RCN 218-070-07-20

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

Plant Yates

Environmental Monitoring Program Report:
Fourth Quarter and Annual 1996
(Final)

DOE DE-FC22-90PC89650
SCS C-90-00284

Prepared for:

Southern Company Services, Inc.
P.O. Box 2625
600 North 18th Street
Birmingham, Alabama 35291-1195

Prepared by:

Radian International LLC
8501 North Mopac Boulevard
P.O. Box 201088
Austin, Texas 78720-1088

Cleared by DOE Patent Counsel.

Legal Notice

This report was prepared by Radian International LLC for Southern Company Services, Inc. pursuant to a cooperative agreement partially funded by the U.S. Department of Energy and neither Southern Company Services, Inc., nor any of its subcontractors, nor the U.S. Department of Energy, nor any person acting on behalf of either:

1. Makes any warranty or representation, express or implied with respect to the accuracy, completeness, or usefulness of the information contained in this report or that the process disclosed in this report may not infringe privately-owned rights; or

2. Assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Department of Energy. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Department of Energy.

Demonstration of Innovative Applications of Technology for the CT-121 FGD Process

Plant Yates

Environmental Monitoring Program Report: Fourth Quarter and Annual 1996

This progress report summarizes activities associated with the environmental monitoring program (EMP) during the third and fourth quarters and calendar year of 1996 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.

Operational testing was completed in December of 1994 and operation of the scrubber was turned over to Georgia Power Company. Post-operational-phase monitoring under the EMP was limited to groundwater monitoring. Post-operational-phase groundwater monitoring began during the first quarter of 1995 and continued through the fourth quarter of 1996. With the completion of the two-year post-operational-phase, EMP monitoring has now been completed, and this is the last of the quarterly reports to be submitted under the project.

Reports containing the results of groundwater monitoring conducted during the third and fourth quarters of 1996 are attached (Attachments A and B, respectively).

Attachment A

Groundwater Monitoring Report for the Third Quarter of 1996

Table of Contents

List of Figures

List of Tables

1.0 Introduction

This report summarizes the results of groundwater monitoring performed during the third calendar quarter of 1996 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 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.

Period 2 ended in December 1994. Groundwater monitoring was initiated in Period 0 and will continue through 24 months of Period 3.

1.2 Purpose and Scope of Groundwater Monitoring

The CT-121 process produces gypsum, which is being disposed of 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 pre-operational groundwater monitoring was conducted on September 3-4 and October 14, 1992. The results from this monitoring effort were presented in the report "Interim Data Report of Pre-operational Groundwater Monitoring: September 3-4 and October 14, 1992."

Operational-phase groundwater monitoring, performed on a quarterly basis, was initiated in the fourth quarter of 1992. Monitoring was conducted for the suite of parameters shown in Table 1. Samples were 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 organic compounds (VOCs). These parameters have been added to comply with requirements of the permit issued by the Environmental Protection Division of the Georgia DNR.

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		

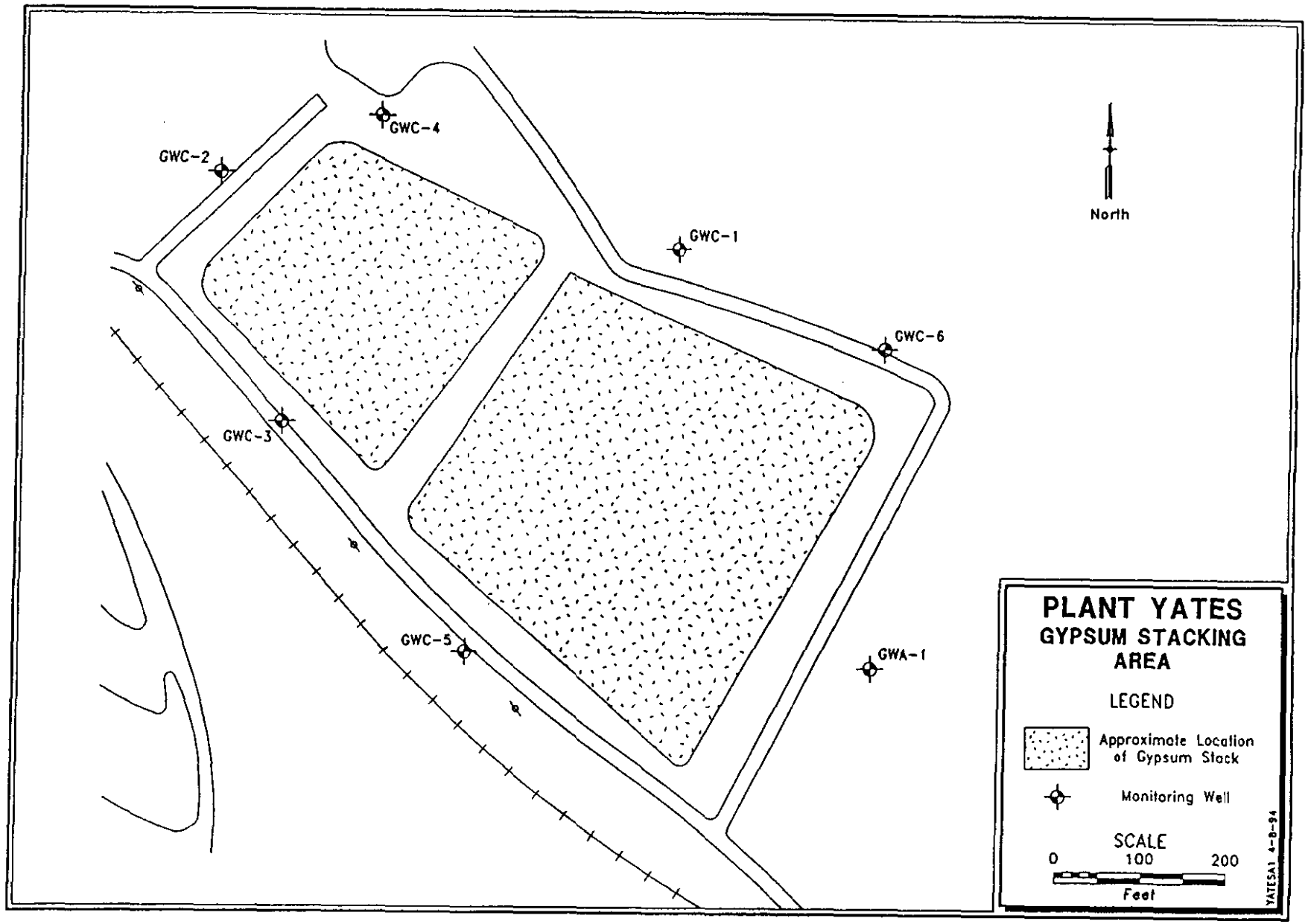


Figure 1. Locations of Groundwater Monitoring Wells

The post-demonstration groundwater monitoring period began in the first quarter of 1995 and will be conducted over a period of two years for the same parameters and at the same frequency as during the operational phase.

1.3 Report Contents

This report presents the results of quarterly post-demonstration groundwater monitoring for the third calendar quarter of 1996. The groundwater monitoring wells were sampled on September 13-14, 1996.

Section 2 is a brief summary of the groundwater sampling and analytical methods used to conduct the monitoring. The results of the monitoring 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 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 gasoline-powered 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 (1) after at least three wetted casing volumes of water were removed or (2) immediately following recovery if a well was purged dry.

Table 2 summarizes the groundwater samples collected during this monitoring period. Samples were obtained from the upgradient well (GWA-1) and five of the six downgradient

Table 2. Summary of Groundwater Samples Collected at Plant Yates on September 13-14, 1996

Well ID	Sample ID	Analyses
GWA-1	GWA-1-23-1	Anions, TOC, TOX, and Metals
GWC-1	GWC-1-23-1	Anions, TOC, TOX, Metals, and Radionuclides
GWC-2	GWC-2-23-1	Anions, TOC, TOX, Metals, Radionuclides, and VOCs
GWC-3	GWC-3-23-1 GWC-3-23-2	Anions, TOC, TOX, Metals, Radionuclides, and VOCs Duplicate for Radionuclides only
GWC-4	GWC-4-23-1 GWC-4-23-2	Anions, TOC, TOX, Metals, and Radionuclides Duplicate for Anions, TOC, TOX, and Metals
GWC-5	GWC-5-23-1	Anions, TOC, TOX, Metals, and Radionuclides
GWC-6	None	Well dry; no samples collected

wells (GWC-1, GWC-2, GWC-3, GWC-4, and GWC-5). As has been the case during all previous rounds of monitoring, no samples were collected from side-gradient well GWC-6 since this well was dry. A Sample for radionuclides analyses was not obtained from well GWA-1 because of insufficient groundwater volume. Duplicate samples were collected from wells GWC-3 (for radionuclides) and GWC-4 (for all other analytes). The radionuclides duplicate sample was collected at well GWC-3 because sample filtration was excessively slow at well GWC-4 for the large sample volumes required for radionuclides analysis. Because several volatile organic compounds, including benzene, toluene, ethylbenzene, and xylenes were detected in samples from wells GWC-2 and GWC-3, aliquots were collected again this quarter from these wells for VOC analysis.

To preserve the integrity of the groundwater samples before analyses, proper sample container, preservation, 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. Because the conductivity sensor for the field meter was not functioning, conductivities were measured using an instrument in the Plant Yates scrubber laboratory. Unpreserved sample aliquots were used for this purpose.

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
TOX	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
TOX	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

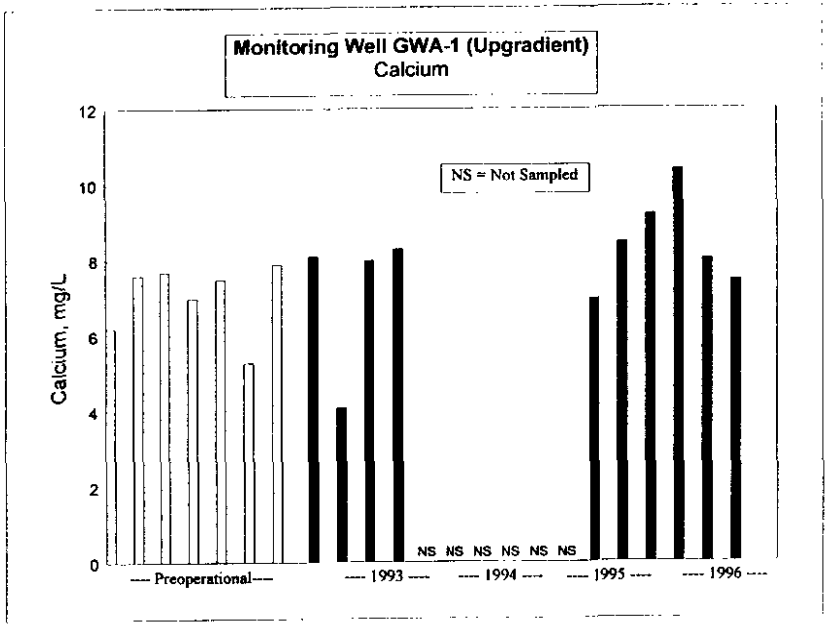
The results of the third-quarter 1996 groundwater monitoring are presented in Table 5. The concentrations of all of the monitored dissolved constituents in the groundwater near the gypsum stacking area continue to be low.

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. The representative species selected are those present in appreciable concentrations in the gypsum slurry, including the major cations and anions (i.e., calcium, magnesium, chloride, 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 concentration-versus-time 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. As has been the case since monitoring began, samples were not obtained from downgradient well GWC-6.

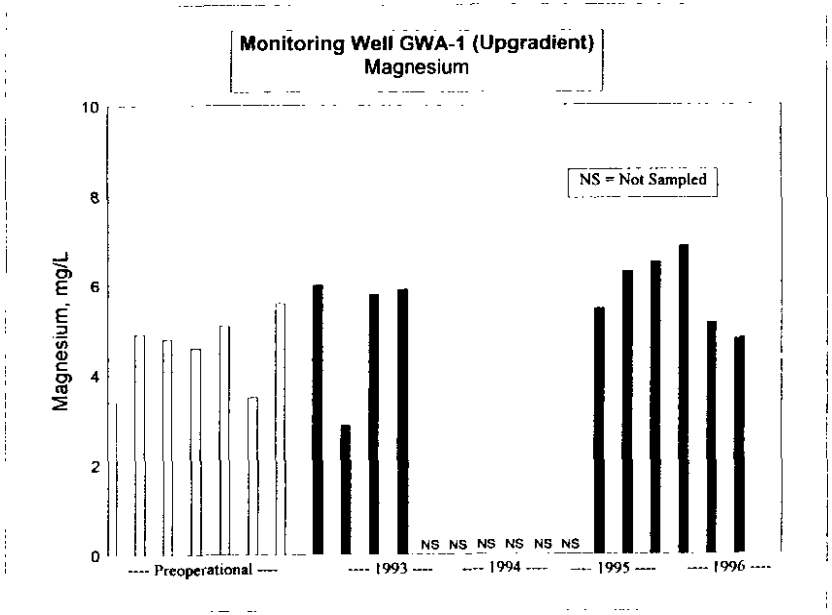
The concentrations of chloride, magnesium, and calcium in the water from downgradient well GWC-4 were similar to those found during the previous quarter's monitoring, but are significantly higher than those measured during the preoperational period. A generally upward trend in the concentrations of these gypsum constituents was first noticed in the fourth quarter of 1993. There have been no significant increases in the levels of these species in either the upgradient well or the other downgradient wells.

The source(s) of the higher levels of gypsum constituents in well GWC-4 is (are) not clearly apparent. However, there are several potential sources, and three of the more plausible are briefly described below:

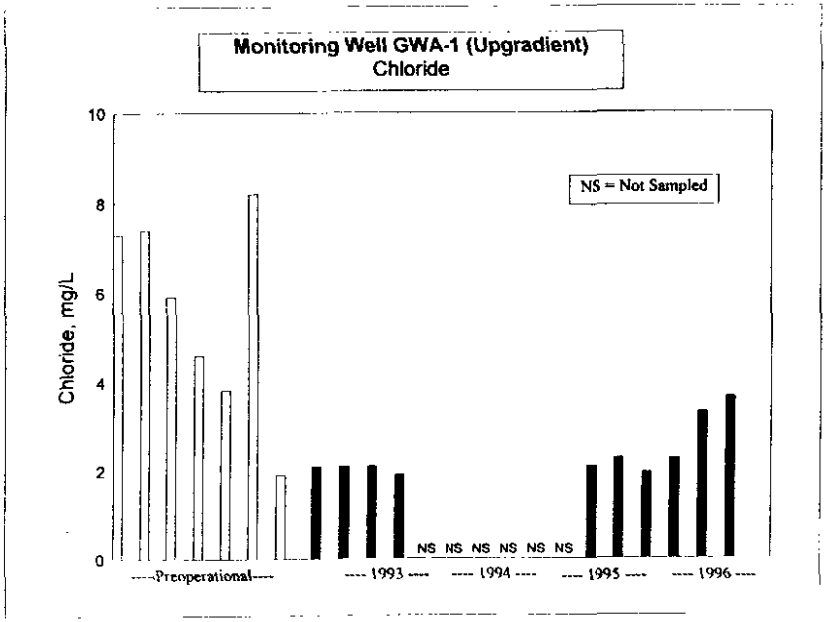
- A breach of the dike surrounding the gypsum pond occurred on July 24, 1993. This breach happened in the vicinity of well GWC-4. Since the increase in the levels of chloride, magnesium, and calcium in GWC-4 was first noticed in the fourth quarter of 1993, it seemed likely that the increase was the result of the dike breach. The validity of this assumption appeared to be reinforced in the first quarter of 1995, when the levels of the three species declined in GWC-4. Such a



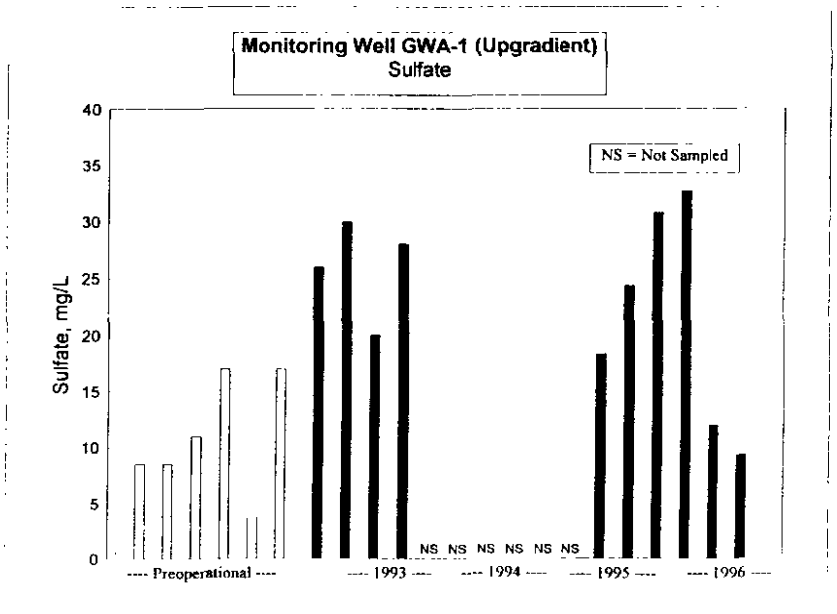
(a) Calcium



(b) Magnesium

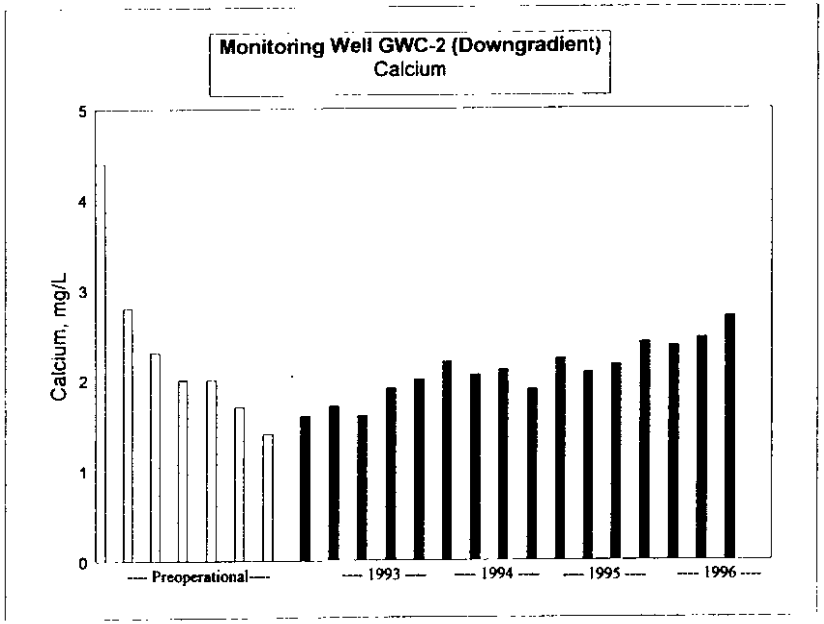


(c) Chloride

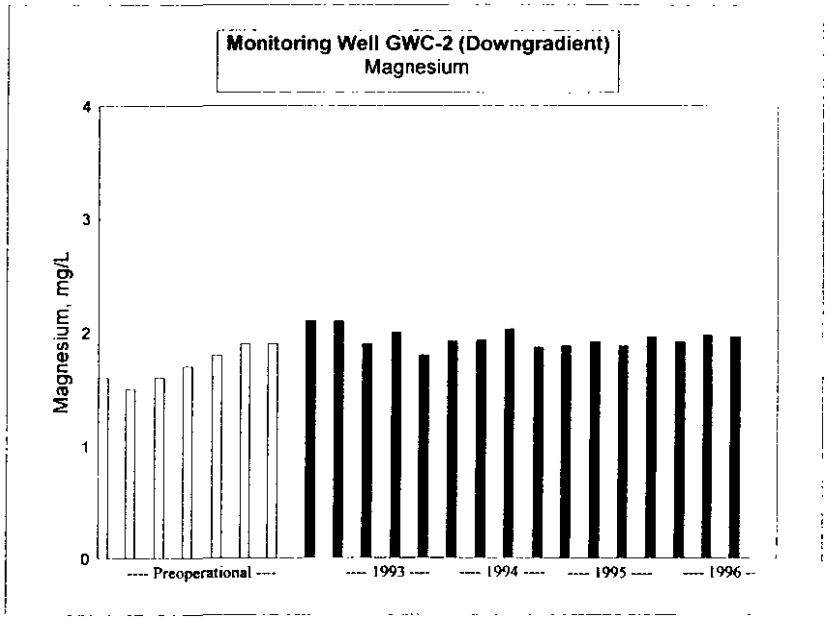


(d) Sulfate

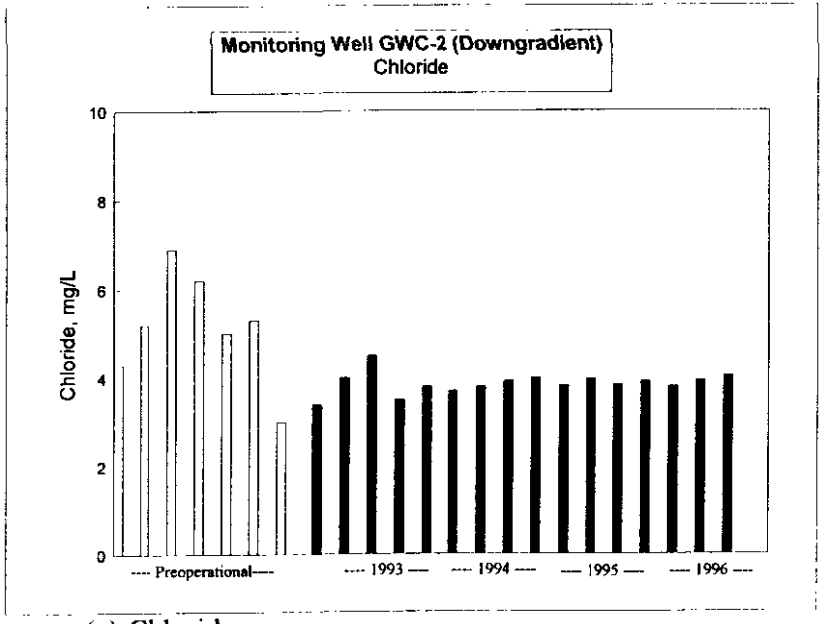
Figure 2. Historical Data for Representative Species from Well GWA-1 (Upgradient)



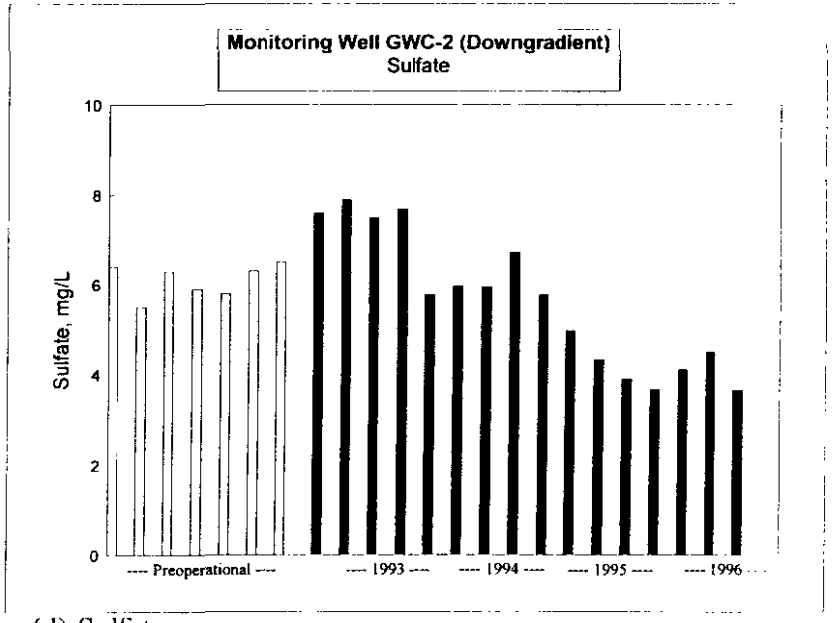
(a) Calcium



(b) Magnesium

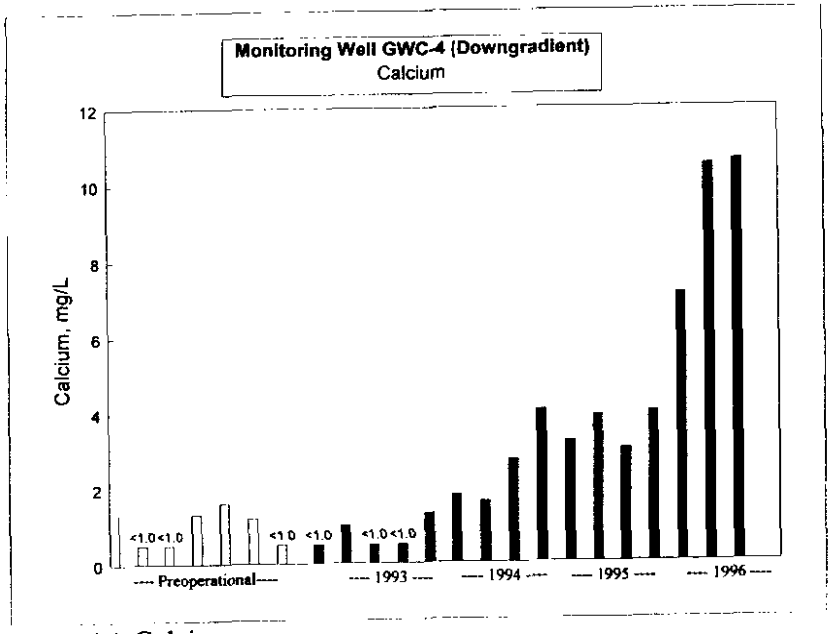


(c) Chloride

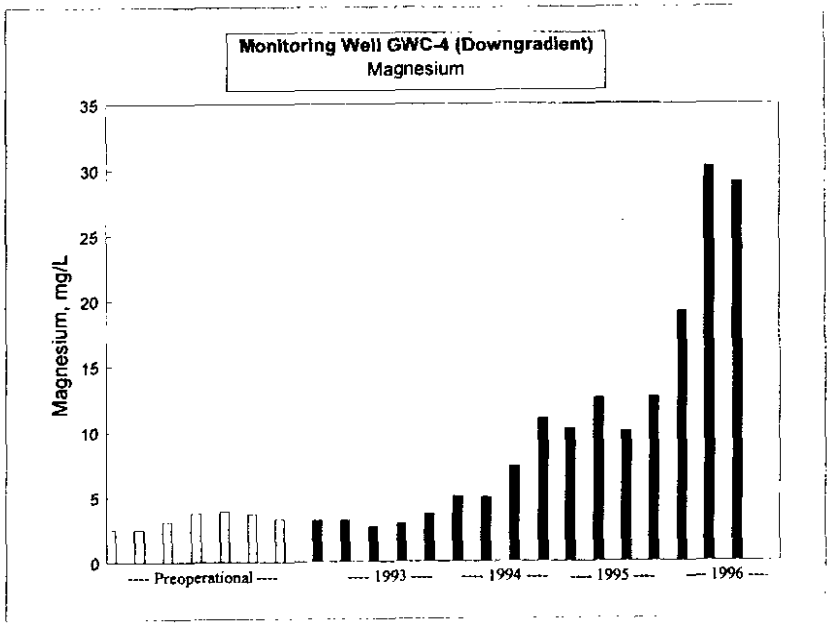


(d) Sulfate

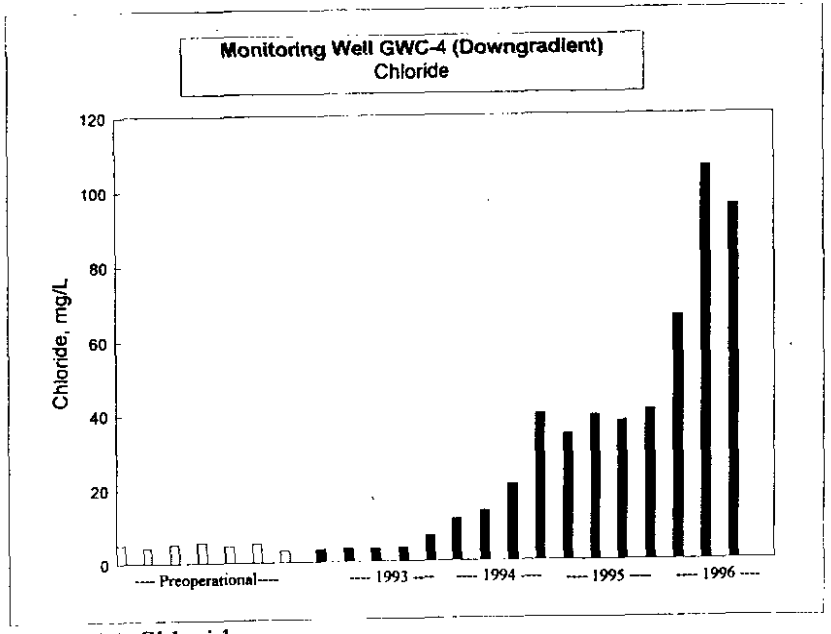
Figure 3. Historical Data for Representative Species from Well GWC-2 (Downgradient)



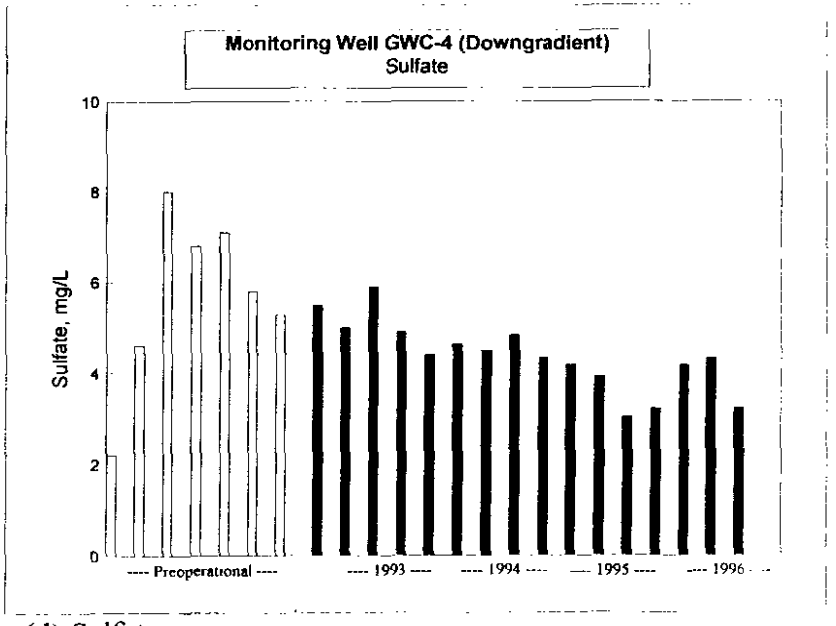
(a) Calcium



(b) Magnesium



(c) Chloride



(d) Sulfate

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

Table 5. Results of Groundwater Monitoring Conducted September 13-14, 1996 (3rd Quarter 1996)

Parameter	GWA-1-23-1	GWC-1-23-1	GWC-2-23-1	GWC-3-23-1[a]	GWC-4-23-1[a]	GWC-5-23-1
pH	6.54	5.96	5.50	5.19	4.94	5.39
Conductivity (µS/cm)	58	75	62	38	330	64
Temperature (°C)	23	18	18	17	18	17
Eh (mV)	218	264	348	177	415	200
Alkalinity (mg/L $CaCO_3$)	27.8	32.2	17.4	9.7	6.8	10.1
Total Dissolved Solids (mg/L)	88 [b]	81 [b]	82 [b]	56 [b]	229 [b]	66 [b]
Bromide (mg/L)	<0.0493	<0.0493	<0.0493	<0.0493	0.737	<0.0493
Chloride (mg/L)	3.65	2.57	4.04	4.31	95.5	3.00
Total Organic Carbon (mg/L)	<0.117	0.379 [c]	0.217 [c]	0.159 [c]	1.25	0.672
Fluoride (mg/L)	0.0800 [b]	0.0495 [b]	0.0349 [b]	0.0320 [b]	0.0352 [b]	0.0224 [b]
Nitrate-Nitrite (mg/L as N)	0.774	0.310	1.01	0.212	2.02	0.127
Sulfate (mg/L)	9.34	0.694	3.66	1.49	3.21	7.82
Radium 226 (pCi/L)	N/M	0.330 ± 0.481	<0.390	0.480 ± 0.542	<0.210	<0.190
Radium 228 (pCi/L)	N/M	<0.590	<0.850	<0.470	<0.460	<0.450
Gross Alpha (pCi/L)	N/M	<0.20	<0.33	<1.2	<0.58	<1.5
Gross Beta (pCi/L)	N/M	<0.78	<0.93	<4.0	<1.8	<4.9
Gamma Scan (pCi/L):						
Ac-228	N/M	-5.45 ± 10.6	0.00 ± 13.7	4.93 ± 11.8	-7.78 ± 14.6	1.21 ± 13.4
Bi-214	N/M	14.4 ± 7.83	10.1 ± 9.43	8.65 ± 7.56	11.1 ± 11.6	7.96 ± 9.06
Pb-214	N/M	12.0 ± 7.21	6.55 ± 7.28	9.47 ± 7.27	7.99 ± 7.85	15.3 ± 7.66
K-40	N/M	-21.0 ± 48.3	8.82 ± 59.0	-48.5 ± 45.2	3.24 ± 63.7	-7.66 ± 55.5
Silver (mg/L)	<0.000501	<0.000501	0.000920 [c]	<0.000501	0.000880 [c]	<0.000501
Aluminum (mg/L)	0.0348 [b,c]	0.0385 [b,c]	0.0429 [b,c]	0.0388 [b,c]	0.0708 [b]	0.0368 [b,c]
Arsenic (mg/L)	<0.000887	<0.000887	<0.000887	<0.000887	<0.000887	<0.000887
Boron (mg/L)	<0.0479	<0.0479	<0.0479	<0.0479	1.98	<0.0479
Barium (mg/L)	0.0143	0.00818	0.0102	0.0109	0.0626	0.00805

Table 5 (Continued)

Parameter	GWA-1-23-1	GWC-1-23-1	GWC-2-23-1	GWC-3-23-1[a]	GWC-4-23-1[a]	GWC-5-23-1
Beryllium (mg/L)	0.000670 [b,c]	0.000240 [b,c]	<0.000162	0.000330 [b,c]	0.00107 [b]	0.000300 [b,c]
Bismuth (mg/L)	<0.00271	<0.00271	<0.00271	<0.00271	<0.00271	0.00376 [c]
Calcium (mg/L)	7.46 [b]	5.85 [b]	2.70 [b]	0.505 [b]	10.6 [b]	1.90 [b]
Cadmium (mg/L)	0.000180 [c]	<0.000156	<0.000156	<0.000156	<0.000156	<0.000156
Cobalt (mg/L)	<0.000580	<0.000580	<0.000580	<0.000580	0.00381	<0.000580
Copper (mg/L)	<0.00136	<0.00136	<0.00136	<0.00136	<0.00136	<0.00136
Chromium (mg/L)	0.00177 [c]	0.00109 [c]	0.00312	0.00158 [c]	0.00044 [c]	0.00143 [c]
Mercury (mg/L)	<0.000039	<0.000039	<0.000039	<0.000039	<0.000039	<0.000039
Iron (mg/L)	0.0157 [c]	<0.0135	<0.0135	<0.0135	<0.0135	<0.0135
Potassium (mg/L)	1.47 [b]	0.922 [b]	0.507 [b]	0.337 [b]	0.716 [b]	0.278 [b]
Lithium (mg/L)	NM	NM	NM	NM	NM	NM
Magnesium (mg/L)	4.80	3.80	1.96	1.41	29.0	2.06
Manganese (mg/L)	0.00164 [c]	0.000740 [c]	0.00281	0.00336	0.475	0.00364
Molybdenum (mg/L)	0.00104 [c]	<0.000705	<0.000705	<0.000705	<0.000705	<0.000705
Sodium (mg/L)	4.16	4.04	7.16	5.36	9.64	5.96
Nickel (mg/L)	0.00326 [c]	0.000810 [c]	0.0177	0.00342 [c]	0.00131 [c]	0.00476
Phosphorus (mg/L)	0.00743 [c]	0.0152 [c]	<0.00471	<0.00471	0.00854 [c]	<0.00471
Lead (mg/L)	<0.00126	<0.00126	<0.00126	<0.00126	0.00410 [c]	<0.00126
Sulfur (mg/L)	4.11	0.176	1.40	0.504	1.38	3.29
Antimony (mg/L)	0.00135 [c]	0.00273 [c]	<0.000919	0.00145 [c]	<0.000919	0.00405 [c]
Selenium (mg/L)	0.00174 [c]	0.00132 [c]	0.00169 [c]	0.00112 [c]	0.00183 [c]	0.00164 [c]
Silicon (mg/L)	16.2	11.8	13.8	10.1	11.1	11.1
Tin (mg/L)	0.00169 [b,c]	0.00151 [b,c]	0.00164 [b,c]	<0.00111	0.00213 [b,c]	<0.00111
Strontium (mg/L)	0.0214	0.0171	0.0133	0.00484	0.0809	0.0155
Tellurium (mg/L)	<0.00170	<0.00170	<0.00170	<0.00170	<0.00170	<0.00170
Titanium (mg/L)	0.00037 [c]	0.00032 [c]	0.00061 [c]	<0.000200	0.00036 [c]	<0.000200
Thallium (mg/L)	<0.00168	<0.00168	<0.00168	<0.00168	<0.00168	<0.00168
Uranium (mg/L)	0.0958 [b]	0.0885 [b]	0.0664 [b]	0.101 [b]	0.105 [b]	0.0981 [b]

Table 5 (Continued)

Parameter	GWA-1-23-1	GWC-1-23-1	GWC-2-23-1	GWC-3-23-1[a]	GWC-4-23-1[a]	GWC-5-23-1
Vanadium (mg/L)	<0.000681	<0.000681	0.000770 [c]	<0.000681	<0.000681	<0.000681
Tungsten (mg/L)	0.00713 [c]	0.0107	0.00660 [c]	<0.00183	0.00334 [c]	0.00289 [c]
Zinc (mg/L)	<0.00309	0.00318 [c]	<0.00309	<0.00309	<0.00309	<0.00309
TOX (µg/L)	<20.9	<20.9	<20.9	<20.9	50.8 [c]	<20.9
VOCs (µg/L):						
Acetone	NM	NM	<1.26	<0.489	NM	NM
Acrolein	NM	NM	<1.21	<0.707	NM	NM
Acrylonitrile	NM	NM	<0.364	<0.712	NM	NM
Benzene	NM	NM	<0.0470	<0.0378	NM	NM
Bromodichloromethane	NM	NM	<0.0698	<0.0393	NM	NM
Bromoform	NM	NM	<0.0849	<0.174	NM	NM
Bromomethane	NM	NM	<0.190	<0.0632	NM	NM
2-Butanone (MEK)	NM	NM	<0.289	<0.260	NM	NM
Carbon disulfide	NM	NM	<0.0786	<0.0485	NM	NM
Carbon tetrachloride	NM	NM	<0.113	<0.0474	NM	NM
Chlorobenzene	NM	NM	<0.0688	<0.0258	NM	NM
Chloroethane	NM	NM	<0.114	<0.0741	NM	NM
Chloroform	NM	NM	<0.122	<0.0409	NM	NM
Chloromethane	NM	NM	<0.141	<0.0454	NM	NM
3-Chloropropene	NM	NM	<0.0951	<0.0340	NM	NM
Dibromochloromethane	NM	NM	<0.166	<0.141	NM	NM
Dibromomethane	NM	NM	<0.169	<0.0621	NM	NM
trans-1,4-Dichloro-2-butene	NM	NM	<0.181	<0.389	NM	NM
Dichlorodifluoromethane	NM	NM	<0.153	<0.0651	NM	NM
1,1-Dichloroethane	NM	NM	<0.0864	<0.0919	NM	NM
1,2-Dichloroethane	NM	NM	<0.125	<0.105	NM	NM
1,1-Dichloroethene	NM	NM	<0.0767	<0.0802	NM	NM
cis-1,2-Dichloroethene	NM	NM	<0.0831	<0.0770	NM	NM

Table 5 (Continued)

Parameter	GWA-1-23-1	GWC-1-23-1	GWC-2-23-1	GWC-3-23-1[a]	GWC-4-23-1[a]	GWC-5-23-1
trans-1,2-Dichloroethene	NM	NM	<0.103	<0.0641	NM	NM
1,2-Dichloropropane	NM	NM	<0.0853	<0.0541	NM	NM
cis-1,3-Dichloropropene	NM	NM	<0.0545	<0.0538	NM	NM
trans-1,3-Dichloropropene	NM	NM	<0.0732	<0.0667	NM	NM
Ethyl methacrylate	NM	NM	<0.0914	<0.121	NM	NM
Ethylbenzene	NM	NM	<0.107	<0.0649	NM	NM
2-Hexanone	NM	NM	<0.193	<0.208	NM	NM
Iodomethane	NM	NM	<0.0553	<0.0652	NM	NM
4-Methyl-2-pentanone (MIBK)	NM	NM	<0.172	<0.0809	NM	NM
Methylene chloride	NM	NM	<0.159	<0.177	NM	NM
Styrene	NM	NM	<0.0981	<0.0406	NM	NM
1,1,1,2-Tetrachloroethane	NM	NM	<0.141	<0.0612	NM	NM
1,1,2,2-Tetrachloroethane	NM	NM	<0.227	<0.0412	NM	NM
Tetrachloroethene	NM	NM	<0.167	<0.0487	NM	NM
Toluene	NM	NM	<0.0619	<0.0492	NM	NM
1,1,1-Trichloroethane	NM	NM	<0.0927	<0.0993	NM	NM
1,1,2-Trichloroethane	NM	NM	<0.179	<0.119	NM	NM
Trichloroethene	NM	NM	<0.0931	<0.0854	NM	NM
Trichlorofluoromethane	NM	NM	<0.336	<0.0640	NM	NM
1,2,3-Trichloropropane	NM	NM	<0.256	<0.101	NM	NM
Vinyl acetate	NM	NM	<0.0525	<0.0612	NM	NM
Vinyl chloride	NM	NM	<0.232	<0.0767	NM	NM
m & p-Xylene	NM	NM	<0.131	<0.0688	NM	NM
o-Xylene	NM	NM	<0.0789	<0.0490	NM	NM

[a] Duplicate samples were collected for radionuclide analysis (GWC-3-2) and for the remaining parameters (GWC-4-2).
[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.

decline would be expected as the amount of spilled material remaining in the soil diminished due to gradual downward migration in the soil. However, no further decrease in the GWC-4 concentrations occurred over the following three quarters of 1995. In fact, further increases in the levels of chloride, magnesium, and calcium were noted in the first and second quarters of 1996. These concentrations leveled off during the current quarter. Although this behavior could still be due to the 1993 breach (e.g., due to changes in rainfall patterns and/or acidity of the rain could cause higher migration rates and/or increased leaching of the soil), other factors could be contributing to or causing higher levels of gypsum constituents in the groundwater in the vicinity of GWC-4.

- The groundwater sampling team has noticed that there appear to have been periodic leaks from a slurry pump and associated valves and fittings that are in close proximity (i.e., within 30-40 feet) to GWC-4. Slurry has periodically leaked onto the ground and flowed across the soil surface to form small pools within 10-15 feet of GWC-4. This material could be the source of at least some of the increased levels of chloride, magnesium, and calcium observed during the first three quarters of 1996 monitoring.

- The possibility that the increased levels of the gypsum slurry constituents in GWC-4 could be caused by a leak in the liner under the gypsum stacking area cannot be discounted. There is no indication of leakage in the monitoring results from the other wells, but this does not preclude the presence of a liner leak at a location immediately upgradient from GWC-4.

At this time, it is not possible to determine which, if any, of the possible causes described above is contributing the bulk of the chloride, etc., being seen in GWC-4. Some clarification may be forthcoming as more results of the continuing groundwater monitoring activities become available.

Because several volatile organic compounds were detected in some of the groundwater samples during last quarter's monitoring, samples from GWC-2 and GWC-3 were analyzed for VOCs again this quarter. This time, extra care was taken in handling the samples to assure that they were not contaminated with organics from other sources (e.g., gasoline fumes from the Well Wizard pump). No VOCs were found above the method detection limits in the samples from either well. It is likely that the VOCs found during last quarter's monitoring were present due to sample contamination.

4.0 Summary of QA/QC Activities

A number of QA/QC activities are being 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 analytical 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. Recoveries were low in one of two matrix spike samples for silicon (74%), boron (72%), and magnesium (74%); in the other matrix spike sample for these species, recoveries close to 100% were obtained. For TOX, the matrix spike recoveries were low in both samples (67% and 71%). The results for these analytes, especially TOX, may be somewhat suspect.

- 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 measured 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 10-20%). Unusually large differences between sample duplicates were obtained for chromium, nickel, lead, and tin. For these species, the measured concentrations were all near the detection limit, where less accurate results can be expected. The results of the duplicate analyses performed for TDS and TOX were within specified quality limits.

Table 6. Results for Duplicate Samples—Third Quarter 1996

Parameter	Units	Sample GWC-4-23-1	Field Duplicate GWC-4-23-2	% Diff. [a]	Duplicate Analysis GWC-4-23-2	% RPD [b]	Spec. Limit
Total Dissolved Solids	mg/L	229 [c]	261 [c]	14.0	271 [c]	3.8	15
Bromide	mg/L	0.737	0.808	9.6			
Chloride	mg/L	95.5	107	12.0			
Fluoride	mg/L	0.0352 [c]	0.035 [c]	-0.6			
Sulfate	mg/L	3.21	3.25	1.2			
Total Organic Carbon	mg/L	1.25	1.03	-17.6			
Nitrate-Nitrite as N	mg/L	2.02	2.2	8.9			
Total Organic Halides	µg/L	50.8 [d]	60.6 [d]	19.3	54 [d]	12.3	20
Silver	mg/L	0.000880 [d]	<0.000501	NC			
Aluminum	mg/L	0.0708 [c]	0.072	1.7			
Boron	mg/L	1.98	2.03	2.5			
Barium	mg/L	0.0626	0.0639	2.1			
Beryllium	mg/L	0.00107 [c]	0.00115 [c]	7.5			
Calcium	mg/L	10.6 [c]	11.0 [c]	3.8			
Cobalt	mg/L	0.00381	0.00411	7.9			
Chromium	mg/L	0.00044 [d]	0.00078 [d]	77.3			
Potassium	mg/L	0.716 [c]	0.730 [c]	2.0			
Magnesium	mg/L	29	30	3.4			
Manganese	mg/L	0.475	0.486	2.3			
Sodium	mg/L	9.64	9.85	2.2			
Nickel	mg/L	0.00131 [d]	0.00173 [d]	32.1			
Phosphorus	mg/L	0.00854 [d]	0.0070 [d]	-18.0			
Lead	mg/L	0.0041 [d]	0.00248 [d]	-39.5			
Sulfur	mg/L	1.38	1.40	1.4			
Antimony	mg/L	<0.000919	0.00263 [d]	NC			
Selenium	mg/L	0.00183 [d]	0.00181 [d]	-1.1			
Silicon	mg/L	11.1	11.3	1.8			
Tin	mg/L	0.00213 [c,d]	0.00145 [c,d]	-31.9			
Strontium	mg/L	0.0809	0.0828	2.3			
Titanium	mg/L	0.00036 [d]	0.00028 [d]	-22.2			
Uranium	mg/L	0.105 [c]	0.128 [c]	21.9			
Tungsten	mg/L	0.00334 [d]	<0.00183	NC			

[a] % Difference = (GWC-4-23-2 - GWC-4-23-1)/GWC-4-23-1 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.

Appendix A

Historical Monitoring Data for Selected Parameters

Table A-1. Historical Monitoring Data for Selected Parameters

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
Well: GWA-1 (Formerly CW-1)								
pH	5.86	6.27	5.6	6.7	6.05	5.94	6.4	5.7
Conductivity	98	114	112	121	104	85	116	101
Alkalinity	15.6	22.3	25.8	27.1	25	16.4	35.4	22.7
TDS	94	87	86	84	90	77	99	110
Chloride	7.3	7.4	5.9	4.6	3.8	8.2	1.9	2.1
Sulfate	4.5	8.5	8.5	11	17	3.7	17	26
Calcium	6.2	7.6	7.7	7	7.5	5.3	7.9	8.1
Magnesium	3.4	4.9	4.8	4.6	5.1	3.5	5.6	6.0
Sodium	4.2	4.8	4.9	4.3	4.4	3.8	4.1	4.2
Silicon	9.8	11	14	16	17	9.6	15	17
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	6.82	6.1	5.9	NS	NS	NS	NS	NS
Conductivity	128	100	110	NS	NS	NS	NS	NS
Alkalinity	28	27	24.8	NS	NS	NS	NS	NS
TDS	110	116	99	NS	NS	NS	NS	NS
Chloride	2.1	2.1	1.9	NS	NS	NS	NS	NS
Sulfate	30	20	28	NS	NS	NS	NS	NS
Calcium	4.1	8.0	8.3	NS	NS	NS	NS	NS
Magnesium	2.9	5.8	5.9	NS	NS	NS	NS	NS
Sodium	4.0	4.4	4.3	NS	NS	NS	NS	NS
Silicon	11	18	17	NS	NS	NS	NS	NS
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	
Well: GWA-1 (Formerly CW-1) (Continued)								
pH	NS	6.31	6.38	6.08	NM	6.14	6.54	
Conductivity	NS	116	165	118	NM	116	58	
Alkalinity	NS	28.6	23	NM	NM	NM	27.8	
TDS	NS	108	114	93	113	105	88	
Chloride	NS	2.10	2.27	1.94	2.26	3.3	3.65	
Sulfate	NS	18.3	24.4	30.8	32.7	12	9.34	
Calcium	NS	6.98	8.47	9.21	10.4	8.03	7.46	
Magnesium	NS	5.47	6.30	6.51	6.87	5.16	4.80	
Sodium	NS	4.29	4.53	3.50	4.65	4.34	4.16	
Silicon	NS	16.6	17.6	13.2	14.3	16.8	16.2	

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
Well: GWC-1 (Formerly CW-2)								
pH	6.09	5.79	5.62	5.93	6.04	5.96	6.1	4.5
Conductivity	81	70	72	63	63	66	78	57
Alkalinity	21.7	22.9	24.4	22.1	20.5	25.8	27.8	23.3
TDS	81	51	59	52	48	64	64	68
Chloride	3.5	2.8	3.1	3.4	2.8	2.5	2.5	2.6
Sulfate	7.6	5	2.8	<0.05	1.2	1.5	3.2	3.3
Calcium	3.9	3.6	3.8	3.2	3.4	3.6	4.3	4.0
Magnesium	2.3	2.5	2.8	2.2	2.4	2.5	3.2	3.0
Sodium	5.9	5.2	4.3	4.1	4.2	4.1	4.0	4.0
Silicon	9	9	9.2	11	11	11	11	12
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	5.83	6.0	6.0	6.1	5.89	5.91	6.09	6.09
Conductivity	67	57	61	74	61	60	68	76
Alkalinity	22.5	24.1	27.3	29.9	25	30.1	25	22
TDS	43	74	70	22	66	56	64	46
Chloride	2.6	2.6	2.5	3.5	2.43	2.77	2.71	2.68
Sulfate	2.2	<2.5	2.6	3.3	1.75	1.77	1.64	1.19
Calcium	8.8	4.1	4.1	5.1	4.72	4.65	5.00	4.50
Magnesium	6.2	2.9	3.0	3.7	3.14	3.39	3.70	3.33
Sodium	4.2	4.0	3.8	4.3	4.12	4.16	4.32	4.10
Silicon	16	12	12	12.7	11.9	11.9	11.8	10.9
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	
Well: GWC-1 (Formerly CW-2) (Continued)								
pH	6.05	5.70	6.00	5.92	6.04	5.84	5.96	
Conductivity	77	66	79	82	86	83	75	
Alkalinity	29.1	31.0	31	31.2	24.2	35	32.2	
TDS	63	72	58	49	71	63	81	
Chloride	2.64	2.76	2.77	2.45	2.20	2.47	2.57	
Sulfate	1.23	1.10	1.06	<0.0491	1.06	<0.154	0.69	
Calcium	5.30	5.12	5.12	5.86	5.91	5.62	5.85	
Magnesium	3.65	3.83	3.80	4.23	4.11	3.68	3.80	
Sodium	4.21	4.15	4.28	4.44	4.38	3.88	4.04	
Silicon	10.9	11.8	12.3	10.0	11.6	11	11.8	

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
Well: GWC-2 (Formerly CW-3)								
pH	5.64	5.6	5.04	5.5	4.97	5.65	5.5	4.6
Conductivity	76	69	64	66	33	71	66	56
Alkalinity	23.5	19.3	15.2	16.9	12.2	17.5	18.2	17.3
TDS	76	50	55	55	63	65	79	71
Chloride	4.3	5.2	6.9	6.2	5	5.3	3.0	3.4
Sulfate	6.4	5.5	6.3	5.9	5.8	6.3	6.5	7.6
Calcium	4.4	2.8	2.3	2	2	1.7	1.4	1.6
Magnesium	1.6	1.5	1.6	1.7	1.8	1.9	1.9	2.1
Sodium	7.3	7.4	6.9	7	7.5	7.6	7.5	7.4
Silicon	10	10	9.3	12	11	11	11	13
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	5.29	5.4	5.6	5.75	5.5	5.72	5.63	5.34
Conductivity	67	56	49	53	57	59	60	66
Alkalinity	12.5	14.1	15.9	15.7	14	16.2	7.0	6.9
TDS	68	77	60	27	76	58	60	65
Chloride	4.0	4.5	3.5	3.8	3.7	3.79	3.92	4.00
Sulfate	7.9	7.5	7.7	5.78	5.97	5.95	6.73	5.78
Calcium	1.7	1.6	1.9	2.0	2.19	2.05	2.11	1.89
Magnesium	2.1	1.9	2.0	1.8	1.92	1.93	2.03	1.87
Sodium	7.5	6.7	6.8	7.0	7.15	7.09	7.17	6.96
Silicon	12.0	11	13	12.9	13.3	13.0	12.9	12.2
Parameter	**Round 17 *28-29 Mar 95***	**Round 18 *13-14 Jun 95***	**Round 19 *11-12 Sep 95***	**Round 20 *12-13 Dec 95***	**Round 21 *18-19 Mar 96***	**Round 22 *20-21 Jun 96***	**Round 23 *13-14 Sep 96***	
Well: GWC-2 (Formerly CW-3) (Continued)								
pH	5.53	5.39	5.41	5.45	5.79	5.48	5.50	
Conductivity	65	65	67.5	67	66	59	62	
Alkalinity	13.3	14.5	13.5	13.0	NM	15	17.4	
TDS	63	64	54	53	69	75	82	
Chloride	3.81	3.97	3.83	3.91	3.79	3.93	4.04	
Sulfate	4.98	4.33	3.90	3.68	4.11	4.52	3.66	
Calcium	2.23	2.08	2.16	2.41	2.37	2.46	2.70	
Magnesium	1.88	1.92	1.88	1.96	1.92	1.98	1.96	
Sodium	6.79	6.85	6.94	7.11	7.04	6.6	7.16	
Silicon	12.2	13.4	13.5	12.9	13.7	13.4	13.8	

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
Well: GWC-3 (Formerly CW-4)								
pH	5.4	5.15	4.8	4.73	6.19	5.08	5.25	3.8
Conductivity	40	35	30	34	32	35	32	27
Alkalinity	11.5	15.2	9.9	11	7	11.1	10.0	8.9
TDS	50	35	31	34	39	41	28	37
Chloride	3	2.8	3.2	3.4	3.1	3.1	2.0	2.3
Sulfate	2.6	2.1	<0.05	<0.05	0 9	1.5	1.7	2.6
Calcium	1	<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
Sodium	4.4	4.5	4.3	4.1	4.6	4.3	4.1	4.0
Silicon	8	7.8	3.9	8.5	8.6	8.3	8.3	9.3
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	5.23	5.2	5.3	5.5	5.18	5.43	5.41	5.06
Conductivity	33	27	27	22	28	29	30	36
Alkalinity	7.0	8.5	9.1	9.3	7.5	8.5	77	4.8
TDS	44	52	21	<8.7	42	36	39	30
Chloride	2.7	2.9	2.8	2.8	2.77	2.76	2.91	3.02
Sulfate	1.6	<2.5	<2.5	<0.06	1.38	1.52	<0.0471	1.01
Calcium	<1.0	<1.0	<1.0	<1.0	0.392	0.321	0.328	0.335
Magnesium	<1.0	<1.0	<1.0	<1.0	0.962	0.935	1.00	1.02
Sodium	4.1	3.9	3.8	4.1	4.35	4.14	4.17	4.34
Silicon	9.0	8.7	9.2	9.7	10.1	9.16	9.15	8.94
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	
Well: GWC-3 (Formerly CW-4)								
pH	5.10	5.10	5.02	5.27	5.25	5.08	5.19	
Conductivity	36	37	45	39	42	41	38	
Alkalinity	8.6	8.5	9.0	9.1	7.4	9.2	9.7	
TDS	44	52	37	36	49	49	56	
Chloride	3.15	3.13	3.64	3.52	3.46	3.83	4.31	
Sulfate	<0.0471	0.968	0.595	0.233	<0.0491	0.192	1.49	
Calcium	0.441	0.314	0.389	0.436	0.361	0.433	0.505	
Magnesium	1.10	1.08	1.21	1.26	1.11	1.32	1.41	
Sodium	4.39	4.47	4.83	5.14	5.14	4.89	5.36	
Silicon	8.97	8.90	9.94	5.18	9.48	9.63	10.1	

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
Well: GWC-4 (Formerly CW-5)								
pH	5.34	4.97	4.8	4.6	5.03	5.4	5.05	3.9
Conductivity	62	62	66	72	54	70	72	58
Alkalinity	12.5	15.3	13.1	15.1	8.6	14.2	11.5	8.0
TDS	61	52	60	51	58	64	61	65
Chloride	5	4.2	5	5.6	4.5	5.2	3.1	3.4
Sulfate	2.2	4.6	8	6.8	7.1	5.8	5.3	5.5
Calcium	1.3	<1.0	<1.0	1.3	1.6	1.2	<1.0	<1.0
Magnesium	2.5	2.5	3.1	3.8	3.9	3.7	3.3	3.2
Sodium	5.4	5.8	5.3	5.1	5	5.2	4.8	4.9
Silicon	9.9	9.1	4.7	9.7	9.2	10	8.6	9.5
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	5.04	5.2	5.2	5.2	4.98	5.2	5.10	4.92
Conductivity	64	52	54	63	72	81	108	188
Alkalinity	6.0	6.9	7.0	9.2	5.0	10.3	5.0	3.8
TDS	63	55	44	20	64	75	93	110
Chloride	3.6	3.6	3.8	6.7	11.3	13.5	20.8	39.7
Sulfate	5.0	5.9	4.9	4.4	4.64	4.50	4.83	4.34
Calcium	1.0	<1.0	<1.0	1.3	1.81	1.62	2.73	4.04
Magnesium	3.2	2.7	2.9	3.7	5.05	4.98	7.32	11.0
Sodium	4.7	4.4	4.4	5.0	5.33	4.87	5.80	7.86
Silicon	8.7	8.3	9.3	9.8	9.91	9.18	9.91	10.1
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	
Well: GWC-4 (Formerly CW-5) (Continued)								
pH	5.10	4.98	4.79	4.89	4.98	4.71	4.94	
Conductivity	163	148	180	196	288	412	330	
Alkalinity	9.0	4.6	4.5	4.2	5.6	6.9	6.8	
TDS	113	132	123	107	175	266	229	
Chloride	34.1	39.1	37.5	40.5	66	106	95.5	
Sulfate	4.18	3.91	3.03	3.21	4.18	4.33	3.21	
Calcium	3.21	3.89	3.03	3.99	7.10	10.5	10.6	
Magnesium	10.2	12.5	10.0	12.6	19.1	30.2	29.0	
Sodium	7.63	8.61	8.42	8.00	9.36	9.95	9.64	
Silicon	9.36	10.0	10.4	11.4	10.8	10.3	11.1	

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
Well: GWC-5								
pH							5.6	4.4
Conductivity							61	60
Alkalinity							14.8	13.5
TDS							91	86
Chloride							1.8	2.6
Sulfate							8.8	10
Calcium							2.1	2.7
Magnesium							1.9	2.3
Sodium							6.0	6.2
Silicon							12	14
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	6.13	5.4	5.6	7.0	5.38	5.42	5.53	5.57
Conductivity	54	41	40	39	43	45	43	47
Alkalinity	12.5	10.2	11.5	10.8	8.6	10.8	13.0	11.2
TDS	67	56	50	29	53	61	61	45
Chloride	2.7	2.9	2.5	2.6	2.34	2.48	2.67	2.70
Sulfate	7.4	6.7	5.5	5.3	6.56	7.65	6.68	5.75
Calcium	2.2	1.6	1.4	1.3	1.65	1.38	1.26	1.20
Magnesium	1.8	1.5	1.4	1.3	1.6	1.55	1.46	1.32
Sodium	5.7	5.5	5.2	5.5	5.74	5.77	5.38	5.43
Silicon	13	12	12	11.4	11.8	11.3	10.5	10.3
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	
Well: GWC-5 (Continued)								
pH	5.52	5.60	5.20	5.28	5.54	5.24	5.39	
Conductivity	50	52	60	53	67	64	64	
Alkalinity	9.5	8.5	11.0	9.1	4.7	10.6	10.1	
TDS	50	64	64	45	72	76	66	
Chloride	2.54	2.62	2.70	2.93	2.78	2.98	3.00	
Sulfate	6.45	6.64	6.80	7.20	13.3	9.87	7.82	
Calcium	1.51	1.31	1.48	1.97	2.28	1.96	1.90	
Magnesium	1.59	1.73	1.78	6.02	2.65	2.36	2.06	
Sodium	5.34	5.54	6.12	5.82	6.43	5.82	5.96	
Silicon	10.3	11.1	11.5	16.2	11.3	11.3	11.1	

Appendix B

QA/QC Results

Table B-1. Results for Duplicate Samples—Third Quarter 1996

Parameter	Units	Sample GWC-4-23-1 [a]	Field Duplicate GWC-4-23-2 [a]	% Diff. [b]	Duplicate Analysis GWC-4-23-2	% RPD [c]	Spec. Limit
Total Dissolved Solids	mg/L	229 [d]	261 [d]	14.0	271 [c]	3.8	15
Bromide	mg/L	0.737	0.808	9.6			
Chloride	mg/L	95.5	107	12.0			
Fluoride	mg/L	0.0352 [d]	0.035 [d]	-0.6			
Sulfate	mg/L	3.21	3.25	1.2			
Total Organic Carbon	mg/L	1.25	1.03	-17.6			
Nitrate-Nitrite as N	mg/L	2.02	2.2	8.9			
Total Organic Halides	ug/L	50.8 [e]	60.6 [e]	19.3	54 [e]	12.3	20
Gross alpha	pCi/L	<1.2	<1.4	N/C			
Gross beta	pCi/L	<4.0	<4.8	N/C			
Pb-214	pCi/L	9.47 ± 7.27	5.49 ± 4.72	N/C			
Ac-228	pCi/L	4.93 ± 11.8	-2.47 ± 6.19	N/C			
Bi-214	pCi/L	8.65 ± 7.56	5.89 ± 5.06	N/C			
K-40	pCi/L	-48.5 ± 45.2	-53.9 ± 25.6	N/C			
Ra-226	pCi/L	0.480 ± 0.542	<0.180	N/C			
Ra-228	pCi/L	<0.470	<0.430	N/C			
Silver	mg/L	0.000880 [e]	<0.000501	NC			
Aluminum	mg/L	0.0708 [d]	0.072	1.7			
Arsenic	mg/L	<0.000887	<0.000887	NC			
Boron	mg/L	1.98	2.03	2.5			
Barium	mg/L	0.0626	0.0639	2.1			
Beryllium	mg/L	0.00107 [d]	0.00115 [d]	7.5			
Bismuth	mg/L	<0.00271	<0.00271	NC			
Calcium	mg/L	10.6 [d]	11.0 [d]	3.8			
Cadmium	mg/L	<0.000156	<0.000156	NC			
Cobalt	mg/L	0.00381	0.00411	7.9			
Copper	mg/L	<0.00136	<0.00136	NC			
Chromium	mg/L	0.00044 [e]	0.00078 [e]	77.3			
Mercury	mg/L	<0.000039	<0.000039	NC			
Iron	mg/L	<0.0135	<0.0135	NC			
Potassium	mg/L	0.716 [d]	0.730 [d]	2.0			
Magnesium	mg/L	29	30	3.4			
Manganese	mg/L	0.475	0.486	2.3			
Molybdenum	mg/L	<0.000705	<0.000705	NC			
Sodium	mg/L	9.64	9.85	2.2			
Nickel	mg/L	0.00131 [e]	0.00173 [e]	32.1			
Phosphorus	mg/L	0.00854 [e]	0.0070 [e]	-18.0			

Table B-1 (Continued)

Parameter	Units	Sample GWC-4-23-1 [a]	Field Duplicate GWC-4-23-2 [a]	% Diff. [b]	Duplicate Analysis GWC-4-23-2	% RPD [c]	Spec. Limit
Lead	mg/L	*0.0041* [e]	*0.00248* [e]	-39.5			
Sulfur	mg/L	1.38	1.40	1.4			
Antimony	mg/L	<0.000919	0.00263 [e]	NC			
Selenium	mg/L	0.00183 [e]	0.00181 [e]	-1.1			
Silicon	mg/L	11.1	11.3	1.8			
Tin	mg/L	0.00213 [d,e]	0.00145 [d,e]	-31.9			
Strontium	mg/L	0.0809	0.0828	2.3			
Tellurium	mg/L	<0.00170	<0.00170	NC			
Titanium	mg/L	*0.00036* [e]	*0.00028* [e]	-22.2			
Thallium	mg/L	<0.00168	<0.00168	NC			
Uranium	mg/L	0.105 [d]	0.128 [d]	21.9			
Vanadium	mg/L	<0.000681	<0.000681	NC			
Tungsten	mg/L	0.00334 [e]	<0.00183	NC			
Zinc	mg/L	<0.00309	<0.00309	NC			

[a] Duplicates for radionuclides were GWC-3-23-1 and GWC-3-23-2.

[b] % Difference = (GWC-4-23-2 - GWC-4-23-1)/GWC-4-23-1 x 100%.

[c] RPD = Relative Percent Difference, defined as follows:

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

[d] Detected in the method blank.

[e] 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.

Attachment B

Groundwater Monitoring Report for the Fourth Quarter of 1996

Table of Contents

List of Figures

List of Tables

1.0 Introduction

This report summarizes the results of groundwater monitoring performed during the fourth calendar quarter of 1996 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 was conducted at Georgia Power Company's Plant Yates Unit 1, located near Newnan, Georgia. With the completion of the fourth quarter 1996 groundwater monitoring, all EMP monitoring has now been completed.

1.1 Project Summary

The purpose of this ICCT project was 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 was 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 consisted of four distinct 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.

Period 2 ended in December 1994. Groundwater monitoring was initiated in Period 0 and continued through 24 months of Period 3; the last round of groundwater monitoring under the EMP was completed during the fourth quarter of 1996.

1.2 Purpose and Scope of Groundwater Monitoring

The CT-121 process produces gypsum, which is being disposed of 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 pre-operational groundwater monitoring was conducted on September 3-4 and October 14, 1992. The results from this monitoring effort were presented in the report "Interim Data Report of Pre-operational Groundwater Monitoring: September 3-4 and October 14, 1992."

Operational-phase groundwater monitoring, performed on a quarterly basis, was initiated in the fourth quarter of 1992. Monitoring was conducted for the suite of parameters shown in Table 1. Samples were analyzed each quarter for all parameters shown except for radionuclides, which are monitored semiannually.

Beginning in the second quarter of 1994, monitoring was also performed quarterly for total organic halides (TOX) and annually for volatile organic compounds (VOCs). These

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		

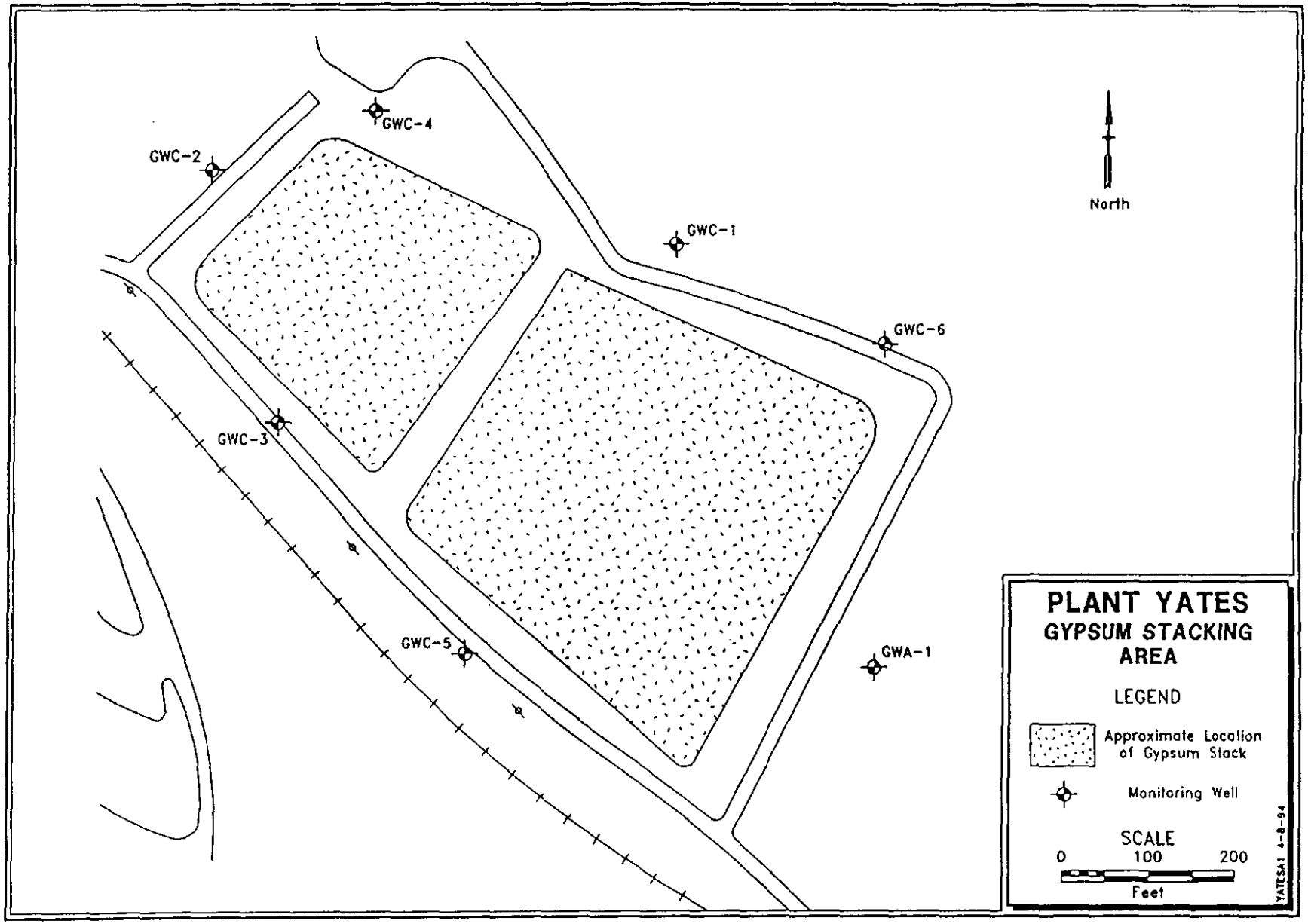


Figure 1. Location of Groundwater Monitoring Wells

parameters were added to comply with requirements of the permit issued by the Environmental Protection Division of the Georgia DNR.

The post-demonstration groundwater monitoring period began in the first quarter of 1995 and was conducted over a period of two years (i.e., until the fourth quarter of 1996) for the same parameters and at the same frequency as during the operational phase.

1.3 Report Contents

This report presents the results of quarterly post-demonstration groundwater monitoring for the fourth calendar quarter of 1996. The groundwater monitoring wells were sampled on November 22-23, 1996.

Section 2 is a brief summary of the groundwater sampling and analytical methods used to conduct the monitoring. The results of the monitoring 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 trends for selected parameters and the results for field and laboratory duplicates are given in the appendices. Note that the results of metals analyses were not available at the time this report was prepared.

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 gasoline-powered 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 (1) after at least three

wetted casing volumes of water were removed or (2) immediately following recovery if a well was purged dry.

Table 2 summarizes the groundwater samples collected during this monitoring period. Samples were obtained from the upgradient well (GWA-1) and five of the six downgradient wells (GWC-1, GWC-2, GWC-3, GWC-4, and GWC-5). As has been the case during all previous rounds of monitoring, no samples were collected from side-gradient well GWC-6 since this well was dry. Duplicate samples were collected from well GWC-4.

To preserve the integrity of the groundwater samples before analyses, proper sample container, preservation, 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 during this quarter's monitoring.

3.0 Summary of Results

The results of the fourth-quarter 1996 groundwater monitoring are presented in Table 5. Results are not included for metals since analytical data had not been received by the time this report was prepared.

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. The representative species selected are those present in appreciable concentrations in the gypsum slurry, including the major cations and anions (i.e., calcium, magnesium, chloride, 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 concentration-versus-time 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. As has been the case since monitoring began, samples could not be obtained from downgradient well GWC-6 because the well was dry.

Table 2. Summary of Groundwater Samples Collected at Plant Yates on November 22-23, 1996

Well ID	Sample ID	Analyses
GWA-1	GWA-1-24-1	Anions, TOC, TOX, and Metals
GWC-1	GWC-1-24-1	Anions, TOC, TOX, and Metals
GWC-2	GWC-2-24-1	Anions, TOC, TOX, and Metals
GWC-3	GWC-3-24-1	Anions, TOC, TOX, and Metals
GWC-4	GWC-4-24-1 GWC-4-24-2	Anions, TOC, TOX, and Metals Duplicate for Anions, TOC, TOX, and Metals
GWC-5	GWC-5-24-1	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
TOX	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
TOX	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
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.

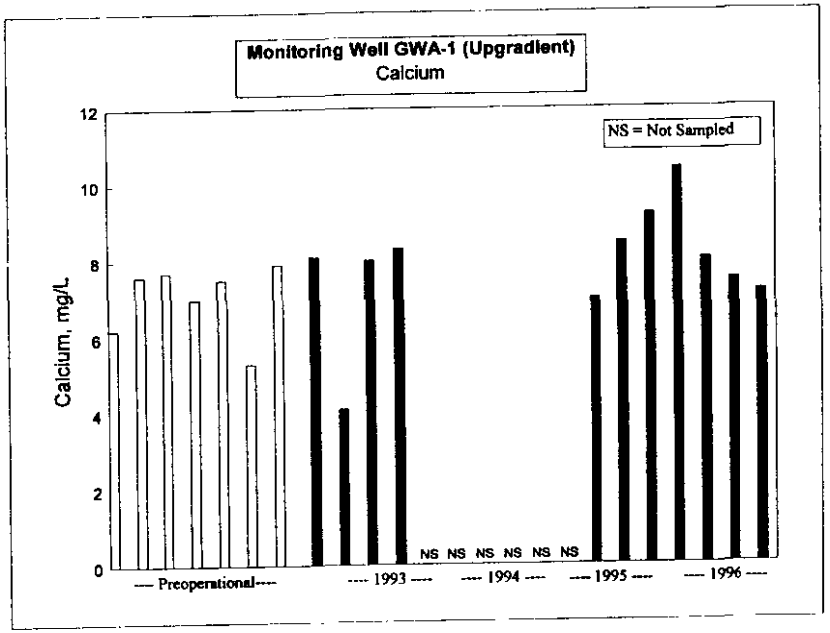
Table 5. Results of Groundwater Monitoring Conducted November 22-23, 1996 (4th Quarter 1996)

Parameter	GWA-1-24-1	GWC-1-24-1	GWC-2-24-1	GWC-3-24-1	GWC-4-24-1[a]	GWC-5-24-1
pH	5.70	5.65	5.47	5.06	4.48	5.23
Conductivity (µS/cm)	93	70	58	35	365	47
Temperature (°C)	17.3	16.3	16.6	17.1	18.1	17.1
Eh (mV)	159	184	226	246	289	237
Alkalinity (mg/L $CaCO_3$)	30.8	34	16.4	11.0	0	11.8
Total Dissolved Solids (mg/L)	102[b]	72[b]	68[b]	61[b]	233[b]	61[b]
Bromide (mg/L)	<0.0493	<0.0493	<0.0493	<0.0493	0.920	<0.0493
Chloride (mg/L)	3.02	2.70	4.35	4.49	117	2.92
Total Organic Carbon (mg/L)	0.215[b,c]	0.202[b,c]	0.371[b,c]	0.205[b,c]	0.897[b]	0.253[b,c]
TOX (µg/L)	<20.9	27.3[c]	<20.9	<20.9	<20.9	<20.9
Fluoride (mg/L)	0.0724[b]	0.0389[b]	0.0233[b]	0.0266[b]	0.0296[b]	0.0181[b]
Nitrate-Nitrite (mg/L as N)	0.462[b]	0.442[b]	1.03[b]	0.296[b]	2.12[b]	0.080[b]
Sulfate (mg/L)	14.2	1.55	4.04	1.27	4.28	8.47
Silver (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Aluminum (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Arsenic (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Boron (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Barium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Beryllium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Bismuth (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Calcium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Cadmium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Cobalt (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Copper (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Chromium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Mercury (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Iron (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]

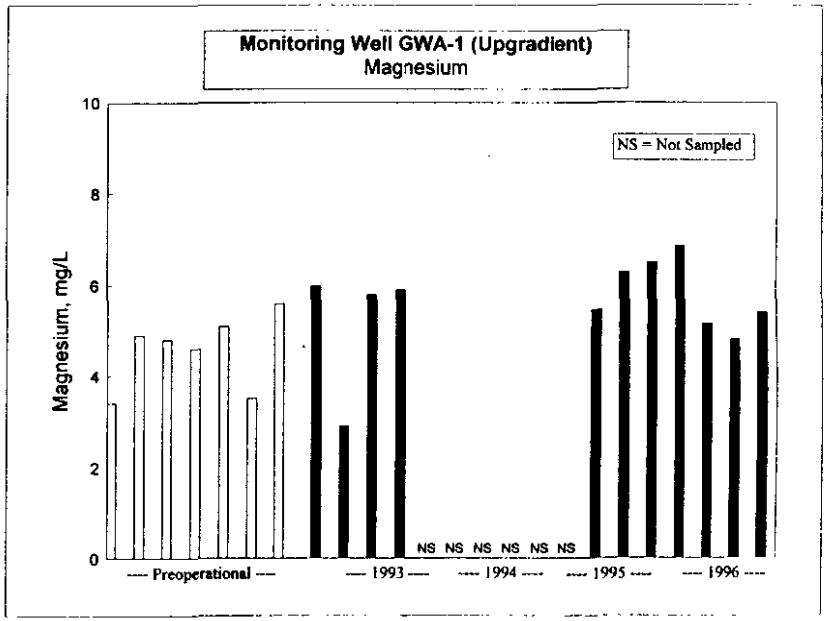
Table 5 (Continued)

Parameter	GWA-1-24-1	GWC-1-24-1	GWC-2-24-1	GWC-3-24-1	GWC-4-24-1[a]	GWC-5-24-1
Potassium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Lithium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Magnesium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Manganese (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Molybdenum (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Sodium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Nickel (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Phosphorus (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Lead (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Sulfur (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Antimony (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Selenium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Silicon (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Tin (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Strontium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Tellurium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Titanium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Thallium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Uranium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Vanadium (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Tungsten (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]
Zinc (mg/L)	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]	NA[d]

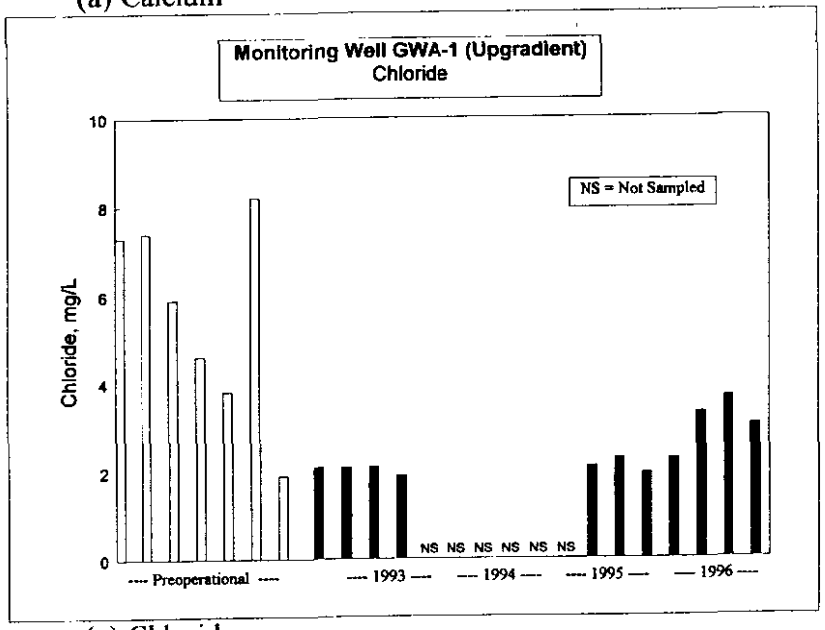
[a] A duplicate sample was collected from this well (GWC-4-24-2).
[b] Detected in the method blank.
[c] Less than five times the detection limit; results are expected to be less accurate as concentrations approach the detection limit.
[d] Results of metals analyses had not been received by the time this report was prepared.



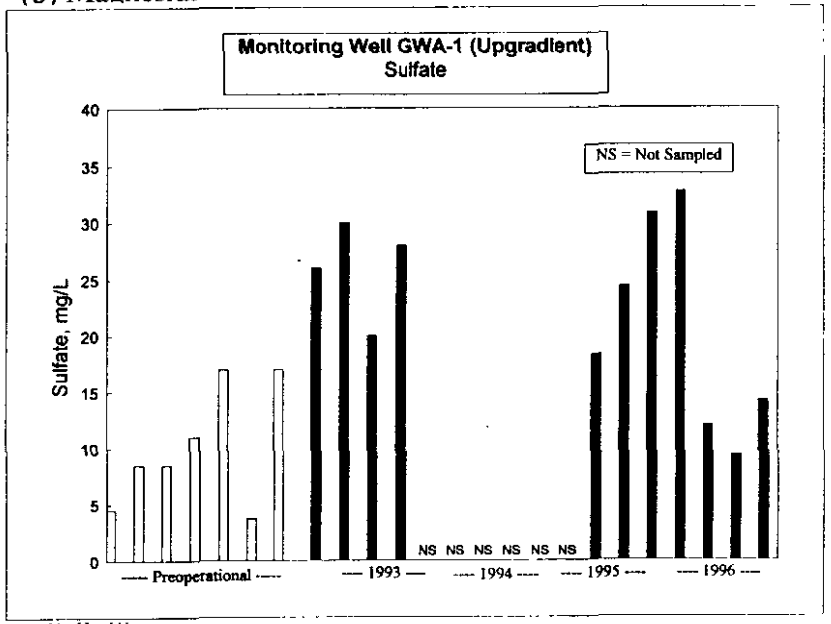
(a) Calcium



(b) Magnesium

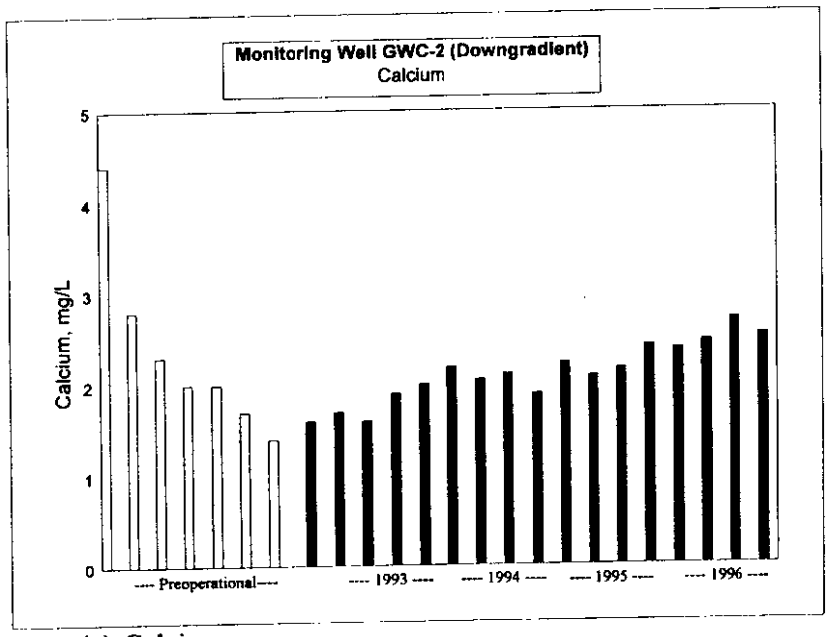


(c) Chloride

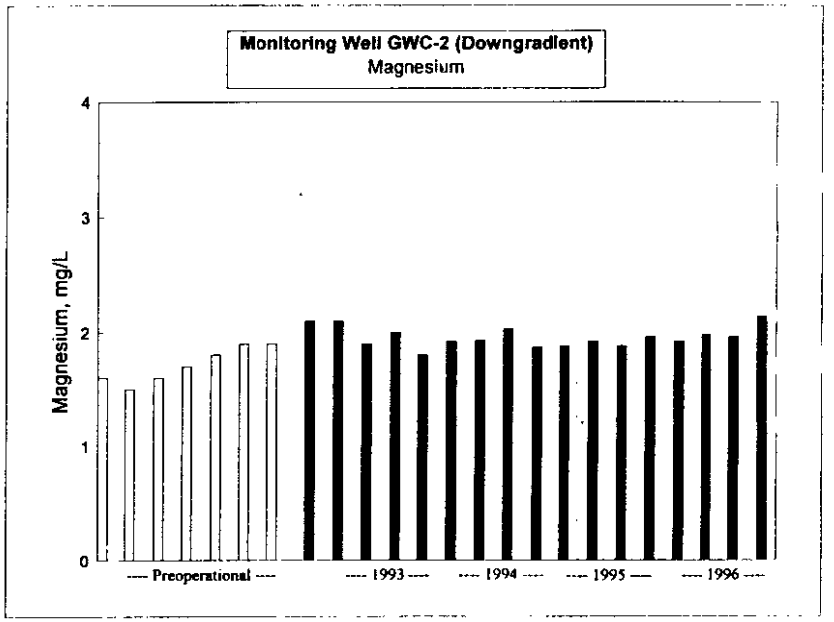


(d) Sulfate

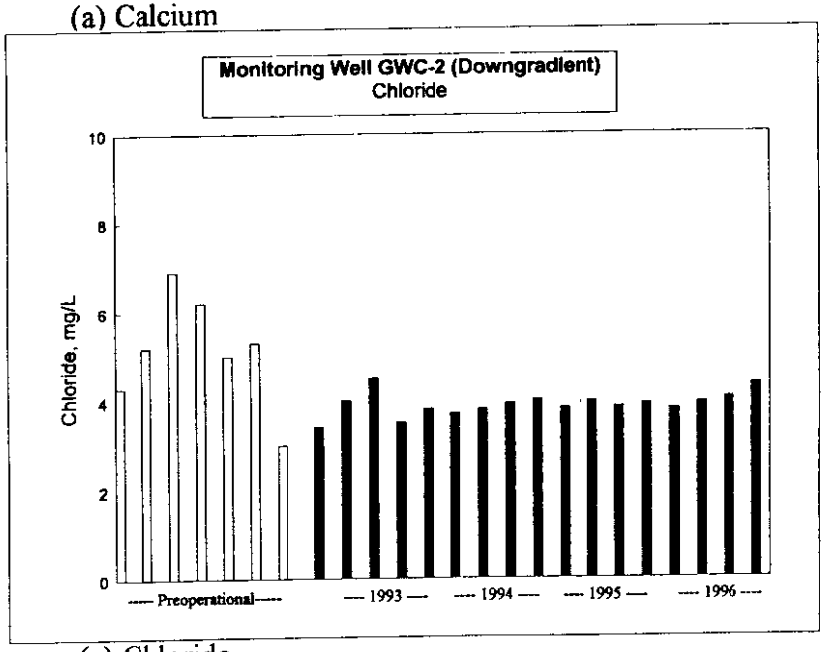
Figure 2. Historical Data for Representative Species from Well GWA-1 (Upgradient)



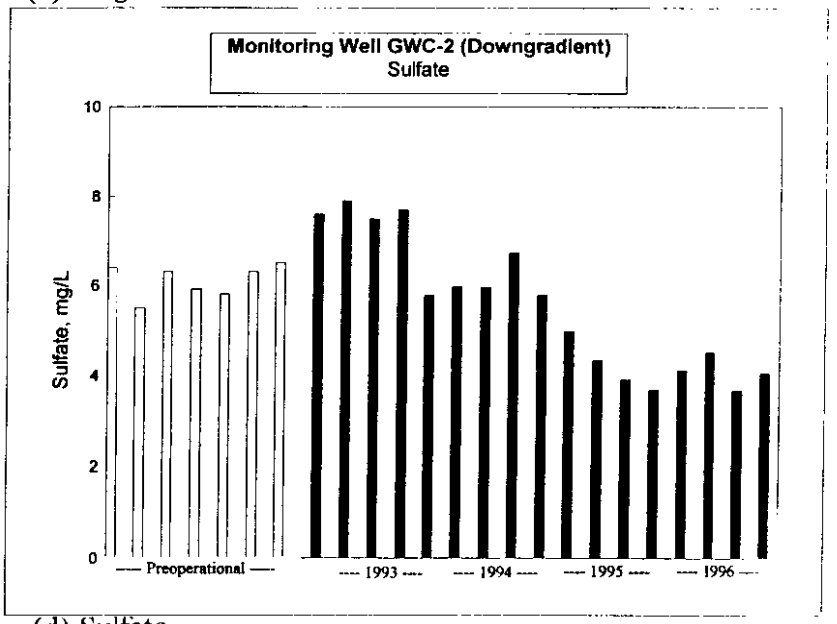
(a) Calcium



(b) Magnesium

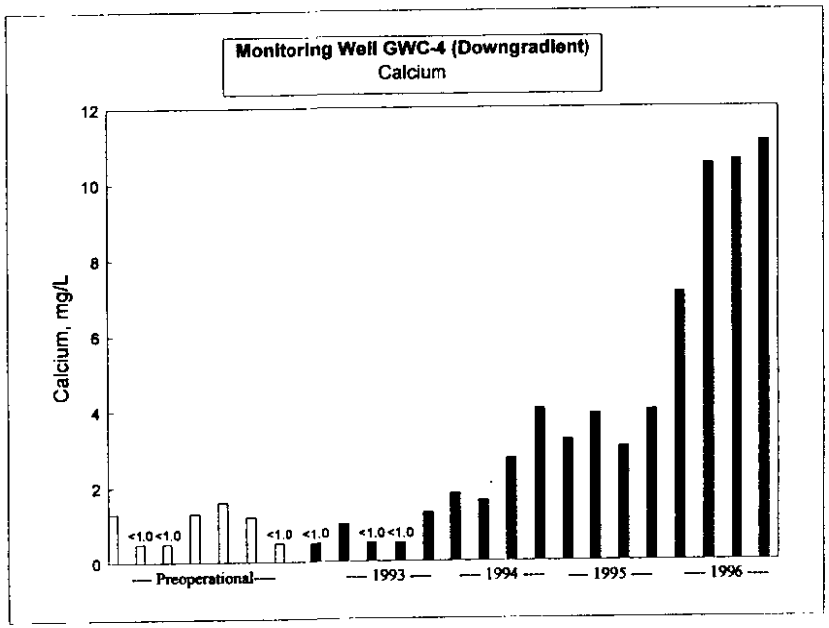


(c) Chloride

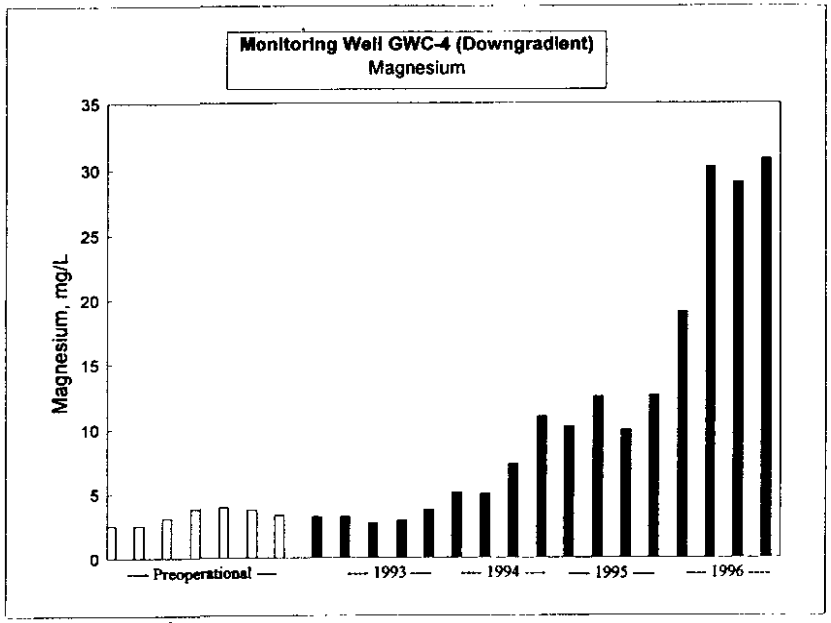


(d) Sulfate

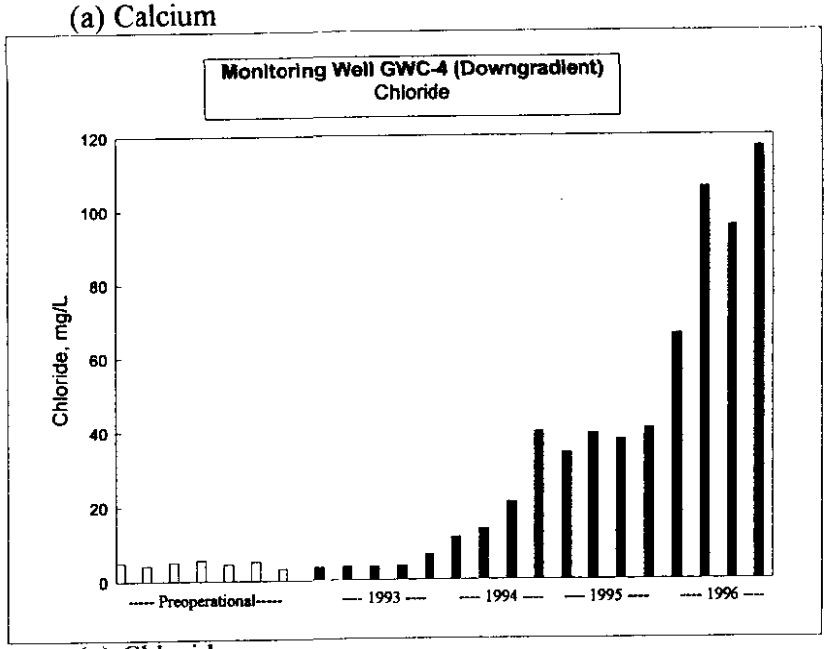
Figure 3. Historical Data for Representative Species from Well GWC-2 (Downgradient)



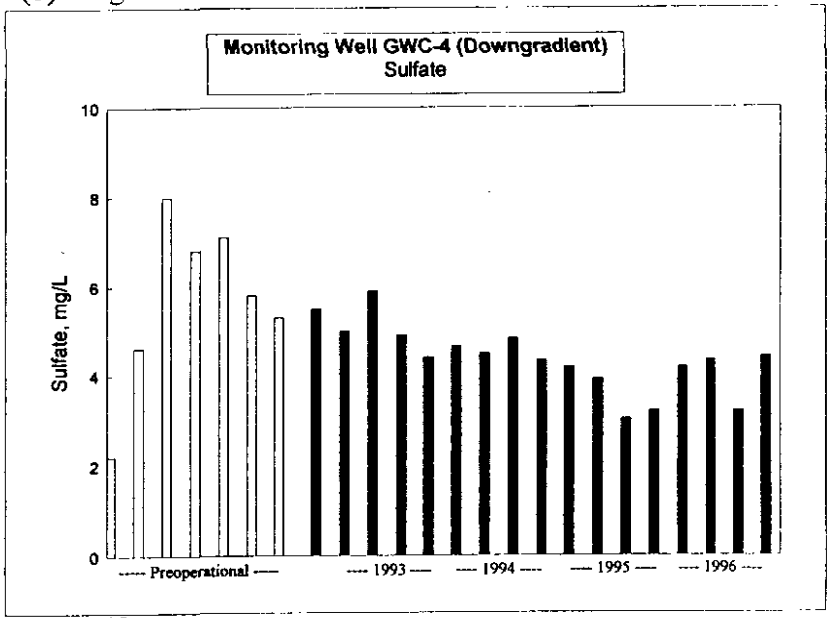
(a) Calcium



(b) Magnesium



(c) Chloride



(d) Sulfate

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

The concentration of chloride in the water from downgradient well GWC-4 was slightly higher than that found during the previous quarter's monitoring. Because the results of metals analyses were not available at the time this report was prepared, no comparisons can be made for calcium and magnesium. A generally upward trend in the concentrations of these gypsum constituents was first noticed in the fourth quarter of 1993. There have been no significant increases in the levels of these species in either the upgradient well or the other downgradient wells.

The source(s) of the higher levels of gypsum constituents in well GWC-4 is (are) not clearly apparent. However, there are several potential sources, and three of the more plausible are briefly described below:

- A breach of the dike surrounding the gypsum pond occurred on July 24, 1993. This breach happened in the vicinity of well GWC-4. Since the increase in the levels of chloride, magnesium, and calcium in GWC-4 was first noticed in the fourth quarter of 1993, it seemed likely that the increase was the result of the dike breach. The validity of this assumption appeared to be reinforced in the first quarter of 1995, when the levels of the three species declined in GWC-4. Such a decline would be expected as the amount of spilled material remaining in the soil diminished due to gradual downward migration in the soil. However, no further decrease in the GWC-4 concentrations occurred over the following three quarters of 1995. In fact, further increases in the levels of magnesium and calcium have been noted in the first three quarters of 1996, although the increases appear to have stabilized in the latter two quarters. The chloride levels in GWC-4 have also stabilized in the last three quarters of 1996. Although this behavior could still be due to the 1993 breach (e.g., due to changes in rainfall patterns and/or acidity of the rain could cause higher migration rates and/or increased leaching of the soil), other factors could be contributing to or causing higher levels of gypsum constituents in the groundwater in the vicinity of GWC-4.

- The groundwater sampling team has noticed that there appear to have been periodic leaks from a slurry pump and associated valves and fittings that are in close proximity (i.e., within 30-40 feet) to GWC-4. Slurry has periodically leaked onto the ground and flowed across the soil surface to form small pools within 10-15 feet of GWC-4. This material could be the source of at least some of the observed increases in chloride, magnesium, and calcium concentrations.

- The possibility that the increased levels of the gypsum slurry constituents in GWC-4 could be caused by a leak in the liner under the gypsum stacking area cannot be discounted. There is no indication of leakage in the monitoring results

from the other wells, but this does not preclude the presence of a liner leak at a location immediately upgradient from GWC-4.

At this time, it is not possible to determine which, if any, of the possible causes described above is contributing the bulk of the chloride, etc., being seen in GWC-4. Some clarification may be forthcoming as more results of the continuing groundwater monitoring activities become available.

4.0 Summary of QA/QC Activities

A number of QA/QC activities are being 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 analytical 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 measured above the detection limit in at least one sample. Complete results are provided in Appendix B. Results are not shown for metals since the sample analyses were not available at the time this report was prepared. Differences in the duplicate analyses results were small (i.e., less than 10-20%) for all species except TOC. For TOC, the measured concentrations

were near the detection limit, where less accurate results can be expected. The results of the duplicate analyses performed for TDS were within specified quality limits.

Table 6. Results for Duplicate Samples—Fourth Quarter 1996

Parameter	Units	Sample GWC-4-24-1	Field Duplicate GWC-4-24-2	% Diff. [a]	Duplicate Analysis GWC-4-24-2	% RPD [b]	Spec. Limit
Total Dissolved Solids	mg/L	233 [c]	225 [c]	-3.4	236 [c]	4.8	15
Bromide	mg/L	0.92	0.93	1.1			
Chloride	mg/L	117	114	-2.6			
Fluoride	mg/L	0.0296 [c]	0.0298 [c]	0.7			
Sulfate	mg/L	4.28	4.42	3.3			
Nitrate-Nitrite as N	mg/L	2.12 [c]	1.98 [c]	-6.6			
Total Organic Carbon	mg/L	0.897 [c]	0.462 [c]	-48.5			
Total Organic Halides	ug/L	<20.9	22 [d]	NC			

[a] % Difference = (GWC-4-24-2 - GWC-4-24-1)/GWC-4-24-1 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.

Appendix A

Historical Monitoring Data for Selected Parameters

Table A-1. Historical Monitoring Data for Selected Parameters

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
Well: GWA-1 (Formerly CW-1)								
pH	5.86	6.27	5.6	6.7	6.05	5.94	6.4	5.7
Conductivity	98	114	112	121	104	85	116	101
Alkalinity	15.6	22.3	25.8	27.1	25	16.4	35.4	22.7
TDS	94	87	86	84	90	77	99	110
Chloride	7.3	7.4	5.9	4.6	3.8	8.2	1.9	2.1
Sulfate	4.5	8.5	8.5	11	17	3.7	17	26
Calcium	6.2	7.6	7.7	7	7.5	5.3	7.9	8.1
Magnesium	3.4	4.9	4.8	4.6	5.1	3.5	5.6	6.0
Sodium	4.2	4.8	4.9	4.3	4.4	3.8	4.1	4.2
Silicon	9.8	11	14	16	17	9.6	15	17

Parameter	Round 9 30-31 Mar 93	Round 10 21 Jun 93	Round 11 23-24 Sep 93	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	6.82	6.1	5.9	NS	NS	NS	NS	NS
Conductivity	128	100	110	NS	NS	NS	NS	NS
Alkalinity	28	27	24.8	NS	NS	NS	NS	NS
TDS	110	116	99	NS	NS	NS	NS	NS
Chloride	2.1	2.1	1.9	NS	NS	NS	NS	NS
Sulfate	30	20	28	NS	NS	NS	NS	NS
Calcium	4.1	8.0	8.3	NS	NS	NS	NS	NS
Magnesium	2.9	5.8	5.9	NS	NS	NS	NS	NS
Sodium	4.0	4.4	4.3	NS	NS	NS	NS	NS
Silicon	11	18	17	NS	NS	NS	NS	NS

Parameter	Round 17 28-29 Mar 95	Round 18 13-14 Jun 95	Round 19 11-12 Sep 95	Round 20 12-13 Dec 95	Round 21 18-19 Mar 96	Round 22 20-21 Jun 96	Round 23 13-14 Sep 96	Round 24 22-23 Nov 96
Well: GWA-1 (Formerly CW-1) (Continued)								
pH	NS	6.31	6.38	6.08	NM	6.14	6.54	5.70
Conductivity	NS	116	165	118	NM	116	58	93
Alkalinity	NS	28.6	23	NM	NM	NM	27.8	30.8
TDS	NS	108	114	93	113	105	88	102
Chloride	NS	2.10	2.27	1.94	2.26	3.3	3.65	3.02
Sulfate	NS	18.3	24.4	30.8	32.7	12	9.34	14.2
Calcium	NS	6.98	8.47	9.21	10.4	8.03	7.46	NA
Magnesium	NS	5.47	6.30	6.51	6.87	5.16	4.80	NA
Sodium	NS	4.29	4.53	3.50	4.65	4.34	4.16	NA
Silicon	NS	16.6	17.6	13.2	14.3	16.8	16.2	NA

Parameter	Round 1 6 Sep 90
Well: GWC-1 (Formerly CW-2	
pH	6.09
Conductivity	81
Alkalinity	21.7
TDS	81
Chloride	3.5

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
Well: GWC-2 (Formerly CW-3)								
pH	5.64	5.6	5.04	5.5	4.97	5.65	5.5	4.6
Conductivity	76	69	64	66	33	71	66	56
Alkalinity	23.5	19.3	15.2	16.9	12.2	17.5	18.2	17.3
TDS	76	50	55	55	63	65	79	71
Chloride	4.3	5.2	6.9	6.2	5	5.3	3.0	3.4
Sulfate	6.4	5.5	6.3	5.9	5.8	6.3	6.5	7.6
Calcium	4.4	2.8	2.3	2	2	1.7	1.4	1.6
Magnesium	1.6	1.5	1.6	1.7	1.8	1.9	1.9	2.1
Sodium	7.3	7.4	6.9	7	7.5	7.6	7.5	7.4
Silicon	10	10	9.3	12	11	11	11	13
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	5.29	5.4	5.6	5.75	5.5	5.72	5.63	5.34
Conductivity	67	56	49	53	57	59	60	66
Alkalinity	12.5	14.1	15.9	15.7	14	16.2	7.0	6.9
TDS	68	77	60	27	76	58	60	65
Chloride	4.0	4.5	3.5	3.8	3.7	3.79	3.92	4.00
Sulfate	7.9	7.5	7.7	5.78	5.97	5.95	6.73	5.78
Calcium	1.7	1.6	1.9	2.0	2.19	2.05	2.11	1.89
Magnesium	2.1	1.9	2.0	1.8	1.92	1.93	2.03	1.87
Sodium	7.5	6.7	6.8	7.0	7.15	7.09	7.17	6.96
Silicon	12.0	11	13	12.9	13.3	13.0	12.9	12.2
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	**Round 24 22-23 Nov 96**
Well: GWC-2 (Formerly CW-3) (Continued)								
pH	5.53	5.39	5.41	5.45	5.79	5.48	5.50	5.47
Conductivity	65	65	67.5	67	66	59	62	58
Alkalinity	13.3	14.5	13.5	13.0	NM	15	17.4	16.4
TDS	63	64	54	53	69	75	82	68
Chloride	3.81	3.97	3.83	3.91	3.79	3.93	4.04	4.35
Sulfate	4.98	4.33	3.90	3.68	4.11	4.52	3.66	4.04
Calcium	2.23	2.08	2.16	2.41	2.37	2.46	2.70	NA
Magnesium	1.88	1.92	1.88	1.96	1.92	1.98	1.96	NA
Sodium	6.79	6.85	6.94	7.11	7.04	6.6	7.16	NA
Silicon	12.2	13.4	13.5	12.9	13.7	13.4	13.8	NA

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
Well: GWC-3 (Formerly CW-4)								
pH	5.4	5.15	4.8	4.73	6.19	5.08	5.25	3.8
Conductivity	40	35	30	34	32	35	32	27
Alkalinity	11.5	15.2	9.9	11	7	11.1	10.0	8.9
TDS	50	35	31	34	39	41	28	37
Chloride	3	2.8	3.2	3.4	3.1	3.1	2.0	2.3
Sulfate	2.6	2.1	<0.05	<0.05	0.9	1.5	1.7	2.6
Calcium	1	<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
Sodium	4.4	4.5	4.3	4.1	4.6	4.3	4.1	4.0
Silicon	8	7.8	3.9	8.5	8.6	8.3	8.3	9.3
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	5.23	5.2	5.3	5.5	5.18	5.43	5.41	5.06
Conductivity	33	27	27	22	28	29	30	36
Alkalinity	7.0	8.5	9.1	9.3	7.5	8.5	77	4.8
TDS	44	52	21	<8.7	42	36	39	30
Chloride	2.7	2.9	2.8	2.8	2.77	2.76	2.91	3.02
Sulfate	1.6	<2.5	<2.5	<0.06	1.38	1.52	<0.0471	1.01
Calcium	<1.0	<1.0	<1.0	<1.0	0.392	0.321	0.328	0.335
Magnesium	<1.0	<1.0	<1.0	<1.0	0.962	0.935	1.00	1.02
Sodium	4.1	3.9	3.8	4.1	4.35	4.14	4.17	4.34
Silicon	9.0	8.7	9.2	9.7	10.1	9.16	9.15	8.94
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	**Round 24 22-23 Nov 96**
Well: GWC-3 (Formerly CW-4)								
pH	5.10	5.10	5.02	5.27	5.25	5.08	5.19	5.06
Conductivity	36	37	45	39	42	41	38	35
Alkalinity	8.6	8.5	9.0	9.1	7.4	9.2	9.7	11.0
TDS	44	52	37	36	49	49	56	61
Chloride	3.15	3.13	3.64	3.52	3.46	3.83	4.31	4.49
Sulfate	<0.0471	0.968	0.595	0.233	<0.0491	0.192	1.49	1.27
Calcium	0.441	0.314	0.389	0.436	0.361	0.433	0.505	NA
Magnesium	1.10	1.08	1.21	1.26	1.11	1.32	1.41	NA
Sodium	4.39	4.47	4.83	5.14	5.14	4.89	5.36	NA
Silicon	8.97	8.90	9.94	5.18	9.48	9.63	10.1	NA

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
Well: GWC-4 (Formerly CW-5)								
pH	5.34	4.97	4.8	4.6	5.03	5.4	5.05	3.9
Conductivity	62	62	66	72	54	70	72	58
Alkalinity	12.5	15.3	13.1	15.1	8.6	14.2	11.5	8.0
TDS	61	52	60	51	58	64	61	65
Chloride	5	4.2	5	5.6	4.5	5.2	3.1	3.4
Sulfate	2.2	4.6	8	6.8	7.1	5.8	5.3	5.5
Calcium	1.3	<1.0	<1.0	1.3	1.6	1.2	<1.0	<1.0
Magnesium	2.5	2.5	3.1	3.8	3.9	3.7	3.3	3.2
Sodium	5.4	5.8	5.3	5.1	5	5.2	4.8	4.9
Silicon	9.9	9.1	4.7	9.7	9.2	10	8.6	9.5
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	5.04	5.2	5.2	5.2	4.98	5.2	5.10	4.92
Conductivity	64	52	54	63	72	81	108	188
Alkalinity	6.0	6.9	7.0	9.2	5.0	10.3	5.0	3.8
TDS	63	55	44	20	64	75	93	110
Chloride	3.6	3.6	3.8	6.7	11.3	13.5	20.8	39.7
Sulfate	5.0	5.9	4.9	4.4	4.64	4.50	4.83	4.34
Calcium	1.0	<1.0	<1.0	1.3	1.81	1.62	2.73	4.04
Magnesium	3.2	2.7	2.9	3.7	5.05	4.98	7.32	11.0
Sodium	4.7	4.4	4.4	5.0	5.33	4.87	5.80	7.86
Silicon	8.7	8.3	9.3	9.8	9.91	9.18	9.91	10.1
Parameter	**Round 17 28-29 Mar 95**	**Round 18 13-14 Jun 95**	**Round 19 11-12 Sep 95**	**Round 20 12-13 Dec 95**	**Round 21 18-19 Mar 96**	**Round 22 20-21 Jun 96**	**Round 23 13-14 Sep 96**	**Round 24 22-23 Nov 96**
Well: GWC-4 (Formerly CW-5) (Continued)								
pH	5.10	4.98	4.79	4.89	4.98	4.71	4.94	4.48
Conductivity	163	148	180	196	288	412	330	368
Alkalinity	9.0	4.6	4.5	4.2	5.6	6.9	6.8	0
TDS	113	132	123	107	175	266	229	233
Chloride	34.1	39.1	37.5	40.5	66	106	95.5	117
Sulfate	4.18	3.91	3.03	3.21	4.18	4.33	3.21	4.28
Calcium	3.21	3.89	3.03	3.99	7.10	10.5	10.6	NA
Magnesium	10.2	12.5	10.0	12.6	19.1	30.2	29.0	NA
Sodium	7.63	8.61	8.42	8.00	9.36	9.95	9.64	NA
Silicon	9.36	10.0	10.4	11.4	10.8	10.3	11.1	NA

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
Well: GWC-5								
pH							5.6	4.4
Conductivity							61	60
Alkalinity							14.8	13.5
TDS							91	86
Chloride							1.8	2.6
Sulfate							8.8	10
Calcium							2.1	2.7
Magnesium							1.9	2.3
Sodium							6.0	6.2
Silicon							12	14
Parameter	**Round 9 30-31 Mar 93**	**Round 10 21 Jun 93**	**Round 11 23-24 Sep 93**	**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	6.13	5.4	5.6	7.0	5.38	5.42	5.53	5.57
Conductivity	54	41	40	39	43	45	43	47
Alkalinity	12.5	10.2	11.5	10.8	8.6	10.8	13.0	11.2
TDS	67	56	50	29	53	61	61	45
Chloride	2.7	2.9	2.5	2.6	2.34	2.48	2.67	2.70
Sulfate	7.4	6.7	5.5	5.3	6.56	7.65	6.68	5.75
Calcium	2.2	1.6	1.4	1.3	1.65	1.38	1.26	1.20
Magnesium	1.8	1.5	1.4	1.3	1.6	1.55	1.46	1.32
Sodium	5.7	5.5	5.2	5.5	5.74	5.77	5.38	5.43
Silicon	13	12	12	11.4	11.8	11.3	10.5	10.3
Parameter	***Round 17 28-29 Mar 95***	***Round 18 13-14 Jun 95***	***Round 19 11-12 Sep 95***	***Round 20 12-13 Dec 95***	***Round 21 18-19 Mar 96***	***Round 22 20-21 Jun 96***	***Round 23 13-14 Sep 96***	***Round 24 22-23 Nov 96***
Well: GWC-5 (Continued)								
pH	5.52	5.60	5.20	5.28	5.54	5.24	5.39	5.23
Conductivity	50	52	60	53	67	64	64	47
Alkalinity	9.5	8.5	11.0	9.1	4.7	10.6	10.1	11.8
TDS	50	64	64	45	72	76	66	61
Chloride	2.54	2.62	2.70	2.93	2.78	2.98	3.00	2.92
Sulfate	6.45	6.64	6.80	7.20	13.3	9.87	7.82	8.47
Calcium	1.51	1.31	1.48	1.97	2.28	1.96	1.90	NA
Magnesium	1.59	1.73	1.78	6.02	2.65	2.36	2.06	NA
Sodium	5.34	5.54	6.12	5.82	6.43	5.82	5.96	NA
Silicon	10.3	11.1	11.5	16.2	11.3	11.3	11.1	NA

Appendix B

QA/QC Results

Table B-1. Results for Duplicate Samples—Fourth Quarter 1996

Parameter	Units	Sample GWC-4-24-1	Field Duplicate GWC-4-24-2	% Diff. [a]	Duplicate Analysis GWC-4-24-2	% RPD [b]	Spec. Limit
Total Dissolved Solids	mg/L	233 [c]	225 [c]	-3.4	236 [c]	2.2	15
Bromide	mg/L	0.92	0.93	1.1			
Chloride	mg/L	117	114	-2.6			
Fluoride	mg/L	0.0296 [c]	0.0298 [c]	0.7			
Sulfate	mg/L	4.28	4.42	3.3			
Nitrate-Nitrite as N	mg/L	2.12 [c]	1.98 [c]	-6.6			
Total Organic Carbon	mg/L	0.897 [c]	0.462 [c]	-48.5			
Total Organic Halides	ug/L	<20.9	22 [d]	NC			
Silver	mg/L	0.0013 [c]	0.0011 [c]	-15.4			
Aluminum	mg/L	0.0666 [c]	0.0588 [c]	-11.7			
Antimony	mg/L	<0.0042	<0.0042	NC			
Arsenic	mg/L	<0.0027	<0.0027	NC			
Boron	mg/L	1.77	1.85	4.5			
Barium	mg/L	0.0648	0.0653	0.8			
Beryllium	mg/L	0.001	0.001	0.0			
Calcium	mg/L	11.1	11.3	1.8			
Cadmium	mg/L	<0.0002	<0.0002	NC			
Cobalt	mg/L	0.0044 [c]	0.0045 [c]	2.3			
Copper	mg/L	0.00057	0.00066	15.8			
Chromium	mg/L	0.0017 [d]	0.0018 [d]	5.9			
Mercury	mg/L	0.00005 [d]	0.00005 [d]	0.0			
Iron	mg/L	0.0203 [d]	0.0255 [d]	25.6			
Potassium	mg/L	0.644	0.643	-0.2			
Magnesium	mg/L	30.8	31.3	1.6			
Manganese	mg/L	0.583	0.593	1.7			
Molybdenum	mg/L	<0.0038	<0.0038	NC			
Sodium	mg/L	10.1	10.0	-1.0			
Nickel	mg/L	<0.0010	0.0018 [d]	NC			
Lead	mg/L	<0.0011	<0.0011	NC			
Selenium	mg/L	<0.0026	<0.0026	NC			
Silicon	mg/L	11.7	11.6	-0.9			
Tin	mg/L	<0.0173	<0.0173	NC			

Table B-1 (Continued)

Parameter	Units	Sample GWC-4-24-1	Field Duplicate GWC-4-24-2	% Diff. [a]	Duplicate Analysis GWC-4-24-2	% RPD [b]	Spec. Limit
Strontium	mg/L	0.0892	0.0905	1.5			
Titanium	mg/L	0.0018 [d]	<0.0014	NC			
Thallium	mg/L	<0.0032	<0.0032	NC			
Vanadium	mg/L	<0.00060	<0.00060	NC			
Zinc	mg/L	0.007	0.003	-57.1			

[a] % Difference = (GWC-4-24-2 - GWC-4-24-1)/GWC-4-24-1 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.