CROW BUTTE RESOURCES, INC.

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August 28, 2003

Ms. Susan Frant
Branch Chief
Fuel Cycle Licensing Branch
Division of Fuel Cycle Safety and Safeguards
c/o Document Control Desk
U.S. Nuclear Regulatory Commission
Washington D.C. 20555

Subject: Request for Amendment
Source Materials License SUA-1534
Docket Number 40-8943

Dear Ms. Frant:

Crow Butte Resources, Inc. (CBR) is submitting this request for an amendment to Source Materials License SUA-1534 concerning the required excursion monitoring parameters. License Condition 10.4 states:

10.4 The licensee shall establish upper control limits (UCLs) in designated upper aquifer and perimeter monitor wells before lixiviant is injected in each wellfield unit. The UCLs shall be established by collecting and analyzing groundwater samples from those designated wells according to the following criteria:

A. Three samples shall be collected from each designated monitoring well at a minimum density of: 1) one upper aquifer monitoring well per 5 acres of wellfield area, and 2) all perimeter monitoring wells. These samples shall be collected at least 14 days apart. The results of these analyses shall constitute the baseline for each designated well.

B. The samples shall be analyzed for the following indicator parameters: chloride, sodium, sulfate, conductivity, and total alkalinity.

C. The UCLs shall be calculated for each indicator parameter, in each monitoring well, as equal to 20 percent above the maximum concentration measured for that parameter, among the three baseline samples. For those indicator parameters with baseline concentrations that average 50 mg/L or less, the UCL for that parameter may be calculated as equal to 20 percent above the maximum baseline concentration, the baseline average plus 5 standard deviations, or the baseline average plus 15 mg/L.

NMSS01

CBR requests that sodium and sulfate be removed from the list of required indicator parameters in License Condition 10.4 B. The basis for this request is that these parameters provide no additional information with respect to the timely identification of an excursion. Sodium is not a reliable excursion indicator due to the potential for cation exchange reactions in the aquifer. Sulfate concentrations in groundwater are naturally more variable compared to alkalinity, chloride, and conductivity, which limit its use as a reliable excursion indicator. Sulfate concentrations may also be affected by various biological and geochemical reactions.

The current indicator parameters were chosen during the licensing process for the Research and Development (R&D) facility. Wyoming Fuel Company (a precursor of CBR) originally proposed that chloride, conductivity, and uranium be used as excursion indicator parameters[1]. During the licensing and Underground Injection Control (UIC) permitting process, comments made by the U.S. Environmental Protection Agency (EPA)[2] concerning excursion indicator parameters resulted in the selection of the five parameters currently in use. To support the selection of these parameters, Wyoming Fuel referenced NUREG/CR-3136[3], which discussed the desirable properties for selection of appropriate excursion indicators. Four of the selected parameters (chloride, sodium, sulfate, and TDS measured by specific conductance) were discussed in NUREG-3136 as acceptable indicator parameters. Source Materials License SUA-1441, issued on January 4, 1985, incorporated the use of the five parameters currently required by License Condition 10.4 B.

In the twenty years since the original R&D License Application, experience gained by the uranium solution mining industry indicates that sodium and sulfate are generally not desirable excursion indicators due to the factors noted above. NUREG/CR-3709[4], which was published shortly after the R&D License was approved, noted that sodium was susceptible to cation exchange in the formation and that the differences in concentration between the injection solution and the formation water may not be preserved as the solution flows towards a monitor well. NUREG/CR-3709 also noted that natural oxidation of pyrite may produce large, localized variations in sulfate concentrations. These early recommendations

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[1] Wyoming Fuel Company, *Application and Supporting Environmental Report for NRC Research and Development Source Materials License, Dawes County, Nebraska*, February 11, 1983.

[2] U.S. Environmental Protection Agency (EPA), letter from Morris Kay, Region VII Administrator to George Ludwig, Acting Director, Nebraska Department of Environmental Control, April 22, 1983.

[3] U.S. Nuclear Regulatory Commission, *Aquifer Restoration at In-Situ Leach Uranium Mines: Evidence for Natural Restoration Processes*, (W. J. Deutsch, et al), Pacific Northwest Laboratory, NUREG/CR-3136, PNL-4604, April 1983.

[4] U.S. Nuclear Regulatory Commission, *Methods of Minimizing Ground-Water Contamination from In Situ Leach Uranium Mining*, (W. J. Deutsch, et al), Pacific Northwest Laboratory, NUREG/CR-3709, PNL-5319, March 1985.

have been reinforced by NRC Staff in NUREG-1569[5], which provides guidance for staff review of applications to develop and operate in situ leach facilities and notes similar limitations in the use of sodium and sulfate as excursion indicators.

Experience at the Crow Butte Uranium Project supports this industry experience. Data from the four excursions of mining solutions that have occurred at Crow Butte have shown increases of all five excursion indicators, but the magnitude of the sodium increase has been small compared to the other four indicators. Variation of sulfate concentrations has been noted in many monitor wells during routine monitoring without comparable changes in the other parameters. In one case, this apparently natural variation has resulted in a false excursion.

In August 2003, CBR contracted with Summit Geoscience to perform a review of the current excursion monitoring program and the appropriateness of the indicator parameters in use. In the attached report, Summit Geoscience reviewed the technical literature and site monitoring data and concluded that the continued monitoring of chloride, alkalinity, and conductivity would provide reliable early indication of an excursion of mining solutions. The continued monitoring of sulfate and sodium concentrations was not recommended for reliable excursion monitoring.

Based on general industry experience and specific experience gained during operations at Crow Butte, CBR requests that License Condition 10.4 B be amended as follows:

10.4B *The samples shall be analyzed for the following indicator parameters: chloride, conductivity, and total alkalinity.*

CBR is submitting a similar request to the Nebraska Department of Environmental Quality (NDEQ) to modify the Class III UIC Permit that authorizes mineral extraction activities at the mine. If you have any questions concerning this amendment request, please feel free to contact me at (308) 665-2215.

Sincerely,
CROW BUTTE RESOURCES, INC.

Michael L. Griffin
Manager of Health, Safety, and Environmental Affairs

[5] U.S. Nuclear Regulatory Commission, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications*, NUREG-1569, June 2003.

Attachments: As Stated

cc: U.S. Nuclear Regulatory Commission
Mr. John Lusher - ADDRESSEE ONLY
Fuel Cycle Licensing Branch
Mail Stop T-8A33
Washington, DC 20555

SUMMIT GEOSCIENCE
Environmental Consulting Services
Fort Collins, CO
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TECHNICAL MEMORANDUM

DATE: August 26, 2003

TO: Mike Griffin - Crow Butte Resources, Inc. (CBR)

FROM: David Levy - Summit Geoscience

SUBJECT: **Evaluation of the CBR Groundwater Excursion Monitoring Program**

1.0 Introduction

A technical evaluation of CBRs groundwater monitoring excursion program was conducted for their uranium in situ leach facility in northwestern Nebraska. The purpose is to provide technical support to CBRs license and permit modifications to remove sodium and sulfate from the required list of excursion indicators. Geochemical interpretation of groundwater quality trends indicates that water quality monitoring for alkalinity, chloride, and conductivity is adequate to provide timely notice regarding groundwater excursions. Sodium and sulfate were found to be less dependable indicators and therefore are not required for reliable excursion monitoring.

2.0 Selection of Excursion Indicators

Excursion indicators are typically selected based on a comparison of mining solution chemistry to the natural baseline groundwater quality. Ideal excursion indicators should be readily-measurable parameters with two additional important characteristics: (1) Excursion indicators should be present in significantly higher concentrations in mining waters compared to the natural groundwater, and (2) excursion indicators should not be significantly attenuated by geochemical reactions in the aquifer (in other words, the indicator behaves as a conservative tracer).

A comparison between mining solution and native groundwater chemistry is shown in Table 1. Total carbonate alkalinity (alkalinity), chloride, sodium, sulfate, and total dissolved solids (TDS) concentrations in mining solutions are elevated approximately 3-fold compared to native groundwater. Uranium concentrations in the enriched fluids are commonly elevated by more than two orders of magnitude when compared to natural groundwater.

Table 1: Comparison Between Mining Solution and Native Groundwater Chemistry. [1]

Parameter	Mining Solution	Native Groundwater
	(mg/L)	
Alkalinity (as $CaCO_3$)	875	293
Chloride	583	204
Sodium	1,117	412
Sulfate	1,128	358
TDS	3,728	1,170
Uranium	45	0.0922

[1] Data are representative of lixiviant chemistry and baseline groundwater quality for Mine Unit 1.

The parameters listed in Table 1 are potentially good excursion indicators based solely on their elevated concentrations in mining solutions. For certain constituents, however, geochemical reactions may influence their concentrations in groundwater and render them ineffective as reliable excursion indicators. The important reactions controlling dissolved constituents in groundwater are: (1) Precipitation as mineral phases, (2) adsorption to iron and manganese oxides, (3) ion exchange with clay minerals, and (4) biological transformations (Langmuir, 1997).

Precipitation and adsorption mechanisms are important factors controlling trace metal concentrations in groundwater. Uranium, for instance, can precipitate as a solid phase under reducing groundwater conditions, or become adsorbed to oxide surfaces under oxidizing conditions (Langmuir, 1997). Therefore, uranium is considered a poor excursion indicator due to the potential for geochemical attenuation in the aquifer (USNRC, 2003).

Ion exchange reactions also act to control dissolved cation concentrations in groundwater. For example, calcium (Ca^{2+}) and sodium (Na^{+}) are held by electrostatic forces on the surfaces of negatively-charged clay minerals. The degree of cation retention depends on their relative concentrations in solution, clay mineralogy, and the composition of the exchange phase (Bohn and others, 1985). As a consequence, dissolved cations are not considered reliable excursion indicators due to potential retention by clay minerals along excursion pathways (USNRC, 2003).

Biological transformations also preclude the use of certain constituents as excursion indicators. Ammonium (NH_4^{+}) may be transformed to nitrate (NO_3^{-}) in oxidizing environments, and both nitrate and sulfate are subject to gaseous losses under reducing conditions (Langmuir, 1997). Furthermore, the use of sulfate as an excursion indicator may produce false excursions in cases where oxidizing conditions exist in the vicinity of a monitoring well (USNRC, 2003).

3.0 Excursion Monitoring and Established Upper Control Limits

Following baseline water quality characterization, upper control limits (UCLs) were assigned to constituents which would be indicative of production solution migration from the well fields. The excursion indicators are chloride, conductivity, sodium, sulfate, and alkalinity. Chloride is an excellent indicator of the process solution (Table 1) and acts as a conservative tracer in groundwater (Drever, 1988). Alkalinity has also proven to be a good indicator in operations where sodium bicarbonate is added to the injection stream (USNRC, 2003). Conductivity was selected because it is a rapidly-obtainable, indirect measure of TDS, and has been accepted as a reliable excursion indicator for other similar in situ leach operations (Staub and others, 1986).

The U.S. NRC suggests that ISL operators propose a minimum of three excursion indicators for excursion monitoring (USNRC, 2003). CBR has routinely monitored well field perimeters for chloride, alkalinity, and conductivity. Sodium and sulfate have been included as additional routine parameters because of their elevated concentrations in mining solutions (Table 1). Operational monitoring consists of sampling the monitor wells no more than 14 days apart followed by analysis for the five excursion indicators. Upper control limits have been set at 20% above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/l, the UCL may be determined by adding 5 standard deviations or 15 mg/l to the baseline average for the indicator.

4.0 Water Quality Trends from Excursion Status Wells

Water quality data collected from perimeter monitor wells in the mining zone have indicated true excursions of mining solutions in Mining Units 5 and 6. Monitor Wells CM5-11, CM6-6, and CM6-7 experienced excursions due to over-pumping of injection fluid, and an excursion in Well SM6-12 resulted from a surface leak of mining solution that entered the shallow aquifer through a well casing (Figure 1). For each excursion, the concentrations of alkalinity, chloride, and sulfate exhibited rapid and conservative response as shown by identical breakthrough times (Figure 1). The simultaneous increase in conductivity demonstrates that conductivity is a reliable excursion indicator. Increasing trends in sodium were also indicative of excursions, but the magnitude of the sodium increase was small compared to the remaining indicators (Figure 1).

Well SM7-23 was also placed on excursion status early after startup due to exceedence of the single parameter UCL for sulfate. However, the concentrations of the remaining excursion indicators remained relatively constant (Figure 2). Consequently, CBR requested an amendment to SUA-1534 in September 2001 to increase sulfate UCL's for Wells SM7-23 and SM7-24. Monitor well data from non-excursion status wells shows that the natural variability in sulfate concentrations tends to be greater when compared to the other indicators (Figure 3). As a consequence, the reliability of sulfate as an excursion indicator is limited due to the natural variability of sulfate at the CBR site.

Sulfate is also a poor excursion indicator because of the potential for induced oxidation in the vicinity of monitor wells (USNRC, 2003). In Well SM7-23, the exceedence in the single parameter sulfate UCL was accompanied by a decrease in pH, which is consistent with the oxidation of pyrite and the resulting release of acidity (Figure 4). However, a pH decrease is

inconsistent with the occurrence of an excursion, where pH should increase due to elevated bicarbonate levels in the injection solution. For example, both sulfate and pH increased simultaneously in Well CM5-11 (Figure 5), where exceedence of multiple UCL's indicates a true excursion (Figure 1).

5.0 Proposed Modification to Excursion Monitoring Program

CBR proposes to modify the existing groundwater excursion monitoring program by reducing the required list of analytes to: (1) Alkalinity, (2) chloride, and (3) conductivity. Monitoring data from the site have shown that these three parameters behave conservatively and provide timely notice regarding groundwater excursions. CBR therefore requests that analyses for sodium and sulfate no longer be required based on the following conclusions:

- Sodium breakthrough occurs simultaneously with alkalinity, chloride, and conductivity during a solution excursion. Analysis for sodium provides no additional information with respect to the timely identification of an excursion.

- Sodium concentration peaks in excursion wells are of low magnitude compared to alkalinity, chloride, and conductivity concentration peaks. Sodium is not a reliable excursion indicator due to the potential for cation exchange reactions in the aquifer.

- Sulfate concentrations in groundwater are naturally more variable compared to alkalinity, chloride, and conductivity. Natural variability limits the use of sulfate as a reliable excursion indicator.

- Sulfate concentrations are affected by various biological and geochemical reactions and therefore sulfate does not behave conservatively. Pyrite oxidation can cause sulfate concentrations to increase significantly, while the concentrations of alkalinity, chloride, and conductivity remain constant.

REFERENCES

Bohn, H.L., B.L. McNeal, and G.A. O'Connor. 1985. Soil Chemistry. 2nd Edition. John Wiley & Sons, New York. 341 pp.

Drever, J.I. 1988. The Geochemistry of Natural Waters. 2nd Edition. Prentice-Hall, Inc., NJ. 437 pp.

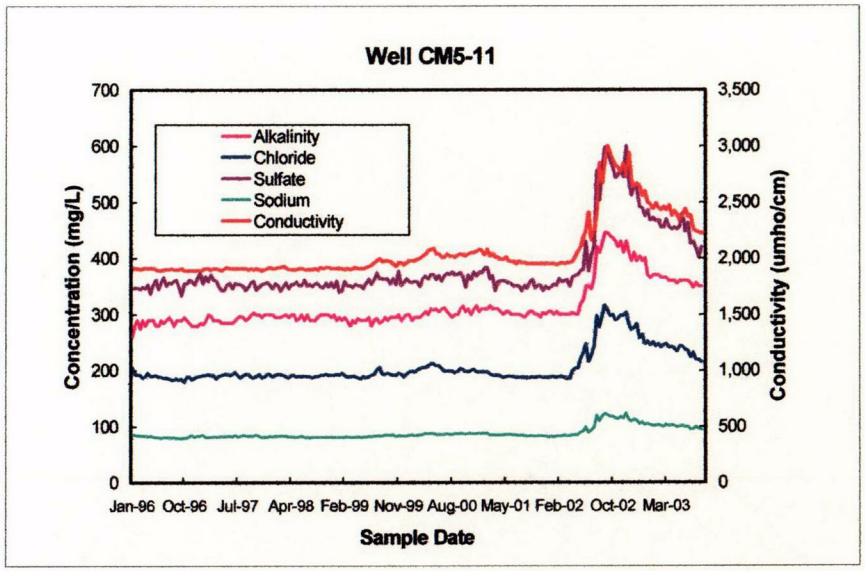
Langmuir, D.L. 1997. Aqueous Environmental Geochemistry. Prentice-Hall, Inc., NJ. 600 pp.

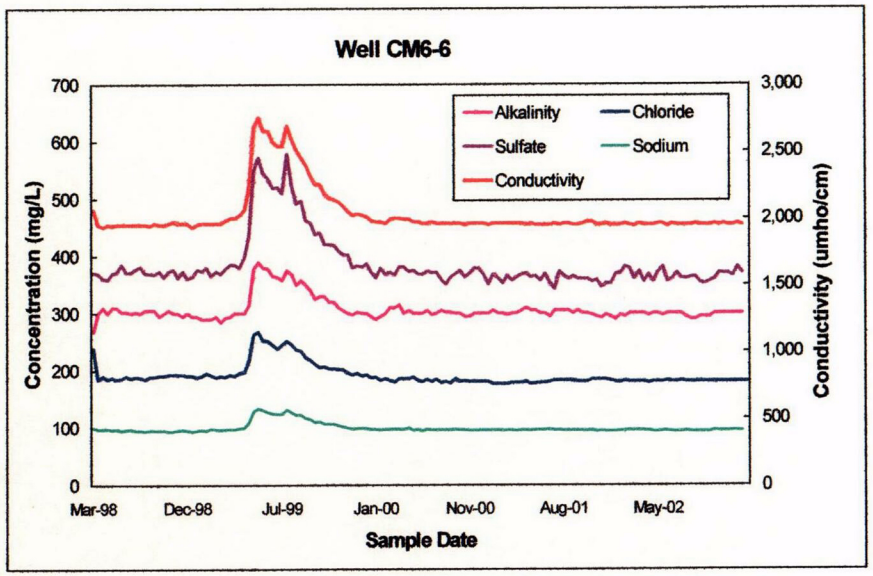
Nordstrom, D.K. 1982. Aqueous pyrite oxidation and the consequent formation of secondary minerals. pp. 37-56. In Acid Sulfate Weathering. Soil Science Society of America. Madison, WI.

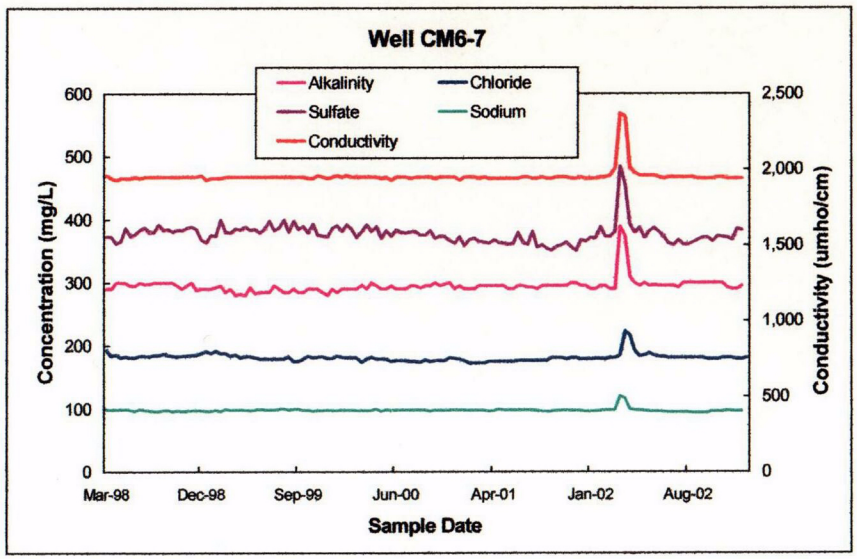
Staub, W.P. and others. 1986. NUREG/CR-3967. An Analysis of Excursions at Selected *In Situ* Uranium Mines in Wyoming and Texas. USNRC, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 2003. Standard Review Plan for In Situ Leach Uranium Extraction License Applications (NUREG-1569). Office of Nuclear Material Safety and Safeguards. Washington, D.C.

Figure 1: Historical Excursions for Mine Unit 5 and 6 Perimeter Monitor Wells.







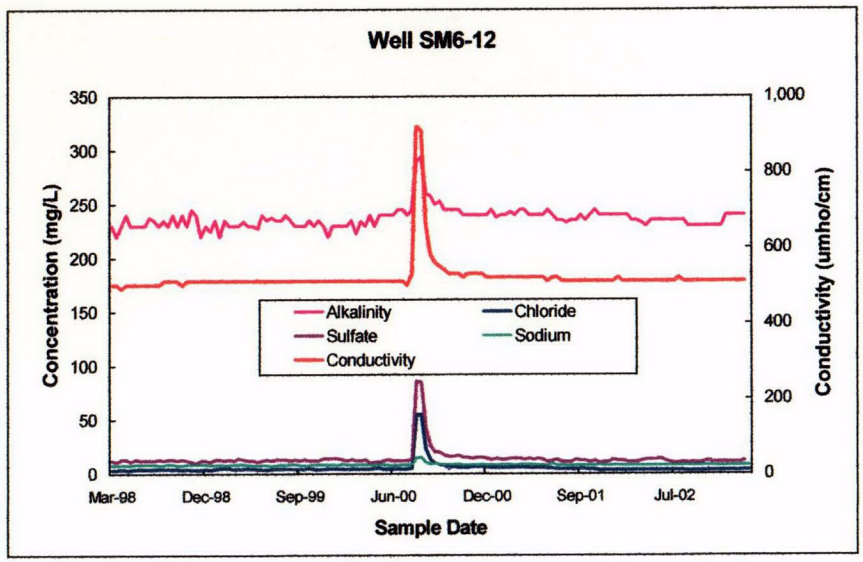


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Figure 2: Well SM7-23 Trend History Showing Increase in Sulfate. Alkalinity, Chloride, and Sodium Remain Relatively Stable.

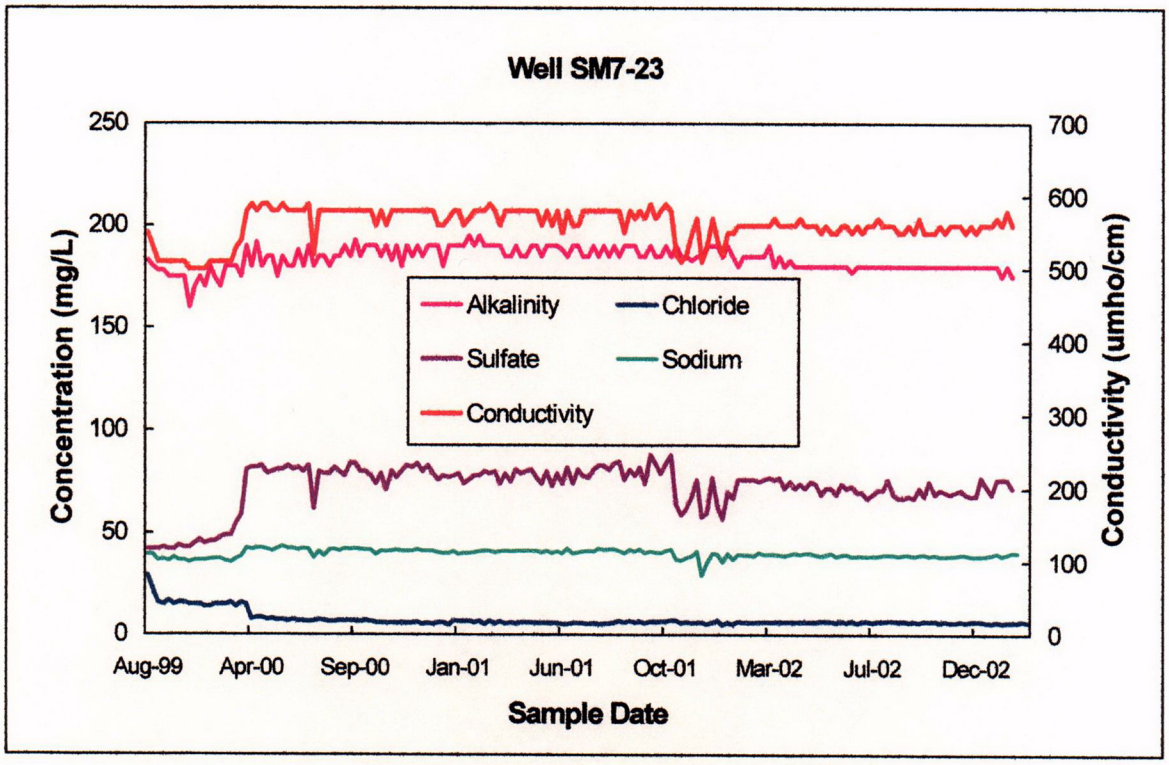

Figure 3: Well CM7-1 Trend History Showing Natural Sulfate Variability for a Non-Excursion Status Well.

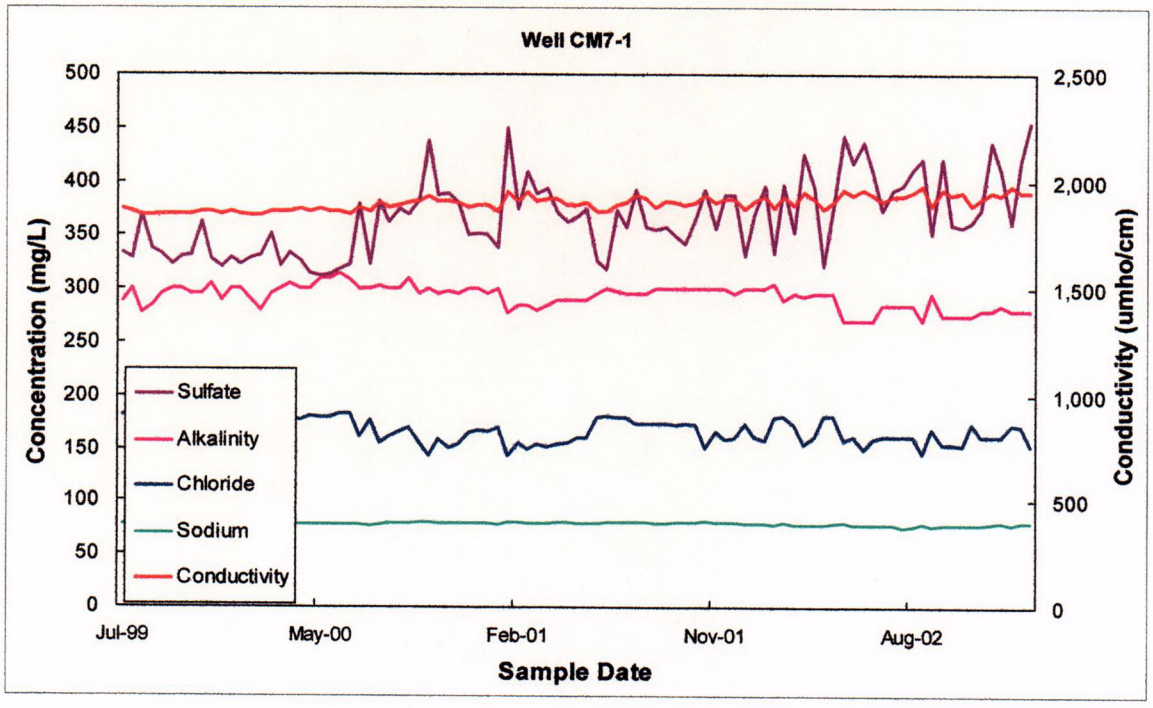

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Figure 4: Trend in Decreasing pH That Accompanied the Increase in Sulfate as Well SM7-23 Entered Excursion Status Based on Sulfate Alone.

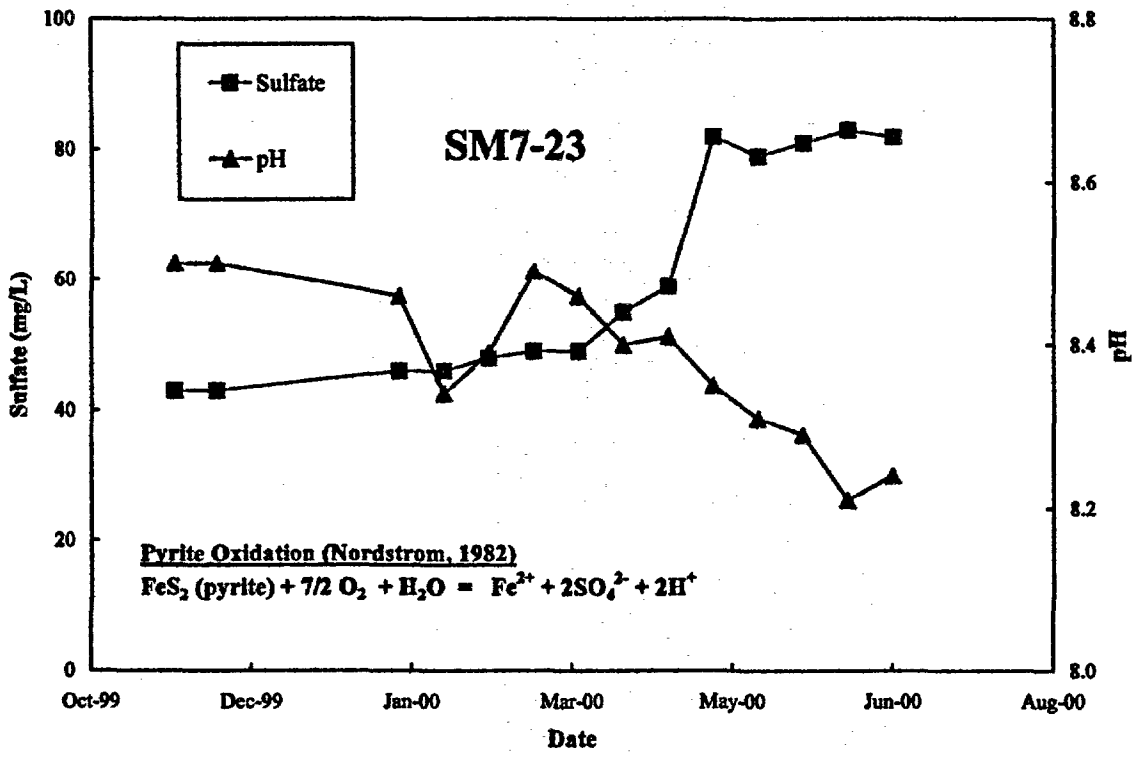
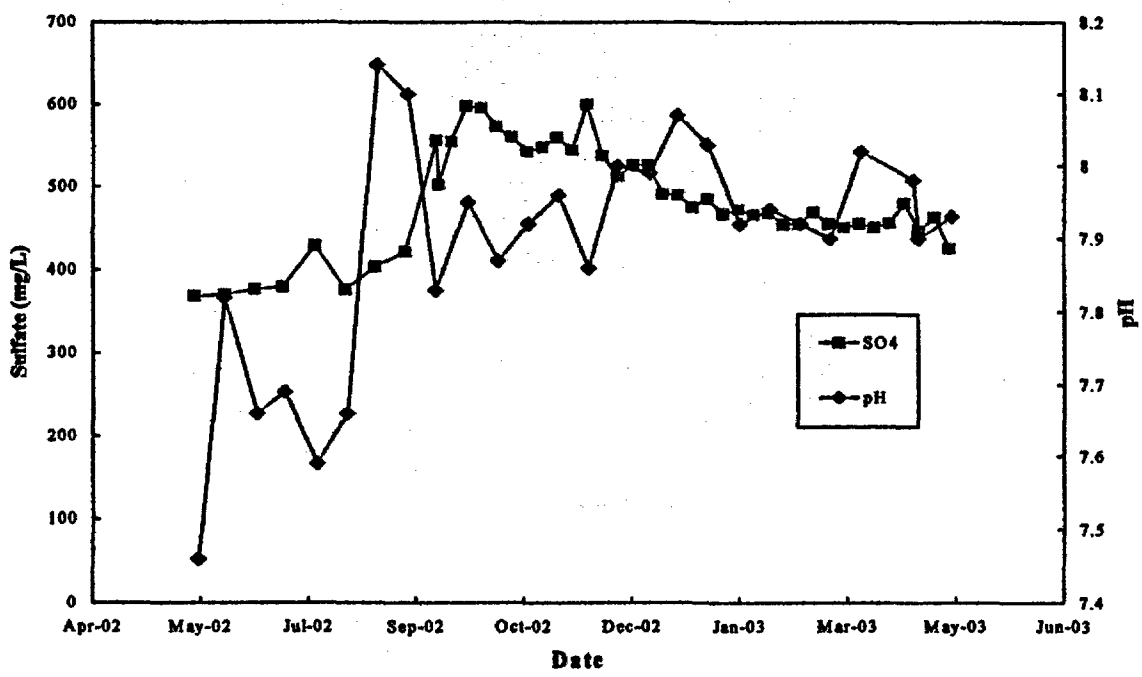


Figure 5: Trend in Increasing pH That Accompanied the Increase in Sulfate for a True Excursion in Well CM5-11 Based on All Excursion Parameters.



SUMMIT GEOSCIENCE
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TECHNICAL MEMORANDUM

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FROM: David Levy - Summit Geoscience

SUBJECT: **Evaluation of the CBR Groundwater Excursion Monitoring Program**

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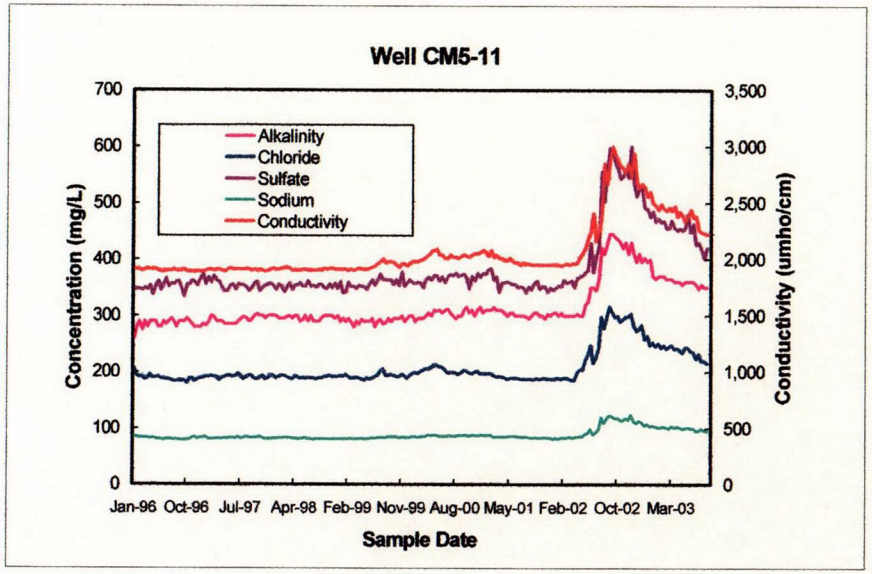
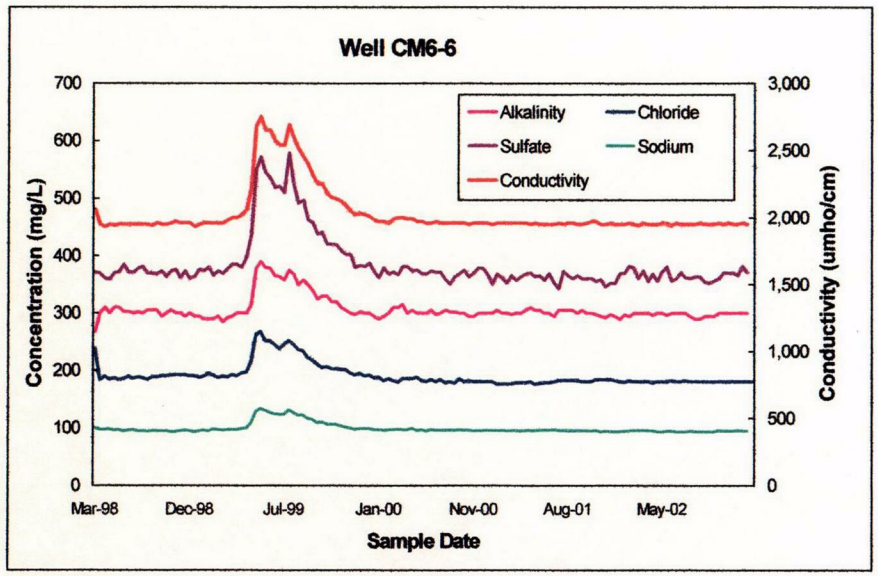
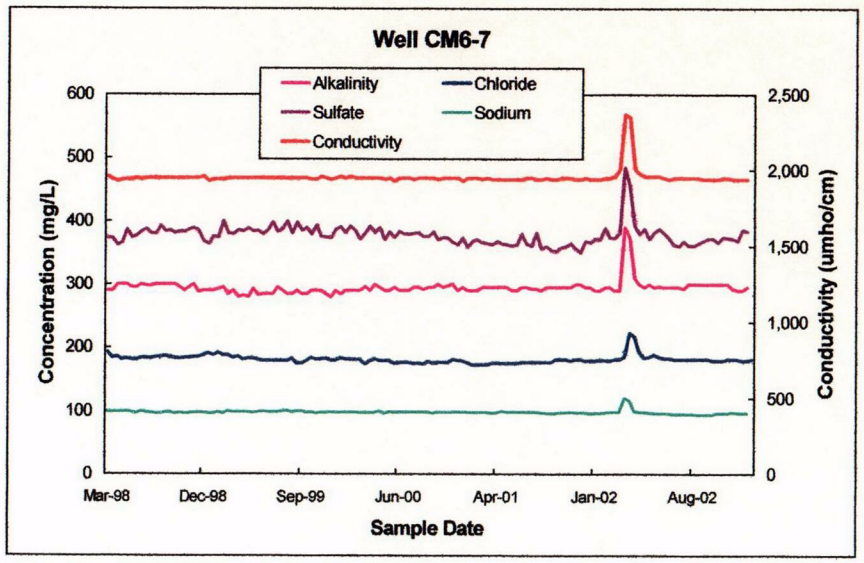






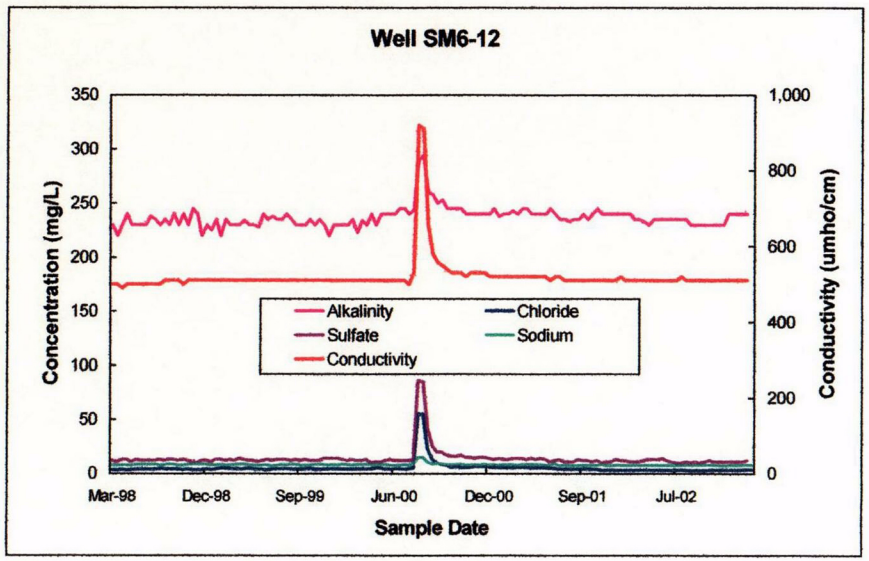


Figure 2: Well SM7-23 Trend History Showing Increase in Sulfate. Alkalinity, Chloride, and Sodium Remain Relatively Stable.

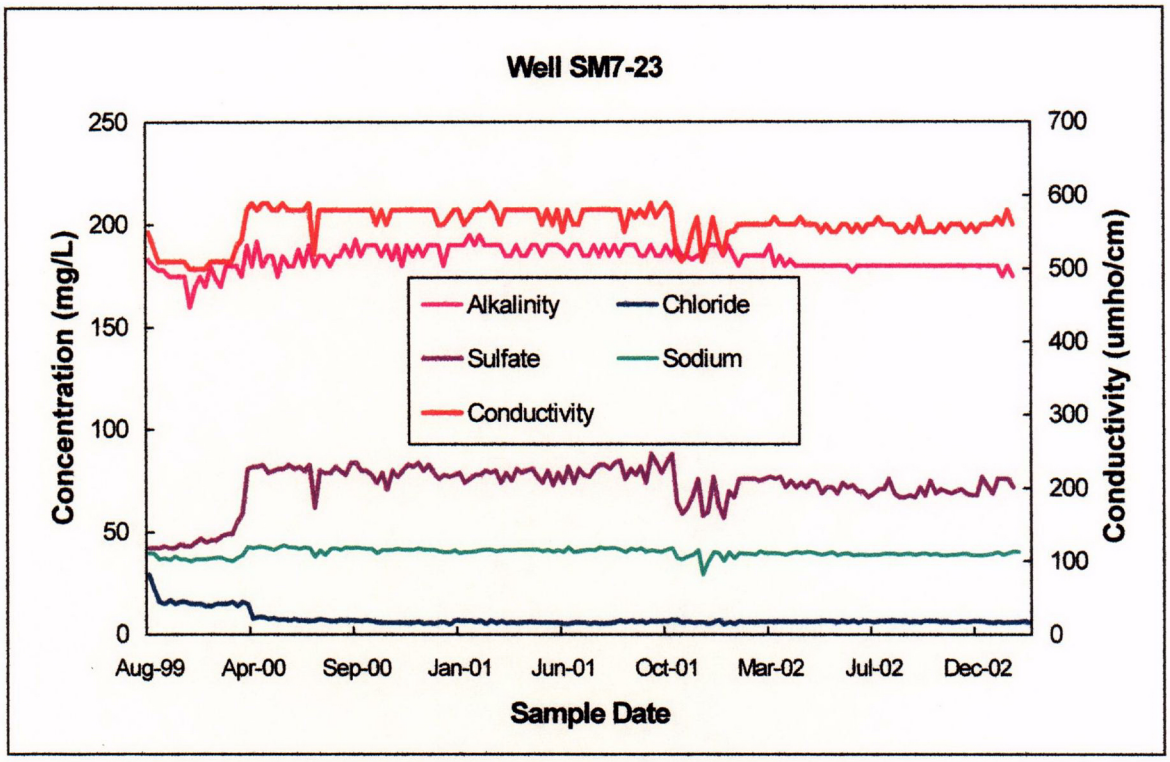
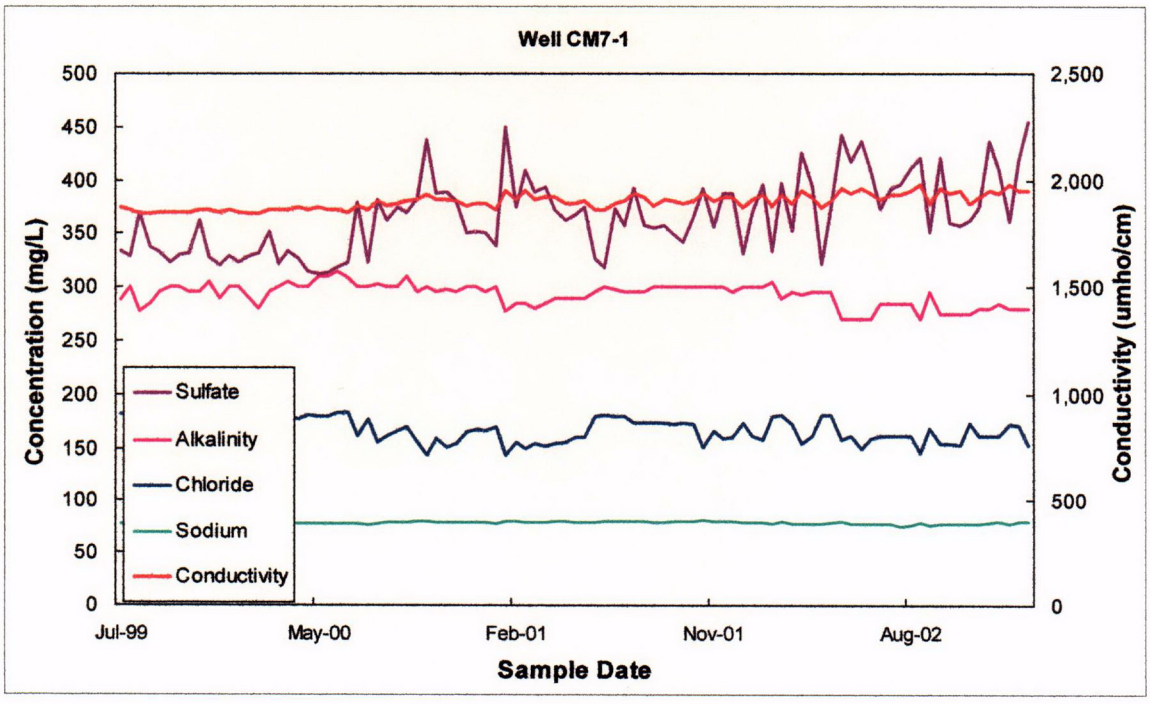


Figure 3: Well CM7-1 Trend History Showing Natural Sulfate Variability for a Non-Excursion Status Well.



C04

Figure 4: Trend in Decreasing pH That Accompanied the Increase in Sulfate as Well SM7-23 Entered Excursion Status Based on Sulfate Alone.

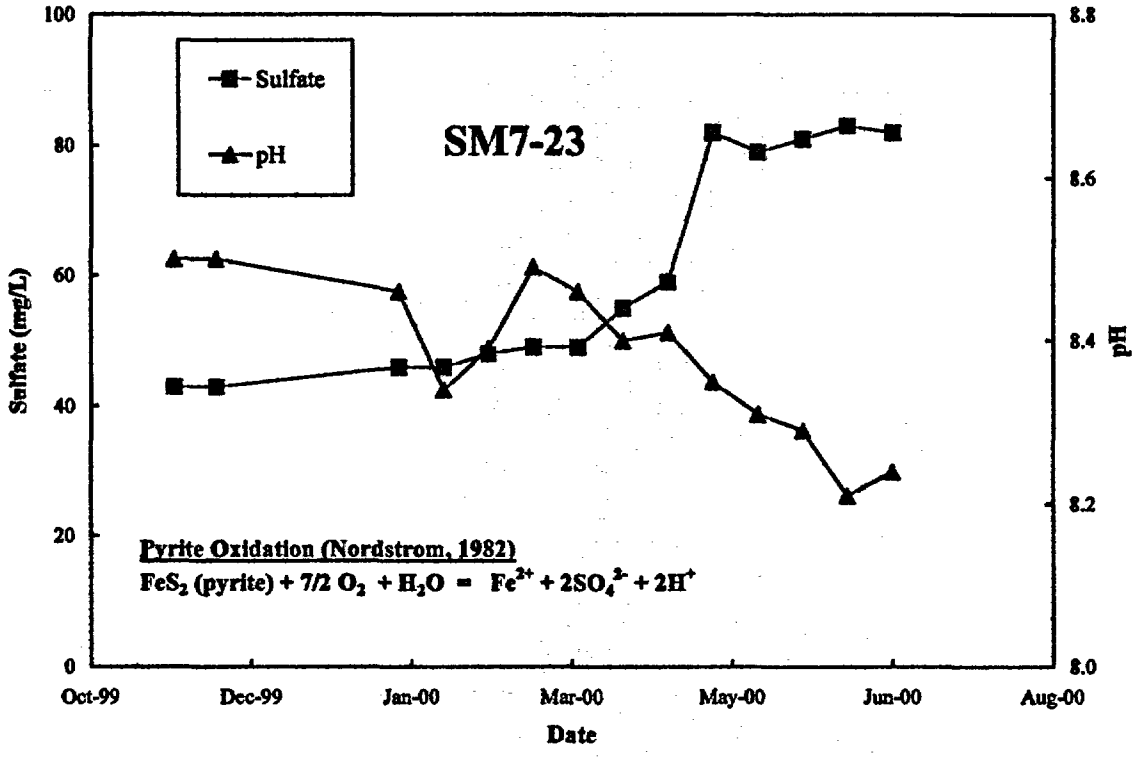
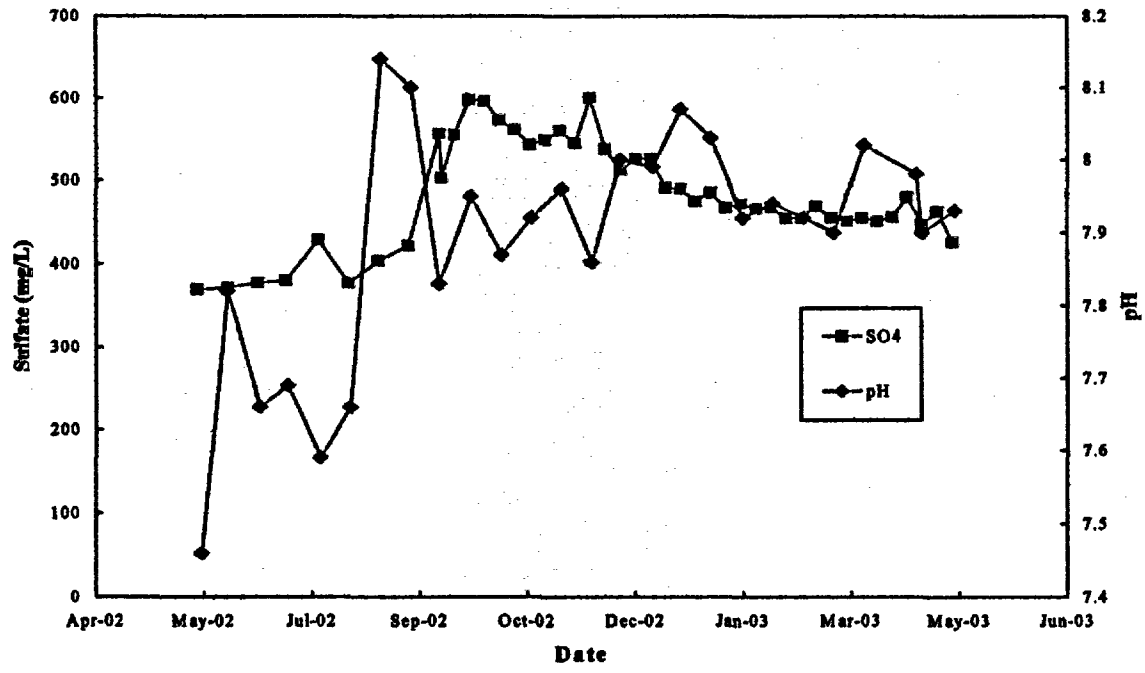



Figure 5: Trend in Increasing pH That Accompanied the Increase in Sulfate for a True Excursion in Well CM5-11 Based on All Excursion Parameters.