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Mr. Keith I. McConnell, Deputy Director
Decommissioning and Uranium Recovery Licensing Directorate
Division of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management Programs
U.S. Nuclear Regulatory Commission
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Mr. Mark D. Purcell
Remedial Project Manager
Superfund Division
U.S. Environmental Protection Agency, Region 6
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Re: Executive Summary
2010 Groundwater Corrective Action Annual Review Report
Materials License No. SUA-1475
United Nuclear Corporation's Church Rock Tailings Site, Gallup, New Mexico

Dear Messrs. McConnell and Purcell:

On behalf of United Nuclear Corporation (UNC), Chester Engineers has prepared this annual performance review of the groundwater corrective action at UNC's Church Rock Mill and Tailings Site near Gallup, New Mexico, pursuant to License Condition 30C. This report is for the 2010 operating year and represents the period from October 2008 through October 2009. This cover letter serves as an Executive Summary of the report.

This report focuses on both active remediation and the groundwater performance of the natural geochemical systems without active remediation. As indicated in the U.S. Environmental Protection Agency's (EPA's) *First Five-Year Review Report* (EPA, 1998) and by the approvals to decommission or temporarily shut off the former pumping systems, the agencies recognized that those corrective action pumping systems had reached the limit of their effectiveness. EPA (1988b) recommended that Technical Impracticability (TI) Waivers, Alternate Concentration Limits (ACLs), and Monitored Natural Attenuation (MNA) be used to complete the corrective action program. Those Record of Decision (ROD) recommendations continue to be timely.

During 2010, part of Zone 3 underwent continued extraction well pumping that started during the hydrofracture program in 2005 and which was most recently supplemented, in 2009, with extraction started in the NW-series wells located along the northernmost area of impact. During 2010, injection testing of two wells in the northern part of Zone 3 in Section 36 has supported a new remedial enhancement program that will start with pilot testing of a new injection well beginning in January 2011. The conclusions and recommendations of this annual report are provided below.

Conclusions

An unexpectedly large number of detections and exceedances of lead-210 (Pb-210) occurred in the laboratory analytical results for the samples collected in October 2010. These detections span the entire ~ 8,000-ft length of the Site and all three hydrostratigraphic units. There is no physical or chemical reason that can explain these sudden, synchronous detections. UNC is presently in discussion with the laboratory to determine what, if any, analytical issues might explain the sudden increase in detections.

The current Site standard for Pb-210 is 1 pCi/L (NRC Source Materials License), which was the idealized lower limit of detection 30 years ago (see NRC, 1980). The developing Site-Wide Supplemental Feasibility Study (SWSFS) will address this issue in more detail, including the relevance of Pb-210 statistics associated with the background water quality. Background water Pb-210 concentrations define the following ranges: 1 to 14 pCi/L (Southwest Alluvium); 1 to 11 pCi/L (Zone 3); and 1 to 9 pCi/L (Zone 1).

- *Excluding the unexpected detections of Pb-210, there are no exceedances of hazardous constituents outside the UNC property within seepage-impacted groundwater – this is the case for all three hydrostratigraphic units.*
- *If NRC approves UNC's Zone 1 ACL application, then groundwater quality will be in full compliance with the NRC groundwater protection standards in Zone 1 (leaving aside for now the unexpected Pb-210 detections).*
- *Excluding the unexpected detections of Pb-210 and the first-time occurrence of a uranium exceedance in POC Well 509 D, which all occurred during October 2010, groundwater quality is in full compliance with the NRC groundwater protection standards in the Southwest Alluvium.*
- Groundwater levels in the Southwest Alluvium continued to decline in 2010, indicating that the artificially recharged zone of saturation continues to become naturally dewatered as the groundwater drains down the arroyo. However, groundwater to the north of the Nickpoint apparently has become ponded and is no longer flowing to the southwest.

- Hydraulic containment is not a necessary feature of the corrective action program in the Southwest Alluvium because of the geochemical attenuation that occurs naturally. Furthermore, prior pumping of extraction wells did not contain the constituents and would not do so in the future.
- Mapping of bicarbonate isoconcentration contours is the most meaningful method of delineating seepage-impacted water in the Southwest Alluvium.
- Evaluation and prediction of constituent concentrations in the Southwest Alluvium is predicated on understanding the geochemical evolution of both the background water quality and later changes associated with passage of the seepage-impact front. Hazardous constituents derived from seepage impact are effectively attenuated to acceptable concentrations within the Site boundary.
- Sulfate, TDS, and manganese are non-hazardous constituents that exceed standards outside the Site boundary in both seepage-impacted and background wells. Sulfate (the primary component of TDS) tends to temporarily fall below the standard in the migrating reaction zone associated with the front and northwestern flank of the migrating seepage-impacted groundwater in the Southwest Alluvium. Ahead of this migrating front, background concentrations for sulfate and TDS tend to exceed the standards but this water quality is unrelated to seepage impact and application of the Site standards is inappropriate. Behind this migrating front, impacted groundwater quality offsite will tend to have sulfate and TDS levels approximately equal to, or lower than, those in the background water due to equilibration with the mineral gypsum. Ahead of the current seepage-impact front, downgradient background well SBL 1 has shown very high sulfate and TDS and minor exceedances of manganese, cobalt, and nickel that are not due to seepage impact. Similarly, background waters in the other two hydrostratigraphic units also have shown exceedances of Site standards. For example, in Zone 3, Well NBL 1 has shown background exceedances of arsenic, cobalt, molybdenum, nickel, and combined radium. In Zone 1, Well EPA 4 has shown background exceedances of sulfate, manganese, combined radium, and Pb-210 (see Appendices A, B, and C).
- The upward trend in TDS at Well GW 2 can be explained by either declining saturation levels and/or continued dissolution of alluvium mineral salts. Heterogeneous distribution of the soluble alluvium minerals very likely affects the inter-well variations in concentrations of common dissolved ions.
- Concentrations of uranium in the Southwest Alluvium are an indicator that natural attenuation is at least as effective a remedy as pumping. With the exceptions of POC Wells GW 3 and 509 D, and non-POC Well EPA 25, uranium concentrations and concentration time trends have either stabilized (e.g., Wells GW 1 and GW 2) or shown decreasing trends (e.g., Well 802) since the pumps were turned off. The gradual

increasing trend of concentrations at GW 3 post-dates, for the most part, the shutoff. However, this does not necessarily indicate a causal relationship. For example, nearby Southwest Alluvium Wells GW 1 and GW 2 have exhibited different concentration changes over the same time-frame. It is not clear what physical or chemical mechanism stemming from the shutoff could account for changes so heterogeneous in degree and timing over a relatively small downgradient area. Many Southwest Alluvium wells have shown that variously gradual to steep uptrends and downtrends in uranium are typical, whether they occur during pumping or in the absence of pumping. For example, since October 2008, Well 509 D has shown a sharp increase in uranium and it exceeded the Site standard of 0.3 mg/L for the first time in October 2010.

- Uranium concentrations in the Southwest Alluvium are not related to the migration of uranium in tailings fluids. In fact, tailings solutions are far more depleted in uranium than are background solutions. This is an important consideration for the SWSFS because it means the uranium in tailings-impacted water is not degrading the water quality. The range of uranium concentrations in the background water has been empirically shown to be the same as the range within impacted water (GE, 2006). Uranium and bicarbonate concentrations are usually covariant in the Southwest Alluvium groundwater, i.e., when the concentration of the bicarbonate parameter changes, uranium changes with it provided that there is uranium available for dissolution or desorption in the sediments. This observation has held for both the 11 years of active pumping and the 9.7 years of post-pumping monitoring, and is theoretically expected based on principles of aqueous chemistry.
- At downgradient Well 624 the increase in bicarbonate to a chart plateau starting in May 2000 is attributed to the migration of the bicarbonate "front" associated with tailings seepage-impact. However, this well shows no covariance between the bicarbonate and uranium concentrations. At least two interpretations are possible: (1) at this well location there is little to no adsorbed or precipitated uranium (i.e., solid phase) within the alluvial sediments; and (2) aqueous uranium that originated from upgradient tailings seepage impact has been strongly attenuated during transport and it has not reached this location.
- Both the Southwest Alluvium and Zone 1 natural systems are at least as effective as the former active remediation systems in attenuating the seepage-impacted water. Acidic seepage is being neutralized, resulting in attenuation of metals and radionuclides. Natural geochemical conditions related to gypsum equilibrium and bicarbonate availability will control sulfate and manganese concentrations in both hydrostratigraphic units, regardless of whether or not the extraction wells are operated.

- Groundwater levels in Zone 3 continued to decline in 2010, indicating that the artificially recharged zone of saturation continues to diminish as the groundwater drains down the dip of the bedrock layers. Pumping of extraction wells since 2005 has locally accelerated the rate of water level decline in Zone 3.
- Groundwater quality along the northern tracking wells in Zone 3 has been oscillating between degrading and improving trends over the last eight years. Individual well water-quality trends of improvement and degradation have become collectively asynchronous since May 2007, which approximately coincides with an increase in the size and rapidity of water-quality oscillations. The variations in water quality indicate that there have been local and variable degrees of mixing of impacted water with background water drawn in from the west. This is interpreted to have been a consequence of the designed actions of extraction wells upgradient and, since February 2009, downgradient of the northern tracking wells.
- UNC installed five new extraction wells (the NW-series) north of Well NBL 1 during September 2008. Pumping of three of these wells began in February 2009, and the pumping regime was re-optimized during early November 2009. This remedy enhancement in Zone 3 is meant to intercept and extract impacted groundwater.
- Full seepage impact has occurred at Well PB 4 since November 2008 (based on bicarbonate concentrations < 50 mg/L) or January 2009 (based on pH < 5.0). To the north of this well, there is no unequivocal basis for picking a single location representing the leading edge of moderate seepage impact. Pumping in the northernmost part of Zone 3 has created a mixing zone of background and impacted water, which makes a single-line plume boundary depiction in this area inappropriate. However, based on specific (though oscillating) water quality trends, the northernmost edge of full impact is diagrammatically located along Well NBL 1 – bicarbonate and pH measurements just to the north, in the NW-series of wells, suggest that fully impacted water has not advanced beyond NBL 1.
- During October and November 2009, Zone 3 northern background Well NBL 2 was injection tested to determine the amount of water that non-impacted areas might accept. The results of this testing were reported in Chester Engineers (2009d), which included a proposal to install a new array of injection wells (with alkalinity-amended injection water) between the NW-series wells and the northern property boundary. In July 2010, injection testing was done in a new well, IW A, in the area of the NW-series wells. The results support the proposal (in the Remedial Design Report (RDR), Chester Engineers, 2010c) to conduct pilot testing of IW A, which will probably start in January 2011. If this pilot testing is successful, then the RDR recommends the addition of one or two additional injection wells in this area.

- The degree of seepage impact in Zone 1 is diminishing. Groundwater elevations in Zone 1 continued to decline in 2010, causing the saturated thickness that accommodates groundwater flow and constituent migration to diminish in the updip parts of this bedrock stratigraphic unit.
- Outside the UNC property boundary in Zone 1, the post-pumping groundwater quality continues to improve overall (Tables 17 and 18). The exceedances of sulfate and TDS in Wells EPA 5 and EPA 7 reflect geochemical equilibrium of the groundwater with gypsum; these constituents are non-hazardous.
- In Zone 1, the continuing improvement in offsite water quality, combined with the stability of onsite concentrations, leads to the conclusion that the Zone 1 groundwater corrective action program has achieved success. However, closure will require meeting the Site standards, which will require that ACLs be established for POC Wells 604 (aluminum, manganese, and nickel) and 614 (TTHMs and chloride). UNC has submitted an ACL application to NRC requesting revised groundwater protection standards for nickel in Well 604 and TTHMs in Well 614 (NRC's License does not have standards for aluminum, manganese, or chloride).
- The screened and assembled remedial alternatives for the Site have been presented in the Revised SWSFS Part II (Chester Engineers, 2009b). EPA provided comments on this document in September 2010 (EPA, 2010), which also included comments from NRC and NMED. UNC is presently working on further revisions to SWSFS Parts I and II, to be submitted to EPA for review prior to development of Part III. At the request of EPA, UNC is presently developing a new baseline risk assessment for the Site. The provisional proposed Site remedy has been presented for the operable unit (Chester Engineers, 2009b), while incorporating key factors for each of the three hydrostratigraphic units.

Recommendations

UNC and NRC should discuss the implications and relevance of the NRC's Site standard for Pb-210 of 1 pCi/L, in the context of recent laboratory analytical and reporting protocol changes that appear to correlate with the unusually frequent detections and exceedances during October 2010. The laboratory's Pb-210 case narratives recommend that UNC and the relevant regulatory agencies discuss the analytical results and compliance issues.

UNC has previously requested deletion of Pb-210 from the Site standards, which NRC denied (Earth Tech, 2001b and 2001c; NRC, 2001). An additional 10 years of chemical analytical data have accrued, and the recent laboratory protocols and results indicate that it is time to revisit issues regarding Pb-210 including (1) sample-specific minimum detectable concentrations and analytical results, and (2) implications of Site background water quality statistics. Relevant background information is found in NRC (1980), U.S. Geological Survey (2008), and N.A. Water Systems (2008d).

Recommendations for Closure of Southwest Alluvium Remedial Action

The predicted performance of the Southwest Alluvium natural attenuation system is summarized on Table 6. The continuing assessment of natural attenuation in this annual report is the basis for the following recommendations for the Southwest Alluvium corrective action system:

1. Decommission the pumping wells. Attenuation via natural geochemical processes has been shown to be at least as effective as pumping. Implement a No Further Action remedial alternative.

2. Change performance monitoring from quarterly to an annual basis because the seepage-impacted water quality is largely stable, the offsite impacted water quality is not hazardous, and a yearly frequency is sufficient for tracking the migration of the seepage-impact front (estimated to be moving southwestward toward Well SBL 1 at an average rate of 21 ft per year).

3. EPA should consider adopting the revised NRC standards (NRC, 2006b) for chloroform (revised to a total trihalomethanes (TTHMs) Site-wide standard of 80 μg/L) and combined radium (revised to 5.2 pCi/L standard for the Southwest Alluvium). EPA should also consider (a) revising their current ROD uranium standard of 5 mg/L and adopting the NRC Site-wide standard of 0.3 mg/L (based on the review of dissolved uranium occurrences in the Southwest Alluvium presented by UNC (GE, 2006)), and (b) adopting the NRC's (1996) proposed standards for sulfate, TDS, and nitrate (throughout all three Site hydrostratigraphic units). Sulfate, TDS and manganese should be waived as constituents of concern based on NRC's (1996) background water quality analysis report and multiple reports by UNC (many of which are summarized in the SWSFS Part I; N.A. Water Systems, 2007b).

4. Excepting the unexpected detections of Pb-210 in the samples from October 2010, and the first-time occurrence of a uranium exceedance in Well 509 D, the Southwest Alluvium is in full compliance with the NRC groundwater protection standards. EPA's longstanding reluctance to issue a TI Waiver for sulfate and TDS is confusing because there are no known groundwater analyses anywhere in the Southwest Alluvium, seepage-impacted or not, that meet the New Mexico Standards for sulfate and TDS. In lieu of eliminating sulfate and TDS concentrations as ARARs, a TI Waiver for sulfate and TDS could best be applied in a non-traditional sense in that there would not be a classic TI zone. Instead, UNC proposes that the projected 200-year seepage front (as extrapolated during 2004) be used, which we understand to be compatible with NRC guidance. Background water quality has shown modest exceedances of manganese, cobalt, and

nickel; it is appropriate that the EPA consider revising the ROD to recognize the historic background water quality for these constituents in the Southwest Alluvium. We now have available statistically derived background concentrations for all constituents (data permitting) in all three hydrostratigraphic zones (N.A. Water Systems, 2008f).

5. As first put forth by the NRC (1996), and further developed in several geochemistry (Earth Tech, 2000d and 2002c) and annual reports (Earth Tech, 2002d; N.A. Water Systems, 2004, 2005b, 2007a), there is quite simply no method to achieve the standards for sulfate, TDS and manganese – short of dewatering the alluvium. The last drop of water left in the alluvium would exceed the standards for these parameters. UNC once again requests approval of a TI Waiver for sulfate and TDS to the extrapolated, downgradient impact zone in the year 2204 shown in Figure 58. The ongoing development of a SWSFS will formally evaluate and prioritize the most appropriate remedial course of action; however, many of the actions required to meet closure are administrative and have been the subject of longstanding discussions.

Recommendations for Zone 3 Remedial Action

Continue Zone 3 remediation using the natural system to stabilize the seepage impacts, in conjunction with the current pumping system that provides capture of some of the downgradient migration of seepage-impacted water, and dewaters the hydrostratigraphic unit.

UNC has recently proposed (Chester Engineers, 2009d; 2010c) the installation of an array of injection wells in northern Zone 3 between the NW-series wells and the northern property boundary. Alkalinity-amended injection water will serve two key purposes: to neutralize impacted groundwater, and to provide a hydraulic barrier to the northward advance of the impacted water. Some of the alkalinity-amended water will flow to the south toward extraction by the NW-series of wells, while some of the alkalinity-amended water will flow to the north onto Navajo land. The proposed injection array will lead to a new configuration of a mixing zone of impacted, background, and non-impacted, amended waters along the NW-series wells. Pilot testing of new injection Well IW A will probably begin in January 2011.

The proposed plan intends to neutralize and geochemically stabilize the impacted water; continue to extract impacted water flowing from the south; and to impede northward advance of the impacted water. The effective life-span of the NW-series of wells is hard to predict, although experience suggests that well fouling from multiple causes will limit the spans to several years. The life-span of the new injection wells is uncertain because such wells have no historic counterparts at the site to serve as examples; however, one should assume that fouling will eventually become an issue.

Declining yields from the current extraction-well array indicate that hydraulic control is temporary. This has always been the case for pumping in Zone 3. Zone 3 saturated thicknesses are quite low (especially considering well losses), and any future pumping to reduce the pressure head will obtain only limited short-term results. Because the bedrock slope drives groundwater flow to the north, there is an irreducible elevation head that cannot be decreased by pumping. Counteracting this force is the reduction of effective porosity by the seepage-induced chemical alteration of feldspar to clay. This reduces the bedrock permeability, which retards the migration of the seepage. Eventually, there will be a balance developed between the irreducible elevation head and the trapping of the seepage-impacted groundwater due to the diminished bedrock permeability. Although the timing and location of such a balance cannot be predicted, such a development is likely. UNC recommends that consideration be given to other regulatory tools to manage the inherent physical limitations to the Zone 3 bedrock-groundwater system. As with Zone 1 and the Southwest Alluvium, the tools might include: ACLs, TI Waivers, MNA, and ICs.

EPA should consider revision of the ROD background concentrations for the following metals in Zone 3: arsenic, molybdenum, nickel, cobalt and manganese. Uranium should also be addressed and UNC recommends that EPA adopt the NRC standard for uranium.

Sulfate, TDS and manganese should be waived as constituents of concern based on NRC's (1966) background water quality analysis report.

Recommendations for Closure of Zone 1 Remedial Action

The predicted performance of the Zone 1 natural attenuation system is summarized on Table 18. Implement the following recommendations toward closure of the Zone 1 corrective action system:

1. EPA should consider adopting the current NRC Site-wide groundwater protection standard of 80 μg/L for TTHMs (this group of compounds includes chloroform). This value is the current MCL.
2. EPA should consider adopting the current NRC standard of 9.4 pCi/L for combined radium in Zone 1. This value is based on background water quality statistical analysis that was done for NRC in 2006 (N.A. Water Systems, 2006a), as part of an approved License amendment.
3. The Zone 1 seepage-impacted area has attained ALARA goals. Toward completing the corrective action program for Zone 1, UNC has submitted to NRC an ACL application for nickel in POC Well 604 and TTHMs in POC Well 614.
4. As first put forth by the NRC (1996), and further developed in several geochemistry (Earth Tech, 2000c) and annual reports (Earth Tech, 2000e; N.A. Water Systems, 2004, 2005b, 2007a), there is no method to achieve the standards for sulfate and TDS, and Zone 1 has already been dewatered to the extent that is feasible (the final pumping wells were

decommissioned in 1999 because their yields were less than the decommissioning limit). It is not appropriate to tie remediation progress to sulfate or TDS concentrations. Even the last drop of water left in Sections 1 and 2 of Zone 1 would exceed the standards for these parameters. The EPA should approve a TI Waiver for sulfate and TDS in the TI zone shown in Figure 58. Remedial alternatives to be presented in the final, complete SWSFS should be closely coordinated with the necessary TI Waiver(s), ACL applications, ICs, and potentially appropriate changes in Site remediation standards (EPA, 2008b).

Please contact Mr. Roy Blickwedel (General Electric Corporation) at (610) 992-7935 if you have any questions or need additional information.

Sincerely,

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MDJ: 10-6209-SC-103

Enclosures (2 hard and 2 pdf copies for each addressee)

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