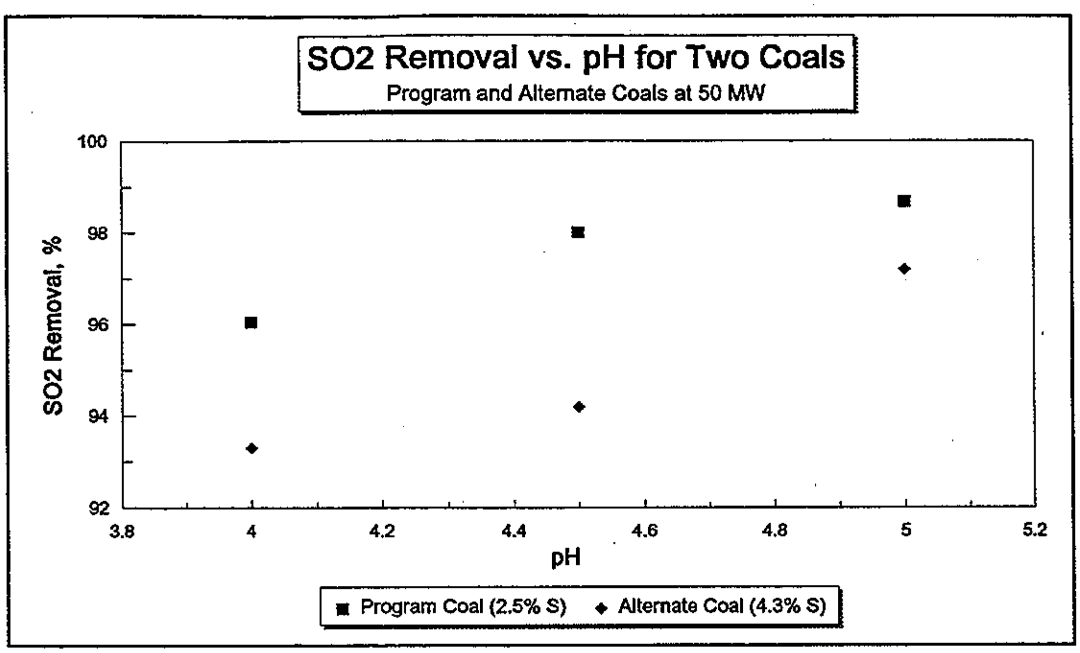


Figure 4-14. Comparison of SO_2 Removals for Program and Alternate Coals: 50 MW

Table 4-2

Scrubber Operating Conditions During PM and SO_3 Monitoring

Test No.	Unit Load, MW	pH	JBR ΔP, in. W.C.
P1-1	100.7	4.5	8.2
P1-2	100.3	4.5	12.1
P1-3	100.3	4.5	16.1
P1-4	75.4	4.5	8.2
P1-5	75.3	4.5	12.3
P1-6	75.3	4.5	16.2
P1-7	49.7	4.5	8.2
P1-8	49.2	4.5	12.2
P1-9	49.8	4.5	16.1

collected three samples from each stream during each test. The complete results are presented in Appendix A, Tables A-2 and A-4; the average PM rates (in lb/MMBtu) at each operating condition are shown in Figure 4-15. The particulate loading in the stack gas were relatively constant and always low (less than 0.015 lb/MMBtu). With only two exceptions, the JBR inlet gas loadings show a general decrease as the load decreased. This is consistent with the fact that ESPs are more efficient at lower gas flow rates (i.e., lower loads). The removal efficiency was about 90% for all of the tests conducted at 75 and 100 MW and for the 50 MW test conducted with a pressure drop of 8 in. WC. Lower apparent removals were obtained for the remaining 50 MW tests; this was actually due to decreases in the JBR inlet gas loading and not to increases in the outlet gas loading.

Particulate matter size distributions for the JBR inlet and stack gas streams were presented in SRI's report.[3] Figures showing the cumulative percent versus particle diameter from that report are reproduced in Appendix B. The results show that the scrubber was relatively ineffective at collecting particulate matter with a diameter less than about 1 micrometer, and that the outlet particle size distribution was relatively insensitive to changes in either load or scrubber pressure drop.

4.1.3 Sulfur Trioxide

SO_3 concentrations in the JBR inlet gas and stack gas were measured by SRI three to four times during each of the first nine parametric tests. The individual measurements are shown in Appendix A, Tables A-3 and A-5; mean values are plotted in Figure 4-16. There were no consistent trends in SO_3 concentration with load or JBR pressure drop, and SO_3 was found in the stack gas in all tests. In most cases, the SO_3 concentrations entering and leaving the JBR were both approximately 2-3 ppmv (corrected to 3% O_2); there was little or no removal across the scrubber.

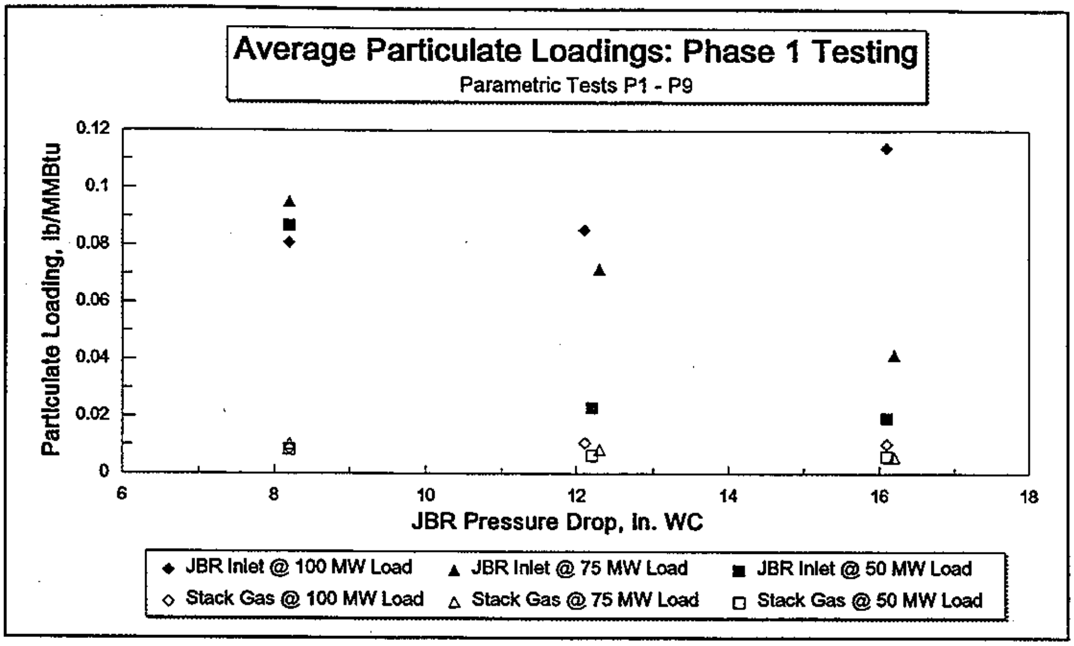


Figure 4-15. Average JBR Inlet and Stack Gas Particulate Matter Loadings

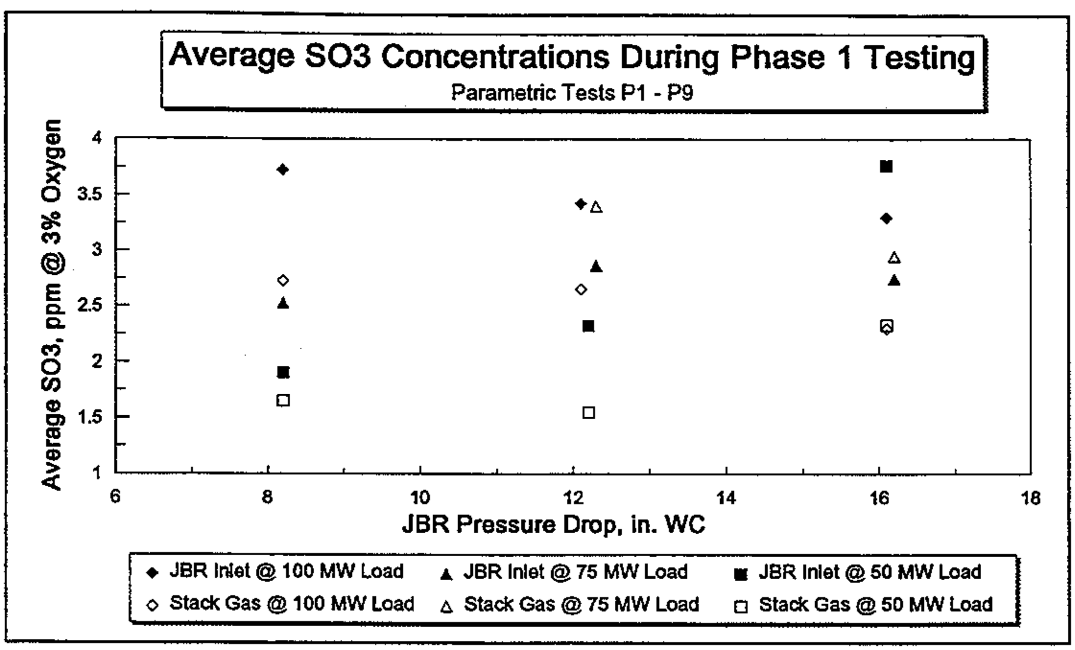


Figure 4-16. Average JBR Inlet and Stack Gas Sulfur Trioxide Concentrations

4.1.4 Water Vapor

Water vapor concentrations in the JBR inlet gas and stack gas were measured during each of the first nine Parametric tests. The results are presented in Figure 4-17. As expected, the flue gas leaving the JBR was typically saturated with water vapor, based on the measured pressure and temperature.

4.2 Compliance Monitoring

As part of the EMP, the opacity of the flue gas inlet to the JBR is measured using a continuous opacity monitor. Georgia Power provides periodic reports to the Georgia Department of Natural Resources detailing the daily excess opacity emissions. Copies of these reports have been provided as appendices to the quarterly EMP progress reports. A summary of the daily excess opacity emissions measured during Period 1 (first quarter 1993 through first quarter 1994) is provided in Table 4-3. The applicable emission limit for this source is 40% opacity during any six-minute monitoring period. The table shows the number of minutes during which this limit was exceeded as well as the total number of minutes of operating time for each quarter. The fraction of time the opacity limit was exceeded during Phase 1 was very small (i.e., 0.42% of the total operating time). The majority of the excess emissions occurred during boiler start up or shut down periods.

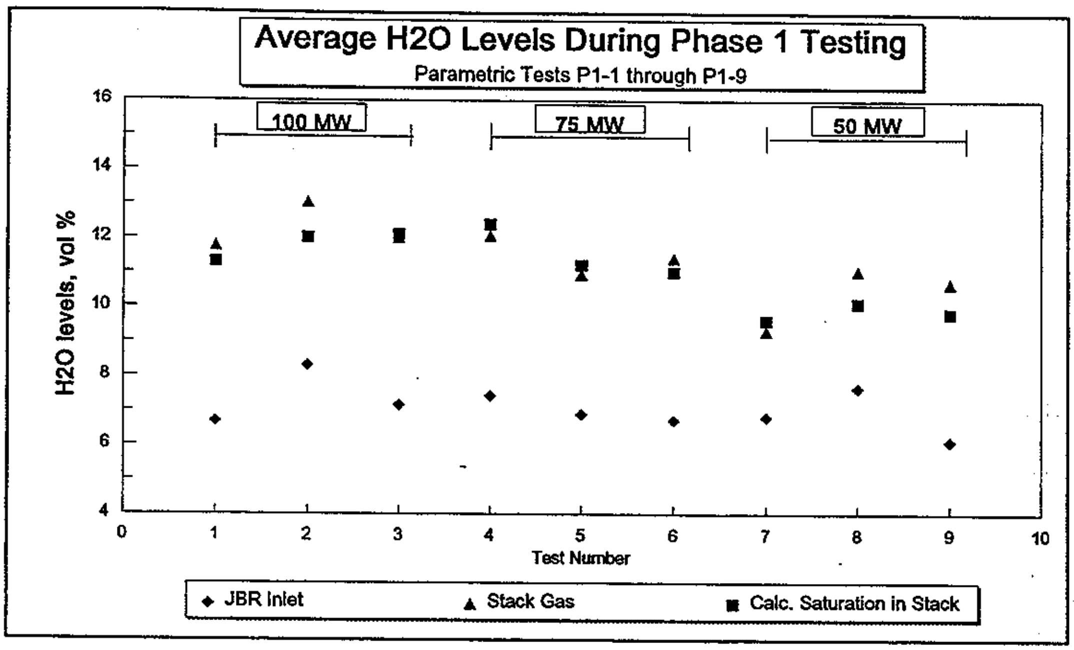


Figure 4-17. Average JBR Inlet and Stack Gas Water Vapor Concentrations

Table 4-3

JBR Inlet Gas Excess Opacity Emissions Summary

	1st Quarter 1993	2nd Quarter 1993	3rd Quarter 1993	4th Quarter 1993	1st Quarter 1994
Total Operating Time	100,421	76,497	112,305	86,603	109,380
Duration of excess opacity emissions due to:					
Startup/shutdown	156	840	174	210	570
Control equipment problems	0	0	0	0	0
Process problems	0	30	0	0	6
Other known causes	0	0	0	0	72
Unknown causes	0	0	0	0	0
Total duration of excess emissions, % of operating time	0.16%	1.14%	0.15%	0.24%	0.59%

Note: All times in minutes.

Source: Quarterly Air Emission Reports prepared by Georgia Power Company for Georgia DNR.

5.0 AQUEOUS STREAM MONITORING RESULTS

This section presents a summary of the Period 1 aqueous stream monitoring results. Tables containing the complete results for the EMP aqueous stream parameters are provided in Appendix A.

Table 5-1 shows the actual and planned monitoring frequencies for each of the aqueous stream parameters. As shown, the majority of the monitoring specified in the EMP was performed as planned. Although not shown in Table 5-1, groundwater monitoring was performed for all EMP parameters as planned, although at least one well and sometimes two were dry at the time of sampling.

The results of supplemental monitoring of the aqueous process streams, groundwater monitoring, and compliance monitoring are discussed in separate subsections.

5.1 Aqueous Process Stream Supplemental Monitoring

A number of aqueous process streams were monitored as specified in the EMP, including limestone slurry, makeup water, gypsum stack return, JBR overflow, and JBR underflow. The results for each stream are discussed below.

5.1.1 Limestone Slurry

The limestone slurry solids content during all Phase 1 test periods is shown as a function of time in Figure 5-1. The solids content of the limestone feed slurry averaged 30% by weight over all Period 1 tests. The variability as measured by the coefficient of variation (defined as the sample standard deviation divided by the sample mean) was 12 percent.

Table 5-1

Aqueous Process Streams: Actual and Planned Monitoring[a]

Parameter	Ash Transport Water	Final Plant Discharge	JBR Overflow	JBR Underflow	Limestone Slurry	Gypsum Stack Return	Makeup Water
Liquid Phase							
pH		32/28	56/54	56/54		57/54	3/14
Total Suspended Solids	32/28						
Oil & Grease	32/28						
Chloride			56/54			57/54	5/14
Sulfite			55/54				2/14
Sulfate			56/54			57/54	5/14
Carbonate			55/54			56/54	1/14
Trace Elements			4/6			4/6	
Solid Phase							
Solids Content			56/54	56/54	55/54		
Inert Content			17/54	56/54	55/54		
Calcium			50/54	56/54	55/54		
Magnesium				56/54	55/54		
Sulfite				55/54			
Sulfate			50/54	56/54			
Carbonate			49/54	56/54	55/54		
Trace Elements				8/6			
TCLP				1/1 [b]			

[a] 56/54 = 56 actual/54 planned.
[b] A sample was obtained for TCLP analysis, but maximum allowable holding time was exceeded.

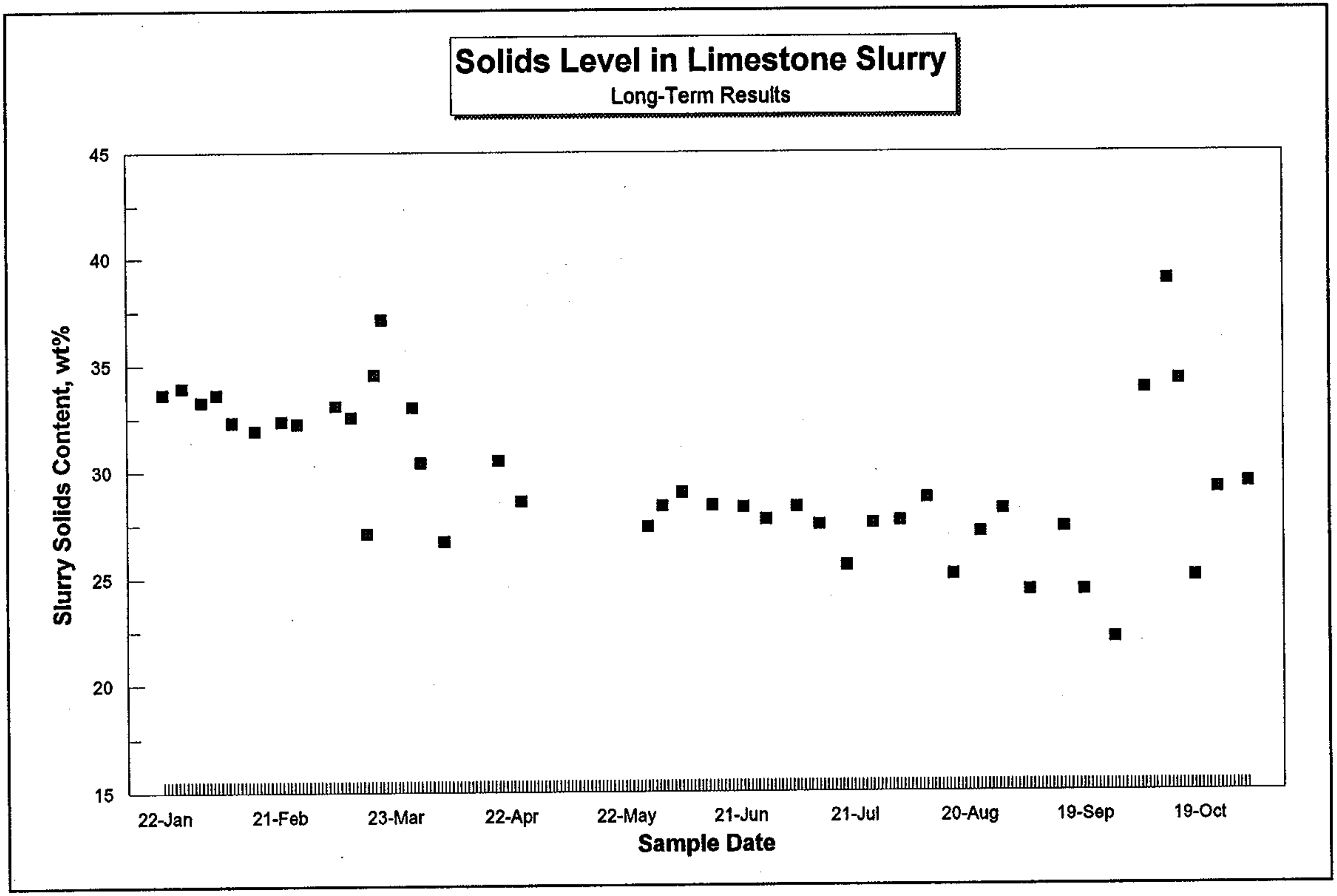


Figure 5-1. Limestone Slurry Solids Content

The limestone composition over time is shown in Figure 5-2. The composition was relatively constant; the initial program limestone consisted primarily of calcium carbonate with a small amount of magnesium carbonate and about 2% inerts. The alternate limestone contained slightly more magnesium carbonate and a correspondingly lower concentration of inerts.

5.1.2 Makeup Water

The results of the makeup water analyses performed during Period 1 are given in Table 5-2. The majority of the scrubber makeup water is taken from the ash pond.

5.1.3 Gypsum Stack Return

The composition of the gypsum stack return liquor is plotted against time in Figure 5-3. The results show that the chloride content of the liquor continued to increase over time during Phase 1 and did not appear to have reached a steady level by the end of that test period. The sulfate concentration was relatively constant over time. The carbonate level was low and varied from one set of tests to another. The results observed were consistent with a typical scrubber system operating with a relatively tightly closed water balance.

Aqueous phase trace element concentrations in the gypsum stack return liquor are shown in Appendix A, Table A-8.

5.1.4 JBR Overflow

The JBR Overflow slurry solids content is plotted in Figure 5-4. The solids content averaged nearly 21% by weight; the coefficient of variation was 14 percent.

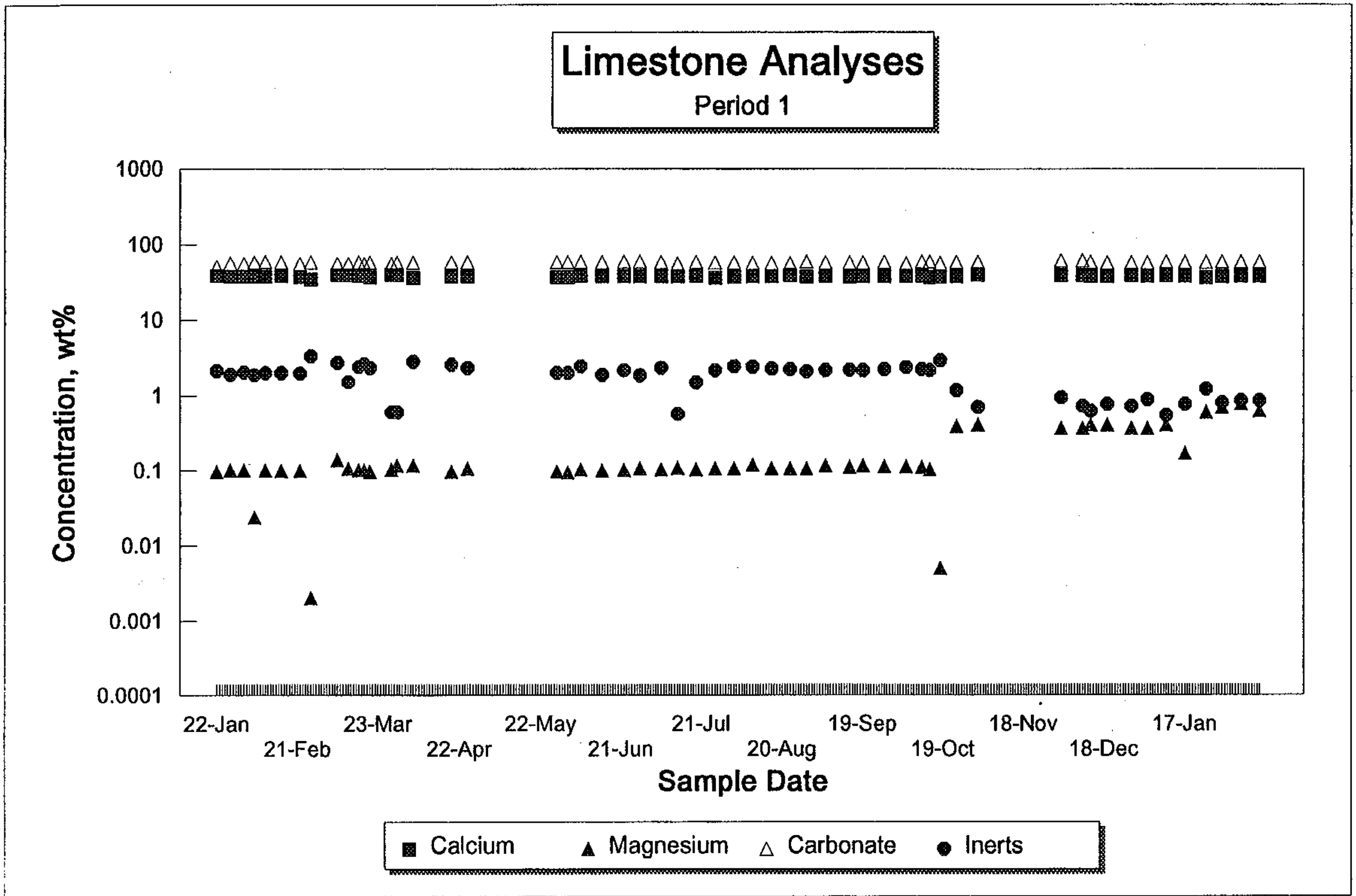


Figure 5-2. Limestone Composition

Table 5-2

Makeup Water Analyses: Period 1

Test ID	Date	pH	Liquid Phase, mg/L			
			Carbonate	Sulfite	Sulfate	Chloride
L1-3	06-Jun-93	6.75		0.8	46	42
L1-3	09-Aug-93	6.08	36	0.8	152	22
HR1-4	04-Oct-93				67	35
AL1-1	10-Jan-94	7.36			13	37
AC1-10	14-Feb-94				110	138

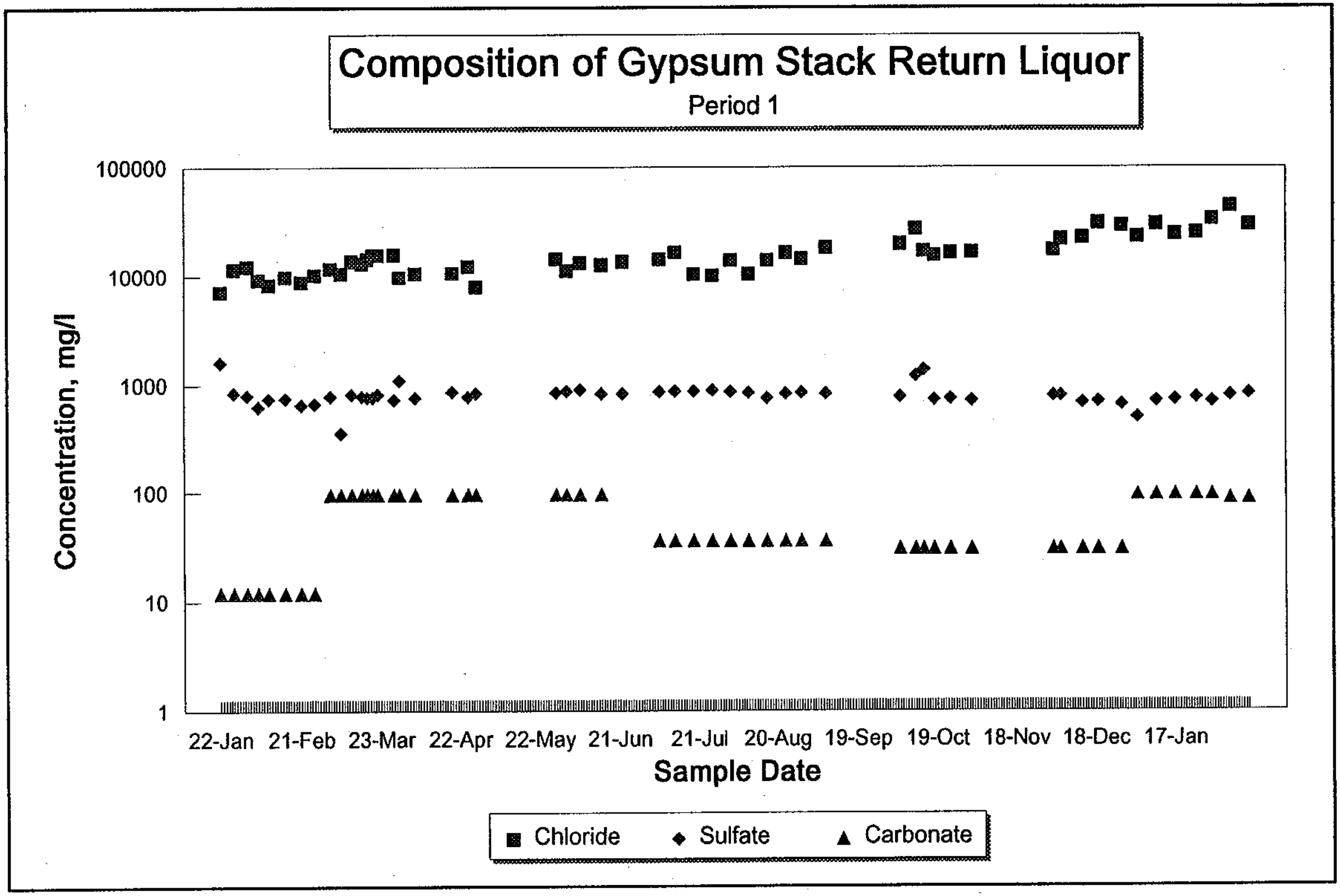


Figure 5-3. Gypsum Stack Return Liquor Composition

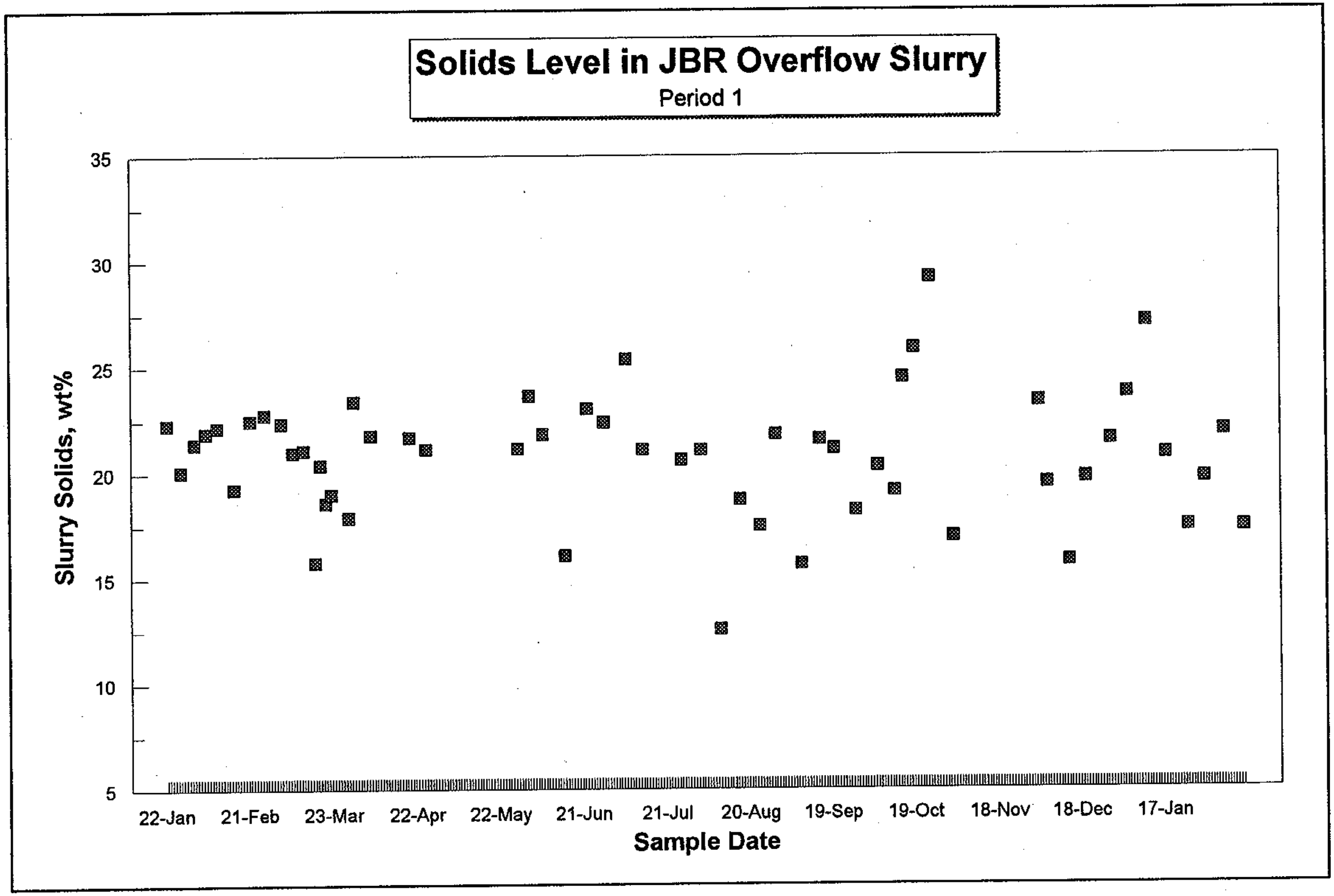


Figure 5-4. JBR Overflow Slurry Solids Content

The concentrations of chloride and sulfate in the JBR overflow liquor, shown in Figure 5-5, exhibited the same trends as for the gypsum stack return stream; the chloride concentration was still increasing by the end of Phase 1, and the sulfate concentration was relatively steady.

The JBR overhead solids consisted primarily of calcium sulfate, based on the relative concentrations of calcium and sulfate ions and the low sulfite concentration that was typically measured. These results are shown graphically in Figure 5-6. The measured data show that the absorbed sulfur dioxide was usually completely converted from sulfite to sulfate. A small amount of carbonate (due to unconverted limestone) was also present.

Measured trace element concentrations in the JBR overflow liquor are presented in the Appendix A, Table A-11.

5.1.5 JBR Underflow

As shown in Figure 5-7, the solids content of the JBR underflow slurry was virtually identical to that measured in the overflow stream; i.e., 21% by weight. The coefficient of variation was 12%.

The composition of the JBR underflow solids was consistent with the measurements of the JBR overflow solids as shown in Figure 5-8. The JBR underflow solids consisted principally of calcium sulfate with a small amount of unreacted carbonate.

The JBR underflow solids were analyzed periodically for trace elements; the results are presented in Appendix A, Table A-13.

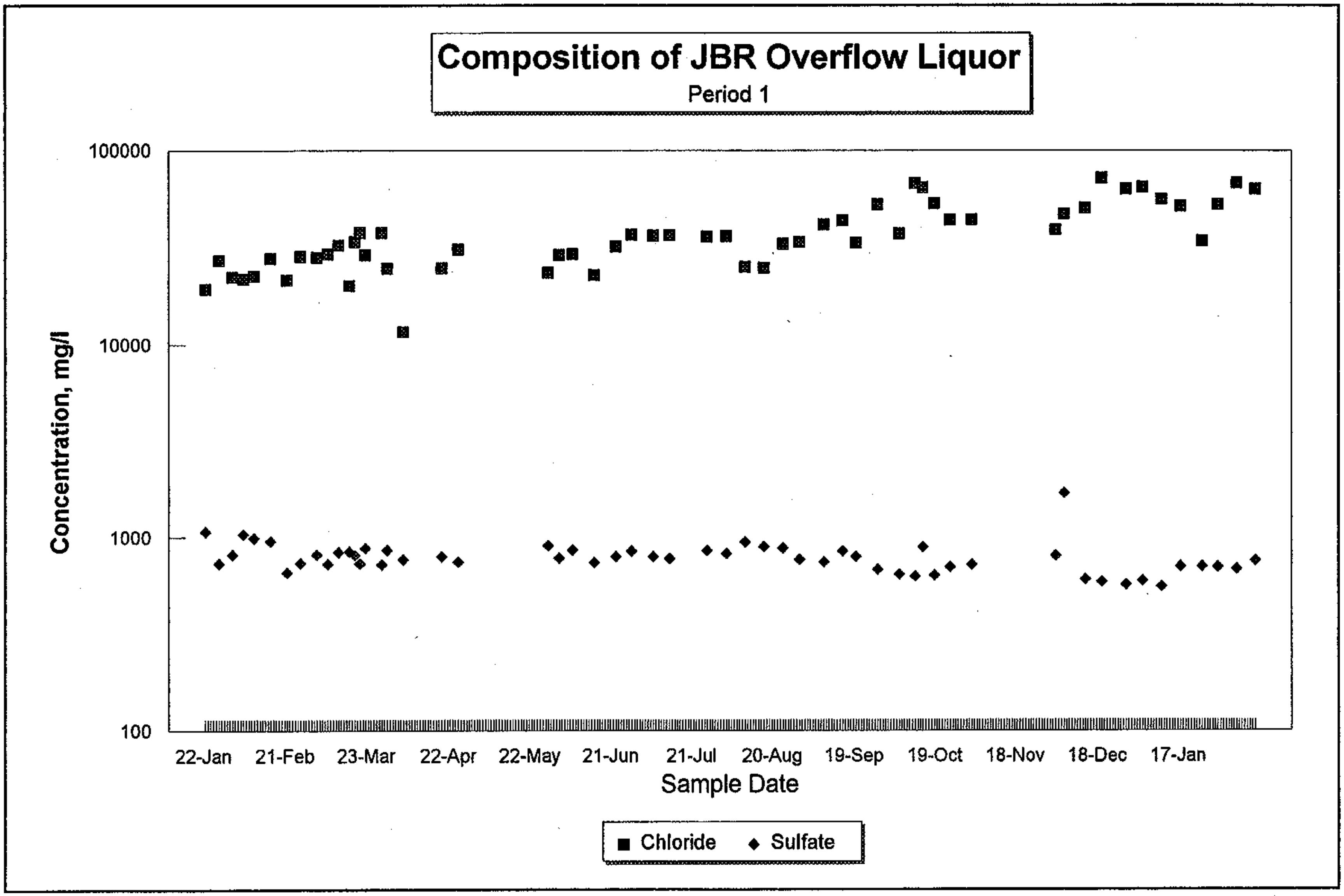


Figure 5-5. JBR Overflow Liquor Composition

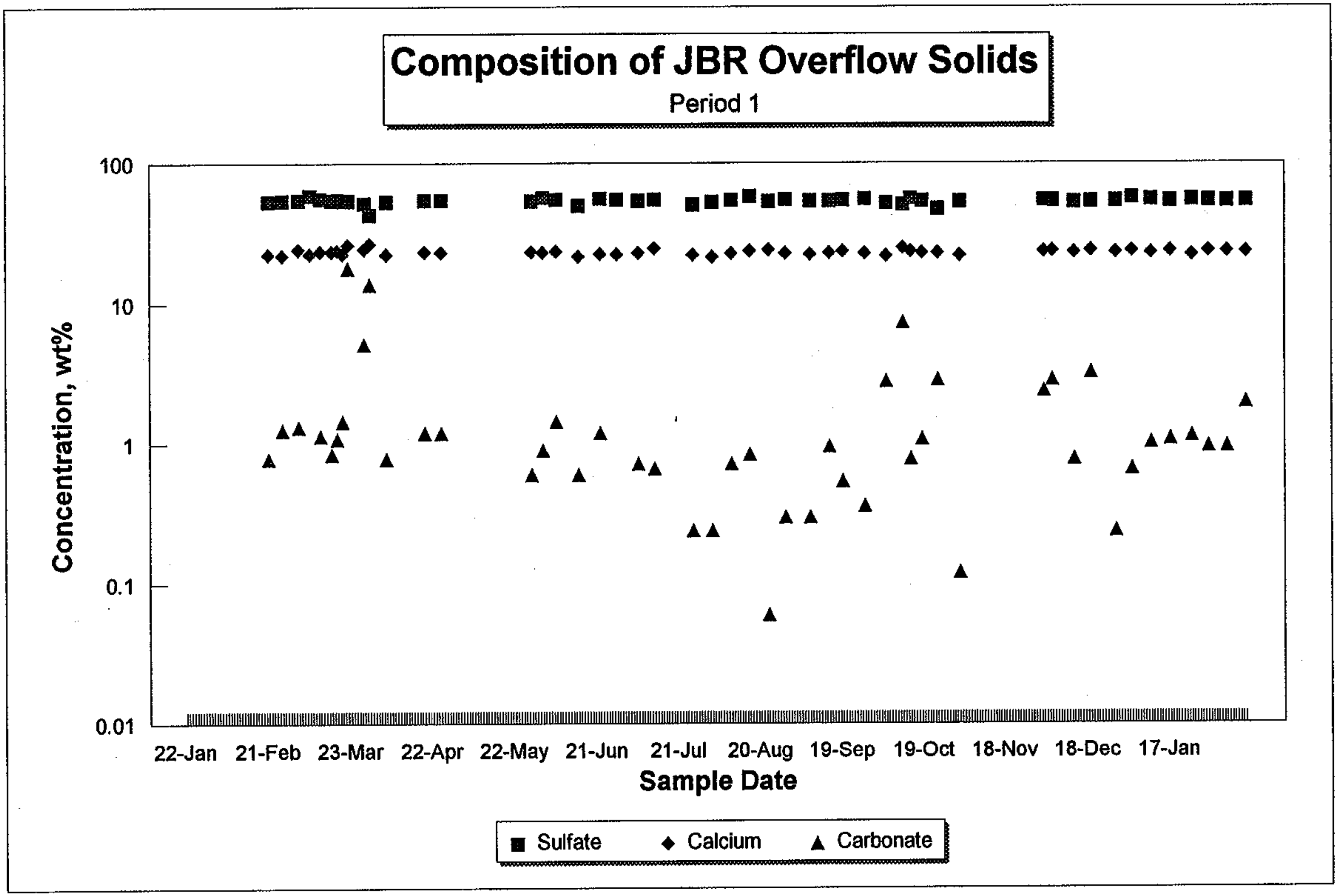


Figure 5-6. JBR Overflow Solids Composition

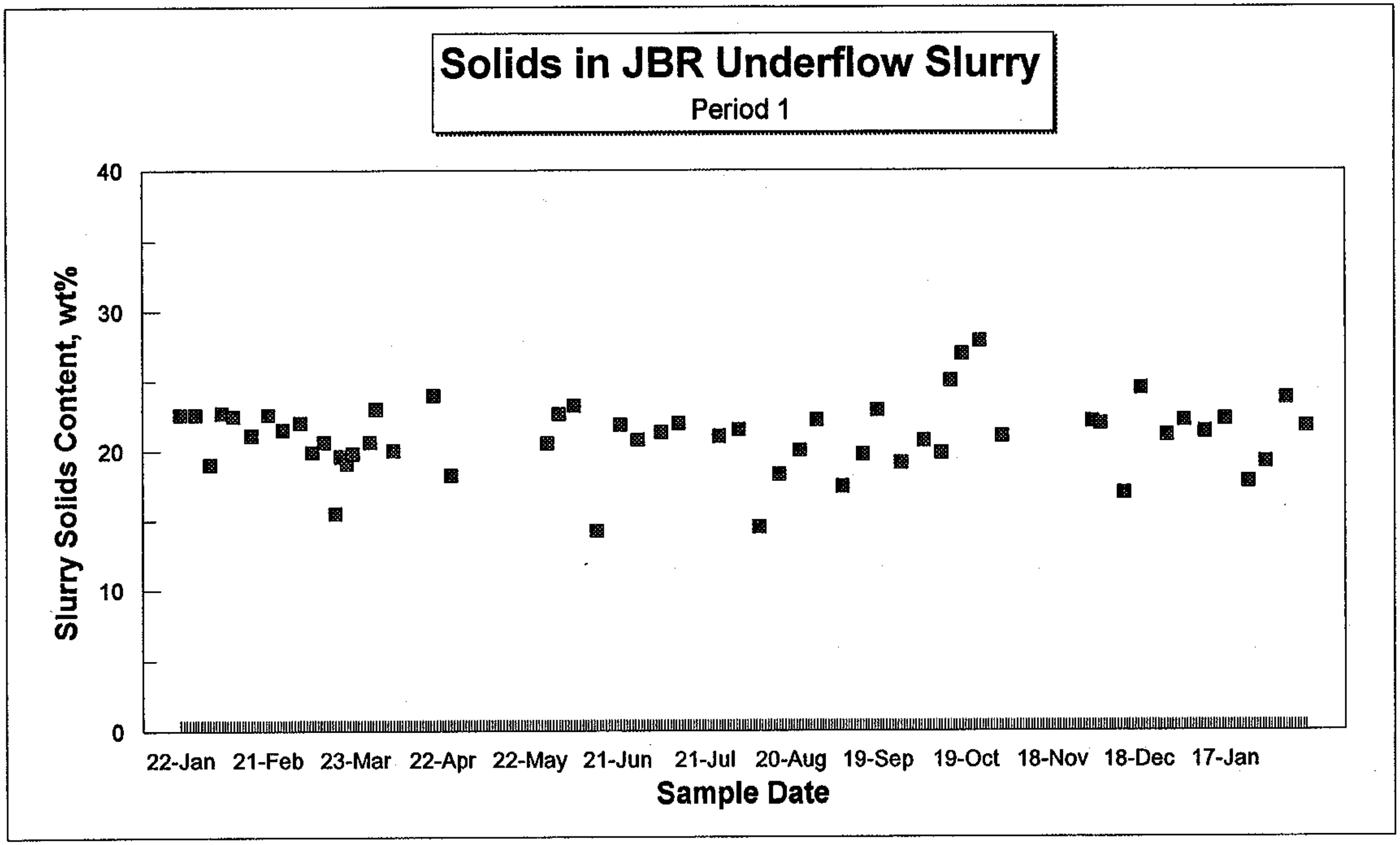


Figure 5-7. JBR Underflow Slurry Solids Content

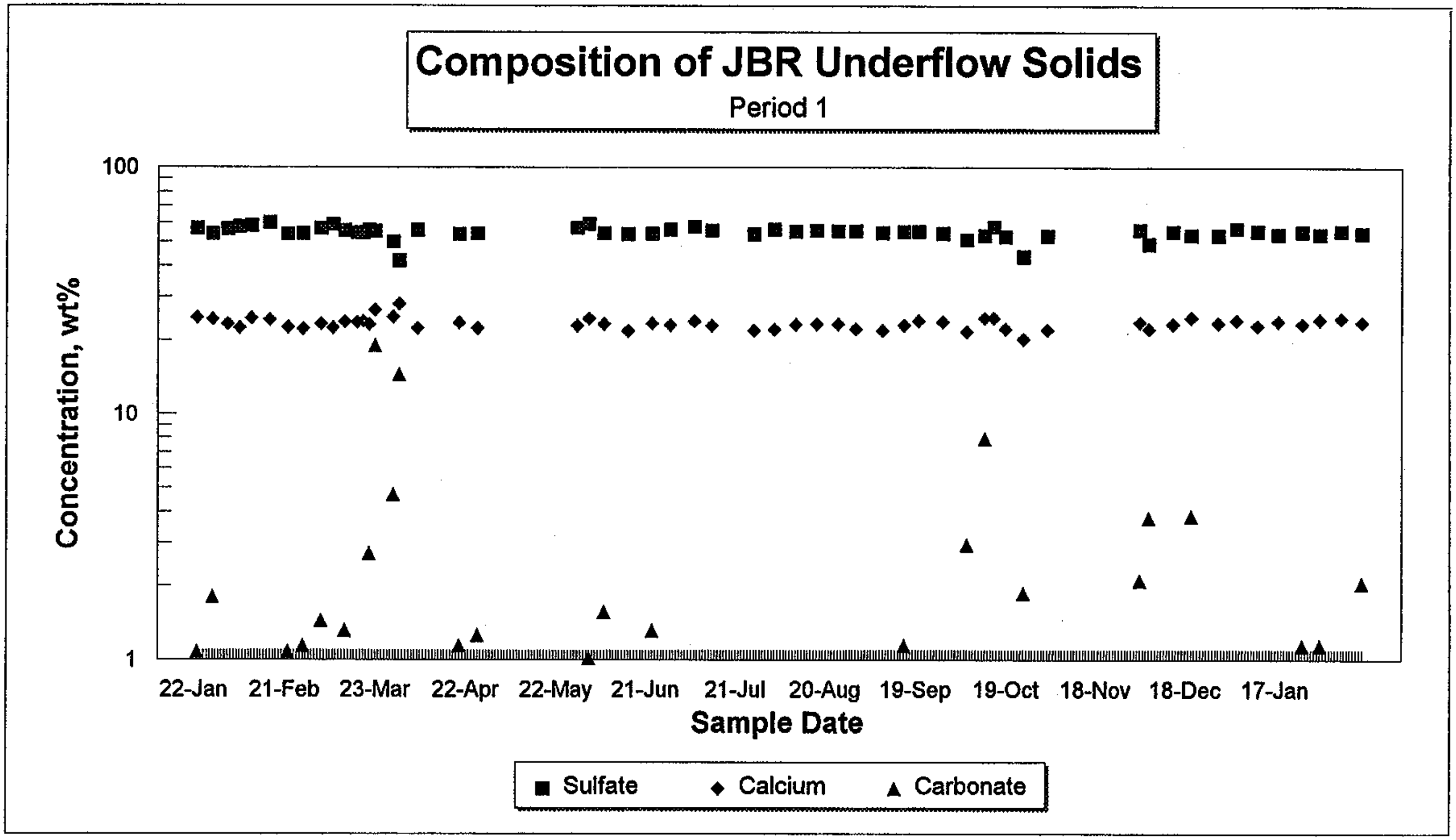


Figure 5-8. JBR Underflow Solids Composition

5.2 Groundwater Monitoring

The groundwater in the vicinity of the gypsum stacking area is monitored to demonstrate that the gypsum stacking area can be operated in an environmentally benign and acceptable manner. Seven monitoring wells (one up-gradient and six down-gradient) have been installed and are monitored quarterly during the operational phases of the project. The locations of the monitoring wells are shown in Figure 5-9. Monitoring was also performed over a period of more than a year prior to construction to define baseline compositions. Groundwater monitoring reports are included as appendices to the quarterly EMP progress reports.

To help determine whether the material in the gypsum stacking area is having an impact on groundwater quality, the monitoring data for a selected number of representative species from all of the monitoring rounds conducted to date are tabulated and examined each quarter. The representative species selected are those present in appreciable concentrations in the gypsum slurry, including the major cations and ions (i.e., calcium, magnesium, chloride, and sulfate), as well as several other indicator parameters, such as pH, TDS, conductivity, and alkalinity. Example plots of groundwater concentration versus time for several species from the up-gradient monitoring well (GWA-1) are provided in Figures 5-10; data for these species from two down-gradient wells (GWC-2 and GWC-4) are provided in Figures 5-11 and 5-12. Monitoring results obtained through the fourth quarter of 1993 are included in the figures.

The measured concentrations for all monitored parameters are generally close to the historically observed (baseline) concentrations of these species. There is no evidence of any systematic increases in the concentrations of the monitored groundwater constituents. Based on the results obtained to date, there is no indication of leakage from the gypsum stacking area into the underlying groundwater.

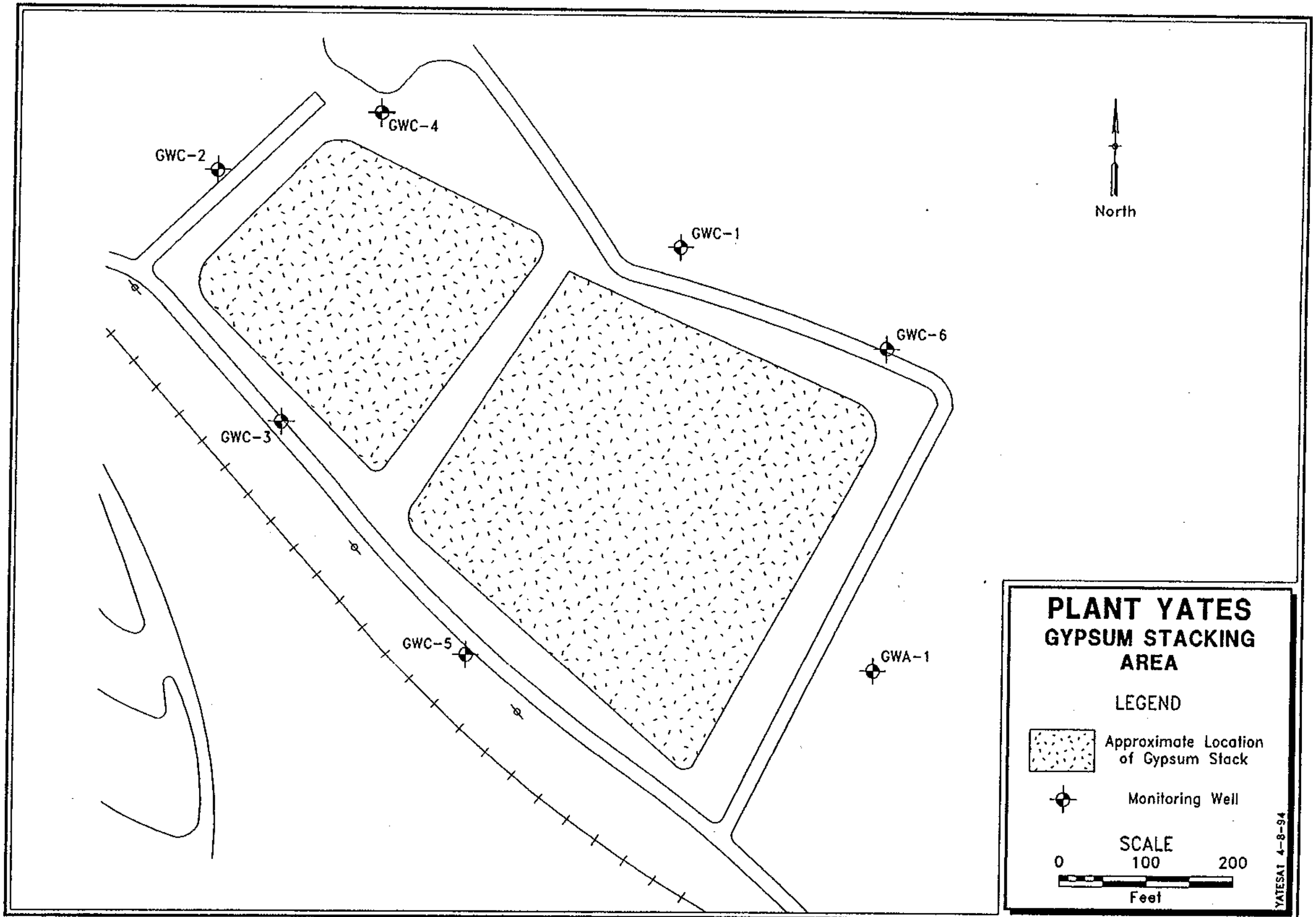


Figure 5-9. Location of Groundwater Monitoring Wells

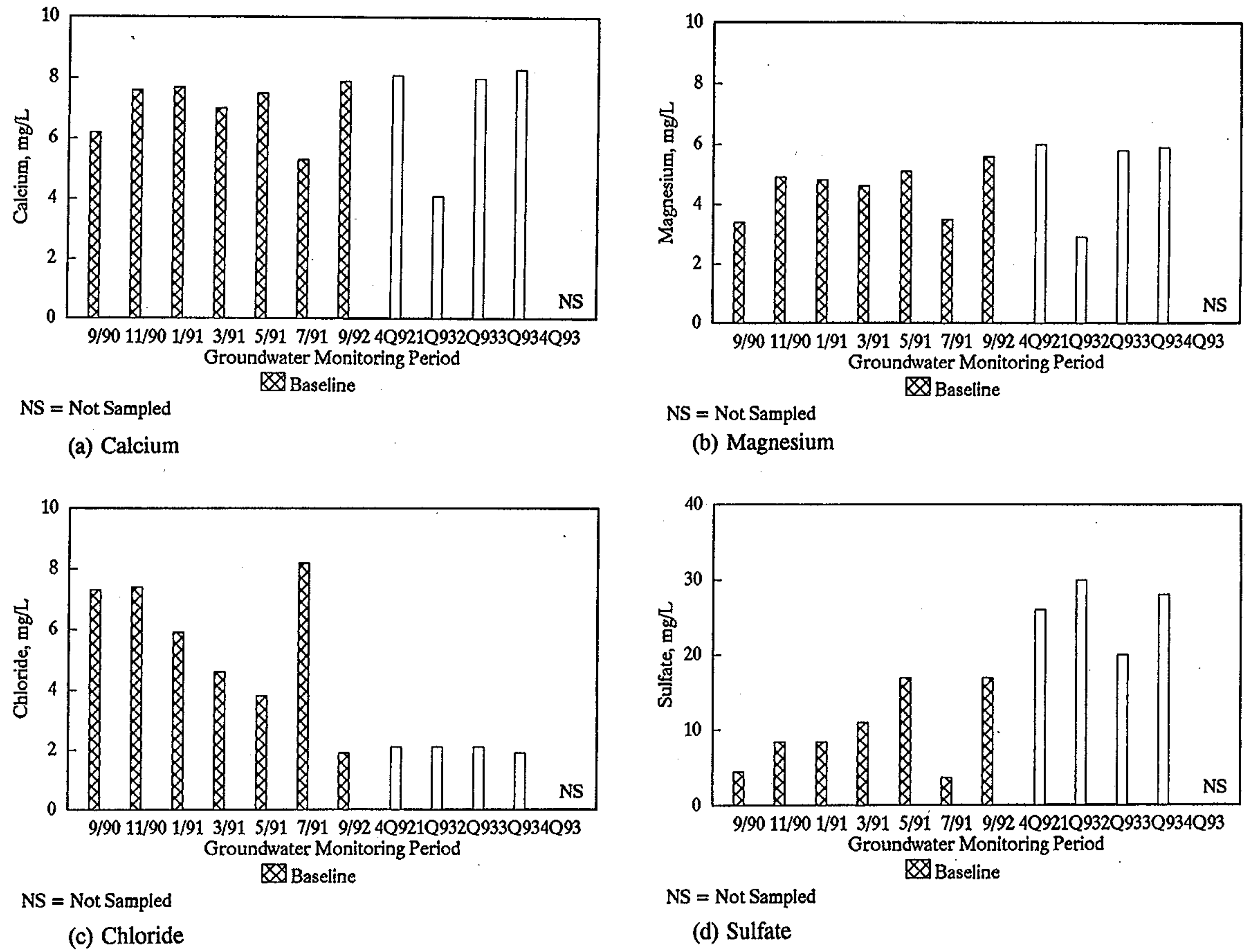


Figure 5-10. Historical Data for Representative Species from Well GWA-1 (Upgradient)

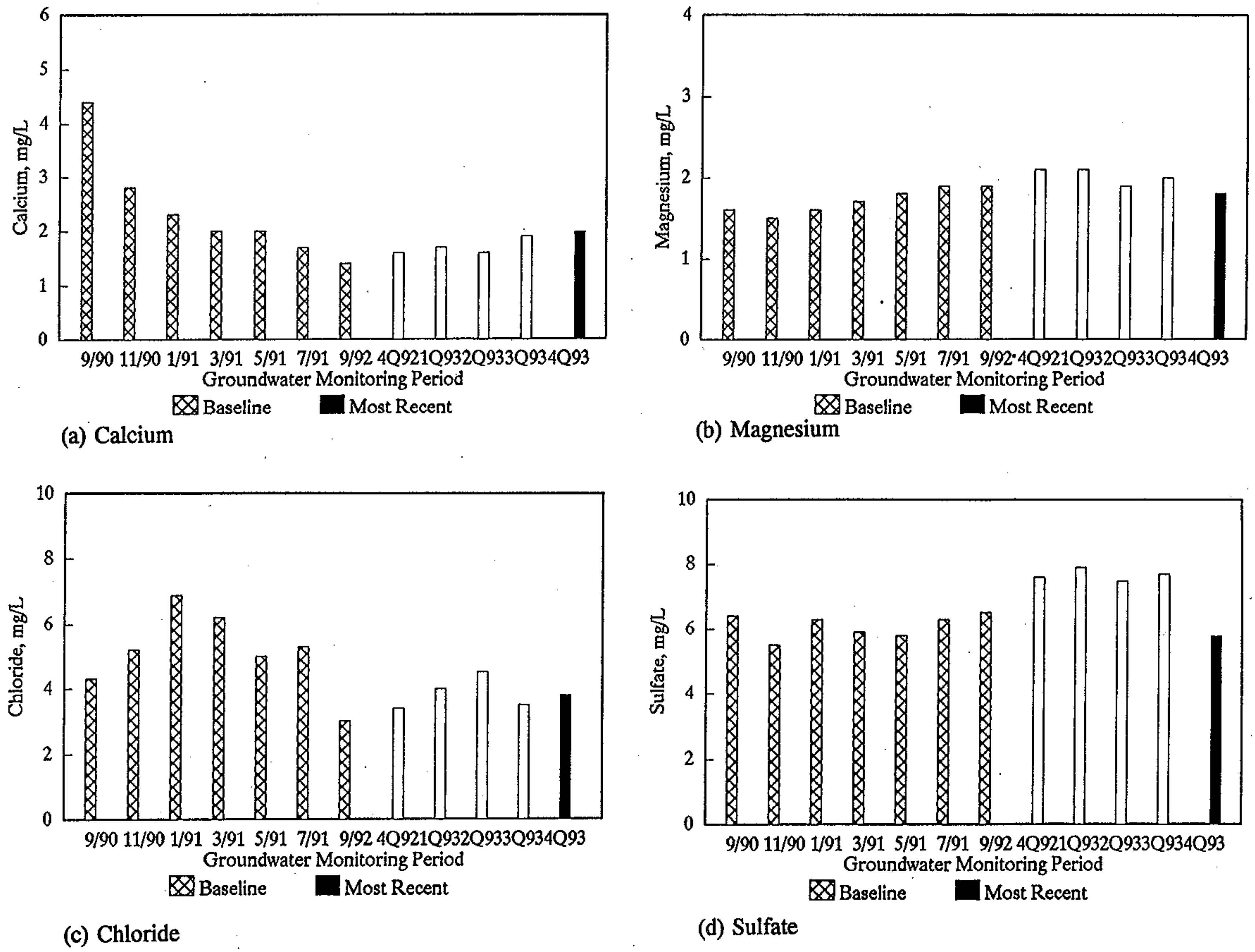
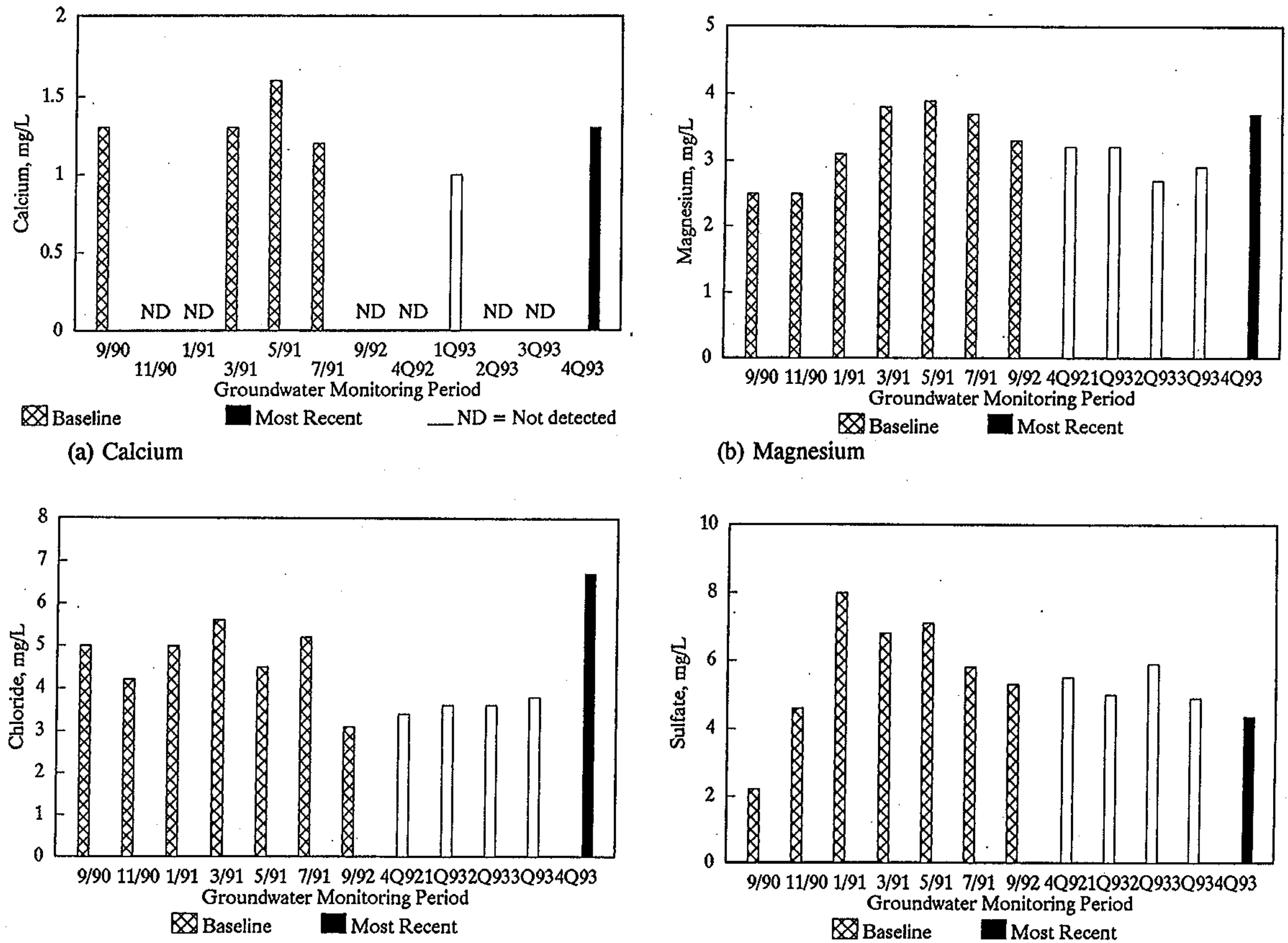


Figure 5-11. Historical Data for Representative Species from Well GWC-2 (Downgradient)



(a) Calcium

(b) Magnesium

(c) Chloride

(d) Sulfate

Figure 5-12. Historical Data for Representative Species from Well GWC-4 (Downgradient)

5.3 Compliance Monitoring

Compliance monitoring of ash transport water and final plant discharge is included in the EMP. The results presented here were compiled from quarterly compliance reports submitted by Georgia Power Company to the Environmental Protection Division of the Georgia Department of Natural Resources. Copies of these compliance reports are included as appendices to the EMP quarterly progress reports submitted to DOE as part of this project. The data summarized in this section were taken from the compliance reports from the first quarter of 1993 through the first quarter of 1994.

Table 5-3 summarizes the results obtained during Period 1; averages, standard deviations, number of data points, and ranges are shown for each parameter, together with the corresponding NPDES permit limits. There were no exceedances of the regulatory limits imposed by the plant's NPDES permit.

Table 5-3

Aqueous Streams: Period 1 Compliance Monitoring Results

Parameter	Mean	Std. Dev.	Data Points	Range	Permit Limits
Ash Transport Water					
TSS (mg/L)	1.9	0.9	32	1-4	30 Ave./100 Max.
Oil & Grease (mg/L)	<5	0	32	0-<5	15 Ave./20 Max.
Final Plant Discharge					
pH	6.75	0.26	32	6.14-7.22	6.0 Min./9.0 Max.

6.0 SOLID STREAM MONITORING RESULTS

Monitoring of the coal feed to the Unit 1 boiler is included in the EMP to provide data on composition changes that could affect the interpretation of other monitoring results. Monitoring consists primarily of daily proximate analyses plus sulfur content and heating value. Ultimate analyses and trace element determinations are also performed semi-annually.

Table 6-1 shows the actual and planned monitoring frequencies for each of the coal analyses. The monitoring specified in the EMP was performed substantially as planned. The detailed coal analysis results are provided in Appendix A, Tables A-14 (proximate analyses), A-15 (ultimate analyses) and A-16 (trace elements).

A statistical summary of the daily proximate analyses performed during Period 1 is presented in Table 6-2. Figure 6-1 presents the average proximate analyses for each of the Period 1 test blocks. As can be seen, the composition of the program coal feed to Unit 1 was consistent during the parametric, long-term, and auxiliary test blocks. The composition of the alternate coal was similar to that of the program coal except for its higher sulfur content (4.3% versus 2.4%).

Table 6-1

Solid Streams: Actual and Planned Monitoring[a]

Parameter	Coal Feed
Proximate Analysis, Sulfur, and HHV	303/303
Ultimate Analysis, Chlorine and Fluorine	6/3
Trace Elements	2/3

[a] 303/303 = 303 actual/303 planned.

Table 6-2

Statistical Summary of Coal Proximate Analyses

Parameter	Parametric Tests			Long-Term Tests		
	Mean	Std. Dev.	Range	Mean	Std. Dev.	Range
Moisture, wt%	12.89	1.17	6.66-15.37	11.74	1.01	8.31-14.28
Volatiles, wt%	33.9	1.1	26.4-35.0	33.9	0.7	31.5-35.3
Fixed C, wt%	43.5	1.2	41.2-48.6	45.0	0.8	43.3-48.9
Ash, wt%	9.68	0.74	8.7-11.36	9.41	0.58	8.59-11.27
Sulfur, wt%	2.42	0.18	1.53-2.70	2.34	0.13	1.76-2.84
HHV, Btu/lb	11,185	269	10,690-12,340	11,431	207	11,024-12,481
Parameter	Auxiliary Tests			Alternate Coal Tests		
	Mean	Std. Dev.	Range	Mean	Std. Dev.	Range
Moisture, wt%	12.49	1.11	8.98-14.98	8.95	1.10	7.19-10.85
Volatiles, wt%	33.6	0.5	32.2-34.4	37.9	0.6	36.7-38.8
Fixed C, wt%	44.3	0.8	42.8-48.1	43.2	0.7	41.7-44.5
Ash, wt%	9.60	0.53	8.47-10.80	9.89	0.25	9.43-10.62
Sulfur, wt%	2.37	0.16	1.71-2.62	4.30	0.09	4.17-4.49
HHV, Btu/lb	11,272	180	10,847-12,058	11,936	139	11,670-12,141

All parameters are reported on an as-burned basis.

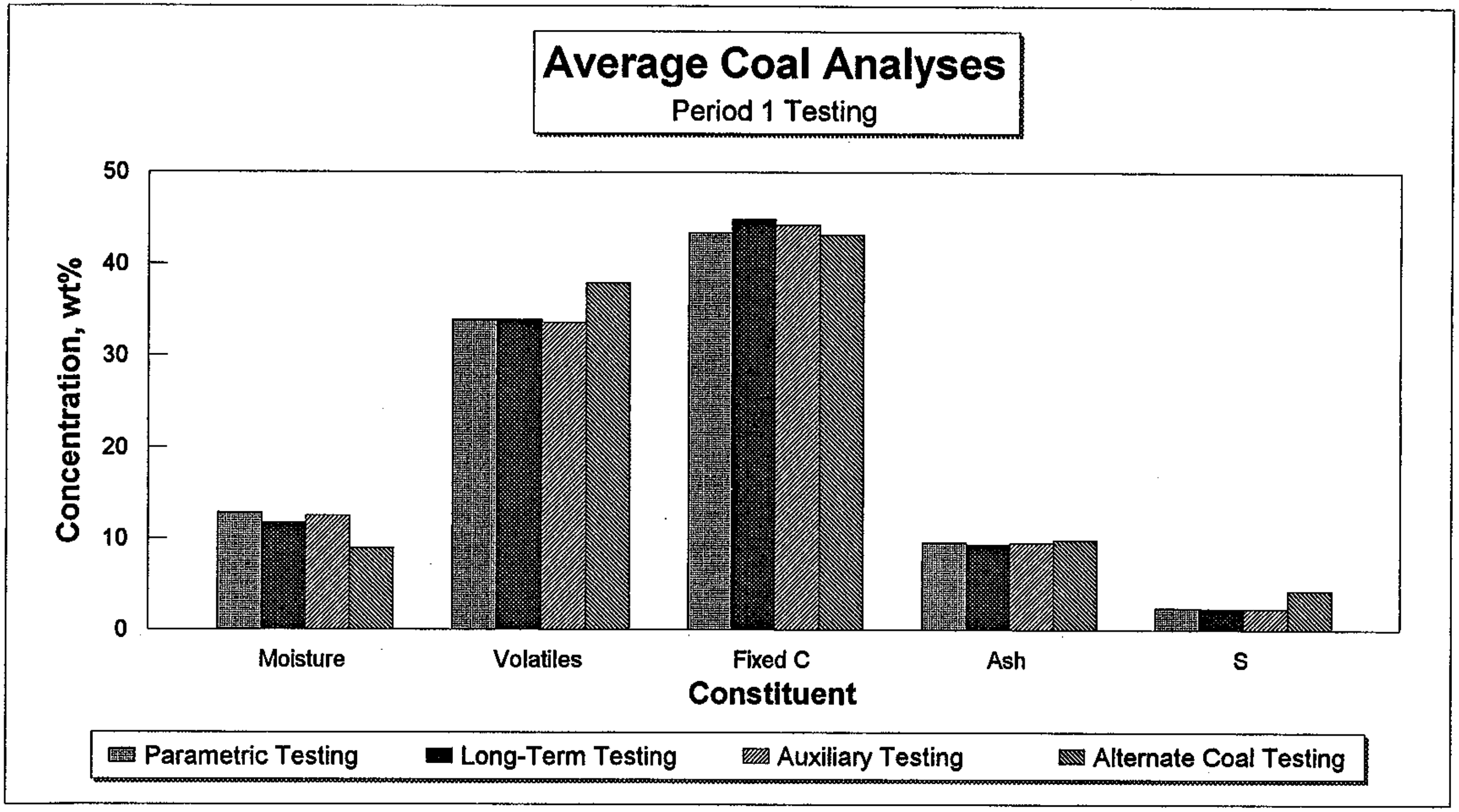


Figure 6-1. Average Coal Proximate Analytical Results

7.0 QUALITY ASSURANCE/QUALITY CONTROL

The environmental monitoring plan for the ICCT project at Plant Yates includes a quality assurance/quality control plan. That plan describes procedures for producing data of acceptable quality, including:

- Adherence to accepted sampling and analytical methods;
- Adequate documentation and sample custody; and
- Quality assessment measures.

This section presents the results of each of these QA/QC procedures performed during Period 1 testing.

7.1 Adherence to Accepted Methods

The sampling and analytical methods specified by the Environmental Monitoring Plan were summarized in Section 3 of this report. As discussed in Section 3, the specified procedures were used during Period 1 with only a few exceptions.

Compliance with analytical method protocols by personnel conducting ground-water sampling and on-site laboratory personnel was assessed as part of a technical systems audit conducted by Radian personnel during the first quarter of 1993. The audit found no deficiencies in the groundwater monitoring; sample collection and documentation procedures specified in the Groundwater Monitoring Test Plan had been effectively implemented. Procedures and quality control practices had also been implemented in the on-site laboratory but several recommendations were made, including consistent use of these procedures and additional personnel training. There were no formal recommendations requiring responses.

7.2 Adequate Documentation and Sample Custody

For compliance monitoring, the documentation and custody procedures that are part of the state-approved compliance monitoring programs for Plant Yates were followed during EMP activities.

Procedures for documentation and sample custody for supplemental monitoring were reviewed as part of the technical systems audit, as discussed above. No major problems were found, although some minor recommendations were made to improve logbook format.

Documentation for instrument calibrations, calibration checks, and related maintenance activities are recorded in log books. Six log books are used:

1. CEM flow rates and gas concentrations;
2. pH instrument calibrations;
3. ΔP cells;
4. Density measurements;
5. Flow meters; and
6. Level meters.

7.3 Quality Assessment Measures

A measure of the reproducibility of the test results was obtained by running several of the parametric tests in duplicate. Unit load and the scrubber operating conditions were duplicated to the extent possible. Due to differences in the JBR inlet gas SO_2 concentration caused by variations in coal sulfur content, the SO_2 removal results were corrected to 2200 ppmv to allow for direct comparison. The data in Table 7-1 are from the Low- Particulate Parametric

Table 7-1

Duplicate Test Results: SO_2 Removal

Test No.	SO_2 Removal, %	Std. Dev.	Test No.	SO_2 Removal, %	Std. Dev.	Test. No.	SO_2 Removal, %	Std. Dev.
P1-1	74.8	2.5	P1-22	72.5	0.9			
P1-2	91.3	0.5	P1-23	89.0	0.7			
P1-3	97.1	0.3	P1-24	95.8	0.3			
P1-19	80.2	1.1	P1-19R	78.0	2.7			
P1-20	93.6	0.4	P1-20R	93.6	1.1			
P1-21	98.3	0.2	P1-21R	98.2	0.1			
P1-35	85.9	1.1	P1-36	87.3	1.5			
P1B-2	97.5		P1B-2R	96.9				
P1B-6	98.1		P1B-6R	98.3				
P1B-9	94.1		P1B-9R2	88.4		P1B-9R3	95.2	
P1B-10	82.0		P1B-10R	76.5				

Test Block Report.[4] These results show good agreement between the duplicate tests; the observed variability was judged acceptable.

A measure of the accuracy of the SO_2 measurements obtained using the CEMs was provided during the first nine parametric tests, when SRI measured SO_2 concentrations in the JBR inlet and stack gas streams using EPA Method 6. The average CEM and Method 6 results for each test are shown in Table 7-2. Over the nine tests, the average difference in SO_2 concentration measured by the JBR inlet duct instrument and by Method 6 was 3.8%. The average difference between the stack concentrations measured by the CEM and those measured by Method 6 was 4.9%. At both test locations, the CEM concentration measurements were lower than the levels measured by Method 6. The CEMs should be able to provide data of sufficient quality for the purposes of this project.

Quality assessment of the groundwater monitoring results was provided by the analysis of replicate samples and by the use of sample splits analyzed by an independent laboratory. The results of the replicate analyses were included in the quarterly groundwater monitoring reports. An overall summary for the four 1993 groundwater monitoring rounds (Rounds 9-12) is provided in Table 7-3 for those analytical parameters that were present above detection limits. Acceptable accuracy was typically obtained for most parameters. Larger differences between replicate analyses were seen primarily for parameters that were present at concentrations less than five times the detection limit, where less accurate results are expected.

A comparison of the results of groundwater analyses performed by Radian and the independent laboratory for the first eight campaigns (rounds) is shown graphically in Figure 7-1. The figure shows the average relative percent differences (RPDs) for species that were analyzed by both laboratories and that were typically present above their respective detection limits in most samples. Species not detected by either laboratory are not included in the figure. The average RPDs for four of five species were within 20%, which corresponds to the goal of Radian's laboratory for duplicate sample analyses. A higher average RPD was found for

Table 7-2

Comparison of Average SO_2 Measurements by CEM and Method 6

Test No.	JBR Inlet Gas			Stack Gas		
	CEM	Method 6	% Diff.[a]	CEM	Method 6	% Diff.[a]
P1-1	2158	2286	-5.6	528	538	-1.9
P1-2	2185	2288	-4.5	188	205	-8.3
P1-3	2180	2267	-3.8	63	71	-11.3
P1-4	2156	2279	-5.4	388	385	0.8
P1-5	2166	2188	-1.0	120	128	-6.3
P1-6	2220	2314	-4.1	49	49	0.0
P1-7	2329	2376	-2.0	282	311	-9.3
P1-8	2323	2444	-5.0	95	106	-10.4
P1-9	2355	2421	-2.7	46	45	2.2
Average Difference			-3.8	Average Difference		-4.9

Units: ppmv @ 3% O_2.

[a] % Difference = (CEM - Method 6)/Method 6 x 100 percent.

Table 7-3

Results of Duplicate Groundwater Analyses: Period 1

Parameter	Sample	Field Duplicate	% Diff.[a]	Duplicate Analysis of Field Dup.	% RFD[b]	Spec. Limit
1st Quarter 1993						
Total Organic Carbon	<1.0	3.0[c]				
Total Dissolved Solids	44[c]	42[c]	-4.5			
Chloride	2.7	2.7	0.0			
Sulfate	1.6	1.6	0.0			
Calcium	2.2[c]	<1.0				
Magnesium	1.8[c]	<1.0				
Manganese	0.041[c]	<0.010				
Silicon	13	8.8	-32.3			
Sodium	5.7	4.0[c]	-29.8			
Strontium	0.013[c]	0.0036[c]	-72.3			
2nd Quarter 1993						
Total Dissolved Solids	52	50	-3.8	49	2.0	
Chloride	2.91	2.96	1.7			
Nitrate-nitrite	0.0387[c]	0.0309[c]	-20.2	0.0336	8.4	
Lead	0.0033[c]	<0.0030				
Silicon	8.73	9.10	4.2			
Sodium	3.88	4.03	3.9			

Table 7-3 (Continued)

Parameter	Sample	Field Duplicate	% Diff.[a]	Duplicate Analysis of Field Dup.	% RFD[b]	Spec. Limit
3rd Quarter 1993						
Total Dissolved Solids	21.0[c]	30.0[c]	42.9	31.0[c]	3.3	15
Bromide	0.342	0.342	0.0	0.343	0.3	
Chloride	2.82	2.77	-1.8			
Nitrate-Nitrite (as N)	0.0475[c]	0.0523[c]	10.1	0.0556[c]	6.1	20
Sodium	3.8	3.94	3.7			
Lead	0.006	0.005	-16.7			
Silicon	9.15	9.42	3.0			
Strontium	0.00307	0.00307	0.0			
4th Quarter 1993						
Chloride	2.79	3.15	12.9	2.78	12.5	20
Nitrate-Nitrite (as N)	0.059	0.056	-6.4	0.058	3.7	20
Bismuth	0.099[d]	0.074[d]	-25.0			
Sodium	4.1	4.0	-1.2			
Silicon	9.7	9.6	-1.1			

Units are mg/L for all parameters shown.

[a] % Difference = (Field Duplicate - Sample)/Sample x 100%

[b] $\% \text{ RPD} = \frac{\text{(Larger Value - Smaller Value)}}{\text{(Larger Value + Smaller Value)/2}} \times 100\%$

[c] Measured concentration is less than five times the detection limit; results are expected to be less accurate as the concentration approaches the detection limit.

[d] Detected in the method blank.

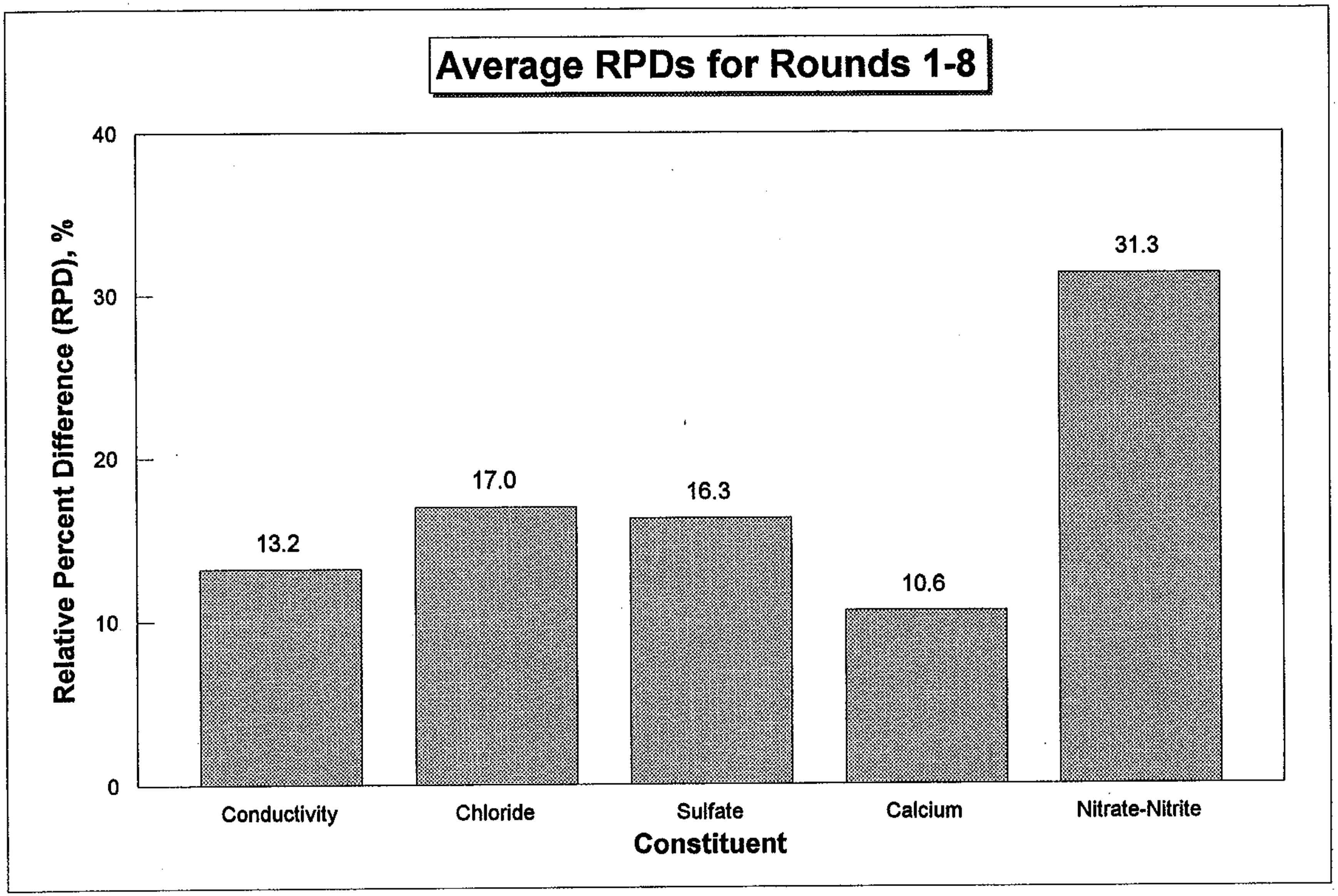


Figure 7-1. Average Relative Percent Difference (RPD) Between Groundwater Analyses by Two Laboratories

nitrates–nitrites, but this parameter was typically present at low concentrations, where small absolute differences can translate into large percentage differences. Based on these measures, the groundwater data should be of sufficient quality to meet the purposes of this project.

8.0 COMPLIANCE REPORTING

During Period 1, which began in January 1993 and ended in February 1994, compliance reports were submitted by Georgia Power Company to the Environmental Protection Division of the Georgia Department of Natural Resources, in accordance with the requirements of Plant Yates' Source 1 (comprising Units 1-3) air operating permit (No. 4911-038-4838-0), as amended; and of Plant Yates NPDES permit (Permit No. GA0001473). The air operating permit was amended effective December 28, 1990 to account for the CT-121 system. In addition, as part of the conditions of the DNR-issued permit for the gypsum stacking area, monitoring of the groundwater is required before, during, and for two years after the demonstration.

The air operating permit requires weekly monitoring of coal feed composition (i.e., sulfur, ash moisture, and heating value), annual particulate matter emissions (as total particulate loading), and continuous monitoring of the opacity of the flue gas inlet to the JBR. In addition, a semiannual progress report on the CT-121 project is required under the amended air operating permit. The NPDES permit requires that the pH and concentrations of suspended solids and oil and grease be monitored twice a month for various aqueous discharge streams. Groundwater samples from seven wells are monitored quarterly for anions, TOC, metals, and semiannually for radionuclides.

Copies of the compliance reports have been included as appendices to the quarterly and annual EMP reports for this project.

9.0 CONCLUSIONS

The following conclusions were drawn based on the results of the Period 1 EMP monitoring:

- The CT-121 demonstration scrubber was found to be capable of removing well over 90% of the flue gas SO_2 during parametric tests conducted using the 2.5% sulfur program coal. As expected, SO_2 removal was found to be directly proportional to scrubber slurry pH and jet bubbling reactor (JBR) deck pressure drop and inversely proportional to unit load and inlet flue gas SO_2 concentration.

- The average SO_2 removal achieved during the long-term load-following tests was nearly 94%, although it was necessary to operate at somewhat higher pH and pressure drop than expected from model predictions. The causes of this discrepancy were found to be (1) scrubber deck and tube fouling and (2) flue gas bypassing due to erosion of scrubber internals.

- SO_2 removals during operation with the alternate limestone were similar to those obtained with the initial program limestone. However, a decision was made to use the alternate limestone for all future tests based on improvements in gypsum properties.

- Even when the boiler was fired using a 4.3% sulfur coal, over 90% SO_2 removal could be achieved by the scrubber at most test conditions.

- The particulate matter loading in the JBR outlet flue gas was relatively consistent and low (i.e., less than 0.015 lb/MMBtu) for all test conditions. Particulate matter removal across the JBR was about 90% except for some 50 MW load tests; in these cases the apparently lower removal was actually due to decreased JBR inlet gas loadings.

- The scrubber was found to be relatively inefficient in removing particles with a diameter smaller than 1 micrometer. The particle size distribution measured in the JBR outlet gas was relatively unaffected by changes in load at a constant pressure drop.

- The SO_3 concentration in the JBR inlet and outlet gas streams was typically 2-3 ppmv (at 3% O_2). There was little or no change in concentration across the JBR.

- As expected, the JBR outlet gas was typically saturated with water vapor.

- The limestone slurry solids concentration to the scrubber averaged about 30% solids by weight. The limestone consisted primarily of calcium carbonate, with a small amount of magnesium carbonate; about 2% inerts were also present. The alternate limestone contained slightly more magnesium and correspondingly less inerts.

- The concentrations of chloride and sulfate ions in the gypsum stack return liquor were consistent with a scrubber system operating with a relatively closed water balance. The sulfate concentration was relatively consistent over time, while it appeared that the chloride concentration was continuing to increase throughout the Phase 1 test period. The results for the JBR underflow liquor were consistent with those for the gypsum stack return liquor.

- The JBR overflow and underflow slurry solids concentrations averaged 21% by weight. The solids were found to consist primarily of calcium sulfate; the sulfite concentration was typically very low, consistent with the high level of oxidation expected for this scrubber. Low carbonate concentrations were typically found, indicative of the high limestone utilization achieved at most test conditions.

- There is no evidence that the liner installed under the gypsum stacking area has developed any leaks, based on the groundwater monitoring results obtained both prior to and after gypsum stacking area construction.

- There were no exceedances of Plant Yates' NPDES permit limitations in the monitored aqueous discharge streams.

- The main program coal composition was found to be consistent during all test blocks. The alternate coal composition was found to be similar to the program coal except for its higher sulfur content (i.e., 4.3% compared to 2.4%).

10.0 REFERENCES

1. Southern Company Services, Inc. *Environmental Monitoring Plan: CT-121 Flue Gas Desulfurization Project at Plant Yates.* Birmingham, Alabama. December 18, 1990.

2. Radian Corporation. *100-MW Demonstration of Cost Reductions to the CT-121 FGD Process on High-Sulfur, Coal-Fired Boilers: Low-Particulate Auxiliary Test Block Report.* Austin, Texas. June 10, 1994.

3. Southern Research Institute. *Particulate Sampling of CT-121 Wet Scrubber, Georgia Power Company Plant Yates Unit 1: ESP Operational Test Phase, January 21 through 31, 1993 Tests.* Birmingham, Alabama. March 19, 1993.

4. Radian Corporation. *100-MW Demonstration of Cost Reductions to the CT-121 FGD Process on High-Sulfur, Coal-Fired Boilers: Low-Particulate Parametric Test Block Report.* Austin, Texas. July 21, 1993.

APPENDIX A

Period 1 EMP Monitoring Data Summary Tables

Table A-1

Average Process Parameter and SO_2 Data for Period 1 Testing Periods

Test No.	Date	Unit Load, MW	pH	JBR ΔP, in. WC	Inlet SO_2 ppmv @ 3% O_2	Outlet SO_2 ppmv @ 3% O_2	SO_2 Removal, Percent
Parametric Tests							
P1-1		100.7	4.5	8.2	2158	528	75.5
P1-2		100.3	4.5	12.1	2185	188	91.4
P1-3		100.3	4.5	16.1	2180	63	97.1
P1-4		75.4	4.5	8.2	2156	388	82.0
P1-5		75.3	4.5	12.3	2166	120	94.5
P1-6		75.3	4.5	16.2	2220	49	97.8
P1-7		49.7	4.5	8.2	2329	282	87.9
P1-8		49.2	4.5	12.2	2323	95	95.9
P1-9		49.8	4.5	16.1	2355	46	98.0
P1-10		49.7	5.0	8.2	2388	291	87.8
P1-11		50.4	5.0	12.2	2327	83	96.4
P1-12		50.4	5.0	16.2	2262	30	98.7
P1-13		50.7	4.0	8.2	2252	453	79.9
P1-14		50.0	4.0	12.2	2322	174	92.5
P1-15		50.2	4.0	16.2	2271	90	96.0
P1-16		75.2	4.0	8.2	2323	692	70.2
P1-17		75.2	4.0	12.2	2328	317	86.4
P1-18		75.0	4.0	16.2	2235	144	93.6
P1-19		75.1	5.0	8.2	2513	586	76.7
P1-19R		74.9	5.0	8.1	2293	529	76.9
P1-20		76.4	5.0	12.2	2560	198	92.3
P1-20R		74.6	5.0	12.1	2350	161	93.1
P1-21		75.0	5.0	16.2	2509	51	98.0
P1-21R		74.7	5.0	16.1	2105	36	98.3
P1-22		99.6	4.5	8.2	2399	757	68.4
P1-23		100.0	4.5	12.1	2449	322	86.9
P1-24		99.7	4.5	16.1	2446	123	95.0
P1-25		99.6	5.0	8.1	2263	716	68.4
P1-26		99.6	5.0	12.1	2216	230	89.6
P1-27		99.5	5.0	16.1	2205	68	96.9
P1-28		99.3	4.0	8.1	2282	726	68.2

Table A-1 (Continued)

Test No.	Date	Unit Load, MW	pH	JBR ΔP, in. WC	Inlet SO_2 ppmv @ 3% O_2	Outlet SO_2 ppmv @ 3% O_2	SO_2 Removal, Percent
P1-29		99.9	4.0	12.1	2231	383	82.8
P1-30		99.7	4.0	16.1	2206	175	92.1
P1-31		100.9	4.0	12.1	2131	348	83.7
P1-32		100.0	4.5	12.1	2129	320	85.0
P1-33		100.7	5.0	12.1	2098	210	90.0
P1-34		100.8	5.4	12.1	2151	158	92.7
P1-35		99.7	5.3	12.1	2097	276	86.8
P1-36		100.1	5.4	12.1	2121	251	88.2
Long-Term Tests—24-hour Averages							
L1-1	01-Apr-93	82.9	4.0	12.2	1972	390	80.3
	02-Apr-93	68.0	4.0	12.3	2175	262	87.9
	03-Apr-93	66.7	4.0	12.3	2177	228	89.5
	04-Apr-93	70.1	4.0	12.2	2142	316	85.3
	05-Apr-93	84.0	4.0	12.2	2051	471	76.9
	06-Apr-93	77.0	4.0	12.2	1939	374	80.8
	07-Apr-93	56.0	4.0	12.2	2032	206	89.8
	08-Apr-93	61.8	4.0	12.2	2061	244	88.2
L1-2	15-Apr-93	53.0	5.4	13.8	1613	45	95.0
	16-Apr-93	76.5	5.0	14.1	1970	58	97.0
	17-Apr-93	73.5	5.0	13.8	2028	101	95.1
	18-Apr-93	70.9	4.9	14.3	2038	98	95.2
	19-Apr-93	84.7	5.0	14.0	2061	144	93.0
	20-Apr-93	79.1	5.0	14.0	2078	141	93.2
	21-Apr-93	81.3	5.0	14.0	2081	143	93.1
	22-Apr-93	84.2	5.0	14.0	2080	136	93.5
	23-Apr-93	78.6	5.1	14.2	1978	98	95.1
	24-Apr-93	71.8	5.0	14.1	2005	96	95.2
	25-Apr-93	64.6	5.0	14.1	2063	92	95.6
	26-Apr-93	72.9	5.0	14.0	2157	147	93.2
	27-Apr-93	61.6	5.1	14.0	2102	93	95.6
	28-Apr-93	50.4	5.0	14.0	2069	78	96.2
L1-3	29-May-93	100.2	4.5	14.1	2041	111	94.6
	30-May-93	100.1	4.5	14.0	2005	109	94.6
	31-May-93	99.9	4.5	13.9	1941	107	94.5
	01-Jun-93	70.9	4.5	14.0	2033	86	95.8

Table A-1 (Continued)

Test No.	Date	Unit Load, MW	pH	JBR ΔP, in. WC	Inlet SO_2 ppmv @ 3% O_2	Outlet SO_2 ppmv @ 3% O_2	SO_2 Removal, Percent
L1-3	02-Jun-93	56.6	4.5	14.0	2055	73	96.4
	03-Jun-93	79.6	4.5	14.0	2035	112	94.5
	04-Jun-93	78.1	4.5	14.1	2086	116	94.4
	05-Jun-93	81.4	4.5	14.4	2094	122	94.2
	06-Jun-93	71.0	4.5	14.2	2076	94	95.4
	07-Jun-93	79.6	4.5	14.2	2104	93	95.6
	08-Jun-93	84.6	4.5	14.2	2078	95	95.4
	10-Jun-93	65.6	4.5	14.0	2051	42	97.9
	13-Jun-93	72.8	4.6	14.3	1928	52	97.3
	14-Jun-93	78.4	4.5	14.1	1994	70	96.5
	15-Jun-93	80.0	4.5	14.0	2109	93	95.6
	16-Jun-93	91.3	4.5	14.1	2137	157	92.7
	17-Jun-93	81.5	4.5	14.1	2140	138	93.5
	18-Jun-93	81.6	4.5	14.1	2169	160	92.6
	19-Jun-93	78.2	4.5	14.1	2132	145	93.1
	20-Jun-93	74.9	4.5	14.1	2232	153	93.1
	21-Jun-93	89.9	4.6	14.1	2281	140	93.9
	22-Jun-93	100.9	4.5	14.1	2120	181	91.6
	23-Jun-93	100.9	4.5	14.1	2175	201	90.8
	24-Jun-93	100.3	4.5	14.1	1988	224	88.7
	25-Jun-93	100.2	4.5	14.1	2128	239	88.8
	26-Jun-93	100.4	4.5	14.1	1917	175	90.6
	30-Jun-93	101.8	4.5	14.1	2227	276	87.6
	01-Jul-93	100.8	4.5	14.1	2200	209	90.5
	02-Jul-93	92.3	4.5	14.2	2206	211	90.4
	03-Jul-93	70.3	4.5	14.1	2206	153	93.0
	04-Jul-93	69.0	4.5	14.1	2264	162	92.9
	05-Jul-93	57.9	4.5	14.1	2279	133	94.2
	06-Jul-93	79.5	4.5	14.1	2295	187	91.9
	07-Jul-93	77.6	4.5	14.1	2308	199	91.4
	08-Jul-93	76.2	4.5	14.1	2323	185	92.0
	09-Jul-93	76.3	4.5	14.1	2356	171	92.8
	10-Jul-93	71.5	4.5	14.1	2254	153	93.2
	11-Jul-93	70.0	4.5	14.1	2216	147	93.4
	12-Jul-93	79.0	4.5	14.1	2290	170	92.6

Table A-1 (Continued)

Test No.	Date	Unit Load, MW	pH	JBR ΔP, in. WC	Inlet SO_2 ppmv @ 3% O_2	Outlet SO_2 ppmv @ 3% O_2	SO_2 Removal, Percent
L1-3	13-Jul-93	80.6	4.5	14.1	2263	161	92.9
	14-Jul-93	73.4	4.5	14.1	2214	166	92.5
	15-Jul-93	78.1	4.5	14.1	2078	173	91.7
	16-Jul-93	75.8	4.5	14.1	2152	165	92.4
	17-Jul-93	77.0	4.5	14.2	2207	166	92.4
	18-Jul-93	85.8	4.5	14.2	2276	203	91.0
	19-Jul-93	87.3	4.5	14.1	2180	116	94.7
	20-Jul-93	86.2	4.5	14.1	2227	162	92.8
	21-Jul-93	80.3	4.5	14.2	2260	159	92.9
	23-Jul-93	79.5	4.5	14.1	2228	125	94.4
	24-Jul-93	72.1	4.5	14.1	2144	116	94.6
	25-Jul-93	78.6	4.5	14.1	2105	133	93.7
	26-Jul-93	74.3	4.5	14.1	2269	145	93.6
	28-Jul-93	96.1	4.5	14.1	2182	157	92.8
	29-Jul-93	84.4	4.5	14.1	2098	145	93.1
	30-Jul-93	79.9	4.5	14.1	2002	131	93.5
	31-Jul-93	76.9	4.5	14.1	2070	130	93.8
	01-Aug-93	58.2	4.5	14.1	2002	83	95.9
	02-Aug-93	61.0	4.5	14.1	1904	78	95.9
	03-Aug-93	55.8	4.5	14.1	2003	88	95.6
	04-Aug-93	56.9	4.5	14.1	2032	109	94.6
	05-Aug-93	53.1	4.5	14.1	2000	85	95.7
	08-Aug-93	63.8	4.5	14.0	2098	86	95.9
	09-Aug-93	68.7	4.5	14.1	1980	83	95.8
	10-Aug-93	60.3	4.5	14.1	1889	58	96.9
	11-Aug-93	70.6	4.5	14.1	2085	90	95.7
	12-Aug-93	66.9	4.5	14.1	2064	82	96.0
	13-Aug-93	58.5	4.5	14.1	1978	70	96.5
	14-Aug-93	58.9	4.5	14.1	1932	70	96.4
	15-Aug-93	65.0	4.5	14.1	2025	81	96.0
	16-Aug-93	50.5	4.5	14.1	2071	64	96.9
	19-Aug-93	75.1	4.5	14.1	1953	133	93.2
	20-Aug-93	72.0	4.5	14.1	1992	137	93.2
	21-Aug-93	65.5	4.5	14.2	2041	129	93.7
	22-Aug-93	54.2	4.5	14.1	1966	78	96.0

Table A-1 (Continued)

Test No.	Date	Unit Load, MW	pH	JBR ΔP, in. WC	Inlet SO_2 ppmv @ 3% O_2	Outlet SO_2 ppmv @ 3% O_2	SO_2 Removal, Percent
L1-3	23-Aug-93	74.6	4.5	14.1	2028	115	94.4
	24-Aug-93	61.7	4.5	14.1	2070	93	95.5
	25-Aug-93	67.1	4.5	14.1	1910	104	94.6
	26-Aug-93	67.0	4.5	14.2	2083	108	94.8
	27-Aug-93	64.9	4.5	14.2	2059	100	95.1
	28-Aug-93	60.5	4.5	14.2	2076	103	95.0
	29-Aug-93	58.5	4.5	14.2	2058	103	95.0
	30-Aug-93	67.9	4.5	14.2	2028	132	93.5
	31-Aug-93	72.6	4.5	14.1	2009	138	93.2
	01-Sep-93	73.5	4.5	14.2	2048	137	93.4
	02-Sep-93	73.5	4.5	14.2	2104	141	93.3
	03-Sep-93	62.3	4.5	14.2	2151	124	94.2
	04-Sep-93	53.0	4.5	14.2	2100	96	95.5
	07-Sep-93	50.3	4.5	14.2	2076	66	96.8
	08-Sep-93	52.2	4.5	14.1	2011	71	96.4
High SO_2 Removal Tests							
HR1-1		88	4.8	18.2	2260	51	97.8
HR1-2		75	4.8	18.2	2290	58	97.5
HR1-3		50	4.8	18.2	2220	50	97.8
HR1-4		91	4.8	18.2	2080	63	97.0
Alternate Limestone—"Clean" Parametric Tests							
P1B-1		101.3	4.4	10.2	2210	391	82.3
P1B-2		51.0	4.5	16.2	2170	61	97.2
P1B-3		52.3	4.5	10.2	2270	166	92.7
P1B-4		100.7	4.5	16.2	2190	165	92.5
P1B-5		49.8	5.0	16.1	2220	29	98.7
P1B-6		100.6	4.9	16.2	2200	40	98.1
P1B-7		48.7	5.0	10.2	2130	91	95.7
P1B-9		50.8	4.0	16.2	2350	114	94.7
P1B-10		101.6	4.0	10.2	2270	572	74.8
P1B-11		100.1	4.0	16.2	2110	156	92.6
P1B-12		49.7	4.0	10.2	2080	216	89.7
P1B-13		80.4	5.1	16.2	2270	63	97.2

Table A-1 (Continued)

Test No.	Date	Unit Load, MW	pH	JBR ΔP, in. WC	Inlet SO_2 ppmv @ 3% O_2	Outlet SO_2 ppmv @ 3% O_2	SO_2 Removal, Percent
Alternate Limestone—Load-Following							
AL1-1		55.5	4.8	14.2	2250	95	95.8
AL1-2		59.7	4.0	10.1	1810	180	90.5
Alternate Coal Parametric Tests							
AC1-1		49.5	4.0	10.2	3560	670	81.1
AC1-2		49.9	4.0	16.1	3700	250	93.3
AC1-3		75.0	4.0	16.1	3580	NA	--
AC1-4		74.4	4.0	16.1	3390	380	88.7
AC1-5		46.2	4.5	16.1	3610	210	94.2
AC1-6		75.0	4.5	16.1	3510	250	92.9
AC1-7		75.0	4.5	10.1	3660	NA	--
AC1-8		49.6	4.5	10.1	3700	690	81.4
AC1-9		50.9	5.0	16.2	3760	100	97.2
AC1-10		75.5	5.0	10.2	3820	810	79.0
AC1-11		74.7	5.0	16.2	3590	200	94.5
AC1-12		49.5	5.0	10.2	3490	470	86.4

NA = Not available due to CEM problems.

Table A-2

JBR Inlet Gas PM Loading and Moisture: Period 1 Parametric Tests

Date	Time	Load, MW	Gas Flow, Kacfm	H_2O, vol%	PM Loading	
					gr/acf	lb/MMBtu
21-Jan-93	1119-1237	100	452	6.0	0.0216	0.077
	1325-1410	100	465	7.6	0.0200	0.073
	1631-1744	100	460	6.4	0.0256	0.092
	Mean	100	459	6.7	0.0224	0.081
22-Jan-93	0741-0851	100	452	8.9	0.0216	0.077
	0950-1103	100	454	7.4	0.0250	0.089
	1221-1332	100	465	8.6	0.0251	0.090
	Mean	100	457	8.3	0.0239	0.085
23-Jan-93	0731-0845	100	466	6.0	0.0333	0.118
	1004-1124	100	469	7.8	0.0297	0.109
	1235-1350	100	464	7.6	0.0310	0.115
	Mean	100	466	7.1	0.0313	0.114
25-Jan-93	0800-0918	75	364	7.2	0.0337	0.128
	1107-1217	75	362	7.0	0.0227	0.087
	1328-1443	75	372	8.0	0.0184	0.070
	Mean	75	366	7.4	0.0249	0.095
26-Jan-93	0804-1052	75	452	6.5	0.0216	0.077
	1200-1316	75	386	7.2	0.0167	0.067
	1409-1520	75	374	6.9	0.0181	0.071
	Mean	75	404	6.9	0.0188	0.072
27-Jan-93	0706-0820	75	376	6.7	0.0113	0.043
	0916-1026	75	368	6.0	0.0108	0.041
	1208-1319	75	367	7.4	0.0107	0.041
	Mean	75	370	6.7	0.0109	0.042
29-Jan-93	0722-0832	50	264	6.9	0.0077	0.033
	0946-1054	50	267	6.9	0.0422	0.173
	1215-1324	50	287	6.6	0.0132	0.054
	Mean	50	273	6.8	0.0210	0.087
30-Jan-93	0708-0819	50	262	7.2	0.0054	0.021
	0934-1043	50	259	7.9	0.0079	0.033
	1213-1328	50	264	7.8	0.0036	0.015
	Mean	50	262	7.6	0.0056	0.023
31-Jan-93	0658-0808	50	266	5.5	0.0055	0.022
	0900-1009	50	261	6.4	0.0043	0.018
	1107-1217	50	260	6.4	0.0045	0.018
	Mean	50	262	6.1	0.0048	0.019

Table A-3

JBR Inlet Gas Sulfur Species and Moisture: Period 1

Date	Time	Load, MW	Flue Gas Temp, °F	SO_2, ppmv @ 3% O_2	SO_3, ppmv @ 3% O_2	H_2O, vol%
21-Jan-93	1052-1105	100	254	2224	3.4	
	1128-1142	100	255	2251	4.4	
	1332-1345	100	257	2358	3.8	
	1408-1421	100	257	2311	3.3	
	Mean	100	256	2286	3.7	
	1435	100	260			7.4
22-Jan-93	0825-0838	100	260	2275	4.1	
	0901-0914	100	261	2335	3.2	
	0934-0947	100	260	2257	3.2	
	1103-1116	100	261	2285	3.2	
	Mean	100	261	2288	3.4	
	1129	100	265			7.8
23-Jan-93	0821-0834	100	256	2307	3.3	
	0858-0911	100	255	2288	3.2	
	0936-0949	100	258	2244	3.2	
	1106-1119	100	258	2227	3.5	
	Mean	100	257	2267	3.3	
	1134	100	260			6.7
25-Jan-93	0916-0929	75	241	2241	2.3	
	0952-1005	75	242	2255	2.4	
	1025-1038	75	241	2285	2.6	
	1212-1225	75	244	2335	2.8	
	Mean	75	242	2279	2.5	
	1239	75	244			6.8
26-Jan-93	1049-1102	75	243	2239	2.8	
	1122-1135	75	243	2162	2.9	
	1154-1207	75	244	2162	2.9	
	Mean	75	243	2188	2.9	
	1220	75	245			6.2
27-Jan-93	0752-0805	75	237	2298	2.6	
	0829-0842	75	239	2318	2.6	
	0904-0916	75	238	2354	2.8	
	1054-1107	75	242	2286	3.0	
	Mean	75	239	2314	2.8	
	1120	75	244			6.5

Table A-3 (Continued)

Date	Time	Load, MW	Flue Gas Temp, °F	SO_2, ppmv @ 3% O_2	SO_3, ppmv @ 3% O_2	H_2O, vol%
29-Jan-93	0807-0819	50	235	2364	2.2	
	0839-0852	50	236	2352	1.5	
	0912-0925	50	237	2374	1.9	
	1047-1059	50	239	2414	2.0	
	Mean	50	237	2376	1.9	
	1113	50	240			6.1
30-Jan-93	0756-0809	50	237	2458	2.1	
	0832-0844	50	237	2429	1.9	
	0906-0919	50	239	2421	2.0	
	1046-1054	50	242	2468	3.3	
	Mean	50	239	2444	2.3	
	1108	50	242			5.6
31-Jan-93	0741-0753	50	239	2423	3.5	
	0823-0835	50	239	2411	3.8	
	1003-1015	50	241	2428	4.0	
	Mean	50	240	2421	3.8	
	1030	50				5.7

Table A-4

Stack Gas PM Loading and Moisture: Period 1 Parametric Tests

Date	Time	Load, MW	Gas Flow, Kacfm	H_2O, vol%	PM Loading	
					gr/acf	lb/MMBtu
21-Jan-93	1116-1233	100	377	12.0	0.0034	0.011
	1518-1639	100	383	11.1	0.0025	0.007
	1636-1758	100	383	12.2	0.0025	0.008
	Mean	100	381	11.8	0.0028	0.009
22-Jan-93	0737-0845	100	377	13.2	0.0034	0.011
	0952-1103	100	381	12.8	0.0038	0.012
	1219-1426	100	383	13.1	0.0031	0.009
	Mean	100	380	13.0	0.0034	0.011
23-Jan-93	0730-0838	100	388	12.0	0.0026	0.008
	1022-1128	100	382	12.0	0.0048	0.014
	1238-1343	100	379	12.0	0.0030	0.009
	Mean	100	383	12.0	0.0035	0.010
25-Jan-93	0829-0937	75	315	12.0	0.0031	0.010
	1110-1219	75	311	12.0	0.0030	0.010
	1331-1439	75	312	12.2	0.0036	0.011
	Mean	75	313	12.1	0.0032	0.010
26-Jan-93	0808-1108	75	377	11.0	0.0034	0.011
	1205-1312	75	308	10.6	0.0023	0.007
	1404-1511	75	299	11.2	0.0024	0.007
	Mean	75	328	10.9	0.0027	0.008
27-Jan-93	0704-0811	75	305	10.9	0.0013	0.005
	0917-1027	75	303	11.7	0.0018	0.006
	1132-1250	75	299	11.6	0.0018	0.006
	Mean	75	302	11.4	0.0016	0.006
29-Jan-93	0723-0831	50	226	9.0	0.0030	0.010
	0946-1114	50	221	11.8	0.0017	0.006
	1217-1330	50	224	9.6	0.0027	0.009
	Mean	50	224	10.1	0.0025	0.008
30-Jan-93	0709-0817	50	220	11.3	0.0022	0.007
	0942-1057	50	218	10.9	0.0024	0.008
	1222-1331	50	225	10.9	0.0011	0.004
	Mean	50	221	11.0	0.0019	0.006
31-Jan-93	0657-0805	50	229	10.9	0.0022	0.008
	0902-1011	50	231	10.2	0.0014	0.005
	1144-1252	50	234	10.9	0.0014	0.005
	Mean	50	231	10.7	0.0017	0.006

Table A-5

Stack Gas Sulfur Species and Moisture: Period 1 Parametric Tests

Date	Time	Load, MW	Flue Gas Temp, °F	SO_2, ppmv @3% O_2	SO_3, ppmv @3% O_2	H_2O, vol%
21-Jan-93	1052-1107	100	122	537	2.8	
	1128-1142	100	121	517	2.7	
	1332-1347	100	120	508	2.7	
	1408-1413	100	121	588	2.7	
	Mean	100	121	538	2.7	
	1435	100	120			12.4
22-Jan-93	0825-0838	100	121	223	2.7	
	0901-0914	100	123	208	2.7	
	0934-0948	100	124	195	2.7	
	1103-1116	100	122	193	2.5	
	Mean	100	123	205	2.7	
	1132	100	122			13.5
23-Jan-93	0821-0840	100	120	91	2.2	
	0859-0919	100	120	67	2.3	
	0936-0954	100	120	67	2.3	
	1106-1123	100	119	60	2.4	
	Mean	100	120	71	2.3	
	1133	100	119			12.3
25-Jan-93	0917-0931	75	117	370	2.6	
	0953-1007	75	117	422	2.6	
	1025-1039	75	116	385	2.8	
	1212-1226	75	117	361	2.1	
	Mean	75	117	385	2.5	
	1103	75	117			10.8
26-Jan-93	1049-1103	75	116	122	3.4	
	1122-1136	75	116	140	3.4	
	1154-1208	75	115	121	3.4	
	Mean	75	116	128	3.4	
	1215	75	116			11

Table A-5 (Continued)

Date	Time	Load, MW	Flue Gas Temp, °F	SO_2, ppmv @ 3% O_2	SO_3, ppmv @ 3% O_2	H_2O, vol%
27-Jan-93	0752-0810	75	116	49	3.0	
	0829-0846	75	117	48	3.0	
	0904-0922	75	118	49	3.0	
	1054-1111	75	117	49	2.8	
	Mean	75	117	49	3.0	
	1115	75	117			11.8
29-Jan-93	0807-0821	50	115	303	1.7	
	0840-0854	50	115	312	1.7	
	0913-0926	50	114	314	1.7	
	1048-1100	50	115	314	1.5	
	Mean	50	115	311	1.7	
	1105	50	115			10.1
30-Jan-93	0756-0814	50	114	101	1.6	
	0832-0849	50	114	106	1.6	
	0906-0923	50	115	111	1.2	
	1047-1104	50	115	107	1.8	
	Mean	50	115	106	1.6	
	1108	50	115			9.5
31-Jan-93	0742-0804	50	112	47	2.3	
	0824-0845	50	112	43	2.4	
	1004-1025	50	114	45	2.3	
	Mean	50	113	45	2.3	
	1030	50	114			10.5

Table A-6

Makeup Water Analyses: Period 1

Test ID	Date	pH	Liquid Phase, mg/L			
			Carbonate	Sulfite	Sulfate	Chloride
L1-3	06-Jun-93	6.75		0.8	46	42
L1-3	09-Aug-93	6.08	36	0.8	152	22
HR1-4	04-Oct-93				67	35
AL1-1	10-Jan-94	7.36			13	37
AC1-10	14-Feb-94				110	138

Table A-7

Gypsum Stack Return Analyses: Period 1

Test ID	Date	pH	Liquid Phase, mg/L		
			Carbonate	Sulfate	Chloride
Parametric Tests					
P1-2	22-Jan-93	6.5	12	1,593	7,179
P1-6	27-Jan-93	6.0	12	835	11,615
P1-9	01-Feb-93	5.7	12	800	12,382
P1-12	05-Feb-93	6.2	12	624	9,256
P1-14	09-Feb-93	6.5	12	737	8,370
P1-18	15-Feb-93	6.4	12	747	9,883
P1-21	21-Feb-93	6.3	12	649	8,945
P1-24	26-Feb-93	6.9	12	668	10,304
P1-27	04-Mar-93	6.6	96	780	11,912
P1-28	08-Mar-93	6.6	96	354	10,636
P1-21R	12-Mar-93	6.7	96	815	13,898
P1-31	16-Mar-93	6.7	96	778	13,118
P1-32	18-Mar-93	6.6	96	765	14,429
P1-33	20-Mar-93	6.4	96	761	15,777
P1-34	22-Mar-93	6.6	96	811	15,777
P1-35	28-Mar-93	6.5	96	726	15,989
P1-36	30-Mar-93	6.8	96	1,085	9,785
Long-Term Tests					
L1-1	05-Apr-93	6.62	96	755	10,650
L1-2	19-Apr-93	6.60	96	854	10,795
	25-Apr-93	6.70	96	775	12,320
L1-3	28-May-93	7.01	96	834	8,048
	01-Jun-93	6.35	96	863	11,266
	06-Jun-93	6.11	96	897	13,240
	14-Jun-93	6.54	96	823	12,766
	22-Jun-93	6.50		822	13,537
	28-Jun-93	6.73	96	845	14,440
	06-Jul-93	6.35	36	860	14,315
	12-Jul-93	6.23	36	866	16,523
	19-Jul-93	5.91	36	868	10,480
	26-Jul-93	7.05	36	888	10,149

Table A-7 (Continued)

Test ID	Date	pH	Liquid Phase, mg/L		
			Carbonate	Sulfate	Chloride
L1-3	02-Aug-93	6.51	36	857	14,003
	09-Aug-93	6.51	36	841	10,425
	16-Aug-93	6.60	36	746	13,959
	23-Aug-93	6.17	36	823	16,432
	29-Aug-93	6.34	36	839	14,461
	07-Sep-93	5.08	36	826	18,243
High Removal Tests					
HR1-1	14-Sep-93	6.31	36	873	20,044
	19-Sep-93	6.13	31	878	12,752
	27-Sep-93	6.34	31	778	22,632
HR1-4	05-Oct-93	6.46	31	771	19,809
	11-Oct-93	5.53	31	1,195	27,306
	14-Oct-93	6.51	31	1,361	16,957
	18-Oct-93	6.26	31	727	15,562
	24-Oct-93	6.49	31	736	16,411
Alternate Limestone Tests					
P1A-11	01-Nov-93	5.48	31	708	16,582
P1B-1	02-Dec-93	6.77	31	789	17,281
P1B-5	05-Dec-93	6.81	31	793	21,922
P1B-9R	13-Dec-93	6.58	31	680	22,509
P1B-9R2	19-Dec-93	6.45	31	698	30,493
AL1-1	28-Dec-93	5.97	31	648	29,029
	03-Jan-94	6.88	95	494	22,915
	10-Jan-94	6.43	95	704	29,813
	17-Jan-94	6.47	95	723	24,065
Alternate Coal Tests					
AC1-1	25-Jan-94	6.61	95	753	24,995
	31-Jan-94	6.45	95	698	33,292
AC1-3	07-Feb-94	5.39	88	787	43,221
AC1-10	14-Feb-94	6.31	88	825	29,160

Table A-8

Gypsum Stack Return Liquid-Phase Trace Metals: Period 1

Element	Units	14-Jun-93	12-Jul-93	09-Aug-93	14-Sep-93
Aluminum	mg/L	0.5	1.49	0.44	0.26
Antimony	mg/L	0.01	0.008[a]	<0.006	<0.0139
Arsenic	mg/L	<0.008	<0.007	<0.002	<0.001
Barium	mg/L	1.09	0.07	0.91	1.25
Beryllium	mg/L	0.001[b]	<0.004	0.003[b]	<0.0026
Boron	mg/L	473	29	414	718
Cadmium	mg/L	0.14	0.01	0.14	0.25
Copper	mg/L	0.03	0.02	<0.06	0.03
Chromium	mg/L	0.03	0.005[b]	0.03	0.04
Cobalt	mg/L	0.09	0.009[b]	0.13	0.19
Iron	mg/L	0.39	<0.02	<0.09	<0.028
Lead	mg/L	<0.003	<0.003	<0.00008	<0.008
Manganese	mg/L	107	6.8	530	157
Mercury	mg/L			0.0007	0.0023
Molybdenum	mg/L	0.06	0.005[b]	0.07	0.09
Nickel	mg/L	0.57	0.06	0.47	0.77
Potassium	mg/L	44	2.5	43.5	65.2
Selenium	mg/L	0.08	0.16	0.06	<0.002
Silicon	mg/L	13.8	1.7	14.4	15.1
Sodium	mg/L	90.1	5.3	92.3	139
Vanadium	mg/L	0.08	0.003[b]	0.09	0.14

[a] Value less than five times detection limit.

[b] Value less than detection limit.

Table A-9

Limestone Analyses—Period 1 Tests

Test ID	Date	Slurry Solids, wt%	Solid Phase, wt%			
			Calcium	Magnesium	Carbonate	Inerts
Parametric Tests						
P1-2	22-Jan-93	33.64	38.9	0.1	51.1	2.1
P1-6	27-Jan-93	33.94	38.1	0.1	57.0	1.9
P1-9	01-Feb-93	33.28	38.1	0.1	56.2	2.0
P1-12	05-Feb-93	33.61	38.2	0.0	58.2	1.9
P1-14	09-Feb-93	32.31	38.3	0.1	59.9	2.0
P1-18	15-Feb-93	31.93	38.9	0.1	58.9	2.0
	22-Feb-93	32.36	37.4	0.1	56.3	2.0
P1-24	26-Feb-93	32.24	34.9	0.0	58.4	3.3
	08-Mar-93	33.09	39.8	0.1	55.6	2.7
	12-Mar-93	32.54	39.3	0.1	55.7	1.5
	16-Mar-93	27.07	38.8	0.1	59.2	2.4
	18-Mar-93	34.54	39.6	0.1	55.8	2.6
	20-Mar-93	37.13	37.0	0.1	58.0	2.3
	28-Mar-93	33.02	40.2	0.1	56.5	0.6
	30-Mar-93	30.40	39.8	0.1	57.5	0.6
Long-Term Tests						
L1-1	05-Apr-93	26.72	36.2	0.1	57.6	2.78
L1-2	19-Apr-93	30.49	38.0	0.1	58.4	2.54
	25-Apr-93	28.58	38.1	0.1	58.7	2.31
L1-3	28-May-93	27.39	37.2	0.1	58.2	1.98
	01-Jun-93	28.34	37.1	0.1	58.9	1.99
	06-Jun-93	28.99	38.9	0.1	59.5	2.43
	14-Jun-93	28.38	38.3	0.1	58.4	1.88
	22-Jun-93	28.27	38.1	0.1	59.9	2.16
	28-Jun-93	27.72	37.8	0.1	59.6	1.83
	06-Jul-93	28.30	38.2	0.1	59.2	2.31
	12-Jul-93	27.46	38.2	0.1	56.3	0.56
	19-Jul-93	25.55	38.6	0.1	58.9	1.49
	26-Jul-93	27.53	36.3	0.1	57.7	2.14
	02-Aug-93	27.66	37.8	0.1	57.5	2.43

Table A-9 (Continued)

Test ID	Date	Slurry Solids, wt%	Solid Phase, wt%			
			Calcium	Magnesium	Carbonate	Inerts
L1-3	09-Aug-93	28.73	38.4	0.1	57.0	2.39
	16-Aug-93	25.13	38.0	0.1	56.9	2.24
	23-Aug-93	27.12	39.4	0.1	55.6	2.21
	29-Aug-93	28.19	37.4	0.1	59.4	2.08
	05-Sep-93	24.40	38.4	0.1	57.8	2.14
High Removal Tests						
HR1-1	14-Sep-93	27.33	37.5	0.1	57.8	2.18
	19-Sep-93	24.40	38.4	0.1	57.8	2.14
	27-Sep-93	22.15	38.0	0.1	58.8	2.22
HR1-4	05-Oct-93	33.84	38.3	0.1	55.9	2.36
	11-Oct-93	38.93	38.6	0.1	59.6	2.21
	14-Oct-93	34.26	36.8	0.1	59.6	2.16
	18-Oct-93	25.02	37.6	0.0	57.2	2.87
	24-Oct-93	29.16	37.8	0.4	58.6	1.16
Alternate Limestone Tests						
P1A-11	01-Nov-93	29.40	39.6	0.4	59.3	0.69
P1B-1	02-Dec-93	29.16	39.3	0.4	61.6	0.94
	10-Dec-93	28.12	39.4	0.4	61.6	0.72
	13-Dec-93	24.00	38.1	0.4	58.4	0.62
P1B-9R2	19-Dec-93	20.58	38.1	0.4	57.8	0.77
	28-Dec-93	30.82	39.1	0.4	57.5	0.72
AL1-1	03-Jan-94	32.00	38.9	0.4	58.0	0.88
	10-Jan-94	31.30	39.2	0.4	59.8	0.55
	17-Jan-94	33.69	38.7	0.2	58.4	0.76
Alternate Coal Tests						
AC1-1	25-Jan-94	26.85	37.0	0.6	59.1	1.21
	31-Jan-94	32.85	38.4	0.7	59.8	0.80
AC1-3	07-Feb-94	32.51	38.6	0.8	59.5	0.85
AC1-10	14-Feb-94	33.22	39.0	0.6	59.6	0.85

Table A-10

JBR Overflow Analyses: Period 1

Test ID	Date	pH	Liquid Phase, mg/L				Slurry Solids, wt%	Solid Phase, wt%			
			Carbonate	Sulfite	Sulfate	Chloride		Calcium	Carbonate	Sulfate	Inerts
Parametric Tests											
P1-2	22-Jan-93	4.4	12	0.8	1,072	19,499	22.3				
P1-6	27-Jan-93	4.6	12	1.6	729	27,329	20.1				
P1-9	01-Feb-93	4.7	18	0.0	812	22,570	21.4				
P1-12	05-Feb-93	5.2	12	1.6	1,038	21,919	21.9				
P1-14	09-Feb-93	4.5	12	0.8	986	22,746	22.2				
P1-18	15-Feb-93	4.2	12	0.0	958	28,136	19.3				
P1-21	21-Feb-93	5.1	12	0.8	657	21,760	22.5	22.5	0.8	53.4	0.00
P1-24	26-Feb-93	4.6	12	1.6	733	28,801	22.8	22.2	1.3	54.3	1.52
P1-27	04-Mar-93	5.0	96	0.8	812	28,433	22.4	24.4	1.3	54.9	
P1-28	08-Mar-93	4.0	96	0.8	725	29,568	21.0	22.8	0.0	58.7	
P1-21R	12-Mar-93	5.1	96	0.8	838	32,794	21.1	23.6	1.1	55.8	
P1-31	16-Mar-93	4.2	96	0.8	844	20,385	15.8	23.6	0.8	54.5	
P1-32	18-Mar-93	4.5	96	0.8	809	34,283	20.4	24.1	1.1	55.3	
P1-33	20-Mar-93	5.0	96	0.8	732	38,041	18.6	22.8	1.4	54.3	
P1-34	22-Mar-93	5.6	96	1.6	876	29,213	19.0	26.3	18.0	54.3	
P1-35	28-Mar-93	5.4	96	1.6	720	37,935	17.9	24.6	5.2	52.1	0.44
P1-36	30-Mar-93	5.7	96		860	24,853	23.4	26.8	13.8	42.9	

Table A-10 (Continued)

Test ID	Date	pH	Liquid Phase, mg/L				Slurry Solids, wt%	Solid Phase, wt%			
			Carbonate	Sulfite	Sulfate	Chloride		Calcium	Carbonate	Sulfate	Inerts
Long-Term Tests											
L1-1	05-Apr-93	4.03	96	0.8	768	11,719	21.80	22.4	0.8	53.2	
L1-2	19-Apr-93	5.18	96	0.8	794	25,119	21.71	23.4	1.2	54.9	
	25-Apr-93	5.03	96	0.8	742	31,270	21.16	23.3	1.2	54.9	
L1-3	28-May-93	4.39	96	0.8	905	23,780	21.17	23.5	0.6	53.8	
	01-Jun-93	4.81	96	1.6	780	29,186	23.67	23.3	0.9	57.0	
	06-Jun-93	4.58	96	0.8	858	29,661	21.86	23.8	1.4	55.3	
	14-Jun-93	4.63	96	1.6	740	23,082	16.09	21.8	0.6	50.0	
	22-Jun-93	4.34		4.8	792	32,316	23.06	22.8	1.2	56.1	
	28-Jun-93	4.07	96	2.4	846	37,054	22.41	22.6		55.1	
	06-Jul-93	4.17	114	0.8	793	36,707	25.39	23.0	0.7	53.9	1.29
	12-Jul-93	4.61	114	0.8	773	36,781	21.13	24.8	0.7	55.3	
	26-Jul-93	4.78	114	1.6	852	36,234	20.63	22.4	0.2	51.0	
	02-Aug-93	4.52	114	0.8	820	36,377	21.11	21.6	0.2	52.7	
	09-Aug-93	4.26	114	0.8	945	25,308	12.57	22.9	0.7	54.9	
	16-Aug-93	4.70	114	1.6	894	25,016	18.74	23.9	0.8	57.8	
	23-Aug-93	4.62	114	1.6	880	33,387	17.50	24.3	0.1	53.5	
	29-Aug-93	4.62	114	1.6	768	33,970	21.83	22.9	0.3	55.2	
	07-Sep-93	4.27	114	1.6	744	41,954	15.69	22.6	0.3	53.9	

Table A-10 (Continued)

Test ID	Date	pH	Liquid Phase, mg/L				Slurry Solids, wt%	Solid Phase, wt%			
			Carbonate	Sulfite	Sulfate	Chloride		Calcium	Carbonate	Sulfate	Inerts
High Removal Tests											
HR1-1	14-Sep-93	4.42	114	1.6	849	43,785	21.60	23.1	1.0	53.8	
	19-Sep-93	4.72	93	1.6	795	33,758	21.16	23.8	0.5	54.6	
HR1-4	27-Sep-93	4.75	93	0.8	678	53,109	18.20	23.0	0.4	55.5	
	05-Oct-93	4.76	93	1.6	640	37,424	20.33	21.9	2.8	51.9	
	11-Oct-93	4.84	93	11.2	624	68,070	19.12	25.0	7.4	50.6	
	14-Oct-93	4.08	93	19.2	886	64,950	24.49	23.7	0.8	56.0	
	18-Oct-93	4.10	93	22.4	633	53,557	25.88	23.1	1.1	53.9	
	24-Oct-93	4.83	93	0.8	702	44,103	29.23	23.2	2.9	47.4	
Alternate Limestone Tests											
P1A-11	01-Nov-93	4.59	93	0.8	721	44,403	16.98	22.2	0.1	53.2	0.87
P1B-1	02-Dec-93	4.38	93	1.6	801	39,270	23.39	23.8	2.4	54.8	0.81
P1B-5	05-Dec-93	4.62	93	32.0	1,705	47,226	19.52	24.0	2.9	54.2	1.09
P1B-9R	13-Dec-93	4.05	93	1.6	601	50,750	15.82	23.3	0.8	52.9	1.45
P1B-9R2	19-Dec-93	4.87	93	1.6	587	72,432	19.77	24.0	3.2	53.1	1.08
AL1-1	28-Dec-93	4.60	93	1.6	565	63,966	21.58	23.2	0.2	53.8	0.70
	03-Jan-94	4.40	173	0.8	592	65,319	23.77	23.9	0.7	56.9	0.77
	10-Jan-94	4.51	173	0.8	552	56,648	27.13	23.1	1.0	55.3	1.13
	17-Jan-94	4.58	173	1.6	705	52,045	20.86	24.0	1.1	54.0	0.94
Alternate Coal Tests											
AC1-1	25-Jan-94	4.06	173	2.4	703	34,504	17.44	22.4	1.1	55.0	0.71
	31-Jan-94	4.61	173	1.6	701	53,080	19.73	23.8	1.0	54.4	0.59
AC1-3	07-Feb-94	4.10	170	0.0	685	68,770	21.97	23.8	1.0	53.8	0.49
AC1-10	14-Feb-94	5.15	170	0.8	757	63,879	17.40	23.4	2.0	54.3	0.58

Table A-11

JBR Overflow Liquid-Phase Trace Metals: Period 1

Element	Units	14-Jun-93	12-Jul-93	09-Aug-93	14-Sep-93
Aluminum	mg/L	4.67	0.45	18.9	7.75
Antimony	mg/L	0.02	0.01[b]	0.07	<0.0139
Arsenic	mg/L	<0.011	<0.008	<0.002	0.01
Barium	mg/L	2.09	0.18	2.12	3.08
Beryllium	mg/L	0.01	<0.004	0.01	<0.0016
Boron	mg/L	894	70	899	1510
Cadmium	mg/L	0.25	0.02	0.31	0.51
Copper	mg/L	0.23	0.03	0.32	0.31
Chromium	mg/L	0.04	<0.007	0.02	0.04
Cobalt	mg/L	0.18	0.02	0.27	0.4
Iron	mg/L	0.162[b]	<0.02	<0.019	<0.0319
Lead	mg/L	<0.004	0.001[b]	0	<0.008
Manganese	mg/L	193	16.4	212	332
Mercury	mg/L			0.003	0.0056
Molybdenum	mg/L	0.014[b]	0.014[b]	<0.014	0.07
Nickel	mg/L	0.98	0.08	1.1	1.6
Potassium	mg/L	78.1	5	94	150
Selenium	mg/L	0.12	0.09	0.16	0.09
Silicon	mg/L	24.6	3.1	35.2	29.1
Sodium	mg/L	153	11.9	194	297
Vanadium	mg/L	0.12	<0.007	0.08	0.17

[a] Value less than five times detection limit.

[b] Value less than detection limit.

Table A-12

JBR Underflow Analyses: Period 1

Test ID	Date	pH	Slurry Solids, wt%	Solid Phase, wt%					
				Calcium	Magnesium	Sulfite	Sulfate	Carbonate	Inerts
Parametric Tests									
P1-2	22-Jan-93	4.5	22.6	24.7	0.00	0.00	56.8	1.1	1.66
P1-6	27-Jan-93	4.8	22.6	24.2	0.00	0.08	53.8	1.8	0.00
P1-9	01-Feb-93	4.9	19.0	23.2	0.00	0.00	56.3	0.7	1.20
P1-12	05-Feb-93	5.3	22.7	22.4	0.00	0.00	57.4	0.7	1.27
P1-14	09-Feb-93	4.9	22.5	24.5	0.00	0.00	58.0	0.8	0.94
P1-18	15-Feb-93	4.4	21.1	24.2	0.00	0.00	59.7	0.5	0.56
P1-21	21-Feb-93	5.2	22.6	22.5	0.00	0.00	53.6	1.1	0.67
P1-24	26-Feb-93	4.8	21.5	22.2	0.02	0.00	54.0	1.1	2.41
P1-27	04-Mar-93	5.2	22.0	23.2	0.15	0.08	56.8	1.4	1.98
P1-28	08-Mar-93	4.5	19.9	22.4	0.07	0.00	58.7	0.5	2.12
P1-21R	12-Mar-93	5.4	20.6	23.7	0.02	0.00	55.5	1.3	0.26
P1-31	16-Mar-93	4.9	15.5	23.6	0.00	0.00	54.6	0.5	1.76
P1-32	18-Mar-93	5.2	19.6	23.8	0.00	0.00	54.2	0.8	1.83
P1-33	20-Mar-93	5.2	19.1	23.1	0.02	0.08	55.8	2.7	1.63
P1-34	22-Mar-93	5.5	19.8	26.5	0.05	0.08	55.4	19.0	0.00
P1-35	28-Mar-93	5.3	20.6	24.8	0.02	0.08	50.0	4.7	0.45
P1-36	30-Mar-93	5.7	23.0	28.0	0.05	0.08	41.9	14.5	0.51
Long-Term Tests									
L1-1	05-Apr-93	4.98	20.02	22.2	0.02	0.16	55.8	0.5	1.63
L1-2	19-Apr-93	5.12	23.96	23.5	0.02	0.00	53.7	1.1	2.03
	25-Apr-93	5.27	18.25	22.3	0.02	0.00	53.8	1.3	1.63
L1-3	28-May-93	4.71	20.55	22.9	0.00	0.00	57.1	0.7	1.82
	01-Jun-93	4.74	22.64	24.4	0.00	0.00	59.1	1.0	1.71
	06-Jun-93	4.63	23.24	23.2	0.00	0.00	54.2	1.6	2.17
	14-Jun-93	5.02	14.24	21.7	0.00	0.00	53.7	0.5	0.86
	22-Jun-93	4.86	21.86	23.4	0.00	0.08	53.9	1.3	1.59
	28-Jun-93	4.82	20.77	23.0	0.00	0.00	56.0	0.6	1.86
	06-Jul-93	4.54	21.3	23.8	0.00	0.00	57.6	0.5	1.66
	12-Jul-93	4.81	21.98	22.8	0.00	0.08	55.6	0.3	0.38
	26-Jul-93	5.10	21.04	21.8	0.00	0.00	53.7	0.5	1.58

Table A-12 (Continued)

Test ID	Date	pH	Slurry Solids, wt%	Solid Phase, wt%					
				Calcium	Magnesium	Sulfite	Sulfate	Carbonate	Inerts
Parametric Tests									
P1-2	22-Jan-93	4.5	22.6	24.7	0.00	0.00	56.8	1.1	1.66
L1-3	02-Aug-93	5.17	21.51	22.1	0.02	0.00	56.2	0.3	0.80
	09-Aug-93	4.54	14.55	23.1	0.02	0.00	54.9	0.8	1.68
	16-Aug-93	5.08	18.31	23.2	0.02	0.00	55.6	0.9	1.49
	23-Aug-93	4.68	20.03	23.2	0.02	0.00	55.3	0.2	1.86
	29-Aug-93	4.55	22.22	22.1	0.00	0.00	55.3	0.3	1.03
	07-Sep-93	3.83	17.45	21.9	0.02	0.00	54.6	0.3	2.10
High Removal Tests									
HR1-1	14-Sep-93	4.81	19.76	22.9	0.02		54.9	1.1	3.27
	19-Sep-93	5.27	22.90	23.9	0.05	0.00	55.0	0.5	0.48
	27-Sep-93	4.28	19.13	23.7	0.02	0.00	54.2	0.4	1.63
HR1-4	05-Oct-93	5.05	20.71	21.6	0.02	0.00	51.0	2.9	2.40
	11-Oct-93	4.35	19.84	24.6	0.07	11.85	53.0	7.9	2.21
	14-Oct-93	4.32	25.01	24.6	0.02	4.88	57.4	0.9	2.03
	18-Oct-93	4.80	26.91	22.2	0.00	0.08	52.4	1.0	2.05
	24-Oct-93	5.10	27.85	20.2	0.12	0.00	43.6	1.9	15.54
Alternate Limestone Tests									
P1A-11	01-Nov-93	4.67	21.04	22.0	0.07	0.00	52.7	0.1	0.94
P1B-1	02-Dec-93	5.06	22.10	23.6	0.12	0.08	55.8	2.1	0.94
P1B-5	05-Dec-93	4.70	21.92	22.2	0.10	0.16	48.9	3.8	0.82
P1B-9R	13-Dec-93	4.34	16.99	23.2	0.15	0.16	54.9	0.4	1.41
	19-Dec-93	5.18	24.46	24.7	0.17	0.08	53.2	3.8	1.06
	28-Dec-93	4.84	21.10	23.4	0.07	0.00	53.1	0.1	0.70
AL1-1	03-Jan-94	4.8	22.15	24.0	0.12	0.00	56.7	0.7	0.77
	10-Jan-94	4.65	21.36	22.9	0.15	0.00	55.1	0.7	0.76
	17-Jan-94	4.98	22.26	23.8	0.12	0.00	53.7	1.0	0.59
Alternate Coal Parametric Tests									
AC1-1	25-Jan-94	4.52	17.79	23.2	0.17	0.00	55.0	1.1	0.71
	31-Jan-94	5.17	19.22	24.2	0.12	0.00	53.6	1.1	0.52
AC1-3	07-Feb-94	4.28	23.77	24.4	0.44	0.00	55.2	1.0	0.51
AC1-10	14-Feb-94	5.14	21.74	23.6	0.22	0.00	54.1	2.0	0.43

Table A-13

JBR Underflow Solid-Phase Trace Metals: Period 1

Element	25-Jun-93	14-Jun-93	28-Jun-93	12-Jul-93	26-Jul-93	09-Aug-93	23-Aug-93	14-Sep-93
Aluminum	848	676	709	621	307	661	909	979
Antimony	0.1	0.09	0.2	0.1	0.09	0.1	0.09	0.09
Arsenic	<0.31	<0.31	0.31	<0.31	<0.31	<0.31	<0.31	<0.30
Barium	1.64	1.84	1.95	1.62	1.37	1.78	3.5	4.05
Beryllium	0.12	0.12	0.18	0.12	0.13	<0.058	<0.056	<0.0535
Boron	105	30	139	99	116	108	93	186
Cadmium	<0.279	<0.27	<0.281	<0.273	<0.266	<0.284	<0.271	<0.261
Copper	2.59	2.42	1.66	1.52	1.19	4.47	4.95	4.41
Chromium	8.85	8.54	7.99	6.89	7.39	8.15	7.3	9.29
Cobalt	1.1	0.52	1.08	1.52	1.19	4.47	4.95	4.41
Iron	1460	1440	1320	1060	1080	1340	1590	1920
Lead	0.69	0.69	1.13	0.79	1.19	0.96	0.99	1.52
Manganese	32	15.4	31.9	24.2	28.6	37.3	31.1	517
Mercury	0.118	0.0875	0.102	0.0325	0.045	0.0575	0.0975	0.0975
Molybdenum	0.72	0.79	0.65	1.23	0.75	1.12	0.6	0.83
Nickel	1.71	1.25	1.82	1.5	1.07	2.13	1.2	2.52
Potassium	179	139	215	222	147	164	113	220
Selenium	2.25	<0.147	4.06	2.57	3.07	1.92	4.55	2.95
Silicon	683	459	399	355	374	442	594	374
Sodium	<25.1	24.1	45.5	36.8	44.2	34.8	31.4	57.6
Vanadium	<4.17	7.05	7.92	7.14	6.32	7.72	7.37	8.73

Note: Units are mg/kg.

Table A-14

Coal Proximate Analyses (As Burned)—Period 1

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
Parametric Tests						
15-Jan-93	12.86	11.12	33.0	43.0	2.38	10,834
16-Jan-93	13.06	10.98	33.4	42.6	2.37	10,922
17-Jan-93	13.90	10.60	33.2	42.3	2.32	10,858
18-Jan-93	13.14	10.74	33.1	43.0	2.42	10,972
19-Jan-93	12.98	10.69	33.3	43.1	2.39	10,981
20-Jan-93	12.79	10.71	33.5	43.0	2.45	10,987
21-Jan-93	14.70	10.54	33.0	41.8	2.42	10,726
22-Jan-93	13.67	10.89	33.3	42.0	2.44	10,777
23-Jan-93	13.39	10.91	33.3	42.4	2.39	10,859
24-Jan-93	15.13	10.82	32.6	41.4	2.34	10,690
25-Jan-93	13.88	10.64	26.4	42.2	2.31	10,869
26-Jan-93	13.56	10.89	32.8	42.7	2.29	10,859
27-Jan-93	13.07	9.38	33.8	43.7	2.48	11,225
28-Jan-93	13.09	9.34	33.9	43.6	2.48	11,098
29-Jan-93	12.84	9.14	34.2	43.8	2.55	11,299
30-Jan-93	12.49	9.13	34.3	44.0	2.50	11,308
31-Jan-93	13.05	9.76	34.9	42.3	2.63	11,093
01-Feb-93	6.66	11.36	33.4	48.6	1.53	12,340
02-Feb-93	12.03	10.61	34.1	43.2	2.57	10,955
03-Feb-93	12.23	10.29	34.3	43.2	2.54	11,045
04-Feb-93	11.93	10.24	34.5	43.2	2.56	11,216
05-Feb-93	12.15	9.81	34.4	43.6	2.50	11,297
06-Feb-93	11.67	9.76	34.7	43.9	2.48	11,331
07-Feb-93	12.52	10.79	34.4	42.3	2.57	11,015
08-Feb-93	13.27	10.91	33.9	41.9	2.57	10,919
09-Feb-93	13.50	9.26	33.7	43.5	2.40	11,159
10-Feb-93	14.27	9.37	33.1	43.3	2.44	11,039
11-Feb-93	14.18	9.49	33.2	43.2	2.43	11,045
12-Feb-93	15.00	9.22	33.3	42.5	2.45	10,932
13-Feb-93	14.35	9.65	33.6	42.5	2.46	10,950
14-Feb-93	13.44	9.93	33.7	42.9	2.41	11,053

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
15-Feb-93	13.46	10.37	33.7	42.5	2.32	11,009
16-Feb-93	14.20	9.68	34.1	42.0	2.66	10,941
17-Feb-93	13.62	9.84	34.4	42.2	2.69	11,007
18-Feb-93	13.77	9.86	33.6	42.8	2.65	10,990
20-Feb-93	13.63	9.96	33.6	42.8	2.65	11,004
21-Feb-93	15.37	9.91	32.9	41.8	2.56	10,764
22-Feb-93	15.16	9.86	33.8	41.2	2.64	10,804
23-Feb-93	12.63	9.11	34.6	43.7	2.48	11,324
25-Feb-93	12.92	9.35	34.6	43.2	2.52	11,197
26-Feb-93	13.32	9.39	34.3	43.0	2.56	11,163
27-Feb-93	12.81	9.54	34.6	43.1	2.55	11,249
28-Feb-93	12.70	9.52	34.6	43.2	2.59	11,225
01-Mar-93	13.05	9.89	34.3	42.8	2.60	11,102
02-Mar-93	13.92	10.64	33.3	42.1	2.40	10,884
03-Mar-93	12.82	8.89	34.5	43.8	2.38	11,368
04-Mar-93	11.40	9.76	33.7	45.2	2.14	11,494
05-Mar-93	13.32	9.13	33.5	44.0	2.42	11,196
06-Mar-93	13.23	8.84	34.0	44.0	2.42	11,237
07-Mar-93	12.24	8.95	34.6	44.2	2.39	11,362
08-Mar-93	12.65	8.97	34.6	43.8	2.48	11,374
09-Mar-93	12.65	8.98	34.7	43.7	2.38	11,376
10-Mar-93	12.67	9.11	34.8	43.5	2.70	11,305
11-Mar-93	12.31	8.96	34.8	43.9	2.63	11,379
12-Mar-93	11.90	9.18	34.5	44.5	2.37	11,440
13-Mar-93	10.96	9.96	32.9	46.2	1.90	11,674
14-Mar-93	13.29	8.81	34.3	43.6	2.31	11,296
15-Mar-93	12.65	9.00	34.6	43.8	2.49	11,314
16-Mar-93	12.74	8.99	34.6	43.6	2.45	11,318
17-Mar-93	12.28	8.93	34.5	44.4	2.33	11,414
18-Mar-93	12.67	8.90	34.5	44.0	2.44	11,366
19-Mar-93	12.30	9.02	34.9	43.8	2.42	11,353
20-Mar-93	12.85	8.92	34.6	43.7	2.36	11,308
21-Mar-93	12.46	9.03	34.7	43.9	2.39	11,390
22-Mar-93	12.59	8.84	34.7	43.9	2.39	11,364
23-Mar-93	12.00	8.84	34.3	44.8	2.38	11,401

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
24-Mar-93	11.61	8.89	34.6	44.8	2.38	11,493
25-Mar-93	11.55	8.81	35.0	44.7	2.37	11,520
26-Mar-93	12.19	9.29	33.1	45.4	2.27	11,443
27-Mar-93	12.27	9.33	33.6	44.8	2.27	11,450
28-Mar-93	12.25	9.35	33.4	44.9	2.21	11,463
29-Mar-93	13.02	8.73	34.3	44.0	2.35	11,329
30-Mar-93	12.71	8.70	34.3	44.3	2.28	11,400
31-Mar-93	11.15	9.58	33.7	45.6	2.02	11,570
Long-Term Tests						
02-Apr-93	12.88	8.69	34.3	44.1	2.41	11,328
03-Apr-93	12.24	9.15	34.4	44.1	2.36	11,365
04-Apr-93	12.22	8.88	34.7	44.2	2.52	11,446
05-Apr-93	12.05	8.86	33.2	45.9	2.15	11,739
06-Apr-93	12.94	8.97	34.6	43.4	2.42	11,300
07-Apr-93	12.60	8.98	34.5	43.9	2.23	11,360
15-Apr-93	12.04	9.00	34.0	44.9	2.23	11,507
16-Apr-93	13.36	8.85	33.5	44.3	2.20	11,328
17-Apr-93	12.08	8.96	34.2	44.8	2.30	11,461
18-Apr-93	11.07	9.30	34.1	45.4	2.27	11,606
19-Apr-93	12.12	8.81	34.5	44.6	2.35	11,448
20-Apr-93	12.59	9.09	34.4	43.9	2.26	11,372
21-Apr-93	12.55	9.27	34.3	44.0	2.26	11,325
22-Apr-93	11.98	9.27	34.3	44.5	2.29	11,415
23-Apr-93	11.33	9.39	34.1	45.1	2.32	11,553
24-Apr-93	11.50	9.20	34.3	45.0	2.34	11,506
25-Apr-93	12.04	9.22	34.0	44.7	2.38	11,457
26-Apr-93	11.75	9.22	34.3	44.7	2.28	11,518
27-Apr-93	11.60	8.99	34.9	44.5	2.32	11,538
28-Apr-93	11.68	9.21	34.4	44.6	2.33	11,497
01-Jun-93	11.81	8.95	34.4	44.9	2.23	11,338
02-Jun-93	10.96	8.86	35.0	45.1	2.29	11,623
03-Jun-93	11.60	8.80	34.5	45.2	2.29	11,556
04-Jun-93	11.86	8.75	34.7	44.7	2.32	11,491
05-Jun-93	11.27	8.84	35.2	44.7	2.36	11,507
06-Jun-93	10.79	9.03	35.1	45.1	2.35	11,545

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
07-Jun-93	10.59	9.13	35.3	45.0	2.34	11,572
08-Jun-93	9.77	9.24	35.3	45.7	2.34	11,725
09-Jun-93	12.85	9.50	31.5	46.8	1.84	12,481
10-Jun-93	9.85	9.24	35.2	45.7	2.37	11,696
12-Jun-93	10.22	8.91	34.2	46.6	2.23	11,864
13-Jun-93	11.16	9.02	34.5	45.4	2.24	11,621
14-Jun-93	11.15	9.10	34.1	45.7	2.23	11,601
15-Jun-93	11.34	9.05	34.3	45.3	2.38	11,544
16-Jun-93	10.96	8.93	35.2	45.0	2.38	11,583
17-Jun-93	9.33	9.30	34.5	46.9	2.22	11,896
18-Jun-93	10.50	9.47	34.5	45.6	2.35	11,640
19-Jun-93	12.39	9.43	34.2	44.0	2.54	11,215
20-Jun-93	11.49	10.09	33.8	44.7	2.41	11,309
21-Jun-93	11.89	9.24	34.4	44.5	2.43	11,330
22-Jun-93	11.68	9.62	33.7	45.0	2.43	11,340
23-Jun-93	11.11	9.38	34.8	44.6	2.41	11,464
24-Jun-93	12.76	9.33	33.9	44.0	2.49	11,200
26-Jun-93	11.75	10.26	33.4	44.6	2.36	11,186
27-Jun-93	11.50	10.92	33.5	44.2	2.38	11,196
28-Jun-93	12.58	10.95	33.2	43.3	2.28	11,024
29-Jun-93	13.12	9.80	33.4	43.6	2.41	11,094
30-Jun-93	13.66	9.27	33.4	43.6	2.45	11,103
01-Jul-93	12.90	9.39	33.7	44.0	2.45	11,144
02-Jul-93	12.59	9.50	33.3	44.6	2.45	11,209
03-Jul-93	13.07	9.66	33.2	44.1	2.43	11,174
04-Jul-93	11.85	9.76	33.8	44.6	2.45	11,296
05-Jul-93	12.24	9.70	33.7	44.3	2.44	11,230
06-Jul-93	11.30	9.76	33.9	45.1	2.41	11,355
07-Jul-93	10.07	9.78	33.9	46.3	2.36	11,705
08-Jul-93	11.62	9.90	34.4	44.1	2.54	11,205
09-Jul-93	12.85	9.80	33.9	43.5	2.56	11,149
10-Jul-93	10.38	9.60	33.6	46.4	2.19	11,740
11-Jul-93	11.91	9.85	33.9	44.3	2.44	11,339
12-Jul-93	11.75	10.04	33.8	44.5	2.46	11,319
13-Jul-93	12.93	9.33	33.7	44.1	2.39	11,215

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
14-Jul-93	12.98	9.18	33.3	44.6	2.31	11,266
15-Jul-93	13.54	8.99	33.4	44.1	2.36	11,176
16-Jul-93	11.66	9.27	33.2	45.8	2.15	11,544
17-Jul-93	13.50	9.06	33.7	43.7	2.41	11,143
18-Jul-93	13.80	8.92	33.4	43.9	2.36	11,106
19-Jul-93	13.47	8.82	33.6	44.1	2.33	11,195
20-Jul-93	11.94	8.88	34.2	45.0	2.51	11,403
21-Jul-93	12.39	8.99	34.0	44.7	2.44	11,339
23-Jul-93	11.32	9.15	34.1	45.4	2.42	11,505
24-Jul-93	11.31	9.14	34.5	45.1	2.40	11,480
25-Jul-93	10.86	9.11	34.2	45.8	2.30	11,613
26-Jul-93	11.34	9.58	34.3	44.8	2.58	11,428
28-Jul-93	9.78	9.87	34.2	46.2	2.19	11,680
29-Jul-93	12.09	8.92	33.8	45.1	2.25	11,467
30-Jul-93	11.90	8.92	33.8	45.4	2.21	11,498
31-Jul-93	12.15	9.03	34.0	44.8	2.42	11,379
01-Aug-93	12.01	8.77	34.1	45.1	2.29	11,463
02-Aug-93	11.14	9.41	33.6	45.9	2.28	11,540
03-Aug-93	11.76	8.67	33.8	45.8	2.23	11,548
04-Aug-93	11.61	9.01	33.9	45.6	2.34	11,540
05-Aug-93	11.76	9.00	33.8	45.4	2.35	11,499
08-Aug-93	14.28	8.85	33.3	43.5	2.60	11,081
09-Aug-93	12.72	8.91	33.3	45.1	2.37	11,360
10-Aug-93	13.29	9.05	32.4	45.2	2.06	11,282
11-Aug-93	11.82	8.83	33.8	45.6	2.37	11,538
12-Aug-93	12.62	8.59	33.6	45.2	2.38	11,406
13-Aug-93	12.25	8.73	33.4	45.6	2.28	11,535
14-Aug-93	12.36	10.42	32.9	44.3	2.31	11,155
15-Aug-93	12.70	9.87	33.1	44.3	2.84	11,245
16-Aug-93	12.53	8.85	33.2	45.5	2.16	11,474
17-Aug-93	11.14	9.38	33.4	46.0	2.24	11,564
18-Aug-93	12.09	9.93	33.0	45.0	2.23	11,280
19-Aug-93	11.40	9.60	33.5	45.5	2.28	11,449
20-Aug-93	11.47	10.17	33.8	44.5	2.39	11,368
21-Aug-93	10.78	10.44	33.5	45.3	2.26	11,464

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
23-Aug-93	8.31	11.27	31.5	48.9	1.76	11,971
24-Aug-93	10.72	10.69	33.4	45.2	2.39	11,388
25-Aug-93	10.70	10.77	33.2	45.3	2.30	11,434
26-Aug-93	10.92	10.58	33.1	45.3	2.33	11,412
27-Aug-93	11.06	10.29	33.4	45.3	2.47	11,392
28-Aug-93	11.87	10.66	33.2	44.2	2.36	11,216
29-Aug-93	10.89	10.35	33.7	45.1	2.32	11,405
30-Aug-93	10.10	9.08	34.6	46.2	2.31	11,690
31-Aug-93	10.88	9.38	34.5	45.3	2.46	11,481
01-Sep-93	10.71	10.13	33.8	45.4	2.43	11,460
02-Sep-93	10.92	10.08	33.8	45.3	2.45	11,439
03-Sep-93	10.96	9.99	33.7	45.3	2.42	11,420
04-Sep-93	11.25	9.69	33.8	45.3	2.40	11,394
07-Sep-93	10.64	10.23	33.2	46.0	2.40	11,408
Auxiliary Test Block						
13-Sep-93	11.08	10.30	34.4	44.2	2.59	11,386
14-Sep-93	11.15	10.32	34.3	44.2	2.60	11,345
15-Sep-93	10.38	10.69	33.3	45.5	2.41	11,495
16-Sep-93	9.83	10.50	33.5	46.2	2.31	11,614
17-Sep-93	11.13	10.46	33.6	44.9	2.47	11,364
18-Sep-93	11.06	10.47	33.6	44.9	2.55	11,388
19-Sep-93	11.06	10.30	34.3	44.3	2.47	11,411
20-Sep-93	10.01	9.79	33.2	47.0	1.82	11,760
21-Sep-93	13.30	9.49	33.0	44.2	2.23	11,205
22-Sep-93	12.53	10.45	32.7	44.3	2.22	11,142
23-Sep-93	12.87	9.51	32.7	45.0	2.25	11,273
24-Sep-93	12.32	10.00	33.0	44.7	2.14	11,267
25-Sep-93	12.87	9.69	33.0	44.4	2.33	11,187
26-Sep-93	12.58	9.90	33.5	44.1	2.50	11,174
27-Sep-93	11.95	9.93	33.4	44.7	2.43	11,314
28-Sep-93	10.53	10.49	34.0	45.0	2.45	11,469
29-Sep-93	12.45	9.39	33.9	44.3	2.52	11,305
04-Oct-93	11.06	9.43	34.2	45.4	2.47	11,494
05-Oct-93	11.10	9.51	34.1	45.3	2.47	11,461
06-Oct-93	12.61	9.63	33.7	44.0	2.52	11,216

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
07-Oct-93	12.35	9.48	33.9	44.3	2.53	11,267
08-Oct-93	12.46	9.31	33.5	44.6	2.34	11,282
09-Oct-93	11.71	9.23	34.2	44.9	2.37	11,420
10-Oct-93	12.29	8.93	33.9	44.8	2.48	11,409
11-Oct-93	12.89	9.00	33.9	44.3	2.56	11,232
12-Oct-93	11.57	9.59	34.1	44.7	2.41	11,414
13-Oct-93	11.68	9.83	33.7	44.8	2.38	11,403
14-Oct-93	10.64	9.75	34.3	45.3	2.47	11,470
15-Oct-93	11.08	9.60	34.3	45.0	2.42	11,477
16-Oct-93	11.96	9.34	34.2	44.5	2.40	11,322
17-Oct-93	11.51	9.57	34.2	44.7	2.41	11,348
18-Oct-93	11.25	9.47	34.3	44.9	2.43	11,421
19-Oct-93	11.53	9.61	34.3	44.6	2.50	11,393
23-Oct-93	12.71	9.61	33.3	44.3	2.39	11,188
24-Oct-93	12.33	9.04	33.8	44.9	2.30	11,335
25-Oct-93	12.80	8.79	33.7	44.6	2.29	11,377
26-Oct-93	12.90	8.68	33.8	44.6	2.35	11,321
27-Oct-93	12.40	8.76	33.9	44.9	2.26	11,381
28-Oct-93	12.47	8.73	33.9	44.9	2.31	11,375
29-Oct-93	11.85	8.96	33.5	45.7	2.19	11,416
30-Oct-93	14.16	8.47	32.4	44.9	2.15	11,166
31-Oct-93	13.86	8.62	32.9	44.6	2.29	11,157
01-Nov-93	12.71	8.94	33.3	45.0	2.22	11,312
02-Nov-93	13.29	8.79	33.2	44.7	2.29	11,302
03-Nov-93	13.00	8.93	33.3	44.7	2.29	11,285
04-Nov-93	13.56	8.71	33.2	44.5	2.21	11,291
28-Nov-93	13.48	8.76	33.6	44.2	2.26	11,188
29-Nov-93	12.91	9.34	33.4	44.4	2.24	11,280
01-Dec-93	12.95	9.48	34.0	43.5	2.56	11,239
02-Dec-93	13.00	9.66	33.9	43.4	2.60	11,216
03-Dec-93	12.90	9.71	34.0	43.5	2.56	11,172
04-Dec-93	12.41	9.63	34.0	44.0	2.47	11,307
05-Dec-93	13.65	9.53	33.4	43.3	2.38	11,160
06-Dec-93	11.90	9.77	34.4	44.1	2.51	11,352
07-Dec-93	12.23	9.86	34.1	43.9	2.46	11,337

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
08-Dec-93	12.63	9.92	33.8	43.7	2.43	11,237
09-Dec-93	12.01	9.78	34.1	44.0	2.50	11,367
10-Dec-93	13.67	9.32	33.4	43.6	2.29	11,203
11-Dec-93	13.43	9.48	33.5	43.6	2.31	11,206
12-Dec-93	12.67	9.75	33.5	44.0	2.41	11,279
13-Dec-93	12.43	9.90	33.5	44.1	2.45	11,233
14-Dec-93	12.09	9.13	34.1	44.7	2.47	11,435
15-Dec-93	13.29	9.27	33.6	44.0	2.60	11,217
16-Dec-93	12.50	9.35	34.1	44.0	2.54	11,225
17-Dec-93	12.44	9.30	34.1	44.1	2.53	11,368
18-Dec-93	12.89	9.02	34.1	43.9	2.54	11,324
19-Dec-93	12.88	9.17	34.2	43.8	2.58	11,340
20-Dec-93	13.12	9.20	34.0	43.7	2.55	11,162
21-Dec-93	13.58	9.06	34.1	43.2	2.62	11,187
22-Dec-93	13.77	9.23	34.1	42.9	2.56	11,175
23-Dec-93	14.25	9.12	33.9	42.8	2.50	10,978
25-Dec-93	13.75	9.33	33.7	43.2	2.52	11,140
26-Dec-93	13.79	9.17	33.9	43.2	2.44	11,145
27-Dec-93	12.26	10.07	33.9	43.9	2.49	11,348
28-Dec-93	12.42	10.12	33.6	43.8	2.50	11,228
29-Dec-93	12.17	10.30	33.7	43.8	2.39	11,287
30-Dec-93	12.02	9.65	34.3	44.1	2.39	11,291
31-Dec-93	12.15	9.67	34.1	44.1	2.38	11,265
02-Jan-94	12.48	9.71	33.5	44.3	2.25	11,252
03-Jan-94	12.83	10.01	33.3	43.8	2.23	11,163
05-Jan-94	14.07	9.43	32.9	43.6	2.28	11,056
06-Jan-94	14.98	9.40	32.6	43.0	2.27	10,919
07-Jan-94	14.04	9.48	33.2	43.3	2.29	10,997
08-Jan-94	14.44	9.47	32.9	43.1	2.26	10,913
09-Jan-94	13.81	9.84	33.0	43.4	2.22	10,847
10-Jan-94	12.75	9.76	33.7	43.9	2.36	11,116
11-Jan-94	12.80	9.47	33.6	44.1	2.37	11,086
12-Jan-94	14.92	9.36	32.2	43.5	2.29	10,869
13-Jan-94	13.23	9.83	32.2	44.7	2.14	11,169
14-Jan-94	13.85	9.91	32.7	43.6	2.26	10,959

Table A-14 (Continued)

Date	H_2O, wt%	Ash, wt%	Volatiles, wt%	Fixed C, wt%	Sulfur, wt%	HHV, Btu/lb
15-Jan-94	14.05	9.70	32.7	43.5	2.23	10,968
16-Jan-94	11.94	10.58	32.8	44.6	2.20	11,266
17-Jan-94	12.59	10.70	33.2	43.5	2.31	11,003
18-Jan-94	13.01	10.53	33.5	43.0	2.39	11,056
19-Jan-94	12.67	10.25	33.1	43.9	2.36	11,152
20-Jan-94	9.93	10.69	33.4	45.9	1.95	11,716
21-Jan-94	8.98	10.13	32.7	48.1	1.71	12,058
24-Jan-94	12.22	10.80	32.7	44.3	1.99	11,185
25-Jan-94	8.18	9.89	37.4	44.6	3.59	12,058
Alternate Coal Test Block						
26-Jan-94	7.87	9.99	38.6	43.6	4.49	12,122
27-Jan-94	7.56	10.07	38.8	43.5	4.38	12,141
28-Jan-94	10.85	9.65	37.7	41.7	4.23	11,745
29-Jan-94	9.54	9.74	38.4	42.2	4.22	11,913
30-Jan-94	9.20	9.79	38.6	42.4	4.17	11,941
01-Feb-94	8.14	10.04	38.7	43.2	4.20	12,049
02-Feb-94	8.06	10.08	38.1	43.9	4.20	12,052
03-Feb-94	7.94	9.96	38.4	43.7	4.40	12,045
04-Feb-94	7.70	9.90	38.2	44.2	4.36	12,071
05-Feb-94	10.80	9.77	36.7	42.7	4.19	11,670
06-Feb-94	9.55	9.74	37.4	43.2	4.28	11,843
07-Feb-94	9.01	9.74	37.4	43.6	4.32	11,950
08-Feb-94	9.16	9.86	38.6	42.3	4.28	11,862
09-Feb-94	8.73	9.94	37.7	43.7	4.28	11,953
10-Feb-94	9.28	9.58	37.7	43.4	4.31	11,820
11-Feb-94	10.83	9.43	37.1	42.6	4.21	11,746
12-Feb-94	9.97	10.05	37.3	42.7	4.40	11,769
13-Feb-94	8.63	10.09	37.9	43.3	4.43	11,981
14-Feb-94	9.01	9.79	37.1	44.0	4.24	11,922
15-Feb-94	7.19	10.62	37.7	44.5	4.38	12,118

Table A-15

Coal Ultimate Analyses—Period 1

Parameter	22-Jan-93	22-Jun-93	13-Oct-93	09-Jan-94	27-Jan-94	22-Feb-94
Carbon, wt%	60.72	64.29	64.72	62.53	66.9	67.45
Hydrogen, wt%	4.01	4.32	4.37	4.15	4.7	4.79
Nitrogen, wt%	1.19	1.29	1.28	1.25	1.16	1.15
Sulfur, wt%	2.45	2.53	2.4	2.26	4.28	4.41
Oxygen, wt%	6.62	5.99	6.58	7.21	5.52	5.87
Moisture, wt%	13.88	11.64	11.47	13.26	7.67	6.43
Ash, wt%	11.12	9.94	9.18	9.34	9.76	9.9
Chlorine, ppmw	988	1173	NA	NA	737	961
Fluorine, ppmw	29	15	58	75	92	93

As received basis.

NA = Not analyzed.

Table A-16

Coal Trace Element Analyses—Period 1

Element	Units	22-Jun-93	22-Feb-94
Aluminum	ppmw	14,500	11,600
Antimony	ppmw	<1.0	<1.0
Arsenic	ppmw	2	1.3
Barium	ppmw	47	43
Beryllium	ppmw	3	3
Calcium	ppmw	4,500	2,300
Cadmium	ppmw	1.2	<1.0
Copper	ppmw	15	8
Chromium	ppmw	23	18
Cobalt	ppmw	8	7
Iron	ppmw	8,900	20,500
Lead	ppmw	12	2
Magnesium	ppmw	700	500
Manganese	ppmw	40	27
Mercury	ppmw	0.03	0.14
Molybdenum	ppmw	4	2
Nickel	ppmw	19	12
Phosphorus	ppmw	300	200
Potassium	ppmw	2,400	1,300
Selenium	ppmw	<2.0	<2.0
Silicon	ppmw	27,300	23,600
Sodium	ppmw	800	500
Sulfur	ppmw	28,600	47,100
Titanium	ppmw	700	600
Vanadium	ppmw	38	24

APPENDIX B

Particle-Size Distributions: JBR Inlet and Outlet Gas Streams

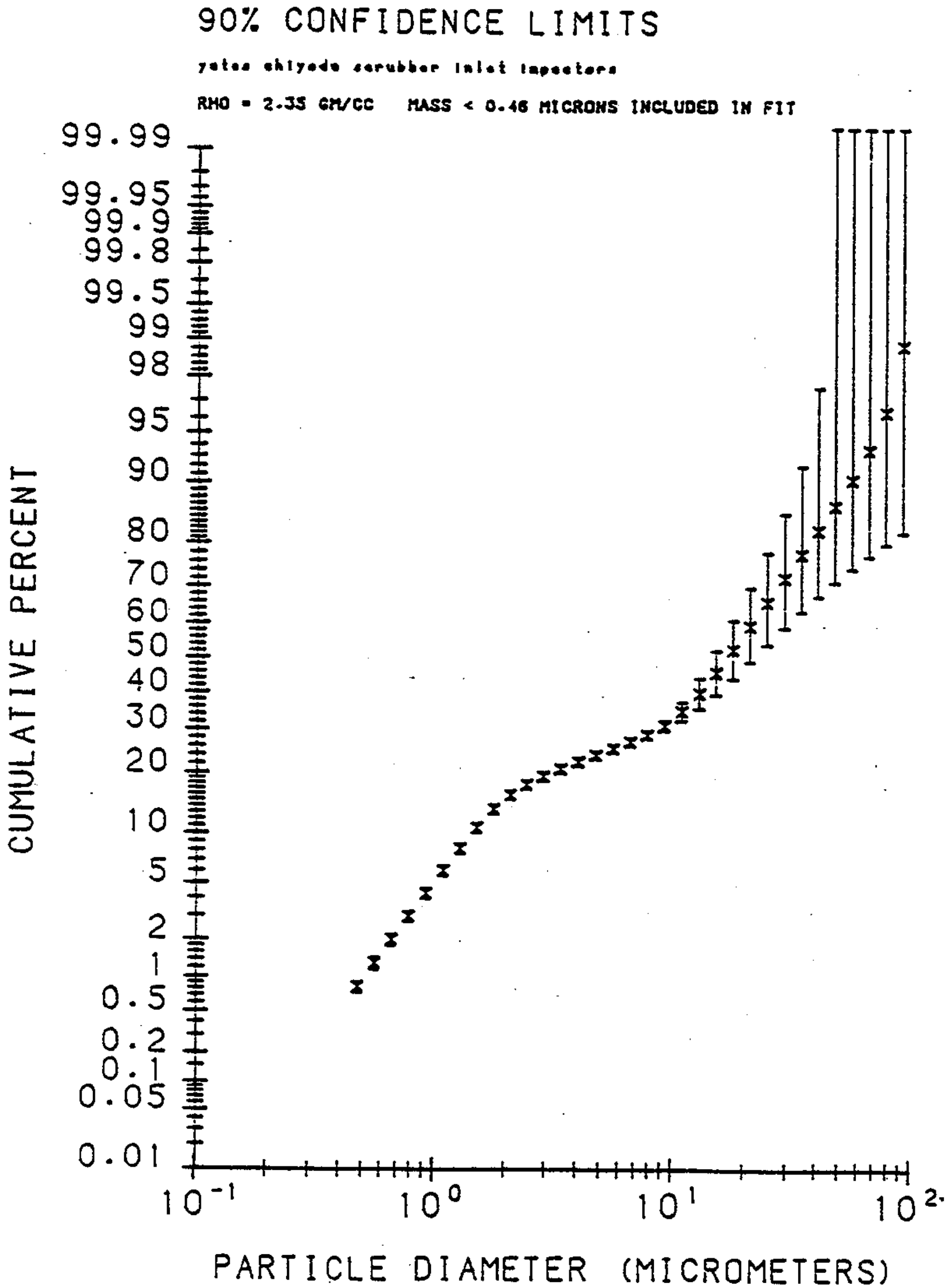


Figure B-1. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 100 MW, 8" ΔP, January 21, 1993

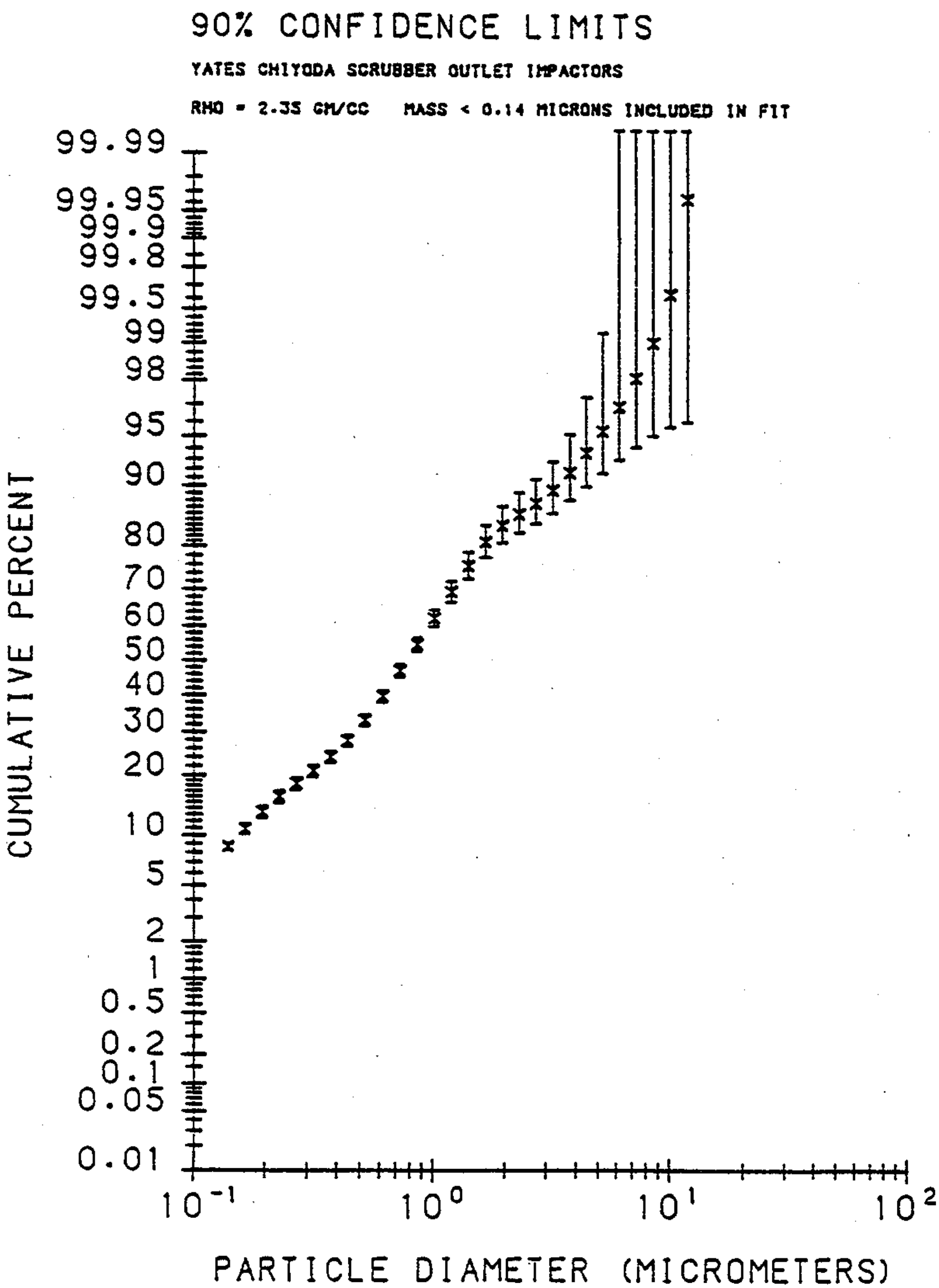


Figure B-2. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 100 Mw, 8" ΔP, January 21, 1993

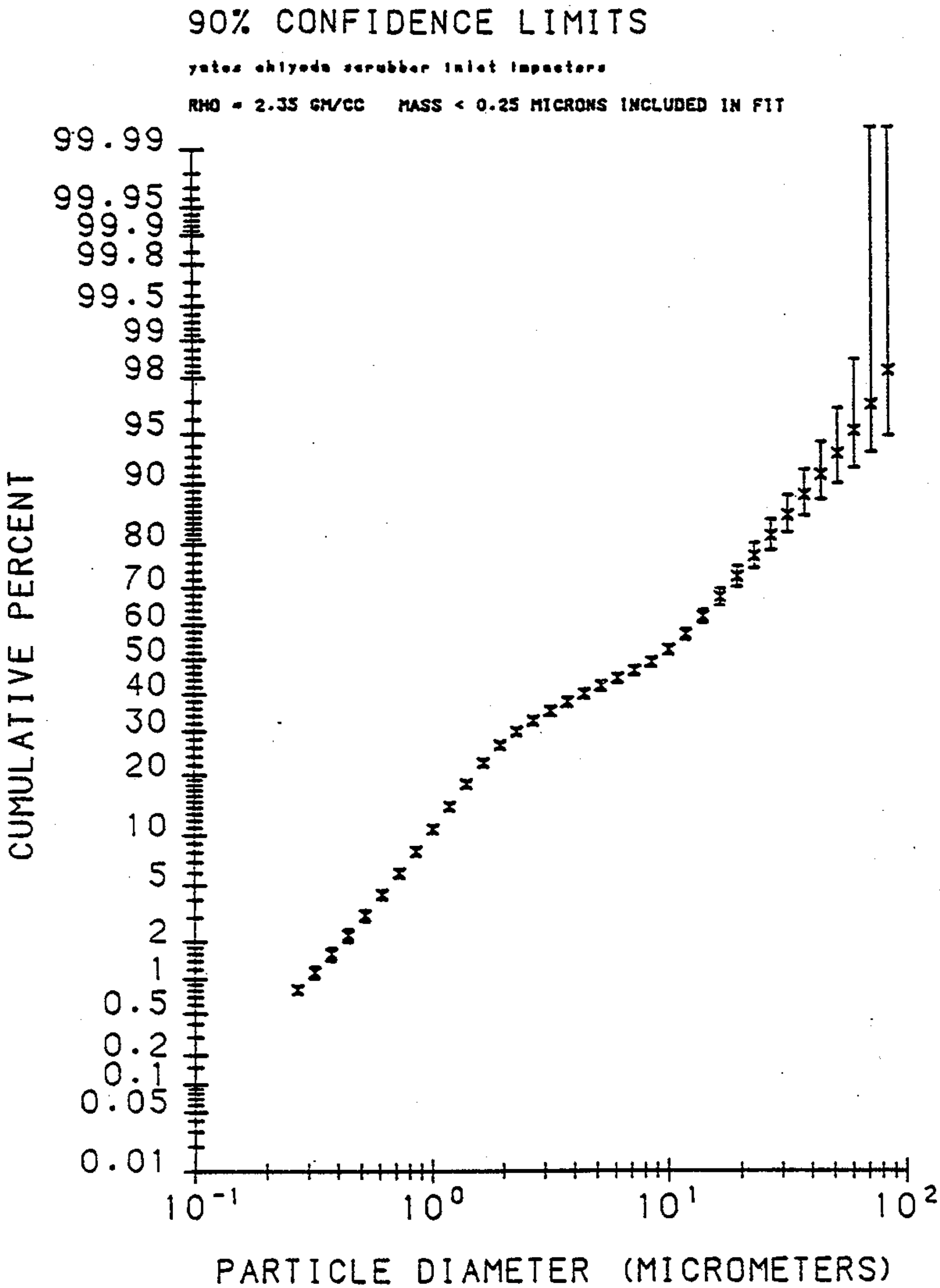


Figure B-3. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 100 MW, 12" ΔP, January 22, 1993

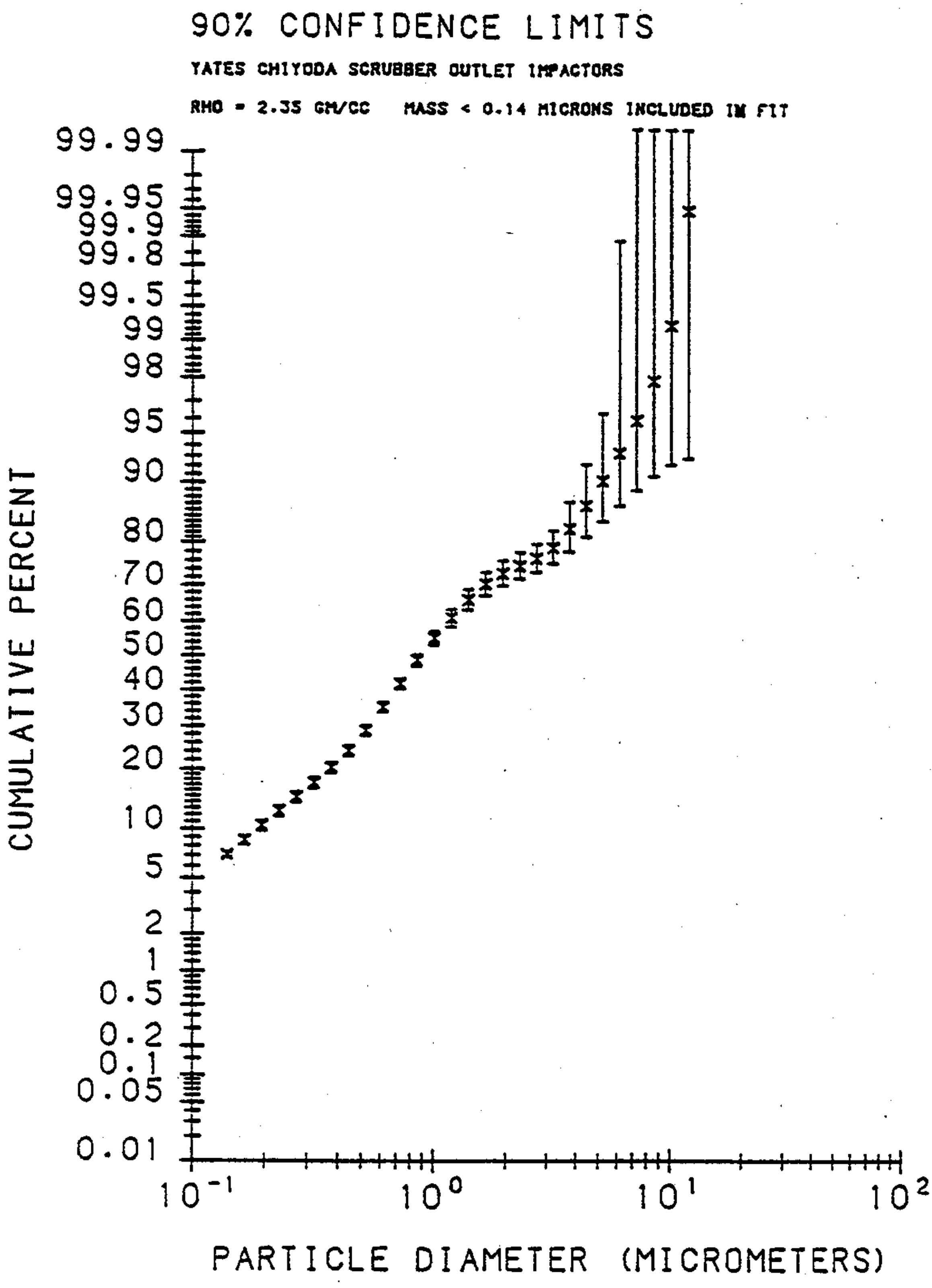


Figure B-4. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 100 MW, 12" ΔP, January 22, 1993

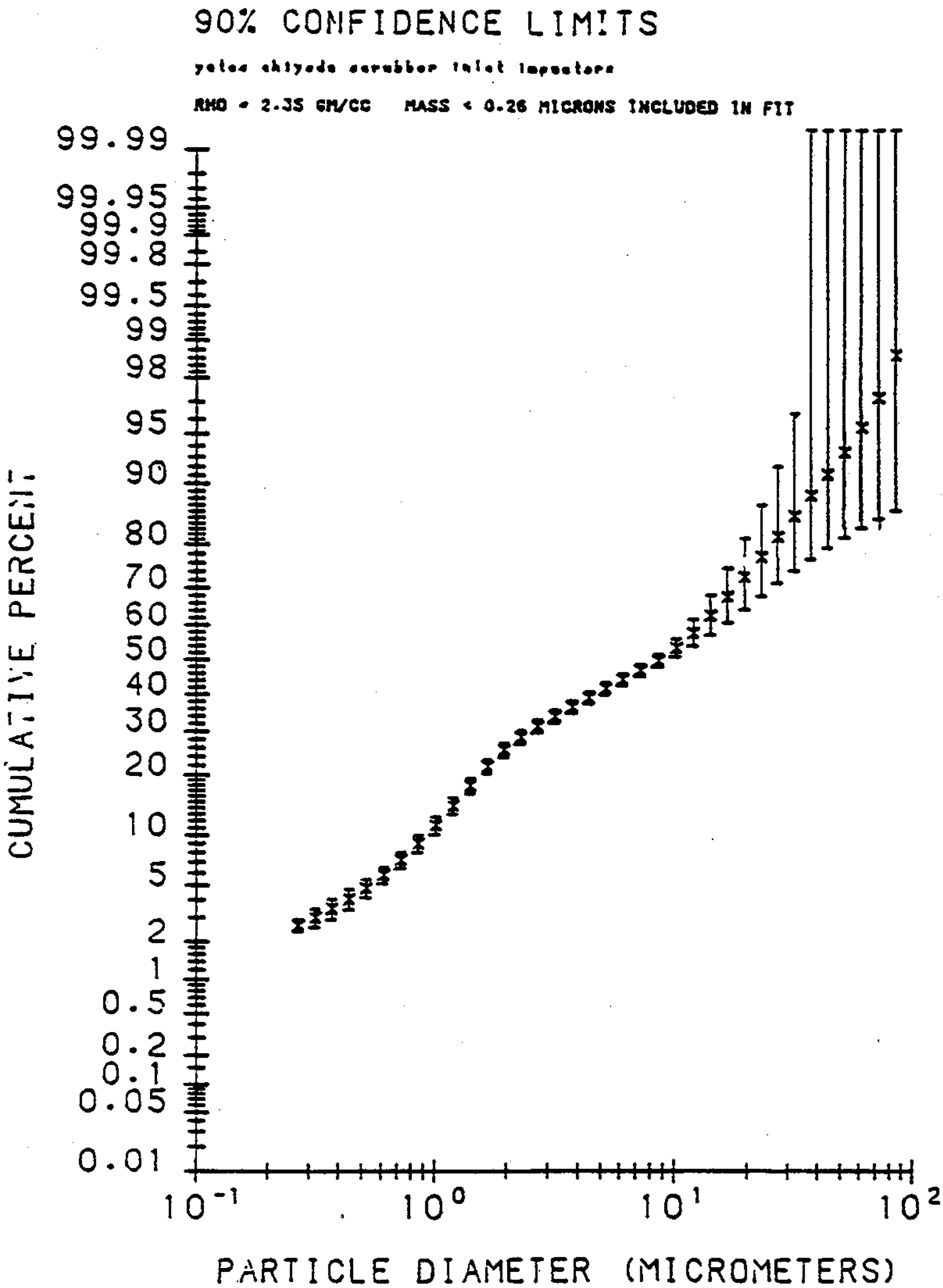


Figure B-5. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 100 MW, 16" ΔP, January 23, 1993

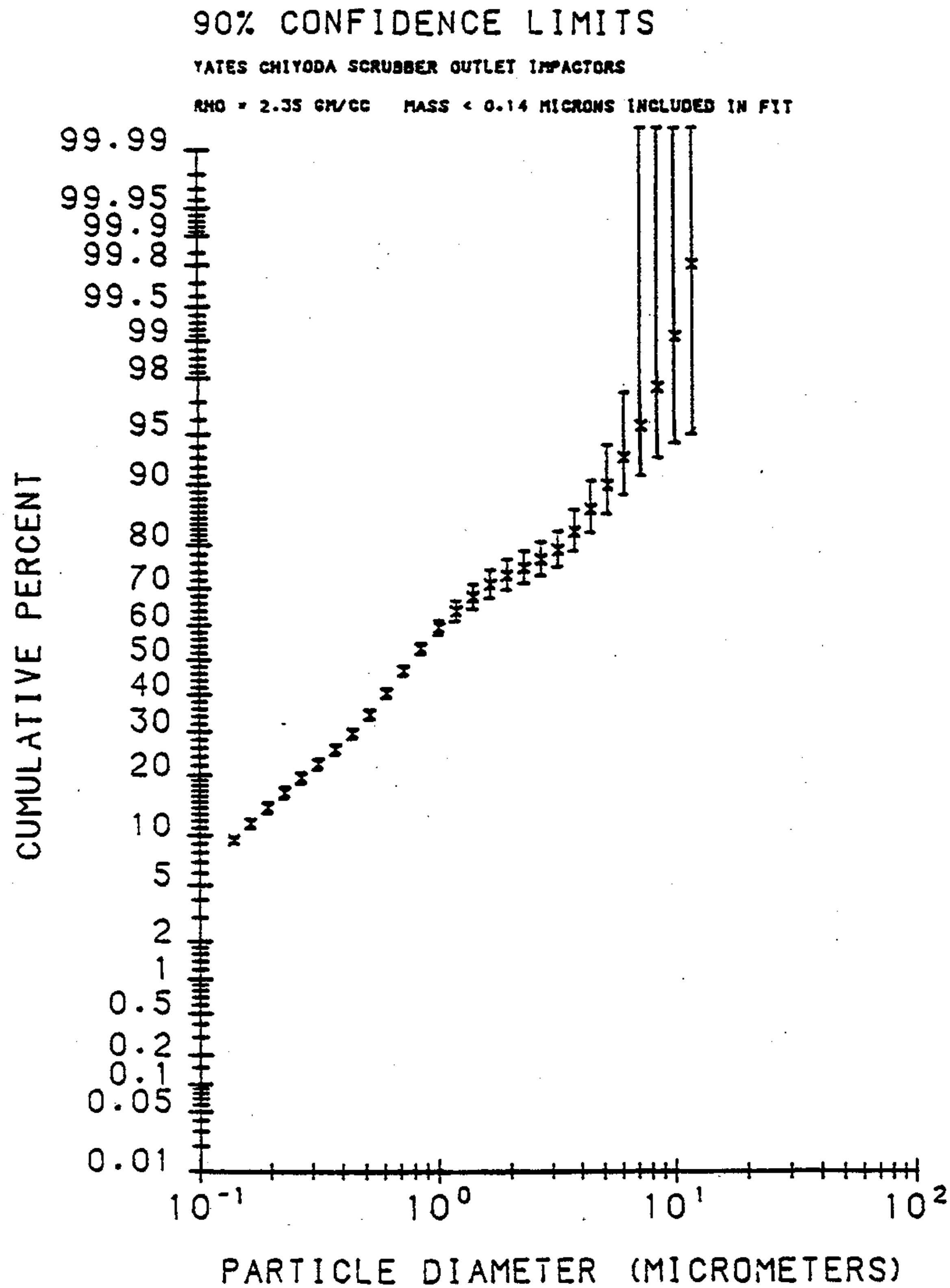


Figure B-6. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 100 MW, 16" ΔP, January 23, 1993

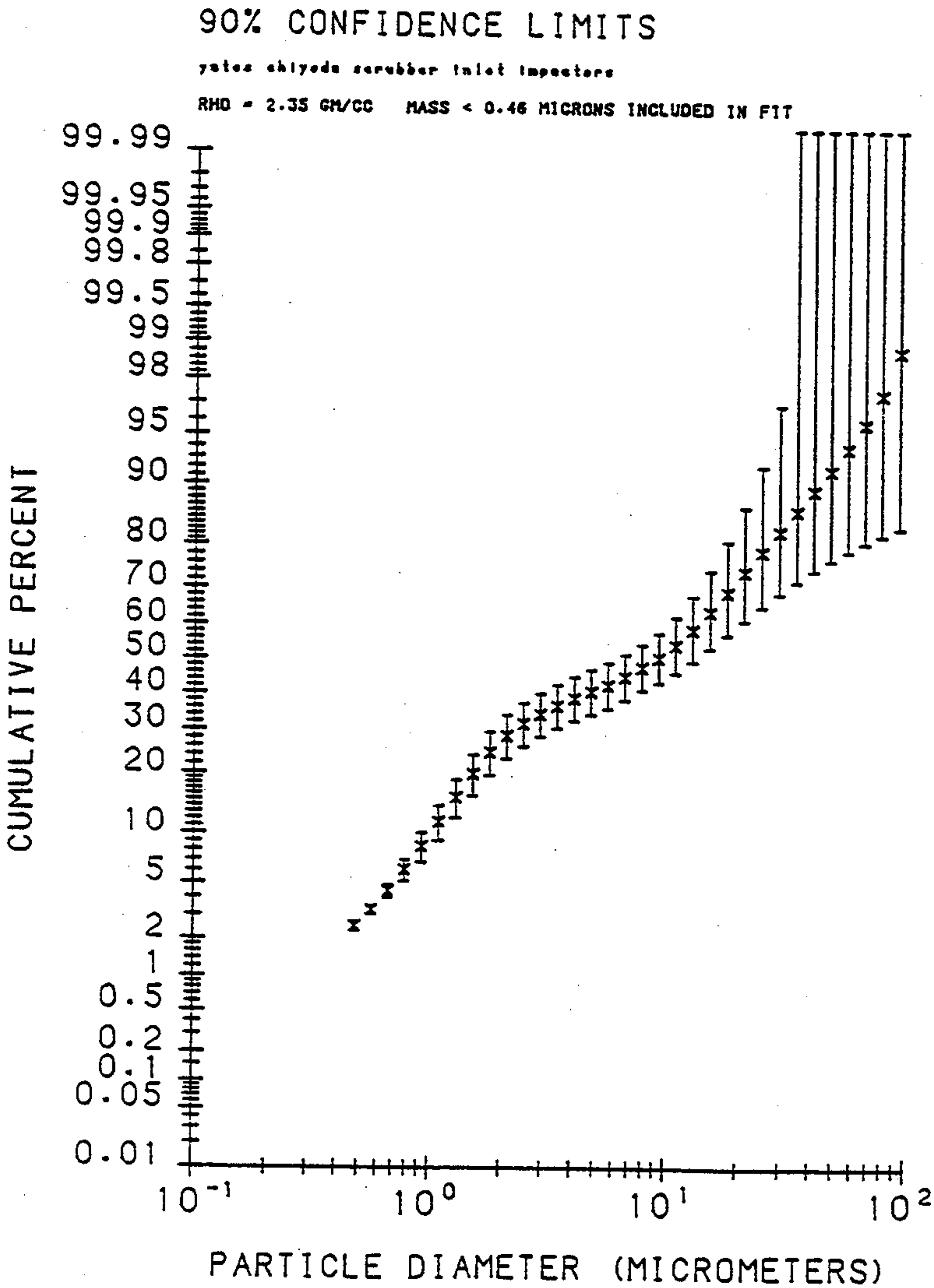


Figure B-7. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 75 MW, 8" ΔP, January 25, 1993

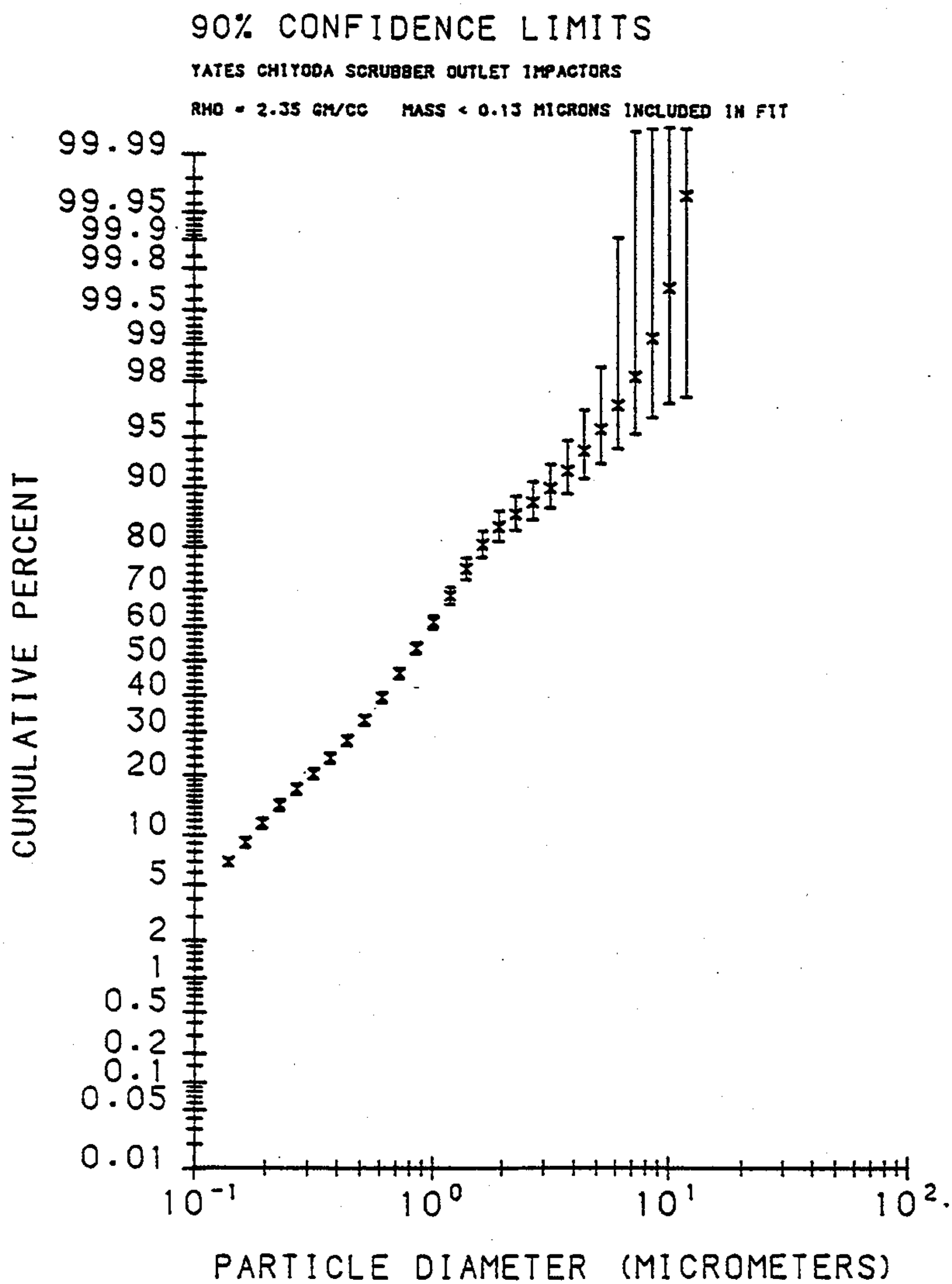


Figure B-8. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 75 MW, 8" ΔP, January 25, 1993

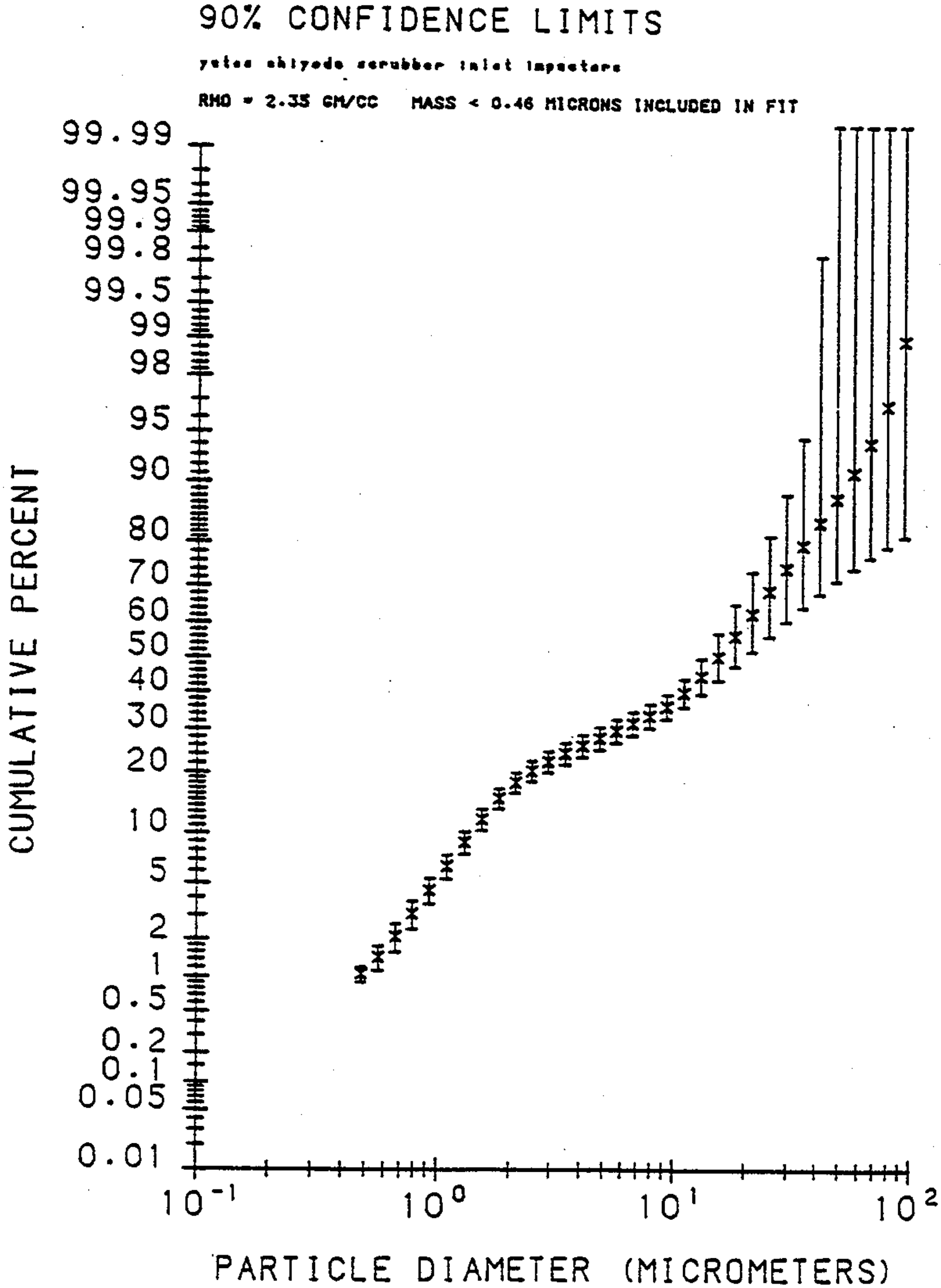


Figure B-9. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 75 MW, 12" ΔP, January 26, 1993

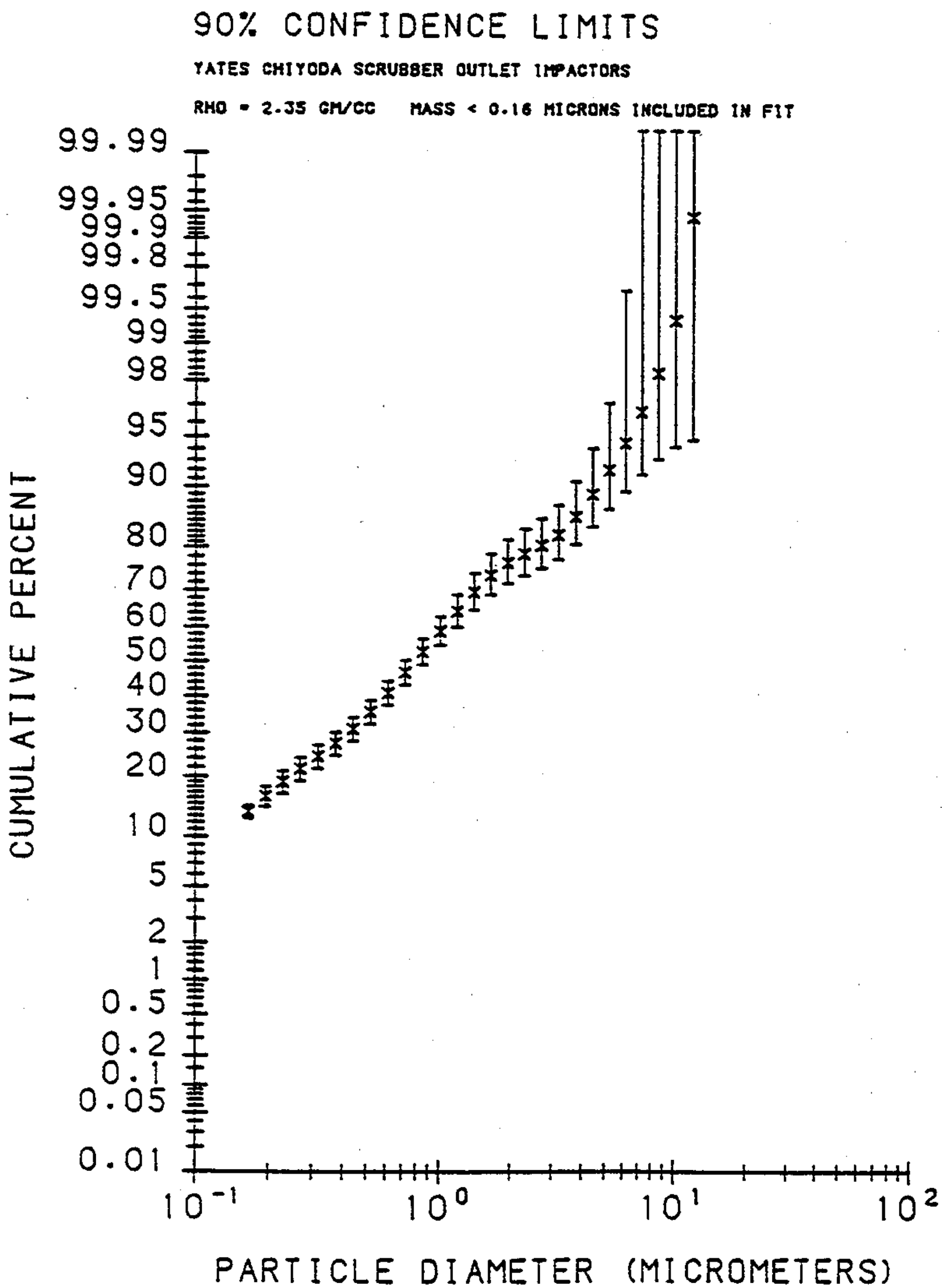


Figure B-10. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 75 MW, 12" ΔP, January 26, 1993

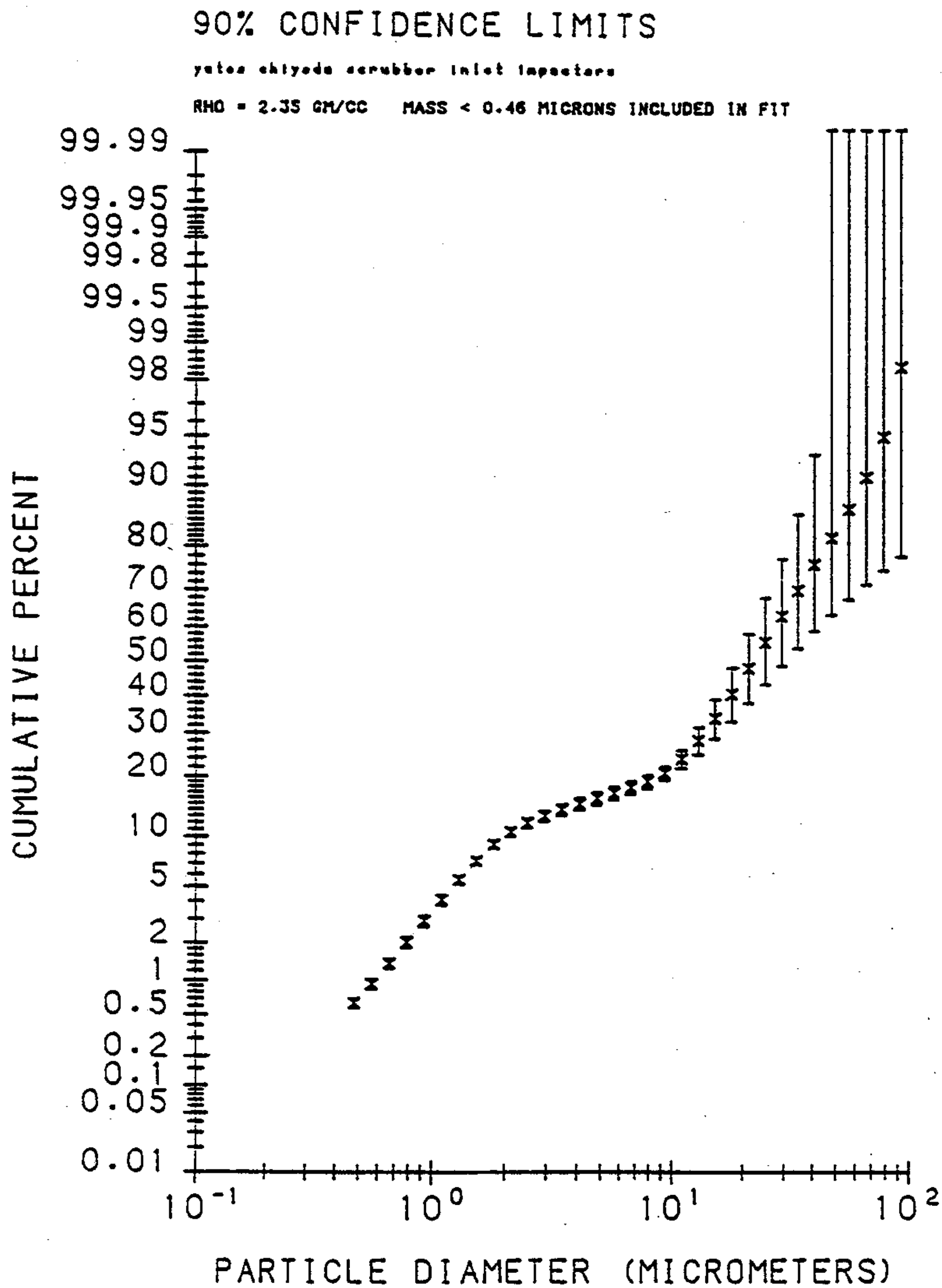


Figure B-11. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 75 MW, 16" ΔP, January 27, 1993

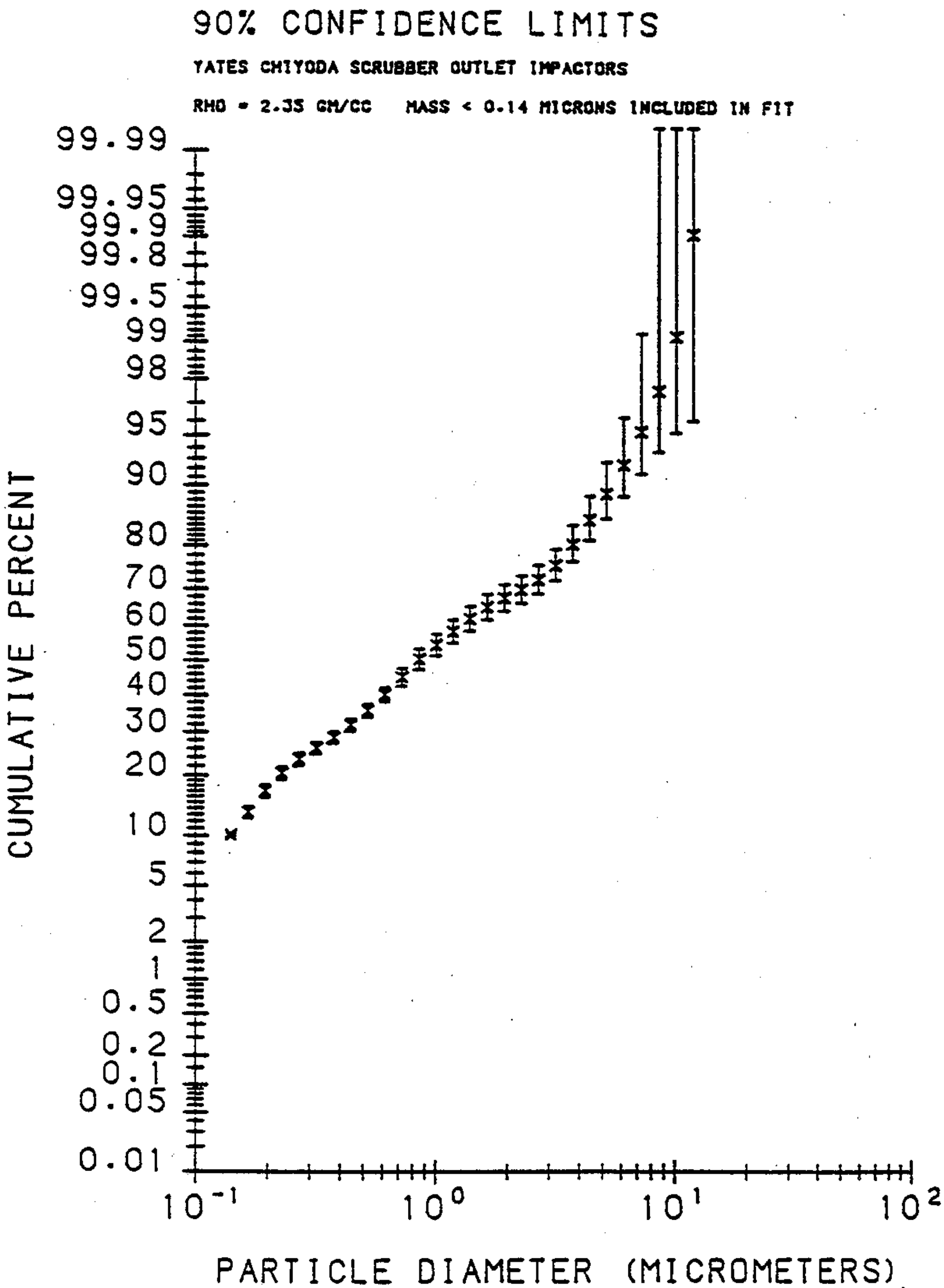


Figure B-12. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 75 MW, 16" ΔP, January 27, 1993

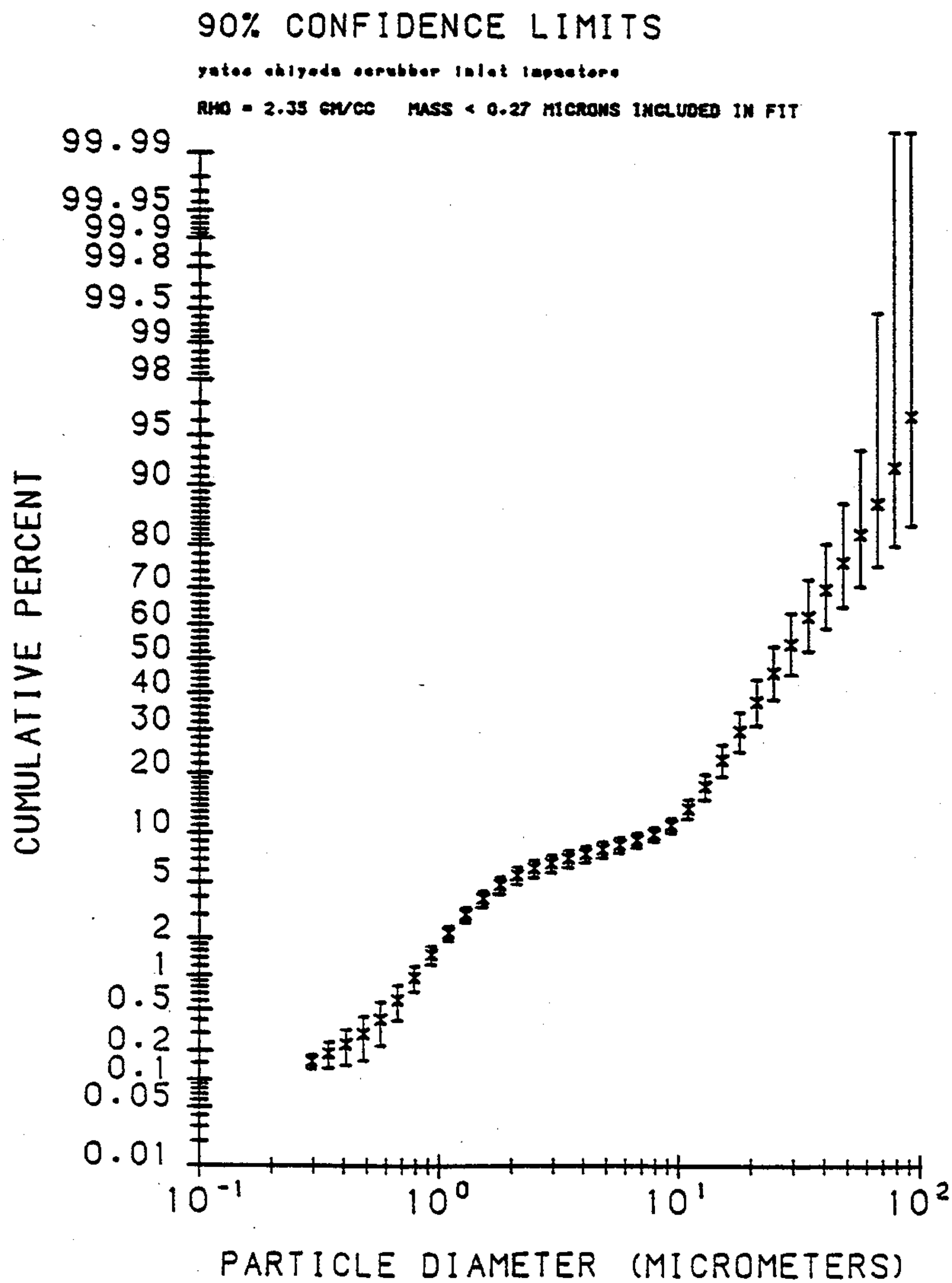


Figure B-13. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 50 MW, 8" ΔP, January 29, 1993

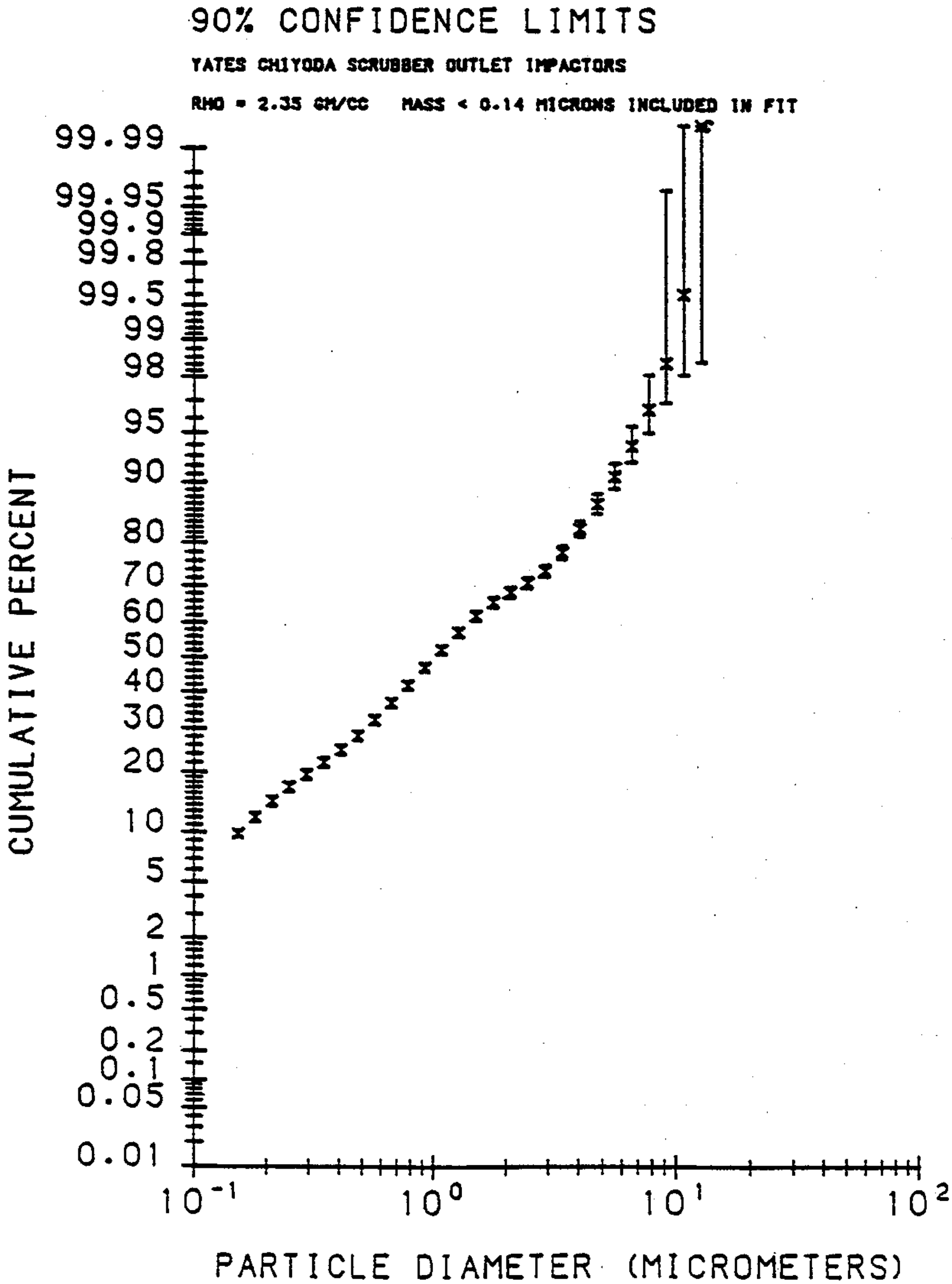


Figure B-14. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 50 MW, 8" ΔP, January 29, 1993

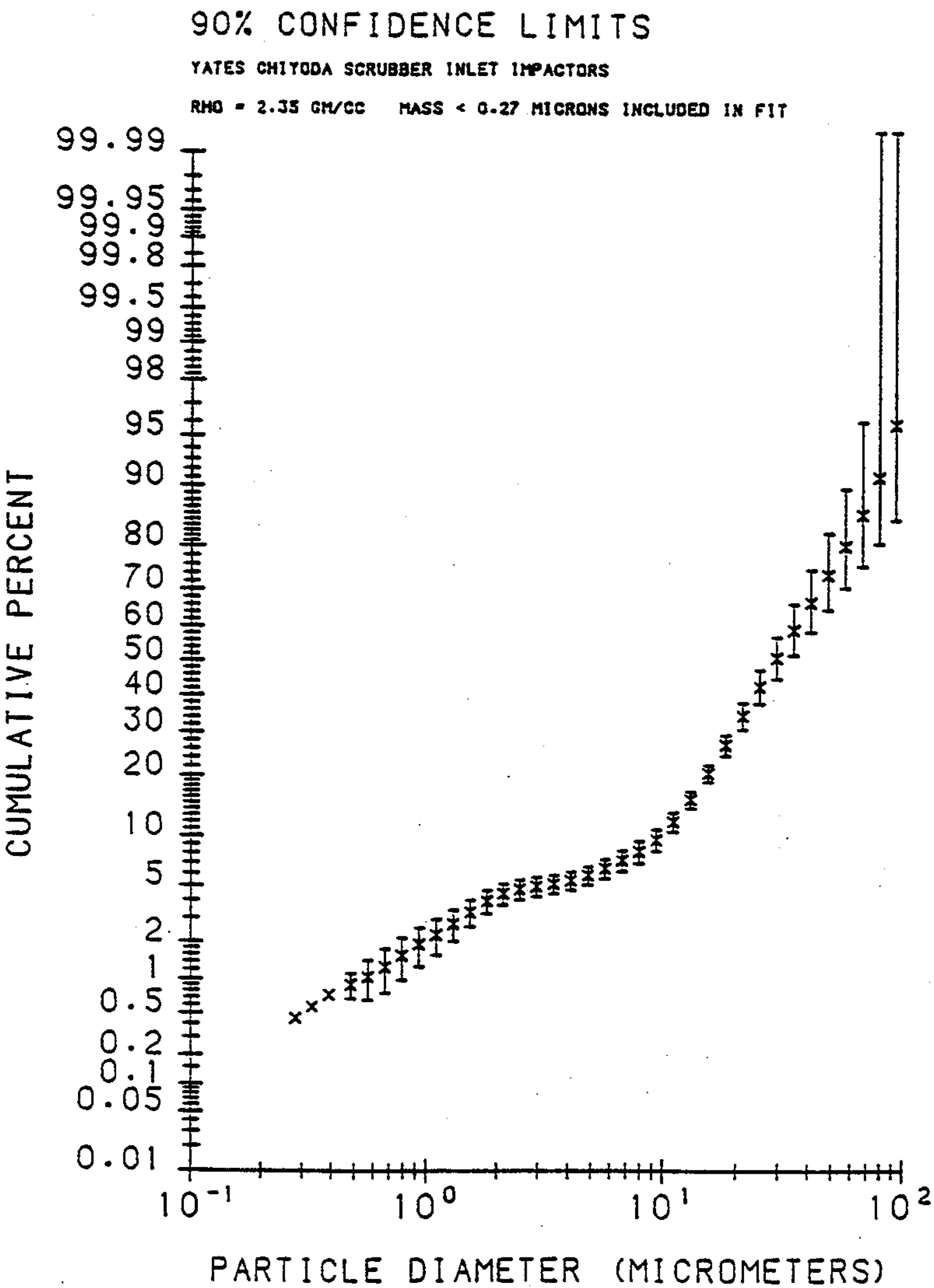


Figure B-15. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 50 MW, 12" ΔP, January 30, 1993

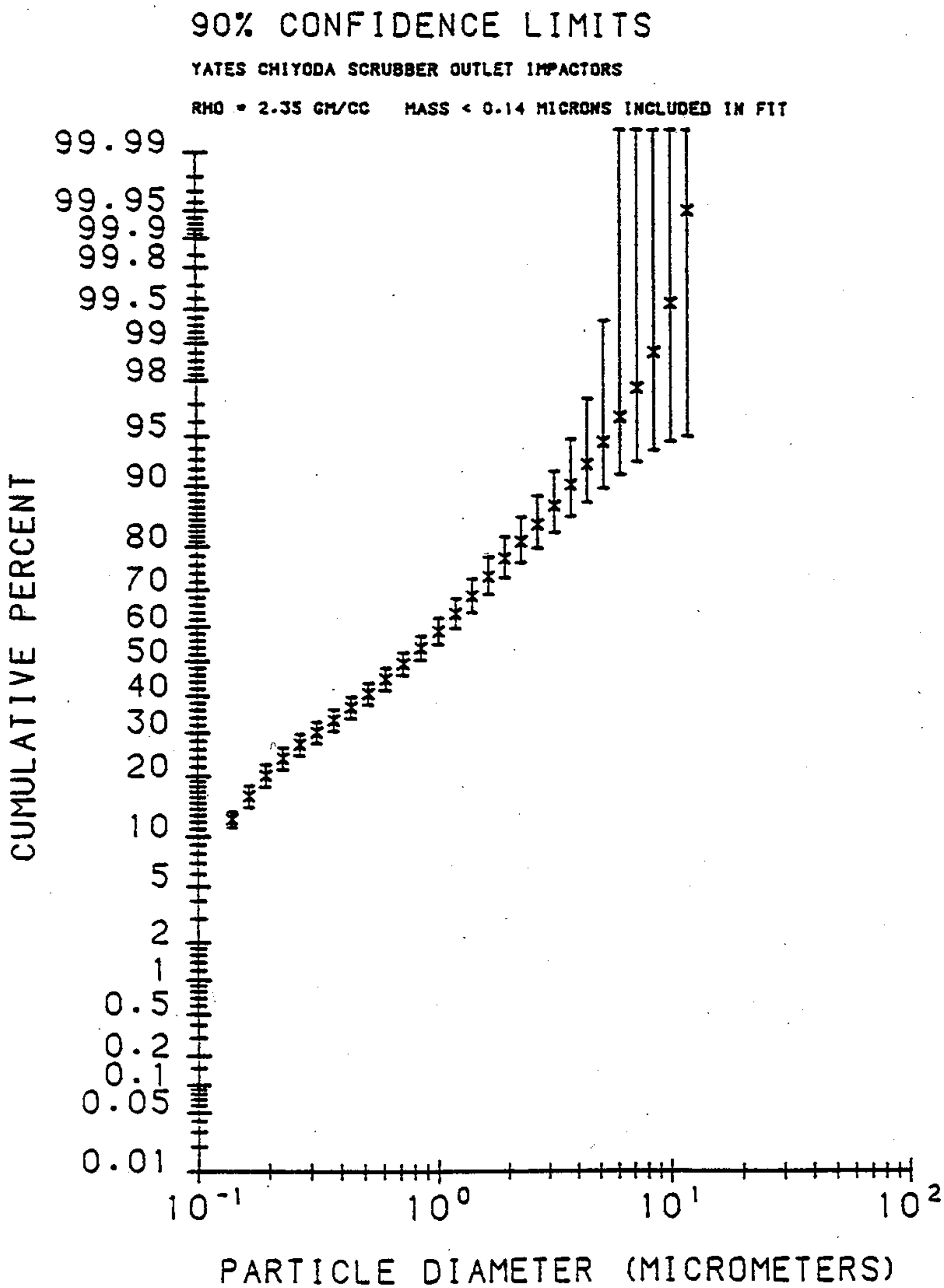


Figure B-16. Outlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 50 MW, 12" ΔP, January 30, 1993

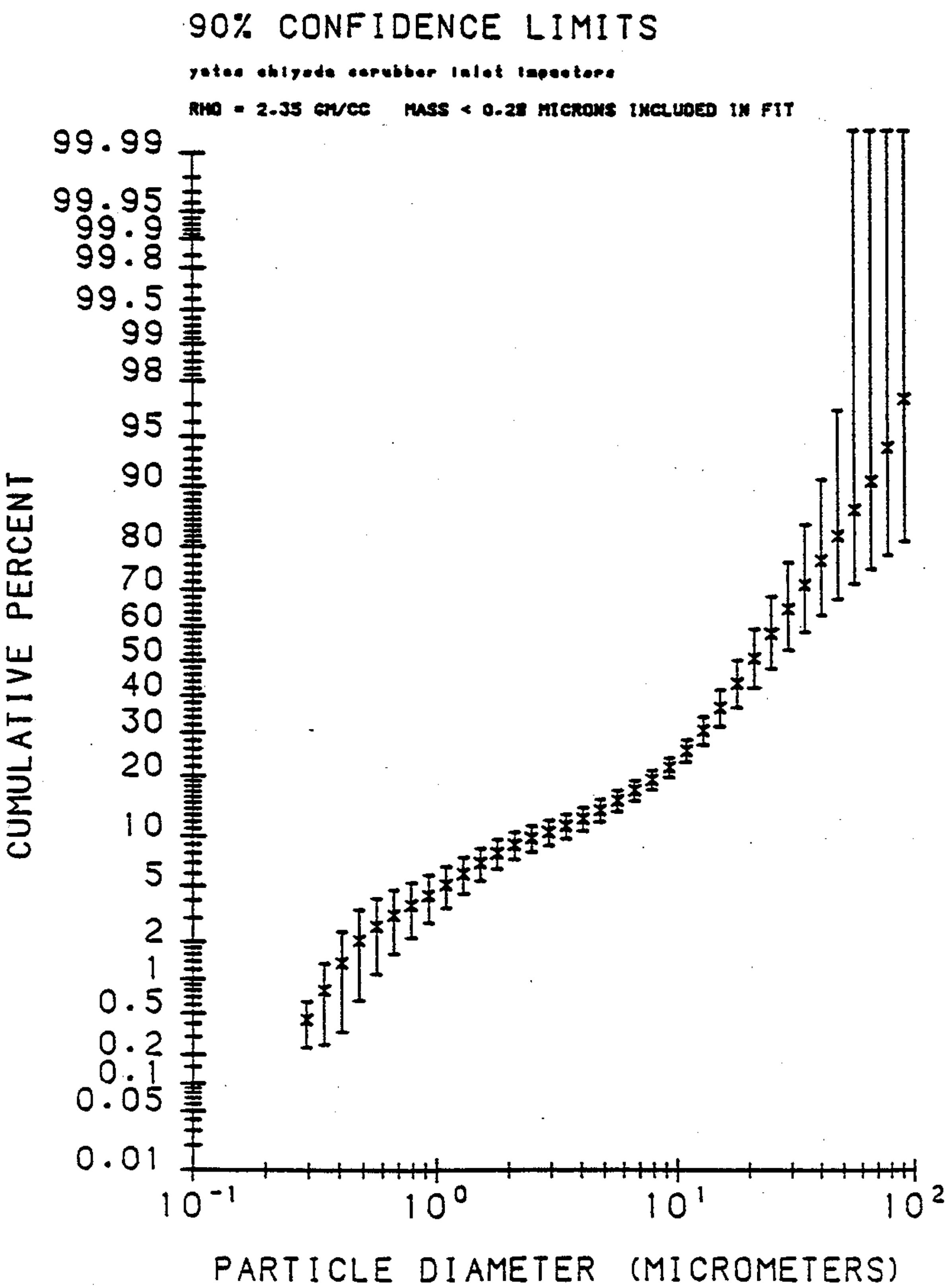


Figure B-17. Inlet Cumulative Percent vs. Particle Diameter for Chiyoda Scrubber, 50 MW, 16" ΔP, January 31, 1993