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January 4, 2002

40-8907

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Subject: **License No. SUA-1475, 2001 Groundwater Corrective Action Annual Review Report and Request For Meeting**
United Nuclear Corporation's Church Rock Site, Gallup, New Mexico

Dear Messrs. Leach and Lyssy:

On behalf of United Nuclear Corporation (United Nuclear), Earth Tech, Inc. (Earth Tech) is providing this annual performance review of the ground water corrective action at United Nuclear's Church Rock Mill and Tailings site near Gallup, New Mexico, pursuant to License Condition 30C. This report is for the 2001 operating year and represents the period from October 2000 through October 2001. An extension of the December 31, 2001 submittal date for this report was granted in a telephone conversation with Ken Hooks of the Nuclear Regulatory Commission on December 20, 2001.

This report differs from the previous reports in that this performance monitoring evaluation focuses on the performance of the natural systems without active remediation. As indicated in the U.S. Environmental Protection Agency's *Five-Year Review Report* (September 1998) and by the approvals to decommission or temporarily shut off the three corrective action systems, the agencies recognized that the corrective actions have reached the limit of effectiveness in Zone 1 and may have reached their limit of effectiveness in Zone 3 and the Southwest Alluvium. Also, the presentations and reports prepared to document the geochemical processes in each formation (Earth Tech, 2000c and 2000d; General Electric Corporation [General Electric], 2000 [references cited herein refer to reference list in the *2001 Annual Review Report*]) show that the natural geochemical mechanisms are at least as effective as the active remediation systems in controlling the migration of contaminants. The *2001 Annual Review* focuses on how these natural processes are performing.

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Please note that the Monitored Natural Attenuation Test is ongoing in the Southwest Alluvium. Because a detailed review on the performance of the Southwest Alluvium natural system is already being reported quarterly (Earth Tech, 2001b, 2001c and 2001d), the section on the Southwest Alluvium in this report is limited to a discussion of the pumping systems and mass extraction. The fourth quarter report for the Monitored Natural Attenuation Test will be submitted in mid-February 2002.

RECOMMENDATIONS

Based on the results of the annual performance evaluation, the following recommendations are made for Zone 1 and Zone 3:

Zone 1

Proceed to closure of the Zone 1 remedial action system using a combination of:

- Monitored Natural Attenuation (MNA) – metals and radionuclides
- Technical Impracticability (TI) Waiver – sulfate, total dissolved solids (TDS), and manganese
- Institutional Controls – support MNA and TI

Zone 3

Continue remediation using the natural system and allow time for the natural system to stabilize the seepage impacts. The geochemical mechanisms in Zone 3 are similar to those in Zone 1 and, given more time and no disruption from active remediation, are expected to successfully attenuate constituent concentrations within the property boundary. The revised monitoring program requested by the NRC and implemented in 2001 will be a useful tool for evaluating the stability of the seepage impacts and performance of the natural system in attenuating constituents. United Nuclear anticipates that by this time next year there will be sufficient data to demonstrate the stability of the seepage plume and the effectiveness of the natural system in attenuating constituent concentrations to background concentrations.

Assuming that the Zone 3 system does perform similarly to the Zone 1 system, the next step will be to proceed with closure of the Zone 3 remedial action system using a combination of:

- MNA or Alternate Concentration Limits (ACLs) – metals and radionuclides
- TI – sulfate, TDS and manganese

REQUEST FOR MEETING

United Nuclear requests a meeting sometime during the week of February 25, 2002, in Santa Fe, New Mexico, to discuss the:

- Findings of this Annual Review,

- Procedures for corrective action completion for Zone 1,
- Monitoring requirements for Zone 3 to demonstrate plume stability and containment within the property boundary,
- Conclusions from the Southwest Alluvium Natural Attenuation Test, and
- Procedures for corrective action completion for the Southwest Alluvium.

Please contact Roy Blickwedel (General Electric Corporation) at (610) 992-7935 or me at (570) 925-5063 to let us know your availability for attending the requested meeting during the last week of February. Also, please contact us if you have any questions or need additional information.

Very truly yours,
Earth Tech, Inc.

Suzie du Pont
Project Manager

Enclosure

cc: Roy Blickwedel, General Electric Corporation
Robin Brown, New Mexico Environment Department
Larry Bush, United Nuclear
Ken Hooks, Nuclear Regulatory Commission
Bob Lawrence, Davis, Graham & Stubbs (w/o enclosure)
Diana Malone, Navajo Superfund
George Padilla, Navajo Superfund
Bill von Till, Nuclear Regulatory Commission

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REPORT

ANNUAL REVIEW - 2001
GROUNDWATER CORRECTIVE ACTION

CHURCH ROCK SITE

January 2002

Prepared for:

United Nuclear Corporation
Gallup, New Mexico

Prepared by:

Earth Tech, Inc.
2 Market Plaza Way
Mechanicsburg, PA 17055

REPORT

ANNUAL REVIEW - 2001
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ACL	alternate concentration limit
Canonie	Canonie Environmental Services Corporation
Earth Tech	Earth Tech, Inc.
EPA	U.S. Environmental Protection Agency
General Electric	General Electric Company
gpm	gallons per minute
MCL	maximum contaminant level
mg/L	milligrams per liter
MNA	monitored natural attenuation
NRC	Nuclear Regulatory Commission
pCi/L	picocuries per liter
POE	point of exposure
Rust	Rust Environment and Infrastructure
Smith Technology	Smith Technology Corporation
TDS	total dissolved solids
TI	technical impracticability
United Nuclear	United Nuclear Corporation

1.0 INTRODUCTION

On behalf of United Nuclear Corporation (United Nuclear), Earth Tech, Inc. (Earth Tech) has prepared this annual performance review of the groundwater corrective action at United Nuclear's Church Rock Mill and Tailings site near Gallup, New Mexico, pursuant to License Condition 30C. United Nuclear has submitted an annual review report at the end of each operating year since 1989. This report is the thirteenth in the series and includes water quality analyses and water level elevations for the fourth quarter of 2000 through the fourth quarter of 2001.

This report differs from the previous reports in that this performance monitoring evaluation focuses on the performance of the natural systems without active remediation. As indicated in the U.S. Environmental Protection Agency's (EPA's) Five-Year Review Report (EPA, 1998) and by the approvals to decommission or temporarily shut off the three corrective action systems, the agencies recognized that the corrective actions have reached the limit of their effectiveness. Also, the presentations and reports prepared to document the geochemical processes in each formation (Earth Tech, 2000c and 2000d; General Electric Company [General Electric], 2000) show that the natural geochemical mechanisms are at least as effective as the active remediation systems in controlling the migration of contaminants. This report focuses on how these natural processes are performing.

1.1 SITE ORIENTATION

Figure 1-1 is a site map that shows the location of the extraction wells that operated during 2001, performance monitoring wells, the evaporation ponds, and the reclaimed tailings areas. The figure also shows the remedial action target area for each geologic formation where the impacts of tailings seepage were originally identified and corrective action is being implemented. Additional background information on site facilities and activities is available in the previous annual reviews.

1.2 CORRECTIVE ACTION SYSTEMS

The corrective (or remedial) action systems for tailings seepage remediation were installed and began operating during the summer and fall of 1989. These systems have been decommissioned or, in the case of the Southwest Alluvium, temporarily shut off, and performance monitoring is ongoing. The Zone 1 system was decommissioned in July 1999 in accordance with the letter from the Nuclear Regulatory Commission (NRC) dated July 30, 1999 (NRC, 1999a). The 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 agencies agreed that the system could be decommissioned. This decision is documented in an e-mail letter from the EPA dated November 15, 2000 (Lyssy, 2000). The Southwest Alluvium system was temporarily shut off in January 2001 to allow implementation of the Natural Attenuation Test, which was discussed and approved during the November 14 and 15, 2000, meeting in Santa Fe, New Mexico, and documented in the November 15, 2000, letter from EPA.

1.3 PERFORMANCE MONITORING

The Corrective Action Plan (United Nuclear, 1989a), Remedial Design Report (Canonie Environmental Services Corp. (Canonie), 1989a) and Remedial Action Plan (United Nuclear, 1989b) approved by the NRC and EPA describe the performance monitoring program. The program has been modified over time as described in the annual reports (Canonie, 1989b, 1990, 1991, 1992b, 1993b and 1995; Smith Technology, 1995 and 1996; Rust Environment and Infrastructure, 1997; Earth Tech, 1998, 1999, and 2000e) to adjust the monitoring requirements as the corrective action has taken effect. The NRC and EPA have approved all modifications.

In accordance with the EPA's request in 1999, United Nuclear developed a revised monitoring program that was implemented beginning with the second quarter 2000 sampling event. The revised program is documented in the letters dated January 13, 2000, (Earth Tech, 2000a) and April 26, 2000 (Earth Tech, 2000b). Details of the revised monitoring program for each formation are provided in the performance monitoring portion of the following sections and in the appendices.

The field and laboratory data collected from the fourth quarter of 1989 through the fourth quarter of 2001 are summarized in the tables in Appendices B (Southwest Alluvium), C (Zone 3), and D (Zone 1). These tables have been modified to reflect the revised background standards for sulfate, nitrate and total dissolved solids (TDS) that were recommended by the NRC in its report evaluating background for the site (NRC, 1996) and supported by the New Mexico Environment Department (NMED) as documented in its letter to the EPA dated January 6, 1998 (NMED, 1998). These revised standards are 2,125 milligrams per liter (mg/L) for sulfate, 190 mg/L for nitrate and 4,800 mg/L for TDS. The quarterly laboratory data sheets for the 2001 operating year are included at the end of the respective appendices. The original field and laboratory data for the period from 1989 to 2000 are included in the previous annual reviews.

1.4 SOUTHWEST ALLUVIUM

Currently a Natural Attenuation Test is in progress in the Southwest Alluvium. The test involves temporarily shutting off the pump-back wells and monitoring the water quality and water levels on a monthly basis. The results are reported on a quarterly basis, including statistical analyses comparing baseline (pumping) and test (post-pumping) data (Earth Tech, 2001b, 2001c, and 2001d). Because a detailed review on the performance of the natural system is already being reported, the section on the Southwest Alluvium in this report is limited to a discussion of the pumping systems and mass extraction. The methodology, calculations and results of the calculations are presented in Appendix A. The performance monitoring data are included in Appendix B.

1.5 REPORT ORGANIZATION

The report has been organized with each formation presented in a separate section:

- Section 2.0 Southwest Alluvium
- Section 3.0 Zone 3
- Section 4.0 Zone 1
- Section 5.0 Conclusions and Recommendations
- Section 6.0 References

The mass extraction calculations and monitoring data are contained in separate appendices for each formation:

- Appendix A Mass Extraction (Southwest Alluvium only)
- Appendix B Southwest Alluvium Monitoring Data
- Appendix C Zone 3 Monitoring Data
- Appendix D Zone 1 Monitoring Data

This report is the third in the series of quarterly reports and covers the period from August 2001 through October 2001.

2.0 SOUTHWEST ALLUVIUM

2.1 OPERATION OF EXTRACTION WELLS

The corrective action for the Southwest Alluvium in 2001 continued the operation of three of the four extraction wells (802, 803, and 808) until January 2001 when the wells were temporarily shut off for the Natural Attenuation Test. The pumps will remain off until the natural attenuation test is completed. As documented in the 1999 Annual Review, Well 801 was decommissioned at the end of July 1999 because it pumped at a rate of less than 0.5 gallon per minute (gpm) for the previous eight years. The operational data are summarized in Table 2-1.

2.2 MASS OF CHEMICAL CONSTITUENTS REMOVED

In accordance with the requirements of the NRC and EPA, the mass of chemical constituents extracted was calculated for the time period when the extraction wells were operating. The constituents with concentrations that exceeded NRC standards and/or EPA Applicable or Relevant and Appropriate Requirements within the target area were included in the calculation. TDS concentrations were not included in the mass extraction calculations because TDS are mainly composed of constituents that are included in the calculations (e.g., sulfate).

Appendix A presents the methodology and calculations used to determine the mass extracted. The results of the calculations are presented in the tables in the appendix.

2.3 PERFORMANCE MONITORING EVALUATION

An evaluation of the performance monitoring data is not provided in this report because, as discussed in Section 1.4 above, this information is already presented in the quarterly reports prepared for the Natural Attenuation Test. However, the field and laboratory data collected between October 2000 and October 2001 are included in Appendix B.

3.0 ZONE 3

3.1 CORRECTIVE ACTION SUMMARY

The corrective action in Zone 3 performed as designed to enhance dewatering of the seepage-impacted area and remove constituent mass. Corrective action in Zone 3 consisted of pumping the three different sets of extraction wells shown on Figure 3-1:

- Northeast Pump-back System (shown in red)
- Stage 1 Remedial Action (shown in green)
- Stage II Remedial Action (shown in blue)

The Northeast Pump-back wells began operating in 1983 to capture acidic seepage from the North Cell of the tailings impoundment. The Stage I and Stage II wells were added later as part of the Remedial Action Plan (United Nuclear, 1989b) implemented in 1989. As discussed in the Technical Memorandum, Change in Zone 3 Saturated Thickness (Earth Tech, 2001a) submitted to the NRC April 23, 2001, the loss of saturated thickness over time resulted in a decrease in the efficiency of the extraction wells to the point that only three of the total 24 wells were still pumping at rates greater than 1.0 gpm when the system was turned off in 2000. Figure 3-2 provides a summary of the pumped volumes and the number of wells pumping over the period of the corrective action. Even when the maximum of 24 wells was operating, the yield was less than 25 gpm because of the limited saturation in the area.

The remediation system wells operated as designed to speed the process of the natural draining of the water from Zone 3. The effect of this enhancement of the natural drainage is illustrated by the graph on Figure 3-3. The graph shows saturated thickness over time for wells located within the influence of the extraction wells. The saturated thickness was increasing in the early 1980s when mine water was being discharged. Water levels began to decline after 1986 when the mine water discharge ceased. Once the Stage I wells were turned on (marked by the red dashed line), the rate of decline in water levels and saturated thickness increased as indicated by the steeper trend line (black arrows). This trend continued for several years after the Stage II wells were turned on (marked by the green dashed line) until the saturated thickness for the wells was reduced to less than approximately 25 feet. After this time, the decline in saturated thickness slowed to rates representing natural drainage.

The effect of pumping to enhance Zone 3 dewatering is illustrated in plan view on Figure 3-4, which shows contours of saturated thickness as of the fourth quarter 2001 after the pumping wells were shut off. As shown, the eastern extent of saturation has contracted to the west so that now the boundary of saturation is approximately where the 25-foot saturated thickness contour was located in 1989 (shown on Figure 3-1). Also, the wells located to the west, closer to the recharge area, have lost substantial saturation. For example, Well EPA 14 had 76 feet of saturation in 1989 and now has only 41 feet.

Table 3.1 compares the saturated thickness data for 1989 and the fourth quarter 2001 to illustrate the change in saturation that has occurred. Values greater than 25 feet are shaded. Note that in 1989 the majority of the wells had more than 25 feet of saturated thickness. The average saturated thickness has decreased by 68 percent since 1989 and was only 16.5 feet as of the fourth quarter 2001. Also, only four of the wells monitored for water level now have saturated thicknesses greater than 25 feet.

The reduction in saturated thickness has decreased the area in Zone 3 where pumping is technically practicable. As demonstrated by the empirical data from 18 years of remedial action pumping, once the saturated thickness is reduced to about 25 feet or less, well efficiency declines and pumping rates drop below 1 gpm. As a result, by June 2000, all but three of the remedial action wells met the decommissioning criterion of pumping 1 gpm or less. Figure 3-4 shows that these three wells, Wells 716, 717 and 718, are located in an area where the saturated thickness is at or greater than 25 feet.

The only locations with sufficient saturated thickness to practicably extract Zone 3 water are downgradient from the seepage-impacted area. Extraction in these areas has not been and would not be beneficial because the rate of downgradient plume migration is increased and natural attenuation is hindered as demonstrated by the evaluation of seepage impacts at EPA 14 (General Electric, 2000). A slower rate of migration is preferred because it allows the natural attenuation process to work more effectively to neutralize seepage impacts. Therefore the Zone 3 system was approved for shutdown in November 2000 as documented in November 15, 2000, letter from the EPA (Lyssy, 2000).

As discussed in Section 3.3, the 2001 data for Well EPA 14 confirm that shutting off the pumping wells is having a positive effect by allowing the natural system to be reestablished. Although seepage-impacted water continues to migrate to Well EPA 14, the changes in water quality at this well from seepage migration are beginning to stabilize as the effects of the extraction pumping begin to dissipate.

3.2 MASS OF CHEMICAL CONSTITUENTS REMOVED

The mass of chemical constituents removed was calculated for the twelve-year period from July 1989 through June 2000. These calculations were presented in the previous annual reviews and the final summary is presented in the 2000 Annual Review (Earth Tech, 2000e).

3.3 PERFORMANCE MONITORING EVALUATION

The performance monitoring program in Zone 3 currently in effect is summarized in Table 3.2. As shown, this consists of quarterly monitoring of water levels in 23 wells and water quality in 11 wells. This program went into effect in the second quarter of 2000 and was modified during the 2001 operational year at the request of the NRC. The modifications are shaded in the table and include:

- Adding water quality monitoring at Wells EPA 13, 717, and 719;
- Adding Well 708 for water level and water quality monitoring; and
- Installing Well NBL-01 as a new downgradient monitoring well.

Well NBL-01 was added to the monitoring program at the request of the agencies during the November 2000 meeting in Santa Fe. The location of NBL-01, shown on Figure 3-4, was discussed during the November 2000 meeting and was selected to bound the downgradient edge of the seepage-impacted water. The well was drilled in July 2001 and was completed to a depth of 196 feet. The drilling log, well completion form and geophysical log are included in Appendix C.

3.3.1 Water Level Evaluation

Water level data for Zone 3 are listed in Tables C.1 and C.2 in Appendix C. Water levels for the fourth quarter of 2001 are listed on the piezometric surface map for Zone 3 shown on Figure 3-5. As shown, groundwater in Zone 3 flows to the north-northeast approximately parallel with the eastern extent of Zone 3 saturation. The direction of flow has shifted from east to north as the recharge from the alluvium to the west has declined since mine water recharge ceased in 1986.

The effect of recharge from the mine water in the alluvium and drawdown from the extraction well systems is dissipating and water levels throughout the system are reaching an asymptotic level where changes in water level are very small. Figure 3-6 shows water levels over time in the downgradient wells located approximately outside the influence of the pumping wells. As the graph shows, water levels began to decline after 1986 when the mine water discharge ceased. Since that time, water levels (and saturated thickness) have declined steadily as the mine water naturally drains out of the formation.

The same pattern of decreasing water levels is also evident for the wells located within the influence of the extraction wells, shown on Figure 3-3. As discussed above, the pumping wells enhanced the natural drainage by temporarily increasing the rate of water level decline. This trend continued until the saturated thickness was reduced to less than approximately 25 feet. After the saturated thickness decreased to 25 feet, the decline in water levels slowed to rates representing natural drainage. Both Figures 3-3 and 3-6 show that after about 1996 water level trends throughout Zone 3 have flattened and the rate of drainage as reached natural levels.

3.3.2 Water Quality Evaluation

Groundwater in Zone 3 in the vicinity of the Church Rock tailings impoundment was created by mine water that was discharged to Pipeline Arroyo. This mine water percolated into the alluvium and then into the underlying Zone 3 formation and created a temporary saturation in the vicinity of the tailings impoundment. Figure 3-5 shows the recharge area where the mine water in the alluvium percolated into the underlying Zone 3 formation. The temporary saturation created by the mine water discharge is the recognized background water for Zone 3 (EPA, 1988).

The background water in Zone 3 was later impacted by acidic seepage from the North Cell of the tailings impoundment. The acidic seepage contained elevated concentrations of metals, radionuclides, and major ions such as sulfate and chloride. Source remediation (neutralizing and later dewatering the North Cell) plus neutralization of the seepage by natural attenuation and mixing with the background water have reduced concentrations of constituents.

Currently the seepage-impacted water, including constituents exceeding the site standards, is contained within the property boundary in Section 36. Although a portion of the seepage-impacted water also extends off the property into Section 1, this area was eliminated as a point of exposure (POE) because there is only 5 feet of saturation and because this minor saturation was projected to drain out in about 10 years. The decision to eliminate this area as a POE is documented in the letter from the NRC dated September 16, 1999 (NRC, 1999b).

3.3.2.1 Current Extent of Seepage Impacts

The delineation of the extent of seepage impacts in Zone 3, as in the Southwest Alluvium and in Zone 1, is based primarily on the three constituents, pH, chloride and bicarbonate.

Figure 3-7 shows the approximate extent of seepage impacts in Zone 3 as of October 2001. This extent is based on an evaluation of the pH, chloride and bicarbonate concentrations over time both in wells that are seepage-impacted, such as Wells 613, 518 and 517, and in background wells such as Wells EPA 1, 411 and 420. Over time, seepage impacts in Zone 3 have migrated to the east-northeast toward and then along the edge of saturation. The easterly component of flow was the result of the hydraulic head of the alluvial recharge to the west.

pH

As shown on Figure 3-7, water with pH of less than 4.0 extends from the tailings area at Well 613 eastward to Wells 708 and 711 and then northward to Wells 719 and 504 B. Until recently, the acidic pH water (less than 4.0) was limited to the area between Wells 613 and 518. However, as predicted in the EPA's Five-Year Review Report (EPA, 1998) and discussed in the Technical Memorandum (General Electric, 2000) continued pumping of the downgradient wells has had the detrimental effect of pulling the seepage further downgradient. Until May 2000, Wells 708 and 711 had pH values greater than 4.0, but after that time they dropped to below 3.0. The pH at Well 719 was consistently greater than 6.0 during the time the well was pumping. However, between July 1999, when the well was turned off, and April 2001, when it was added to the Zone 3 monitoring program, the pH dropped to below 3.0. Well 504 B had pH values consistently between 5.0 and 6.0 until July 2001 when the field pH dropped to below 4.0.

Bicarbonate and Chloride

As discussed in the Technical Memorandum (General Electric, 2000) bicarbonate concentrations greater than 500 mg/L and chloride concentrations greater than 60 mg/L provide an indication that seepage is migrating into previously unimpacted areas. The bicarbonate concentrations indicate reaction between the acidic seepage and the formation and chloride is used because it was present in elevated concentrations in the tailings liquor.

Figures 3-8 and 3-9 graph bicarbonate and chloride over time, respectively. The wells that have been strongly impacted by seepage, such as Wells 613, 518, 517, 501 B and 502 B, have very low or nondetected concentrations of bicarbonate, typically 0 mg/L. In contrast, the unimpacted wells, such as Wells EPA-1, 420 and 411, have concentrations of bicarbonate, ranging between 100 and 500 mg/L. A similar pattern is evident for chloride where wells such as 613, 518 and 517 have, or have had, chloride concentrations over 100 mg/L. Chloride concentrations in the unimpacted wells are typically less than about 50 mg/L. However, the pattern for chloride is not as clear as it is for bicarbonate because the impacted wells located further downgradient have not exhibited elevated concentrations over 100 mg/L. Instead, the concentrations remain in the 20-mg/L to 50-mg/L range.

Increasing concentrations of bicarbonate and chloride in a well indicate that seepage impacts are migrating to that location. As described in the Technical Memorandum (General Electric, 2000), seepage began impacting Well EPA 14 in about 1996. Figures 3-8 and 3-9 show that bicarbonate concentrations began increasing in 1996 and continued this trend with bicarbonate concentrations increasing to greater than 500 mg/L and chloride concentrations increasing to over 60 mg/L in this well. More recently, the bicarbonate concentrations decreased to less than 100 mg/L as more-acidic seepage migrated into the vicinity of the well. The increases in bicarbonate and chloride in EPA 14 were followed in 2000 and 2001 by increases in metals concentrations to levels greater than the cleanup standards, confirming that the seepage had migrated to this area. Therefore, the extent of seepage impacts includes EPA 14 on Figure 3-7.

The seepage impacts also extend to Well 717 as indicated by the trends in bicarbonate and chloride concentrations on Figures 3-8 and 3-9. The concentrations of bicarbonate and chloride are increasing in Well 717 (red triangles) and now exceed the concentrations (500 mg/L bicarbonate and 60 mg/L chloride) that are used to indicate seepage impacts. The fact that the pH at this well is still neutral (pH of 7.01 in October 2001), bicarbonate is elevated and no metals exceed the site cleanup standards confirms that neutralization processes are attenuating the seepage.

Seepage impacts extend beyond Wells 719 and 504 B where the pH is below 4.0, bicarbonate concentrations are at or near 0 mg/L, and metals concentrations are elevated above the site cleanup standards. As discussed in the Technical Memorandum (General Electric, 2000) seepage impacts in Well 504 B became evident sometime between 1993 and 1996. However, neutralization of the acidic seepage has been occurring as indicated by the fact that, until recently, pH was greater than 5.0, bicarbonate has averaged about 30 mg/L and metals concentrations have remained low compared to concentrations closer to the source area.

Seepage impacts may be migrating to the vicinity of downgradient Wells 420 and 411. Figures 3-8 and 3-9 show that the concentrations of bicarbonate and chloride have been increasing in these wells in a pattern similar to that in EPA 14. Well 411 is no longer monitored because the well filled with oil. Concentration increases in Wells 411 and 420 have been evident over a much longer period than would be expected if the cause was solely migration of seepage. Changes in the background water chemistry as the chemistry of the alluvial recharge water continues to evolve could also be contributing to the trends. Future monitoring at Well 420 will help confirm whether the changes are related to seepage impacts or to natural changes in the unimpacted background water.

The water quality from the new downgradient Well NBL-01 was also evaluated for seepage impacts. As shown on Figures 3-7 through 3-9, the pH, bicarbonate and chloride concentrations all fall within the background, or unimpacted, range. Therefore the extent of seepage impacts remains upgradient from this well.

3.3.2.2 Performance of the Natural System

Zone 3, like the Southwest Alluvium and Zone 1, has natural geochemical processes that control the migration of constituents associated with the acidic seepage. These processes neutralize the acidic seepage, which causes attenuation and adsorption of the metals and radionuclides. Evidence for the neutralization process includes:

- Increase in pH and corresponding decrease in metals and radionuclide concentrations with distance from the source area (North Cell), and
- Increase in bicarbonate in wells such as EPA 14 and 717 when acidic seepage begins migrating into a previously unimpacted area.

These processes have been somewhat disrupted by the long-term extraction in the formation, especially in the downgradient areas. As discussed in the Technical Memorandum (General Electric, 2000), in recent years pumping the Stage II wells caused the seepage to migrate downgradient at a faster rate. The clearest evidence for this effect is the change in water quality at Well EPA 14 in response to the shift in pumping from the Stage I to the Stage II wells after 1996 (General Electric, 2000). Turning off the extraction wells is expected to gradually slow the migration and allow the natural processes more time to attenuate the seepage. The effect of turning off the wells is beginning to be evident at Well EPA 14. Constituent concentrations are beginning to stabilize after the accelerated changes in water quality resulting from the downgradient pumping.

A review of Table C.1 in Appendix C shows that the following constituents exceed the site standards in Zone 3:

- Sulfate and TDS,
- Chloroform,
- Metals (aluminum, arsenic, beryllium, cadmium, cobalt, manganese, molybdenum, and nickel), and
- Radionuclides (uranium, combined radium-226 and -228, thorium, vanadium and gross alpha).

How the geochemical processes are controlling the migration of these constituents in Zone 3 is discussed below.

Sulfate and TDS

Figure 3-10 is a graph of sulfate over time and Figure 3-11 shows the approximate extent of sulfate exceeding the site standard as of October 2001. Sulfate exceeds the standard in both the seepage-impacted and background areas. For example, Figure 3-10 shows that Well EPA 1, which is located about 1,200 feet downgradient from the furthest extent of the seepage-impacted water, consistently had sulfate concentrations in the range of 2,500 mg/L to 3,000 mg/L. Higher concentrations are evident at wells such as 613 and 518 where seepage impacts have been greatest.

Overall the sulfate concentration trends are flat with concentrations stabilizing between 1,700 mg/L and 4,000 mg/L. Concentrations are expected to remain at these levels because, as in the Southwest Alluvium and Zone 1, sulfate is controlled by gypsum equilibrium. Modeling of the Zone 3 water chemistry has shown that the water throughout the formation is saturated with gypsum. As a result, sulfate concentrations are controlled by natural conditions whether or not active remediation is implemented.

TDS concentrations will also continue to exceed the site standards because, as in the other two formations, sulfate makes up the greatest percentage of the TDS.

Chloroform

Figure 3-12 is a graph of chloroform concentrations over time. Chloroform exceeds the site standards only at the two wells located closest to the source area (Wells 517 and 613). As shown on Figure 3-12, these chloroform concentrations are less than the maximum contaminant level (MCL) of 0.1 mg/L (100 micrograms per liter), particularly at Well 517 where the concentrations are an order of magnitude lower. Because the extent of chloroform exceeding the site standard is limited to adjacent to the source area and concentrations are all below the MCL, chloroform is not considered a constituent of concern for Zone 3.

Metals

Figure 3-13 presents graphs of metals concentrations over time for the eight metals that exceed site standards. Two additional metals, uranium and vanadium, also exceed the standards; these are discussed later with the radionuclides. The metals exhibit a consistent pattern of higher concentrations in wells such as 613, 517 and 719 that have acidic pH and much lower concentrations where the pH is more neutral. This difference in metals concentrations is the result of attenuation as the formation and the background water neutralize the acidic seepage.

The attenuation of metals occurs throughout the seepage-impacted area, including areas where the pH is less than 4.0. Figure 3-14 is a modified version of Figure 3-13 that shows only selected wells to better illustrate the attenuation process. Well 613 represents the center of seepage closest to the source area where pH has ranged between 2.0 and 3.0 since the well was first monitored in 1980. On six of the eight graphs, this well exhibits the highest metals concentrations. For example, aluminum concentrations in Well 613 are between 650 mg/L and 800 mg/L. In contrast, aluminum concentrations in wells located further downgradient are all below 100 mg/L. This includes Well 719, which has a pH less than 3.0. Attenuation of the aluminum is also illustrated in plan view on Figure 3-15, which shows that aluminum concentrations are exceeded in only a limited portion of the seepage-impacted area.

The elevated aluminum concentrations at Well EPA 14 confirm that seepage has migrated into the area. However, based on the October 2001 data, it appears that the accelerated downgradient seepage migration (due to pumping) has begun to reverse. The aluminum was first reported in detectable concentrations in May 2000 and continued to increase to the highest reported concentration in July 2001. The concentration then decreased in October to levels just above the standard. This same pattern is evident for the other metals and, if the trend continues, metals concentrations are expected to stabilize or even decrease to below the standards at this location.

The effectiveness of the natural system in attenuating the metals and mitigating the impacts from seepage is illustrated by the metals concentrations at Well 719. Although this well has a pH similar to that reported for Well 613 (less than 3.0), the concentrations of metals are typically much lower. In fact, the metals concentrations are similar to concentrations in the other wells located downgradient in the seepage-impacted area and are either below the standards (arsenic, cadmium and molybdenum) or exhibit a decreasing trend (aluminum, beryllium, cobalt, nickel, and manganese). The decreasing concentration trend indicates that since the pumping wells were turned off the downgradient seepage migration is slowing and the natural system is beginning to become more effective in attenuating seepage impacts.

Some of the metals will continue to be present in elevated concentrations at more neutral pH as illustrated by Figures 3-16 (manganese) and 3-17 (cobalt and nickel). Figure 3-16 shows that manganese exceedances are much more widespread than are aluminum exceedances. This is because manganese is less easily attenuated than other metals and reductions in concentration depend on the availability of bicarbonate. At Well 717, where bicarbonate concentrations are over 500 mg/L, the manganese standard is not exceeded. The same condition existed at Well EPA 14 when the bicarbonate concentration was greater than 500 mg/L. However, since bicarbonate concentrations began decreasing manganese concentrations correspondingly increased to levels above the site standard. As in the Southwest Alluvium and Zone 1, manganese concentrations may never meet the site cleanup standards in Zone 3 if sufficient bicarbonate is not available to reduce the concentrations.

Figure 3-17 shows that cobalt and nickel have a pattern of exceedances similar to manganese. These two metals typically do not attenuate until the pH is about 6.5 or greater. With the exception of Well 717, the pH throughout the seepage-impacted area is less than 6.5. As a result, cobalt and nickel will remain stable at or near current concentrations until the pH increases further.

Some metals concentrations are also exceeded in the unimpacted wells. Exceedances of metal standards in the background water are particularly evident for arsenic and molybdenum. As shown on Figure 3-14, these two constituents have elevated concentrations in the unimpacted Wells EPA 1 and NBL-01 while very low to nondetect concentrations were reported for wells impacted by the acidic seepage, including Well 613. This pattern of exceedances is the reverse of what is expected for metals associated with the seepage and indicates that, for at least these two constituents, the primary source of detectable concentrations is the background water and not seepage.

A review of Figures 3-13 and 3-14 show that many of the other metals also exceed the site standards in at least one background well, typically EPA 1. For example, nickel and cobalt have been exceeding and continue to exceed their respective site standards in the background areas. Nickel concentrations in NBL-01 exceed the standard and both cobalt and nickel concentrations exceeded the standard at Well EPA 1. Therefore, although neutralization of the acidic seepage will continue to reduce metals concentrations, the natural site conditions may prevent them from being reduced to below the current site standards.

Radionuclides

Figure 3-18 presents the graphs of radionuclide concentrations over time for the four radionuclides that exceed the site standards. The figure shows that, like the metals, the radionuclides are typically present in elevated concentrations in wells such as 613, 517 and 719 that have acidic pH, and much lower concentrations are reported where the pH is more neutral. This reduction in the radionuclide concentrations is due to attenuation by neutralization and adsorption. In fact, except for the combined radium, the concentrations of the radionuclides exceed the site standards only in the vicinity of Wells 613 and 719, where the pH is less than 3.0.

Figure 3-19 shows the approximate extent of combined radium-226 and -228 exceeding the site standards as of October 2001. Radium is less easily attenuated than the other radionuclides and reductions in concentration are in part controlled by coprecipitation with gypsum. Also, combined radium concentrations have been and continue to be exceeded in the background water. For example, historic data from Wells 411, 420 and 504 B plus recent data from NBL-01 show that combined radium concentrations in the unimpacted areas have ranged from 5.0 picocuries per liter (pCi/L) to over 30 pCi/L. Therefore, although neutralization of the acidic seepage will continue to attenuate the radionuclides, the natural site conditions may prevent combined radium from being reduced to concentrations below the current site standards.

Zone 3 Natural System Performance Summary

The Zone 3 natural system is successfully attenuating the seepage impacts by neutralization and attenuation. Concentrations of metals and radionuclides decrease downgradient from the source area even where the pH is still acidic. This attenuation process is slow, particularly close to the source area, where the pH is acidic and constituent concentrations are much higher than those in areas further from the source. As indicated by the water quality at Well 613, neutralization of the source area could take a very long time. However, these higher constituent concentrations have been and will continue to be attenuated as the seepage migrates downgradient. The rate of downgradient migration is beginning to slow as the system continues to stabilize from the effects of the extraction pumping. As a result, seepage impacts are expected to stabilize within the property boundary in Section 36 near the area where the current extent of seepage impacts has been delineated. Continued monitoring at NBL-01 and the other wells will verify whether these expectations will be met.

4.0 ZONE 1

4.1 CORRECTIVE ACTION SUMMARY

Corrective action in Zone 1 has consisted of source remediation (neutralization of and later dewatering Borrow Pit No. 2) and pumping a series of extraction wells from 1984 through 1999. Figure 4-1 presents a summary of the pumping program for Zone 1 including the well systems pumped, the number of wells operating for each system and the combined annual pumping rates. The productivity of the formation was always limited as indicated by the maximum combined pumping rate of 14 gpm achieved by the 17 East and North Cross-dike Pump-back wells. The productivity declined steadily over time and by July 1999, when the system was decommissioned, the three remaining wells combined were producing at an average annual rate of 0.65 gpm. The three remaining Zone 1 corrective action system wells (615, 616 and 617) were decommissioned at the end of July 1999 in accordance with the letter from NRC dated July 30, 1999 (NRC, 1999).

4.2 MASS OF CHEMICAL CONSTITUENTS REMOVED

The mass of chemical constituents removed was calculated for the ten-year period from July 1989 through July 1999. These calculations were presented in the previous annual reviews and the final summary is presented in the 1999 Annual Review (Earth Tech, 1999).

4.3 PERFORMANCE MONITORING EVALUATION

The performance monitoring program in Zone 1 that is currently in effect is summarized in Table 4.1. As shown, this consists of quarterly monitoring of water levels in 17 wells and water quality in eight wells. This program has not been modified since it went into effect the second quarter of the 2000 operating year.

4.3.1 Water Level Evaluation

Water level data for Zone 1 is listed in Tables D.1 and D.2 in Appendix D. Water levels for the fourth quarter of 2001 are listed on the piezometric surface map for Zone 1 shown on Figure 4-2. As shown, the ground water in Zone 1 flows to the north-northeast approximately parallel with the projected eastern extent of Zone 1 saturation. The direction of flow has rotated from east to the north since the local source of recharge, Borrow Pit No. 2, was dewatered. The direction of flow is expected to rotate a little further to the north-northwest to more closely reflect the dip of the Zone 1 formation as the system continues to drain out.

The effect of recharge from the mine water in the alluvium and tailings water in the borrow pit on water levels in Zone 1 has dissipated and water levels are reaching an asymptotic level where changes in water level are very small. Figure 4-3 is a graph of Zone 1 water levels over time. As shown, in the past few years water levels in all parts of the formation have flattened because the hydraulic head (recharge from mine water in the alluvium and water in Borrow Pit No. 2) no longer exists. The system is now draining out, but this process is slow because, as documented by the performance of the extraction wells, the permeability of the formation is low.

4.3.2 Water Quality Evaluation

Groundwater in Zone 1 in the vicinity of the Church Rock tailings impoundment was created by mine water that was discharged to Pipeline Arroyo. This mine water percolated into the alluvium and then into the underlying Zone 1 formation and created a temporary saturation in the vicinity of the tailings impoundment. The temporary saturation created by the mine water discharge is the recognized background water for Zone 1 (EPA, 1988).

Zone 1 water was later impacted by acidic seepage from Borrow Pit No. 2, shown on Figure 4-1, which was located on the eastern side of the tailings impoundment. The acidic seepage contained elevated concentrations of metals, radionuclides, and major ions such as sulfate and chloride. Source remediation (neutralization of and later dewatering the borrow pit) plus neutralization of the seepage by natural attenuation and mixing with the background water has reduced concentrations of most of the constituents to below the cleanup standards established for the site. However, cleanup standards are still exceeded in parts of Zone 1, including off the Church Rock property in Section 1.

4.3.2.1 Current Extent of Seepage Impacts

Figure 4-4 shows the current extent of seepage impacts. The seepage impacts are delineated by chloride concentrations greater than 50 mg/L as was discussed in the Zone 1 Groundwater Geochemistry Report (Earth Tech, 2000c). As shown the seepage has migrated to the east-northeast in Section 1 but has not yet reached the downgradient wells EPA 2 and EPA 4 located near the northern Section 1 boundary. Migration of the seepage further east is limited by the extent of the Zone 1 saturation, which is marked by the dashed line on the figure.

Review of Table D.1 in Appendix D shows that constituent concentrations exceed the cleanup standard. However, all these constituents are attenuated relative to chloride so that only the following constituents exceed the site cleanup standards off the property in Section 1:

- Sulfate and TDS - at Wells EPA 4, EPA 5 and EPA 7
- Metals - at Wells EPA 4 (manganese), EPA 5 (cobalt and nickel) and EPA 7 (manganese and nickel).
- Radionuclides - combined radium-226 and -228 at Wells EPA 2, EPA 4 and EPA 5
- Chloroform - at Well EPA 7

Within the property boundary the same set of constituents exceeds the standards with the addition of chloride (Wells 515 A and 614) and aluminum (Well 604). None of the other metals or radionuclides is present in concentrations exceeding the site standards.

As expected, the extent of seepage impacts has not changed since the wells were turned off, and in fact the water quality has continued to improve. For example, the acidic pH plume (pH less than 4.0) shown on Figure 4-4 continues to contract as indicated by the increase in field pH at Well 604. The pH at this well has increased from 3.9 in 1989 to almost 5.0 in 2001. The natural attenuation processes (acid neutralization by the Zone 1 formation materials and mixing with the neutral background water) continue to successfully attenuate the acidic seepage, metals, and other constituents associated with the seepage. This process is enhanced by the low permeability of the formation, which slows water migration and allows sufficient time for the natural processes to complete the attenuation of constituents.

Although chloroform concentrations exceed the cleanup standards, it is not considered a constituent of concern for Zone 1. As shown in the table in Appendix D and on Figure 4-5, chloroform is detected in elevated concentrations within the property boundary but it has been detected in only one well (Well EPA 7) outside the property boundary. The primary occurrence of chloroform is within the acidic seepage either immediately adjacent to the borrow pit or at Well EPA 7 where a small portion of the acidic seepage migrated outward from the property boundary. The chloroform concentrations in Well EPA 7 are decreasing to near the site standard and are well below the EPA's MCL of 0.100 mg/L (100 micrograms per liter). Because chloroform has been detected outside the property boundary in only one well, the concentrations are very low, and the concentrations are decreasing, it is not considered a constituent of concern for the Zone 1.

4.3.2.2 Performance of the Natural System

The natural system is performing as predicted to attenuate the acidic seepage in Zone 1. Figure 4-6 is a copy of the slide from the March 2000 presentation showing the predicted performance of the Zone 1 natural system based on Earth Tech's understanding of the geochemical processes in the formation. As shown, sulfate and TDS concentrations are not expected to meet site standards because of gypsum equilibrium that will not allow sulfate concentrations to meet the water quality standards. Manganese may meet the standards if sufficient bicarbonate is available to allow for attenuation. The remaining metals and radionuclides are expected to meet the standards through attenuation by neutralization and adsorption.

Sulfate and TDS

Figure 4-7 is a graph of Zone 1 sulfate concentrations over time and Figure 4-8 shows the extent of sulfate exceeding the standard as of October 2001. Review of Figures 4-7 and 4-8 shows that sulfate concentrations exceed the standard in both the seepage-impacted and background water in Zone 1. Currently Well EPA 2 is the only location with sulfate concentrations below the standard but, as shown on Figure 4-7, this well had concentrations exceeding the standard prior to October 1993.

Sulfate concentrations in the individual wells have stayed within the same overall range over time with some increases and decreases within that range. This condition is evident regardless of whether the pumping wells were operating. Based on the current overall stable concentration trends and the results of the geochemical evaluation presented in the May 2000 report (Earth Tech, 2000c), sulfate concentrations are not expected to meet the cleanup standards within Section 1 or further downgradient in Section 36.

Manganese

Figure 4-9 is a graph of Zone 1 manganese concentrations over time and Figure 4-10 shows the extent of manganese exceeding the standard as of October 2001. Manganese concentrations exceed the site cleanup standard in both the seepage-impacted and background water. As shown on Figure 4-9, the higher concentrations in the background water are typically equal to or slightly greater than the current cleanup standard. In contrast, concentrations in the seepage-impacted water are much higher, especially in those wells that had acidic seepage. These concentrations have decreased over time as the acidic seepage has been neutralized but the magnitude of the decrease is in part controlled by concentrations of bicarbonate (Earth Tech, 2000c).

Figure 4-11 is a graph of bicarbonate over time. The seepage-impacted wells that have had high bicarbonate concentrations (greater than 1,000 mg/L), such as Wells 614, EPA 5, and Wells 516 A, have either never had exceedances of the manganese standard or exhibited a decrease in manganese concentrations to below the standard. Wells 515 A, 604 and EPA 7 still have manganese concentrations above the standard because, although neutralization has attenuated some of the manganese, bicarbonate concentrations are not yet sufficiently high to reduce the concentrations to below the standard. Recently EPA 7 bicarbonate concentrations have increased to over 500 mg/L and, as shown on Figure 4-9, the manganese exhibited a corresponding decrease in concentration.

Based on the recent data, manganese concentrations will continue to exceed the cleanup standard in both the background (Well EPA 4) and seepage-impacted (EPA 7) water in Section 1. However, if EPA 7 continues with its current trend of increasing bicarbonate, the manganese concentration could decrease to below the standard within the next few years. Exceedance of the manganese standard within the property boundary will continue unless sufficient bicarbonate is generated by the neutralization process to reduce the manganese concentrations.

Metals - Cobalt and Nickel

Besides manganese, the only metals that exceed the site standard outside the property boundary in Section 1 are cobalt and nickel. The remaining metals were attenuated within the property boundary, primarily by the neutralization processes. Figure 4-12 presents graphs of cobalt and nickel over time and Figure 4-13 shows the approximate extent of these the two constituents exceeding the standard as of October 2001. As shown, concentrations of nickel and cobalt exceeding the standard are limited primarily to the area within the property boundary where the acidic seepage has not been fully neutralized.

Cobalt and nickel are attenuated less easily than the other metals and typically do not adsorb fully until the pH is about 6.5 or greater. This is why they are the only metals, other than manganese, that are still present in concentrations exceeding the standard off the property in Section 1. Figure 4-14 is a graph of pH over time. Comparison of this graph to the graphs on Figure 4-12 shows that the wells with cobalt and nickel concentrations exceeding the standard also have pH values around 6.0 or below. This condition is evident for Wells 604, 515 A, 516 A (prior to 1995) and EPA 7. Currently the cobalt and nickel concentrations in Well EPA 7 are fluctuating around the standard as the pH in the water increases to above 6.0. Recently, concentrations of cobalt and nickel increased slightly above the standard in EPA 5, probably due to a slight decrease in the pH. Over time, as the neutralization process continues, nickel and cobalt will be adsorbed and attenuated to concentrations below the standards.

Combined Radium-226 and -228

Figure 4-15 is a graph of combined radium over time and Figure 4-16 shows the approximate extent of combined radium exceeding the standard as of October 2001. Similar to the metals, the combined radium is attenuated by neutralization and adsorption. As a result, the primary exceedances of the standard are reported within the property boundary in the area where the pH is more acidic. Radium is attenuated at lower pH than cobalt and nickel, as evident from the only slightly elevated concentrations reported for Wells 604 and 515 A. Figure 4-15 also shows that the combined radium standard has been exceeded in all three background wells (EPA 2, EPA 4, and EPA 8), indicating that it is naturally elevated in the Zone 1 water. The combined radium concentrations are expected to decrease to at least background levels and possibly below the standard as the neutralization process continues.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This annual review evaluated the performance of the Zone 3 and Zone 1 natural systems without the influence of active remediation. An evaluation of the Southwest Alluvium was not included because this information is available in the quarterly reports that are submitted as part of the Natural Attenuation Test that is currently in progress. The conclusions and recommendations of this evaluation are provided below.

5.1 CONCLUSIONS

The results of the evaluation indicate that both the Zone 3 and Zone 1 natural systems are at least as effective as, if not more effective than, the active remediation systems in attenuating the seepage-impacted water. Acidic seepage is being neutralized, resulting in attenuation of metals and radionuclides. Geochemical conditions related to gypsum equilibrium and bicarbonate availability will limit the reduction of sulfate and manganese concentrations in both formations regardless of whether or not the extraction wells are operated.

Zone 3 is still recovering from the effects of downgradient pumping as indicated by the continued decrease in bicarbonate concentrations and increase in metals concentrations at Well EPA 14 plus the migration of acidic seepage further downgradient to Well 719. However, the downgradient migration is beginning to stabilize and, as a result, the natural geochemical processes will have more time to complete the attenuation process. The metals and radionuclide concentrations are expected to be attenuated to background levels or the site standards within the property boundary.

5.2 RECOMMENDATIONS

Based on the results of the annual performance evaluation, the following recommendations are made for Zone 1 and Zone 3:

Zone 1

Proceed to closure of the Zone 1 remedial action system using a combination of:

- **Monitored Natural Attenuation (MNA)** – for metals and radionuclides
- **Technical Impracticability (TI) Waiver** – for sulfate, TDS, and manganese
- **Institutional Controls** – for support MNA and TI

Zone 3

Continue remediation using the natural system and allow time for the natural system to stabilize the seepage impacts. The geochemical mechanisms in Zone 3 are similar to those in Zone 1 and, given more time and no disruption from active remediation, are expected to successfully attenuate constituent concentrations within the property boundary. The revised monitoring program requested by the NRC and implemented in 2001 will be a useful tool for evaluating the stability of the seepage impacts and the performance of the natural system in attenuating constituents. United Nuclear anticipates that, by this time next year, there will be sufficient data to demonstrate the stability of the seepage plume and the effectiveness of the natural system to attenuate constituent concentrations to background concentrations.

Assuming that the Zone 3 system does perform similarly to Zone 1, the next step will be to proceed with closure of the Zone 3 remedial action system using a combination of:

- **MNA or Alternate Concentration Limits (ACL)** – for metals and radionuclides
- **TI Waiver** – for sulfate, TDS and manganese

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TABLES

TABLE 2.1

SUMMARY OF OPERATIONAL DATA
SOUTHWEST ALLUVIUM EXTRACTION WELLS

Well No.	Annual Average Pumping Rate (gpm)												
	1990 (1)	1991 (2)	1992 (3)	1993 (4)	1994 (5)	1995 (6)	1996 (7)	1997 (8)	1998 (9)	1999 (10)	2000(11)	2001(12)	1990-2001
801(13)	1.2	0.5	0.4	0.2	0.2	0.1	0.1	0.1	0.08	0.08	0.00	0.00	0.25
802	11.1	12.5	11.9	9.0	9.8	9.7	9.1	10.1	11.02	9.62	9.31	5.80	9.91
803	2.0	2.6	2.5	3.0	3.2	3.5	3.1	2.9	3.84	3.56	3.83	3.68	3.14
808 (14)		10.0	15.5	19.9	15.6	12.3	12.2	7.2	4.34	3.50	2.50	3.35	9.67
Total Pumping Rate	14.3	25.6	30.3	32.1	28.8	25.6	24.5	20.3	19.29	16.76	15.64	11.94	22.98
Volume Pumped (millions of gallons) (15)	7.4	12.4	17.2	18.1	15.7	12.9	12.2	9.2	9.0	7.5	7.7	1.7	131.0

Notes:
1. Average pumping rate calculated for the period between October 13, 1989 and October 12, 1990.
2. Average pumping rate calculated for the period between October 13, 1990 and October 11, 1991, except Well 808, which calculated for the period between June 26, 1991 (i.e., well startup) and October 11, 1991.
3. Average pumping rate calculated for the period between October 12, 1991 and October 8, 1992.
4. Average pumping rate calculated for the period between October 9, 1992 and October 8, 1993.
5. Average pumping rate calculated for the period between October 9, 1993 and October 14, 1994.
6. Average pumping rate calculated for the period between October 15, 1994 and September 29, 1995.
7. Average pumping rate calculated for the period between September 30, 1995 and September 27, 1996.
8. Average pumping rate calculated for the period between September 28, 1996 and September 26, 1997.
9. Average pumping rate calculated for the period between September 27, 1997 and September 25, 1998.
10. Average pumping rate calculated for the period between October 02, 1998 and September 27, 1999.
11. Average pumping rate calculated for the period between September 28, 1999 and September 29, 2000.
12. Average pumping rate calculated for the period between September 30, 2000 and January 12, 2001.
13. Well 801 decommissioned at the end of July 1999.
14. Well 808 began operation on June 26, 1991.
15. Data obtained from system flowmeter.

gpm = gallons per minute

TABLE 3.1
CHANGE IN ZONE 3 SATURATED THICKNESS OVER TIME
CHURCH ROCK SITE

Well Number[1]	Saturated Thickness		Change (feet)	Change (percentage)
	3rd Quarter 1989	4th Quarter 2001		
402	--	33.10	--	--
411	62.5	--	--	--
420	56.3	22.78	-33.5	-60%
424	--	34.97	--	--
446	--	11.81	--	--
501 B	20.2	0.00	-20.2	-100%
502 B[2]	48.5	20.00	-28.5	-59%
504 B	40.1	13.87	-26.3	-65%
517	42.7	14.43	-28.2	-66%
518[2]	37.2	17.38	-19.8	-53%
608[3]	--	21.03	--	--
613[4]	67.2	21.12	-46.1	-69%
EPA 01	14.7	0.00	-14.7	-100%
EPA 03	8.3	0.00	-8.3	-100%
EPA 09	8.1	4.79	-3.3	-41%
EPA 11	30.8	--	--	--
EPA 12	10.7	0.00	-10.7	-100%
EPA 13	24.8	11.33	-13.5	-54%
EPA 14	76.3	40.74	-35.6	-47%
EPA 15	60.8	0.00	-60.8	-100%
EPA 17	1.4	0.00	-1.4	-100%
EPA 18	2.5	0.00	-2.5	-100%
701	46.1	18.71	-27.4	-59%
702	24.1	10.81	-13.3	-55%
703[2]	32.6	20.80	-11.8	-36%
705	--	--	--	--
706	--	20.66	--	--
707	58.8	23.84	-35.0	-59%
708	49.8	20.87	--	--
709	56.1	--	--	--
710	45.5	17.97	-27.5	-61%
711	43.7	21.65	-22.1	-50%
712	39.1	12.48	-26.6	-68%
713	34.2	12.77	-21.4	-63%
714[5]	50.1	23.67	-26.4	-53%
715[2,5]	47.6	19.56	-28.0	-59%
716[5]	58.3	--	--	--
717[5]	57.6	33.14	-24.5	--
718[5]	51.1	--	--	--
719[5]	39.9	20.30	-19.6	-49%
720[5]	33.1	--	--	--
NBL-01[5]	--	31.50	--	--
Average	39.5	16.5	-22.7	-68%

Notes:

[1] Wells 9D and 106 D were not included because they appear to be completed above the bottom of Zone 3. Measurements of saturated thickness in these wells may be less than actual conditions. Well 126 was not included because it was completed above the bottom of Zone 3. Measurements of saturated thickness in this well are less than actual conditions. Wells 600, 610 and 672 were not included because they were used solely as pumping wells, therefore no water level data are available.

[2] Last water level for Wells 502 B, 518, 703, and 715 measured in January 2000.

[3] Well 608 was pumping in 1989, no water level available. Last water level measured in January 2000.

[4] Water level for Well 613 measured in 1983 before pumping started. Water level data for 1989 are not available because the well was pumping.

[5] Water levels for the Stage II wells were measured June 1991 when well installed. Not included in 1989 average saturated thickness calculation.

[6] Well NBL-01 installed in July 2001, first water level measured August 2001.

Shading indicates saturated thickness greater than 25 feet.

"--" indicates that no data is available.

TABLE 3.2

ZONE 3 PERFORMANCE MONITORING PROGRAM
2001 OPERATING YEAR
CHURCH ROCK SITE

Well	Water Level	Water Quality	NRC POC	Purpose
Continue Monitoring				
420	X	X		Postmining-pretailings background, track plume.
711	X	X		Track saturation and plume, replace 502B based on results of low flow purge testing performed in January 2000.
504 B	X	X		Track saturation and plume, extensive data set.
517	X	X	Y	Track plume, extensive data set.
EPA 9	X			Extent of saturation, water quality not necessary.
EPA 13	X	X		Extent of saturation. Water quality added 2nd quarter 2001.
EPA 14	X	X		Postmining-pretailings background, track plume.
702	X			Water level only, track saturation.
710	X			Water level only.
712	X			Water level only.
713	X			Water level only.
714	X			Water level only.
613	X	X		Extensive data set, track saturation and source.
701	X			Water level only (decommissioned pumper).
706	X			Water level only (decommissioned pumper).
707	X			Water level only (decommissioned pumper).
708	X	X		Added to program 2nd quarter 2001.
717	X	X		Water level. Water quality added 2nd quarter 2001.
719	X	X		Water level. Water quality added 2nd quarter 2001.
Additional Wells, Not Included In Original Performance Monitoring Program				
402	X			Long-term water level for migration path.
424	X			Long-term water level for migration path.
446	X			Long-term water level for migration path.
NBL-01	X	X		Well drilled and installed June 2001. Water level and water quality to track downgradient extent of seepage.
Total	23	11		
Eliminated From Monitoring				**Reason For Elimination**
9 D				Dry
106 D				Dry
411				Oil, cannot get water level or sample.
501 B			Y	Dry
EPA 1				Dry
EPA 3			Y	Dry
EPA 11				Unuseable since 1990 - water level below pump, pump cemented in well.
EPA 12				Dry
EPA 15				Dry
EPA 17				Dry
EPA 18				Dry
126				Dry
502 B				Failed low-flow test, use 711
518			Y	Failed low-flow test, use 517
608				Not needed (formerly water level only)
703				Not needed (formerly water level only)
715				Not needed (formerly water level only)
709				Not needed (decommissioned pumper)
716				Not needed (pumper)
718				Not needed (pumper)
720				Not needed (decommissioned pumper)

Note:
Shading indicates changes to the revised monitoring program implemented in 2nd quarter 2001 at the NRC's request.

TABLE 4.1

ZONE 1 PERFORMANCE MONITORING PROGRAM
2001 OPERATING YEAR
CHURCH ROCK SITE

Well[1]	Water Level[2]	Water Quality[2]	NRC POC	Purpose
Continue Monitoring				
515A	X	X		Track transition area
604	X	X	Y	Track center of seepage
614	X	X	Y	Track transition area
EPA 2	X	X		Postmining-pretailings background water quality
EPA 4	X	X	Y	Postmining-pretailings background water quality
EPA 5	X	X		Track transition area
EPA 7	X	X	Y	Track transition area, edge of saturation
EPA 8	X			Track edge of saturation
142	X	X		Premining background
143	X			Water level only, use 142
Additional Wells, Not Included In Original Performance Monitoring Program				
505A	X			Long-term water level for migration path
502A	X			Long-term water level for migration path
501A	X			Long-term water level for migration path
504A	X			Long-term water level for migration path
412	X			Long-term water level for migration path
Total	17	8		
Eliminated From Monitoring				**Reason For Elimination**
141				No longer useable, plugged during arroyo flooding
516A			Y	Failed low-flow testing
619				Anomalous water quality and water level
615				Decommissioned pumper, not needed - use 515 A
616				Decommissioned pumper, not needed - use 604
617				Decommissioned pumper, not needed

Notes:

[1] No wells within the tailings reclamation cap were included.

[2] Water level and water quality monitored on a quarterly basis.