

Docket
04-8907

BBL®

an ARCADIS company

Transmitted Via Fed Ex

June 19, 2006

William von Till
11545 Rockville Pike
Two White Flint North
Rockville, Maryland 20852-2738
Mail Stop T-8A33

Mark Purcell
Superfund Division (6SF-LP)
U.S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Re: United Nuclear Corporation Church Rock Site
Gallup, New Mexico
BBL Project # 0201.20871 #5

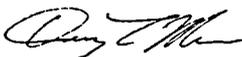
Dear Mr. von Till and Mr. Purcell:

On behalf of United Nuclear Corporation (UNC), please find enclosed a copy of the revised In Situ Alkalinity Stabilization Pilot Study (Pilot Study) for the Church Rock site located in Gallup, New Mexico. The Pilot Study has been revised pursuant to the United States Environmental Protection Agency's (USEPA's) letters submitted to UNC on November 23, 2005 and May 12, 2006.

If you have any questions regarding the revisions, please contact me.

Sincerely,

BLASLAND, BOUCK & LEE, INC.



Douglas L. Musser, P.G.
Associate

MMH/jlc
Enclosure

Mr. William von Till and Mr. Mark Purcell

June 19, 2006

Page 2 of 2

cc: Roy S. Blickwedel, General Electric Company
Larry Bush, United Nuclear Corporation
Robin Brown, New Mexico Environmental Department
Diana Malone, NNEPA
Margaret Carrillo-Sheridan, P.E., Blasland, Bouck & Lee, Inc.

REPORT

UNC Church Rock Site In-Situ Alkalinity Stabilization Pilot Study

**United Nuclear Corporation
Gallup, New Mexico**

**October 2005
Revised June 2006**

BBL[®]
an ARCADIS company

REPORT

*UNC Church Rock Site
In-Situ Alkalinity
Stabilization Pilot Study*

**United Nuclear Corporation
Gallup, New Mexico**

**October 2005
Revised June 2006**

BBL[®]
an ARCADIS company

Table of Contents

Section 1. Introduction	1-1
1.1 Problem Statement and Objectives	1-1
1.2 Background Information.....	1-2
1.2.1 Hydrogeologic Setting.....	1-2
1.2.2 Remedial History and Current Status	1-4
Section 2. Regulatory Considerations.....	2-1
2.1 Permitting/Regulatory Approval Requirements	2-1
2.2 Site-Specific Groundwater Quality Standards	2-2
Section 3. Geochemical Principals and Calculations.....	3-1
3.1 Background.....	3-1
3.2 Pilot Study Strategy	3-2
Section 4. Pilot Study	4-1
4.1 Technology Review	4-1
4.2 Well Injection and Recovery Network.....	4-2
4.3 Well Design and Installation	4-3
4.4 Groundwater Monitoring During Pilot Test	4-3
4.5 Field Procedures.....	4-4
4.6 Pilot Study Results.....	4-5
Section 5. Schedule	5-1

Acronyms and Abbreviations

References

Table

3-1 2004 Average Water Quality

Figures

- 1-1 Site Layout and Performance Monitoring Well Locations 2004 Operating Year
- 1-2 Zone 3 Potentiometric Surface Map – October 2004
- 1-3 Zone 3 Approximate Extent of Seepage Impacts – October 2004
- 3-1 Bicarbonate vs. Time
- 4-1 Typical Schematic of the In-Situ Leach Mining Process
- 4-2 Schematic of the Groundwater Sweep Process
- 4-3 Pilot Study Location
- 4-4 Approximate Locations of Injection Wells
- 4-5 Well Details
- 4-6 Piping and Instrumentations Diagram

Attachments

- A Substantive UIC Permit
- B Technical Memorandum dated January 26, 2006
- C Technical Memorandum dated March 31, 2006
- D Pilot Study Wellfield Design

1. Introduction

1.1 Problem Statement and Objectives

As discussed in the Record of Decision (ROD), United States Environmental Protection Agency ([USEPA], 1988) groundwater within the Zone 3 aquifer has been impacted by metals and radioactive substances including Radium-226/228 and gross alpha. The current site remedy includes removal of the Zone 3 groundwater and treatment via evaporation. According to the USEPA, First- and Second Five-year Review Reports (USEPA, 1998; USEPA, 2003), the current remedy will not meet the remedial objectives for Zone 3 listed in the ROD and the Unilateral Administrative Order (UAO) (USEPA docket # Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] 6-11-89). Therefore, this In-Situ Alkalinity Stabilization Pilot Study (Pilot Study) will evaluate an alternative approach to enhance the ongoing Zone 3 remediation.

This Pilot Study will evaluate the use of alkalinity injection wells to enhance the ongoing remediation of Zone 3 in addition to using extraction wells alone at the United Nuclear Corporation (UNC) Church Rock Site (site) located in Gallup, New Mexico. This Pilot Study has been prepared on behalf of UNC by Blasland, Bouck & Lee, Inc. (BBL).

Initially, the pilot studies were designed to test the injection of alkalinity-rich groundwater from an unimpacted part of the Southwest Alluvium into the Zone 3 aquifer. The injected water (hereinafter referred to as "fixiviant") would flow through the Zone 3 formation to recovery wells where the fixiviant would be pumped to the surface for treatment and disposal. However, concerns were expressed by New Mexico Environment Department (NMED) that the groundwater from the Southwest Alluvium did not meet applicable groundwater standards for sulfate, total dissolved solids and manganese. Following the original submission of this pilot study and subsequent discussions, NMED identified groundwater withdrawn from geologic formations below Zone 3 (the Dakota Formation) via the onsite Mill Well as a potential alternative source of groundwater to use as the injection water. Theoretically, injection of the Mill Well water amended to add alkalinity (i.e., fixiviant) into Zone 3 would effect the following changes:

1. The pH of the Zone 3 groundwater would increase from acidic (pH<4) to mildly acidic/basic or neutral (pH~6-8);
2. Groundwater migration of target Zone 3 groundwater constituents of concern (such as cadmium, cobalt, nickel, radium-226/228, Th-230) would be reduced or eliminated via changes in aqueous/solid partitioning and precipitation reactions as a result of the increased pH conditions; and
3. Groundwater and fixiviant withdrawn by the extraction wells would recover uranium (and other chemical species) in solution, which could then be handled via the existing evaporation system. Seepage-impacted water is currently difficult to recover from Zone 3 due to limited saturated thicknesses and well yields. The injected water will assist to displace the seepage-impacted water toward recovery wells.

The specific pilot study described herein will be conducted to assess the effectiveness of this proposed remedial approach. In addition, information obtained from the pilot study will be used to prepare a full-scale design, if groundwater remediation via injection is deemed a viable and effective remedy for the Zone 3 aquifer.

In October 2004, MWH, on behalf of UNC, developed a Supplemental Feasibility Study (SFS) (MWH, 2004) which evaluated several alternative remedies. The remedies that were evaluated included in-situ geochemical

fixation via the injection of alkalinity-laden solutions into the acidic, tailings-impacted groundwater. The in-situ geochemical remediation was removed from the potential alternatives during the first phase of the SFS due to lack of reliability of the approach. The SFS indicated that the alternative is limited by hydraulic conditions within the Zone 3 hydrostratigraphic unit which might:

- limit the effective radius of influence of the reactant introduced into the system due to the moderate permeability of formation;
- cause fouling and blocking of the aquifer due to the blockage of pore spaces by precipitated minerals; and/or
- result in spreading the seepage-impacted groundwater to unimpacted regions.

The approach presented in this document is different from the in-situ geochemical remediation that was discussed in the SFS because it includes recovery wells. By combining injection with recovery, the issues associated with the in-situ geochemical remediation discussed in the SFS are minimized. Significantly better control over the movement of both the fixiviant and the seepage-impacted groundwater can be realized using such an approach. It is akin to the hydraulic concepts used for in-situ leach mining, but with very different geochemical goals (see Section 3).

The introduction of the amended Mill Well water to Zone 3 and collection of the fixiviant would ultimately flush out the current groundwater located in Zone 3. The amended Mill Well water will replace the lower pH water with high alkalinity water and cause the dissolved Zone 3 constituent (metals) to precipitate out of Zone 3 (this is why the hazardous constituents have not migrated very far away from the tailings impoundments). This alternative is controlled hydraulically by controlling the rate at which the amended Mill Well water is injected and the rate at which the fixiviant is extracted. By controlling the amount of water that is injected and recovered, the saturation thickness can be maintained and the effective radius of influence increased.

The SFS also indicated that in-situ remediation might not be effective because of the potential for fouling and blocking off of the aquifer due to the blockage of pore spaces by precipitated materials. Because of the increased hydraulic control of the proposed remedy, the amount of precipitation can be more easily managed. Even if precipitation of metals and radionuclides did not occur, the combined injection-recovery scheme presented in this document represents a major improvement in handling the problems that rendered the recovery-only remedy to be impractical. The main problem has been that recovery well yields decline over time, and are inadequate to recover the core of seepage-impacted water, especially as saturated thicknesses decline. Over time, the recovery wells have been relocated further downdip into previously unimpacted parts of Zone 3 to maintain the desired yields. This resulted in the unintended advance of seepage-impacted water (Earth Tech, 2001).

1.2 Background Information

1.2.1 Hydrogeologic Setting

The site is located approximately 17 miles northeast of Gallup, New Mexico, in McKinley County (Figure 1-1). The site operated as a uranium mill and an unlined tailings pond area from 1977 until early 1982. The site is located in an arid, remote setting.

The stratigraphy at the site is made up of the following units (MWH, 2004):

-
- Alluvium
 - Dilco Coal Member of Crevasse Canyon Formation
 - Upper Gallup Sandstone, comprised of:
 - Zone 3, upper sandstone
 - Zone 2, shale and coal
 - Zone 1, lower sandstone
 - Mancos Shale

Mine water in the alluvium percolated into the underlying Zone 3 hydrostratigraphic unit. The mine water discharge, along with the existing saturation, if any, from the alluvium (prior to tailing disposal) is considered by National Research Council (NRC) and USEPA to be the background water for Zone 3 (USEPA, 1988; 1998). The background water was later impacted by acidic seepage from mine tailings. The seepage fluids contained elevated (i.e., above background conditions) concentrations of metals, radionuclides, and major ions including sulfate and chloride.

Zone 3 water levels from October 2004 are shown on the piezometric surface map on Figure 1-2. Water level data from 1989 through the fourth quarter of 2004 indicate groundwater flows toward the north and northeast, approximately parallel with the eastern limit of Zone 3 saturation (Veolia, 2004). Since the Pipeline Arroyo ceased discharging in 1986, Zone 3 groundwater flow directions have shifted from easterly-to-northerly to north-northeasterly-to-northeasterly as recharge from, and groundwater mounding within, the alluvium to the southwest and west have decreased (Veolia, 2004). The Zone 3 effects from alluvium recharge and extraction-well pumping drawdowns have largely dissipated, and the rates of water level change are mostly very small (Veolia, 2004). Extraction wells temporarily accelerated the local rates of water level decline until the saturated thickness was reduced to less than 25 feet, after which substantial losses in well yield occurred (Earth Tech, 2001).

In January 2004, UNC submitted the results of a study undertaken to evaluate the potential for the covered, tailings to still provide recharge to Zone 3 via leakage (USFilter, 2004). The report concluded that it was very unlikely, but recommended that additional investigation be conducted in one area where possible leakage could not be ruled out with certainty. In July 2004, two piezometers (Z3 M-2 and Z3 M-1) were installed north of the northeastern boundary of the Central Cell. Water levels were measured in October 2004 and indicated that the piezometers Z3 M-1 and Z3 M-2 were effectively dry and the southeasterly portion of Zone 3 appears to be entirely unsaturated (Veolia, 2004). As indicated in Veolia's 2004 annual report, the piezometer installation and groundwater monitoring data collected from 1989 through the fourth quarter of 2004 indicate that neither groundwater recharge nor seepage impact into Zone 3 are occurring (Veolia, 2004).

Figure 1-3 shows the general location of the recharge area, located to the north and northeast of the North Cell, where mine water in the alluvium percolated into the underlying Zone 3 hydrostratigraphic unit. This figure shows the saturated portion of the alluvium/Zone 3 contact as well as the unsaturated portion of this same contact zone.

1.2.2 Remedial History and Current Status

Several remedial activities have been conducted at the site to address tailings seepage in groundwater. The remedial activities that have taken place in Zone 3 of the site are briefly discussed below. Additional information may be obtained in the following documents:

- *Reclamation Engineering Services, Geohydrologic Report* (Canonie Environmental, 1987);
- *Record of Decision* (USEPA, 1988);
- *Memorandum, Change in Zone 3 Saturation, United Nuclear Church Rock Site, Gallup, New Mexico* (Earth Tech, 2001);
- *Five-Year Review Report, Second Five-Year Review Report for the United Nuclear Corporation Ground Water Operable Unit* (USEPA, 2003);
- *Annual Review Report – 2004 Groundwater Corrective Action* (Veolia, 2004); and
- *Supplemental Feasibility Study Zone 3 Hydrostratigraphic Unit* (MWH, 2004).

Following placement on the National Priorities List (NPL), the USEPA conducted a Remedial Investigation from 1984-1987. On September 30, 1988, the USEPA issued a ROD which presented a site remedy that included pumping impacted groundwater from Zone 3 and disposing of the water in evaporation ponds. On June 29, 1989, the USEPA issued a UAO Docket No. CERCLA 6-11-89 to UNC requiring UNC to implement the site remedy selected in the ROD. In August 1989, the USEPA-selected remedy of extracting groundwater from Zone 3 and pumping the groundwater to evaporation ponds was implemented; 12 new extraction wells were installed and operated.

The performance of the remedial activities were monitored as described in the USEPA- and NRC-approved Corrective Action Plan (UNC, 1989a), Remedial Design Report (Canonie, 1989a), and Remedial Action Plan (UNC, 1989b). Several modifications were made to the monitoring program and are discussed in the annual reports (Canonie, 1989b, 1990, 1991, 1992, 1993, and 1995; Smith Technology, 1995 and 1996; Rust, 1997; and Earth Tech, 1998, 1999, 2000a, 2002a and 2002c), to adjust the monitoring requirements as the corrective action has taken effect.

On July 30, 1999, NRC, USEPA, and NMED approved the decommissioning of 10 Zone 3 wells because they met the decommissioning criteria of producing less than 1 gallon per minute (gpm). In May 2000, UNC submitted a license amendment request to shut off remaining Zone 3 pumping wells (Earth Tech, 2000b). The request was based on the conclusion that the operation of the Zone 3 pumping wells increased the hydraulic gradient and accelerated the rate of downgradient plume migration. Zone 3 system was shut down in June 2000 for maintenance and repairs. Prior to the Zone 3 system being brought back on line, the USEPA and NMED agreed with the license amendment submitted in May 2000. The NRC amended the license to shut off the remaining Zone 3 pumping wells (NRC, December 29, 2000 License Amendment). This amendment included a provision for UNC to submit a modified corrective action plan, an application for Alternate Concentration Limits (ACLs), or an alternative to the specific requirements of 10 CFR Part 40, Appendix A if the license standards are not achievable.

At the request of the USEPA (2004), a SFS (MWH, 2004) was conducted by MWH on behalf of UNC. The SFS was conducted to develop conceptual alternatives and/or enhancements to the existing remedy that would better contain, and ideally withdraw, seepage-impacted groundwater. The report presented the following information:

- Groundwater modeling of the Zone 3 sandstone unit;
- Pilot-hole hydrofracturing study results;
- An analysis of remedial alternatives; and
- Conclusions and recommendations for enhancing or optimizing remedies for Zone 3.

UNC is conducting an ongoing, extended pilot investigation to evaluate the suitability of hydrofracturing to enhance the extraction potential within the impacted area of Zone 3 and to prevent seepage-impacted groundwater from migrating offsite (MACTEC, 2003). The pilot investigation included installing and hydrofracturing several new wells. Preliminary data suggest that the new wells are better positioned to capture tailing-impacted water, but that the yields are not any different without hydrofracture.

2. Regulatory Considerations

2.1 Permitting/Regulatory Approval Requirements

In accordance with 42 USC 9621.121(e) of CERCLA, the procurement of permits from federal, state, or local authorities is not required for the implementation of remedial action activities at a NPL site. However, the remedial activities are required to be implemented in a manner that complies with the substantive requirements of applicable permits and authorizations. Described below is the approval/permitting process required by the State of New Mexico for injection of water into the subsurface.

According to federal regulations (subpart 147.1600 of Title 40 of the Code of Federal Regulations [40 CFR 147.1600]), in New Mexico the underground injection control (UIC) program is administered by the State of New Mexico and approved by the USEPA. The UIC program was established by the Safe Drinking Water Act to regulate underground injection (i.e., the placement of fluids underground).

The New Mexico regulations indicate that the type of injection wells UNC is proposing are Class V Wells (in situ groundwater management injection wells used to inject a fluid that facilitates groundwater remediation). According to 20.6.2.1201 of the New Mexico Regulations, any person intending to inject fluids into a well shall file a notice with the Groundwater Quality Bureau. The notice shall state the following:

- The name of the person making the discharge
- The address of the person making the discharge;
- The location of the discharge
- An estimate of the concentration of water contaminants in the discharge; and
- The quantity of the discharge.

Based on the information provided in the notice of intent, the Groundwater Quality Bureau will notify the person proposing the discharge if a discharge permit is required and if the injection activity is prohibited or not. According to 20.6.2.5004, the injection of the amended water from the Dakota Formation aquifer would be allowed.

Based on the data collected from the Mill Well, a discharge permit would most likely be required to inject amended water from the Dakota Formation aquifer into Zone 3. As part of the discharge permit, a discharge plan would need to be submitted to the Secretary of the Groundwater Quality Bureau for approval following notice from the Secretary (of the Groundwater Quality Bureau) that a discharge permit is required. The discharge plan presents the details of the discharge method, the characteristics of the injection fluid, the current groundwater conditions, an operational plan, a monitoring plan, a contingency plan and also a closure plan. The relevant permit information is provided by this Pilot Study.

Also, the State of New Mexico (under 20.6.2.3108) requires that public notice be made (for Class V wells) to the general public in the locale of the proposed discharge. Under CERCLA, the public has been and will be informed of the activities that take place at the site.

According to the New Mexico Regulations (20.6.3101) the purpose of the discharge permit process is to control the discharge to the groundwater so that there is no degradation of the groundwater beyond the existing concentrations. The purpose of injecting the amended water from the Mill Well is to improve the groundwater quality in Zone 3. The permit process regulated by the New Mexico Government also requires reporting and

monitoring of the injection wells. This Pilot Study details the monitoring activities to be documented and submitted to USEPA, NRC, and NMED.

Therefore, while the activities planned in this Pilot Study would require a permit under current regulations, the operations, monitoring and documentation activities presented in this Pilot Study would meet the substantive UIC permit requirements. Attachment A provides a completed (in draft form) State of New Mexico UIC permit.

2.2 Site-Specific Groundwater Quality Standards

The site-specific groundwater quality standards are the Applicable or Relevant and Appropriate Requirements (ARARs) presented in the ROD (USEPA, 1988). The table below presents the ARARs for this site. Several Maximum Contaminant Levels (MCLs) have been revised since the issuance of the ROD (USEPA, 1988) and the most current MCLs are presented in this table below. Also presented in the table is the average of most recent data obtained (from quarterly sampling conducted in 2004) from the Mill well (which represents the source of injection water) and wells 517 and 518 (which represent Zone 3 groundwater). As presented in the table below, the quality of the water from the Mill Well meets the ARARs for the site.

Contaminant	Groundwater Protection Standards mg/L	Source of ROD Standard	Concentrations measured in Mill Well	Average Concentrations measured in Wells 517 and 518
Aluminum	5.0	New Mexico Water Quality Control Commission (NMWQCC)	<0.06	39.375
Arsenic ^b	0.010	MCL	<0.0005	<0.001
Barium	1.0	MCL, NMWQCC	NA	NA
Beryllium ^c	0.004	Health-based	<0.004	0.0325
Cadmium ^d	0.005	MCL, NMWQCC	0.0001	0.0066
Chromium	0.05	MCL, NMWQCC	NA	NA
Cobalt	0.05	NMWQCC	<0.02	0.88
Copper	1.0	NMWQCC	NA	NA
Iron	5.5	Background Level	NA	NA
Lead	0.05	MCL, NMWQCC	0.034	<0.5
Manganese	2.6	Background Level	0.04	12.0
Mercury	0.002	MCL, NMWQCC	NA	NA
Molybdenum	1.0	NMWQCC	<0.02	<0.1
Nickel	0.2	NMWQCC	0.07	0.8525
Selenium	0.05	MCL	0.002	<0.001
Silver	0.05	MCL, NMWQCC	NA	NA
Vanadium	0.7	Health-based	<0.01	<0.1
Zinc	10	NMWQCC	NA	NA
Chloride	250	NMWQCC	154	42.48
Sulfate ^e	2,125	Background Level	1,180	4,113.75

Contaminant	Groundwater Protection Standards mg/L ^e	Source of ROD Standard	Concentrations measured in Mill Well	Average Concentrations measured in Wells 517 and 518
Nitrate ^e	190	Background Level	0.02	0.963
TDS ^e	4,800	Background Level	2,180	6,193.75
Radium -226 and -228	5 pCi/L	MCL	2.39	13.09
Uranium -238 ^f	0.03	NMWQCC	0.0081	0.15
Thorium -230 ^g	15 pCi/L	MCL	0.14	3.6
Gross Alpha	15 pCi/L	MCL	16	14

Notes:

- a) In milligrams per Liter (mg/L), except as noted.
- b) Arsenic MCL of 0.01 mg/L published since ROD issuance.
- c) Beryllium MCL of 0.004 mg/L published since ROD issuance.
- d) Cadmium MCL reduced to 0.005 mg/L since ROD issuance.
- e) Background standards proposed in 1996 NRC Report.
- f) Uranium MCL reduced to 0.03 mg/L, effective 12/03,
- g) Based on 15 pico Curies per Liter (pCi/L) gross alpha.
- h) NA = not available.
- i) Average concentrations measure in Well 517 based on data collected during sampling events held in January 2004, April 2004, July 2004, and October 2004. Average concentrations measured in Well 518 based on data collected during sampling events held in April 1999, July 1999, October 1999, and January 2000.

3. Geochemical Principals and Calculations

3.1 Background

Historical milling operations at the site involved application of strong sulfuric acid to extract uranium from ore materials. By-products from the ore processing were discharged to the tailings ponds. Acidic solutions associated with the tailings ponds seeped into partially saturated alluvium and sandstone formations. Partial saturation of the formations resulted primarily from mine-dewatering discharge, which is referred to as post-mining, pre-tailings water, and which represents background groundwater at the site (as previously discussed in Section 1).

The proposed pilot studies described herein involve approaches to reduce concentrations of Constituents of Concern (COCs) derived from the tailings ponds that seeped into the post-mining, pre-tailings background water. Historical monitoring indicate that the background groundwater contains relatively high concentrations of inorganic constituents, particularly calcium, sodium, sulfate, nitrate, uranium, molybdenum, thorium, and total dissolved solids (TDS). Elevated concentrations of these background constituents can influence the geochemical behavior of target COCs, due to complex formation, competition for available surface adsorption/exchange sites on solid phases, and influences on precipitation/dissolution and redox reactions. Review of historical monitoring results suggests that exceedances of groundwater criteria for COCs within Zone 3 within and beyond areas of seepage impacts reflect geochemical influences from the relatively saline background water. For example, Table 3-1 presents a summary of recent groundwater quality data, including:

- monitoring well NBL-01, which is located within Zone 3 downgradient of seepage impacts;
- monitoring well 613, located within Zone 3, in the core area of seepage impacts, closest to the tailings ponds;
- monitoring well 517, located within Zone 3, within an area of seepage impacts, nearest the planned pilot study; and
- Mill Well water, collected from groundwater located below the Gallup Sandstone, which represents the Dakota Formation groundwater to be used as the fixiviant.

The majority of the tailings ponds are constructed on alluvium, whereas portions of the central and northern ponds are in direct contact with the partially saturated sandstone formations. The alluvium contains sufficient calcium carbonate and other minerals that serve to buffer/neutralize the acidic seepage from the tailings ponds. Zone 3 of the upper Gallup Sandstone, which represents the target area for the pilot studies, however, has comparatively less buffering capacity than the southwest alluvium or Zone 1 of the upper Gallup.

Historical groundwater quality monitoring of Zone 3 has documented the migration of the low-pH front. Figure 3-1 presents concentration-versus-time plots for bicarbonate for two monitoring wells (EPA 14 and 504b) located within the area of seepage impacts. The plot for EPA 14 illustrates how a relatively gradual increase in bicarbonate ion, indicative of dissolution of carbonate minerals, has been followed by a rapid decrease in bicarbonate and pH as the buffering capacity of the formation is exhausted. The plot for 504b illustrates how once the buffering capacity of the formation is exhausted, acidic conditions remain without some type of natural or human-induced neutralizing process. The low pH associated with the migrating front will tend to maintain

elevated concentrations of target COCs, unless processes (either natural or human-induced) act to change the acidic conditions.

Thermodynamic speciation calculations using programs such as PHREEQC and MINTEQA2 have indicated that gypsum (hydrated calcium sulfate) ranges from at or near equilibrium to slightly oversaturated everywhere in the alluvium and sandstone formations, including regions not impacted from tailings seepage. Widespread occurrence of gypsum indicates that relatively high aqueous concentrations of calcium, sulfate, and TDS will likely remain in groundwater absent some relatively dilute solutions that could migrate through the formations to dissolve all the gypsum, and ultimately remove/reduce aqueous concentrations of these inorganic constituents. Such a scenario, however, is unlikely if not impossible, because of the widespread natural occurrence of gypsum within the geologic formations. Infiltration of virtually any aqueous solution when combined with gypsum's presence and reactive geochemical behavior will result in mineral dissolution and relatively high concentrations of calcium, sulfate, and TDS. This Pilot Study therefore does not attempt to mitigate the natural processes that produce exceedances of groundwater protection standards.

3.2 Pilot Study Strategy

The approach to be tested by the Pilot Study involves injecting alkaline groundwater into areas where seepage-induced acidic conditions exist. The alkaline solutions will serve to neutralize the acidic water along a mixing front, and ultimately will entirely displace the seepage-impacted groundwater. Recovery wells located hydraulically downgradient of injection locations will remove the seepage-impacted groundwater as well as that mixed with the injected solutions. Increased groundwater pH associated with the injected alkaline groundwater will serve to greatly reduce migration and/or completely immobilize COCs via chemical precipitation and surface adsorption reactions.

As previously indicated monitoring well NA-02 was initially identified as the water source to be used as the injected-water fixiviant. Geochemical modeling was performed using PHREEQC to evaluate how injection of water like that from NA-02 may react with materials within the area of low-pH seepage impacts. Modeling results indicated that such water would likely prove effective in raising the pH and promoting retardation and/or immobilization of the target COCs. In fact, it was anticipated that during the field-testing, constituents would be removed to an even greater extent than the model predictions.

A series of laboratory batch-mixing experiments were designed and implemented to evaluate potential geochemical reactions likely to occur during the pilot testing, including those predicted by the modeling, as well as those that were not quantified in the PHREEQC simulations. The approach involved various mixtures of groundwater from seepage-impacted areas with solutions proposed to be used as a fixiviant. The batch-mixing experiments also included aqueous mixtures with aquifer solids collected from surficial outcrop samples of the Zone 3 Gallup Sandstone.

The results of the initial batch-testing experiments were presented and discussed in the technical memorandum BBL submitted to GE on January 26, 2006, which is included as Attachment B. The technical memorandum concluded that that alluvial groundwater could serve as a suitable fixiviant to retard and/or immobilize target COCs. Review of the January 2006 technical memorandum by NMED, however, resulted in concerns that the groundwater from the Southwest Alluvium (i.e. well NA-02) did not meet applicable groundwater standards with respect to TDS, sulfate, and manganese. NMED suggested that use of groundwater from the geologic formations below Zone 3 via the onsite Mill Well be considered as a potential alternative source of groundwater to serve as a fixiviant.

BBL performed additional geochemical modeling and bench testing to evaluate the suitability of water from the Mill Well as a fixiviant". Results from these analyses were provided in the technical memorandum BBL submitted to GE on March 31, 2006, which is included in Attachment C. Results indicated that Mill Well water should prove effective as a fixiviant, provided that alkalinity enhancement occur for application within areas of most severe seepage impacts (i.e. vicinity of well 613). Although Mill Well water without added-alkalinity would likely neutralize seepage-impacted groundwater near well 517, where the proposed pilot study will occur, it appeared prudent to conduct the field pilot test with alkalinity-enhanced Mill Well water. This will assist in evaluating potential well-fouling issues, and also provide greater confidence that the proposed fixiviant will successfully neutralize/stabilize groundwater where seepage impacts are greatest during full-scale operations.

4. Pilot Study

4.1 Technology Review

The remedial approach and pilot study described in this document are hydraulically similar to in-situ leach (ISL) technology and “groundwater sweeping” or aquifer flushing used by the mining industry. ISL and aquifer flushing offers some useful insight into the hydraulics and configuration of the pilot study. Accordingly, a literature review summarizing select ISL technology-related documents relevant to the current site conditions and pilot study are presented below. Design and operational considerations follow in subsequent sections.

The geochemical objectives between ISL mining and the current in-situ alkalinity stabilization pilot study described herein are different. In very simple terms, the objective of ISL mining is to mobilize a valued commodity from solid minerals. Our application has the objective of fixing and/or displacing and recovering hazardous constituents from tailings-impacted groundwater.

ISL technology, also known as in-situ solution mining, involves leaving the ore in the ground formation and using liquids, which are pumped through the formation, to recover the minerals out of the ore by leaching. ISL mining was first tried on an experimental basis in Wyoming during the early 1960s for extracting uranium from sandstone rocks. The first commercial uranium mine, using ISL, began operating in 1974. As of June, 2003, about a dozen projects are licensed to operate in the U.S. (Nuclear Issues Briefing Paper 40, June 2003).

Deposits suitable for ISL occur in permeable sand or sandstones. A schematic of the in-situ leach mining process, showing an injection well with a production well, is presented by the U.S. Nuclear Regulatory Commission and is included as Figure 4-1. A schematic of the “groundwater sweep” or aquifer flushing process, whereby contaminated ground water from the ISL mining operation is removed by pumping, is presented by the United States Department of Energy (USDOE) and is included as Figure 4-2.

A thorough field case history of ISL technology, “The Smith Ranch Project: a 1990s In Situ Uranium Mine”, was presented at the Uranium Institute 24th Annual International Symposium in 1999 (Freeman and Stover, 1999). The Smith Ranch Project explored ISL technology through a series of pilot tests to determine production parameters, such as well spacing and injection flow. The pilot tests were arranged as 5-spot patterns, and various lixiviant chemistries were evaluated. Following the success of the pilot studies, the production scale well field layout and design was completed, including the leaching of uranium and the ultimate restoration of the aquifer by aquifer flushing. Regulatory reviews and licensing followed, and the Smith Ranch proceeded to full-scale production, including environmental restoration by aquifer flushing.

In the article “Groundwater Restoration at Wyoming Uranium Solution Mining Sites”, (Catchpole, Garling, and Neumann), two successful case histories are presented that are relevant to the pilot study at the Church Rock site: Bison Basin and Reno Creek. The Bison Basin project used sodium carbonate/bicarbonate as the lixiviant and oxygen as the oxidant to release uranium and maintain its mobility. The pilot well field consisted of four injection wells and three recovery wells arranged in a line-drive configuration, and operated at a flow rate of 25 gallons per minute. The test was conducted for three months. The baseline concentration, post restoration concentration, and DEQ restoration requirements were presented and compared in the article. The uranium leach was successful, and the DEQ restoration requirements were met using aquifer flushing.

The Reno Creek project followed a similar protocol, but utilized a 5-spot configuration for more efficient injection and extraction. Again, the uranium leach and the aquifer restoration by aquifer flushing were successful.

A Final Environmental Statement (FES) prepared by the NRC for the Bison Basin commercial-scale license application concluded that "...the applicant has demonstrated that restoration of the aquifer to its original potential use condition is achievable." These two case histories, along with the Smith Ranch project, show that ISL and aquifer flushing can be used in an environmentally acceptable manner that can clean up land and water resources for future use. This pilot study utilizes a combined ISL and post-ISL aquifer flushing approach for aquifer restoration.

4.2 Well Injection and Recovery Network

The pilot study will be conducted in the field to assess the effectiveness of injection remediation for the Zone 3 groundwater. Figure 4-3 presents the pilot study location in relation to the general site layout, and a detailed layout appears in Figure 4-4. The pilot study will occur downgradient of the contaminant source and will use some of the wells already in place. Wells 0608, 0517, 0518, IW-1, IW-2, IW-3, IW-4, EW-1, and EW-2 will be used in the pilot study. The pilot test well field is a nine-spot pattern, which builds upon the five-spot layout traditionally used by the ISL industries, with the addition of four hydraulic-control extraction wells on the perimeter of the well field. The net rates of injection and production are nearly balanced across the well field (with slightly higher withdrawal to injection rates), such that fluid flow away from the well field is eliminated.

The pilot study well field includes a central extraction well (EW-1) surrounded by four, to-be-installed injection wells (IW-1 through IW-4). The central extraction well will provide the primary monitoring location to evaluate the effectiveness of the technology in terms of removing and/or immobilizing the target COCs. The four surrounding injection wells will provide a means to inject fixiviant. In addition, the injection wells will hydraulically isolate the central extraction well from the surrounding groundwater flow system, and provide a controlled, closed hydraulic system for monitoring the effectiveness of treatment over time during the pilot test. The four outer extraction wells (wells 608, 517, 518, and EW-2) will provide overall hydraulic control during the pilot study. Attachment D shows the schematic layout of the pilot test area, and presents pertinent hydraulic parameters, estimated pilot test pumping rates, calculated time for initial breakthrough of injected water at the central extraction well, and calculated time for 1 pore-volume exchange within the zone surrounding the central extraction well. These calculations are based on the hydraulic parameters in the MWH (2004) modeling report, with extraction and injection wells screened over the entire saturated thickness of Zone 3; drawdown to within 3 feet of the base of Zone 3 inside each extraction well; and assumed well efficiency of 50%. The pilot study well field design can be summarized as follows:

- 9 wells (3 existing, 6 new), relative spacing and locations shown on Figure 4-4 and in Attachment D;
- 5 extraction wells with a combined rate of approximately 4.0 gpm;
- 4 injection wells with a combined rate of 3.3 gpm;
- net pumping rate = 0.7 gpm (net extraction to maintain hydraulic control);
- time for initial breakthrough of injected water at central extraction well estimated as 14 days; and
- time for one complete pore volume exchange between injection wells and central extraction well estimated as 37 days.

In the event that the pilot study indicates that the remedial approach presented in this document is effective, a full-scale approach to remediation will be designed. In this case, the plume will most likely be covered by a grid

pattern of injection and extraction wells. Groundwater modeling will likely be used to assist in designing the grid spacing and distribution based on the bench-scale and pilot study results.

4.3 Well Design and Installation

The well design and installation approach is consistent with prior well installation practices at the site. The wells consist of a 6 inch-diameter PVC type casing of Schedule 80 rating, extending approximately 10 feet into the top of the Gallup Sandstone (Zone 3), and a 5 3/4" diameter open borehole extending from the bottom of casing to just below the top of the coal seam at the base of Zone 3. The general well installation procedure included the following steps:

- Drill a rotary hole of 9 7/8" or 10 1/2" diameter to a depth determined from previous geologic data obtained from 517, 518, and 608, which will be at least 10' into the Gallup (Zone 3) Sandstone.
- Set a capped 6 1/2" OD diameter PVC casing of Schedule 80 material and cement it from the bottom upward using a neat cement. The cement will be allowed to set 24 hrs. or longer as the conditions dictate.
- Drill out the cap with a 5 7/8" rotary bit and finish the hole to just below the top of the coal seam at the base of Zone 3.

UNC assisted in determining the final design and installation approach for the injection and recovery wells. Well construction details depicting the design of the extraction and recovery wells are included on Figure 4-5. The newly-installed wells have an open-borehole construction.

4.4 Groundwater Monitoring During Pilot Test

The hydraulic head in the injection and recovery wells will be precisely monitored during the test. The injection rates will most likely range between 1-3 gallons per minute, and the recovery rates will be spread around the recovery wells to balance the injection rates. The rates calculated in Attachment D will be the starting point based on the estimated hydraulic parameters. They will be revised in the field as necessary.

Groundwater samples will be collected from the injectant source and from recovery wells during the pilot test. Samples will be collected at frequent intervals (twice weekly) to monitor the quality of the injectant and to identify arrival and breakthrough of the injectant at the recovery wells. The suite of chemical constituents analyzed as part of the on-going monitoring program, identified in Table 3-1, will be analyzed after each pore volume of injectant has migrated to the recovery wells.

Preliminary estimates of travel times from the injection wells to the recovery wells indicate pore volume removal can be achieved in approximately 37 days (Attachment D). Evaluation of daily analytical results for pH and chloride should assist in identifying when pore volume removal is achieved. If the results suggest significantly different travel times than originally estimated, adjustments will be made for sampling and analyses for Table 3-1 constituents.

The schedule for sampling and analysis during the pilot test includes:

-
- Twice weekly samples collected from the storage tank containing the injectant solution, and the recovery wells. Samples will be analyzed for: pH, TDS, specific conductance, and chloride;
 - Sampling from recovery wells following unit pore-volume removal. Samples will be analyzed for constituents identified in Table 3-1, which correspond to those analyzed as part of the on-going monitoring program for Zone 3 groundwater.

4.5 Field Procedures

The general field procedures for conducting the pilot study are as follows:

1. Install pilot injection and extraction wells as described in Section 4.3. Convert existing wells to be used as extraction or injection wells as appropriate, using the necessary piping, fittings, equipment, and instrumentation.
2. Stage an approximately 18,000-gallon, insulated polyethylene tank at the injection site to store groundwater collected from the Dakota aquifer (Mill Well), to be used for injection. The storage tank should include level instrumentation for high and low level alarms and on/off control of the source water pump.
3. Install necessary piping, fittings, and instrumentation to allow amended Mill Well water to be gravity-injected from the storage tank to the four injection wells (see Figure 4-6).
4. Install piping as necessary to convey groundwater from the extraction wells to the existing surge tank for discharge to the on-site evaporation pond.
5. Connect Mill Well water supply for injection (i.e., the same water supply source used for the bench-scale study) to the injection water storage tank. Electrically connect level controller at storage tank to pump control panel for automatic on/off pump control.
6. Perform single-well pumping tests (i.e., specific-capacity tests of approximately one to two hours each) at the nine wells within the pilot study well field to determine the pre-pilot hydraulic conductivity values and well yields.
7. Fill the injection water storage tank with water from the Mill Well.
8. Gravity feed alluvial groundwater from the storage tank to the pilot injection well in accordance with pre-determined operating parameters (i.e., flow rate, pressure, etc.) and procedures (the amounts and chemistry of the injection water will be based on the results of the bench-scale test).
9. Begin monitoring, sampling, and analysis based on flow velocities and modeling predictions. Upon the start of the pilot study, monitoring will commence immediately for determining the pre-modified chemistry of the groundwater. Samples will be collected based on anticipated travel times but at a minimum on a weekly basis. The species and parameters to be monitored include: pH, U, TDS, Ni, Co, Mo, As, Al, Mn, SO₄, Ra-226/228, Gross Alpha, Be, Cd, Th-230, and Chloride. Twice weekly sampling for analyses of select constituents such as pH, specific conductance, and chloride will be performed to monitor groundwater migration. Laboratory analysis will be subcontracted by BBL.

-
10. Perform single-well pumping tests (specific-capacity tests of approximately one to two hours each) at the nine wells within the pilot study well field to determine the post-pilot hydraulic conductivity values and well yields; these data will be compared to the pre-pilot data to evaluate whether any reduction in well yield and/or hydraulic conductivity may have occurred during the pilot study. These post-pilot hydraulic tests will be performed at the same pumping rates and for the same duration as the pre-pilot pumping tests.

The analysis of the laboratory results will be ongoing and begin immediately after sample collection during the pilot study so that the hydraulic front, indicated by increased alkalinity and rising pH, and the chemical reaction front (indicated by changes in metal and radionuclide concentrations) can be determined.

4.6 Pilot Study Results

Following completion of the Pilot Study, BBL will prepare a report presenting the results. The report will include the following information:

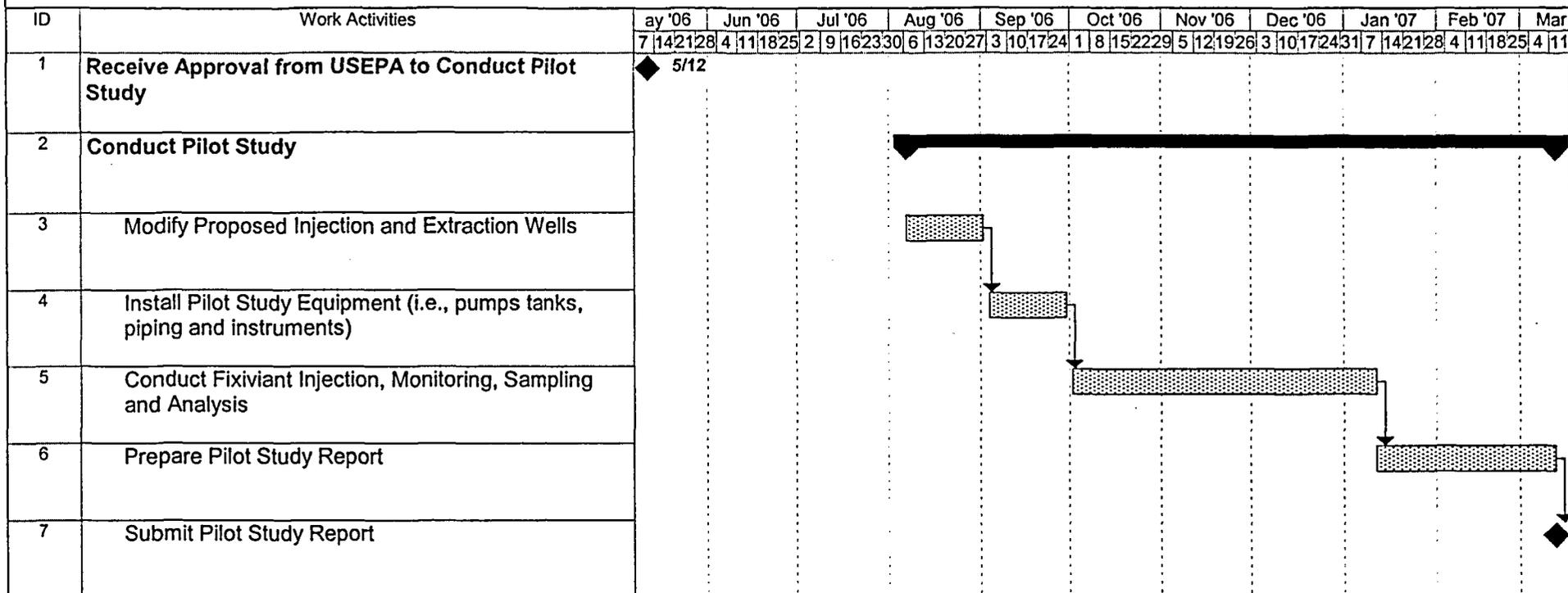
- Introduction and Site Background;
- Description of Pilot Study Activities;
- Pilot Study Results;
- Summary and Conclusions; and
- Recommendations.

The Pilot Study Results Report will also include validated analytical data and figures presenting the area of the pilot study and graphical representation of select analytical data.

5. Schedule

The anticipated schedule for the bench-scale test and pilot study is attached.

In-Situ Alkalinity Stabilization Pilot Study Project Schedule



Note:

1. Pilot Study is dependent upon USEPA's approval.

Date: Thu 6/15/06

Task



Summary



Milestone



Acronyms and Abbreviations

ACLs – Alternate Concentration Limits
ARARs – Applicable or Relevant and Appropriate Requirements
BBL – Blasland, Bouck & Lee, Inc.
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COC – Constituent of Concern
DEQ – Department of Environmental Quality
FES – Final Environmental Statement
gpm – gallons per minute
ISL – in-situ leach
mg/L – milligrams per liter
MCLs – Maximum Contaminant Levels
NMED – New Mexico Environment Department
NMWQCC – New Mexico Water Quality Control Commission
NPL – National Priorities List
NRC – National Research Council
pCi/L – pico Curies per liter
P&ID – Piping and Instrumentation Diagram
ROD – Record of Decision
SFS – Supplemental Feasibility Study
TDS – total dissolved solids
UAO – Unilateral Administrative Order
UIC – underground injection control
UNC – United Nuclear Corporation
USDOE – United States Department of Energy
USEPA – United States Environmental Protection Agency

References

Canonie Environmental Services Corp. 1987. *Reclamation Engineering Services Geohydrologic Report*. Prepared for UNC Mining and Milling, Gallup, New Mexico.

Canonie Environmental Services Corp., 1989a, *Remedial Design Report, Church Rock Site, Gallup, New Mexico*. April.

Canonie Environmental Services Corp., 1989b, *Ground Water Corrective Action, Annual Review - 1989, Church Rock Site, Gallup, New Mexico*. December.

Canonie Environmental Services Corp., 1990, *Ground Water Corrective Action, Annual Review - 1990, Church Rock Site, Gallup, New Mexico*. December.

Canonie Environmental Services Corp., 1991, *Ground Water Corrective Action, Annual Review - 1991, Church Rock Site, Gallup, New Mexico*. December.

Canonie Environmental Services Corp., 1992, *Ground Water Corrective Action, Annual Review - 1992, Church Rock Site, Gallup, New Mexico*. December.

Canonie Environmental Services Corp., 1993, *Ground Water Corrective Action, Annual Review - 1993, Church Rock Site, Gallup, New Mexico*. December.

Canonie Environmental Services Corp., 1995, *EPA Remedial Action and NRC Ground Water Corrective Action, Five-Year Review (1989-1994)*. January.

Catchpole, Garling, and Neuman. Groundwater Restoration at Wyoming Uranium Solution Mining Sites. Source: <http://www.wma-minelife.com/uranium/papers/isltxt01.html>

Earth Tech, Inc., 1998, *Ground Water Corrective Action, Annual Review - 1998, Church Rock Site, Gallup, New Mexico*. December.

Earth Tech, Inc., 1999, *Ground Water Corrective Action, Annual Review - 1999, Church Rock Site, Gallup, New Mexico*. December.

Earth Tech, Inc., 2000a, *Ground Water Corrective Action, Annual Review - 2000, Church Rock Site, Gallup, New Mexico*. December.

Earth Tech, 2000b, Letter to Greg Lyssy, Subject: "Response to Agency Comments on the January 13, 2000, Letter titled 'Source Materials License SUA-1475, Technical Support for Proposed License Amendments', for United Nuclear Corporation Church Rock Site", April 26.

Earth Tech, 2001, "Technical Memorandum – Change in Zone 3 Saturated Thickness, United Nuclear Church Rock Site, Gallup, New Mexico." Submitted to Bill von Till, U.S. Nuclear Regulatory Commission by Earth Tech, Inc. April.

Earth Tech, Inc., 2002a, *Ground Water Corrective Action, Annual Review - 2001, Church Rock Site, Gallup, New Mexico*. January.

Earth Tech, 2002b, *Annual Review Report – 2002 – Groundwater Corrective Action, Church Rock Site, Gallup, New Mexico*. December.

Earth Tech. 2002c. *Results of Zone 3 Aquifer Test*. Prepared for General Electric Company, Church Rock Site, New Mexico (May 22, 2002).

Freeman and Stover, 1999. The Smith Ranch Project: a 1990's In-Situ Uranium Mine Source: <http://www.world-nuclear.org/sym/1999/freeman.htm>

MACTEC. 2003. *Final Report, Hydraulic Fracturing Pilot Test Results and Preliminary Full Scale Design, United Nuclear Church Rock Facility*. Prepared for United Nuclear Corporation (December 23, 2003).

MWH. 2004. *Supplemental Feasibility Study, Zone 3 Hydrostratigraphic Unit, Church Rock Uranium Mill Tailings Site*. Prepared for United Nuclear Corp., Gallup, New Mexico (October 2004).

National Research Council. Final Environmental Statement. Source: U.S. Nuclear Regulatory Commission, 1997 and U.S. Department of Energy, 1995.

National Research Council, 2000. License Amendment. December 29, 2000.

Nuclear Issues Briefing Paper 40, June 2003, Source: <http://www.uic.com.au/nip40.htm>

Rust Environment and Infrastructure, 1997, Ground Water Corrective Action, Annual Review - 1997, Church Rock Site, Gallup, New Mexico. December.

Smith Technology Corporation (Smith Environmental Technologies Corporation), 1995, *Ground Water Corrective Action, Annual Review - 1995, Church Rock Site, Gallup, New Mexico*. December.

Smith Technology Corporation, 1996, Ground Water Corrective Action, Annual Review - 1996, Church Rock Site, Gallup, New Mexico. December.

United Nuclear Corporation, 1989a, *Corrective Action Plan, Church Rock Uranium Mill Tailings Facility*. April.

United Nuclear Corporation, 1989b, *Remedial Action Plan, Church Rock Uranium Mill Tailings Facility*. April

United States Environmental Protection Agency. 1988. Record of Decision, United Nuclear Corp., Church Rock, NM.

United States Environmental Protection Agency, 1998, *Five-Year Review Report*. September.

United States Environmental Protection Agency. 2003. *Second Five-Year Review Report for the United Nuclear Corporation Groundwater Operable Unit, Church Rock, McKinley County, New Mexico, September 2003*.

United States Environmental Protection Agency, 2004, Letter on "Hydraulic Fracturing for Zone 3 and Supplemental Feasibility Study, United Nuclear Corporation Church Rock Superfund Site, Administrative Order (Docket No. CERCLA 6-11-89);" March 10, 1994, with additional comments on March 19, 2004.

USFilter, 2004, *Rationale and Field Investigation Annual Report Work Plan to Evaluate Recharge and Potential Cell Sourcing to the Zone 3 Plume*, January 19, 2004.

Veolia Environment. 2004. *Annual Review Report – 2004, Groundwater Corrective Action Church Rock Site, Church Rock, New Mexico*. Prepared for United Nuclear Corporation, Gallup, New Mexico (December 2004).

Tables

TABLE 3-1

UNC CHURCH ROCK
GALLUP, NEW MEXICO

IN-SITU ALKALINITY STABILIZATION PILOT STUDY

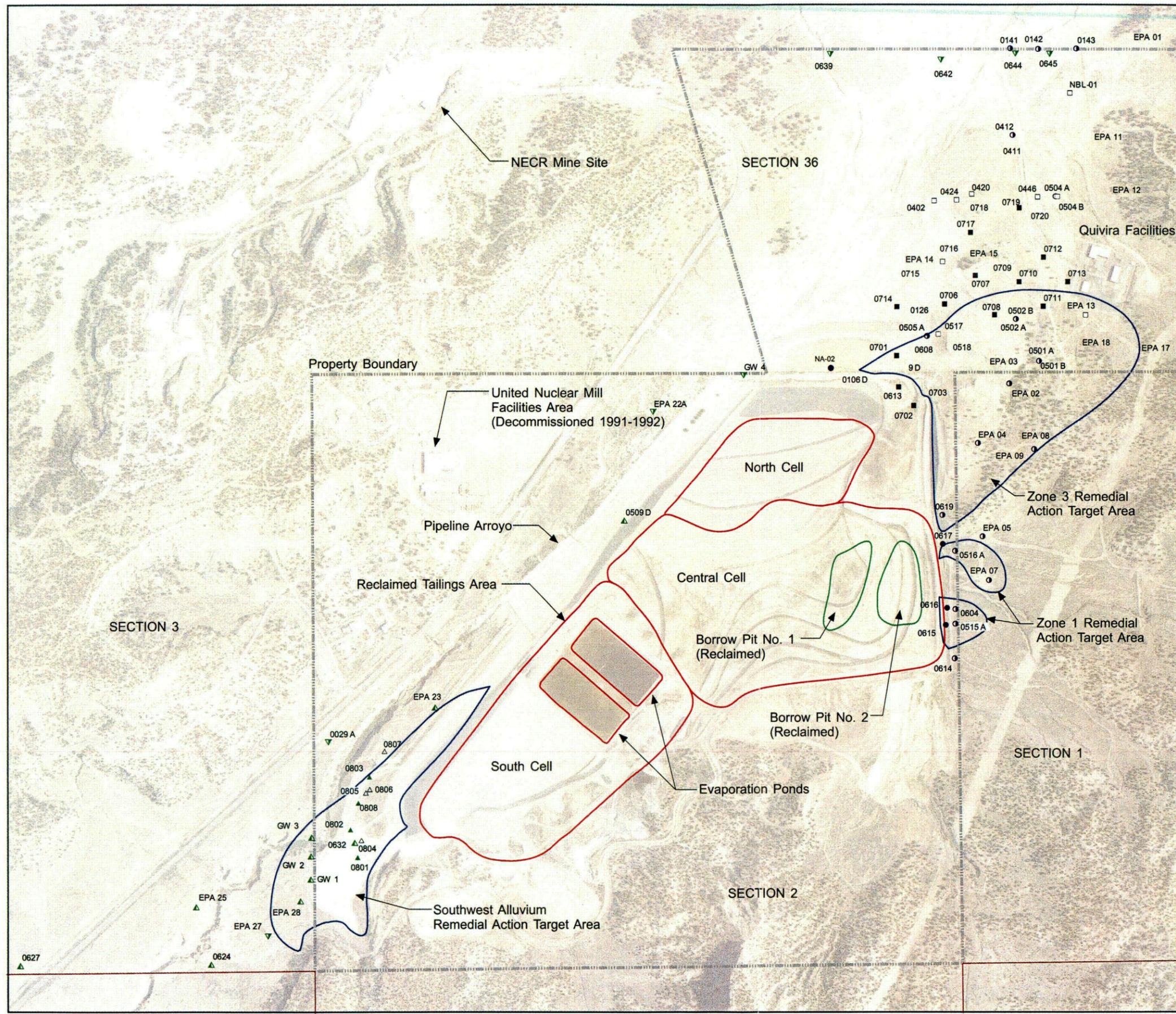
WATER QUALITY

Constituent	Units	NRC Standard	EPA Standard	Monitoring Wells			
				613	517	NBL-01	Mill Well 1
Field pH	SU	NA	NA	2.82	4.28	6.44	8.6
Lab TDS	mg/l	NA	4800	12950	4820	3800	2180
Ca	mg/l	NA	NA	462	502	662	16.1
Mg	mg/l	NA	NA	734	446	202	4.2
Na	mg/l	NA	NA	307	156	131	716
K	mg/l	NA	NA	1.1	12.2	7.7	3.6
HCO3	mg/l	NA	NA	< 1	< 1	288	196
SO4	mg/l	NA	2125	9523	3213	2315	1180
Chloride	mg/l	NA	250	170	48	37	154
NH4 as N	mg/l	NA	NA	296	11	0.46	0.65
NO3 as N	mg/l	NA	190	11.9	0.81	< 0.10	0.02
Chloroform	mg/l	0.001	NA	0.13	0.005	< .001	NA
Al	mg/l	NA	5	744	7	< 0.1	<0.06
As	mg/l	0.05	0.05	< 0.001	< 0.001	0.79	<0.0005
Be	mg/l	0.05	0.017	0.17	< 0.01	< 0.01	<0.004
Cd	mg/l	0.01	0.01	0.030	0.005	< 0.005	0.0001
Co	mg/l	NA	0.05	1.84	0.65	0.073	<0.02
Pb	mg/l	0.05	0.05	< 0.05	< 0.05	< 0.05	0.034
Mn	mg/l	NA	2.6	55.4	6.9	2.8	0.04
Mo	mg/l	NA	1	< 0.1	< 0.1	1.75	<0.02
Ni	mg/l	0.05	0.2	1.70	0.58	0.117	0.07
Se	mg/l	0.01	0.01	< 0.001	< 0.001	< 0.001	0.002
V	mg/l	0.1	0.7	2.43	< 0.1	< 0.1	<0.01
U	mg/l	0.3	5	1.48	0.0557	0.14	0.0081
Rad-226	pci/l	NA	NA	10.7	7.9	7.1	1.7
Rad-228	pci/l	NA	NA	< 1.0	10.5	3.9	0.69
Rad Total	pci/l	5	5	10.7	18.3	10.9	2.39
Th-230	pci/l	5	NA	411	0.325	< 0.2	-0.14
Pb-210	pci/l	1	NA	< 1.0	< 1.0	< 1.0	NA
Gross Alpha	pci/l	15	15	33.8	14.2	8.1	16

Notes:

1. mg/l = milligrams per liter.
2. NA = not applicable.
3. pci/l = pico curies per liter.
4. SU = standard units.
5. < = constituent was not detected at concentrations above the detection limit.
6. The concentrations for monitoring wells 613, 517, and NBL-01 represent the average of 2004 data. The Mill Well 1 sample was collected on February 28, 2006.

Figures

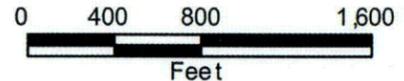


LEGEND:

- Southwest Alluvium**
- ▲ Idled Extraction Well
 - ▲ Monitoring Well
 - △ Water Level Monitoring Well
 - ▼ Dry Monitoring Well
- Zone 3**
- Idled Extraction Well Used for Monitoring
 - Decommissioned or Idle Extraction Well
 - Monitoring Well
 - Dry or Decommissioned Monitoring Well
- Zone 1**
- Decommissioned Extraction Well
 - Decommissioned Monitoring Well
 - Monitoring Well

NOTES:

1. Figure taken from *Annual Review Report - 2004 Groundwater Corrective Action* by NA Water Systems, dated December 2004.



UNC CHURCH ROCK
 GALLUP, NEW MEXICO
**IN-SITU ALKALINITY
 STABILIZATION PILOT STUDY**
**SITE LAYOUT AND PERFORMANCE
 MONITORING WELL LOCATIONS
 2004 OPERATING YEAR**


 an ARCADIS company

**FIGURE
 1-1**

6/16/06 SYR-D85-DJH-KLS-LJP
 NJ2082402/20824g09.cdr

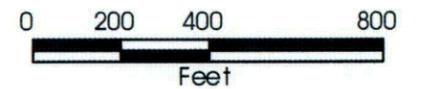


LEGEND:

- Well Names
- Cell Boundaries
- Property Boundary
- - - - - Approximate Eastern Boundary of Zero Saturation
- Groundwater Elevation Contour
- - - - - Inferred Groundwater Elevation Contour

NOTES:

1. Groundwater elevation values are displayed in feet above mean sea level.
2. Well names are displayed with black text.
3. Groundwater elevations are shown with blue text.
4. Aerial photo taken on August 1, 1996.
5. Figure taken from *Annual Review Report - 2004 Groundwater Corrective Action* by NA Water Systems, dated December 2004.

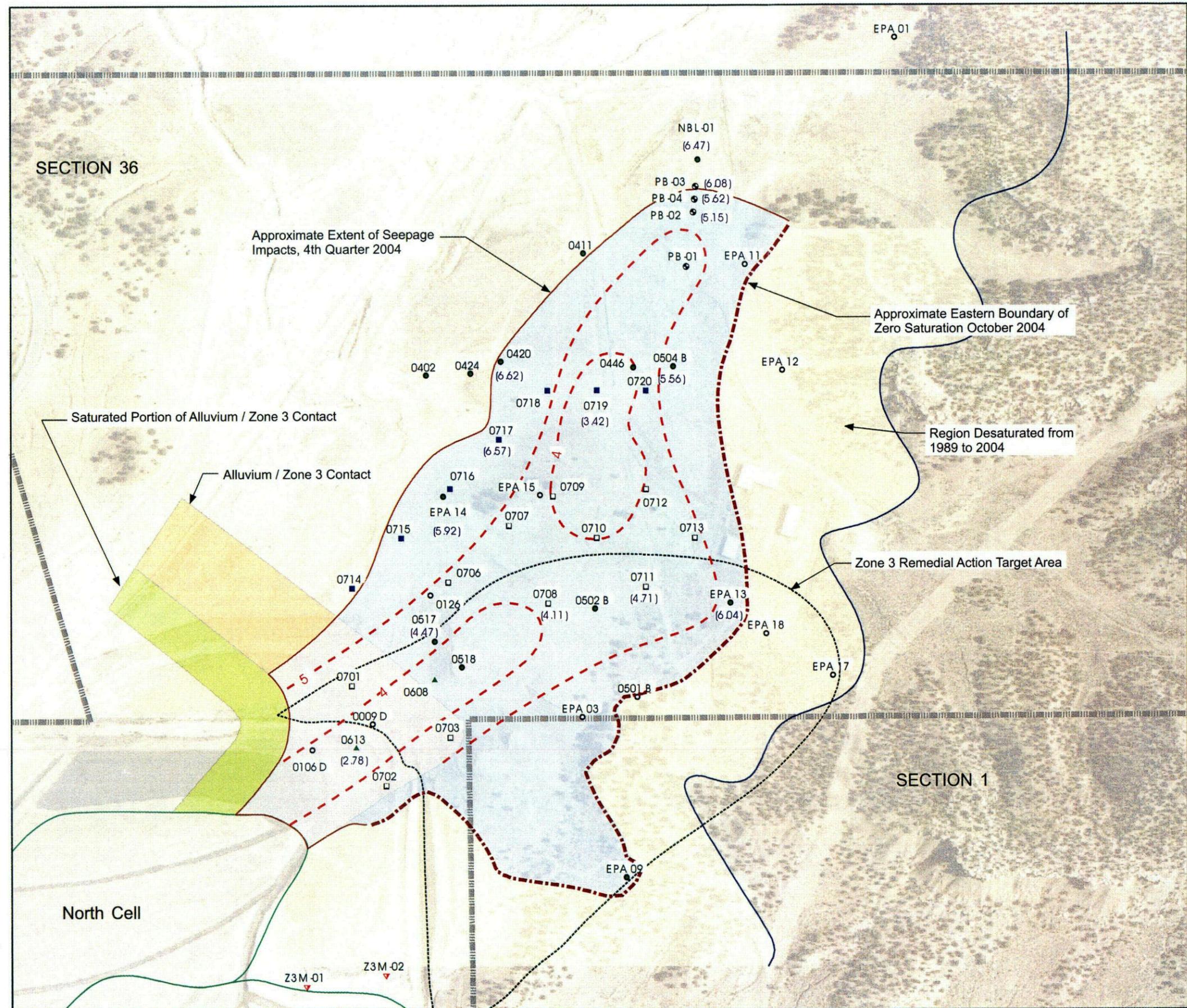


UNC CHURCH ROCK
 GALLUP, NEW MEXICO
**IN-SITU ALKALINITY
 STABILIZATION PILOT STUDY**

**ZONE 3 POTENTIOMETRIC
 SURFACE MAP - OCTOBER 2004**

BBL
 an ARCADIS company

**FIGURE
 1-2**



LEGEND:

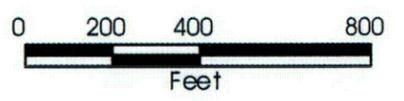
- Property Boundary
- Zone 3 Target Remediation Action Area
- Section Boundary
- Cell Boundary
- Approximate Area Impacted by Tailings Seepage
- - - - pH Contour

WELLS:

- Monitoring
- Dry Monitoring
- Stage I Extraction
- Stage II Extraction
- Plume Boundary
- ▲ Northeast Pump-Back
- ▼ Piezometer
- - - - - Approximate Eastern Boundary of Zero Saturation

NOTES:

1. All locations are approximate.
2. Values for field measured pH are shown with purple text and enclosed in parentheses.
3. Aerial Photo taken August 1, 1996.
4. Figure taken from *Annual Review Report - 2004 Groundwater Corrective Action* by NA Water Systems, dated December 2004.



UNC CHURCH ROCK
GALLUP, NEW MEXICO
IN-SITU ALKALINITY
STABILIZATION PILOT STUDY

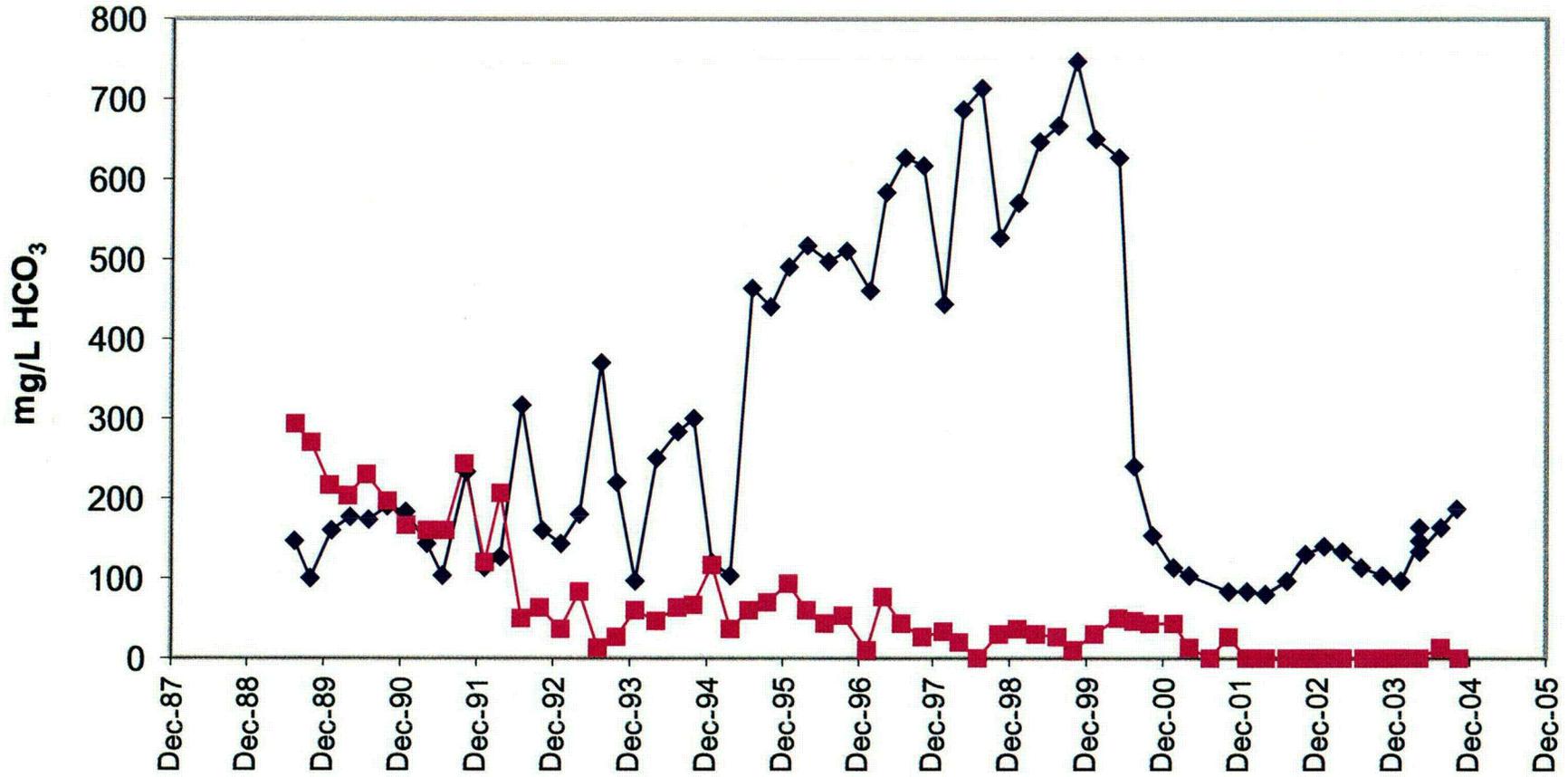
**ZONE 3 APPROXIMATE EXTENT OF
SEEPAGE IMPACTS - OCTOBER 2004**

BBL
an ARCADIS company

**FIGURE
1-3**

6/16/06 SYR-D85-DJH-KLS-LJP
N20824002/CDR/20824g08.cdr

Bicarbonate vs Time EPA 14 and 504b



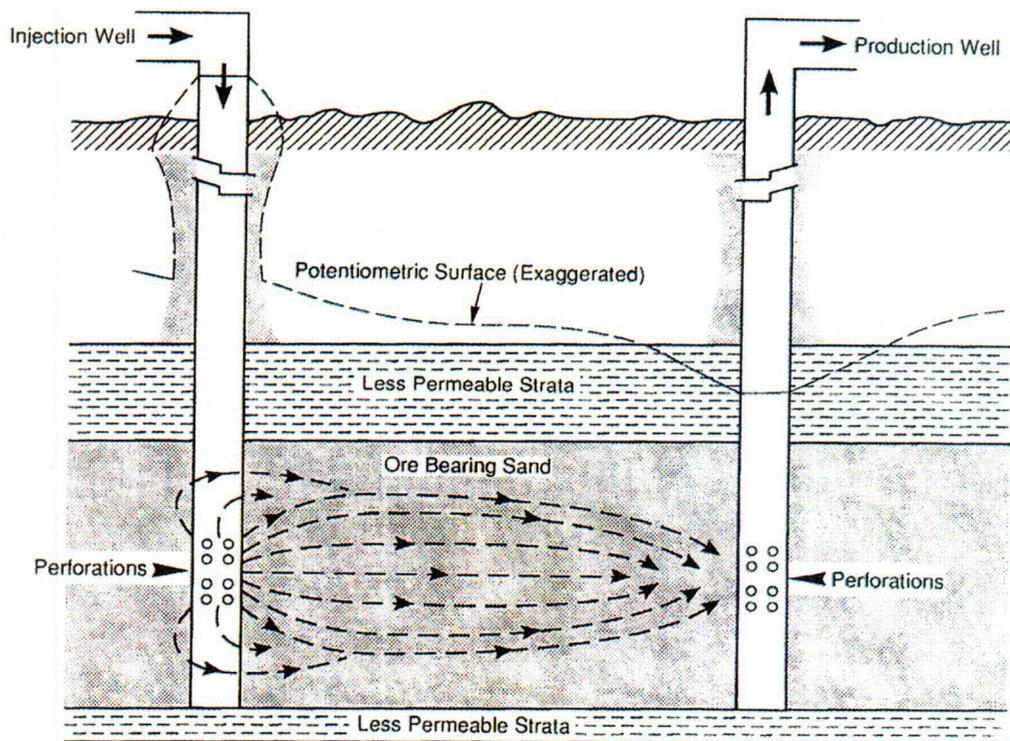
◆ EPA 14 ■ 0504 B

UNC CHURCH ROCK
GALLUP, NEW MEXICO
IN-SITU ALKALINITY
STABILIZATION PILOT STUDY

BICARBONATE VS TIME

BBL
an ARCADIS company

FIGURE
3-1



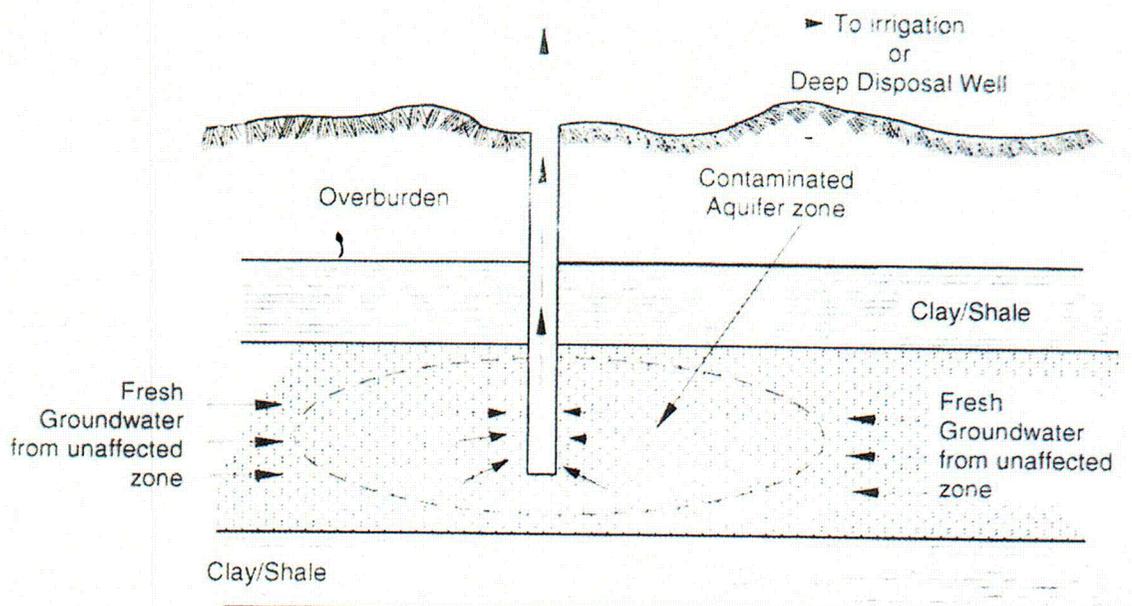
REFERENCE:
 FIGURE TAKEN FROM <http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6870/cr6870.pdf>

UNC CHURCH ROCK
 GALLUP, NEW MEXICO
**IN-SITU ALKALINITY
 STABILIZATION PILOT STUDY**

**TYPICAL SCHEMATIC OF THE
 IN-SITU LEACH MINING PROCESS**



**FIGURE
 4-1**



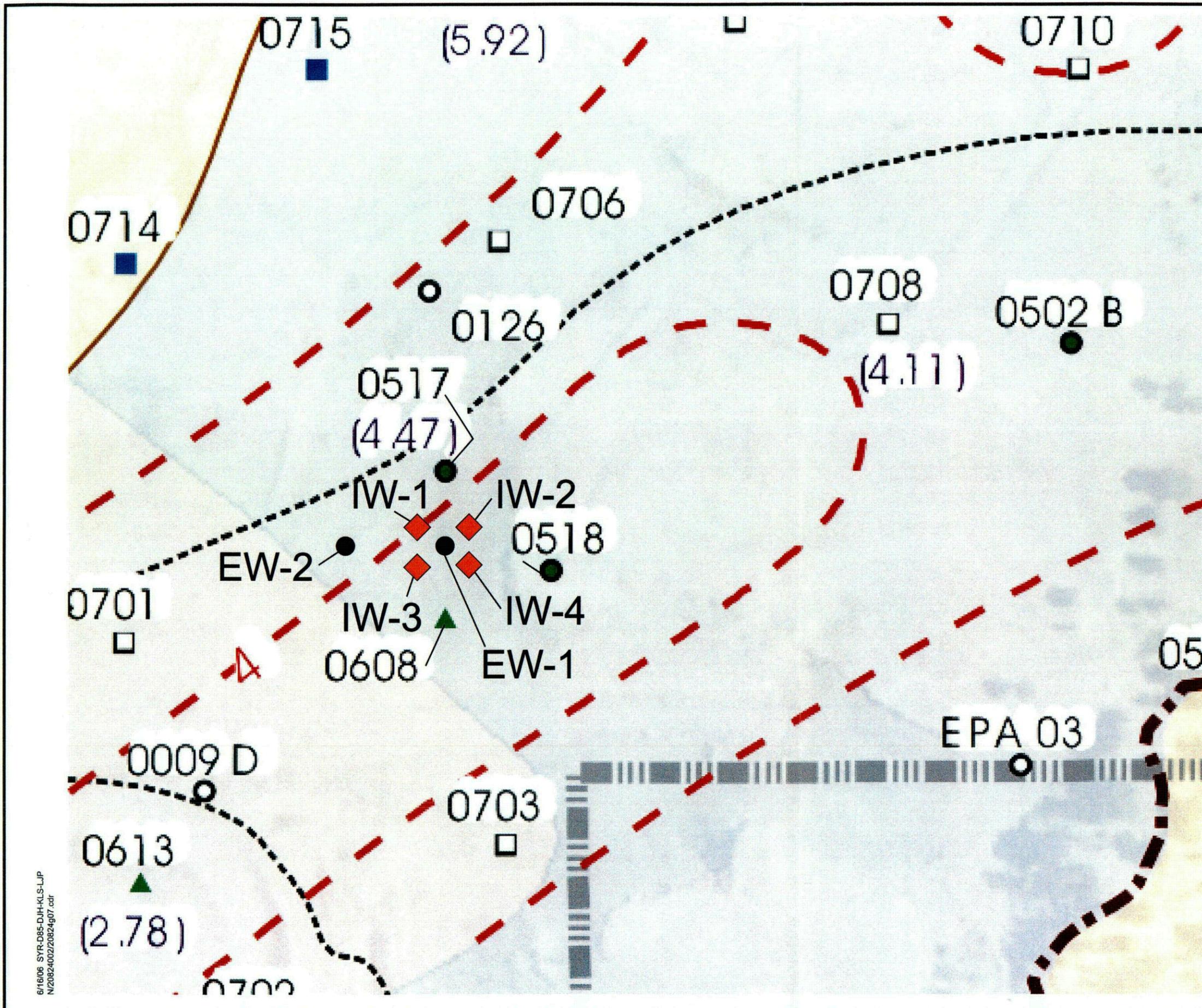
REFERENCE:
 FIGURE TAKEN FROM <http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6870/cr6870.pdf>

UNC CHURCH ROCK
 GALLUP, NEW MEXICO
**IN-SITU ALKALINITY
 STABILIZATION PILOT STUDY**

**SCHEMATIC OF THE
 GROUNDWATER SWEEP PROCESS**



**FIGURE
 4-2**



LEGEND:

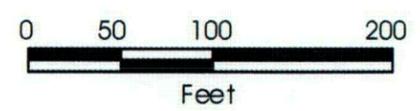
- ▬▬▬▬▬▬ Property Boundary
- Zone 3 Target Remediation Action Area
- Cell Boundary
- Approximate Area Impacted by Tailings Seepage
- - - - pH Contour

WELLS:

- Monitoring
- Dry Monitoring
- Stage I Extraction
- Stage II Extraction
- ▲ Northeast Pump-Back
- ▼ Piezometer
- Extraction Well
- ◆ Injection Well
- Approximate Eastern Boundary of Zero Saturation

NOTES:

1. All locations are approximate.
2. Figure taken from *Annual Review Report - 2004 Groundwater Corrective Action* by NA Water Systems, dated December 2004.

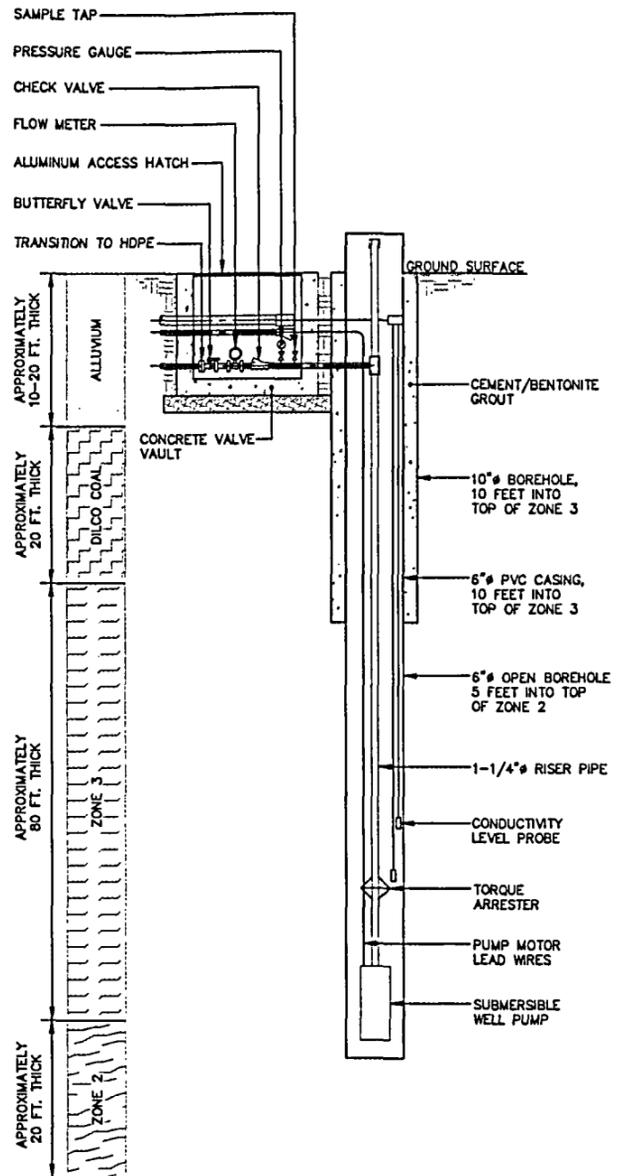


UNC CHURCH ROCK
 GALLUP, NEW MEXICO
 IN-SITU ALKALINITY
 STABILIZATION PILOT STUDY
**APPROXIMATE LOCATIONS OF
 PROPOSED INJECTION AND
 EXTRACTION WELLS**


 an ARCADIS company

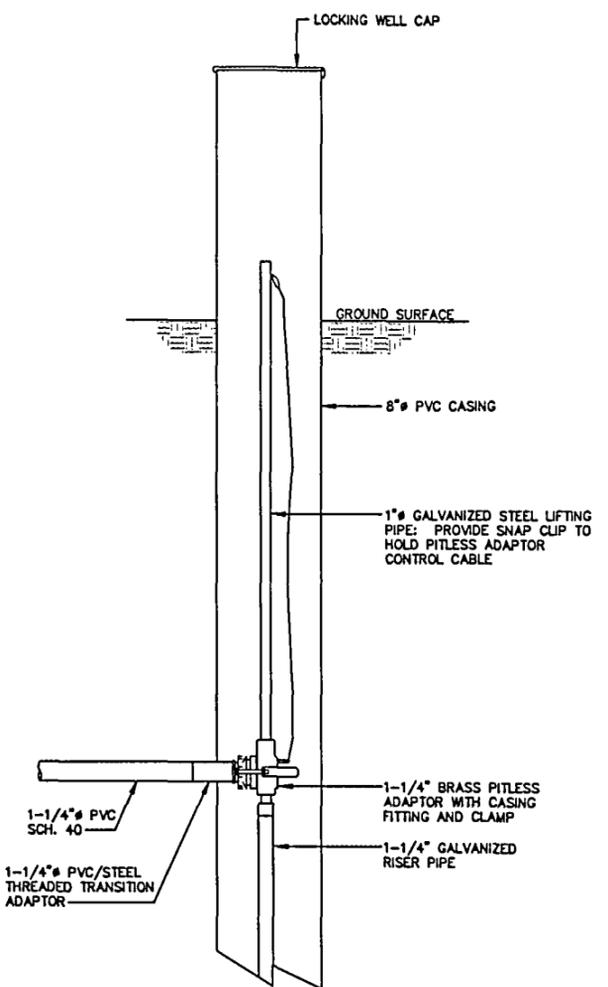
**FIGURE
 4-4**

6/16/06 SYR-D85-DJH-KLS-LJP
 N2082400220824907.cdr



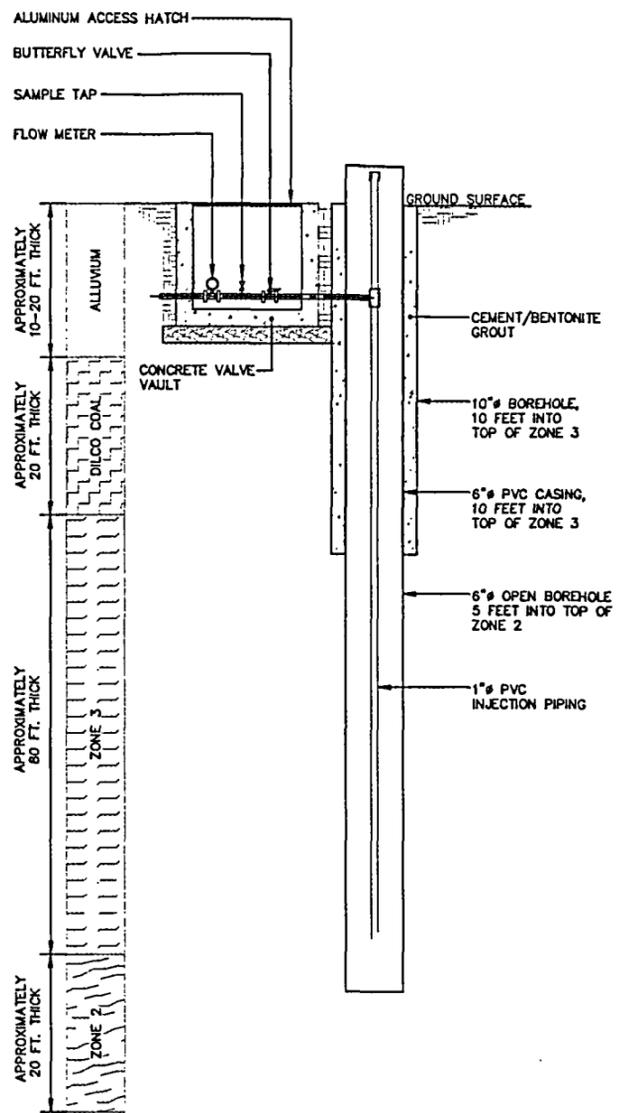
EXTRACTION WELL DETAIL

NOT TO SCALE



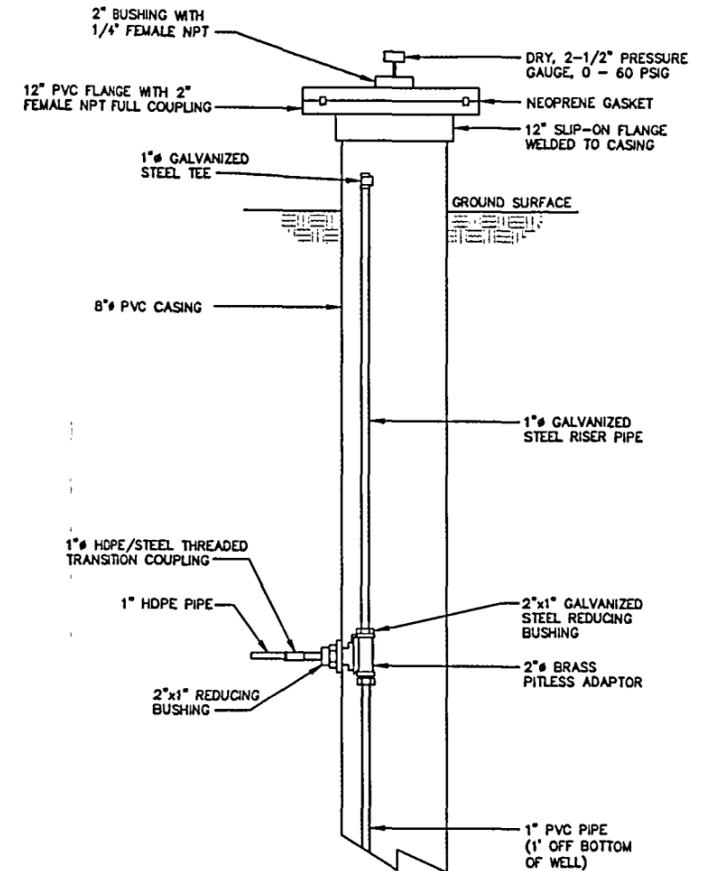
EXTRACTION WELL HEAD DETAIL

NOT TO SCALE



INJECTION WELL DETAIL

NOT TO SCALE



INJECTION WELL HEAD DETAIL

NOT TO SCALE

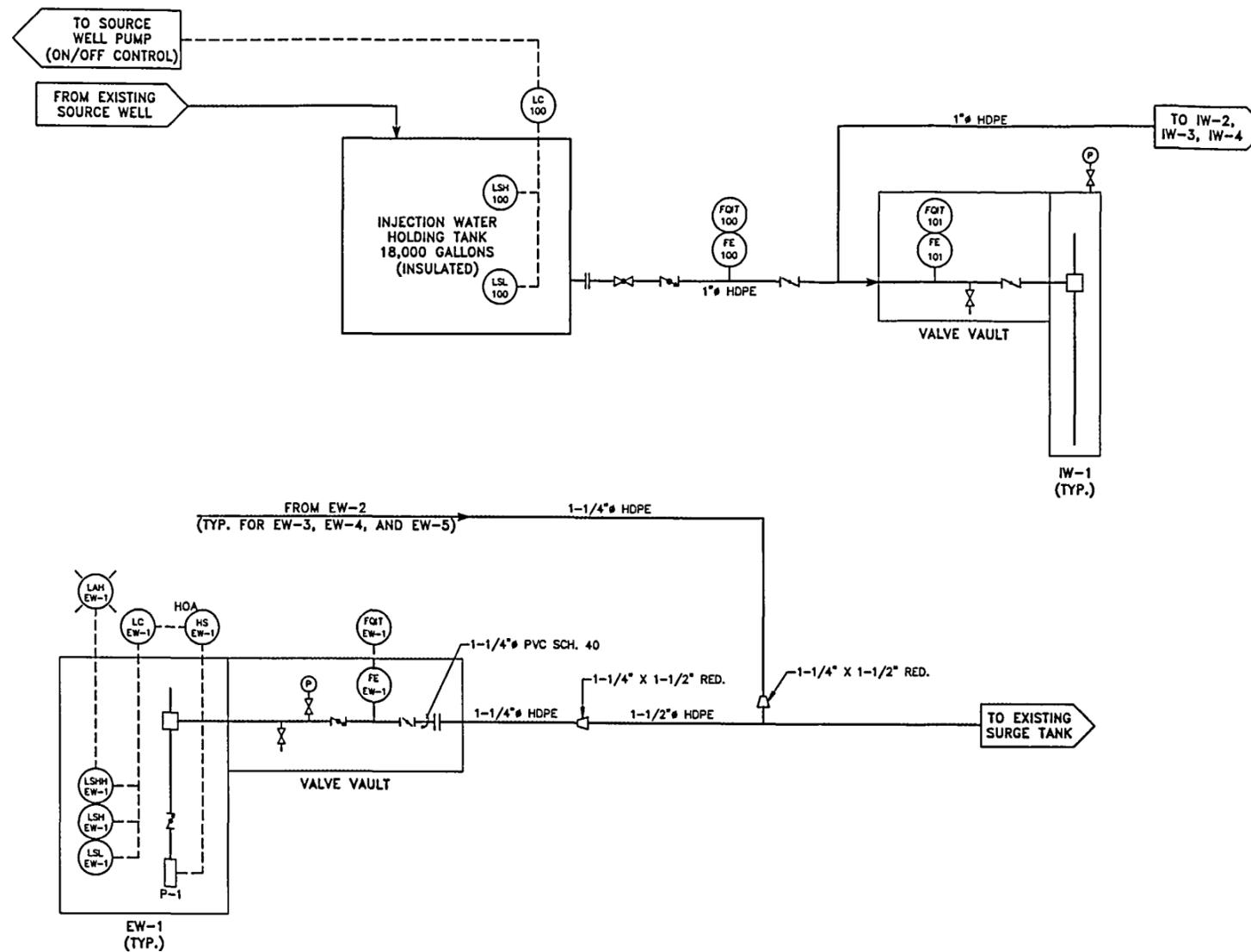
X: NONE
 L: DWG OFF-REF
 P: PAGESET/PLT-DL
 4/18/06 STR-85-BCP LIP BCP
 C:20671001/REPORT/20671001.DWG

UNC CHURCH ROCK
 GALLUP, NEW MEXICO
**IN-SITU ALKALINITY
 STABILIZATION PILOT STUDY**

WELL DETAILS

BBL
 an ARCADIS company

FIGURE
4-5



- LEGEND:**
- BALL VALVE
 - BUTTERFLY VALVE
 - CHECK VALVE
 - FLANGE TO FLANGE CONNECTION
 - PRESSURE GAUGE
 - REDUCER
 - SAMPLE TAP
 - MAIN PANEL MOUNT
 - LOCAL FIELD MOUNT

- ABBREVIATIONS:**
- EW EXTRACTION WELL
 - FE FLOW ELEMENT
 - FOIT TOTALIZING FLOW TRANSMITTER
 - HOA HAND-OFF-AUTO
 - HS HAND SWITCH
 - IW INJECTION WELL
 - LC LEVEL CONTROLLER
 - LAHH LEVEL ALARM HIGH-HIGH
 - LSH LEVEL SWITCH HIGH
 - LSHH LEVEL SWITCH HIGH-HIGH
 - LSL LEVEL SWITCH LOW
 - RED. REDUCER
 - SCH. SCHEDULE
 - TYP. TYPICAL

SPECIFICATIONS:

1. EXTRACTION WELL PUMPS SHALL BE GRUNDFOS MODEL 10REDI-F103-140 OR EQUAL, CAPABLE OF A MINIMUM OF 1 GPM WHILE OPERATING WITH 150' OF TOH, WITH 1/3HP, 230V, SINGLE PHASE MOTOR.
2. FLOW METERS SHALL CONSIST OF SIGNET 2536 PADDLEWHEEL SENSOR OR EQUAL WITH POLYPROPYLENE BODY, WITON O-RINGS AND PVDF ROTOR CONNECTED TO A SIGNET MODEL B550 DISPLAY WITH RATE AND TOTAL CAPABILITIES, ONE SENSOR INPUT AND ONE 4-20 MA OUTPUT.

NOTE:

1. HEAT TRACE AND INSULATE ALL ABOVE GROUND PIPING.

UNC CHURCH ROCK
GALLUP, NEW MEXICO
IN-SITU ALKALINITY
STABILIZATION PILOT STUDY

**PIPING AND INSTRUMENTATION
DIAGRAM**

BBL
an ARCADIS company

FIGURE
4-6

Attachment A

Substantive UIC Permit



BILL RICHARDSON
GOVERNOR

State of New Mexico
ENVIRONMENT DEPARTMENT

Ground Water Quality Bureau
Harold Runnels Building
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502-6110
Telephone (505) 827-2900
Fax (505) 827-2965
www.nmenv.state.nm.us



RON CURRY
SECRETARY

DERRITH WATCHMAN-MOORE
DEPUTY SECRETARY

GROUND WATER DISCHARGE PERMIT APPLICATION

Enclosed is a Ground Water Discharge Permit Application Form (Form) and checklist. Section 20.6.2.3104 NMAC of the NM Water Quality Control Commission Regulations (20.6.2 NMAC) requires that any person proposing to discharge effluent or leachate so that it may move directly or indirectly into ground water must have an approved discharge permit, unless a specific exemption is provided for in the Regulations. The enclosed Form is a general guideline for use by applicants to ensure that an application is complete and provides all of the information required by sections 20.6.2.3106, 20.6.2.3107, 20.6.2.3108, and 20.6.2.3109 NMAC.

Mail **three complete copies** of your application with a **\$100 filing fee** check made payable to the New Mexico Environment Department (NMED) at the address below:

George Schuman, Program Manager
Ground Water Pollution Prevention Section
NM Environment Department
P. O. Box 26110
Santa Fe, NM 87502

Pursuant to Regulation 20.6.2.3108 NMAC, NMED will, within thirty (30) days of deeming the application administratively complete, publish a public notice and allow 30 days for public comment before taking final action on a discharge permit. A public hearing will be held if NMED determines that there is significant public interest. It takes approximately 180 days to process a complete application and issue a discharge permit if no public hearing is held.

All applications must be accompanied by a filing fee of \$100. **An additional fee will be assessed prior to permit issuance** to cover the estimated cost to the NMED for investigation, and, issuance of the permit. **Permit fees are listed in the Regulation 20.6.2.3114 NMAC.**

If you have any questions about this discharge permit application, call the Ground Water Pollution Prevention Section at 505-827-2900

COMPLETION CHECKLIST

<input type="checkbox"/>	All portions of the Ground Water Discharge Permit Application Form have been addressed. (The application will not be considered complete if there are omissions, which will delay publication of the public notice and issuance of the permit.)
<input type="checkbox"/>	Submitter has included operational, monitoring, contingency, and closure plans that are appropriate for the proposed treatment and disposal system, and meet the site-specific conditions for the proposed facility.
<input type="checkbox"/>	Plans and specifications for the entire effluent or leachate conveyance, collection, treatment, distribution, and disposal system have been included as required by Regulation 20.6.2.1202 NMAC. For septic tank/leachfield systems, designs should be consistent with NMED's guidelines for Plans and Specifications for Discharge Permit Applications Using Septic Tank/Leachfields.
<input type="checkbox"/>	The application has been signed and dated by the responsible party, generally the owner or lessee.
<input type="checkbox"/>	If your facility site includes an archeological site on the State Register of Cultural Properties or National Register of Historic Places, the State Historic Preservation Office has the authority to require an archeological or historical study prior to NMED taking final action on your discharge permit.
<input type="checkbox"/>	Four maps have been included: 1) area United States Geological Survey (USGS) topographic map that includes the location of the facility and all of the information required in the application item 7.b, 2) local road map clearly defining the location of the facility and the route to get to the facility, 3) detailed site map that includes all discharge locations (lagoons, leachfields, land application areas, outfalls...), all water supply and monitoring wells, all water courses on the property and all buildings and 4) United States Department of Agriculture (USDA) soils map.
<input type="checkbox"/>	Three copies of all required information have been enclosed.
<input type="checkbox"/>	A filing fee check in the amount of \$100, has been enclosed, made payable to the NM Environment Department at the address on page 1.
<input type="checkbox"/>	The SUMMARY OF APPLICANT'S PUBLIC NOTICE REQUIREMENTS has been reviewed and the option for Public Notice Has been selected on the application page 3.

ADMINISTRATIVE COMPLETENESS

To be deemed administratively complete for publication of a public notice, the following information must be provided. [20.6.2.3106, 20.6.2.3108 NMAC]

Review the **SUMMARY OF APPLICANT'S PUBLIC NOTICE REQUIREMENTS** (attached) to select an option below.

Public Notice Option 1 Public Notice Option 2 Public Notice Option 3

1. Name of the proposed discharger and facility [20.6.2.3106, 20.6.2.3108.C.1 NMAC]:

Type of facility or operation (dairy, municipal wwtp, mining, school, etc.): mining

	Name	Address*	City	State	Zip	Telephone & Fax
Facility*	United Nuclear Corporation (UNC) Church Rock Site		Gallup	NM		
Owner	United Nuclear Corporation					
Responsible Party						
Facility Representative	Roy Blickwedel	640 Freedom Business Center	King of Prussia	PA	19406	(610) 992-9935
Consultant	Blasland, Bouck & Lee, Inc. (BBL)	6723 Towpath Road, PO Box 66	Syracuse	NY	13214	P(315)446-9120 F(315)449-4111
Other (specify)						

*For the facility address, enter physical address- not mailing address.

2. Locations of the Discharges [20.6.2.3106.C.2 and 20.6.3108.C.2 NMAC]:

List the locations of the discharges covered by this permit. Add rows as necessary to include all discharge locations. Sections should be described to the nearest ¼ of a ¼ of a ¼ section (please see attachment).

Discharge Location (lagoons, leachfields, land application areas, outfalls, etc.)	County	Township	Range	Section	Latitude	Longitude
Injection wells (IW-1, IW-2, IW-3, and IW-4)	Refer to Figure 4-4 of the In-Situ Alkalinity Stabilization Pilot Study (Pilot Study).					

--	--

3. Brief Description of Discharge [20.6.2.3108.C.3 NMAC]:

Briefly describe the activities which produce the discharge(s) including the treatment and disposal methods. Attach additional pages as necessary.

The activities producing the discharge include injection of alkalinity-rich groundwater from an unimpacted portion of the Dakota Formation into injection wells located within the Zone 3 aquifer. The injected Dakota groundwater would then flow through the Zone 3 formation and increase pH, which will reduce or eliminate groundwater constituents of concern from migrating (based on geochemical reactions between the alluvium and Zone 3 groundwater). The mixture of injected Dakota groundwater would then be extracted. The extracted groundwater will be placed into existing evaporation ponds.

4. Discharge Characteristics [20.6.2.3106.C.1 and 20.6.2.3108.C.4 NMAC]:

4.a. Quantity:

Peak design discharge rate* in gallons per day (gpd) (design capacity of the treatment and disposal system):	4,752 gpd
Average discharge rate on annual basis in gpd (actual flow):	4,752 gpd
Methods used to meter or calculate discharge volume:	

*Peak design discharge rate is the maximum volume of wastewater the system was designed to treat on a daily basis. This is generally based on the capacity of the different components of the system (size of lagoons, volume of tanks, etc.)

4.b. Quality: Add rows as necessary to include all contaminants and toxic pollutants.

Contaminant(s) or Toxic Pollutant(s) generally associated with facility type (contaminants of concern are listed in 20.6.2.7. and 20.6.2.3103 NMAC)	Effluent Concentration (mg/L)
See Section 2.2 of the Pilot Study	To Be Determined

4.c. Flow Characteristics:

Number of days per week discharge occurs:	7
Number of months per year discharge occurs (specify months):	Approximately 3 months

Is flow continuous or intermittent:	Continuous
-------------------------------------	------------

5. Ground Water Conditions [20.6.2.3106.C.3 and 20.6.2.3108.C.5 NMAC]:

Sources for this information may be the New Mexico State Engineers Office, NMED, GWPPS web site (www.nmenv.state.nm.us), and USGS reports. If you do not have a TDS value, take a sample from the nearest well to the discharge location and submit the results from the analysis.

Depth to ground water below the discharge site:	Depth to Zone 3 groundwater: 60 feet below ground surface
Flow direction of ground water below the site:	Northeasterly – Zone 3
Flow gradient of ground water below the site:	0.035 feet per foot in area of injection
Reference* or source for depth, direction and gradient:	Geohydrologic Report (Canonie Environmental, 1987).

* If determined from well logs, please provide photocopies of well logs with application. If depth is derived from a report include copies of appropriate pages and complete reference to report including author, title, and publication date.

Total Dissolved Solids (TDS) concentration (mg/L) of ground water below the site:	6,193.75
Reference or source for TDS:	Average concentration for 2004 sampling of representative wells 517 and 518

TECHNICAL ADEQUACY

To be deemed technically adequate, for purposes of issuing the discharge permit, the following information must be provided. [20.6.2.3106, 20.6.2.3107, 20.6.2.3109 NMAC]. Operational, monitoring, contingency, and closure plans must be submitted and must be appropriate for the proposed treatment and disposal type and meet the site specific conditions for the proposed facility.

6. Permit Plans [20.6.2.3106.C.7, 20.6.2.3107.A, and 20.6.2.3109.C NMAC]:

6.a. Operational Plan [20.6.2.3106.C.7 and 20.6.2.3109.C NMAC]:

The operational plan must describe how the system(s) for conveyance, collection, treatment, distribution, and disposal of wastewaters or other discharges will be constructed, operated, inspected, and maintained. The operational plan must demonstrate that ground water standards will not be exceeded.

6.a.i. In the following table, identify all proposed conveyance, collection, treatment distribution, and disposal units included in the operational plan. Add rows as necessary to include all units.

Treatment/Storage/ or Disposal Unit Treatment units (lagoon, mechanical treatment plant, manure separator, clarifier, etc.) Disposal Units (land application area, leachfield, evaporative lagoon, leachstockpile, etc.)	Construction Material	Volumetric Capacity*/Area* (gallons or cubic yards/ acres)
Refer to Sections 4.3 and 4.5 of Pilot Study.		

*Volumetric Capacity must be provided for all tanks, chambers, and impoundments or other storage units.

*Area must be provided for all land application areas, leachfields or other area features.

6.a.ii. Describe in detail the operational plan, including all conveyance, collection, treatment, distribution and disposal systems. Attach additional pages as necessary:

Refer to Sections 4.3 and 4.5 of the Pilot Study.

6.a.iii. Describe the operations and maintenance plan that will be followed to ensure the system is maintained as described. At a minimum the plan must include monthly inspections of all wastewater treatment and disposal units. Attach additional pages as necessary.

Refer to Section 4.7 of the Pilot Study.

6.b. Monitoring Plan [20.6.2.3106.C.5 and 20.6.2.3107.A.1-9 NMAC]:

The monitoring plan must describe how the facility will be monitored to ensure the discharge will not adversely impact ground water quality. The plan must include all monitoring locations (effluent sampling, monitoring wells, lagoons, soil sampling, plant tissue analysis, etc.). Monitoring locations must be included on the facility map.

6.b.i. Monitoring Locations. In the following tables, identify all monitoring locations. Add additional rows as necessary to include all monitoring locations.

Flow, Effluent and Ground Water Monitoring

Monitoring Location	Lat	Long	Northing	Easting	Elevation (also specify at what point in well casing)	Sampling Frequency per year	Reporting Frequency per year	Water or Soil Contaminant Type (please refer to 20.6.2.7.uu, and 20.6.3103 NMAC)
flow meter 1	See Figure 4-4 of the Pilot Study.							(volume measurement)
flow meter 2								(volume measurement)
effluent quality*								
monitoring well 1*								
monitoring well 2*								
monitoring well 3*								

*Identify the sampling locations as designated or named by the facility.

Soil, Plant Tissue and Other Sampling

Monitoring Location*	Lat	Long	Sampling Frequency per year	Reporting Frequency per year	Water or Soil Contaminant Type
land application area soil sampling	Not Applicable				
land application area plant tissue analysis					
Other					
Other					

6.b.ii. Describe in detail the sampling protocols that will be used for sample collection at all monitoring locations. Attach additional pages as necessary. Refer to Section 4.6 of the Pilot Study.

6.b.iii. Standard Monitoring Requirements: The following paragraphs are standard permit conditions. Please read the condition and check the boxes that you will comply with as a condition of your permit.

- All monitoring wells will be installed according to NMED Monitoring Well Construction and Abandonment Guidelines (copy enclosed).
- All monitoring wells (if 3 or more monitoring wells are on site) will be surveyed to a common permanent benchmark and that the survey will be submitted to the NMED, GWQB within 60 days of installation of all monitoring wells. Survey data will include northing, easting, and elevation to the nearest hundredth of a foot. One of the wells may be used as the benchmark.
- This facility will measure the depth to ground water in each monitoring well to the nearest hundredth of a foot prior to purging and sampling, and that three well volumes will be purged from each monitoring well prior to sample collection.
- NA This facility will complete land application data sheets (LADS, copy enclosed) documenting the amount of nitrogen applied to each land application area if applicable. The LADS will incorporate the wastewater volume and analytical results of the wastewater testing to determine total nitrogen applied to each field.

6.c. Contingency Plan [20.6.2.3107.A.10 NMAC]:

The contingency plan must describe the actions to be taken if Regulation 20.6.2.3103 NMAC ground water standards are exceeded or if toxic pollutants are present (20.6.2.7.uu) as a result of discharges regulated under the proposed permit, and to cope with failure of the discharge permit or system.

6.c.i. Standard Contingency Requirements: The following paragraphs are standard permit conditions. Please read the condition and check the boxes that you will comply with as a condition of your permit.

- NA This Facility will comply with the following contingency language:

In the event that monitoring indicates ground water standards are violated or may be violated during the term of the discharge permit or upon post closure monitoring, this facility will collect a confirmation sample from the monitoring wells within 15 days to confirm the initial sampling results. Upon confirmation of contamination, all ground water monitoring will be conducted monthly and a corrective action plan will be submitted to the NMED. The corrective action plan will include a site investigation to define the source, nature and extent of ground water contamination and a proposed abatement option; and a schedule for implementation. The site investigation and abatement option must be consistent with the requirements and provisions of Regulations 20.6.2.4101, 20.6.2.4103, 20.6.2.4106.E, 20.6.2.4107, and 20.6.2.4112 NMAC. The corrective action plan will be submitted to NMED for approval within 30 days of confirmation of ground water contamination, and will be initiated within 30 days of NMED approval.

This facility will comply with the following contingency language:

In the event of a spill or release that is not as prescribed in the approved discharge permit, this facility will take immediate corrective action to contain or mitigate the damage caused by the discharge and will initiate the notifications and corrective actions as required by Regulation 20.6.2.1203 NMAC. Within 24 hours discovery of the incident, this facility will verbally notify NMED and provide the information outlined in Regulation 20.6.2.1203.A.1. NMAC. Within 7 days of discovering the incident, this facility will submit a written verifying the oral notification and providing any additional pertinent information or changes. Within 15 days of the incident, this facility will submit a corrective action plan describing actions taken and/or to be taken to remedy the impact of the unauthorized discharge.

6.c.ii. Specific Contingency Plan:

Describe any additional specific corrective actions or contingencies that will be taken to cope with failure of the discharge system: Attach additional pages as necessary.

Refer to Section 4.5 of the Pilot Study.

6.d. Closure Plan [20.6.2.3107.A.11 NMAC]:

The closure plan must describe the closure actions to be taken to prevent Regulation 20.6.2.3103 NMAC ground water standards from being exceeded, or the introduction of a toxic pollutant in ground water after cessation of operations. At a minimum, the closure plan must include a description of closure measures, post closure monitoring plans, and financial assurance (if required by NMED).

6.d.i. Specific Closure Plan: Describe the specific closure activities to ensure that ground water quality will be protected after cessation of operations. The plan shall include plugging, removal, and/or filling of all conveyance, collection, treatment, distribution and disposal features in order to prevent future discharges at the facility. The plan must also describe how all liquid and solid wastes will be removed and disposed of according to local, state, and federal laws. The plan must also describe how disturbed areas will be backfilled to blend with the original surface topography to prevent future ponding and to prevent a discharge at the facility from occurring after the cessation of operations. Attach additional pages as necessary.

Not applicable.

6.d.ii. Standard Closure Requirements: The following paragraphs are standard permit conditions. Please read the condition and check the boxes that you will comply with as a condition of your permit.

This facility will comply with the following closure requirements:

The discharger will notify NMED at least 30 days prior to cessation of operations and will provide a schedule for implementation of the closure plan.

This facility will conduct post closure monitoring at the frequency and locations prescribed under the active permit for a period approved by NMED. If Regulation 20.6.2.3103 NMAC ground water standards are violated or toxic pollutants are present during post closure monitoring, this facility will implement the contingency plan required in the active permit.

All monitoring wells will be plugged and abandoned in accordance with NMED Monitoring Well Construction and Abandonment Guidelines once NMED has agreed in writing that post closure ground water monitoring may cease.

Once NMED has approved all closure activities, this facility will submit a letter requesting termination of the discharge permit.

TECHNICAL SUPPORT

The following information must be submitted as required by Regulation 20.6.2.3106, and 20.6.2.3109 NMAC.

7. Other Discharge Locations [20.6.2.3106.C.2 NMAC]:

7.a. List the locations of any other discharges at this facility not covered by this permit but permitted under the New Mexico Liquid Waste Disposal Regulations, Hazardous Waste Management Regulations, Federal Clean Water Act (NPDES), and any un-permitted discharges. Add rows as necessary to include all other discharge locations.

Discharge Type (septic tank/leachfields, surface water discharges, etc.)	Permit Identification	Discharge Location Description
Not applicable.		

7.b. Area Map: On the appropriate United States Geological Survey (USGS) 7.5 minute topographic quadrangle map, identify the location of all water supply wells, injections wells, seeps, springs, bodies of water, and watercourses within one mile of the outside perimeter of the discharge site.

8. Flooding Potential [20.6.2.3106.C.4 NMAC]:

8.a. Describe the flooding potential of the discharge site based on the latest Federal Emergency Management Agency flood plain map or site specific analysis:

Based on the FEMA flood plain map date July 4, 1978 (effective date), the discharge area is located within Section 36 which does not have an associated flooding potential.

Source for Information: FEMA flood plain map

8.b. Describe the methods used to control flooding, run-on and run-off at the discharge site (berms, diversion channels, etc.):

9. Geologic and Soil Information [20.6.2.3106.5 NMAC]:

9.a. Lithology: Describe the lithology and thickness of each geologic unit below the discharge site and indicate which units bear water. This information may be obtained from a driller's log or geologic report. Include photocopies of all well logs with the application. Add rows as necessary to include all units.

Unit Description	Thickness (feet)	Water Bearing (Y/N)
Alluvium	0 – 150 feet	Y
Dilco Coal Member of Crevasse Canyon Formation		Y
Upper Gallup Sandstone:		Y
- Zone 3, upper sandstone	70 – 90 feet	Y
- Zone 2, shale and coal	15 – 20 feet	Y
- Zone 1, lower sandstone	80 – 90 feet	Y
Mancos Shale	130 feet	Y

Source for Information: Geohydrologic Report (Canonie Environmental, 1987)

9.b. Soil Map: Attach a copy of the United States Department of Agriculture (USDA) Natrual Resources Conservation Service (NRCS) soil survey map and descriptive information for soil(s) associated with the discharge site.

10. Signatures:

Owner: I certify that I am the legal owner of the property in which all discharges will occur. I certify that I am knowledgeable about the information contained in this application, and believe the information is true, complete and accurate.

Print Name: _____

Signature: _____ Date: _____

Responsible Party* (if property is leased or operated by someone other than the owner):

I certify that I am knowledgeable about the information contained in this application, and believe the information is true, complete and accurate.

Print Name: _____

Signature: _____ Date _____

* Enclose a signed copy of the lease agreement between the responsible party and the owner of the property on which the proposed discharge will occur. Lease agreement should be valid for the duration of the discharge permit or until the discharge permit is modified to reflect a new lessee.

SUMMARY OF APPLICANT'S PUBLIC NOTICE REQUIREMENTS FOR GROUND WATER DISCHARGE PERMITS

The New Mexico Water Quality Control Commission Regulations (20.6.2 NMAC) public notice requirements of 20.6.2.3108 NMAC were revised **effective September 15, 2002** to require the applicant to provide notice to neighboring properties during the discharge permit application process. This document summarizes the applicant's public notice requirements and provides answers to frequently asked questions.

The Water Quality Control Commission Regulations are available on the New Mexico Environment Department's (NMED) internet web site. The web site address is:

www.nmenv.state.nm.us

Click on the heading "Environmental Protection Regulations", then "Water Quality-- Ground and Surface Water Protection". The public notice regulations are in Section 20.6.2.3108 NMAC. You can also call the Ground Water Quality Bureau at (505) 827-2900 and we will mail you a copy of the regulations.

STEP 1 – SELECTING AND IMPLEMENTING A PUBLIC NOTICE OPTION

Anyone applying for a new permit or renewing or modifying an existing permit must provide public notice to neighboring properties (See FAQs). The applicant must select one of three public notice options by checking the selected box on page 3 of the Ground Water Discharge Permit Application. **When the NMED receives the application and deems it administratively complete, we will send the applicant the instructions and materials necessary to implement the selected public notice option.** The applicant must implement the public notice option within 30 days of submitting their application to the NMED. The applicant's public notice options are:

Public Notice Option 1

Posting a sign: The sign must be prominently posted in a conspicuous public location at or near the existing or proposed facility for 30 days. The sign should be visible so that passersby are likely to see it. The sign will be a synopsis of the full public notice prepared by NMED.

and

Sending direct notice to adjacent property owners: The public notice prepared by NMED must be sent to all "adjacent property" "owners of record" by certified mail, return receipt requested.

and

Sending direct notice to the owner of the discharge site: If the applicant is not the owner of the discharge site, the applicant must send the public notice prepared by NMED to the owner, by certified mail, return receipt requested.

Public Notice Option 2

Posting a sign: The sign must be prominently posted in a conspicuous public location at or near the existing or proposed facility for 30 days. The sign should be visible so that passersby are likely to see it. The sign will be a synopsis of the full public notice prepared by NMED.

and

Placing a display advertisement: The display ad must be at least two inches by three inches in size and must be published in a newspaper of general circulation in the location of the proposed discharge. The display ad will be a synopsis of the full public notice prepared by NMED.

and

Sending direct notice to the owner of the discharge site: If the applicant is not the owner of the discharge site, the applicant must send the public notice prepared by NMED to the owner, by certified mail, return receipt requested.

Public Notice Option 3

Sending direct notice to property owners within 1/2 mile of the discharge site: The public notice prepared by NMED must be sent to all property "owners of record" within 1/2 mile of the discharge site by certified mail, return receipt requested.

and

Sending direct notice to the owner of the discharge site: If the applicant is not the owner of the discharge site, the applicant must send the public notice prepared by NMED to the owner, by certified mail, return receipt requested.

Step 2 - Providing Proof that the Applicant Completed Public Notice

Proof of Notice

Within 15 days of completion of the public notice requirements above, the applicant must submit proof of notice to NMED. Depending on the option selected, proof of notice may include list of property owners' names and addresses, copies of certified mail return receipts, a copy of the published display ad indicating the newspaper and date of publication, and an affidavit of sign posting. If the department determines that the notice provided is inadequate, the department may require additional notice in accordance with the requirements above.

Important Definitions

The following definitions are excerpted from the Water Quality Control Commission regulations, 20.6.2 NMAC.

"adjacent properties" means properties that are contiguous to the discharge site or property that would be contiguous to the discharge site but for being separated by a public or private right of way, including roads and highways.

"discharge site" means the entire site where the discharge and associated activities will take place.

"owner of record" means an owner of property according to the property records of the tax assessor in the county in which the discharge site is located.

Frequently Asked Questions

Where can I get a copy of the new public notice regulations?

The Water Quality Control Commission Regulations are available on the New Mexico Environment Department's (NMED) internet web site. The web site address is:

www.nmenv.state.nm.us

Click on the heading "Environmental Protection Regulations", then "Water Quality-- Ground and Surface Water Protection". The public notice regulations are in Section 20.6.2.3108 NMAC.

You can also call the Ground Water Quality Bureau at (505) 827-2900 and we will mail you a copy of the regulations.

When do the new public notice regulations go into effect?

September 15, 2002

Do the new public notice regulations apply to me?

The regulations apply to all applications for new permits, renewals, and modifications that are submitted to NMED on or after September 15, 2002. Page 3 of the application has a section for the applicant to select one of three public notice options. If you submitted an application for a new discharge permit, renewal or modification before September 15, 2002, then the regulations will not apply to you until you renew or modify your permit, even if your permit has not yet been issued.

Where at my facility should the sign be posted?

In many cases the sign should be posted in a location near the front entrance to the facility where it is likely to be seen by passersby. Other conspicuous public locations can be approved in advance by the Ground Water Quality Bureau if they are more likely to provide notice to the public. You can contact the Ground Quality Bureau at the number below to obtain approval for an alternate sign posting location.

Where do I get the sign that will be posted at my facility?

When the NMED receives the application and deems it administratively complete, we will send the applicant the instructions and a laminated poster with an invoice for \$15.00.

How long do I have to keep the sign up at my facility?

The sign must be posted for 30 days.

What properties are considered to be "adjacent" to my property?

"Adjacent properties" are those properties that are contiguous to the discharge site or that would be contiguous to the discharge site except for being separated by a public or private right of way, including roads and highways.

Who are property "owners of record" and where can I find their names and addresses?

An "owner of record" is an owner of property according to the property records of the tax assessor in the county in which the discharge site is located. You can call your county tax assessor and they can, in most cases, provide names and addresses of owners of record within 24 hours. You will need to provide the tax assessor with the location of your discharge site and ask for names and addresses of adjacent properties.

Is there a letter format I should use for the direct notice to property owners?

When the NMED receives the application and deems it administratively complete, we will send the applicant the instructions and materials necessary to provide direct notice to property owners.

What if there are no adjacent properties other than properties I own?

If the applicant owns the adjacent properties, then they must implement Option 2 by posting a sign, placing a display ad and notifying the property owner if the owner is different from the applicant.

Is there a required format for the display advertisement?

When the NMED receives the application and deems it administratively complete, we will send the applicant the instructions and materials necessary to place a display advertisement.

What proof must I provide to the NMED to demonstrate that I provided public notice in accordance with the new regulations?

Within 15 days of completion of the public notice requirements, the applicant must submit proof of notice to NMED. Depending on the option selected, proof of notice may include a list of property owners' names and addresses, copies of certified mail return receipts, a copy of the published display ad indicating the newspaper and date of publication, and a signed affidavit that the sign was posted. If the department determines that the notice provided is inadequate, the department may require additional notice in accordance with the new regulations.

Who do I contact if I have additional questions?

You may contact Jerry Schoepner, Chief of the Ground Water Quality Bureau or Maura Hanning, Manager of the Ground Water Pollution Prevention Section at (505) 827-2900.

Attachment B

**Technical Memorandum dated
January 26, 2006**



To: Roy Blickwedel, P.G
Date: 1/26/06

From: Paul M. Stout, Ph.D., P.G
cc: Mark Purcell, USEPA
Bill Von Till, NRC
Paul Michalak, NRC
Robin Brown, NMED
Kevin Myers, NMED
Margaret Carrillo-Sheridan, P.E., BBL
Michael Gefell, P.G., BBL
Kenneth Kolm, Ph.D., BBL
Douglas Musser, P.G., BBL

Re: UNC Church Rock Site
Gallup, New Mexico
Bench-Scale Testing Results

INTRODUCTION

This technical memorandum (Tech Memo) presents the results of bench-scale testing (bench tests), performed as part of an evaluation to use onsite, non-tailings-impacted alluvial groundwater to stabilize and/or improve the recovery of tailings-impacted groundwater from Zone 3, at the United Nuclear Corporation (UNC) Church Rock Site (site) located in Gallup, New Mexico. The bench-scale testing is one component of a comprehensive program outlined in a document entitled: *In Situ Alkalinity Stabilization Pilot Study (Pilot Test)*, prepared by Blasland, Bouck & Lee, Inc. (BBL) and submitted to USEPA on 12 October 2005.

The overall approach of the Pilot Test involves studies to evaluate the injection of alkalinity-rich groundwater from a non-impacted part of the Southwest Alluvium into the Zone 3 aquifer. The injected water (hereinafter referred to as "fixiviant") will flow through the Zone 3 formation to recovery wells where the fixiviant will be pumped to the surface for treatment and disposal. Theoretically, injection of the alluvium groundwater (i.e., fixiviant) into Zone 3 will effect the following changes:

1. The pH of the Zone 3 groundwater will increase from acidic (pH<4) to mildly acidic/basic or neutral (pH~6-8);
2. Groundwater migration of target Zone 3 groundwater constituents of concern (COCs, such as cadmium, cobalt, nickel, radium-226/228, Th-230) will be reduced in concentration or eliminated via changes in aqueous/solid partitioning and precipitation reactions as a result of the increased pH conditions; and
3. Groundwater and fixiviant withdrawn by the extraction wells will recover uranium (and other chemical species) in solution, which can then be handled via the existing evaporation system. Seepage-impacted water is currently difficult to recover from Zone 3 due to limited saturated thicknesses and well yields. The injected water will assist to displace the seepage-impacted water toward recovery wells.

The bench tests were performed to assess in practice, the theoretical rationale behind the approach to effect the geochemical changes, anticipated to occur by injecting alkaline-rich solutions into an area of seepage impacts. The remainder of this Tech Memo describes the execution of and results from the bench tests, along with discussion of how the results demonstrate that the field-testing portion of the Pilot Test should proceed as originally proposed.

BENCH TESTS: METHODS AND RESULTS

Methods

The bench tests consisted of a series of laboratory batch-mixing experiments, designed to evaluate potential geochemical reactions likely to occur during the field portion of the Pilot Test. The approach included reacting mixtures of groundwater from well 517, located within the seepage-impacted target zone, with non-impacted, alkalinity-rich alluvial groundwater from well NA-02, (i.e. the fixiviant). Groundwater samples were collected (unfiltered) from these two wells and transported to ACZ Laboratories, Inc. of Steamboat Springs, Colorado, who performed the batch-testing, and chemical analyses of aqueous samples collected during and after the tests.

Table 1 presents the materials and mixing ratios evaluated through the batch-testing procedure. Mixtures included various ratios of the two end-member solutions from well Na-02 and well 517, including: 0.1 to 0.9 Batch #3; 0.5 to 0.5, Batch #5; and 0.9 to 0.1, Batch #7. In addition to these aqueous mixtures, batch tests were also performed using the same liquid ratios along with solids from weathered outcrop samples of the Zone 3 Gallup Sandstone collected at the site (Batch #4, #6 and #8). The solid materials were crushed to sand-size and smaller particles, and mixed with water-rock ratios consistent with porosity values characteristic of Zone 3. These batch tests, identified as Batch #1 through #8 in Table 1, represent those contemplated originally in BBL's October 2005 report.

In response to potential issues raised during discussion with representatives from USEPA, NRC, and NMED, two additional batch studies were performed. These tests, identified as Batch #9 and #10 in Table 1, involved diluting the proposed NA-02 fixiviant with high-purity deionized water (DI water), and mixing with rock and target-zone solutions from well 517. Adding the DI water to dilute the fixiviant was designed to simulate potential reactions occurring if the alluvium groundwater were to be pre-treated by reverse osmosis (RO) or comparable method to lower salinity prior to injection into Zone 3.

Aqueous and aqueous/rock mixtures identified in Table 1 were placed in closed carboys and subjected to periodic mild agitation for a one-week period. Aqueous subsamples from the mixtures were collected routinely during the week for analysis of pH and specific conductance. Upon completion of the one-week period, filtered (0.45mm) aliquots were analyzed for the constituents identified in Table 2, which correspond to ones analyzed as part of the on-going monitoring program at the site. Solid materials present within the aqueous-only mixtures (Batch #3, #5 and #7) were analyzed via X-ray diffraction (XRD) to identify crystalline mineral phases. Tables 2 through 6 present information pertaining to the results of the bench tests. Laboratory reports from the bench tests are presented in Appendix A.

Results

Aqueous-Only Mixtures

Table 2 presents analytical results for the Batch tests consisting of aqueous mixtures. It should be noted that although these are considered "aqueous" mixtures, the original groundwater solutions, which were not filtered during sample collection, did contain some solid particulates entrained during the sampling procedure. Analytical results for the aqueous mixtures are identified in the column labeled "Observed ### Aqueous" in Table 2. The columns labeled "Calculated ### Aqueous" represent proportional mixtures of NA02 and 517 based on the observed analytical results for each sample alone. These calculated values are compared with the observed aqueous values within the columns labeled "Difference Observed - Calculated Aqueous", expressed as percentages of the calculated values. Negative differences imply that the specific constituent may have precipitated and/or adsorbed on to solids or the sample container during the test, while positive values imply possible dissolution of solid phases (turbidity) included in the samples. Of course, the differences, particularly minor percentages, may simply reflect analytical uncertainty.

The first point to be made about data presented in Table 2 involves the concentration reductions in constituents of concern (COCs) for mixtures containing higher percentages of the fixiviant, NA-02. Exceedances of applicable groundwater criteria for COCs are highlighted in yellow in this and accompanying tables. For Batch #7, which contains 90% fixiviant, observed concentrations of nickel (Ni), cobalt (Co), and gross alpha exceed the groundwater standards. For Ni and Co, however, this is not surprising, since these constituents slightly exceed applicable standards in NA-02. Results for gross alpha are somewhat meaningless, considering the high analytical error associated with the result, which is essentially equal to the reported concentrations. Large analytical errors are typically associated with highly saline samples (observed TDS value = 9140 mg/L). Furthermore, gross alpha measurements are designed to be more of a screening tool, to determine whether additional isotopic analyses are warranted, for constituents that undergo radioactive alpha decay like ^{226}Ra , ^{230}Th , and ^{232}Th . Concentrations of these radioactive species reported for the Batch #7 sample are all well below applicable groundwater criteria, indicating that the gross alpha results are a non-issue.

Lack of increased concentrations of COCs, observed within aqueous mixtures containing higher concentrations of fixiviant are not surprising, since likely mechanisms to cause such increases would be dissolution/desorption of entrained solids, and/or leaching from the sample containers. At the slightly basic to neutral pH values characteristic of the fixiviant, such reactions are not expected to occur.

Table 3 presents the results for XRD analyses of solid materials collected from the aqueous mixtures. Of the materials reported from the analyses, only gypsum (hydrated calcium sulfate) and amorphous phases may have actually formed during the time frame involved, which includes sample collection through the end of the testing. Other phases detected, such as quartz, feldspars, hematite, and clay minerals, would not form under the low temperature conditions and short time period. These other phases simply reflect the type of suspended solids contained within the original samples.

Detection of gypsum in samples from Batch #3 and #5 may reflect precipitation of this phase before and/or during the experiments. Presented near the bottom of Table 2 are equilibrium saturation indices (SI) for calcite (calcium carbonate), gypsum, and rhodochrosite (manganese carbonate) calculated using the geochemical program PHREEQCI, developed by the United States Geological Survey (USGS). Positive saturation indices indicate oversaturation, negative

ones indicate undersaturation, and zero values would represent equilibrium. The indices reflect a logarithmic scale; consequently, slight deviations at or near equilibrium are not very meaningful, and one typically can equate values near zero indicative of equilibrium conditions with respect to those phases.

Saturation indices near zero for gypsum, combined with its detection in Batch # 3 and #5, and its absence from Batch #7 along with its apparent undersaturated conditions (SI = -0.19) reflect the importance of gypsum in influencing groundwater geochemistry and concentrations of calcium, sulfate, and TDS at the site. Calcite was not detected via XRD analyses, and appears to be oversaturated only for the sample from Batch #7 (SI = 0.52). The absence of calcite in the oversaturated sample is not too surprising, considering the time period involved. Its oversaturation, however, particularly since it involves the sample with the highest proportion of fixiviant, does indicate the potential for it to precipitate in the field given enough time. This in turn is significant because calcite precipitation will serve to immobilize COCs such as Ra species, and perhaps others via co-precipitation reactions. Additionally, calcite precipitation, along with gypsum, may create fouling issues with injection and recovery wells, the assessment of which is a component of the proposed field portion of the Pilot Test. The longer time frame (one to several months) anticipated for the field test should provide additional information regarding potential for calcite precipitation to occur. Oversaturation calculated with respect to rhodochrosite for samples containing the proposed fixiviant indicates the potential for manganese (Mn) concentrations to decrease over time due to precipitation of this mineral phase.

Mixtures with Added Solids from Zone 3

Additional information regarding the geochemical behavior of phases like calcite, gypsum, and various COCs is provided from the batch test results involving mixtures with added solids. Table 4 presents results for the batch tests involving mixtures of the proposed fixiviant with added solids (Batch #4, #6 and #8), along with results for aqueous only mixtures at the same ratios (Batch #3, #5 and #7). Columns labeled "Difference Observed w/Rock - Observed Aqueous" compares the difference between concentrations measured in solutions containing added rock and those containing aqueous only mixtures. Values are expressed as a percentage relative to the aqueous only result. Negative values indicate decreases in solution composition, reflecting adsorption and/or precipitation of constituents, while positive values suggest dissolution/desorption from solids. For nitrogen species, principally nitrate and ammonia, the data suggest a combination of transformation of ammonia to nitrate plus ammonia adsorption.

Many important points about the geochemical influence of the proposed fixiviant on the target COCs are apparent from the results presented in Table 4. The first one can be seen by comparing the results for the 90/10 ratio of fixiviant/impacted mixtures shown in the three columns at the right of Table 4. These three columns probably contain the most important data, because they reflect the greatest influence of the fixiviant on the targeted seepage impacts. Recall the point made above regarding Ni and Co concentrations observed for the aqueous only mixtures, and how the fixiviant concentrations were slightly in excess of the groundwater criteria. Results for the mixtures containing added solids demonstrate that these COCs are strongly adsorbed to aquifer solids, indicated by essentially complete (-100%) sorption for Co and extensive (-83%) sorption for Ni. Similar strong adsorption is apparent for COC species like cadmium (Cd, -83%), Mn (-45%), ammonia (-45%), and to a lesser extent ²²⁶Ra (-13%). These results demonstrate that the approach to use the alkalinity rich alluvium groundwater is effective in neutralizing the acidic conditions within areas of seepage impact, and immobilizing, or reducing the migration of targeted COCs.

Constituents that show concentration increases for the 90/10 mixture containing added solids (positive percentages) include calcium (Ca, +43%), chloride (+34%), sodium (+30%), sulfate (+24%) and alkalinity (+15%). Such increases indicate cation exchange reactions and dissolution of calcite, gypsum, possibly halite (NaCl) if present, and/or other complex salts typically occurring in near-surface desert environments.

Uranium (U) is another constituent showing relatively large percentage concentration increases within the added solids batch tests, compared to the aqueous mixtures for all batches. These results indicate that a U source occurs within Zone 3 Gallup sandstone, which produces aqueous concentrations that slightly exceed (approximately double) the groundwater criteria of 0.03 mg/L. The presence of slightly soluble U within Zone 3 materials is not surprising, evidenced by U concentrations observed at NBL-01, a non-seepage-impacted well in Zone 3, which have trended from about 0.3 to 0.1 mg/L during the period of monitoring performed at the site.

Mixtures with Diluted Fixiviant

Table 5 presents results for the additional batch tests (Batch #9 and #10) performed to evaluate reactions associated with modification of the proposed fixiviant, by diluting the original solution with de-ionized (DI) water. Results are compared with those for the 90/10 mixtures (Batch #7 and #8), since they involve comparable ratios of fixiviant to seepage-impacted solution. Batch tests involving aqueous-only mixtures were not performed for the modified fixiviant; consequently, results are compared to concentrations calculated from the observed concentrations for well NA-02 and well 517 samples, and assuming the DI water is equilibrated with atmospheric concentrations of carbon dioxide and oxygen but contains no other detectable constituents.

Results presented in Table 5 indicate that geochemical reactions involving the modified fixiviant are comparable to those occurring with the proposed unmodified solution. Uranium concentrations also exceed the groundwater criteria, and result in U concentrations (approximately 0.04 to 0.045 mg/L) greater than those within the unmodified fixiviant prior to application to the Zone 3 solids of approximately 0.01 mg/L.

Important characteristics of the modified (diluted) fixiviant compared to that proposed for the Pilot Test concern pH and alkalinity. The modified fixiviant contains no alkalinity, and pH values are calculated to be 4.4 (Batch #9) and 4.6 (Batch #10). These solutions are also undersaturated with respect to gypsum and calcite. Such data illustrate how modification of the proposed fixiviant will require additional treatment following RO or other salinity-reduction approach in order to raise the pH and provide sufficient alkalinity to obtain the desired neutralization/immobilization of the targeted COCs.

Table 6 displays results for the 90/10, added-solid mixtures, along with the end-member aqueous concentrations. This table provides for a more direct comparison of only concentrations of the constituents detected, rather than information about likely geochemical reactions provided in previous tables. The comparison suggests that for the primary, targeted COCs, such as heavy metals (Cd, Co, Ni) and radionuclides, there appears to be little to be gained by modifying the alluvium groundwater proposed for the fixiviant. For some constituents, such as lead (Pb) and ²²⁶Ra, resulting concentrations are actually greater with the modified fixiviant compared to the original. The bench test results demonstrate that it is highly unlikely, if not impossible, for a modified fixiviant to result in groundwater concentrations that would meet drinking-water standards for constituents like TDS, sulfate, and possibly Mn. Lowering the salinity of alluvium

groundwater via RO or similar method will require addition of materials to raise pH and increase alkalinity, which will raise the salinity to higher values than occurring after RO treatment.

The batch test results suggest that TDS concentrations, and those of major inorganic constituents (Ca, Mg, Na, Cl, SO₄), plus Mn, may be lower using modified alluvium groundwater as a fixiviant, rather than the unmodified alluvial groundwater originally proposed. Exactly how much lower, however, remains uncertain at this point, owing to the short time frame for the tests, combined with results from the batch tests for Batch #9 and #10. Undersaturation with respect to gypsum (SI = -0.21), indicated for the Batch #10 test, indicates that equilibrium with the added solids was not achieved during this week-long test containing the most diluted fixiviant. These results suggest that aqueous concentrations of TDS, SO₄, and other major inorganic constituents would likely increase over time in the field compared to results for the batch testing, and compared to the proposed fixiviant.

It is also important to consider that the added solids consisted of weathered Zone 3 outcrop material, which has been exposed to meteoric solutions over many years. Weathering processes would likely make such materials less susceptible to leaching of constituents and concomitant salinity increases when exposed to dilute solutions. The alluvial groundwater, in contrast, has been in direct contact with native deposits for many years, and appears to have equilibrated with solid phases (principally gypsum) that strongly influence groundwater chemistry. Furthermore, batch test results with the diluted fixiviant still generate solutions that exceed groundwater criteria, implying that resulting groundwater would be unfit for direct consumption even with pretreatment/modification of the proposed fixiviant.

CONCLUSIONS

Bench tests, performed to evaluate geochemical reactions anticipated to occur during the field portion of the proposed Pilot Test, indicate that alluvial groundwater can serve as a suitable fixiviant to retard and/or immobilize target COCs. Results of the testing indicate that the alkaline-rich solutions should prove effective in neutralizing the acidity within the areas of seepage impacts. Neutralization reactions will promote precipitation/adsorption of target COCs, especially heavy metals and radium, consistent with the rationale applied when designing the Pilot Test. Overall, results from the bench tests provide evidence that the Pilot Test can proceed as originally proposed without resulting in adverse groundwater impacts, and in fact will improve overall groundwater quality where seepage impacts exist.

Data indicate that the modified fixiviant will be no more effective than that proposed in addressing target COCs, and may actually be less effective for several constituents. In addition, batch tests performed with modified (i.e. diluted) fixiviant suggest that marginal improvement will be achieved in resulting groundwater quality, compared to using unmodified alluvial groundwater. Although batch tests with diluted fixiviant result in lower concentrations of TDS, sulfate, and other major inorganic chemical species, the value of pre-treating the fixiviant to a more dilute solution is diminished because formation solids naturally dissolve and the major ion concentrations essentially get replenished once the fixiviant reacts with formation material. We expect that this phenomenon will be even more pronounced in practice than it was in the batch tests because:

1. added rock samples used during the batch tests were collected from surface outcrop exposed to surficial weathering processes. Such weathered material may be less reactive than underlying, saturated Zone 3 strata; and
2. experiments with the most dilute fixiviant suggest that equilibrium conditions were not reached during the week-long test, indicating a likelihood that salinity and concentrations of major inorganic species will be greater in the field than observed from the batch tests. This is especially true over time as equilibration between the formation and the solutions is more closely approached.

Other important points to consider with respect to bench-test results, the proposed field test, and the efficacy of using modified versus unmodified fixiviant include:

- Although the diluted fixiviant appears to result in lower salinity and concentrations of major inorganic species like Ca, Mg, Na, Cl, and SO₄, resulting groundwater concentrations will still exceed primary drinking water standards for the non-target COCs.
- The proposed fixiviant (unmodified alluvial groundwater) contains lower concentrations of TDS, SO₄, other inorganic ions, and has comparable Mn concentrations, compared to regions with the greatest degree of seepage impacts (such as well 613), located slightly upgradient of the Pilot Test area.
- Issues with manganese concentrations within the alluvial groundwater in excess of applicable groundwater criteria have been cited as a reason to require dilution/modification of the proposed fixiviant. Batch test results demonstrate significant Mn adsorption (approximately 50%), and oversaturation with respect to rhodochrosite (MnCO₃) occurs during the week-long tests. Historical monitoring results within the alluvium document an order-of-magnitude reduction in Mn concentrations, starting with concentrations comparable to those reported for the proposed fixiviant, indicating that Mn concentrations will decrease over time when the proposed fixiviant is injected in the field. Based on the results of the bench scale tests and historical monitoring, the concentration of manganese in solution appears to be dictated more by natural solid-fluid equilibria than by whether or not the solutions are made more or less dilute prior to injection.
- Alluvium groundwater is ideal for use as a fixiviant because it is properly "aged" with regard to native materials and equilibrated with ambient conditions. Such aging is important with respect to potential fouling issues, and the ability to get the solutions into the rock to neutralize the seepage-impacted groundwater.
- One must keep in mind that alluvial groundwater recharges the Zone 3 formation naturally, and that the Pilot Test approach essentially expedites a natural process, which simultaneously reduces/eliminates potential risks associated with seepage impacts.

Roy Blickwedel, P.G.
1/26/06

- It seems to be an imprudent use of resources to pretreat (i.e. dilute) the proposed fixiviant. Pretreatment via RO or similar method will necessitate re-injection of alkalinity removed during the process, and much of the constituents removed, particularly relatively innocuous inorganic constituents, will be returned to groundwater solutions via predictable, common reactions between the fixiviant and native host rock.

Considering the results from the bench tests, in combination with a desire to expedite improvement in groundwater quality within the area of seepage impacts at the site, BBL recommends that the field-portion of the Pilot Test be implemented as originally proposed.

PMS/ams

**TABLE 1
UNC CHURCH ROCK
CHURCH ROCK, NEW MEXICO**

BENCH TESTS FOR IN-SITU ALKALINITY PILOT STUDY

BATCH-TESTING MIXTURES

Batch Test#	Impacted Volume Well 517 (Liters)	Fixiviant Volume Well NA-02 (Liters)	Mixing Ratio Fixiviant/Impacted	Mass Zone 3 Gallup SS (kg)
1	0	4.5	∞	0
2	4.5	0	0	0
3	4.05	0.45	10/90	0
4	10.125	1.125	10/90	27.2
5	2.25	2.25	50/50	0
6	5.625	5.625	50/50	27.2
7	0.45	4.05	90/10	0
8	1.125	10.125	90/10	27.2
9	1.125	5.0625 + 5.0625 DI Water	90/10	27.2
10	1.125	1.688 + 8.438 DI Water	90/10	27.2

Notes:

1. DI = Deionized water.
2. kg = Kilograms.
3. SS = Sandstone.

TABLE 2
UNC CHURCH ROCK
CHURCH ROCK, NEW MEXICO

BENCH TESTS FOR IN-SITU ALKALINITY PILOT STUDY

RESULTS FOR PROPOSED FIXMANT - AQUEOUS MIXTURES

	Units	Groundwater Standard	NA-02	617	Observed 10/90 Aqueous	Calculated 10/90 Aqueous	Difference Observed - Calculated Aqueous	Observed 50/50 Aqueous	Calculated 50/50 Aqueous	Difference Observed - Calculated Aqueous	Observed 90/10 Aqueous	Calculated 90/10 Aqueous	Difference Observed - Calculated Aqueous
BATCH TEST NUMBER			1	2	3			5			7		
ANALYTE													
Aluminum, dissolved	mg/L	5		4.0	1.2	1.5							
Arsenic, dissolved	mg/L	0.01											
Beryllium, dissolved	mg/L	0.004											
Cadmium, dissolved	mg/L	0.005	0.0040	0.0068	0.0066	0.0068	0%	0.0044	0.0054	-19%	0.0039	0.0043	-9%
Calcium, dissolved	mg/L		518	475	489	488	0%	510	497	3%	505	514	-2%
Cobalt, dissolved	mg/L	0.05	0.14	0.82	0.73	0.74	-1%	0.42	0.48	-13%	0.18	0.21	-13%
Lead, dissolved	mg/L	0.05	0.0018	0.0010	0.0009	0.0009	-1%		0.0014	-100%	0.0011	0.0017	-36%
Magnesium, dissolved	mg/L		1020	508	510	510	0%	746	764	-2%	941	969	-3%
Manganese, dissolved	mg/L	2.6	65.20	9.10	14.20	13.69	4%	36.60	37.15	-1%	58.70	60	-1%
Molybdenum, dissolved	mg/L	1	0.001	0.001									
Nickel, dissolved	mg/L	0.2	0.29	0.71	0.65	0.656	-1%	0.46	0.50	-8%	0.35	0.33	5%
Potassium, dissolved	mg/L		44	10	14	14	3%	27	27	0%	39	41	-4%
Selenium, dissolved	mg/L	0.05	0.005										
Sodium, dissolved	mg/L		489	158	188	185	2%	328	323	2%	446	456	-2%
Uranium, dissolved	mg/L	0.03	0.0116	0.0400	0.0283	0.0295	-4%	0.0187	0.0258	-28%	0.0141	0.0144	-2%
Vanadium, dissolved	mg/L												
Gross Alpha	pCi/L	15	2+/-28	65+/-29	53+/-27	54	-2%	22+/-23	34	-34%	34+/-33	8	310%
Gross Beta	pCi/L		57+/-30	65+/-24	46+/-24	48		29+/-29	61		45+/-33		
Radium 226	pCi/L	5	0.28+/-0.28	9.2+/-0.68	6.7+/-0.57	7.0	-4%	1.8+/-0.3	4.7	-62%	0.75+/-0.21	1.17	-36%
Radium 228, total	pCi/L		0.68+/-0.63	8.6+/-1.2	5+/-0.79	5.4	-7%	6.4+/-0.86	4.6	38%	2.7+/-0.64	1.5	83%
Thorium 228	pCi/L		-0.07+/-0.19	0.72+/-0.29	0.15+/-0.22			0.12+/-0.21			0.1+/-0.21		
Thorium 230	pCi/L	15	-0.17+/-0.47	0.3+/-0.34	-0.21+/-0.4			-0.15+/-0.42			-0.26+/-0.42		
Thorium 232	pCi/L		-0.14+/-0.41	-0.03+/-0.34	0.03+/-0.39			-0.06+/-0.38			-0.03+/-0.41		
Bicarbonate as CaCO3	mg/L		671					242			573		
Carbonate as CaCO3	mg/L												
Chloride	mg/L		214	40	59	57	3%	139	127	9%	224	197	14%
Hydroxide as CaCO3	mg/L												
Nitrate as N, dissolved*	mg/L	190	1.34	0.05	0.05	0.05	0%	0.55	0.70	-21%	0.97	1.21	-20%
Nitrate/Nitrite as N, dissolve	mg/L		1.55					0.57			1.03		
Nitrite as N, dissolved	mg/L		0.21					0.02			0.06		
Nitrogen, ammonia	mg/L		346	8.00	48.9	44.8	9%	207	177	17%	390	312	25%
pH	units		7.2	4.0	3.8			6.7			7.0		
pH measured at	C		21.0	21.0	21.0			21.0			21.0		
Residue, Filterable (TDS) @180	mg/L	4800	9530	5360	5520	5504	0%	7380	7445	-1%	9140	9113	0%
Sulfate	mg/L	2125	4070	3560	3710	3695	0%	3920	3815	3%	3270	4019	-19%
Total Alkalinity	mg/L		671					242			573		
Calcite Saturation Index			0.77	-7.67	-8.06			-0.13			0.52		
Gypsum Saturation Index			-0.12	-0.03	-0.01			-0.05			-0.19		
					60% Gypsum XRD			5% Gypsum XRD			No Gypsum XRD		
Rhodochrosite (MnCO3) Saturation Index			1.70	-7.55	-7.77			0.56			1.44		

Notes:

- *Nitrate in 517 samples assumed = 0.05 mg/L for calculations; corresponds to one-half PQL
- Observed ## Aqueous identifies the analytical results for the aqueous mixture.
- Calculated ## Aqueous represent the proportional mixtures of NA-02 and 517 based on the observed analytical results for each sample alone.
- mg/L = milligrams per liter.
- pCi/L = picocuries per liter.
- Results that are shaded indicate that the concentration of the constituent is greater than the groundwater protection standard.

TABLE 3

UNC CHURCH ROCK
CHURCH ROCK, NEW MEXICO

BENCH TESTS FOR IN-SITU ALKALINITY PILOT STUDY

X-RAY DIFFRACTION (XRD) RESULTS FOR AQUEOUS MIXTURES

	10/90 Aqueous	50/90 Aqueous	90/10 Aqueous
BATCH TEST NUMBER	3	5	7
PHASE	%	%	%
Quartz	12	33	36
K-Feldspar		5	5
Plagioclase		7	6
Smectite		<3*	16
Mica/Illite			3
Amorphous	16	17	
Gypsum	60	5	
Hematite	<2*	<2*	
Kaolin	8	29	31
Unaccounted	<5	<5	<5

Notes:

1. Analyses performed by DCM Science Laboratory, Inc., Wheat Ridge, CO.
2. * Asterisk indicates doubt in identification and/or concentrations of phase.

TABLE 4
UNC CHURCH ROCK
CHURCH ROCK, NEW MEXICO

BENCH TESTS FOR IN-SITU ALKALINITY PILOT STUDY

RESULTS FOR PROPOSED MIXTURE -- AQUEOUS/ADDED SOLID MIXTURES

	Units	Groundwater Standard	NA-02	517	Observed 10/90 Aqueous	10/90 Observed w/Rock	Difference Observed w/Rock - Observed Aqueous	Observed 50/50 Aqueous	50/50 Observed w/Rock	Difference Observed w/Rock - Observed Aqueous	Observed 90/10 Aqueous	90/10 Observed w/Rock	Difference Observed w/Rock - Observed Aqueous
BATCH TEST NUMBER			1	2	3	4		5	6		7	8	
ANALYTE													
Aluminum, dissolved	mg/L	5		4.0	1.2								
Arsenic, dissolved	mg/L	0.01											
Beryllium, dissolved	mg/L	0.004											
Cadmium, dissolved	mg/L	0.005	0.0040	0.0068	0.0066			0.0044	0.0006	-86%	0.0039	0.0006	-85%
Calcium, dissolved	mg/L		518	475	489	722	48%	510	728	42%	505	724	43%
Cobalt, dissolved	mg/L	0.05	0.14	0.82	0.73		-100%	0.42	0.08	-86%	0.18		-100%
Lead, dissolved	mg/L	0.05	0.0018	0.0010	0.0009		-100%				0.0011	0.0008	
Magnesium, dissolved	mg/L		1020	508	510	478	-6%	748	671	-10%	941	899	-4%
Manganese, dissolved	mg/L	2.6	65.20	9.10	14.20	6.39	-55%	36.60	19.60	-46%	58.70	32.40	-45%
Molybdenum, dissolved	mg/L	1	0.001	0.001									
Nickel, dissolved	mg/L	0.2	0.29	0.71	0.85		-100%	0.46	0.07	-85%	0.35	0.06	-83%
Potassium, dissolved	mg/L		44	10	14	13	-7%	27	29	7%	39	39	0%
Selenium, dissolved	mg/L	0.05	0.005			0.009			0.007			0.010	
Sodium, dissolved	mg/L		489	156	188	356	89%	328	410	25%	448	579	30%
Uranium, dissolved	mg/L	0.03	0.0116	0.0490	0.0283	0.0348	94%	0.0187	0.0559	199%	0.0141	0.0812	334%
Vanadium, dissolved	mg/L												
Gross Alpha	pCi/L	15	2+/-28	65+/-29	53+/-27	51+/-28	-4%	22+/-23	22+/-32	0%	34+/-33	15+/-27	-56%
Gross Beta	pCi/L		57+/-30	65+/-24	46+/-24	38+/-23	-17%	29+/-29	48+/-30	0.655172414	45+/-33	60+/-36	33%
Radium 226	pCi/L	5	0.28+/-0.28	9.2+/-0.88	6.7+/-0.57	0.48+/-0.19	-93%	1.8+/-0.3	0.65+/-0.21	-64%	0.75+/-0.21	0.65+/-0.2	-13%
Radium 226, total	pCi/L		0.68+/-0.63	8.8+/-1.2	5+/-0.79	0.24+/-0.54	-95%	6.4+/-0.88	3.6+/-0.74	-44%	2.7+/-0.64	2.6+/-0.9	-4%
Thorium 228	pCi/L		-0.07+/-0.19	0.72+/-0.29	0.15+/-0.22	0.17+/-0.22		0.12+/-0.21	0.07+/-0.21		0.1+/-0.21	0.12+/-0.21	
Thorium 230	pCi/L	15	-0.17+/-0.47	0.3+/-0.34	-0.21+/-0.4	-0.27+/-0.45		-0.15+/-0.42	-0.47+/-0.4		-0.26+/-0.42	-0.23+/-0.38	
Thorium 232	pCi/L		-0.14+/-0.41	-0.03+/-0.34	0.03+/-0.39	-0.21+/-0.4		-0.06+/-0.38	-0.07+/-0.42		-0.03+/-0.41	-0.09+/-0.35	
Bicarbonate as CaCO3	mg/L		671			286		242	407		573	660	
Carbonate as CaCO3	mg/L												
Chloride	mg/L		214	40	59	197	234%	139	220	58%	224	300	34%
Hydroxide as CaCO3	mg/L												
Nitrate as N, dissolved*	mg/L	190	1.34	0.05	0.05	19.2	38300%	0.55	13.8	2409%	0.97	24.2	2395%
Nitrate/Nitrite as N, dissolve	mg/L		1.55			19.9		0.57	14.9		1.03	25.1	
Nitrite as N, dissolved	mg/L		0.21			0.67		0.02	1.07		0.06	0.94	
Nitrogen, ammonia	mg/L		346	8.00	48.9	23.8	-51%	207	137	-34%	390	240	-38%
pH	units		7.2	4.0	3.8	7.3		6.7	7.3		7.0	7.3	
pH measured at	C		21.0	21.0	21.0	21.0		21.0	21.0		21.0	21.0	
Residue, Filterable (TDS) @180	mg/L	4800	9530	5360	5520	6100	11%	7380	7510	2%	9140	9250	1%
Sulfate	mg/L	2125	4070	3560	3710	3620	-2%	3920	4060	4%	3270	4060	24%
Total Alkalinity	mg/L		671			286		242	407	68%	573	660	15%

Calcite Saturation Index	0.77	-7.67	-8.06	0.69	-0.13	0.81		0.52	1.01
Gypsum Saturation Index	-0.12	-0.03	-0.01	0.11	-0.05	0.10		-0.19	-0.01
Rhodochrosite (MnCO ₃) Saturation Index	1.70	-7.55	-7.77	0.46	0.56	1.07		1.44	1.50

Notes:

- *Nitrate in 517 samples assumed = 0.05 mg/L for calculations; corresponds to one-half PQL
- Observed ## Aqueous identifies the analytical results for the aqueous mixture.
- Calculated ## Aqueous represent the proportional mixtures of NA-02 and 517 based on the observed analytical results for each sample alone.
- mg/L = milligrams per liter.
- pCi/L = picocuries per liter.
- Results that are shaded indicate that the concentration of the constituent is greater than the groundwater protection standard.

TABLE 5

UNC CHURCH ROCK
CHURCH ROCK, NEW MEXICO

BENCH TESTS FOR IN-SITU ALKALINITY PILOT STUDY

RESULTS FOR PROPOSED AND DILUTED FIXMIANT – AQUEOUS/ADDED SOLID MIXTURES

	Units	Groundwater Standard	NA-02	517	Observed 90/10 Aqueous	90/10 Observed w/Rock	Difference Observed w/Rock - Observed Aqueous	1:1 ratio D/NA2 Observed w/Rock	Calculated 1:1 Aqueous	Difference Observed w/Rock - Calculated Aqueous	5:1 ratio D/NA2 Observed w/Rock	Calculated 5:1 Aqueous	Difference Observed w/Rock - Calculated Aqueous
BATCH TEST NUMBER			1	2	7	8		9			10		
ANALYTE													
Aluminum, dissolved	mg/L	5		4.0				0.0					
Calcium, dissolved	mg/L		518	475	505	724	41%	550	281	96%	417	125	233%
Cobalt, dissolved	mg/L	0.05	0.14	0.82	0.18		-100%	0.02	0.145	-86%	0.01	0.10	-90%
Lead, dissolved	mg/L	0.05	0.0018	0.0010	0.0011	0.0008	-65%	0.0018	0.0009	76%	0.0013	0.0004	251%
Magnesium, dissolved	mg/L		1020	508	941	899	-7%	439	510	-14%	158	204	-22%
Manganese, dissolved	mg/L	2.6	65.20	9.10	58.70	32.40	-46%	11.7	30.3	-61%	1.69	10.7	-84%
Nickel, dissolved	mg/L	0.2	0.29	0.71	0.35	0.08	-82%	0.02	0.2015	-90%	0.01	0.11	-91%
Potassium, dissolved	mg/L		44	10	39	39	-4%	21.7	20.8	4%	11.5	7.60	51%
Selenium, dissolved	mg/L	0.05	0.005			0.010		0.011	0.0023	389%	0.008	0.0008	700%
Sodium, dissolved	mg/L		489	156	446	579	27%	370	236	57%	195	89	119%
Uranium, dissolved	mg/L	0.03	0.0116	0.0400	0.0141	0.0612	324%	0.0449	0.0092	387%	0.0392	0.0057	583%
Gross Alpha	pCi/L	15	2+/-28	65+/-29	34+/-33	15+/-27	81%	39+/-25	7	427%	25+/-16	7	268%
Gross Beta	pCi/L		57+/-30	65+/-24	45+/-33	60+/-36		59+/-24	32	84%	43+/-13	15	186%
Radium 226	pCi/L	5	0.28+/-0.28	9.2+/-0.68	0.75+/-0.21	0.65+/-0.2	-45%	1.3+/-0.28	1.0	24%	1.3+/-0.24	0.96	35%
Radium 226, total	pCi/L		0.68+/-0.63	8.6+/-1.2	2.7+/-0.84	2.6+/-0.9	77%	2.6+/-0.79	1.2	123%	2.7+/-0.83	0.96	181%
Thorium 228	pCi/L		-0.07+/-0.19	0.72+/-0.29	0.1+/-0.21	0.12+/-0.21		0.2+/-0.23			0.15+/-0.22		
Thorium 230	pCi/L	15	-0.17+/-0.47	0.3+/-0.34	-0.26+/-0.42	-0.23+/-0.38		-0.22+/-0.37			0.03+/-0.44		
Thorium 232	pCi/L		-0.14+/-0.41	-0.03+/-0.34	-0.03+/-0.41	-0.09+/-0.35		-0.09+/-0.34	-0.0700	29%	0.12+/-0.41	0	-614%
Bicarbonate as CaCO3	mg/L		671		573	660		459	302	52%	275	112	146%
Chloride	mg/L		214	40	224	300	53%	282	100	181%	158	36	338%
Nitrate as N, dissolved*	mg/L	190	1.34	0.05	0.97	24.2	1898%	23.6	0.61	3782%		0.21	
Nitrate/Nitrite as N, dissolve	mg/L		1.55	0.05	1.03	25.1		24.5	0.70	3388%			
Nitrogen, ammonia	mg/L		346	8.00	390	240	-23%	92.4	157	-41%	21.6	52.7	-59%
pH	units		7.2	4.0	7.0	7.3		7.8	4.4		7.8	4.6	
pH measured at	C		21.0	21.0	21.0	21.0		21.0			22		
Residue, Filterable (TDS) @180	mg/L	4800	9530	5360	9140	9250	2%	5910	4825	22%	3010	1966	53%
Sulfate	mg/L	2125	4070	3560	3270	4060	1%	3470	2188	59%	1700	967	76%
Total Alkalinity	mg/L		671		573	660		459	0		275	0	
Calcite Saturation Index			0.77	-7.67	0.52	1.01		1.26	-4.58		1.07	-4.74	
Gypsum Saturation Index			-0.12	-0.03	-0.19	-0.01		0.00	-0.4		-0.21	-0.83	
					No Gypsum XRD								

Notes:

- *Nitrate in 517 samples assumed = 0.05 mg/L for calculations; corresponds to one-half PCL
- Observed ##/## Aqueous identifies the analytical results for the aqueous mixture.
- Calculated ##/## Aqueous represent the proportional mixtures of NA-02 and 517 based on the observed analytical results for each sample alone.
- mg/L = milligrams per liter.
- pCi/L = picocuries per liter.
- Results that are shaded indicate that the concentration of the constituent is greater than the groundwater protection standard.

TABLE 6

UNC CHURCH ROCK
CHURCH ROCK, NEW MEXICO

BENCH TESTS FOR IN-SITU ALKALINITY PILOT STUDY

PROPOSED AND DILUTED FIXIVANT COMPARISON

	Units	Groundwater Standard	NA-02	517	90/10 Observed w/Rock	1:1 ratio D/NA2 Observed w/Rock	5:1 ratio D/NA2 Observed w/Rock
BATCH TEST NUMBER			1	2	8	9	10
ANALYTE							
Aluminum, dissolved	mg/L	5		4.0			
Arsenic, dissolved	mg/L	0.01					
Beryllium, dissolved	mg/L	0.004					
Cadmium, dissolved	mg/L	0.005	0.0040	0.0068	0.0006		
Calcium, dissolved	mg/L		518	475	724	550	417
Cobalt, dissolved	mg/L	0.05	0.14	0.82		0.02	0.01
Lead, dissolved	mg/L	0.05	0.0018	0.0010	0.0006	0.0016	0.0013
Magnesium, dissolved	mg/L		1020	508	899	439	158
Manganese, dissolved	mg/L	2.6	65.20	9.10	32.40	11.7	1.69
Molybdenum, dissolved	mg/L	1	0.001	0.001		0.02	0.02
Nickel, dissolved	mg/L	0.2	0.29	0.71	0.06	0.02	0.01
Potassium, dissolved	mg/L		44	10	39	21.7	11.5
Selenium, dissolved	mg/L	0.05	0.005		0.010	0.011	0.006
Sodium, dissolved	mg/L		489	156	579	370	195
Uranium, dissolved	mg/L	0.03	0.0116	0.0400	0.0612	0.0449	0.0392
Vanadium, dissolved	mg/L						
Gross Alpha	pCi/L	15	2+/-28	65+/-29	15+/-27	39+/-25	25+/-16
Gross Beta	pCi/L		57+/-30	65+/-24	60+/-36	59+/-24	43+/-13
Radium 226	pCi/L	5	0.28+/-0.28	9.2+/-0.68	0.65+/-0.2	1.3+/-0.28	1.3+/-0.24
Radium 228, total	pCi/L		0.68+/-0.63	8.6+/-1.2	2.6+/-0.9	2.6+/-0.79	2.7+/-0.83
Thorium 228	pCi/L		-0.07+/-0.19	0.72+/-0.29	0.12+/-0.21	0.2+/-0.23	0.15+/-0.22
Thorium 230	pCi/L	15	-0.17+/-0.47	0.3+/-0.34	-0.23+/-0.38	-0.22+/-0.37	0.03+/-0.44
Thorium 232	pCi/L		-0.14+/-0.41	-0.03+/-0.34	-0.09+/-0.35	-0.09+/-0.34	0.12+/-0.41
Bicarbonate as CaCO3	mg/L		671		660	459	275
Carbonate as CaCO3	mg/L						
Chloride	mg/L		214	40	300	282	158
Hydroxide as CaCO3	mg/L						
Nitrate as N, dissolved*	mg/L	190	1.34	0.05	24.2	23.6	
Nitrate/Nitrite as N, dissolve	mg/L		1.55	0.05	25.1	24.5	
Nitrite as N, dissolved	mg/L		0.21		0.94	0.86	0.01
Nitrogen, ammonia	mg/L		346	8.00	240	92.4	21.6
pH	units		7.2	4.0	7.3	7.8	7.8
pH measured at	C		21.0	21.0	21.0	21.0	22
Residue, Filterable (TDS) @180	mg/L	4800	9530	5360	9250	5910	3010
Sulfate	mg/L	2125	4070	3560	4060	3470	1700
Total Alkalinity	mg/L		671		660	459	275

Calcite Saturation Index	0.77	-7.67	1.01	1.26	1.07
Gypsum Saturation Index	-0.12	-0.03	-0.01	0.00	-0.21
Rhodocrosite Saturation Index	1.70	-7.55	1.50	1.38	0.48

Notes:

1. kg = Kilograms.

Attachment C

**Technical Memorandum dated
March 31, 2006**

MEMORANDUM



To: Roy Blickwedel, P.G.
General Electric Company

Date: 3/31/06

From: Paul M. Stout, Ph.D., P.G.
Blasland, Bouck & Lee, Inc.

cc: Mark Purcell, USEPA
Bill Von Till, NRC
Paul Michalak, NRC
Robin Brown, NMED
Kevin Myers, NMED
Margaret Carrillo-Sheridan, P.E., BBL
Michael Gefell, P.G., BBL
Kenneth Kolm, Ph.D., BBL
Douglas Musser, P.G., BBL

Re: UNC Church Rock Site
Gallup, New Mexico
Mill Well Testing Results

INTRODUCTION

This technical memorandum (Tech Memo) presents the results of laboratory testing to evaluate the proposed use of groundwater withdrawn from the former mill domestic supply well (Mill Well), to stabilize and/or improve the recovery of tailings-impacted groundwater from Zone 3, at the United Nuclear Corporation (UNC) Church Rock Site (site) located in Gallup, New Mexico. This Tech Memo provides supplemental information to that presented previously, as part of a comprehensive program outlined in a document entitled: *In Situ Alkalinity Stabilization Pilot Study (Pilot Test)*, prepared by Blasland, Bouck & Lee, Inc. (BBL) and submitted to the United States Environmental Protection Agency (USEPA) on October, 12, 2005. BBL also prepared a January 26, 2006 Tech Memo that described results of bench-scale testing (bench tests) to evaluate the proposed injection of alkalinity-rich groundwater from a non-impacted part of the Southwest Alluvium into Zone 3.

Laboratory testing described in this document was performed in response to discussion with representatives from UNC, BBL, USEPA, the Nuclear Regulatory Commission (NRC) and the New Mexico Environment Department (NMED), concerning the results of bench tests documented in the January 26, 2006 Tech Memo. Concerns were expressed that the groundwater from the Southwest Alluvium, proposed for injection as part of the pilot study, did not meet applicable groundwater criteria for sulfate (SO₄), total dissolved solids (TDS), and manganese (Mn). Consequently, NMED requested that alternative water sources be identified and evaluated for injection into Zone 3 for use as a "fixiviant" for targeted constituents of concern (COCs).

NMED identified groundwater withdrawn from geologic formations below Zone 3 via the onsite Mill Well as a potential alternative source of groundwater to serve as a "fixiviant". Review of existing groundwater quality data for Mill Water samples indicated that this alternative source would satisfy NMED's concerns regarding the presence of SO₄, TDS, and Mn in the proposed fixiviant. Geochemical modeling using PHREEQCI, however, suggested that the Mill Water did not contain sufficient alkalinity to neutralize seepage-impacted groundwater within areas of greatest impact, such as near monitoring well 613. One of the objectives of the laboratory testing, therefore, was to evaluate approaches to increase the alkalinity of the Mill Water, in order to provide sufficient neutralization capability for Zone 3 seepage impacts areas.

The remainder of this Tech Memo provides a description of the analyses and results of the latest laboratory testing. In summary, the results presented below indicate that the Mill Water, with appropriate alkalinity enhancement, should serve as a suitable fixiviant for seepage-impacted groundwater during the pilot study.

LABORATORY TESTING AND RESULTS

Table 1 identifies the testing procedures and the three samples analyzed as part of the Mill Well water evaluation. The first sample, Mill Well 1, involved laboratory analysis of a sample, collected from the Mill Well on February 28, 2006, for a range of major ions, metals, and radionuclides, including COCs for the site.

The other two samples evaluated included: i) Mill Well 2, a Mill Well water sample dosed with sodium bicarbonate (NaHCO_3); and ii) Mill Well 3, a mixture of 9 parts Mill Well 2, and 1 part groundwater from well 517, which is located within an area of seepage impacts where the proposed field portion of the pilot test will be performed. These samples were analyzed for major ion/element chemistry only, because results from the earlier bench tests indicated that injection of the alkaline-rich fixiviant would achieve the treatment objectives for Zone 3 COCs.

Table 2 presents the laboratory analytical results for the three samples submitted for analysis. Also presented are analytical data for well 517.

Saturation indices, calculated using PHREEQCI, are presented for calcite (CaCO_3), magnesite (MgCO_3), and gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Indices for these minerals are provided because in situations where they are oversaturated (i.e. indices > 0), the possibility/likelihood exists that the minerals may precipitate, which may influence well performance (fouling), and constituent migration.

The last two columns in Table 2 describe calculations applicable to the Mill Well 3 sample, which contained a mixture of alkalinity-enhanced Mill Well water, and seepage-impacted groundwater from well 517. These two columns provide information about whether aqueous constituents contained in the mixed solutions may have precipitated or adsorbed/desorbed during the laboratory testing.

The column labeled "Calculated ..." corresponds to the mathematical product calculated by multiplying the analytical results for well 517(1 part) by 9 times the analytical results for Mill Well 2 (9 parts). Comparing the values in this column with the laboratory results for the Mill Well 3 (MW#3) sample, provides an assessment of potential precipitation/sorption reactions occurring during the testing. This is provided in the final column, labeled "Difference Calculated vs. MW#3". Negative values in the final column correspond to percent loss of constituent in the laboratory sample for Mill Well 3, compared to the theoretical mixing calculation presented in the adjacent column. Negative values may be indicative of loss of constituents via precipitation during the experiments, as well as analytical uncertainty. Positive values may reflect analytical uncertainty and/or leaching/desorbing of materials during the test.

Analytical results for the Mill Well 1 sample presented in Table 2 indicate that concentrations of SO_4 , TDS, Mn or the Zone 3 COCs should not be an issue regarding its use as a fixiviant. Results for the Mill Well 2 sample indicate that the added alkalinity will increase TDS, but not as high as the applicable groundwater criteria of 4,800 mg/L.

Results for the Mill Well 3 sample indicate that the alkalinity-enhanced Mill Well water can neutralize seepage-impacted groundwater represented by well 517. The observed pH of 8.6 is in agreement with the calculated mixture (using PHREEQCI) pH value of 8.5. PHREEQCI calculations indicate that if calcite were to precipitate for the Mill Well 3 sample, the resulting equilibrium pH would be approximately 7.8. Data presented in the last two columns in Table 2 suggest that magnesite and/or calcite may have precipitated to some extent during the experiments.

Additional PHREEQCI calculations provide insight regarding the extent to which alkalinity enhancement of the Mill Well water is needed to achieve sufficient neutralizing capacity. Results indicate that the Mill Well water without alkalinity enhancement would be sufficient to neutralize seepage-impacted groundwater from well 517. Calculations assuming a 9/1 (fixiviant/well 517) mixing ratio result in an equilibrium pH of ~7.95 in the absence of alkalinity enhancement. For 9/1 mixtures of fixiviant/well 613, an equilibrium pH of ~4.45 is predicted without alkalinity enhancement, and an equilibrium pH of ~6.6 using alkalinity-enhanced Mill Well water equivalent to the Mill Well 2 sample. Although Mill Well water without added-alkalinity should neutralize seepage-impacted groundwater near well 517, it appears prudent to conduct the field pilot test with alkalinity-enhanced Mill Well water. This will assist in evaluating potential well-fouling issues, and also provide greater confidence that the proposed fixiviant will successfully neutralize/stabilize groundwater where seepage impacts are greatest during full-scale operations.

In conclusion, considering the results from laboratory testing described herein, in combination with bench tests described in the January 2006 Tech Memo, using alkalinity-enhanced Mill Well water should serve as an effective fixiviant. BBL recommends that the field-portion of the Pilot Test be implemented as soon as possible to expedite improvement in groundwater quality within the area of seepage impacts at the site.

PMS/jlc
Attachments

TABLE 1

MILL WELL SAMPLES--LABORATORY PROCEDURES

UNC CHURCH ROCK SITE
IN-SITU ALKALINITY STABILIZATION PILOT STUDY

Sample No.	Sample Procedure	Sample Analyses
Mill Well 1	No additions or mixing Analyze upon receipt at the lab	Full list of analytes listed on Table 2
Mill Well 2	<ol style="list-style-type: none"> 1) Add NaHCO₃ to the Mill Well water at the ratio of 2g/L of water 2) Manually agitate mixture a minimum of three times during a 24 hour period 3) After 24 hours, filter with a 0.45 um filter, split the volume (half for analysis as sample Mill Well 2 and half to be used as sample Mill Well 3[see below]) 	Alkalinity as CaCO ₃ Chloride Nitrate as N, dissolved Nitrate/Nitrite as N, dissolved Nitrite as N, dissolved Nitrogen, ammonia pH (lab) TDS Sulfate Calcium, dissolved Magnesium, dissolved Sodium, dissolved Potassium, dissolved
Mill Well 3	<ol style="list-style-type: none"> 1) Use split of mixture described above in Mill Well 2 2) Add water from Well 517 at a ratio of 9:1 (9 parts Mill Well mixture to 1 part Well 517 water) 3) Manually agitate mixture a minimum of three times during a 24 hour period 4) After 24 hours, filter with a 0.45 um filter, analyze as sample Mill Well 3 for the parameters listed to the right 	Alkalinity as CaCO ₃ Chloride Nitrate as N, dissolved Nitrate/Nitrite as N, dissolved Nitrite as N, dissolved Nitrogen, ammonia pH (lab) TDS Sulfate Calcium, dissolved Magnesium, dissolved Sodium, dissolved Potassium, dissolved

TABLE 2
MILL WATER SAMPLE RESULTS
UNC CHURCH ROCK SITE
IN-SITU ALKALINITY STABILIZATION PILOT STUDY

ANALYTE	GW Standard	517	MillWell #1	MillWell #2	MillWell #3	Calculated, 0.1*517 and 0.9*MW#2	Difference Calculated vs MW#3
Aluminum, dissolved	5	4.0	U				
Arsenic, dissolved	0.01		U				
Beryllium, dissolved	0.004		U				
Cadmium, dissolved	0.005	0.0068	0.0001B				
Calcium, dissolved		475	16.1	15.7	59.4	61.6	-4%
Cobalt, dissolved	0.05	0.82	U				
Lead, dissolved	0.05	0.0010	0.034				
Magnesium, dissolved		508	4.2	4.1	44.6	54.5	-18%
Manganese, dissolved	2.6	9.10	0.04				
Molybdenum, dissolved	1		U				
Nickel, dissolved	0.2	0.71	0.07B				
Potassium, dissolved		10	3.6	3.6	4.1	4.24	-3%
Selenium, dissolved	0.05		0.002				
Sodium, dissolved		156	716	1250	1140	1141	0%
Uranium, dissolved	0.03	0.0400	0.0081				
Vanadium, dissolved			U				
Gross Alpha	15	65	16 +/- 11				
Gross Beta		65	16 +/- 11				
Radium 226	5	9.2	1.7 +/- 0.6				
Radium 228, total		8.6	0.69 +/- 0.73				
Thorium 228		0.72	0.05 +/- 0.08				
Thorium 230	15	-0.3	-0.14 +/- 0.12				
Thorium 232		-0.03	0.02 +/- 0.14				
Bicarbonate as CaCO3			196	1310	1140		
Carbonate as CaCO3			13	136	118		
Chloride		40	154	161	150	149	1%
Hydroxide as CaCO3			U				
Nitrate as N, dissolved*	190	0.05	0.02	0.03	0.02		
Nitrate/Nitrite as N, dissolve			0.02	0.03	0.02		
Nitrite as N, dissolved			U				
Nitrogen, ammonia		8.00	0.65	0.6	1.35	1.34	1%
pH		4.0	8.6	8.7	8.6	8.5	
pH measured at oC		21	22	22	22	22	
Residue, Filterable (TDS) @180	4800	5360	2180	3470	3530	3659	-4%
Sulfate	2125	3560	1180	1200	1390	1436	-3%
Total Alkalinity			209	1440	1260	1296	-3%
Calcite Saturation Index		-7.67	0.37	1.12	1.56	1.51	
Magnesite Saturation Index		-7.98	-0.53	0.29	1.17	1.18	
Gypsum Saturation Index		-0.03	-1.61	-1.84	-1.19	-1.16	

Attachment D

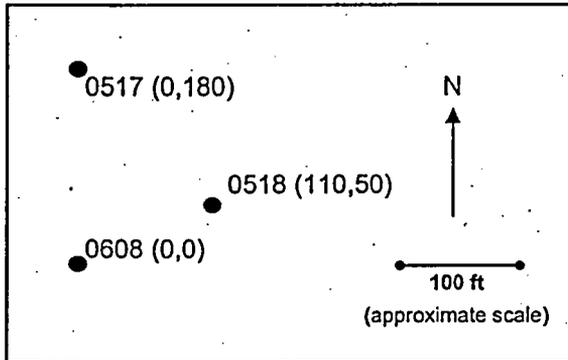
Pilot Study Wellfield Design

UNC Church Rock Site
Church Rock, New Mexico

Pilot Study Well Field Design

Pilot Study Target Area

Vicinity of wells 0517, 0518, and 0608



Zone 3 Hydraulic Parameters

$K = 5E-4 \text{ cm/sec} = 1.4 \text{ ft/day}$

$H = 14 \text{ ft}$

$T = K H = 20 \text{ sqft/day} = 150 \text{ gal/day/ft}$

$S_y = 0.15$ (insensitive parameter, decreasing 10-fold reduces Q at central EW by 2%)

$l = 14/400 = 0.035$

$s(iw) = \pm 11 \text{ ft}$ (+ for extraction, - for injection)

well efficiency = 50%

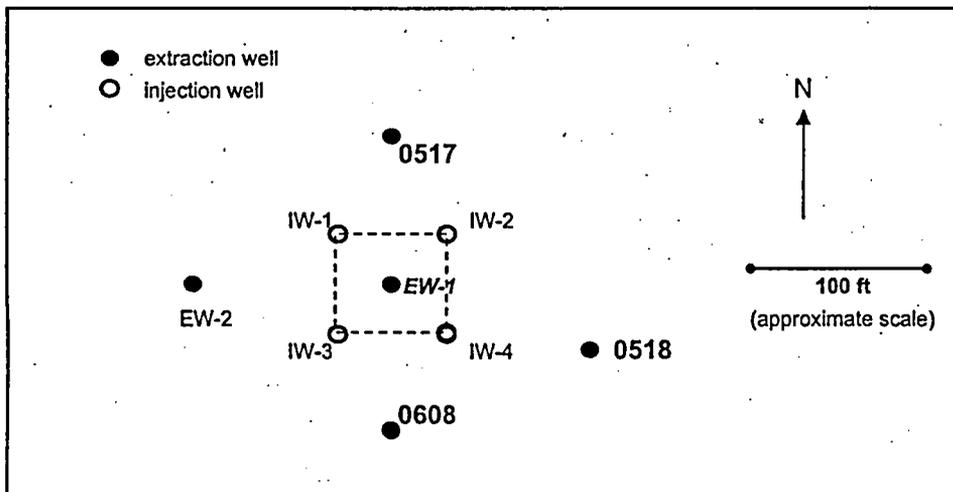
$s(ow) = \pm 6.5 \text{ ft}$ (+ for extraction, - for injection)

$h(ow) = 14 - 6.5 = 7.5 \text{ ft}$ (extraction wells)

$h(ow) = 14 + 6.5 = 20.5 \text{ ft}$ (injection wells)

$t = 30 \text{ days}$ (for Q estimate)

Pilot Study Wellfield Layout - 9 Spot



Hydraulic Assessment

	Well	X (ft)	Y(ft)	s(ow) (ft)	Q, calc (gpm)
1	0608	0	0	6.5	0.75
2	0517	0	180	6.5	0.78
3	0518	110	50	6.5	0.70
4	EW-1	0	90	6.5	1.05
5	EW-2	-110	90	6.5	0.71
6	IW-1	-30	120	-6.5	-0.83
7	IW-2	30	120	-6.5	-0.81
8	IW-3	-30	60	-6.5	-0.83
9	IW-4	30	60	-6.5	-0.84

(calculated using ISINKFLO.EXE, Theis solution for wellfield with specified drawdown)

Total Extraction Rate = 4.0 gpm

Total Injection Rate = 3.3 gpm

Pore Volume Within Square = $(60 \times 60 \times 14) \times 0.15 = 7560 \text{ cf} = 57,000 \text{ gal}$

Extraction Rate @ EW-1 = 1.05 gpm

Time for 1 Pore Volume Exchange Within Square = $57,000 / 1.05 = 54,000 \text{ min} = 37 \text{ days}$

Initial Breakthrough (Travel-Time) Calculation

Pre-Pumping Gradient = 0.035

Pre-Pumping dH in Square = $0.035 \times 60 = 2.1 \text{ ft}$

Pre-Pumping dH Between EW-1 and IWs = $2.1 / 2 = 1.05 \text{ ft}$

Pumping-Induced dH Between EW-1 and IWs = 13 ft

Net dH from IW-3 and IW-4 to EW-1 = $13 + 1.05 = 14.05 \text{ ft}$

Net pumping gradient from IW-3 and IW-4 to EW-1 = $14.05 / 42 = 0.335$

$v = K_i / n = 1.4 \text{ ft/day} (0.335) / 0.15 = 3.1 \text{ ft/day}$

Distance from IWs to EW-1 = 42 ft

Travel Time = $42 / 3.1 = 14 \text{ days}$