Technical Evaluation Report

For the United Nuclear Corporation, Church Rock Uranium Mill, Church Rock, New Mexico: Review of the Application to Amend License Condition 30.B. of Source Material License SUA-1475

Final Report

The U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety
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Enclosure

Technical Evaluation Report
Review of the Application to Amend License Condition 30.B. of Source Material License SUA-1475
United Nuclear Corporation, Church Rock Uranium Mill, McKinley County, New Mexico

DATE:	**March 2015**
DOCKET NO.:	**40-8907**
LICENSE NO. :	**SUA-1475**
LICENSEE:	**United Nuclear Corporation (UNC)**
FACILITY:	**Church Rock Uranium Mill**
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1.0 Summary and Conclusions

By letter dated April 17, 2012, the United Nuclear Corporation (UNC) a subsidiary of General Electric, submitted to the U.S. Nuclear Regulatory Commission (NRC) an application to amend Source Material License SUA-1475 for the former uranium Church Rock Mill site (UNC, 2012a). Specifically, UNC requests to amend License Condition 30.B to establish revised groundwater protection standards in three hydro-stratigraphic units for the following constituents:

- Cadmium, lead, lead-210, nickel, radium-226 and 228, selenium, and thorium-230 within the Southwest Alluvium;
- Lead-210, nickel, radium-226 and 228, thorium-230, and uranium within Zone-1; and,
- Arsenic, cadmium, gross alpha, lead, lead-210, nickel, radium-226 and 228, thorium-230, and uranium within Zone-3.

UNC supplemented its request on November 16, 2012, by submitting a three-dimensional groundwater flow model for the Mill Site and adjacent downgradient areas (UNC, 2012b; Chester Engineering, 2012a, 2012b). On January 10, 2013, the NRC accepted the amendment request for formal review (NRC, 2013a). The NRC issued a Request for Additional Information (RAI) on June 4, 2013 (NRC, 2013b), and UNC provided responses on January 10, 2014, (Chester Engineers, 2014a). The NRC also received a letter from the U.S. Environmental Protection Agency (EPA) dated, April 14, 2014 (EPA, 2014), which states in part, "…it is EPA opinion that the proposed clean-up levels for contaminants of potential concern using the statistically-based 95th percentile upper prediction limits (UPL95) for background water samples in the individual units are reasonable and should be adopted…"

The NRC's review of UNC's amendment request was conducted in accordance with Title 10 of the *Code of Federal Regulations* (CFR) Part 40, Appendix A, paragraph 5B(5) of Criterion 5 and the NRC's guidance document entitled "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, NUREG-1620 rev. 1" (NRC, 2003). The NRC determined that the proposed amendment meets the aforementioned regulatory criteria. An evaluation of the licensee's hydrogeologic and statistical basis for the proposed groundwater protection standards indicated that the licensee had performed a rigorous computational analysis to derive the concentration limits for these updated values.

The proposed amendment would revise groundwater protection standards in Source Material License SUA-1475, Condition 30.B. for the constituents identified in Table 4.1 for three hydro-stratigraphic units: the Southwest Alluvium, and the Upper Gallup Sandstone of Zone 3 and Zone 1. The NRC staff finds that the proposed amendment limit concentrations to levels that are reasonably expected to represent background conditions, which satisfies Criterion 5B(5)(a). This finding is based on the following factors: 1) background groundwater monitoring wells were reviewed and determined to be acceptable for monitoring the intended hydro-stratigraphic units to provide representative samples; 2) background time interval was determined to be representative of background conditions based on geochemical indicators that are known to result from seepage related impacts; and, 3) UPL95 provides a value that represents a reliable and robust upper limit of background groundwater that has not been influenced by seepage-impacts from the Mill Site.

The NRC staff review of the groundwater flow model was narrowly focused on information pertinent to UNC's amendment request, which complemented the discussion on the changing hydrogeologic conditions that existed at the Mill Site. Thus, the NRC staff's analysis of UNCs amendment request and licensing decision did not depend heavily on the flow model.

Future groundwater monitoring performed to determine compliance with License Condition 30.B should use the revised groundwater protection standards, approved herein, to determine the extent of the impacted area under corrective actions by the NRC. Furthermore, it is the NRC's understanding that additional monitoring wells in Zone 3 have been requested by the Navajo Nation Environmental Protection Agency (NNEPA) by letter dated, October 14, 2013 (NNEPA, 2013). The NRC staff agrees that additional monitoring wells, north of the Section 36 boundary on Navajo land, are necessary to track the potential for future migration and to verify the extent of Zone 3 contaminant plume.

Please note that if additional information becomes available that would significantly alter the estimation of background groundwater protection standards, including data that is submitted to the NRC under UNC's licensing requirements or EPA's regulatory requirements, such information will be reevaluated in terms of its impact on remedial actions and established groundwater protection standards for each hydro-stratigraphic unit.

2.0 Background

2.1 Site History

The Mill Site is a non-operating uranium mill site located approximately 17 miles northeast of Gallup in McKinley County, New Mexico. The Mill Site included an ore processing mill and a tailing impoundment area which covers approximately 25 and 100 acres, respectively. The Mill Site operated from May 1977 to May 1982 under a license issued by the New Mexico Environmental Improvement Division. At that time, New Mexico was an Agreement State that had regulatory authority to issue a license to UNC, pursuant to Section 274 of the Atomic Energy Act of 1954, as amended (AEA). In 1981, the EPA placed the Mill Site on the Interim Priority List under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (EPA 1988). In 1983, the Mill Site was placed on the National Priority List by the EPA due to groundwater seepage impacts from the tailings disposal. In 1986, New Mexico relinquished its Agreement State status and ceded its licensing authority to the NRC. By June 1986, the NRC had assumed regulatory authority for uranium mills in the State of New Mexico and subsequently issued a Source Materials License No. SUA-1475 to UNC for the Mill Site (EPA, 2013a). On August 26, 1988, the EPA and NRC signed a Memorandum of Understanding to ensure that the remedial actions at the Mill Site are conducted in a timely and effective manner (EPA, 1988).

The Mill Site is owned by UNC, a subsidiary of General Electric, and is located on privately owned land. The Mill Site encompasses Section 2, Township 16 North, Range 16 West. However, groundwater impacts from the Mill Site extend to Section 36, Township 17 North, Range 16 West, which is also owned by UNC. The Pipeline Arroyo is a major drainage feature that runs through the Mill Site. The land surrounding the Mill Site is sparsely populated and includes Navajo Nation Reservation (north), Tribal Trust Land (east, west), and Indian Allottment Land (south).

The mill was designed to process 4,000 tons of ore per day using conventional crushing, grinding, and acid leach solvent extraction methods. Uranium ore processed at the Mill Site came from the former uranium mines at Northeast Church Rock (NECR) and Kerr McGee Quivira mines. The NECR mine located less than one-mile northwest of the Mill Site began operations in 1968 and was formerly operated by UNC. The Kerr McGee Quivira mines operated by Rio Algom are located to the north and comprise the Quivira Church Rock I mine and Quivira Church Rock IE mine that operated from 1974 to circa 1987. The average ore grade processed was approximately 0.12 percent uranium oxide (EPA, 2013a).

Tailings disposal was conducted at the Mill Site with an estimated 3.5 million tons of tailings disposed in the tailings impoundment. On July 16, 1979, the UNC dam failure also released approximately 93 million gallons of tailings that flowed down the Pipeline Arroyo into the Puerco River drainage system and the underlying alluvium. A small emergency retention pond captured approximately 1,100 tons of solid material from the release (EPA, 2013b). A multi-agency cleanup effort and assessment was conducted and documented in the NRC report entitled “NUREG/CR-2449 Survey of Radionuclide Distributions Resulting from the Church Rock, New Mexico, Uranium Mill Tailings Pond Dam Failure” (NRC, 1981).

Tailings is a byproduct of milling uranium that is typically a sandy coarse grained liquid waste mixture of water, chemicals and waste ore. It is defined as 11e.(2) “byproduct material” under the AEA. Mill tailings or byproduct material that is produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content is regulated by the NRC under UMTRCA.

The reclamation program and groundwater corrective actions at the Mill Site began in June 1986 under the NRC license. UNC submitted a draft reclamation plan in 1987 and the final reclamation plan was approved by the NRC in March 1991. Some significant remedial activities that have been completed at the Mill Site include: mill decommissioning and unrestricted release in 1995; consolidation and final reclamation of the three tailings disposal cells between 1989 and 1995; emplacement of a radon cover that has been in place since 1996; and, backfilling and reclamation of the two borrow pits.

Tailings at the Mill Site are located within the tailings impoundment area comprising three contiguous cells differentiated as the North, Central, and South Cells. The Central Cell also has two borrow pits. Borrow Pit No. 1 was used to dispose of tailings and Borrow Pit No. 2 was used to retain tailings liquids (EPA, 1988). The liquid stored in Borrow Pit No. 2 was neutralized in 1983. However, it has been suggested that prior to 1983, both borrow pits behaved as a single hydraulic unit and provided a source of seepage to the Southwest Alluvium and the Upper Gallup Sandstones of Zone 3 and Zone 1 (EPA, 2013b). Seepage from the three tailings disposal cells, as well as infiltration of mine effluent water during dewatering operations, have contributed to the saturated conditions found in the Southwest Alluvium and Zones 1 and 3 of the Upper Gallup Sandstone (N.A. Water Systems, 2005). An estimated five million gallons of tailings derived liquids previously migrated into the subsurface (EPA, 2003). In addition, infiltration of seepage-impacted water from Borrow Pit Nos. 1 and 2 contributed to the degradation of the groundwater quality.

Between1969 to 1986, large quantities of groundwater were pumped from the nearby NECR and Kerr McGee Quivira mines to dewater the underground workings and were discharged to the Pipeline Arroyo. A portion of the mine discharge infiltrated into the alluvium, altering the subsurface groundwater quality. This man-made polluted groundwater was pumped from the mines which then drained into the Southwest Alluvium and into Zone 1 and Zone 3 of the Upper Gallup Sandstone.

There are several distinct sources of groundwater at the Mill Site:

> 1) The mine effluent discharge from mine dewatering that typically contains uranium, radium and other metals that artificially created water-bearing zones in the hydro-stratigraphic units beneath the Mill Site. This mine effluent discharge is not required to be cleaned up as it considered background groundwater from mining operations;

2) Tailings or seepage-impacted groundwater does not contain much uranium since it was extracted during the milling process (EPA 2013b). However, it may exhibit radioactivity, mainly due to the decay of Uranium-238 chains. This seepage impacted groundwater have a high acidic content due to the acid added during milling tailings disposal and contains radium, metals and other constituents that are required to be cleaned up; and,
3) Background groundwater is defined, for purposes of the NRC's license amendment review, as the quality of the groundwater in the Southwest Alluvium and Upper Gallup Sandstone from mine effluent discharge, but prior to tailings disposal (i.e. post-mining groundwater or pre-tailings groundwater that have not been influenced by milling operations).

Seepage from the tailings impoundment has impacted the Mill Site's background water (i.e. post-mining groundwater or pre-tailings groundwater). Groundwater impacts from the tailings seepage has been observed in the alluvium to the west and southwest of the tailings impoundments. Groundwater has been impacted in Zones 1 and 3 of the Upper Gallup Sandstone through subcrops and hydraulic connections beneath the tailings cells and borrow pits.

2.2 Groundwater Protection Standards

Historically, the NRC approved groundwater protection standards which were incorporated into License Amendment No. 4 by letter dated January 3, 1989 (NRC, 1989). These groundwater protection standards were determined by either using the lower limit of detection when the majority of the sample population was below the lower limit of detection or a value determined by graphical trend analysis, which plotted the water quality from lowest to highest values to determine a deflection point. The values found at the deflection points were used as the groundwater protection standards.

In 1996, the NRC performed a statistical evaluation of background water quality. The evaluation recommended that manganese, sulfate, and TDS should not be regulated site constituents nor should they be used as the bases for corrective actions (NRC, 1996).

In August 2006, revised groundwater protection standards for chloroform and combined radium-226 and 228 were incorporated into the license with the approval of License Amendment No. 37 (NRC, 2006). The EPA Maximum Contaminant Level (MCL) of 0.08 mg/l for total trihalomethanes, which encompasses chloroform, was also incorporated. Groundwater protection standards for combined radium-226 and 228 were calculated from background wells outside of the impacted areas based on the 95th percentile value.

2.3 Water Quality of Discharged Mine Effluents

Two underground uranium mine sites formerly operated in the vicinity of the Mill Site. UNC operated the former NECR mine, which is located to the northwest and adjacent to the Mill Site, and Rio Algom operated the Kerr McGee Quivira mines north of the Mill Site. The 1975 National Pollutant Discharge Elimination System permit for the NECR mine limited discharges of radium-226 to a maximum of 30 pCi/l, suspended solids to a daily average of 100 mg/l and a maximum daily limit of 200 mg/l, and uranium a maximum daily limit of 2 mg/l. Composite samples collected while dewatering the mine in 1975 after a power failure contained an average radium-226 concentration of 23.3 pCi/l. A grab sample was collected on March 14, 1975, after mining activities resumed. This sample contained radium-226 at 57 pCi/l and suspended solids at 320 mg/l. Uranium was present in the discharge at an average concentration of 7.2 mg/l and a maximum of 20 mg/l.

Pipeline Arroyo received mine water discharge from the NECR and Kerr McGee Quivira mines that drained into the local arroyo that traverses the Mill Site and ultimately discharged to the Rio Puerco drainage system. Surface water samples collected downstream of discharges had maximum concentrations of radium-226 at 2.6 pCi/l, which decreased to 0.4 pCi/l at the town of Gallup. Selenium concentrations downstream from the mine discharges ranged from 0.03 mg/l to 0.07 mg/l (EPA, 1975). Discharged mine effluents have contributed to the degraded groundwater quality at the Mill Site.

2.4 Proposed Action

The proposed action is to amend License Condition 30.B. for Source Material License No. SUA-1475 as described in UNC's license amendment application (UNC, 2012a). This amendment request provided a technical analysis of the current groundwater monitoring parameters to be revised for current groundwater protection standards based on background conditions for the following constituents: arsenic, cadmium, gross alpha, lead and lead-210, nickel, radium-226 and 228, selenium, thorium-230, and uranium.

3.0 Hydrogeology and Geology of the Church Rock Mill Site

The Mill Site is located in the northwest corner of New Mexico, west of the Continental Divide on the San Juan Basin of the Colorado Plateau. Situated on alluvial valley fill of Pleistocene age, the Mill Site is also underlain by sandstones and shales of Cretaceous age. The stratigraphic units identified in the vicinity of the Mill Site, in descending order, are as follows:

- Alluvium
- Dilco Coal Member
- Upper Gallup Sandstone
    - Zone 3, upper sandstone
    - Zone 2, shale and coal
    - Zone1, lower sandstone
- D-Cross Member of the Mancos Shale

Of importance to the ongoing groundwater corrective actions at the Mill Site are the water bearing zones of the Southwest Alluvium and the Upper Gallup Sandstones of Zone 3 and Zone 1.

3.1 Southwest Alluvium

Groundwater in the Southwest Alluvium in the vicinity of the Church Rock tailings impoundment was created by mine water that was discharged to Pipeline Arroyo and from recharge derived from local storm flows. This mine water percolated into the alluvium and created a temporary increase in saturation in the vicinity of the tailings impoundment (Earth Tech Inc., 2000a). Groundwater in the Southwest Alluvium flows to the southwest along Pipeline Arroyo. This is the local arroyo that runs through the Mill Site that trends northeast to southwest. It is a major drainage feature that is underlain by alluvial material.

The alluvium underlies most of the tailings at the Mill Site and, therefore, is generally the first stratum contacted by tailings seepage. The alluvium unconformably overlies all of the Cretaceous rock units in the area. The alluvium ranges in age from Pleistocene to recent and generally fills paleo-channels along Pipeline Canyon lineament. Two main lineaments are apparent and expressed as paleo-channels, one following the Pipeline Canyon trend and one trending east-west through the Central Cell and Borrow Pit areas. At some point under the north part of the South Cell the main paleo-channel is joined by the east-west channel. The main channel then continues north to the property line where it makes two high angle bends. The thickness of the alluvium ranges from zero feet in the northeastern and eastern portion of the tailings area to approximately 150 feet in the central tailings area. It consists of light yellow to brown to gray, fine- to coarse-grained sands interbedded with light to dark gray clays that are locally carbonaceous. Generally, the sediments are moderately sorted and interbedded with occasional boulders, and organic matter deposited in interfingering layers. The thickest section of alluvium occurs as infill of a Pleistocene erosion channel underlying the west-central portion of the tailings area. Early pumping tests indicated that the average permeability of the alluvium is 10^{-2} cm/sec with an average transmissivity of 7,000 gpd/ft (Canonie, 1987). The transmissivity has been reduced by subsequent drainage resulting in a reduction of the saturated thickness. Since 2004, UNC has used a value for the hydraulic conductivity of 2 x 10^{-3} cm/sec when calculating Darcy seepage velocities in the Southwest Alluvium. The basis for selecting this value was presented in US Filter, 2004. A new hydraulic conductivity value was subsequently determined and reported in the 2012 Annual Report as 2.5 x 10^{-3} (Chester Engineers, 2013), based on groundwater flow model calibration for the Southwest Alluvium (Chester Engineers, 2012b).

Groundwater levels in the Southwest Alluvium continue to decline (with periodic fluctuations observed), indicating that the artificially recharged zone of saturation continues to become naturally dewatered as the groundwater drains down the arroyo.

3.2 Upper Gallup Sandstone

3.2.1 Zone 3

The Upper Gallup Zone 3 is considered to have been deposited in a coastal barrier environment at the edge of a retreating epeirogenic sea. Zone 3 appears as white to light gray brown, massive, cross-bedded, very friable sandstone, with occasional coaly shale stringers at outcroppings. The distinct cross-beds are indicative of nearshore sandbars in the high energy wave zone of a beach environment.

Locally the Zone 3 sandstone is arkosic, i.e., grains of feldspar supplement the quartz in the rock matrix. The thickness of this unit varies between 70 to 90 feet thick in the tailings area. Hydraulic testing showed that Zone 3 has an average permeability of 10^{-3} cm/sec with an average transmissivity of 1,000 gpd/ft (Canonie, 1987).

Water level data recorded from 1989 through the present indicates that the potentiometric surface continues to decline further reducing the saturated conditions on the eastern portion of the Mill Site. The saturated thickness measured in Zone 3 wells has declined by 76 percent on average since the third quarter of 1989. Between 1989 and the fourth quarter of 2013, a very large portion of the Zone 3 Remedial Action Target Area has been desaturated (Chester Engineers, 2014b). Historically, groundwater flow in Zone 3 was generally east to northeast due to alluvium recharge from historical discharges into Pipeline Arroyo by mining operations and tailings seepage where Zone 3 subcrops below the alluvium. Zone 3 groundwater flow directions became more generally north-northeasterly as recharge from, and groundwater mounding within, the alluvium to the southwest and west has steadily decreased (Chester Engineers, 2012b). Between 2002 and 2013, most wells have shown overall decreasing groundwater elevations (usually with small fluctuations), indicating that the Zone 3 potentiometric field that drives groundwater flow and constituent migration continues to become lower as the groundwater further drains away. Pumping has removed more than 15 million gallons from 2005 through 2013 from the corrective action pumping systems. However, all Zone 3 pumping well capacities decline over time due to the loss of saturated thickness. The overall conditions are such that active remedial operations in Zone 3 are reaching the limits of their effectiveness (Chester Engineers, 2014b)

3.2.2 Zone 2

Zone 2 comprises gray to dark gray to black shale, sandy shale, and coal. At least one laterally continuous, locally pyritic coal seam (1-2 ft. thick) exists at or near the top of this unit. Toward the bottom of Zone 2 is a second less distinct coal seam which appears occasionally as very carbonaceous shale. In general, a gray to dark gray underclay underlies each of the coals. Slickensides and rootlet-like carbonaceous material are associated with the underclay. Occasionally, thin, lenticular, light gray to gray, fine-grained sandstone interbeds are observed in Zone 2.

The thickness of this unit ranges from 15 to 20 feet in the area of the tailings. No decline in water levels was observed in Zone 1 when Zone 3 was pumped. Zone 2 is considered to be an aquiclude in the area of the Mill Site (Canonie, 1987), effectively cutting-off any hydraulic connection between Zone 1 and Zone 3, with the exception of areas beneath and to the south of the tailings impoundment where Zone 2 has been removed by erosion.

3.2.3 Zone 1

Zone 1 comprises fine- to medium-grained massive sandstone with thin beds of carbonaceous shale and coal. The clay and shale content increases with depth. The thickness of this unit ranges from 80 to 90 feet in the area of the tailings. Hydraulic testing showed that the average permeability of Zone 1 is 10^{-4} cm/sec with an average transmissivity of 150 gpd/ft. The permeability is approximately one order less than in Zone 3 (Canonie, 1987). Zone 1 has a very gentle northerly dip direction. The Zone 1 potentiometric surface is separate from the Zone 3 potentiometric surface because the stratigraphically intervening Zone 2 acts as an aquitard.

Earlier groundwater flow in Zone 1 was approximately eastward, reflecting groundwater mounding and recharge from the borrow pits and the alluvium to the west. Since the dewatering of Borrow Pit No. 2 and termination of mine-dewatering groundwater discharge into Pipeline Arroyo, the former mounding has dissipated. The continued dissipation of the groundwater mound over the years has allowed the gentle northerly dip of the Zone 1 sandstone to exert greater control on the flow direction.

3.3 Mancos Shale

The D-Cross Tongue of the Mancos Shale represents a subregional transgression that separates the Upper and Lower Gallup Sandstone. Silty muds and thin sands of the Upper D-Cross Tongue were deposited during a minor transgression followed by a minor regression. The Mancos Shale contains a very low permeability and acts as an aquitard to prevent or retard the downward migration of groundwater. Deep mine shaft pits indicate that the Mancos Shale is approximately 870 feet thick in the vicinity of the Mill Site (N.A. Water Systems, 2011).

4.0 Technical Evaluation

The staff review included an assessment of: (1) information related to the hydrogeology of the Mill Site; (2) monitoring wells used during the proposed timeframe considered to be representative of background conditions; (3) groundwater geochemical characteristics; and (4) statistical analysis used to determine the proposed groundwater protection standards.

4.1 Introduction

UNC is seeking approval to revise groundwater protection standards for Source Materials License SUA-1475, Condition 30.B. UNC has proposed to apply updated background concentrations for each of the three hydro-stratigraphic units which have been designated as the Southwest Alluvium and the Upper Gallup Sandstone Zone 1 and Zone 3. The revised groundwater protection standards listed in Table 4.1 in bold are the proposed standards that would apply throughout each impacted hydro-stratigraphic unit following the NRC's approval of this amendment request. Each hydro-stratigraphic unit has differing geochemical characteristics and therefore, it is necessary to establish unique groundwater protection standards for each unit. Table 4.1 is modified with the proposed nickel concentration of 0.7 mg/l in Zone 1 to the value of 0.07 mg/l due to what appears to be a typographical error in this current amendment request.

Table 4.1 Current and Proposed Groundwater Protection Standards

Constituent	Southwest Alluvium		Zone 1		Zone3	
	Proposed Standard (mg/l)	**Current Standard (mg/l)**	**Proposed Standard (mg/l)**	**Current Standard (mg/l)**	**Proposed Standard (mg/l)**	**Current Standard (mg/l)**
Arsenic	0.05	0.05	0.05	0.05	**0.757**	0.05
Beryllium	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	**0.025**	0.01	0.01	0.01	**0.09**	0.01
Trihalomethanes	0.08	0.08	0.08	0.08	0.08	0.08
Gross Alpha*	15.0	15.0	15.0	15.0	**39.7**	15.0
Lead	**0.7**	0.05	0.05	0.05	**0.08**	0.05
Lead 210*	**5.9**	1.0	**4.7**	1.0	**5.7**	1.0
Nickel	**0.078**	0.05	**0.07**	0.05	**0.569**	0.05
Radium 226 and 228*	**8.2**	5.2	**12.1**	9.4	**35.2**	5.0
Selenium	**0.07**	0.01	0.01	0.01	0.01	0.01
Thorium 230*	**4.5**	5.0	**1.6**	5.0	**17**	5.0
Uranium	0.3	0.3	**0.238**	0.3	**0.359**	0.3
Vanadium	0.1	0.1	0.1	0.1	0.1	0.1
* Indicates units of pCi/l apply						

4.2 Regulatory Requirements

The utilization of background concentrations for groundwater protection standards are outlined in 10 CFR 40, Appendix A, paragraph 5B(5)(a) and (b) of Criterion 5 which states, “At the point of compliance, the concentration of a hazardous constituent must not exceed- a) the Commission approved background concentration of that constituent in groundwater; [or] b) the respective value given in the table in paragraph 5C if the constituent is listed in the table and if the background level of the constituent is below the value listed.”

Point of Compliance (POC) is defined in Appendix A to 10 CFR Part 40 as the site-specific location in the uppermost aquifer where the groundwater protection standards must be met. Criterion 5B(1) provides further discussion of POC. In summary, the objective in selecting the POC is to provide the earliest practical warning that the impoundment is releasing hazardous constituents to the groundwater on the hydraulically downgradient edge of the disposal area as defined in Appendix A to 10 CFR Part 40.

Regarding the Mill Site, the current groundwater protection standards have been exceeded beyond the edge of the disposal area and the NRC, letter dated, January 3, 1989, determined that a corrective action program required by paragraph 5D of Criterion 5 was necessary. Therefore, all groundwater impacted by milling operations covered under license number SUA-1475 are required to meet the Commission approved groundwater protection standards at and beyond the POC as required by Criteria 5B(5) and 5B(1).

4.3 Background Well Network

The set of monitoring wells used to determine background concentrations for the Southwest Alluvium and Zone 1 was originally assessed by NRC staff in a Technical Evaluation Report (TER) dated August 2, 2006 (NRC, 2006). This TER was included as an enclosure to the approval of License Amendment No. 37 dated August 9, 2006. The assessed data set from the monitoring wells ranged from July 1989 through October 2005. The data set from the previously proposed wells were deemed representative to determine background concentrations on the basis that the wells were located outside of the remedial action target areas over the data set range, with the exception of EPA 28. All wells also contained concentrations that were below the key indicator parameters used to determine the presence of tailings seepage impacts with the exception of well 624, which contained bicarbonate concentrations slightly above the key indicator parameter.

The current amendment request utilized the same monitoring well network in the Southwest Alluvium and Zone 1, previously assessed during NRC review of License Amendment No. 37 (NRC, 2006). However, a key difference in this current submittal is that the time interval for the background wells included two more additional years of data and Zone 3 background wells were included in the data set. Therefore, the monitoring wells were reevaluated to determine if they were representative of background conditions for the newly proposed time interval.

4.3.1 Southwest Alluvium

The key indicators of tailings seepage impact in the Southwestern Alluvium are bicarbonate and chloride; bicarbonate at levels greater than 1,000 mg/l combined with chloride concentrations greater than 150 mg/l (Earth Tech, 2000b). Bicarbonate concentrations greater than 1000 mg/l establishes locations that are influenced by the neutralization of low pH tailings pore fluid by dissolution of carbonate minerals contained in the alluvial soils. Chloride is a nonreactive constituent that travels at the same rate as the groundwater and was present in the tailings seepage at high concentrations.

License Amendment No. 37 previously included for review the 13 monitoring wells listed in Table 4.3.1 with the exception of monitoring well GW-4, which was later excluded because the data set included the highest single combined-radium concentration among all Southwest Alluvium groundwater samples. Exclusion of data based entirely on relative concentration can underestimate background concentrations. Underestimation of background concentrations can result in inappropriate corrective actions to occur (i.e., Type I error). Therefore, GW-4 has been included in this amendment request for the review of revised groundwater protection standards.

Table 4.3.1 Southwest Alluvium Background Monitoring Wells

Well Name	Background Date Range	Location
0029A	July 1989 to October 1994	Adjacent to Tailings (South Cell)
624	July 1989 to October 1995	Downgradient of Tailings
627	July 1989 to April 2007	Downgradient of Tailings
639	July 1989 to October 1994	Upgradient of Tailings
642	July 1989 to July 1995	Upgradient of Tailings
644	July 1989 to October 1992	Upgradient of Tailings
645	October 1989 to October 1990	Upgradient of Tailings
EPA 22A	July 1989 to July 1997	Adjacent to Tailings (North Cell)
EPA 25	July 1989 to October 1995	Downgradient of Tailings
EPA 27	July 1989 to July 1997	Downgradient of Tailings
EPA 28	July 1989 to October 2007	Downgradient of Tailings
GW-4	July 1989 to April 1999	Adjacent to Tailings (North Cell)
SBL-1	October 2004 to July 2007	Downgradient of Tailings

Monitoring wells 627 and SBL-1 are located downgradient of the South Cell and are the furthest downgradient wells from the tailings impoundment. Both wells exhibit high concentrations of sulfate and consequently total dissolved solids (TDS). SBL-1 contains the highest sulfate and TDS concentrations of any of the proposed background wells. SBL-1 also contains elevated concentrations of nickel, magnesium, manganese, and cobalt. However, neither well was influenced by seepage-impacted water during the proposed background time interval based on the relatively stable bicarbonate and chloride concentrations.

Monitoring well GW-4 is located adjacent to the North Cell of the tailings impoundment and was one of the original monitoring wells with limited preoperational groundwater data. This monitoring well is in close proximity to the tailing impoundment. A sample taken from GW-4 in March of 1977 contained concentrations of sulfate and TDS similar to concentrations observed during the background time interval. If GW-4 was influenced by seepage impacts during the background time interval, concentrations of sulfate and TDS would be expected to be highly elevated due the well's close proximity to the tailings impoundment. In addition, bicarbonate and chloride concentrations show moderate fluctuations, all of which were below 1000 mg/l and 150 mg/l, respectively, with no apparent upward trending.

Monitoring well 0029A and EPA-22A are located adjacent to the South Cell and North Cell of the tailings impoundment, respectively. Both wells have relatively stable bicarbonate and chloride concentration below the 1000 mg/l and 150 mg/l, respectively. Monitoring well 0029A had exceedances of lead, lead-210, thorium-230, radium-226 and 228, selenium, and cadmium during the proposed background time interval. However, the elevated concentrations were sporadic and typically returned below the detection limit by the next sampling event. Monitoring well EPA-22A had exceedances of lead-210, thorium-230, and radium-226 and -228 during the proposed background time interval. The moderate exceedances in each of these wells were limited and did not show any upward trends that would be expected in wells located in close proximity to the tailings impoundment.

Monitoring wells EPA-25, EPA-27, EPA-28 and 624 are located downgradient of the tailings impoundment and show upward trends for bicarbonate and chloride with the exception of a decreasing bicarbonate trend in EPA-27 and a relatively stable chloride concentration in EPA-28. Monitoring wells 624 and EPA-28 had chloride concentrations that were briefly in excess of 150 mg/l during the proposed background time interval, and monitoring well EPA-25 had one bicarbonate sample above 1000 mg/l during the background time interval. Each of these wells was located outside of the remedial action target area during the proposed background time intervals, but each of the wells contain trends that are indicative of the approaching plume or reaction front created by the neutralization of the acidic tailings seepage.

Monitoring wells 639, 642, 644, and 645 are located upgradient of the tailings impoundment and are considered representative of water quality produced by historic effluent discharges from mining operations that directly impacted the Southwest Alluvium. In an NRC report entitled, “Evaluation of the Statistical Basis for Establishing Background Levels and Remediation Standards at the United Nuclear Corporation Church Rock Uranium Mill Tailings Disposal Facility, June 10, 1996,” the NRC determined that the 600 series wells located at the northern end of the property in Section 36 were likely contaminated by Kerr McGee Quivira mine activities (NRC, 1996). The NRC’s previous decision to exclude these wells from the background analysis is currently inconsistent with the NRC staff’s understanding of background conditions, which includes impacts from operations other than licensed milling operations. Thus, the groundwater protection standards should incorporate offsite impacts that were unrelated to milling operations. The non-milling impacts (i.e., mining activities) can potentially influence downgradient concentrations at the Mill Site.

The Kerr McGee Quivira sediment evaporation pads that are located on a portion of Section 36 are not considered a source of contaminants for the 600 series wells. This Section 36 sediment evaporation pads did not contain water and were only used to dry the sediments collected from the settling ponds at the Kerr McGee Quivira mine site. These sediments were never processed and any liquid that they contained would be similar to the water discharged into Pipeline Arroyo. The moisture contained in the sediments would not have been sufficient to allow contaminants to migrate to the 600 series wells (UNC, 1996).

Water quality in the four-upgradient wells is considered to be un-impacted by milling operations due to the monitoring wells upgradient location with respect to the tailings impoundment. Bicarbonate concentrations ranged from 351 mg/l to 679 mg/l and chloride concentrations ranged from 15.8 mg/l to 169 mg/l for the upgradient wells. Monitoring well 645 contained elevated concentrations of cadmium (<0.01 mg/l to 0.074 mg/l) and selenium (0.016 mg/l to 0.04 mg/l). Monitoring well 645 also contained the highest chloride concentrations compared to any of the background wells with a maximum value of 169 mg/l. Elevated selenium concentrations were observed in monitoring wells 639, 644, and 645 that ranged from 0.001 mg/l to 0.04 mg/l.

4.3.1.1 Conclusions

Monitoring wells EPA-25, EPA-27, EPA-28, and 624 show signs of the initial reaction front created by acid neutralization from the tailings impoundment based on the upward trending of bicarbonate and chloride, which are the designated indicator parameters for seepage impacts in the Southwest Alluvium. The increasing concentrations indicate advancement of the reaction front and cannot be designated as uninfluenced by site operations even though the monitoring wells were outside of the designated impacted area during the proposed background time intervals. While the increasing bicarbonate and chloride concentrations indicate advancement of the reaction front over the proposed time interval, the two constituents are considered conservative indicator parameters compared to the proposed background constituents with respect to travel time. A comparison of the background data to monitoring wells within the impacted area proved difficult due to the lack of elevated NRC regulated constituent concentrations and minimal upward trending of concentrations at wells designated as impacted. The proposed background wells appear to include concentrations that are consistent with conditions at upgradient wells and do not include upward or continuously elevated concentrations of NRC regulated constituents. Therefore, the NRC staff finds that the proposed background monitoring wells are representative of background conditions for the proposed constituents during the background interval.

4.3.2 Zone 1 (Upper Gallup Sandstone)

The extent of seepage impacts for Zone 1 is delineated by a chloride concentration greater than 50 mg/l due to the constituent's known presence in the water of Borrow Pit No. 2 at concentrations 10 times greater than the post mining-pretailings water (Earth Tech, 2000c). As previously mentioned, chloride is a nonreactive conservative tracer that migrates at the same rate as the groundwater and is considered an indicator parameter for tailings seepage impacts in Zone 1. The proposed background wells and background time periods are provided in Table 4.3.2.

Table 4.3.2 Zone 1 Background Monitoring Wells

Well Name	Background Date Range	Location
619	July 1989 – January 2000	Adjacent to Borrow Pit # 2
EPA-02	July 1989 – April 2007	Downgradient
EPA-04	July 1989 – October 2007	Downgradient
EPA-08	July 1989 – January 2000	Downgradient

Chloride concentrations at monitoring wells 619 and EPA-8 contained moderately increasing trends over the background time period with seven chloride samples exceeding 50 mg/l at monitoring well 619 and three elevated samples at EPA-8. Monitoring wells EPA-2 and EPA-4 did not contain any chloride concentrations above 50 mg/l. Chloride trends for monitoring well EPA-4 were indiscernible and a decreasing trend was observed at EPA-2 during the background time interval. Constituent concentrations for the proposed GWPS generally remained below or slightly above the current standards, but did not contain any upward trends during the proposed background intervals with the exception of a slight upward trend for radium-226 and -228 in the second half of the data set for monitoring well EPA-02.

4.3.2.1 Conclusions

While an increasing chloride concentration above 50 mg/l is considered appropriate for delineation of the plume, the ratio of calcium/magnesium (Ca/Mg) was also evaluated due to concentrations above 50 mg/l for chloride for the proposed background wells. Similar to Zone 3, decreasing ratios appear to be consistent with seepage related impacts and a Ca/Mg ratio of approximately 0.8 appears to indicate initial seepage impacts. Monitoring well EPA-5 provides a good example due to the well's long sampling history, which appears to encompass un-impacted, impacted, and recovering conditions. The stable initial Ca/Mg ratio observed at EPA-5 is followed by a significant decreasing Ca/Mg trend corresponding to a period of increasing concentrations of nickel, selenium, and cobalt. A Ca/Mg ratio of approximately 0.6 appears to indicate full seepage impact at EPA-5. A ratio of 0.6 compares favorably to impacted Zone 1 wells 604, 617, 515A, 516A, EPA-5, and EPA-7. However, well 614 is impacted with ratios above 1, but contains unusually high bicarbonate concentrations similar to wells impacted by neutralization in the Southwest alluvium.

The proposed background wells also lack the contaminant characteristics of impacted wells in Zone 1. Impacted wells in Zone 1 typically contain high concentrations of chloride, aluminum, total trihalomethane, manganese, nickel, and cobalt. Concentrations at impacted wells generally show significant increases over time, which is not apparent at the proposed background wells. Therefore, the NRC staff agrees that monitoring wells 619, EPA-2, EPA-4, and EPA-8 are representative of background groundwater conditions during their respective background time intervals.

4.3.3 Zone 3 (Upper Gallup Sandstone)

The proposed background wells and the corresponding background time intervals listed in Table 4.3.3 were evaluated to determine if the Zone 3 wells were representative of background conditions based on pH above 5 and a bicarbonate concentration within the range of 100 mg/l to 500 mg/l (GE, 2000). Non-seepage impacted locations generally contain bicarbonate concentrations that range between 100 mg/l and 500 mg/l since groundwater at these locations has approximately reached equilibrium with the carbonate minerals in strata of Zone 3 (Canonie, 1987). However, pH and bicarbonate are not always definitive indicators of background conditions. Therefore, decreasing ratios of Ca/Mg over time and upward trending constituent concentrations over time were also used to evaluate background conditions.

Table 4.3.3 Zone 3 Background Monitoring Wells

Well Name	Background Date Range	Location
411	July 1989 to January 1998	Downgradient of North Cell
504 B	July 1989 to April 1992	Downgradient of North Cell
517	July 1989 to April 1991	Downgradient of North Cell
EPA 01	July 1989 to October 1997	Downgradient of North Cell
EPA 03	July 1989 to October 1991	Downgradient of North Cell
EPA 11	July 1989 to April 1990	Downgradient of North Cell
EPA 12	July 1989 to April 1992	Downgradient of North Cell
EPA 14	July 1989 to April 1995	Downgradient of North Cell
EPA 15	July 1989 to April 1995	Downgradient of North Cell
EPA 17	July 1989 to April 1992	Downgradient of North Cell
NBL-01	August 2001 to January 2004	Downgradient of North Cell

Molybdenum is not an NRC regulated constituent at the Mill Site, but the NRC evaluated it due to the abnormally high concentrations observed at some of the background wells. Molybdenum has been observed in far downgradient Zone 3 wells at unusually high concentrations. Typical molybdenum concentrations measured from mine effluents and local wells ranged from 0.2 mg/l to 1.9 mg/l. Molybdenum concentrations obtained from a limited number of sampling events for the North Cell and Borrow Pits 1 and 2 ranged from 0.01 mg/l to 18.7 mg/l (Science Applications Inc, 1980). Proposed background wells EPA-01 and EPA-11 exhibited concentrations of molybdenum at 62 mg/l and 68 mg/l respectively in 1989. Proposed background wells 504-B and 411 also exhibited molybdenum concentrations at 24 mg/l and 2 mg/l in 1989. Samples obtained in 1981 (UNC, 1981) from monitoring wells 145, 147, 148, 149, 150, and 401 also exhibit elevated molybdenum concentrations at concentrations ranging from 8.1 mg/l to 17.9 mg/l. Sampling results from 1981 were also obtained from wells 123, 126, 127, 104-D, and 110-D located near the tailings impoundment to the north. Concentrations of molybdenum did not exceed 0.1 mg/l from these wells near the tailings impoundment. The lack of elevated molybdenum concentrations from samples obtained prior to and after 1989 near the impoundment indicates that the elevated molybdenum concentrations in Zone-3 could not have originated from the Mill Site. In addition, the NRC staff requested additional information from UNC regarding the elevated molybdenum concentrations by letter dated June 4, 2013 (NRC, 2013b). UNC responded to the request by letter dated January 10, 2014 (NRC, 2013a).

The NRC staff agrees with UNCs plausible explanation that the observed site molybdenum concentration distributions are related to its complex environmental geochemistry and the presence of potential natural geologic sources of molybdenum such as coal beds and carbonaceous shales in the Zone 3 and Zone 2 bedrock and the overlying Dilco Member. Monitoring wells screened across or within these potential sources appear to be more susceptible to elevated molybdenum concentrations. Monitoring wells EPA-1, EPA-11, and 504-B contain a portion of the screened interval within or at the Zone 2 contact. Monitoring wells 147 and 401, which contain elevated molybdenum concentrations as far back as 1981, have screened intervals and/or sandpacked intervals that extend from Zone 3 through Zone 2 and Zone 1 into the Mancos shale (Chester Engineers, 2014b). The NRC staff would also like to note that the molybdenum was not the only parameter with unusually elevated concentrations. Uranium concentrations at wells 145, 147, 148, 149, 150, and 401 ranged from 0.09 mg/l to 1.10 mg/l with an average concentration of 0.62 mg/l in 1981. The U.S. Department of Energy (DOE) also expressed concerns about the elevated molybdenum concentrations and commented on UNCs response to the NRC RAIs by letter dated, May 1, 2014 (DOE, 2014). In general, DOE's comment was focused on molybdenum concentrations in Zone 3 that were significantly higher than typical naturally occurring concentrations. As previously stated, molybdenum is not an NRC regulated constituent at the Mill Site and does not appear to be related to seepage-impacts for the aforementioned reasons.

Monitoring well EPA-14 meets the background criteria for pH above 5 and bicarbonate concentrations between 100 mg/l and 500 mg/l during the proposed background interval. The Ca/Mg ratio fluctuates moderately with a slight increasing trend. Concentrations of the proposed background constituents generally remain below or slightly above the current NRC site standards with significant increased concentrations observed beginning three to four years after the proposed background time interval indicating the arrival of seepage-impacted groundwater.

Monitoring well NBL-1 is the second furthest downgradient proposed background monitoring well in Zone 3. The background criteria for pH and bicarbonate were met during the proposed background time interval and the Ca/Mg ratio remained relatively stable around 3. The ratio significantly decreases just after the proposed background period and bicarbonate concentrations fluctuate before reducing to undetectable levels indicating that seepage impacts occurred just after the proposed background interval.

Monitoring well 517 meets the background criteria for both pH and bicarbonate. The background time interval appears to be just prior to or at the transition from non-impacted to impacted based on the decreased pH values, decreasing Ca/Mg ratios, bicarbonate concentrations below 100 mg/l, and increasing constituent concentrations shortly after the background time interval indicating the arrival of seepage-impacted groundwater.

Monitoring well 411 meets the background criteria for both pH and bicarbonate during the proposed background time interval. The Ca/Mg ratio shows a significant decrease and subsequent stabilization to approximately 2, which corresponds to an increase in bicarbonate. Further review of the proposed constituent concentrations does not indicate seepage impacts based on the generally stable but elevated concentrations. The concentrations exhibited during the proposed time interval are similar to wells with a portion of the screened interval extending into Zone 2. A review of the wells construction (Chester Engineers, 2011a) indicates that a portion of the screened interval is in fact within Zone 2.

Monitoring well 504B meets the background criteria for both pH and bicarbonate during the proposed background time interval. The Ca/Mg ratio fluctuates, but does not show a decreasing trend until a few years after the proposed background interval. A significant reduction in bicarbonate also occurs just after the proposed background time interval indicating seepage impacts after the proposed background interval. Elevated concentrations of constituents occur during the background time interval, including unusually high molybdenum concentrations. The elevated concentrations are consistent with samples taken from nearby monitoring well 148 in 1981, which contained elevated cobalt (0.138 mg/l), uranium (0.53 mg/l), molybdenum (8.1 mg/l), manganese (3.0 mg/l), and sulfate (3105.3 mg/l) based on the limited parameters sampled (UNC, 1981).

Monitoring well EPA-01 is the furthest downgradient proposed background well in Zone 3. The background criteria for both pH and bicarbonate were met during the proposed background time interval. The Ca/Mg ratio was relatively stable and decreasing trends were not observed, which would be expected based on the distant location of the well. Unusually high molybdenum concentrations are observed and are consistent with wells partially screened in Zone 2. Review of the well log (Chester Engineers, 2011b), indicates that the lower portion of the screen is in fact within Zone 2.

Monitoring well EPA-03 is located on the boundary of sections 1 and 36 northeast of the North Cell. The background criteria for both pH and bicarbonate were met during the proposed background time interval with the exception of one bicarbonate sample below 100 mg/l at 45.5 mg/l. The Ca/Mg ratio did not contain a decreasing trend and remained very stable over the proposed background time interval. Further review of the proposed background constituent concentrations revealed no upward trends.

Monitoring well EPA-11 meets the background criteria for both pH and bicarbonate during the proposed background time interval. The Ca/Mg ratio remained stable over the proposed background time interval further indicating the seepage related impacts had not occurred.

Monitoring well EPA-12 meets the background criteria for both pH and bicarbonate during the proposed background time interval with the exception of a single bicarbonate concentration below 100 mg/l at 75.4 mg/l. The Ca/Mg ratio and bicarbonate trend slightly downward during the background time interval. Seepage impacted wells typically show significant downward trends for both bicarbonate and the ratio of Ca/Mg, which is not the case during the background time interval. The slight downward trends are more likely the result of the decreasing saturated thickness during the proposed background interval. The well log (Chester Engineers, 2011c). reveals that the well is partially screened within Zone 2 and likely contributes to the elevated constituent concentrations observed.

Monitoring well EPA-15 meets the background criteria for both pH and bicarbonate during the proposed background time interval. The Ca/Mg ratio and bicarbonate concentrations remain relatively stable during the proposed background interval, which is followed by a significant reduction in bicarbonate and sudden decreased Ca/Mg ratio indicating that seepage impacts occurred just after the proposed background time interval.

Monitoring well EPA-17 meets the background criteria for both pH and bicarbonate during the proposed background time interval. The Ca/Mg ratio and bicarbonate concentrations remain stable or increasing during the background time interval indicating that seepage impacts had not occurred.

4.3.3.1 Conclusions

The proposed background wells all contained pH values greater than 5 and bicarbonate concentrations between 100 mg/l and 500 mg/l with the exception of monitoring wells EPA-03 and EPA-12, which each contained a single bicarbonate concentration below 100 mg/l. However, the Ca/Mg ratios in EPA-03 were not decreasing and the proposed background constituent concentrations revealed no upward trends during the proposed background time interval. Monitoring well EPA-12 did contain slightly decreasing trends for both bicarbonate and Ca/Mg, but the slow decreasing trends appear to be inconsistent with initial seepage impacts, which typically result in significant decreases in pH and bicarbonate concentrations, e.g., EPA-14, 517, and NBL-01. Elevated concentrations of arsenic, cobalt, manganese, molybdenum, nickel, radium, and lead-210 are present at background wells during the proposed background time interval. As previously discussed above, the NRC staff agrees that the plausible explanation for the elevated concentrations is related to its complex environmental geochemistry and the presence of potential natural geologic sources such as coal beds and carbonaceous shales in the Zone 3 and Zone 2 bedrock and the overlying Dilco Member. Therefore, the NRC staff agrees that the proposed background wells are representative of background conditions during the proposed background time intervals in Zone 3.

4.4 Statistical Method Employed

The amendment request to modify the groundwater protection standards uses the 95th percentile upper prediction limit (UPL95) with future observations as the preferred statistical method to determine background conditions at the Mill Site.

A UPL95 is the upper bound of a statistical prediction interval calculated to include one or more future observations from the same population with a specified confidence. A prediction interval calculated from some set of sample data assumes that the number of future observations (k) is from the same population and will fall within the interval with some specified level of confidence. The interval is constructed to contain all k future observations with the stated confidence. If any future observation exceeds the prediction interval or, in other words, the upper limit of that interval, then the exceedance is evidence of a statistically significant change in conditions. Concentrations of site contaminants will be compared to background concentrations calculated from the upper limit of the prediction interval. If any of the site concentrations exceed the prediction limit, those locations will be considered to be seepage-impacted.

Upper Prediction Limits based upon background data are used as estimates for not-to-exceed values used in point-by-point versus background comparison evaluations. The background data sets used to determine the not-to-exceed values, otherwise known as the groundwater protection standards, must be based on defensible background conditions that were not influenced by operations from the Mill Site. The groundwater protection standards determined from the background population can then be used for comparison to concentrations found onsite or, in this case, after the background time interval used at each of the background wells previously discussed. The comparison results in the determination of current out of compliance locations including future noncompliance if the not-to-exceed groundwater protection standards are exceeded.

The presence of outlying observations is known to distort many statistical methods including the UPL method. However, outliers initially identified by higher than expected concentrations should not be removed simply based on the observed concentration. Outlying observations are often the most important data collected, providing insight into extreme conditions or important causative relationships (USGS, 2002).

The calculation of UPL95 requires specific numeric input on the relevant number of POC wells and the future compliance sampling schedule. The reason for this is that the number of future comparisons of sample results to the statistically derived groundwater protection standards affects the confidence with which inferences of exceedance can be drawn (UNC, 2012a). The number of future POC samples used in the calculations to determine k is based on 6 years of quarterly sampling (24 sample sets) prior to license transfer and 30 years of annual sampling by the DOE post license transfer, yielding a total of 54 sample sets. The number of future samples (k) for each hydro-stratigraphic unit was then calculated by multiplying the samples per POC well times the number of POC wells in the hydro-stratigraphic units as shown in Table 4.4.

Table 4.4 Determination of k Future Samples

Aquifer	Number of Point of Compliance Wells	Estimated Future Observations Per well	Total k Future Observations
Southwest Alluvium	7	54	378
Zone 1	5	54	270
Zone 3	4	54	216

Some constituents in the hydro-stratigraphic units provided too few background groundwater detections, over the entire background data set time period, to calculate statistically significant UPL95s. When a UPL95 could not be calculated and the maximum background concentration exceeds the current groundwater protection standards, the proposed groundwater protection standards values are the maximum detected background concentrations. The maximum detected background concentrations were used for lead in the Southwest Alluvium, nickel in Zone 1, and cadmium and lead in Zone 3.

4.4.1 Conclusions

The NRC staff agrees that the statistical method used to determine background groundwater protection standards is appropriate. The method accounts for known influences affiliated with discharged mine effluent and/or natural geologic sources, which contributed to the spatial variability of background concentrations observed across the Mill Site. A prediction interval is designed so that all future measurements must fall below the upper prediction limit of the interval for each constituent at the stated confidence. If any future observation exceeds the UPL95, this would be statistically significant evidence that groundwater impacts were occurring.

The assumptions used to determine the value of k within each of the hydro-stratigraphic unit is reasonable considering the estimated time remaining to complete groundwater corrective actions and the estimated future groundwater monitoring required by the long-term surveillance plan after the UNC license is transferred to the DOE. The UPL95 increases as the number of future samples increases to ensure that the stated confidence level is maintained. However, the UPL95 increases asymptotically as the number of future samples is increased resulting in smaller and smaller incremental increases as k increases.

The NRC staff issued an RAI to UNC regarding the use of the EPA ProUCL software by letter dated June 4, 2013 (NRC, 2013b). UNC provided responses in a letter dated, January 10, 2014 (UNC, 2013a). The NRC staff subsequently determined that UNC's responses satisfactorily addressed the technical deficiencies (NRC, 2014). The DOE provided comments on UNC's response by letter dated May 1, 2014 (DOE, 2014a), which in summary, was concerned with the time-frame that a final remedial decision would be made for the completion of corrective actions and transfer of the license to the DOE. The intent of the UPL95 proposed by UNC does not require all future samples to be obtained prior to making a final determination that corrective actions are complete. An exceedance of a UPL95 value in the future would indicate that the elevated concentration would be statistically significant evidence that the concentration was not within the background population and that impacts were occurring.

4.5 Groundwater Model

UNC developed a three-dimensional numerical groundwater flow model (flow model) of the Mill Site and the adjacent downgradient region northeast of Gallup, New Mexico to predict the future disposition of three genetic classes of groundwater defined as pre-mining/pre-tailings (natural), post-mining/pre-tailings (background), and groundwater affected by tailings seepage (seepage-impacted). The flow model report (Chester Engineers, 2012a, b) was provided as a supplement to the initial amendment request (UNC, 2012a) to revise the groundwater protection standards at the Mill Site by letter dated, November 16, 2012. The supplemental flow model report describes the conceptual basis, model development methods, capabilities of the model, and the model's limitations. While the report was provided to support decision making regarding the background conditions at the site, the principal objective of the flow model is to support any decision making related to Alternate Concentration Limit (ACL) applications that may be submitted to the NRC in the future. The main focus of the flow model is for the Zone 3 hydro-stratigraphic unit.

The flow model was developed using MODFLOW 2000 version and MODPATH, which are considered industry standard computer programs. Groundwater Modeling System software version 5.3 was used for pre- and post-processing of model data. Surfer version 10 was also used for pre- and post-processing. The flow model is fully three-dimensional, and incorporates the geometries and hydraulic characteristics of each Site hydro-stratigraphic zone that was subject to transient saturation by background and seepage-impacted groundwater described above. The flow model makes extensive use of the MODFLOW cell rewetting process, which is procedural rather than physics-based. While this capability was essential for the model simulation, it can only approximate the propagation of an unconfined wetting front through previously unsaturated geologic media. The model is limited to groundwater flow and purely convective (i.e., nonreactive, non-dispersive) transport. Purely convective transport is simulated by the method of particle tracking.

The transmissive hydro-stratigraphic units represented in the flow model are the unconsolidated materials (principally alluvium), Zone 3, and Zone 1. The Dilco Coal and Zone 2 are aquitards, as is the Mancos Shale. The top contact of the Mancos (equivalent to the bottom contact of Zone 1) forms the base of the model.

4.5.1 Conclusions

The flow model was evaluated by NRC staff and RAIs were provided to UNC by letter dated June 4, 2013 (NRC, 2013b). UNC provided responses to each of the NRC RAIs by letter dated January 10, 2014 (Chester Engineers, 2014a). Subsequently the NRC determined that all technical deficiencies had been addressed and requested that the flow model be updated with the extensive detailed responses to the RAIs (NRC, 2014a). UNC revised the flow model report by letter dated, June 3, 2014 (Chester Engineers, 2014c). On May 1, 2014, NRC staff received comments on the UNC responses from the DOE regarding the flow model (DOE, 2014a), which were subsequently discussed with NRC staff (DOE, 2014b). In general, the comments were concerned with the robustness of the model and its usefulness for decision making in the future. The NRC staff generally agrees with the comments provided by the DOE and the comments will be taken into consideration when the flow model is used to support future licensing actions.

While the flow model did provide useful hydrogeologic information and insight into past, present, and future groundwater flow regimes and transport rates, the NRC staff's analysis of UNC's amendment request and licensing decision did not depend heavily on the flow model for the determination of background conditions at the Mill Site because the staff's analysis and decision was dependent on the interpretation of geochemical conditions to delineate between background and impacted groundwater. However, the NRC staff believes that the precursory review of the groundwater flow model will be beneficial for fulfilling future licensing actions including the overall objective of completing groundwater corrective actions at the Mill Site. The NRC staff may further review and comment on the groundwater flow and transport modeling during future licensing actions when applicable.

5.0 References

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