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

Plant Yates

Environmental Monitoring Program Report:
First Quarter 1995

(Final)

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

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Environmental Monitoring Program Report: First Quarter 1995

This progress report summarizes activities associated with the environmental monitoring program (EMP) during the first calendar quarter of 1995 for the U.S. Department of Energy's Innovative Clean Coal Technology project entitled "Demonstration of Innovative Applications of Technology for the CT-121 FGD Process." This demonstration project was conducted at Georgia Power Company's Plant Yates Unit 1, located near Newnan, Georgia, until January 1995, when operational responsibility was permanently transferred to Georgia Power Company from Southern Company Services, Inc., manager of the demonstration project.

No further operational testing is planned, and monitoring under the EMP will be limited to groundwater monitoring.

Post-operational-phase groundwater monitoring began during the report quarter. A report containing the results of groundwater monitoring conducted during the previous quarter (fourth quarter of 1994) is attached.

ATTACHMENT

GROUNDWATER MONITORING REPORT
FOR THE FOURTH QUARTER OF 1994

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1.0 INTRODUCTION

This report summarizes the results of groundwater monitoring performed during the fourth calendar quarter of 1994 as part of the environmental monitoring program (EMP) for the U.S. Department of Energy's Innovative Clean Coal Technology project entitled "Demonstration of Innovative Applications of Technology for the CT-121 FGD Process." This demonstration project is being conducted at Georgia Power Company's Plant Yates Unit 1, located near Newnan, Georgia.

1.1 Project Summary

The purpose of this ICCT project is to demonstrate the use of the Chiyoda Thoroughbred-121 flue gas desulfurization process as a means of reducing SO_2 and particulate emissions from pulverized-coal utility boilers that use medium-sulfur coal. This project is also designed to demonstrate the lower cost and higher reliability of the CT-121 process compared to conventional wet limestone FGD processes.

The demonstration project at Plant Yates consists of four distinct environmental test periods:

- Period 0: Site Preparation, Construction, and Startup of the Demonstration Project (including background groundwater monitoring [29 months]);
- Period 1: Baseline Testing at Low-Particulate Loading—ESP In Service (12 months);
- Period 2: Testing at High-Particulate Loading—ESP Detuned or Out of Service (12 months); and
- Period 3: Post-Demonstration Groundwater Testing and Gypsum Byproduct Evaluation.

Groundwater monitoring was initiated in Period 0 and will continue through Period 3.

1.2 Purpose and Scope of Groundwater Monitoring

The CT-121 process produces gypsum, which is being stored in an on-site stacking area, where the solids are concentrated as they are allowed to settle, dewater, and dry. The gypsum and gypsum/fly ash stacking area is lined with a synthetic liner 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). One requirement is the regular monitoring of groundwater before, during, and for two years after the demonstration program. The purpose of this monitoring is to demonstrate that the gypsum stacking area can be operated in an environmentally benign and acceptable manner.

In 1990, five groundwater monitoring wells were installed in the vicinity of the proposed gypsum stacking area. These wells were used to monitor baseline groundwater quality prior to construction of the stacking area. Monitoring was conducted every two months from September 1990 through July 1991. Table 1 is a summary of the parameters that were monitored during this period. The results of this monitoring activity were summarized in the report "Environmental Monitoring Program Report of Preconstruction Monitoring: 1990-1991 Background Water Quality."

Following the preconstruction monitoring period, and as a DNR permit requirement, two additional monitoring wells were installed in 1992. The locations of all seven monitoring wells are shown in Figure 1. Because of a delay in the commencement of Phase 1 testing, an additional round of preoperational groundwater monitoring was conducted on September 3-4 and October 14, 1992. The results from this monitoring effort were presented in

Table 1

EMP Groundwater Monitoring Parameters

pH	Conductivity	Temperature
Eh	Alkalinity	Total Dissolved Solids
Bromide	Chloride	Total Organic Carbon
Fluoride	Nitrate-Nitrite	Sulfate
Trace Elements (Dissolved)		
Silver	Aluminum	Arsenic
Boron	Barium	Beryllium
Bismuth	Calcium	Cadmium
Cobalt	Copper	Chromium
Mercury	Iron	Potassium
Lithium	Magnesium	Manganese
Molybdenum	Sodium	Nickel
Phosphorus	Lead	Sulfur
Antimony	Selenium	Silicon
Tin	Strontium	Tellurium
Titanium	Thallium	Uranium
Vanadium	Tungsten	Zinc
Other		
Radionuclides		

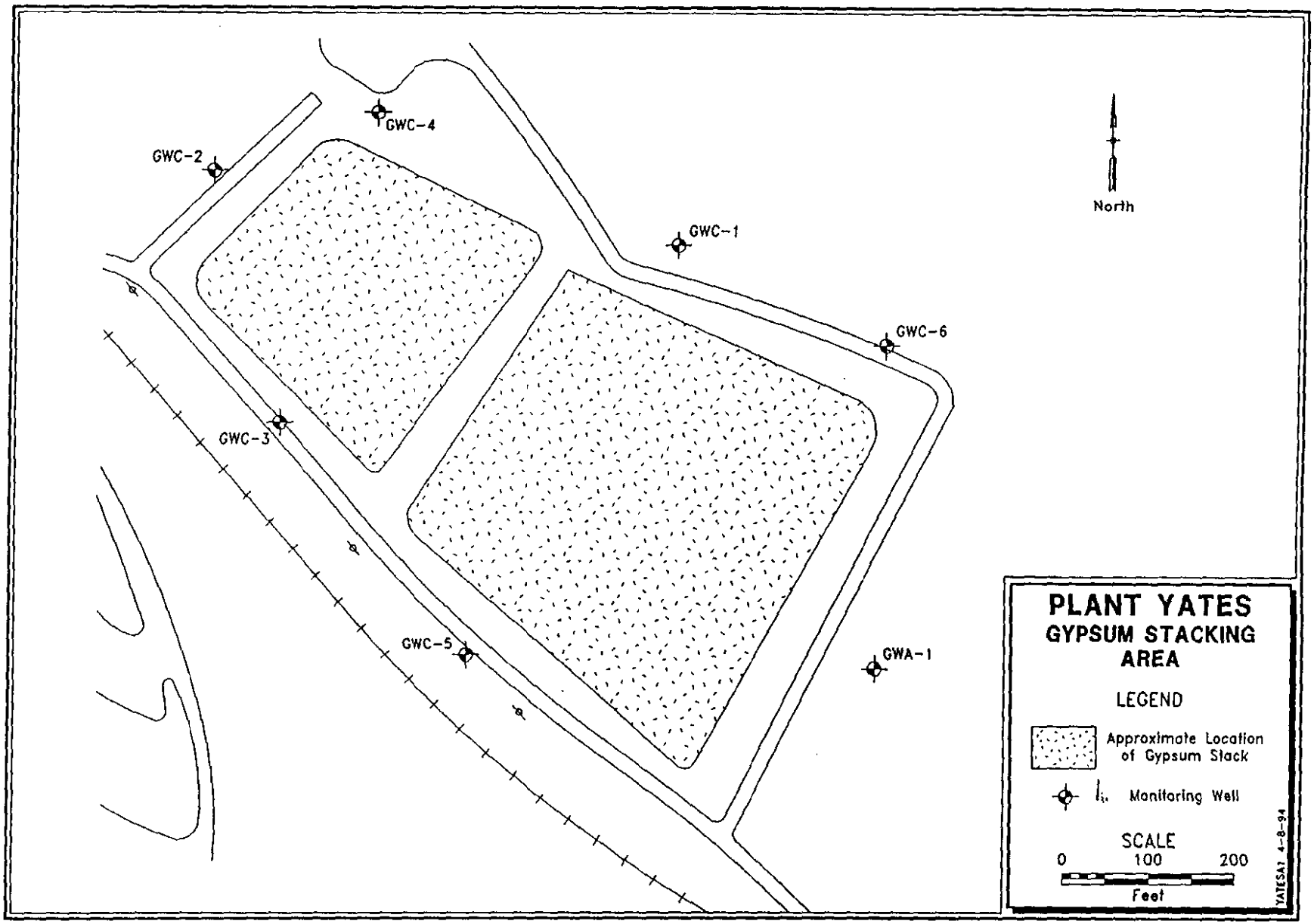


Figure 1. Location of Groundwater Monitoring Wells

the report "Interim Data Report of Preoperational Groundwater Monitoring: September 3-4 and October 14, 1992."

Operational-phase groundwater monitoring, which is performed on a quarterly basis, was initiated in the fourth quarter of 1992. Monitoring is conducted for the suite of parameters shown previously in Table 1. Samples are analyzed each quarter for all parameters shown except for radionuclides, which are monitored semiannually. Beginning in the second quarter of 1994, monitoring is also being performed quarterly for total organic halides (TOX) and annually for volatile organics (VOCs). These parameters have been added to provide information required by the Georgia Environmental Protection Division.

1.3 Report Contents

This report presents the results of quarterly operational-phase groundwater monitoring for the fourth calendar quarter of 1994. The groundwater monitoring wells were sampled on December 20-21, 1994.

Section 2 is a brief summary of the groundwater sampling and analytical methods. Monitoring results are presented in Section 3. Results of quality assurance/quality control (QA/QC) activities associated with sample analyses are summarized in Section 4. Tables of historical data for selected parameters and the analytical results for field and laboratory duplicates are given in the appendices.

2.0 SAMPLING AND ANALYTICAL METHODS

This section describes the methods used to obtain and analyze groundwater samples. These methods were specified in Radian's "Test Plan for Groundwater Monitoring Around the Plant Yates Gypsum Stacking Area," August 30, 1990, as amended.

2.1 Sampling Methods

The QED Well Wizard dedicated sampling system was used to purge the monitoring wells and collect samples. The Well Wizard system utilizes a dedicated Teflon® bladder pump and portable air compressor to extract groundwater samples.

To ensure the collection of a representative sample, standing water was removed from each well by purging a minimum of three wetted casing volumes. Conductivity, pH, redox potential, and temperature were monitored and recorded on field sampling forms during purging. Samples were collected after these indicator parameters stabilized and either after at least three wetted casing volumes of water were removed or immediately following recovery if a well was purged dry.

Samples were obtained from five of the six downgradient wells (GWC-1, GWC-2, GWC-3, GWC-4, and GWC-5). As has been the case during previous rounds of monitoring, well GWC-6 could not be sampled since it was unproductive and contained no water. The upgradient well (GWA-1) was not sampled this quarter since it was also dry. Samples have not been collected from GWA-1 for the past five consecutive quarters. Table 2 summarizes the groundwater samples collected during this monitoring period.

To preserve the integrity of the groundwater samples before analysis, proper sample container, preservation techniques, holding time duration, shipment, and chain-of-custody procedures were followed. Sample bottles, preservation methods, and maximum holding times are summarized in Table 3.

2.2 Analytical Procedures

The analytical methods used in this program are listed in Table 4. There were no deviations from these methods.

Table 2

Summary of Groundwater Samples Collected at Plant Yates on December 20-21, 1994

Well ID	Sample ID	Analyses
GWA-1	None	Well dry; no samples collected
GWC-1	GWC-1-16-1	Anions, TOC, TOX, and Metals
GWC-2	GWC-2-16-1	Anions, TOC, TOX, and Metals
GWC-3	GWC-3-16-1 GWC-3-16-2	Anions, TOC, TOX, and Metals Anions, TOC, TOX, and Metals
GWC-4	GWC-4-16-1	Anions, TOC, TOX, and Metals
GWC-5	GWC-5-16-1	Anions, TOC, TOX, and Metals
GWC-6	None	Well dry; no samples collected

Table 3

Sample Containers, Preservation Method, and Maximum Holding Times

Bottle Label	Containers[a]	Parameter	Preservation Method	Maximum Holding Time (days)
Total Organic Carbon	500-mL Amber Glass	Total Organic Carbon	H_2SO_4 pH<2	28
Anions/TDS	1-L Plastic	Bromide	4 °C	28
		Chloride	4 °C	28
		Fluoride	4 °C	28
		Nitrate-Nitrite	4 °C	28
		Sulfate	4 °C	28
		Total Dissolved Solids	4 °C	7
Total Organic Halogens	250-mL Amber Glass, no headspace	Total Organic Halogens	H_2SO_4 pH<2	28
VOCs	(2) 40-mL VOA Vials	Volatile Organics	HCl pH<2	14
Metals	1-L Plastic	Trace Metals	Filtered On Site Ultrex II HNO_3 pH<2	180
Radioactivity	(3) 1-L Plastic	Radium 226, Radium 228, Gross Alpha, Gross Beta, Gross Gamma	Filtered On Site Ultrex II HNO_3 pH<2	180

[a] Sample containers supplied by either I-Chem or Eagle Picher.

Table 4

Analytical Methods

Parameter	Technique	Reference
pH	Potentiometry	EPA 150.1
Conductivity	Specific Conductance	EPA 120.1
Temperature	Temperature Probe	EPA 170.1
Eh	Electrometry	ASTM D1498
Alkalinity	Titrimetric or Colorimetric	EPA 310.1 or 310.2
Bromide	Ion Chromatography	EPA 300
Chloride	Ion Chromatography	EPA 300
Total Organic Carbon	Combustion/IR	EPA 415.1
Total Organic Halogens	Carbon Adsorption/Combustion/ Electrolytic Titration	SW-846 Method 9020A
VOCs	GC/MS	SW-846 Method 8260
Fluoride	SIE	EPA 340.2
Nitrate/Nitrite	Colorimetry	EPA 353.1
Sulfate	Ion Chromatography	EPA 300
Total Dissolved Solids	Filtration/Evaporation/Gravimetry	EPA 160.2
Mercury	On-site Filtration/Cold Vapor AA	EPA 245.1
Trace Elements	On-site Filtration/AA and ICP-AES	EPA 200.7, 7421 (Cr), 7060 (As), 7421 (Pb), 7041 (Sb), 7740 (Se), and 7841 (Tl)
Radium 226 and 228	Proportional Counter	ASTM D2460
Gross Alpha	Proportional Counter	ASTM D1943
Gross Beta	Proportional Counter	ASTM D1890
Gross Gamma	Gamma Ray Spectrometer	ASTM D2459

Legend:

AA = Atomic absorption spectrophotometry;
SIE = *Specific ion electrode*;
ICP-AES = Inductively coupled plasma-atomic emission spectrometry; and
IR = Infrared detection.
GC/MS = Gas Chromatography/Mass Spectroscopy

References:

EPA "Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020, revised March 1983.
ASTM = American Society for Testing and Material, *Annual Book of ASTM Standards*.
SW-846 "Test Methods for Evaluating Solid Waste," SW-846, 3rd Ed., November 1986.

3.0 SUMMARY OF RESULTS

The results of the fourth-quarter 1994 groundwater monitoring are presented in Table 5. The concentrations of all of the monitored dissolved constituents in the groundwater near the gypsum stacking area continue to be low.

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 were tabulated and examined in detail. The representative species selected are those present in appreciable concentrations in the gypsum slurry, including the major cations and ions (i.e., calcium, magnesium, chlorine, and sulfate), as well as several other indicator parameters such as pH, TDS, conductivity, and alkalinity. The complete set of historical data for these species is provided in Appendix A. Examples of time/concentration plots for several species are provided in Figures 2 through 4. Data are presented for the upgradient well, GWA-1, and two downgradient wells, GWC-2 and GWC-4. The locations of these wells were shown previously in Figure 1. Samples were not obtained this quarter from either the upgradient well, GWA-1 or downgradient well GWC-6. Well GWC-6 has been nonproductive since groundwater monitoring began. Well GWA-1 has been nonproductive for five straight quarters.

For well GWC-2, the measured concentrations for all monitored parameters were generally close to the historically observed concentrations of these species. For well GWC-4, the trend toward increasing concentrations of chloride, magnesium, and calcium that began with the 4th quarter of 1993 continued this quarter. The observed increases may be due to the continuing effects of a breach in the gypsum pond dike that occurred on July 24, 1993, in the vicinity of this well. The contaminant levels in the groundwater at this location are still very low. For example, the latest chloride concentration is still less than 16% of the maximum concentration recommended in the National Secondary Drinking Water Standards (i.e., 39.7 mg/L vs. 250 mg/L).

Table 5

Results of Groundwater Monitoring Conducted December 20-21, 1994 (Fourth Quarter 1994)

Parameter	GWA-1-16-1[a]	GWC-1-16-1	GWC-2-16-1	GWC-3-16-1	GWC-4-16-1	GWC-5-16-1
pH		6.09	5.34	5.06	4.92	5.57
Conductivity (µS/cm)		76	66	36	188	47
Temperature (°C)		15.8	16.6	17.4	18.0	16.9
Eh (mV)		305	267	309	280	53
Alkalinity (mg/L $CaCO_3$)		21.9	6.9	4.8	3.8	11.2
Total Dissolved Solids (mg/L)		46	65	30	110	45
Bromide (mg/L)		<0.00226	<0.0226	<0.0226	0.118	<0.0226
Chloride (mg/L)		2.68	4.00	3.02	39.7	2.7
Total Organic Carbon (mg/L)		<0.357	<0.357	<0.357	<0.357	<0.357
Total Organic Halogens (µg/L)		<11.7	<11.7	<11.7	<11.7	<11.7
Fluoride (mg/L)		0.0476[b]	0.0340[b]	0.0340[b]	0.0300[b]	0.0232[b,c]
Nitrate-Nitrite (mg/L as N)		0.322	1.19	0.246	1.90	0.049
Sulfate (mg/L)		1.19	5.78	1.01	4.34	5.75
Silver (mg/L)		<0.00519	<0.00519	<0.00519	<0.00519	<0.00519
Aluminum (mg/L)		<0.0523	<0.0523	<0.0523	<0.0523	<0.0523
Arsenic (mg/L)		<0.00214	<0.00214	<0.00214	<0.00214	<0.00214
Boron (mg/L)		0.0298[c]	0.0297[c]	<0.0176	0.0527[c]	0.030[c]
Barium (mg/L)		0.00944	0.00944	0.00742	0.0283	0.00742
Beryllium (mg/L)		<0.00051	<0.00051	<0.00051	<0.00051	<0.00051
Bismuth (mg/L)		<0.0275	<0.0275	0.0336[c]	<0.0275	0.0369[b,c]

Table 5 (Continued)

Parameter	GWA-1-16-1[a]	GWC-1-16-1	GWC-2-16-1	GWC-3-16-1	GWC-4-16-1	GWC-5-16-1
Calcium (mg/L)		4.50[b]	1.89[b]	0.335[b]	4.04[b]	1.20[b]
Cadmium (mg/L)		<0.00386	<0.00386	<0.00386	<0.00386	<0.00386[b]
Cobalt (mg/L)		<0.00407	<0.00407	<0.00407	<0.00407	<0.00407
Copper (mg/L)		<0.00916	<0.00916	<0.00916	<0.00916	<0.00916
Chromium (mg/L)		<0.00524	0.00654[c]	<0.00524	<0.00524	<0.00524
Mercury (mg/L)		0.000040[c]	<0.000033	<0.000033	0.00016[c]	<0.000033
Iron (mg/L)		0.033[b]	0.0122[b,c]	0.0203[b,c]	0.0661[b]	0.0246
Potassium (mg/L)		<0.822	<0.822	<0.822	<0.822	<0.822
Lithium (mg/L)		0.011[b,c]	0.0118[b,c]	0.0103[b,c]	0.0118[b,c]	0.0108[b,c]
Magnesium (mg/L)		3.33	1.87	1.02	11.0	1.32
Manganese (mg/L)		<0.00155	0.00696[c]	<0.00155	0.282	0.00697[c]
Molybdenum (mg/L)		<0.00739	<0.00739	<0.00739	<0.00739	<0.00739
Sodium (mg/L)		4.10	6.96	4.34	7.86	5.43
Nickel (mg/L)		<0.0141	0.0393[c]	<0.0141	<0.0141	<0.0141
Phosphorus (mg/L)		<0.109	<0.109	<0.109	<0.109	<0.109
Lead (mg/L)		<0.0022	<0.0022	<0.0022	<0.0022	<0.0022
Sulfur (mg/L)		<0.175	1.65	<0.175	1.22	1.73
Antimony (mg/L)		<0.00146	0.00235[c]	<0.00146	<0.00146	0.0035[c]
Selenium (mg/L)		<0.000592	0.0011[c]	<0.000592	<0.000592	0.00070[c]
Silicon (mg/L)		10.9	12.2	8.94	10.1	10.3[b]
Tin (mg/L)		<0.0145	<0.0145	0.0162[c]	0.0195[c]	0.0162[c]
Strontium (mg/L)		0.0146	0.0109	0.00202[c]	0.0315	0.0097

Table 5 (Continued)

Parameter	GWA-1-16-1[a]	GWC-1-16-1	GWC-2-16-1	GWC-3-16-1	GWC-4-16-1	GWC-5-16-1
Tellurium (mg/L)		<0.177	<0.177	<0.177	<0.177	<0.177[b]
Titanium (mg/L)		<0.00159	<0.00159	<0.00159	<0.00159	<0.00159[b]
Thallium (mg/L)		<0.000536	<0.000536	<0.000536	<0.000536	<0.000536
Uranium (mg/L)		<0.199	<0.199	<0.199	<0.199	<0.199
Vanadium (mg/L)		<0.00454	<0.00454	<0.00454	<0.00454	<0.00454
Tungsten (mg/L)		<0.0408	<0.0408	<0.0408	<0.0408	<0.0408
Zinc (mg/L)		0.0067[b,c]	0.00662[b,c]	<0.00402[b]	0.00633[b,c]	<0.00402

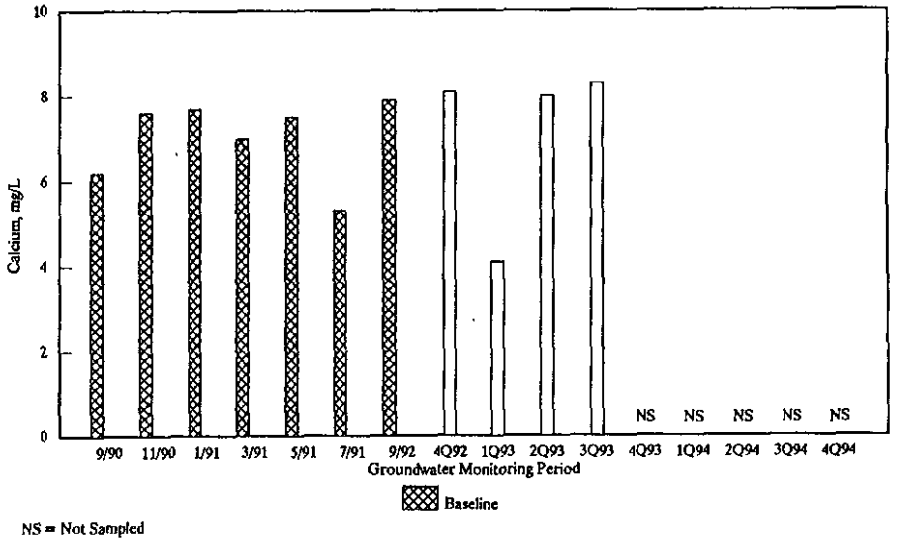
[a] Well was dry; no samples collected.

[b] Detected in the method blank.

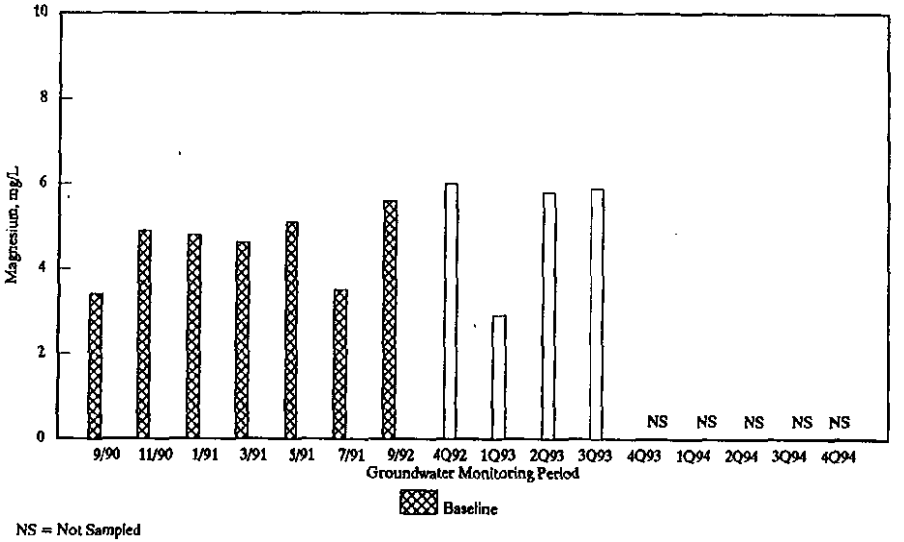
[c] Less than five times the detection limit; results are expected to be less accurate as concentrations approach the detection limit.

[d] Result is questionable; concentration of reagent used in titration is unclear.

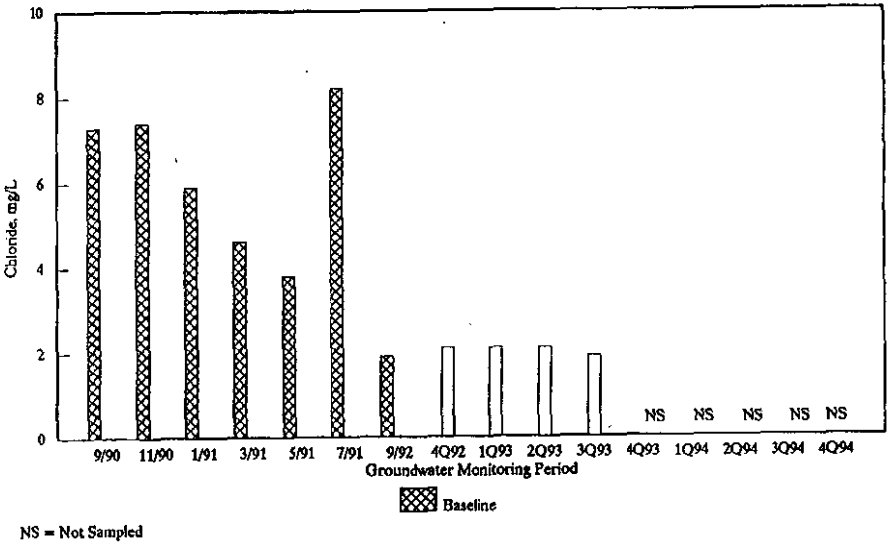
NR = Not reported.



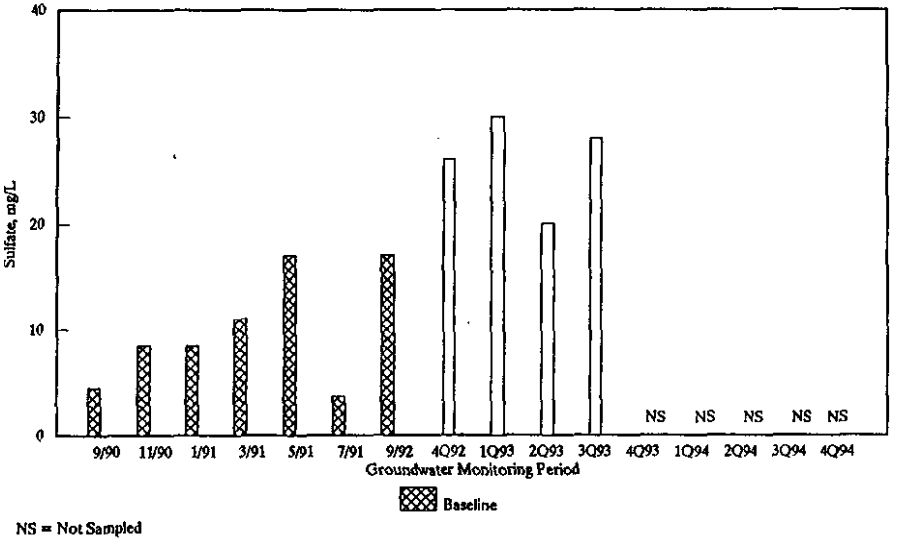
(a) Calcium



(b) Magnesium

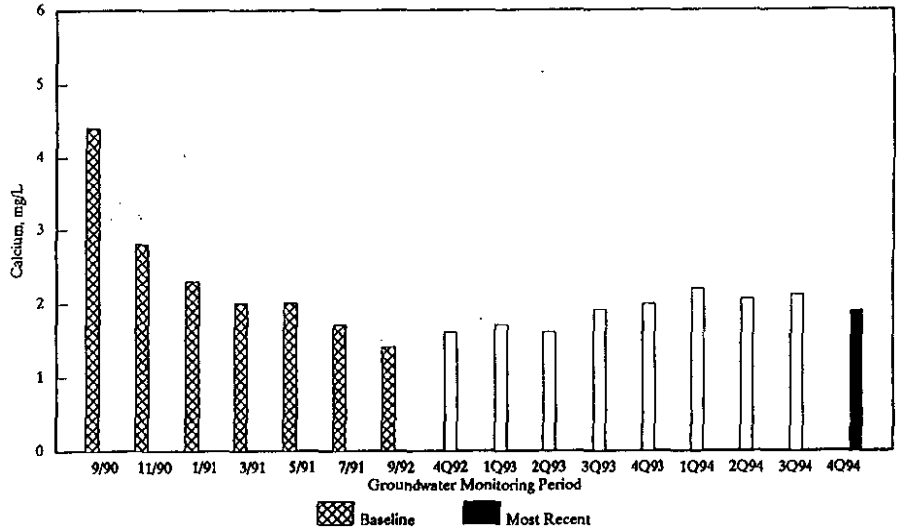


(c) Chloride

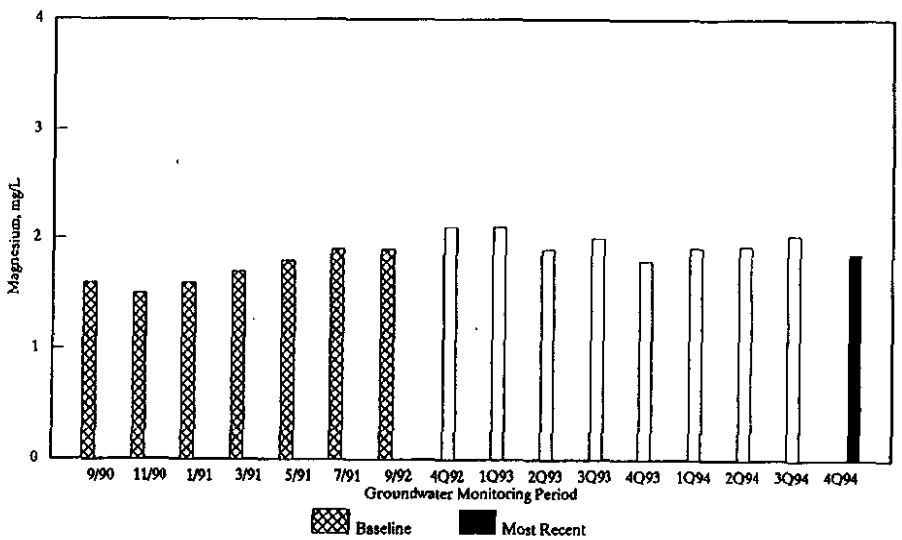


(d) Sulfate

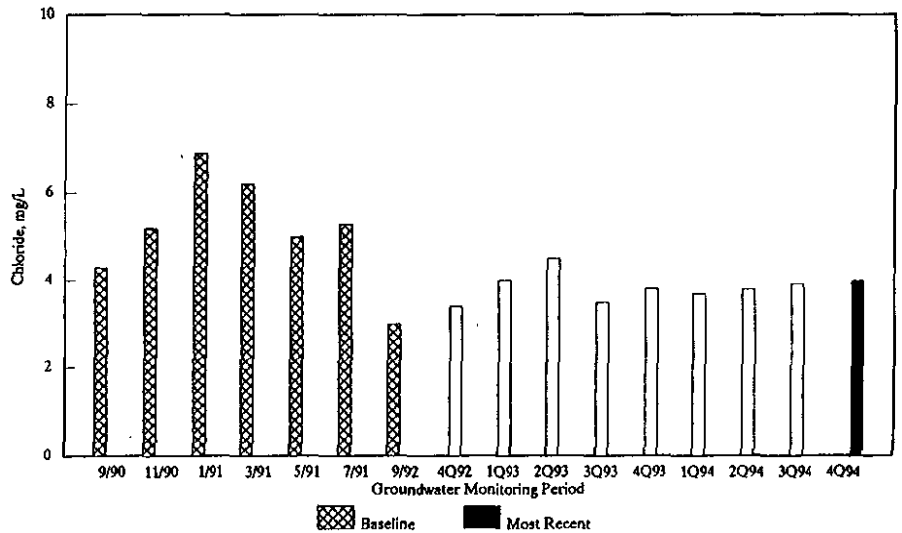
Figure 2. Historical Data for Representative Species from Well GWA-1 (Upgradient)



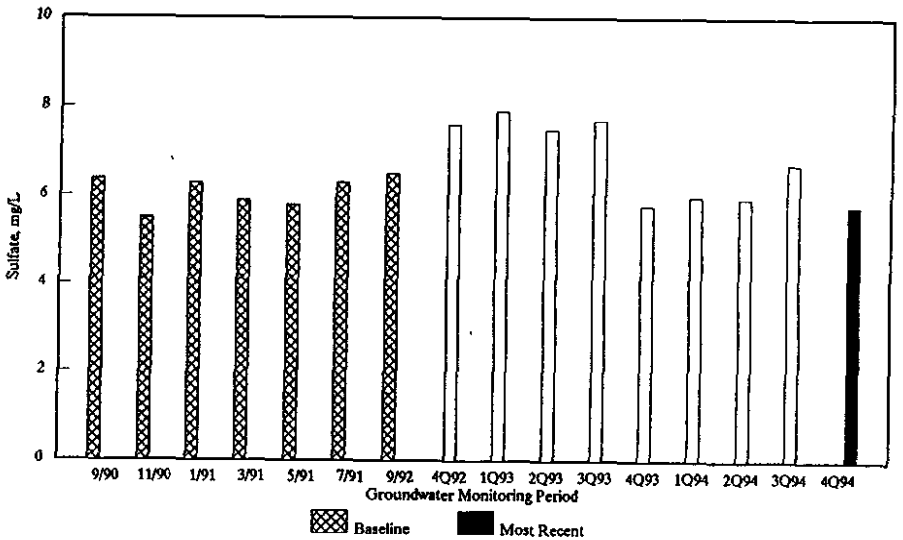
(a) Calcium



(b) Magnesium

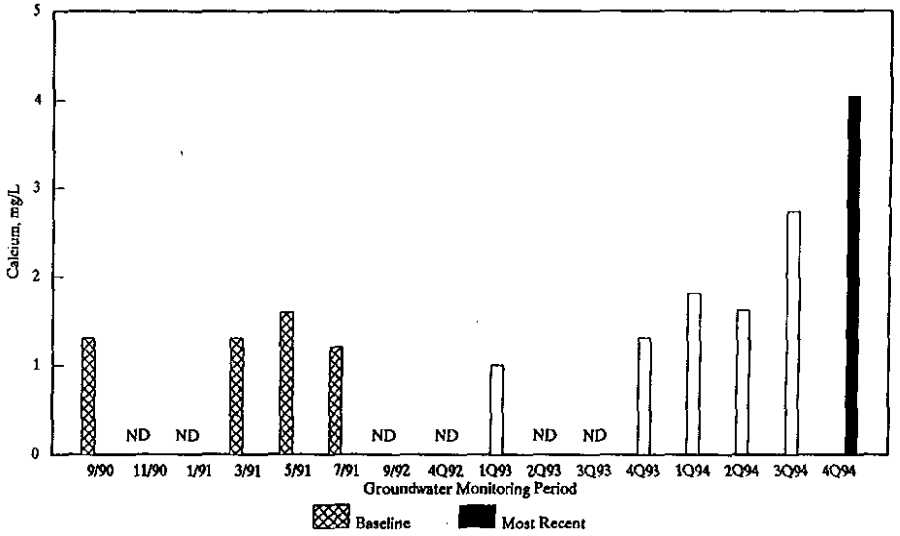


(c) Chloride

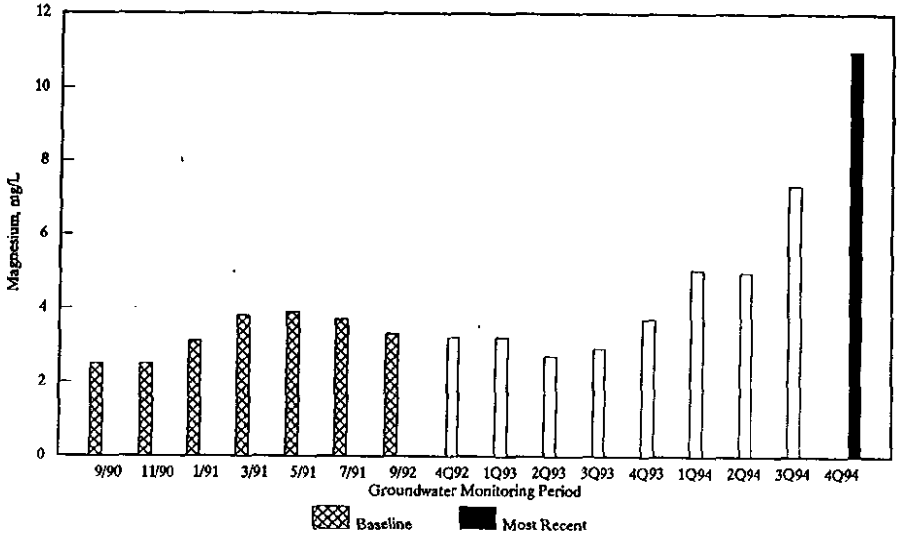


(d) Sulfate

Figure 3. Historical Data for Representative Species from Well GWC-2 (Downgradient)



(a) Calcium



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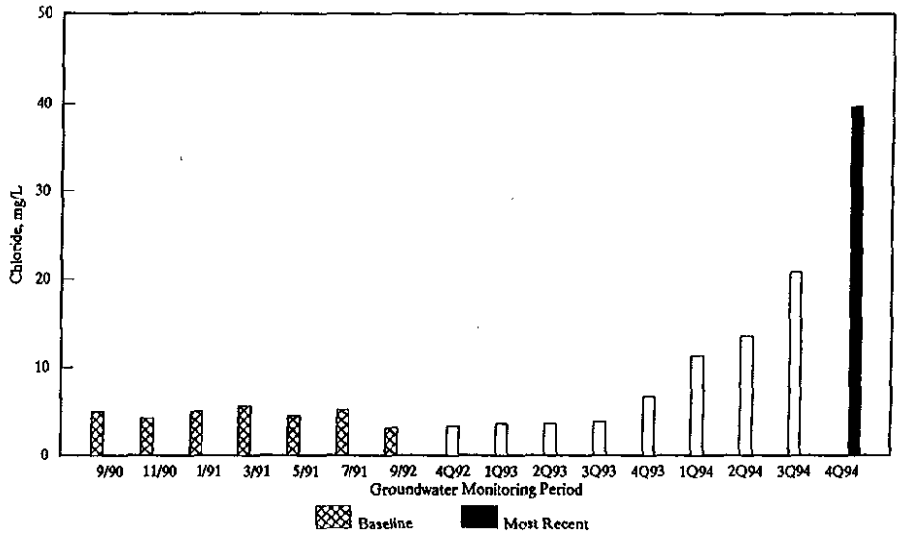
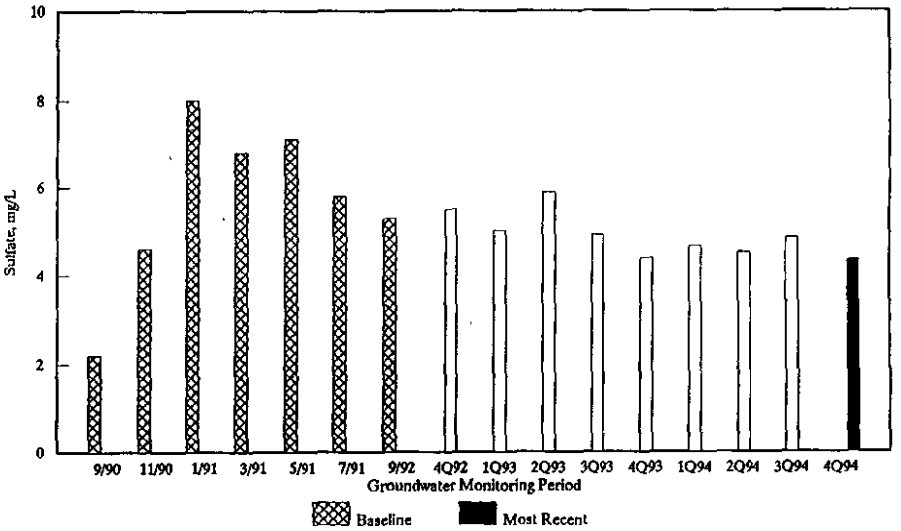


(c) Chloride



(d) Sulfate

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

4.0 SUMMARY OF QA/QC ACTIVITIES

A number of QA/QC activities were performed, as specified in the project's EMP, to assure that the data obtained meet project objectives. These include the following:

- Groundwater samples were split for independent analysis by a laboratory selected by SCS.
- Established sampling and analysis methods were specified and used. All samples were analyzed within the specified holding times, as outlined in Section 2. There were no deviations from the specified methods during this quarter's monitoring effort.
- Chain-of-custody procedures established in the test plan for this project were observed.
- In the laboratory, method blanks, control samples, and matrix spikes were analyzed in conjunction with the sample analyses, following recognized good laboratory practice. Specified recovery limits (typically 80 to 120%) were met for all analytes in the laboratory control samples and matrix spikes.
- Duplicate samples were obtained in the field and analyzed for all parameters. Replicate analyses were performed for a smaller number of parameters.

The results of the analysis of field and laboratory duplicates are summarized in Table 6 for those parameters which were found in concentrations above the detection limit in at least one sample. Complete results are provided in Appendix B. Differences in the duplicate analyses results were small for most species (i.e., less than 10%). For iron and strontium, the percentage differences between the measured concentrations of the sample and the field duplicate were -34% and -20%, respectively; but for both analytes the measured levels were less than five times the method detection limit, where less accurate results can be expected. Similarly, for some parameters, concentrations less than five times the detection limit were found in one sample, while the measured concentration was less than the detection limit in the other sample.

Table 6

Results for Duplicate Samples—4th Quarter 1994

Parameter	Units	Sample GWC-3-16-1	Field Duplicate GWC-3-16-2	% Diff.[a]	Duplicate Analysis GWC-3-16-2	% RPD[b]	Spec. Limit
Total Dissolved Solids	mg/L	30	28	-6.7	31	10	15
Chloride	mg/L	3.02	3.00	-0.7	2.89	3.7	20
Fluoride	mg/L	0.0340[c]	0.0325[c]	-4.4			
Sulfate	mg/L	1.01	<0.0471	NC	1.03	NC	20
Nitrate-Nitrite as N	mg/L	0.246	0.232	-5.7	0.234	0.9	20
Barium	mg/L	0.00742	0.00742	0.0			
Bismuth	mg/L	0.0336[d]	<0.0275	NC			
Calcium	mg/L	0.335[c]	0.338[c]	0.9			
Mercury	mg/L	<0.000033	0.00007[d]	NC			
Iron	mg/L	0.0203[c,d]	0.0133[c,d]	-34.5			
Lithium	mg/L	0.0103[c,d]	0.00948[c,d]	-8.0			
Magnesium	mg/L	1.02	0.999	-2.1			
Sodium	mg/L	4.34	4.34	0.0			
Antimony	mg/L	<0.00146	0.00182[d]	NC			
Silicon	mg/L	8.94	8.92	-0.2			
Tin	mg/L	0.0162[d]	<0.0145	-10.5			
Strontium	mg/L	0.00202[d]	0.00161[d]	-20.3			
Zinc	mg/L	<0.00402[c]	0.00675[c,d]	NC			

[a] % difference = (GWC-3-16-2 - GWC-3-16-1)/GWC-3-16-1 x 100%

[b] RPD = Relative percent difference, defined as follows:

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

[c] Detected in the method blank.

[d] Value is less than five times the detection limit; results are expected to be less accurate as concentrations approach the detection limit.

NC = Not computed.

For sulfate the concentration measured in the field duplicate was less than the detection limit. When this sample was reanalyzed, the result was very close to that of the original sample, making the results for this analyte somewhat suspect.

APPENDIX A

HISTORICAL MONITORING DATA FOR SELECTED PARAMETERS

Table A-1

Historical Monitoring Data for Selected Parameters

Parameter	Baseline Monitoring							Round 8 29-30 Dec 92	Round 9 30-31 Mar 93	Round 10 21 Jun 93	Round 11 23-24 Sep 93
	Round 1 6 Sep 90	Round 2 2 Nov 90	Round 3 8-9 Jan 91	Round 4 11 Mar 91	Round 5 8 May 91	Round 6 1-2 Jul 91	Round 7 3-4 Sep 92				
Well: GWA-1 (Formerly CW-1)											
pH	5.86	6.27	5.6	6.7	6.05	5.94	6.4	5.7	6.82	6.1	5.9
Conductivity	98	114	112	121	104	85	116	101	128	100	110
Alkalinity	15.6	22.3	25.8	27.1	25	16.4	35.4	22.7	28	27	24.8
TDS	94	87	86	84	90	77	99	110	110	116	99
Chloride	7.3	7.4	5.9	4.6	3.8	8.2	1.9	2.1	2.1	2.1	1.9
Sulfate	4.5	8.5	8.5	11	17	3.7	17	26	30	20	28
Calcium	6.2	7.6	7.7	7	7.5	5.3	7.9	8.1	4.1	8	8.3
Magnesium	3.4	4.9	4.8	4.6	5.1	3.5	5.6	6	2.9	5.8	5.9
Sodium	4.2	4.8	4.9	4.3	4.4	3.8	4.1	4.2	4	4.4	4.3
Silicon	9.8	11	14	16	17	9.6	15	17	11	18	17

Parameter	Round 12 5 Jan 94	Round 13 22-23 Mar 94	Round 14 21-22 Jun 94	Round 15 31 Aug 94	Round 16 20-21 Dec 94						
Well: GWA-1 (Formerly CW-1) (Continued)											
pH	NS	NS	NS	NS	NS						
Conductivity	NS	NS	NS	NS	NS						
Alkalinity	NS	NS	NS	NS	NS						
TDS	NS	NS	NS	NS	NS						
Chloride	NS	NS	NS	NS	NS						
Sulfate	NS	NS	NS	NS	NS						
Calcium	NS	NS	NS	NS	NS						
Magnesium	NS	NS	NS	NS	NS						
Sodium	NS	NS	NS	NS	NS						
Silicon	NS	NS	NS	NS	NS						

Table A-1 (Continued)

Parameter	Baseline Monitoring										
	Round 1 6 Sep 90	Round 2 2 Nov 90	Round 3 8-9 Jan 91	Round 4 11 Mar 91	Round 5 8 May 91	Round 6 1-2 Jul 91	Round 7 3-4 Sep 92	Round 8 29-30 Dec 92	Round 9 30-31 Mar 93	Round 10 21 Jun 93	Round 11 23-24 Sep 93
Well: GWC-1 (Formerly CW-2)											
pH	6.09	5.79	5.62	5.93	6.04	5.96	6.1	4.5	5.83	6	6
Conductivity	81	70	72	63	63	66	78	57	67	57	61
Alkalinity	21.7	22.9	24.4	22.1	20.5	25.8	27.8	23.3	22.5	24.1	27.3
TDS	81	51	59	52	48	64	64	68	43	74	70
Chloride	3.5	2.8	3.1	3.4	2.8	2.5	2.5	2.6	2.6	2.6	2.5
Sulfate	7.6	5	2.8	<0.05	1.2	1.5	3.2	3.3	2.2	<2.5	2.6
Calcium	3.9	3.6	3.8	3.2	3.4	3.6	4.3	4	8.8	4.1	4.1
Magnesium	2.3	2.5	2.8	2.2	2.4	2.5	3.2	3	6.2	2.9	3
Sodium	5.9	5.2	4.3	4.1	4.2	4.1	4	4	4.2	4	3.8
Silicon	9	9	9.2	11	11	11	11	12	16	12	12

Parameter	Round 12 5 Jan 94	Round 13 22-23 Mar 94	Round 14 21-22 Jun 94	Round 15 31 Aug 94	Round 16 20-21 Dec 94						
Well: GWC-1 (Formerly CW-2) (Continued)											
pH	6.1	5.89	5.91	6.09	6.09						
Conductivity	74	61	60	68	76						
Alkalinity	29.9	25	30.1	25	22						
TDS	22	66	56	64	46						
Chloride	3.5	2.43	2.77	2.71	2.68						
Sulfate	3.3	1.75	1.77	1.64	1.19						
Calcium	5.1	4.72	4.65	5	4.5						
Magnesium	3.7	3.14	3.39	3.7	3.33						
Sodium	4.3	4.12	4.16	4.32	4.1						
Silicon	12.7	11.9	11.9	11.8	10.9						

Table A-1 (Continued)

Parameter	Baseline Monitoring							Round 8 29-30 Dec 92	Round 9 30-31 Mar 93	Round 10 21 Jun 93	Round 11 23-24 Sep 93
	Round 1 6 Sep 90	Round 2 2 Nov 90	Round 3 8-9 Jan 91	Round 4 11 Mar 91	Round 5 8 May 91	Round 6 1-2 Jul 91	Round 7 3-4 Sep 92				
Well: GWC-2 (Formerly CW-3)											
pH	5.64	5.6	5.04	5.5	4.97	5.65	5.5	4.6	5.29	5.4	5.6
Conductivity	76	69	64	66	33	71	66	56	67	56	49
Alkalinity	23.5	19.3	15.2	16.9	12.2	17.5	18.2	17.3	12.5	14.1	15.9
TDS	76	50	55	55	63	65	79	71	68	77	60
Chloride	4.3	5.2	6.9	6.2	5	5.3	3	3.4	4	4.5	3.5
Sulfate	6.4	5.5	6.3	5.9	5.8	6.3	6.5	7.6	7.9	7.5	7.7
Calcium	4.4	2.8	2.3	2	2	1.7	1.4	1.6	1.7	1.6	1.9
Magnesium	1.6	1.5	1.6	1.7	1.8	1.9	1.9	2.1	2.1	1.9	2
Sodium	7.3	7.4	6.9	7	7.5	7.6	7.5	7.4	7.5	6.7	6.8
Silicon	10	10	9.3	12	11	11	11	13	12	11	13

Parameter	Round 12 5 Jan 94	Round 13 22-23 Mar 94	Round 14 21-22 Jun 94	Round 15 31 Aug 94	Round 16 20-21 Dec 94						
Well: GWC-2 (Formerly CW-3) (Continued)											
pH	5.75	5.5	5.72	5.63	5.34						
Conductivity	53	57	59	60	66						
Alkalinity	15.7	14	16.2	7	6.9						
TDS	27	76	58	60	65						
Chloride	3.8	3.7	3.79	3.92	4						
Sulfate	5.78	5.97	5.95	6.73	5.78						
Calcium	2	2.19	2.05	2.11	1.89						
Magnesium	1.8	1.92	1.93	2.03	1.87						
Sodium	7	7.15	7.09	7.17	6.96						
Silicon	12.9	13.3	13	12.9	12.2						

Table A-1 (Continued)

Parameter	Baseline Monitoring							Round 8 29-30 Dec 92	Round 9 30-31 Mar 93	Round 10 21 Jun 93	Round 11 23-24 Sep 93
	Round 1 6 Sep 90	Round 2 2 Nov 90	Round 3 8-9 Jan 91	Round 4 11 Mar 91	Round 5 8 May 91	Round 6 1-2 Jul 91	Round 7 3-4 Sep 92				
Well: GWC-3 (Formerly CW-4)											
pH	5.4	5.15	4.8	4.73	6.19	5.08	5.25	3.8	5.23	5.2	5.3
Conductivity	40	35	30	34	32	35	32	27	33	27	27
Alkalinity	11.5	15.2	9.9	11	7	11.1	10	8.9	7	8.5	9.1
TDS	50	35	31	34	39	41	28	37	44	52	21
Chloride	3	2.8	3.2	3.4	3.1	3.1	2	2.3	2.7	2.9	2.8
Sulfate	2.6	2.1	<0.05	<0.05	0.9	1.5	1.7	2.6	1.6	<2.5	<2.5
Calcium	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Magnesium	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sodium	4.4	4.5	4.3	4.1	4.6	4.3	4.1	4	4.1	3.9	3.8
Silicon	8	7.8	3.9	8.5	8.6	8.3	8.3	9.3	9	8.7	9.2

Parameter	Round 12 5 Jan 94	Round 13 22-23 Mar 94	Round 14 21-22 Jun 94	Round 15 31 Aug 94	Round 16 20-21 Dec 94						
Well: GWC-3 (Formerly CW-4)											
pH	5.5	5.18	5.43	5.41	5.06						
Conductivity	22	28	29	30	36						
Alkalinity	9.3	7.5	8.5	77	4.8						
TDS	<8.7	42	36	39	30						
Chloride	2.8	2.77	2.76	2.91	3.02						
Sulfate	<0.06	1.38	1.52	<0.0471	1.01						
Calcium	<1.0	0.392	0.321	0.328	0.335						
Magnesium	<1.0	0.962	0.935	1	1.02						
Sodium	4.1	4.35	4.14	4.17	4.34						
Silicon	9.7	10.1	9.16	9.15	8.94						

Table A-1 (Continued)

Parameter	Baseline Monitoring							Round 8 29-30 Dec 92	Round 9 30-31 Mar 93	Round 10 21 Jun 93	Round 11 23-24 Sep 93
	Round 1 6 Sep 90	Round 2 2 Nov 90	Round 3 8-9 Jan 91	Round 4 11 Mar 91	Round 5 8 May 91	Round 6 1-2 Jul 91	Round 7 3-4 Sep 92				
Well: GWC-4 (Formerly CW-5)											
pH	5.34	4.97	4.8	4.6	5.03	5.4	5.05	3.9	5.04	5.2	5.2
Conductivity	62	62	66	72	54	70	72	58	64	52	54
Alkalinity	12.5	15.3	13.1	15.1	8.6	14.2	11.5	8	6	6.9	7
TDS	61	52	60	51	58	64	61	65	63	55	44
Chloride	5	4.2	5	5.6	4.5	5.2	3.1	3.4	3.6	3.6	3.8
Sulfate	2.2	4.6	8	6.8	7.1	5.8	5.3	5.5	5	5.9	4.9
Calcium	1.3	<1.0	<1.0	1.3	1.6	1.2	<1.0	<1.0	1	<1.0	<1.0
Magnesium	2.5	2.5	3.1	3.8	3.9	3.7	3.3	3.2	3.2	2.7	2.9
Sodium	5.4	5.8	5.3	5.1	5	5.2	4.8	4.9	4.7	4.4	4.4
Silicon	9.9	9.1	4.7	9.7	9.2	10	8.6	9.5	8.7	8.3	9.3
Parameter	**Round 12 5 Jan 94**	**Round 13 22-23 Mar 94**	**Round 14 21-22 Jun 94**	**Round 15 31 Aug 94**	**Round 16 20-21 Dec 94**						
Well: GWC-4 (Formerly CW-5) (Continued)											
pH	5.2	4.98	5.2	5.1	4.92						
Conductivity	63	72	81	108	188						
Alkalinity	9.2	5	10.3	5	3.8						
TDS	20	64	75	93	110						
Chloride	6.7	11.3	13.5	20.8	39.7						
Sulfate	4.4	4.64	4.5	4.83	4.34						
Calcium	1.3	1.81	1.62	2.73	4.04						
Magnesium	3.7	5.05	4.98	7.32	11						
Sodium	5	5.33	4.87	5.8	7.86						
Silicon	9.8	9.91	9.18	9.91	10.1						

Table A-1 (Continued)

Parameter	Baseline Monitoring							Round 8 29-30 Dec 92	Round 9 30-31 Mar 93	Round 10 21 Jun 93	Round 11 23-24 Sep 93
	Round 1 6 Sep 90	Round 2 2 Nov 90	Round 3 8-9 Jan 91	Round 4 11 Mar 91	Round 5 8 May 91	Round 6 1-2 Jul 91	Round 7 3-4 Sep 92				
Well: GWC-5											
pH							5.6	4.4	6.13	5.4	5.6
Conductivity							61	60	54	41	40
Alkalinity							14.8	13.5	12.5	10.2	11.5
TDS							91	86	67	56	50
Chloride							1.8	2.6	2.7	2.9	2.5
Sulfate							8.8	10	7.4	6.7	5.5
Calcium							2.1	2.7	2.2	1.6	1.4
Magnesium							1.9	2.3	1.8	1.5	1.4
Sodium							6	6.2	5.7	5.5	5.2
Silicon							12	14	13	12	12

Parameter	Round 12 5 Jan 94	Round 13 22-23 Mar 94	Round 14 21-22 Jun 94	Round 15 31 Aug 94	Round 16 20-21 Dec 94						
Well: GWC-5 (Continued)											
pH	7	5.38	5.42	5.53	5.57						
Conductivity	39	43	45	43	47						
Alkalinity	10.8	8.6	10.8	13	11.2						
TDS	29	53	61	61	45						
Chloride	2.6	2.34	2.48	2.67	2.7						
Sulfate	5.3	6.56	7.65	6.68	5.75						
Calcium	1.3	1.65	1.38	1.26	1.2						
Magnesium	1.3	1.6	1.55	1.46	1.32						
Sodium	5.5	5.74	5.77	5.38	5.43						
Silicon	11.4	11.8	11.3	10.5	10.3						

APPENDIX B

QA/QC RESULTS

Table B-1

Results for Duplicate Samples—4th Quarter 1994

Parameter	Units	Sample GWC-3-16-1	Field Duplicate GWC-3-16-2	% Diff.[a]	Duplicate Analysis GWC-3-16-2	% RPD[b]	Spec. Limit
Total Dissolved Solids	mg/L	30	28	-6.7	31	10	15
Bromide	mg/L	<0.0226	<0.0226	NC	<0.0226	NC	
Chloride	mg/L	3.02	3.00	-0.7	2.89	3.7	20
Fluoride	mg/L	0.0340[c]	0.0325[c]	-4.4			
Sulfate	mg/L	1.01	<0.0471	NC	1.03	NC	20
Total Organic Carbon	mg/L	<0.357	<0.357	NC			
Nitrate-Nitrite as N	mg/L	0.246	0.232	-5.7	0.234	0.9	20
Total Organic Halides	µg/L	<11.7	<11.7	NC			
Silver	mg/L	<0.00519	<0.00519	NC			
Aluminum	mg/L	<0.0523	<0.0523	NC			
Arsenic	mg/L	<0.00214	<0.00214	NC			
Boron	mg/L	<0.0176	<0.0176	NC			
Barium	mg/L	0.00742	0.00742	0.0			
Beryllium	mg/L	<0.00051	<0.00051	NC			
Bismuth	mg/L	0.0336[d]	<0.0275	NC			
Calcium	mg/L	0.335[c]	0.338[c]	0.9			
Cadmium	mg/L	<0.00386	<0.00386	NC			
Cobalt	mg/L	<0.00407	<0.00407	NC			
Copper	mg/L	<0.00916	<0.00916	NC			
Chromium	mg/L	<0.00524	<0.00524	NC			
Mercury	mg/L	<0.000033	0.00007[d]	NC			
Iron	mg/L	0.0203[c,d]	0.0133[c,d]	-34.5			
Potassium	mg/L	<0.822	<0.822	NC			
Lithium	mg/L	0.0103[c,d]	0.00948[c,d]	-8.0			
Magnesium	mg/L	1.02	0.999	-2.1			
Manganese	mg/L	<0.00155	<0.00155	NC			
Molybdenum	mg/L	<0.00739	<0.00739	NC			
Sodium	mg/L	4.34	4.34	0.0			
Nickel	mg/L	<0.0141	<0.0141	NC			
Phosphorus	mg/L	<0.109	<0.109	NC			
Lead	mg/L	<0.0022	<0.0022	NC			
Sulfur	mg/L	<0.175	<0.175	NC			

Table B-1 (Continued)

Parameter	Units	Sample GWC-3-16-1	Field Duplicate GWC-3-16-2	% Diff.[a]	Duplicate Analysis GWC-3-16-2	% RPD[b]	Spec. Limit
Antimony	mg/L	<0.00146	0.00182[d]	NC			
Selenium	mg/L	<0.000592	<0.000592	NC			
Silicon	mg/L	8.94	8.92	-0.2			
Tin	mg/L	0.0162[d]	<0.0145	-10.5			
Strontium	mg/L	0.00202[d]	0.00161[d]	-20.3			
Tellurium	mg/L	<0.117	<0.117	NC			
Titanium	mg/L	<0.00159	<0.00159	NC			
Thallium	mg/L	<0.000536	<0.000536	NC			
Uranium	mg/L	<0.199	<0.199	NC			
Vanadium	mg/L	<0.00454	<0.00454	NC			
Tungsten	mg/L	<0.0408	<0.0408	NC			
Zinc	mg/L	<0.00402[c]	0.00675[c,d]	NC			

[a] % difference = (GWC-3-16-2 - GWC-3-16-1)/GWC-3-16-1 x 100%

[b] RPD = Relative percent difference, defined as follows:

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

[c] Detected in the method blank.

[d] Value is less than five times the detection limit; results are expected to be less accurate as concentrations approach the detection limit.

NC = Not computed.