2.9 BASELINE RADIOLOGICAL CHARACTERISTICS

2.9.1 Introduction

The Moore Ranch Uranium Project (Figure 2.9-1) involves about 7,110 acres located along State Highway 387, approximately 24 miles southwest of the town of Wright. Proposed locations of wellfields, monitoring well rings, and the Central Plant and associated facilities are shown in Figure 2.9-1.

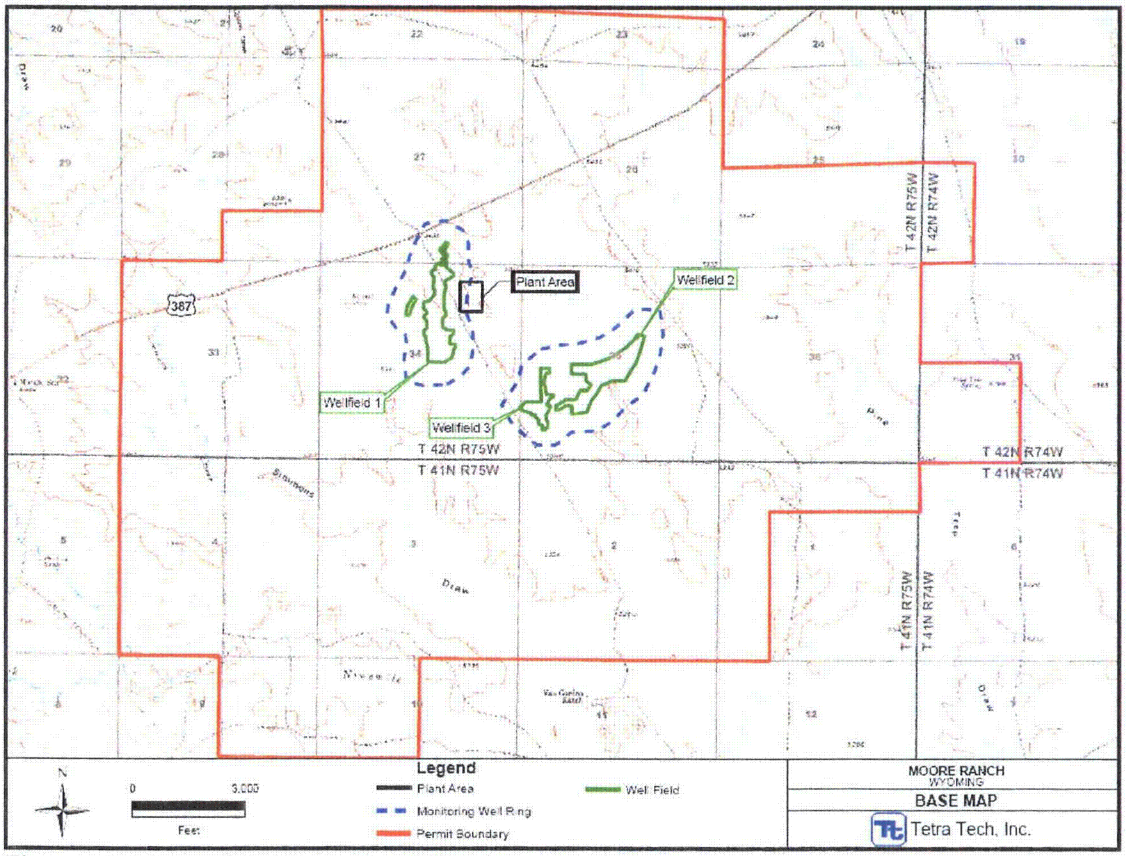

Figure 2.9-1: Map of the Moore Ranch Uranium Project

Topography at the Moore Ranch Uranium Project is primarily low rolling hills interspersed with relatively flat areas and small ephemeral drainages. Vegetation types range from sagebrush to short grass prairie varieties. The site is used extensively for grazing and oil and gas production and includes privately owned land, grazing leases, and state school sections. There are no residents currently within the area.

In 1979 and 1980, baseline radiological sampling and measurements were conducted at this site in support of proposed conventional surface uranium mining (Conoco, 1980). Those studies were never completed as plans for uranium surface mining were abandoned prior to completion of baseline sampling activities. In 2006, EMC contracted Tetra Tech Inc. to assist with the development of a new radiological baseline characterization of the site for proposed ISR uranium recovery operations. Radiological survey planning for this project was developed under the assumption that all phases of the ISR uranium recovery and processing cycle will be performed within the Moore Ranch License Area.

Basic guidance for radiological baseline surveys at uranium recovery sites can be found in Regulatory Guide 4.14 (NRC, 1980). Although Regulatory Guide 4.14 does not address special considerations associated with ISR uranium recovery sites, the U.S. Nuclear Regulatory Commission (NRC) and the Wyoming Department of Environmental Quality / Land Quality Division (WDEQ/LQD) both currently recommend following Regulatory Guide 4.14 for conducting radiological baseline surveys of ISR sites (NRC, 1982; NRC, 2003; WDEQ/LQD, 2007).

Current and historical baseline surveys of the site have both been conducted based on Regulatory Guide 4.14 protocols. As with current survey data, the historical data set is substantial yet still technically incomplete in terms of these regulatory guidelines. Available data from both studies are presented in this report for consideration by the NRC and WDEQ/LQD as potentially sufficient overall documentation of baseline conditions with respect to licensing/permitting applications prior to completion of the current radiological baseline survey program. Remaining data from the current study will be submitted to both agencies as they become available.

Throughout the remainder of this report, reference to data or other aspects of the 1979-1980 Conoco baseline survey are associated with the term "historical survey". All other discussion of baseline survey information refers to recent sampling conducted as a result of proposed ISR uranium mining. Some aspects of current radiological survey efforts have been further developed according to more recent NRC regulatory guidance documents as referenced in applicable sections of this report. The following sections describe methods, activities, and results to date of radiological baseline surveys for the Moore Ranch Uranium Project.

2.9.1.1 References

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project*, Campbell County, Wyoming. Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1982. Regulatory Guide 3.46. *Standard Format and Content of License applications, Including Environmental Reports, for In Situ Uranium*

Solution Mining. Nuclear Regulatory Commission Office of Nuclear Regulatory Research. Washington, D.C.

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

Wyoming Department of Environmental Quality / Land Quality Division (WDEQ/LQD). 2007. *In Situ Mining Permit Application Requirements Handbook. Application Content Requirements – Adjudication and Baseline Information*. March, 2007.

2.9.2 Gamma Survey

Regulatory Guide 4.14 calls for a pre-operational gamma survey covering a maximum area of 1750 acres with up to 80 individual gamma exposure rate measurements (NRC, 1980). The suggested sampling design includes higher density of measurements clustered near the mill location, with more dispersed measurements in a radial pattern at greater distances from the mill. Regulatory Guide 4.14 does not address differences or special considerations associated with ISR uranium mining and recovery operations.

Consistent with ISR License Application guidelines described in Regulatory Guide 3.46 (NRC, 1982) and NUREG-1569 (NRC, 2003), as well as with decommissioning considerations outlined in MARSSIM, the Multi-Agency Radiation Survey and Site Investigation Manual (NRC, 2000), Tetra Tech proposed using more recent GPS-based scanning technologies capable of providing much higher density and more uniform gamma measurements across very large areas. The proposed scanning system can be mounted in various configurations including backpacks, all-terrain vehicles (ATVs), or trucks, and has been used for remedial support at a number of uranium mill site decommissioning projects as well as other radiological site characterization applications in the U.S. and abroad.

Discussions between Tetra Tech and various NRC representatives regarding ISR baseline surveys have resulted in a general consensus that application of an ATV-mounted version of this scanning system for such surveys would likely meet or exceed minimum guidelines outlined in Regulatory Guide 4.14 and other applicable regulatory guidance documents. This system is among current state-of-the-art technologies for conducting radiological site characterizations and can provide far more detailed information on baseline radiological conditions at ISR sites relative to past approaches.

2.9.2.1 Methods

2.9.2.1.1 Baseline Gamma Survey

Various GPS-based scanning system configurations have been field tested and successfully used by Tetra Tech (Figure 2.9-2). For the Moore Ranch survey, the most recently developed Yamaha Rhino-mounted system (Figure 2.9-2, photo C) was used. Given the large size of the site, along with occasional rugged terrain and sagebrush vegetation, these two-seater Rhino ATVs with roll-bar cages and conventional driver control systems (i.e. steering wheel, foot-controlled gas and brake pedals) were best suited for the project. Equipped with special extra-wide tires, these vehicles are well suited to safely negotiating sites like Moore Ranch while minimizing environmental impact.

In addition to addressing safety considerations, roll-bar cages on Rhino ATVs provides a support system for adjustable outriggers designed to mount three Ludlum 44-10 NaI gamma detectors and paired GPS receivers. The detectors are coupled to Ludlum 2350 rate meters housed in a cooler carried in the ATV cargo bed. Simultaneous GPS and gamma exposure rate data are recorded using an onboard PC with data acquisition software developed by Tetra Tech.

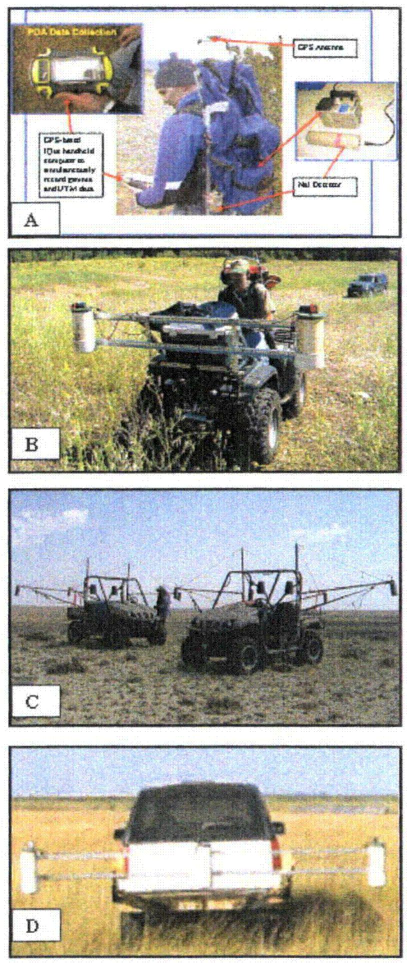

Figure 2.9-2: Various GPS-based scanning system configurations: (A) single detector backpack system; (B) 2-detector ATV-mounted system; (C) 3-detector Rhino-mounted system; (D) 3-detector truck-mounted system.

System configuration involves about 10-foot spacing between detectors (measured perpendicular to direction of travel), with each detector positioned at 4.5 feet above the ground surface. A 3-foot detector height is generally accepted, but not mandated, by the NRC. This height was impractical at the site given the relatively frequent tall brush, ravines, or fence gate crossings. A detector height of 4.5 feet was the lowest practical height for the system under site conditions. Experimental measurements were later performed to statistically quantify any measurement difference between 3-foot and 4.5-foot detector heights.

Based on previous Tetra Tech experiments conducted under similar scanning geometries, lateral detector response to significantly elevated planar (non-point) gamma sources at the ground surface is about 5 feet, giving each detector an estimated "field of view" of about 10 feet in diameter at the ground surface. This does not imply a system detector can pick up readings from a small point source 5 feet away, but does suggest that scattered photons from larger elevated source areas (e.g. 100 m^2) are likely to be detected at that distance. Within this conceptual framework, the scanning track width for each vehicle's scanning system is estimated to be about 30 feet across, perpendicular to the direction of travel. Vehicle scanning speeds ranged between 2 and 10 mph depending on the roughness of the terrain, with an estimated average speed of 6-7 mph.

Data were downloaded daily into a project database and mapped using Gamma Viewer software developed by Tetra Tech (Tetra Tech Inc., 2006). In addition to daily quality control (QC) measurements used to evaluate instrument performance and insure data quality (discussed later), daily scan results were evaluated in terms of general agreement between onboard detectors to help identify any problems that may have occurred during data acquisition throughout the day. Gamma Viewer field maps also helped to assess adequacy of scan coverage on a daily basis.

Initial results indicated that spatial variability in gamma exposure rates at the site was relatively uniform in most areas, prompting use of fairly narrow data bin increments for mapping to better illustrate subtle patterns or trends in variability. In areas near ore bodies or proposed operational facilities, attempts were made to achieve scanning coverage close to 100%. After assessment of initial scanning results for these areas, along with experience gained from scanning other sites, a distance of 15-30 feet between the adjacent detectors in both vehicles was deemed practical and sufficient to resolve smaller-scale variability in the areas targeted for higher density scanning coverage. This vehicle spacing provides an estimated effective ground scan coverage of 75-90%. In one area targeted for high-density scanning, a mechanical problem with one of the vehicles necessitated a reduction in coverage to about 50%. Despite the reduction in coverage, spatial variability in this area can still be adequately determined from the scan track data.

In other portions of the license area, 5-10% was the initial target coverage though practical considerations such as safety, terrain, and natural obstructions often dictated actual distances maintained between vehicles. For most areas of the site, a target distance of 300 feet between vehicles was a conservative goal employed during scanning as this provides an estimated scan coverage of about 15%. In terrain deemed unsafe for ATV scanning, every attempt was made to scan as closely as possible along the perimeters of such terrain.

2.9.2.1.2 Cross-calibration of NaI Detectors against a High-Pressure Ionization Chamber

Gamma exposure rates measured by NaI detectors are only relative measurements as response characteristics of NaI detectors are energy dependent. True gamma exposure rates are best measured with an energy independent system such as a high-pressure ionization chamber (HPIC). Depending on the radiological characteristics of a given site, NaI detectors can have measurement values significantly higher than corresponding HPIC measurement values. NaI systems are useful for ISR mining sites because they can quickly and effectively demonstrate relative differences between pre- and post-operational gamma exposure rate conditions. Unless the same equipment and scanning geometry is used for both surveys, however, it is necessary to normalize the data to a common basis of comparison. This is the purpose of performing NaI/HPIC cross-calibration measurements. Cross-calibration insures that the results of future gamma scans, which are likely to use different detectors (and perhaps different detector heights, detector models, or measurement technologies), can be meaningfully compared against the results of pre-ISR gamma surveys.

To perform NaI/HPIC cross-calibrations, static measurements were taken at various discrete locations covering a range of exposure rates representative of the license area. At each cross-calibration measurement location, 10-20 individual HPIC readings were recorded and averaged. The center of the HPIC's sensitive volume is about 3 feet above the ground surface. A pin flag was pushed into the ground directly below the center of the HPIC to mark the exact spot for subsequent NaI measurements. The ATVs were then systematically positioned such that each NaI detector was located directly above the pin flag when taking measurements. For each NaI detector, 20 individual NaI readings at a 4.5-foot detector height were automatically collected and averaged using a special data acquisition software program. Mean values were recorded. A picture of this process is shown in Figure 2.9-3.

2.9.2.1.3 Gamma / Ra-226 Correlation Grids

Regulatory Guide 4.14 indicates that 40 baseline surface soil samples should be collected at 5-cm depths within 1.5 kilometers from the center of the milling area, with additional samples collected at air monitoring stations. NUREG-1569 suggests that 15-cm depths should also be sampled for consistency with decommissioning criteria. This guidance, combined with the large size of the Moore Ranch Uranium Project area, prompted a number of gamma/Ra-226 correlation grids to be sampled. Depending on the statistical strength of any gamma/Ra-226 relationship, such correlations can be used to estimate approximate Ra-226 soil concentrations (to a 15-cm depth) across the entire site based on gamma survey results.

Figure 2.9-3: Measurements for cross-calibration of NaI detectors against the HPIC at a 4.5-foot NaI detector height.

Correlation soil sampling was conducted as composite sampling over 10x10 meter grids. Within each grid, 10 soil sub-samples were collected to a depth of 15 cm then composited into a single sample. GPS coordinates were taken at the center of each sampling grid and recorded. Samples were sent to Energy Laboratories Incorporated (ELI) in Casper, WY for analysis of Ra-226 concentrations. Samples were dried, crushed, and thoroughly homogenized prior to analysis to insure a representative average radionuclide concentration over each 100 m^2 grid. Samples were then canned, sealed, and held 21 days prior to counting to allow sufficient ingrowth of radon and short-lived progeny before Ra-226 analyses were performed using high-purity germanium (HPGe) gamma spectroscopy (method E901.1).

Following methods described in Johnson et al. (2006), each 100 m^2 soil sampling grid was also scanned using the same ATV-mounted system and detector configuration used to scan the entire license area. The average NaI gamma reading over each grid was calculated and recorded to pair with the corresponding average Ra-226 concentration. A diagram depicting the sampling design for correlation grid measurements is shown in Figure 2.9-4.

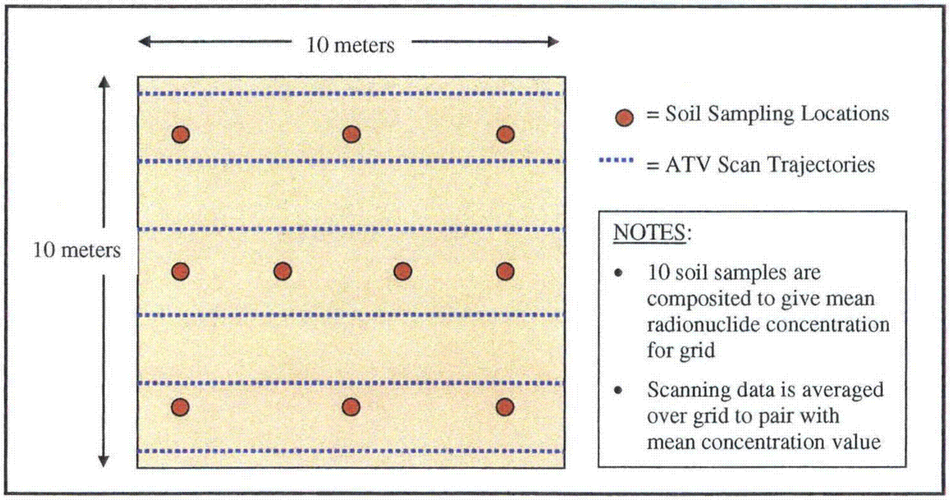

Figure 2.9-4: Diagram of soil sampling / gamma measurement correlation grid design.

2.9.2.1.4 Data Quality Assurance / Quality Control

Data quality assurance and quality control issues for the gamma survey at the Moore Ranch ISR license area are addressed in various ways. In general, quality assurance (QA) includes qualitative factors that provide confidence in the results, while quality control (QC) includes quantitative evidence that supports the validity of results (e.g. data accuracy and precision).

Quality control documentation for this project includes the following:

Daily QC measurements were performed for each NaI detector used in gamma scanning activities and results were plotted on system instrument control charts. Background as well as Cs-137 check-source QC measurements were taken each day indoors under a controlled geometry. Any instrument with measurements falling outside ± 3 standard deviations from the mean of all QC measurements on both background and check source charts indicates unacceptable instrument performance. Detectors performed within acceptable QC limits throughout the project.

Each day, the actual performance of each scanning system was tested in the field by scanning along a designated strip near the vehicle staging area. These "field strip" scans were conducted before and after each day's scanning. Under actual field conditions, scanning systems performed within acceptable QC limits throughout the project.

Re-scanning is an important tool for verification and demonstrating reproducibility of measurements in the field. Part of re-scan verification involved comparing data from various discrete measurement locations across the site (collected as part of HPIC cross-calibration and gamma/Ra-226 correlation grid activities) with original scan data. In general, these discrete measurement data showed good agreement with original continuous scan data (see Section 2.9.2.2.1).

With respect to soil sampling results from Energy Laboratories, final official reports indicated that all QC indicators (e.g. duplicate sample analyses, blanks, laboratory control samples, sample matrix spikes) "met EPA or laboratory specifications" for quality control. No flags or analytical problems were noted in the reports. Copies of these reports are available upon request.

Data quality assurance factors for this project include the following:

- All detectors used for gamma scanning at the license area, along with the HPIC, were calibrated by the manufacturer within one year prior to the date of use on this project.
- A detailed field log book of daily activities was maintained.
- Chain-of-custody protocols were followed for soil sampling and contract laboratory analyses.
- Scanning system methodologies and technology are published in peer-reviewed radiation protection and measurement research publications (Johnson et al., 2006; Meyer et al. 2005a; Meyer et al. 2005b; Whicker et al., 2006).

Daily scan results for each vehicle were reviewed for consistency along track paths for all onboard detectors. Obvious inconsistencies prompted further investigation and in any cases where technical problems were discovered or where the data were otherwise clearly incorrect, the affected data were omitted from the project database. Although a few incorrect data points were discovered and omitted during this project, there were no cases in which significant technical problems with scanning systems or data were detected.

2.9.2.2 Gamma Survey Results

2.9.2.2.1 Baseline Gamma Survey Results

NaI-based gamma survey results are shown in Figure 2.9-5. There is a relatively small degree of variability in gamma exposure rates in most areas of the Moore Ranch site. The centralized area of higher density scanning shown in Figure 2.9-5 covers the approximate region of planned wellfield operations and plant facility locations. The unscanned area along the northern boundary of the site was added to the license area after gamma survey activities had been conducted.

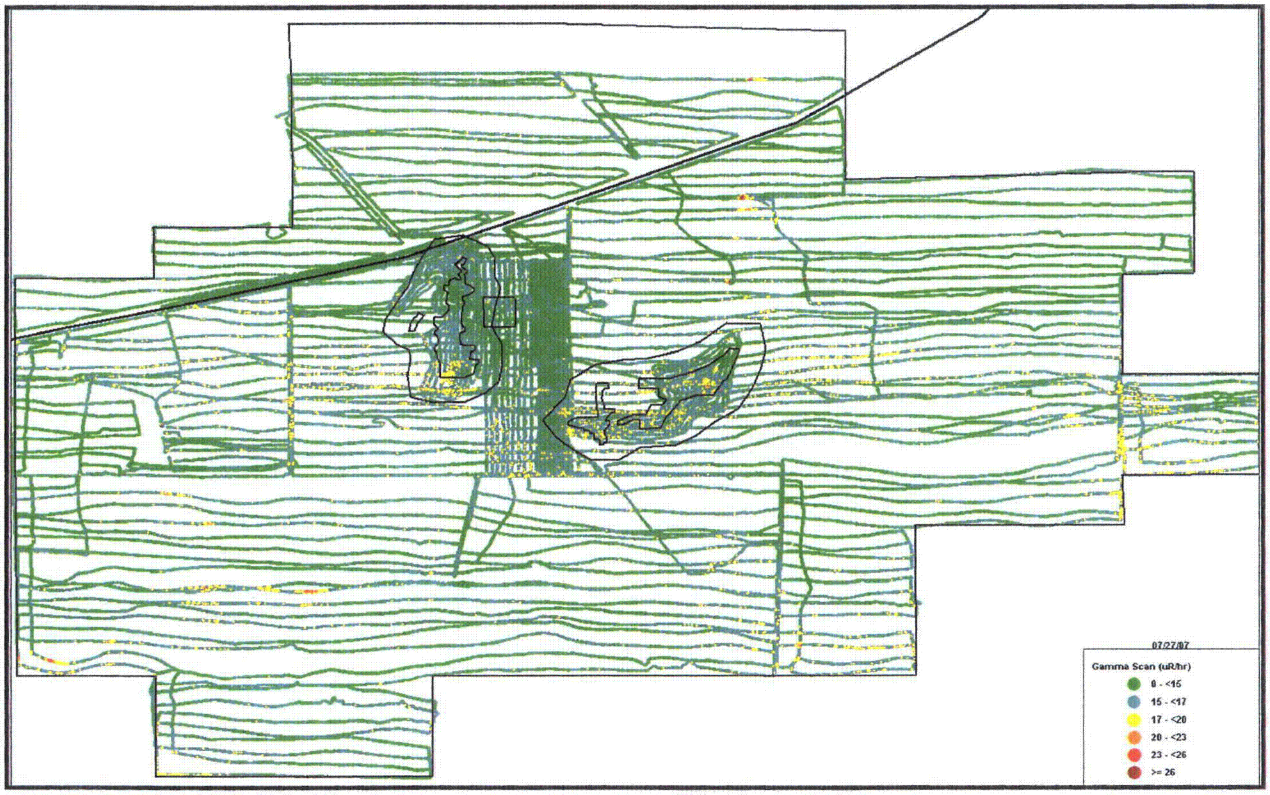

Figure 2.9-5: Baseline gamma survey results for the Moore Ranch site.

Discrete, re-scan measurements taken at HPIC cross-calibration and correlation grid survey locations generally confirmed the results of the ATV scans (Figure 2.9-6). In some cases, areas at the site with the highest readings appear to have certain geomorphologic features that could be associated with higher gamma exposure rates (e.g. hill tops or other areas with outcrops of exposed rocks or unusual soil layers). The most notable example of this was found in the vicinity of HPIC measurement locations "PIC-6" and "CP-6" as shown in the northeast corner of Figure 2.9-6. Here, in a small, localized area at the top of a hill, gamma readings at 4.5 feet above the ground surface approached 40 μR/hr. This is about twice that of scan readings found at most other locations across the site. There are numerous weathered sedimentary rocks lying on the ground surface at this location. Other locations with exposed rocks and soil that are similar in appearance did not exhibit the same apparent association with elevated gamma exposure rates.

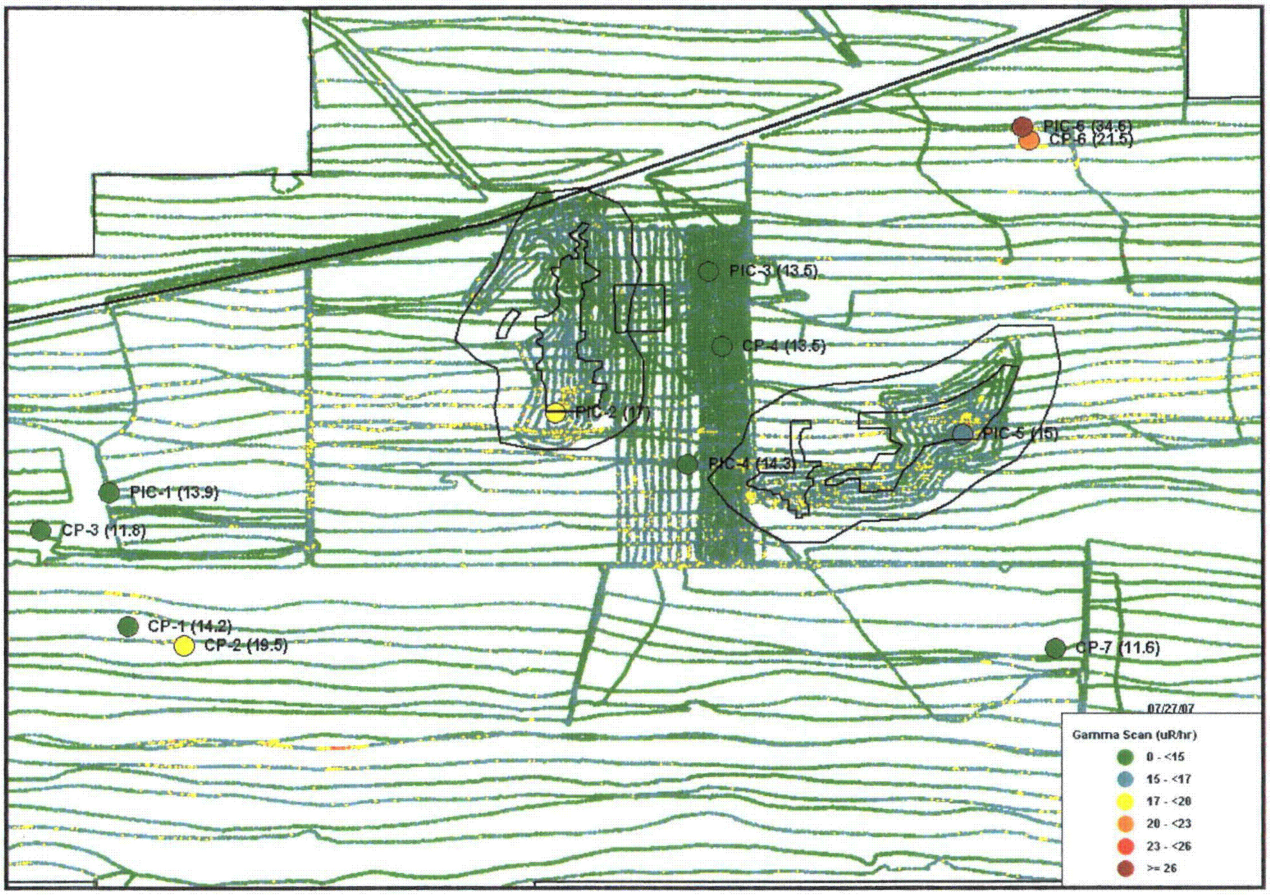

Figure 2.9-6: Select portion of baseline gamma survey results with discrete re-scan measurement overlays (denoted by the large circles).

2.9.2.2.2 HPIC / NaI Cross-calibration Results

Results of the cross-calibration between HPIC and NaI detectors positioned at 4.5-foot detector heights are shown in Figure 2.9-7. Regression coefficients are noticeably different from those measured by Tetra Tech at other uranium recovery sites. Typically, HPIC readings at such sites are expected to be about 60-70% that of NaI readings. In this case, HPIC readings averaged over 90% that of corresponding 3-foot NaI readings. Because this curve is influenced by the presence of a single data point that is of much higher magnitude than the rest (this data point was measured at location "PIC-6" as shown in Figure 2.9-6), another regression was performed that excluded this data point in order to better model the relationship only in the lower range of values (Figure 2.9-8). The vast majority of readings across the site fall in this category (e.g. below 20 μR/hr).

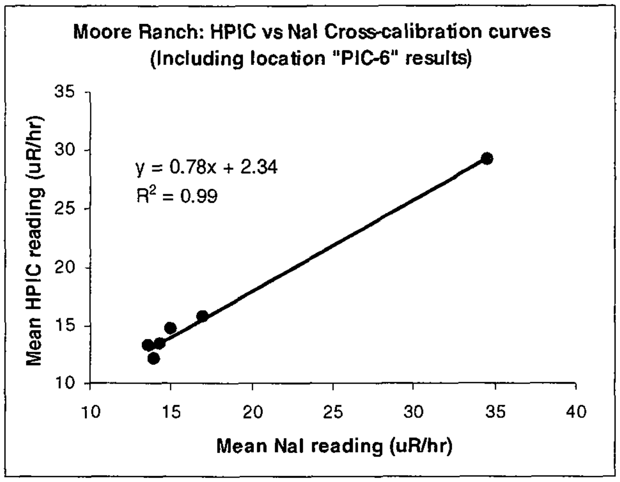

Figure 2.9-7: Cross-calibration curves for the HPIC versus NaI detectors positioned at 4.5-foot detector heights.

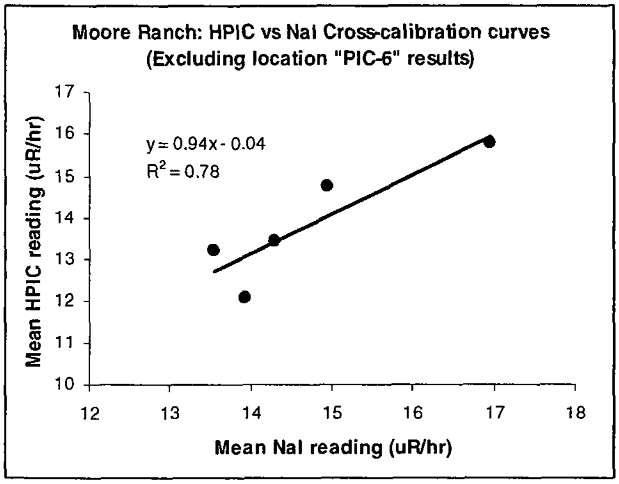

Figure 2.9-8: Cross-calibration curves for the HPIC versus NaI detectors positioned at 4.5-foot detector heights (excluding measurement results for location "PIC-6").

One possible explanation for the small difference between HPIC and NaI readings at the Moore Ranch site could be that terrestrial sources of radioactivity have less influence on NaI readings relative to higher energy cosmic radiation. Photons from terrestrial radioactivity reaching a NaI detector are mostly comprised of low energy scattered photons from adjacent areas. If soil radionuclide concentrations at the site are low, the difference in readings between NaI and HPIC measurement systems might be minimized relative to the site's elevation and related cosmic component. There is some evidence in the literature to support this idea. A study of gamma exposure rates across portions of Colorado indicated that the relative contribution of terrestrial and cosmic sources to total background gamma radiation (Figure 2.9-9) varies significantly depending on geophysical factors and elevation (Stone et al., 1999). Results of current and historical soil sampling data (Section 2.9.3), along with the Ra-226/gamma correlation grid measurements (Section 2.9.2.2.3), confirm generally low Ra-226 concentrations across the site (averaging about 1 pCi/g).

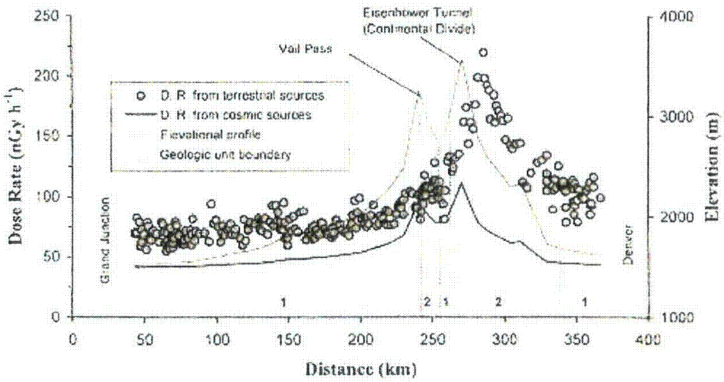

Figure 2.9-9: Estimated background dose rates to air from cosmic and terrestrial sources along I-17 from Grand Junction to Denver with generalized elevation profile and geology superimposed. Geologic units are simplified into two general types: 1 = sedimentary; 2 = granitic. (Adopted from Stone et al., 1999).

2.9.2.2.3 NaI/Ra-226 Correlation Grid Results

An overlay of correlation grid sampling locations, color-coded and annotated to show soil Ra-226 results on the baseline NaI gamma scan map, are shown in Figure 2.9-10. Soil sampling results represent average 15-cm depth Ra-226 concentrations over 100 m^2 sampling grids.

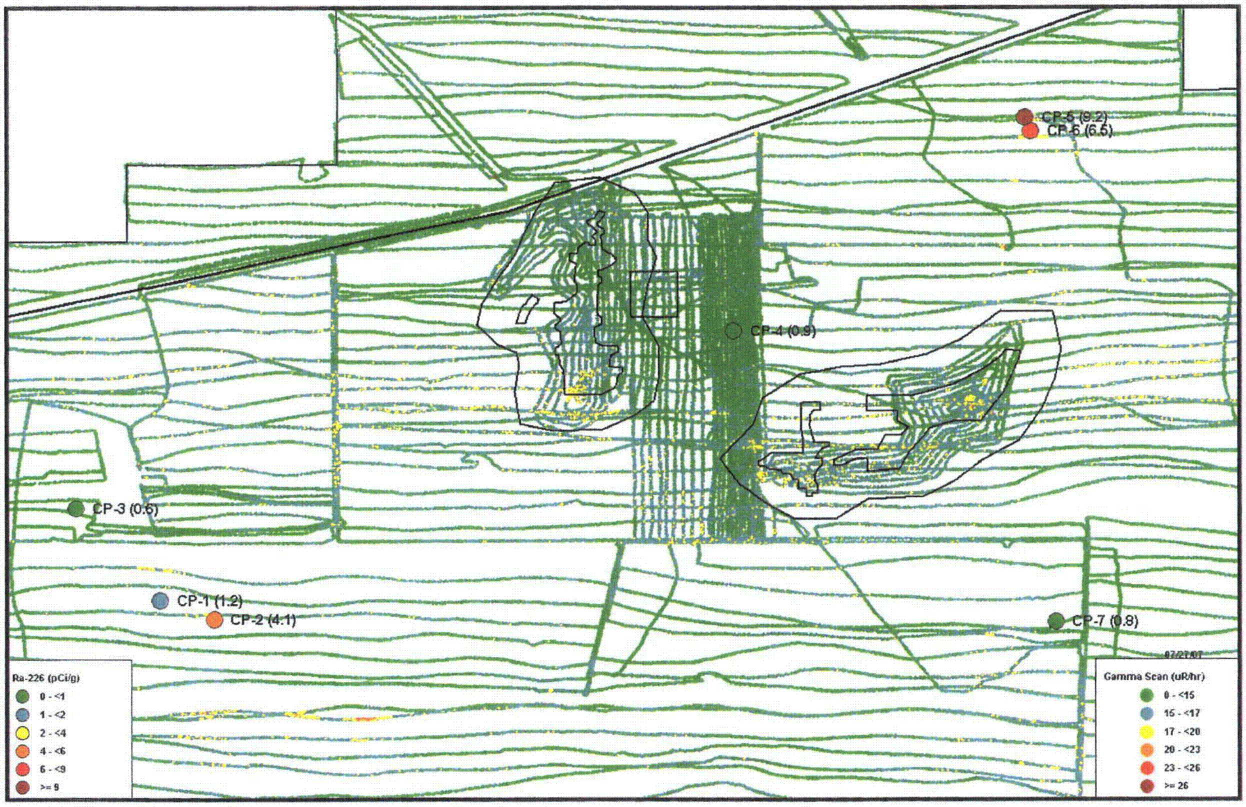

Figure 2.9-10: Overlay of correlation grid measurement locations and soil Ra-226 concentration results on the NaI gamma survey map.

Correlation grid data demonstrated a significant linear relationship (Figure 2.9-11) between mean Ra-226 soil concentration and mean gamma exposure rate across all sampling grids (Table 2.9-1).

Table 2.9-1: Correlation grid locations and results

Sample ID	Latitude dd North	Longitude dd West	Mean NaI Gamma Reading (µR/hr)	Mean Ra-226 (pCi/g)
CP-1	43.55824	105.87460	14.2	1.2
CP-2	43.55736	105.87204	19.5	4.1
CP-3	43.56264	105.87860	11.8	0.6
CP-4	43.57114	105.84736	13.5	0.9
CP-5	43.58133	105.83356	26.1	9.2
CP-6	43.58069	105.83328	21.5	6.5
CP-7	43.55719	105.83210	11.6	0.8

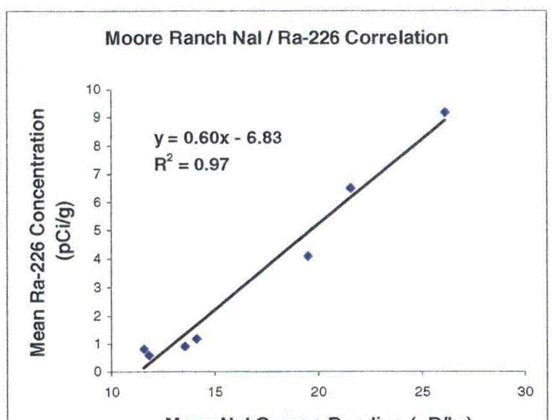

Figure 2.9-11: Correlation between Ra-226 soil concentration and NaI-based gamma exposure rate reading.

2.9.2.2.4 Final Gamma Exposure Rate Mapping

All 2006 gamma survey data have been normalized to a 3-foot HPIC equivalent gamma exposure rate to create a final data set for the Moore Ranch license area. Regression equations from both Figures 2.9-7 and 2.9-8 were used for this purpose. Data values greater than 15 μR/hr were converted to 3-foot HPIC equivalent using the regression in Figure 2.9-7, while all other data were converted using the regression in Figure 2.9-8. The cut-off value of 15 μR/hr was selected because this is the approximate value at which HPIC equivalent values from the two regression equations have about the same degree of difference with NaI readings (Table 2.9-2). Final official results of the gamma baseline survey of the Moore Ranch license area are shown in Figure 2.9-12, an E-sized version included at the end of Section 2.9.

Hypothetical 4.5-foot NaI Exposure Rate Reading (μR/hr)	3-foot HPIC Equivalent (μR/hr) using 4.5-foot Cross-calibration from Figure 2-6	3-foot HPIC Equivalent (μR/hr) using 4.5-foot Cross-calibration from Figure 2-7
12	11.7	11.2
13	12.5	12.2
14	13.3	13.1
15	14.0	14.1
16	14.8	15.0
17	15.6	15.9
18	16.4	16.9

Table 2.9-2: Comparison of predicted 3-foot HPIC equivalent values using the two 4.5-foot NaI cross-calibration equations from Figures 2-6 and 2-7

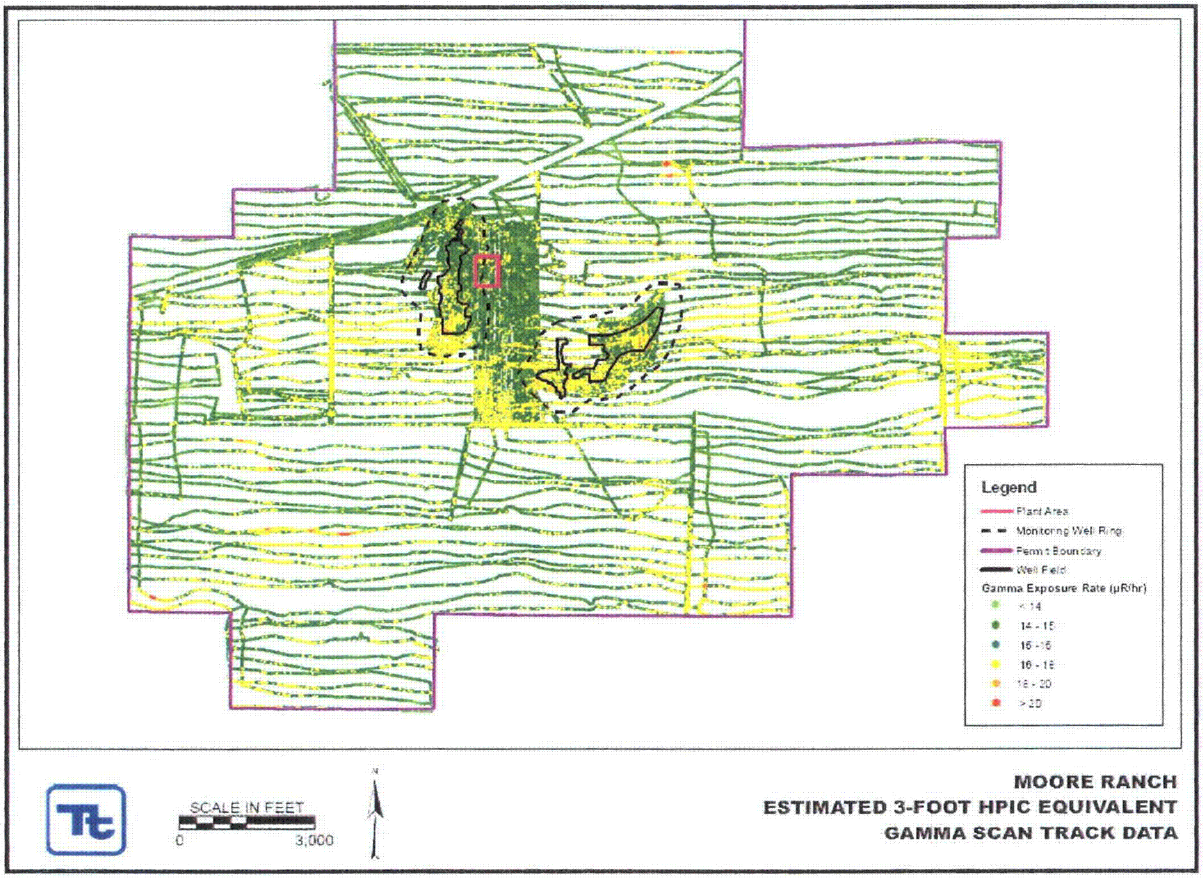

Figure 2.9-12: Estimated 3-foot HPIC equivalent gamma exposure rates in the Moore Ranch Area

Note that unlike the gamma maps shown in previous figures of this report, the final official scan track maps provided as Figure 2.9-12 have a different legend and respective gamma scale increments. This is because the data in the final maps of official gamma survey results have been converted to 3-foot HPIC equivalent values.

A kriging program in ArcGIS, along with the final data set shown in Figure 2.9-12, was used to develop continuous estimates of 3-foot HPIC equivalent gamma exposure rates throughout the license area. Kriging is a geostatistical interpolation procedure that fits a mathematical function to a specified number of nearest points within a defined radius to determine an output value for each location. A given "location" is represented by a cell of specified areal dimensions that may or may not include any measured data points. Values closer to the cell are given more weight than values further away and distances, directions, and overall variability in the data set are all considered in the predictive semivariogram model. Approximate input parameters used for this application were as follows:

Cell size:	10 feet × 10 feet
Max search radius:	300 feet
Semivariogram model:	Exponential
Number of nearest data points:	10

A map of estimated 3-foot HPIC equivalent gamma exposure rates throughout the permit area is shown in Figure 2.9-13, an E-sized version included at the end of Section 2.9.

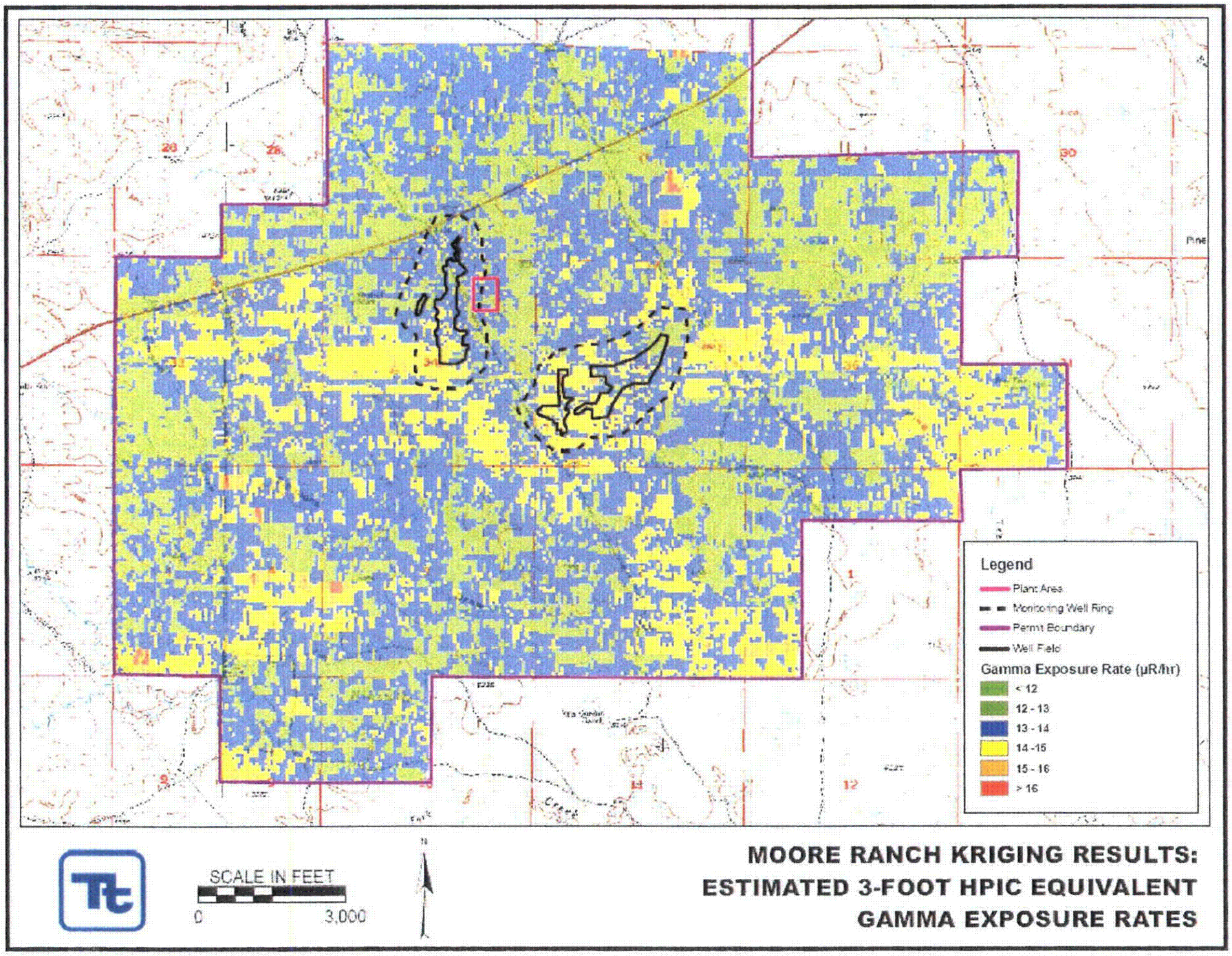

Figure 2.9-13: Continuous, kriged estimates of 3-foot HPIC equivalent gamma exposure rates in the Moore Ranch license area.

2.9.2.2.5 Soil Ra-226 Concentration Mapping

Based on gamma/Ra-226 correlation data, NaI scan results were also converted into estimates of soil Ra-226 concentrations across the site. The linear regression equation shown in Figure 2.9-11, however, did not provide the best possible fit to gamma readings less than 20 μR/hr (the range representing a vast majority of readings across the site as shown in Figure 2.9-14). A power function (Figure 2.9-15) provided a better fit to these data was thus used for converting gamma scan data to Ra-226 concentration estimates.

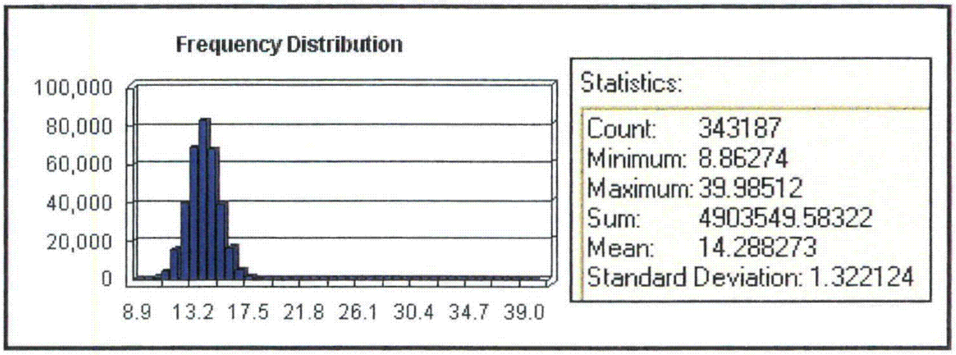

Figure 2.9-14: Frequency histogram of all NaI-based gamma exposure rate survey readings across the Moore Ranch license area.

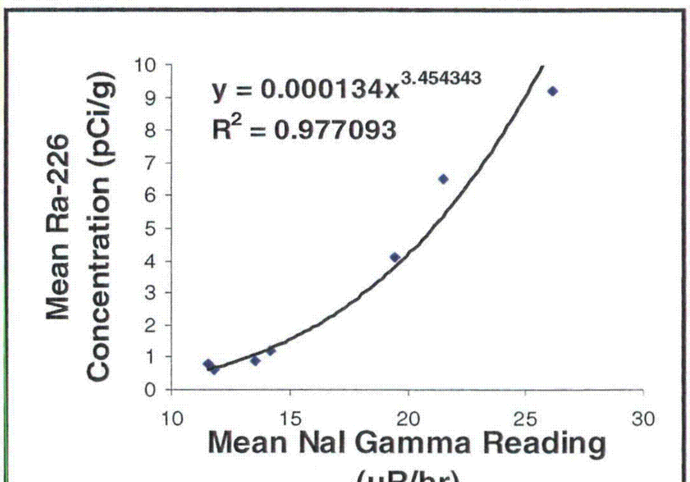

Figure 2.9-15: Power function fitted to gamma/Ra-226 correlation data to best model the relationship for the vast majority of readings across the site (readings < 20 μR/hr).

After conversion using the power function shown in Figure 2.9-15, the data were kriged to estimate continuous Ra-226 concentrations across the site as shown in Figure 2.9-16, an E-sized version included at the end of Section 2.9. This kriged soil Ra-226 concentration map shows good agreement with individual soil sample results (see Section 2.9.3.).

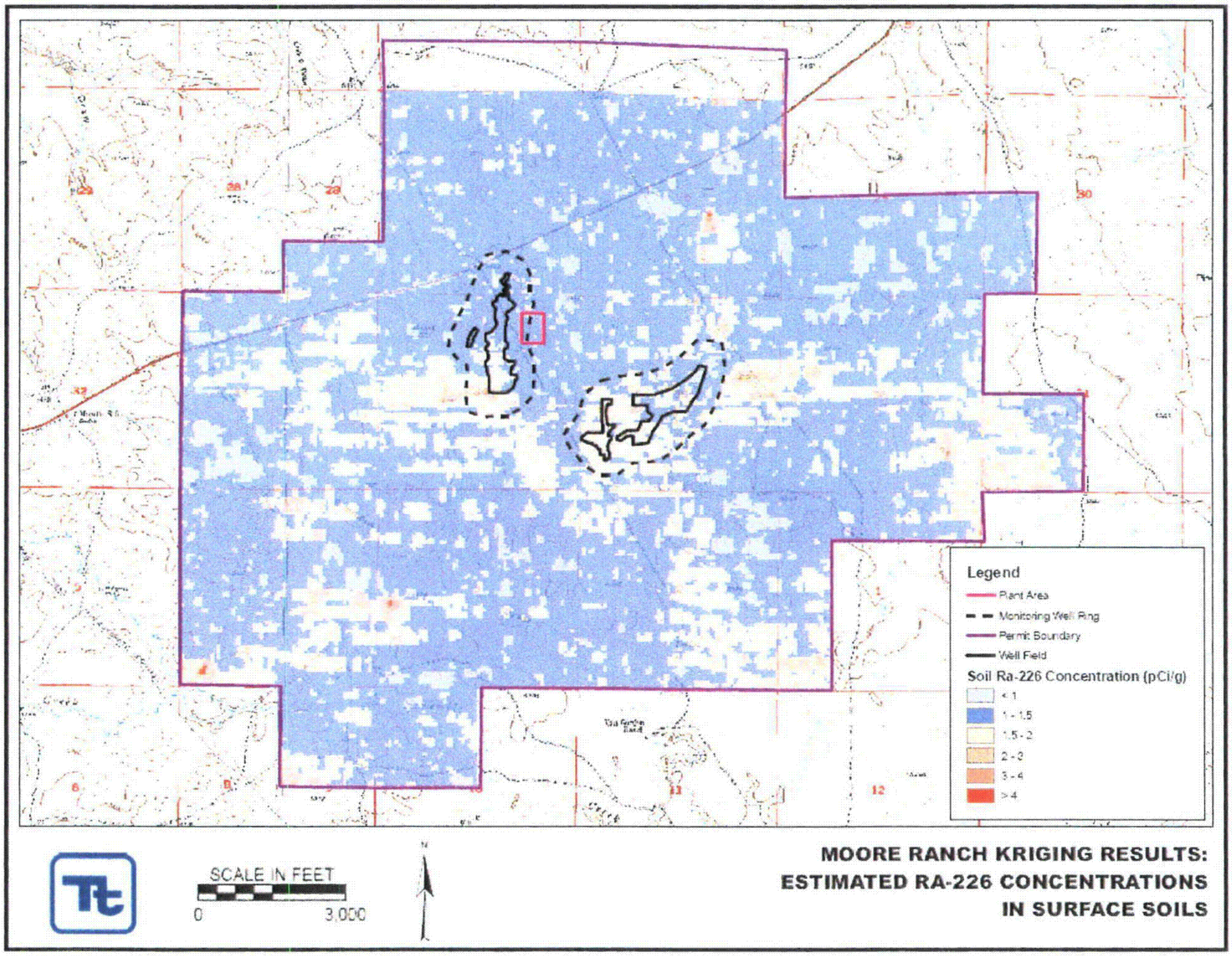

Figure 2.9-16: Continuous, kriged estimates of Ra-226 in the Moore Ranch license area based on gamma survey results.

2.9.2.2.6 Data Uncertainty

For comparison of pre- and post-operational measurements, converting gamma survey data to a 3-foot HPIC equivalent is only one important consideration. It is also necessary to take into account the degree of uncertainty in measurements. Sources of measurement uncertainty include instrument variability, spatial variability in gamma exposure rates (differences in readings due to small differences in measurement location), and temporal variability in gamma exposure rates (differences over time due to changes in soil moisture, barometric pressure, etc. which can affect ambient radon levels and/or photon attenuation characteristics of the soil profile).

Quality control measurements performed each day at an indoor location under controlled geometry indicated instrument variability for background readings was generally on the order of ± 1 μR/hr (based on standard deviations of 20 successive readings). Day-to-day variability in QC measurements along the field strip near the field staging area provides an indication of relatively small-scale spatial variability, as well as temporal variability over successive days, in background gamma exposure rates. Based on instrument control charts maintained over the course of the project, these sources of variability appear to also approach ± 1 μR/hr. These data and observations suggest that the total amount of potential uncertainty in NaI scanning measurements at the staging area ranged up to ± 2 μR/hr. The evidence indicates that approximately the same amount of uncertainty is applicable to 3-foot HPIC equivalent data. The field strip was located in an area having measured background gamma readings in the range of 12 – 14 μR/hr (at the lower end of the range of values found at the site). In areas of higher gamma exposure rates, the degree of uncertainty in measurements may be higher.

2.9.2.3 Conclusions

The 2006 baseline gamma survey of the Moore Ranch Uranium Project area in Campbell County, WY provides a detailed characterization of natural background gamma exposure rates and associated Ra-226 soil concentrations that exist at the site. The data collected are of high quality and should meet or exceed regulatory guidelines for baseline gamma surveys. These data will help insure that any potential radiological contamination that could result from ISR mining activities at the site can be effectively identified for remedial action. High density measurements, HPIC cross-calibrations, gamma/NaI correlations, thorough quality control, and advanced spatial analysis techniques provide the most thorough and accurate documentation possible of these important baseline radiological parameters. This is important for insuring that future remediation can return the land to its pre-operational state. The technology and methods used, while new to the ISR permitting process, are likely to benefit all stakeholders.

2.9.2.4 References

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2.9.3 SOIL SAMPLING

In addition to the estimates of surface soil Ra-226 concentrations presented in Section 2.9.2 of this report (based on gamma survey results), comprehensive baseline soil sampling and analyses were conducted in accordance with Regulatory Guide 4.14 protocols. Data from these sampling efforts represent discrete, systematic locations involving 5-cm sampling depths for surface soils and incremental profile sampling to a depth of 1 meter for subsurface soils (NRC, 1980). With gamma/Ra-226 correlation grid and subsurface soil samplings, 15-cm surface soil depths are also represented in the survey data set. Surface soil radionuclide concentration data from both 5-cm and 15-cm soil depths are presented in this section in accordance with NUREG-1569 application review recommendations (NRC, 2003). In addition, summary descriptive statistics for historical survey data from the site (Conoco, 1980) are presented for comparison purposes and to further augment the overall characterization of soil radionuclide concentrations across the site.

2.9.3.1 Methods

2.9.3.1.1 Surface Soil Sampling

Soil sampling for the current survey was conducted in April of 2007. The surface soil sampling design involved a radial grid pattern with the proposed Moore Ranch Central Plant at the center of the grid. Discrete soil samples were collected along transects radiating in 8 compass directions from the plant at 300 meter intervals. Each transect was about 1,500 meters long, resulting in the collection of 5 samples per transect for a total of 41 "grid samples" that were subsequently analyzed by Energy Laboratories, Inc. (ELI) in Casper, WY. All samples were analyzed for Ra-226, along with other select analytes that are automatically included with ELI's high-purity germanium (HPGe) gamma spectroscopy analysis package for analysis of naturally occurring radionuclides. In addition, 10 percent of these samples were further analyzed for natural uranium (U-nat), Th-230, and Pb-210. An additional 4 surface soil samples were collected at the air particulate monitoring stations per Regulatory Guide 4.14 specifications.

All grid and air station surface soil samples were collected with a hand trowel to a depth of 5 cm, double bagged, and labeled. Location ID numbers, date, and GPS coordinates for each sampling location were recorded in the field log book. Samples were hand-delivered to ELI in Casper, WY along with chain of custody / analysis request forms. Samples were dried, crushed, ground, and thoroughly homogenized prior to analysis. For samples analyzed by HPGe gamma spectroscopy, aliquots were weighed and placed into counting tins, then sealed for about 21 days prior to counting to allow ingrowth of short-lived Ra-226 progeny and approximate equilibrium conditions to become established. Separate aliquots were used for analyses requiring wet radiochemical methods.

2.9.3.1.2 Depth Profile Soil Sampling

Five depth profile sampling locations were selected also based on Regulatory Guide 4.14 recommendations. One location was in the approximate center of planned Moore Ranch Central Plant facilities, with the other four locations located along radial transects used for surface soil sampling, at 750 meters from the plant in four compass directions.

Samples were collected with a hand-coring soil sample collector in 15-cm increments to a depth of 105 cm or until rocks prevented further coring device penetration. Sample collection, lab delivery, chain of custody, sample preparation, and analysis protocols were the same as those described above in Section 2.9.3.1.1 for surface soil samples. All soil depth profile samples were analyzed by HPGe gamma spectroscopy for Ra-226 and ELI's suite of naturally occurring radionuclides. The top-most and bottom-most layers of each depth sampling location were further analyzed for natural U, Th-230, and Pb-210 by wet radiochemical methods.

2.9.3.2 Soil Sampling Results

2.9.3.2.1 Surface Soil Sample Results

Frequency histograms of Ra-226 concentrations for all 0-5 and 0-15 depth samples are provided in Figure 2.9-17, with tabulations of respective summary statistics. The 0-15 cm result statistics include a mix of discrete, depth profile sample locations and composited correlation grid sampling locations. In both categories, results exceeding 2 pCi/g are from samples selectively collected in small, localized areas of higher gamma exposure rate readings. Excluding these few higher results, surface soil Ra-226 concentrations across the site averaged about 1.1 pCi/g.

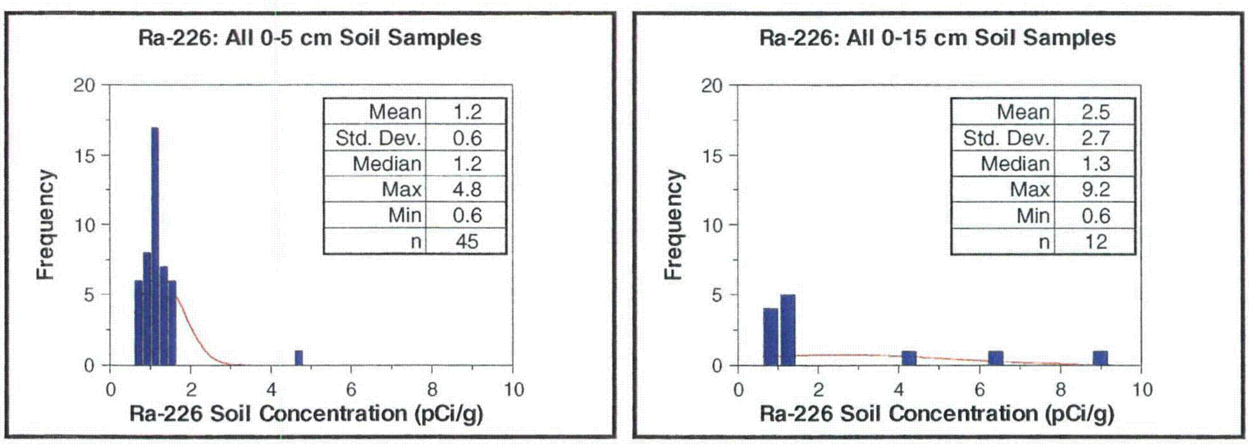


Figure 2.9-17: Frequency histograms and tabular summary statistics for soil Ra-226 concentrations among 0-5 cm and 0-15 cm samples. The 0-15 cm samples included composited correlation grid samples and discrete, depth profile sampling locations.

All 2007 surface soil sampling locations are shown in Figure 2.9-18, with color-coded Ra-226 ranges and annotations to show individual results. Given that low-end measurements averaged about 1.1 pCi/g, and respective analytical uncertainty was on the order of ± 0.2 – 0.5 pCi/g, it is reasonable to conclude that aside from relatively small, localized areas where consistently higher gamma readings exist at the site, baseline soil Ra-226 concentrations are unlikely to exceed 2 pCi/g. This conclusion is supported by comparison of measured soil sampling results with the continuous, kriged map of estimated soil Ra-226 concentrations based on gamma scan data (Figure 2.9-19).

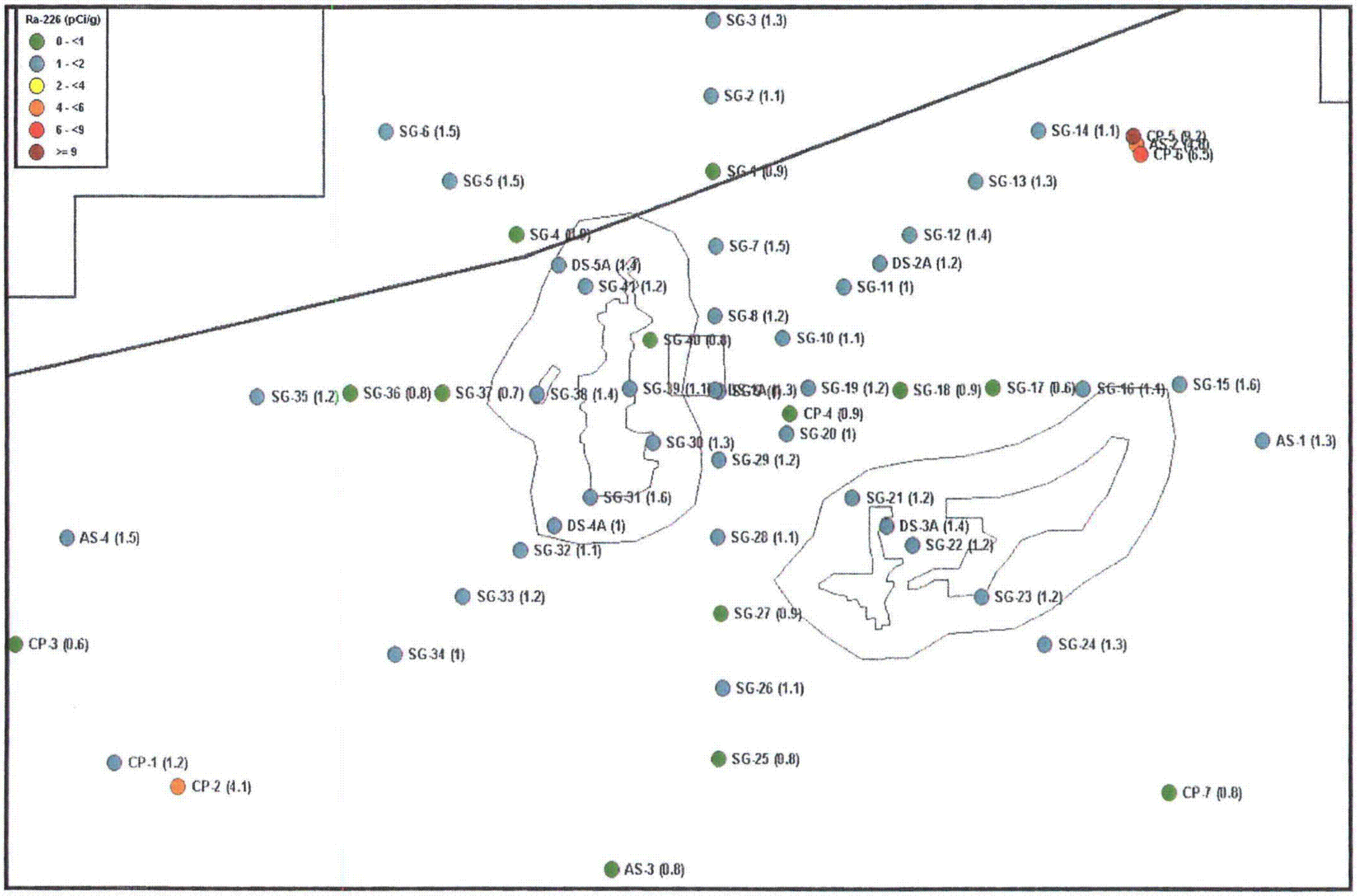


Figure 2.9-18: Surface soil sampling locations with color-coded Ra-226 ranges and individually annotated ID numbers and results.

In general, Figure 2.9-19 shows good agreement between measured and estimated Ra-226 concentrations in surface soils. Although there are apparent differences in some cases, mapping increment breakpoints are somewhat arbitrary for illustrative purposes, and the width of mapping increments is relatively narrow in relation to analytical uncertainties. Furthermore, mapped soil sample results primarily represent discrete samples and small-scale spatial variability (e.g. within a few meters) can be equally significant. In other words, small numerical differences between measured and estimated values (e.g. 0.1 – 0.5 pCi/g) can suggest disagreement on the map in Figure 2.9-19, even though respective results are unlikely to be significantly different in a statistical or truly quantitative sense. Overall, soil sampling results support the validity of continuous kriged estimates of Ra-226 concentrations based on gamma scan data (Figures 2.9-14 and 2.9-19).

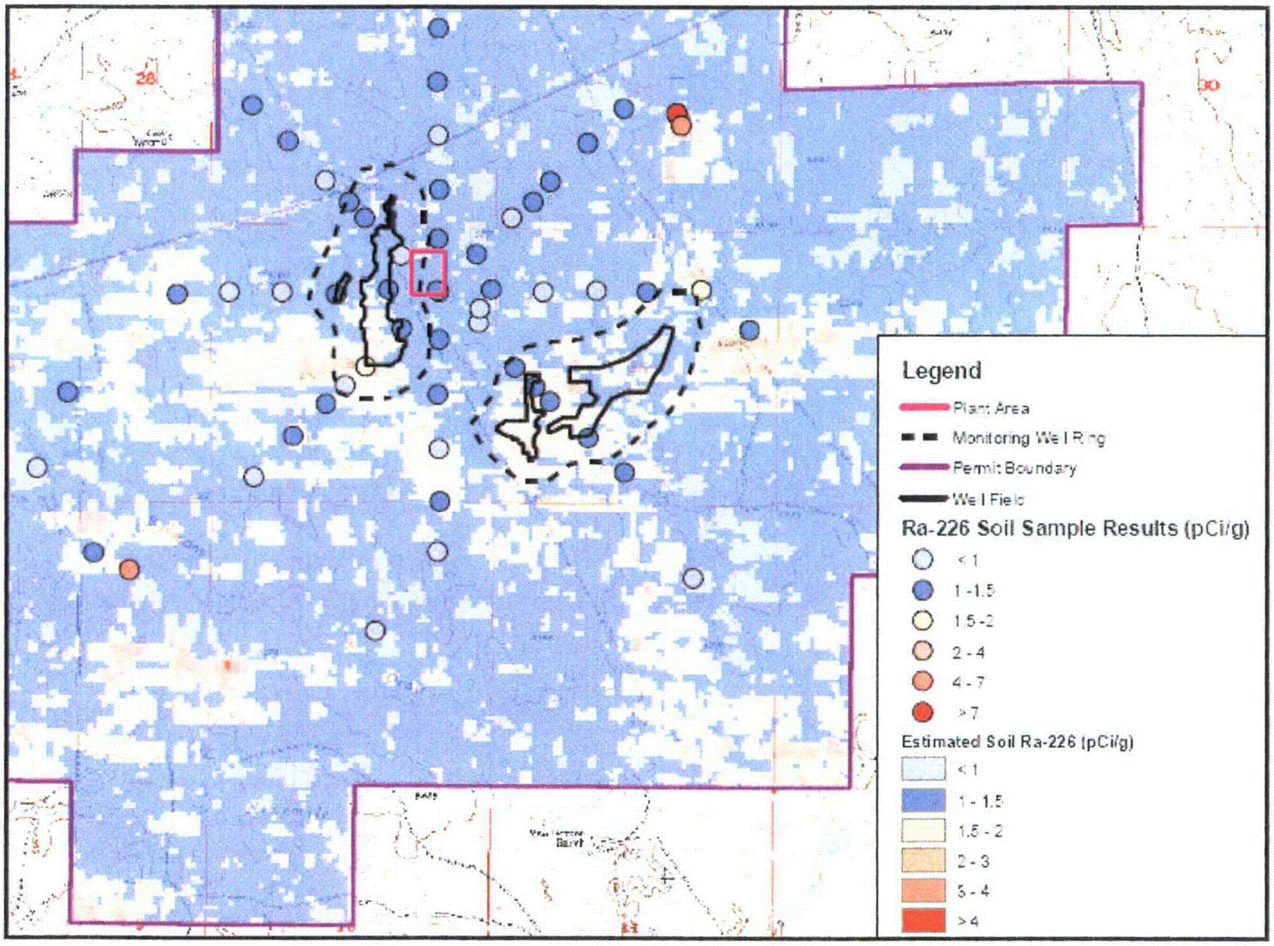


Figure 2.9-19: Gamma survey-based estimates of soil Ra-226 concentrations across the Moore Ranch license area, with an overlay of actual surface soil sample results. Note that mapping increments in the upper half of the scale for soil sample results are widened to better illustrate measured Ra-226 results exceeding 4 pCi/g.

The historical Conoco survey data for surface soil Ra-226 concentrations (Figure 2.9-20) also agree reasonably well with the above results. A t-test comparison of 0-5 cm depth soil sampling results from the current and historical surveys did not reveal a significant difference between data sets at the 95% confidence level ($p = 0.08$), but a non-parametric Wilcoxon Rank Sum did ($p = 0.009$). There is no documented information on what analytical methods were used in the Conoco study. Despite some apparent distributional differences, mean and median values were nearly identical. Qualitatively, both data sets support the earlier conclusion that outside of the few relatively small areas of the site with elevated gamma readings, Ra-226 concentrations in surface soils are unlikely exceed 2 pCi/g. It does not appear that any areas with significantly elevated gamma readings were sampled in the historical survey.

Summary statistics for analytes other than Ra-226 in surface soil samples are given in Table 2.9-3. These statistics are given by sample series as denoted by their respective sample ID prefixes [AS = air station; SG = soil grid; DS (A) = depth sample (surface layer)], as well as for the historical survey data. Cases of higher mean and maximum values in the AS series are attributable to a sample collected in a location where high Ra-226 and gamma readings were also found (see sample locations AS-2, CP-5 and CP-6 in Figure 2.9-18). In general, historical survey data results for these analytes compare reasonably well with current survey data. This is particularly true when looking at median values, which helps reduce the influence of at least one notable exception - the comparatively high maximum Pb-210 value of 60 pCi/g found in one historical sample.

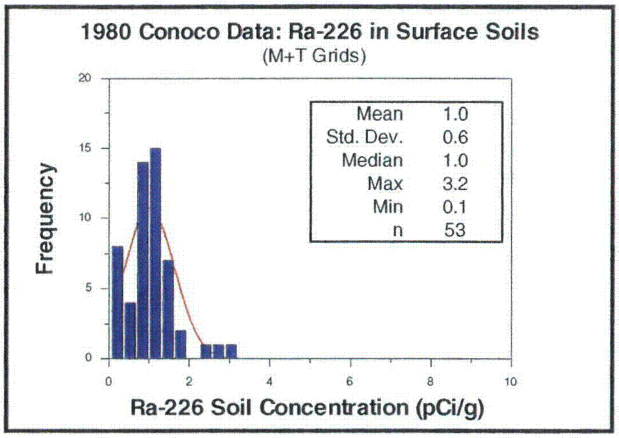


Figure 2.9-20: Frequency histogram and tabular summary statistics for 0-5 cm soil Ra-226 concentrations from the historical Conoco baseline survey.

Table 2.9-3: Summary statistics for Pb-210, Th-230, and U-nat in surface soil samples.

Sample Series	Sample Depth (cm)	Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
AS	0-5	Pb-210	2.3	1.0	2.3	3.5	1.1	4
		Th-230	1.4	1.9	0.5	4.3	0.3	4
		U-nat	1.2	1.1	0.8	2.8	0.6	4
SG	0-5	Pb-210	3.2	1.3	3.2	4.6	2.0	4
		Th-230	0.4	0.1	0.4	0.5	0.3	4
		U-nat	0.8	0.1	0.8	0.9	0.7	4
DS (A)	0-15	Pb-210	0.5	0.4	0.5	1.2	0.1	5
		Th-230	0.4	0.1	0.4	0.5	0.3	5
		U-nat	0.9	0.1	0.9	1.0	0.7	5
Historical Data	0-5	Pb-210	8.4	18.2	2.7	60	1.4	10
		Th-230	1.4	0.6	1.3	2.7	0.8	10
		U-nat	1.6	1.6	0.9	5.1	0.0	10

2.9.3.2.2 Subsurface Soil Sample Results

Subsurface sampling locations and respective surface layer Ra-226 results are shown in Figure 2.9-18, with "DS" sample ID prefixes (labeling for sample location DS-1 is obscured in the figure, but is located in the very center of the radial grid pattern where processing plant facilities will be located). Summary statistics for each depth sample increment and each indicated Regulatory Guide 4.14 analyte are provided in Table 2.9-4. There are no readily apparent trends between analyte and depth, suggesting that vertical distribution of these radionuclides is fairly consistent to a depth of 1 meter. None of the localized areas at the site with consistently higher gamma readings were sampled for subsurface soil profiles as the applicable Regulatory Guide 4.14 grid pattern for this investigation was followed.

Table 2.9-4: Summary statistics for Ra-226, Pb-210, Th-230, and U-nat in depth profile soil samples.

Sample Series	Sample Depth (cm)	Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
DS (A)	0-15	Ra-226	1.3	0.2	1.3	1.4	1.0	5
		Pb-210	0.5	0.4	0.5	1.2	0.1	5
		Th-230	0.4	0.1	0.4	0.5	0.3	5
		U-nat	0.9	0.1	0.9	1.0	0.7	5
DS (B)	15-30	Ra-226	1.4	0.2	1.3	1.6	1.2	5
DS (C)	30-45	Ra-226	1.4	0.3	1.3	1.8	1.1	5
DS (D)	45-60	Ra-226	1.3	0.2	1.2	1.6	1.1	5
DS (E)	60-75	Ra-226	1.1	0.3	1.3	1.4	0.8	5
DS (F)	75-90*	Ra-226	1.1	0.3	1.3	1.4	0.8	5
DS (G)	90-105*	Ra-226	1.1	0.3	1.1	1.4	0.9	4
		Pb-210	0.3	0.1	0.3	0.4	0.1	5
		Th-230	0.5	0.1	0.5	0.7	0.3	5
		U-nat	1.5	1.2	0.8	3.2	0.6	5
DS (A-G)	All depths	Ra-226	1.2	0.2	1.3	1.8	0.8	34
		Pb-210	0.4	0.31	0.4	1.2	0.1	10
		Th-230	0.5	0.13	0.5	0.7	0.3	10
		U-nat	1.2	0.87	0.9	3.2	0.6	10

*One sample was truncated at 85 cm due to rock

Despite differences in depth sampling increments, the historical survey data for Ra-226 in subsurface samples (Table 2.9-5) agree well with the summary statistics provided above in Table 2.9-4. General similarities can also be seen for Pb-210, Th-230, and U-nat in most cases (Table 2.9-6). As with 2007 survey data, there do not appear to be any significant differences or trends with depth for the historical radionuclide data.

Table 2.9-5: Summary statistics of historical baseline survey data (Conoco, 1980) for Ra-226 in subsurface depth profile soil samples.

Sample Series	Sample Depth (ft)	Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
M+T Grids	0-1	Ra-226	1.3	0.4	1.3	2.1	0.7	10
M+T Grids	1-2	Ra-226	1.3	0.5	1.3	2.4	0.8	10
M+T Grids	2-3	Ra-226	1.1	0.4	1.2	1.9	0.6	10

Table 2.9-6: Individual sample results for Pb-210, Th-230, and U-nat in subsurface soil samples from the historical baseline survey.

Sample Series	Sample Depth (ft)	Analyte	Result (pCi/g)
M Grid (center)	0-1	Pb-210	0.8
		Th-230	1.0
		U-nat	1.6
M Grid (center)	1-2	Pb-210	1.6
		Th-230	1.4
		U-nat	2.5
M Grid (center)	2-3	Pb-210	0.6
		Th-230	1.0
		U-nat	1.7
T Grid (center)	0-1	Pb-210	0.6
		Th-230	1.4
		U-nat	2.4
T Grid (center)	1-2	Pb-210	1.1
		Th-230	2.1
		U-nat	2.3
T Grid (center)	2-3	Pb-210	3.1
		Th-230	3.3
		U-nat	3.6

2.9.3.3 Conclusions

Baseline soil radionuclide data from the 2007 survey were collected and analyzed according to Regulatory Guide 4.14 protocols. The corresponding historical survey data generally corroborate 2007 survey results. These data sets, combined with the continuous kriged estimates of Ra-226 concentrations across the site based on the extensive gamma survey data presented in Section 2.9.2, provide a thoroughly detailed and comprehensive characterization of existing soil radionuclide concentrations across the site. This information should meet respective baseline characterization requirements as indicated by the USNRC and the WDEQ/LQD for ISR licensing/permitting applications.

Note: Radionuclides listed in Tables 2.9-4 through 2.9-6 are believed to be in approximate secular equilibrium. Apparent discrepancies may be due to differences in analytical techniques (gamma spectroscopy versus dissolution/wet radiochemistry).

2.9.3.4 References

Conoco, Inc. 1980. Environmental *Report for the Sand Rock Mill Project, Campbell County, Wyoming*. Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

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

2.9.4 Sediment Sampling

In April of 2007, baseline sediment sampling was conducted at the Moore Ranch Uranium Project area in accordance with Regulatory Guide 4.14 protocols (NRC, 1980). Both ephemeral stream drainage channels and surface water impoundments were sampled. In all, 7 samples were collected from three primary stream drainage channels found at the site, at license area boundaries both upstream and downstream of the planned plant location. Stream drainage channel sediment sampling in April was the first of two planned sampling events, the other scheduled to occur in late summer or fall of 2007. These two sampling events are intended to characterize radionuclide content in stream sediments during seasonal runoff and low-flow conditions (NRC, 1980). Although drainage channel sampling locations generally had moist sediments during the spring sampling, none of locations sampled had flowing or standing water present and most were grassy in nature (Figure 2.9-21).

Figure 2.9-21: Sediment sampling: typical ephemeral stream drainage channel at the Moore Ranch site.

Sediment samples were collected from 13 surface water impoundments representing the majority of impoundments found at the site (primarily stockponds). These locations all had surface water present at the time of sampling (Figure 2.9-22). For surface water impoundment sediments, a one-time sampling event is indicated by Regulatory Guide 4.14 as sufficient to document respective radiological conditions.

Figure 2.9-22: Sediment sampling: typical surface water impoundment at the Moore Ranch site.

This section presents results of 2007 sediment sampling at the Moore Ranch Uranium Project area. Summary statistics of sediment sampling data from the historical survey of the site (Conoco, 1980) are presented for comparison purposes and to further augment the overall characterization of radionuclide concentrations in sediments across the site.

2.9.4.1 Methods

2.9.4.1.1 Stream Sediment Sampling

Stream sediment sampling locations were determined from topographical maps to represent the primary drainages found at the site. At each location, four sediment sub-samples were collected with a hand trowel to a depth of 5 cm each, along a transect spanning the width of the lowest portion of the ephemeral stream channel. The four sub-samples were composited to represent the average radionuclide concentration across the drainage channel. Composite sediment samples were subsequently double bagged, and labeled. Location ID numbers, date, and GPS coordinates for each sampling location were recorded in the field log book.

Samples were hand-delivered to ELI in Casper, WY along with chain of custody / analysis request forms. Samples were dried, crushed, ground, and thoroughly homogenized prior to analysis. All samples were analyzed for Ra-226, along with other select analytes that are automatically included with ELI's gamma spectroscopy analysis package for analysis of naturally occurring radionuclides. In addition, all stream sediment samples were further analyzed for U-nat, Th-230, and Pb-210. For samples analyzed by HPGe gamma spectroscopy, aliquots were weighed and placed into counting tins, then sealed for about 21 days prior to counting to allow ingrowth of short-lived Ra-226 progeny and approximate equilibrium conditions to become established. Separate aliquots were used for analyses requiring wet radiochemical methods.

2.9.4.1.2 Surface Water Impoundment Sediment Sampling

Sediment sampling locations for surface water impoundments (hereafter referred to as "ponds") were determined from a combination of topographical maps and consultation with a staff member from EMC familiar with actual pond locations (most ponds were not shown on available maps). At each pond, a single grab sample of sediment was collected with a hand trowel to a depth of 5 cm, in a location near the waters edge that was both convenient for sampling and that appeared relatively undisturbed (Figure 2.9-23). Pond sediment samples were double bagged and labeled. Location ID numbers, date, and GPS coordinates for each sampling location were recorded in the field log book.

Figure 2.9-23: Pond sediment sampling at the Moore Ranch Uranium Project site.

Lab delivery, chain of custody, sample preparation, and analysis protocols for pond sediment samples were the same as those described in above in Section 2.9.4.1.1 for stream sediment samples. All samples were analyzed by gamma spectroscopy for Ra-226 and ELI's suite of naturally occurring radionuclides, as well as for U-nat, Th-230, and Pb-210 by wet radiochemical methods.

2.9.4.2 Sediment Sampling Results

2.9.4.2.1 Stream Sediment Sample Results

Descriptive summary statistics of the stream sediment data for each indicated Regulatory Guide 4.14 analyte are provided in Table 2.9-7. Individual stream drainage channel sampling locations and respective Ra-226 results are shown in Figure 2.9-24, with "SS" sample ID prefixes. In general, stream sediment baseline results are similar to those found for both surface and subsurface soils at the site.

Table 2.9-7: Summary statistics for radionuclide concentrations in stream sediment samples from the Moore Ranch Uranium Project area.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.2	0.30	1.3	1.6	0.7	7
Pb-210	1.7	0.80	1.5	3.2	1.0	7
Th-230	0.5	0.10	0.5	0.7	0.4	7
U-nat	0.8	0.18	0.8	1.0	0.5	7

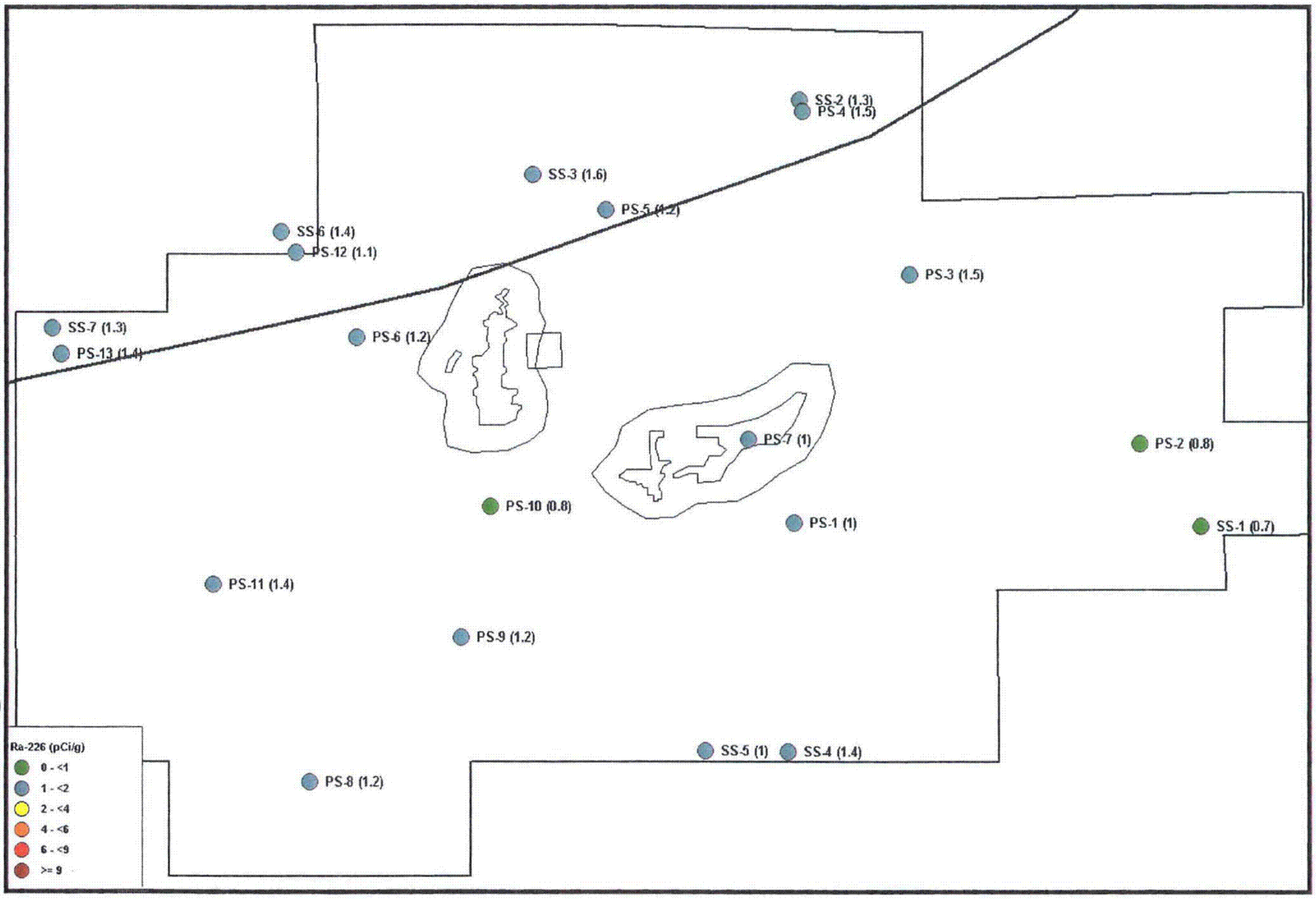


Figure 2.9-24: Sediment sampling locations and respective Ra-226 concentration results for both ephemeral stream drainage channels and surface water impoundments (ponds).

Stream sediment sample results from the historical survey (Conoco, 1980) are summarized in Table 2.9-8. Results for Pb-210 were not completed at the time of the Conoco report, but the other results are very similar to results from the 2007 survey. Because the historical samples were collected in the fall of 1980, they represent "low-flow" conditions and suggest that seasonal variations in stream sediment radionuclide concentrations are not likely to be significant. Furthermore, historical "low-flow" data combined with "high-flow" data collected in the spring of 2007 might be considered by NRC and WDEQ as sufficient overall documentation of stream sediment conditions with respect to license applications.

Table 2.9-8: Summary statistics for radionuclide concentrations in stream sediment samples from the historical 1980 survey.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.3	0.46	1.2	1.8	0.8	4
Pb-210*	-	-	-	-	-	-
Th-230	1.4	0.40	1.4	2.0	0.9	5
U-nat	1.9	1.06	2.1	3.3	0.6	5

* Analysis results not completed at time of 1980 Conoco report

2.9.4.2.2 Pond Sediment Sample Results

Descriptive summary statistics of these data for each indicated Regulatory Guide 4.14 analyte are provided in Table 2.9-9. Individual pond sediment sampling locations and respective Ra-226 results are shown in Figure 2.9-10, with "PS" sample ID prefixes. In general, pond sediment results are similar to those of stream sediments as well as surface/subsurface soils at the site.

Table 2.9-9: Summary statistics for radionuclide concentrations in 2007 pond sediment samples from the Moore Ranch Uranium Project area.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.2	0.24	1.2	1.5	0.8	13
Pb-210	1.1	0.57	1.1	2.2	-0.1	13
Th-230	0.5	0.20	0.4	1.0	0.3	13
U-nat	1.1	0.78	1.0	2.7	0.1	13

Pond sediment sample results from the historical survey (Conoco, 1980) are summarized in Table 2.9-10. Results for Pb-210 were not completed at the time of the Conoco report, but the other results agree reasonably well with pond sediment results from the 2007 survey.

Table 2.9-10: Summary statistics for radionuclide concentrations in pond sediment samples from the historical 1980 survey.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.3	0.93	0.9	3.5	0.4	12
Pb-210*	-	-	-	-	-	-
Th-230	1.3	0.28	1.3	1.6	0.8	12
U-nat	2.1	1.20	1.7	4.5	0.5	13

* Analysis results not completed at time of 1980 Conoco report

2.9.4.3 Conclusions

Baseline sediment radionuclide data from the 2007 survey were collected and analyzed according to Regulatory Guide 4.14 protocols. The corresponding historical survey data generally corroborate 2007 survey results. With respect to stream sediments, the 2007 and historical data sets, while technically incomplete individually, combined may be considered sufficient by the NRC and WDEQ/LQD in terms of adequately characterizing potential seasonal variations in overall radionuclide concentrations. The scheduled second sampling of stream sediments during the fall of 2007 will be carried out as planned and results provided to both agencies as soon as completed. With respect to pond sediment data, the historical data simply augment the 2007 survey data resulting in a more robust respective characterization. This information should be sufficient to meet the completeness requirements for site characterization of sediment radionuclide concentrations for administrative review as indicated by the USNRC and the WDEQ/LQD.

2.9.4.4 References

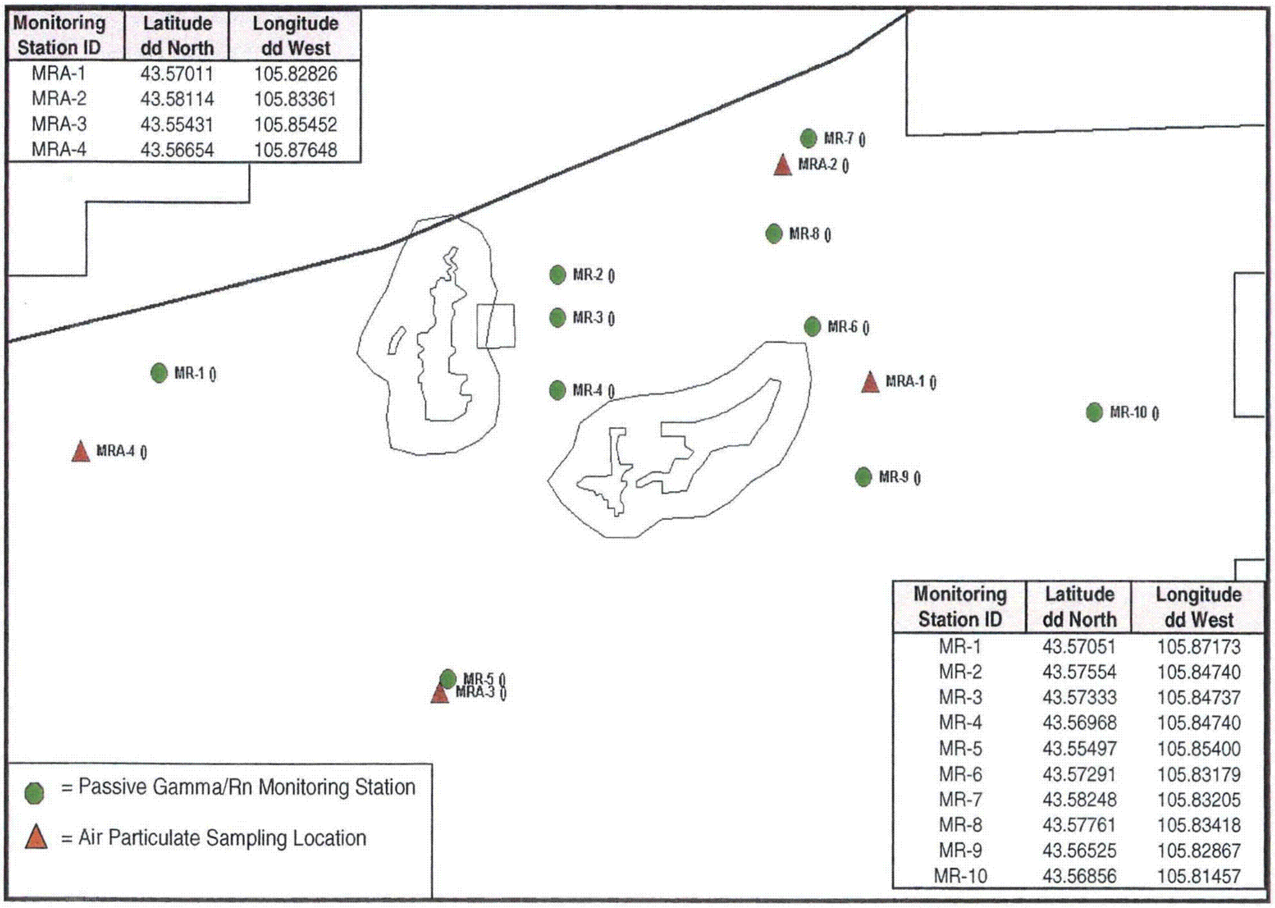
Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming.* Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

2.9.5 Ambient Gamma and Radon Monitoring

Continuous passive monitoring of ambient gamma dose rates and radon concentrations was initiated in December 2006. Regulatory Guide 4.14 calls for 12 consecutive months of respective monitoring data as part of the overall radiological characterization of the site (NRC, 1980). These data are being collected and reported on a quarterly basis. As of the effective date of this report, 2 quarters of 2006-2007 monitoring data (hereafter termed "2007 data") are available and presented in this section.

Corresponding historical data (Conoco, 1980) are also summarized and compared to currently available 2007 monitoring data. The historical data set is also technically incomplete with respect to Regulatory Guide 4.14 specifications, however, the combined data sets might be considered by the NRC and WDEQ/LQD as sufficient documentation of baseline conditions to meet completeness requirements for administrative acceptance of licensing applications prior to completion of the final 2 quarters of data collection and analysis. In either case, those final data will be submitted to both agencies as they become available.



Monitoring Station ID	Latitude dd North	Longitude dd West
MRA-1	43.57011	105.82826
MRA-2	43.58114	105.83361
MRA-3	43.55431	105.85452
MRA-4	43.56654	105.87648

Monitoring Station ID	Latitude dd North	Longitude dd West
MR-1	43.57051	105.87173
MR-2	43.57554	105.84740
MR-3	43.57333	105.84737
MR-4	43.56968	105.84740
MR-5	43.55497	105.85400
MR-6	43.57291	105.83179
MR-7	43.58248	105.83205
MR-8	43.57761	105.83418
MR-9	43.56525	105.82867
MR-10	43.56856	105.81457

Figure 2.9-25: Passive gamma/radon and air particulate monitoring station locations at the Moore Ranch Uranium Project area.

Passive devices for monitoring ambient gamma dose rates and radon levels are each housed at the same station. Station locations were selected based on Regulatory Guide 4.14 guidance, including consideration for the locations of plant facilities, prevailing wind directions, air monitoring stations, and practical access. In all, 10 of these passive stations were installed, including one or more stations located near each air particulate monitoring station. Locations of passive monitoring stations, as well as air particulate sampling stations, are shown in Figure 2.9-25.

2.9.5.1 Methods

2.9.5.1.1 Ambient Gamma Dose Rate Monitoring

Passive monitoring of gamma dose rates at the site is being conducted with thermo-luminescent dosimeters (TLDs) supplied by Landauer, Incorporated. The TLDs are housed in insulated plastic spigot covers, attached to fence posts (Figure 2.9-26). Radon monitoring devices are also housed in these spigot covers.

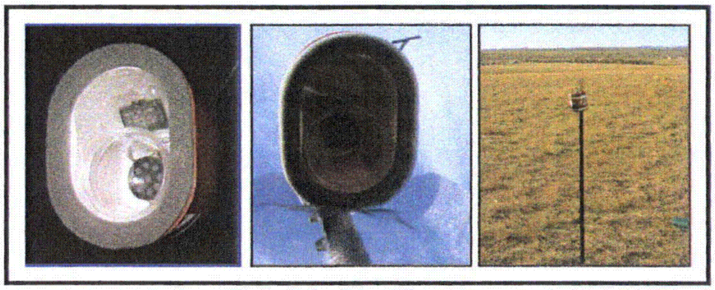


Figure 2.9-26: Photos of passive gamma/radon monitoring station equipment.

Each batch of TLDs contains a "transit" and "deploy" control TLD badge to account for background doses received by field badges when not actually deployed at the site. The transit control is stored at the Tetra Tech office in Fort Collins, Colorado (away from any radioactive sources) at all times except while in transit to and from Landauer. The deploy control badge accompanies the transit control badge at all times except for the short period of time it must travel to or from the site along with field badges during their respective deployment or removal from the site.

Landauer reports a "net" dose result, calculated by subtracting the gross deploy control badge result from each field badge result. This gives the net above background dose, which is useful for occupational dose assessments relative to regulatory dose limits, but is not applicable for environmental monitoring where the total dose received at the site during the monitoring period is of interest. For this, a different calculation is required, one that subtracts only the fraction of control badge dose that corresponds with the amount of time the field badges are not actually deployed at the site. For Moore Ranch, the calculations used to obtain this gamma dose value are outlined as follows:

1. Determine the average daily dose rate for the transit control badge:
    - Assuming the control badge receives background doses at a relatively constant rate, this is calculated as the gross reported dose (mrem), divided by the total number of days from TLD issuance to TLD analysis by the dosimetry vendor.

2. Determine the total dose to the field dosimeter whenever accompanied by the transit control badge:
   - Assume the field badge receives the same average daily dose rate as the transit control badge for all periods while stored or transported together with the transit control badge.
   - Calculate the total dose to the field dosimeter whenever accompanied by the transit control badge as: (Result from step 1 above) × (number of days from TLD issuance to TLD analysis, minus the number of days the field badge was actually deployed at the site)
3. Determine any additional background dose received by the field badge during deployment to and from the site:
   - Calculate the difference between the deploy control badge and the transit control badge, assuming this value represents the additional total dose received by the field badge during transport to and from the site.
4. Calculate total dose received by the field TLD while not deployed at the site:
   - Add the total doses calculated in steps 2 and 3 above.
5. Calculate the total dose received by the field TLD while deployed at the site:
   - Subtract the result in step 4 above from the gross result for the field TLD as reported by the vendor.

Due to scheduling issues involving initial TLD issuance from Landauer versus initial deployment of badges to the site to begin the gamma monitoring program, begin/end dates for the first two quarters of TLD data for Moore Ranch were out of sync with Landauer's normal quarterly schedule. The third quarterly change out will be delayed one month to synchronize the TLD monitoring schedule with Landauer's normal quarterly schedule. This will not affect the results, but should simplify calculations and records keeping.

2.9.5.1.2 Ambient Radon-222 Monitoring

Passive monitoring of Rn-222 air concentrations at the site is being conducted with Radtrak® alpha-track radon gas detectors supplied by Landauer. These radon detectors are housed along with the environmental TLDs as shown in Figure 2.9-26. The radon detectors are supplied by the vendor in special sealed packages designed to prevent the detectors from radon exposure prior to the beginning of the monitoring period. Upon completion of the site monitoring period, special sealing stickers supplied by the vendor are applied to detector openings to prevent further radon exposure until the device is analyzed by the vendor for average Rn-222 concentration (in pCi/L).

Prior to initial deployment of radon detectors to Moore Ranch, it was necessary to open the first quarter's batch of detectors prior to traveling to the site in order construct the housing assemblies. This operation was performed as quickly as possible to minimize any potential radon exposures not due to site conditions. Within a few hours, housing assemblies were completed and this first batch of radon detectors was double-sealed in plastic bags and placed inside the company truck (parked outside in Fort Collins, Colorado) until deployment to the site two days later.

Another issue arose with the first batch of radon detectors while constructing the housing assemblies. Two of the sealed bags (containing 3 radon detectors each) were discovered to be compromised. As a result, one of these detectors was designated for use as a "control" detector and immediately sealed with the sealing sticker. This detector was sent back to Landauer for processing, and a replacement detector was ordered for subsequent deployment to the site. Landauer was notified of the faulty packaging, and no other cases of compromised packaging seals have been discovered.

2.9.5.2 Ambient Gamma and Radon Results

2.9.5.2.1 Ambient Gamma Dose Rate Monitoring

Passive gamma dose monitoring results to date are presented in Table 2.9-11. Assuming conventional radiation weighting and quality dose factors for photons, the estimated gamma dose rates (mrem/hr) shown in Table 2.9-11 agree reasonably well with the gamma exposure rate scan data presented in Section 2.9.2 of this report. Similarly, these gamma dose rate values agree closely with the historical gamma exposure rate data (μR/hr) provided for M and T grids in the Conoco report, which were measured by a pressurized ionization chamber (Conoco, 1980).

Table 2.9-11: Environmental gamma dose rate monitoring data for quarters 1 and 2 at Moore Ranch.

Passive Monitoring Station ID	TLD Issue Date	Field Installation Date	Monitoring End Date*	Landauer GROSS Result (mrems)	Landauer NET Result (mrems)	Estimated Quarterly Field Dose (mrem)[1]	Estimated Daily Field Dose (mrem)[1]	Estimated Field Dose Rate (mrem/hr)[1]
QUARTER 1								
MR-1	10/1/2006	12/4/2006	3/5/2007	47.1	7.3	29.6	0.325	0.014
MR-2	10/1/2006	12/4/2006	3/5/2007	50.3	10.5	32.8	0.360	0.015
MR-3	10/1/2006	12/4/2006	3/5/2007	47.1	7.3	29.6	0.325	0.014
MR-4	10/1/2006	12/4/2006	3/5/2007	47.8	8.0	30.3	0.333	0.014
MR-5	10/1/2006	12/4/2006	3/5/2007	42.1	2.3	24.6	0.270	0.011
MR-6	10/1/2006	12/4/2006	3/5/2007	54.6	14.8	37.1	0.408	0.017
MR-7	10/1/2006	12/4/2006	3/5/2007	51.1	11.3	33.6	0.369	0.015
MR-8	10/1/2006	12/4/2006	3/5/2007	52.1	12.3	34.6	0.380	0.016
MR-9	10/1/2006	12/4/2006	3/5/2007	44.8	5.0	27.3	0.300	0.013
MR-10	10/1/2006	12/4/2006	3/5/2007	41.0	1.2	23.5	0.258	0.011
Transit control	10/1/2006	-	3/5/2007	39.2	-0.6	-	-	-
Deploy control	10/1/2006	-	3/5/2007	39.8	0.0	-	-	-
QUARTER 2								
MR-1	1/1/2007	3/5/2007	6/9/2007	58.4	7.3	34.1	0.355	0.015
MR-2	1/1/2007	3/5/2007	6/9/2007	56.5	10.5	32.2	0.335	0.014
MR-3	1/1/2007	3/5/2007	6/9/2007	55.9	7.3	31.6	0.329	0.014
MR-4	1/1/2007	3/5/2007	6/9/2007	56.3	8.0	32.0	0.333	0.014
MR-5	1/1/2007	3/5/2007	6/9/2007	47.0	2.3	22.7	0.236	0.010
MR-6	1/1/2007	3/5/2007	6/9/2007	68.8	14.8	44.5	0.464	0.019
MR-7	1/1/2007	3/5/2007	6/9/2007	69.9	11.3	45.6	0.475	0.020
MR-8	1/1/2007	3/5/2007	6/9/2007	78.5	12.3	54.2	0.565	0.024
MR-9	1/1/2007	3/5/2007	6/9/2007	73.1	5.0	48.8	0.508	0.021
MR-10	1/1/2007	3/5/2007	6/9/2007	71.8	1.2	47.5	0.495	0.021
Transit control	1/1/2007	-	6/9/2007	74.4	-0.6	-	-	-
Deploy control	1/1/2007	-	6/9/2007	58.7	0.0	-	-	-

1 - Results listed in blue calculated using deploy control dose only due to suspect transit control result

It appears that continuous monitoring of ambient field gamma dose rates at the site with TLDs or other dosimeters was not conducted during the historical Conoco study (no gamma dose rate information was provided in that report). However, given that the field dose rates (mrem/hr) for quarters 1 and 2 in Table 2.9-11 are fairly similar to each other in most cases, and both agree reasonably well with gamma exposure rate data collected in the fall of 2007 (see Section 2.9.2.2.4, Figure 2.9-13), suggests that temporal fluctuations in ambient field gamma dose rates at a given location are unlikely to vary by more than 0.01 mrem/hr. Spatial and temporal variability in background sources of gamma radiation, combined with measurement uncertainty, are likely responsible for the higher degree of variation observed in some cases through two quarters.

2.9.5.2.2 Ambient Rn-222 Monitoring

Passive Rn-22 monitoring results to date are presented in Table 2.9-12. Note that the "control" radon detector for quarter 1 registered a significantly higher value relative to all other detectors. Landauer's review of the records for this detector revealed no analysis or reporting errors. Other than for the early return shipping trip to Landauer, this detector was subject to the exact same conditions as all other detectors in the same batch, suggesting that this detector was somehow exposed to elevated alpha radiation during return shipping. It is thus reasonable to exclude this result from consideration as a control detector as intended. Because all other quarter 1 detectors had readings similar to one another (whether respective packaging was compromised or not), it is also reasonable to assume that the compromised packaging for some detectors did not significantly affect the results of the detectors involved. Therefore, all data for detectors actually deployed in the field in quarter 1 are assumed to be valid as reported.

Table 2.9-12: Ambient radon-222 monitoring data for quarters 1 and 2 at Moore Ranch.

Passive Monitoring Station ID	Radon Detector ID	Package Open Date	Field Installation Date	Quarter End (seal) Date	Quarterly Result (pCi-days/L)[1]	Quarterly Result (pCi/L)[1]
QUARTER 1						
MR-1	4639785	12/2/2006	12/4/2006	3/5/2007	9.4	0.1
MR-2	4639861	12/2/2006*	12/4/2006	3/5/2007	34.4	0.4
MR-3	4639862	12/2/2006*	12/4/2006	3/5/2007	42.3	0.5
MR-4	4639864	12/2/2006*	12/4/2006	3/5/2007	43.5	0.5
MR-5	4639874	12/2/2006	12/4/2006	3/5/2007	34.4	0.4
MR-6	4639875	12/2/2006	12/4/2006	3/5/2007	36.8	0.4
MR-7	4639876	12/2/2006	12/4/2006	3/5/2007	37.4	0.4
MR-8	4639884	12/2/2006*	12/4/2006	3/5/2007	31.3	0.3
MR-9	4639885	12/2/2006*	12/4/2006	3/5/2007	38.6	0.4
MR-10	4639886	12/2/2006*	Not installed**	12/2/2006	35.6	3.6
MR-10	4619417 (replacement)	1/9/2007	1/9/2007	3/5/2007	6.0	0.11
QUARTER 2						
MR-1	4639785	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-2	4639861	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-3	4639862	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-4	4639864	3/5/2007	3/5/2007	6/9/2007	11.5	0.1
MR-5	4639874	3/5/2007	3/5/2007	6/9/2007	12.0	0.1
MR-6	4639875	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-7	4639876	3/5/2007	3/5/2007	6/9/2007	17.9	0.2
MR-8	4639884	3/5/2007	3/5/2007	6/9/2007	18.6	0.2
MR-9	4639885	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-10	4639886	3/5/2007	3/5/2007	6/9/2007	12.0	0.1

[1]Results shown in blue are below analytical reporting limits

*Comprimised packaging seal from Landauer

**Sealed immediately and submitted for analysis - intended as a control detector for units with compromised packaging

Quarter 1 and 2 results are higher on average than Rn-222 concentrations reported in the historical baseline survey (Figures 2.9-27 and 2.9-28), particularly during quarter 1. Considering spatial, temporal, sampling, and analytical variability in radon measurements, however, the range of values for both data sets is not considered inconsistent with the national average ambient outdoor background level of about 0.4 pCi/L (Foster, 1993). No information in the Conoco report is provided with respect to how the historical Rn-222 data were collected or analyzed.

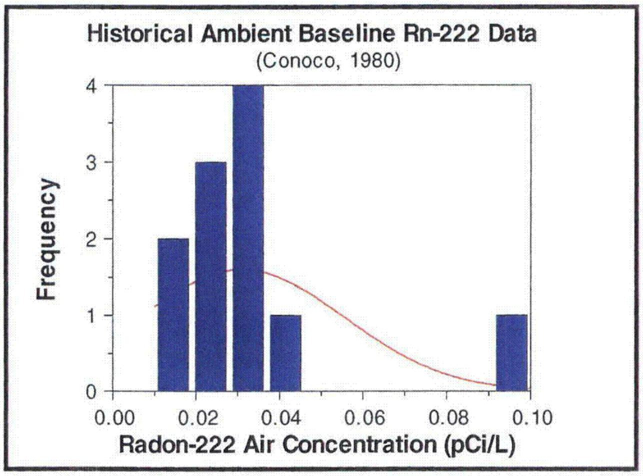


Figure 2.9-27: Frequency histogram of average monthly concentrations across all sampling locations for the historical data.

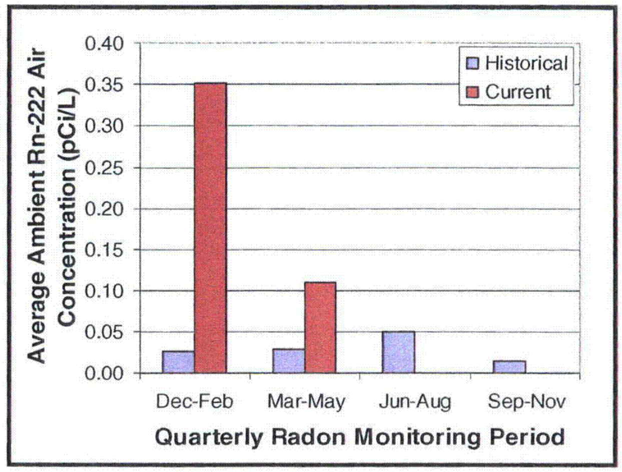


Figure 2.9-28: Current average quarterly results to date for all locations and corresponding average quarterly values across the site based on the historical data.

The historical data were collected on a monthly basis from May 1979 through March 1980. Thus, only the month of April is not represented in that data set. Combined, the historical and current data sets to date provide a reasonable idea of the magnitude of ambient Rn-222 air concentrations that can be expected to result in the remaining quarters of the current radon monitoring program. Based on all currently available data, the remaining quarters are unlikely to produce results in excess of the national average (0.4 pCi/L).

2.9.5.3 Conclusions

Baseline ambient gamma dose rate and radon-222 air concentration data for the 2007 radiological survey of the Moore Ranch Uranium Project area are being collected and analyzed according to Regulatory Guide 4.14 protocols. To date, two quarters of data are available and those results are presented. The remaining data will be submitted to the NRC and WDEQ/LQD as soon as they are available. The historical ambient gamma and radon data from the 1980 Conoco study were evaluated and compared to the current data to allow consideration to determine the completeness of licensing/permitting applications for administrative review prior to completion of the recommended full year of monitoring for these radiological parameters. The data and comparisons presented provide a reasonable indication of the results expected in the remaining quarters of the current year-long baseline monitoring program.

2.9.5.4 References

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming*. Docket No. 40-8743. July, 1980.

Foster, B. 1993. *Radon: An Invisible Threat*. National Conference of State Legislatures. Energy, Science and Natural Resources Program. State Legislative Report, Vol. 18, No. 8, July 1, 1993

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

2.9.6 Air Particulate Monitoring

Continuous monitoring of baseline air particulate radionuclide concentrations was initiated in early February 2007 at four on-site locations. Regulatory Guide 4.14 calls for 12 consecutive months of respective monitoring data as part of the overall radiological characterization of the site (NRC, 1980). These data are being collected and reported on a quarterly basis. As of the effective date of this report, one quarter and one additional month of 2007-2008 monitoring data (hereafter termed "2007 data") are available and are presented in this section. No off-site locations were planned for the air monitoring program as no known residences are currently located within 10 kilometers of the site as described in Regulatory Guide 4.14 (NRC, 1980).

Historical air particulate data as reported in the historical survey report (Conoco, 1980) are believed to be in error. Overall, those data are some 5 to 7 orders of magnitude greater than data collected in 2007, and are clearly inconsistent with any reasonably expected range of background values. Thus, the historical data were not used in this section to augment data from the current study. Miscalculation or mislabeling of radiometric units in the Conoco report may be responsible for the general magnitude of values indicated for those data.

As an alternative to comparisons with historical data from the Conoco report, more recent air monitoring data from other nearby ISR sites in this region of Wyoming have been compiled and compared to current results to date for Moore Ranch.

Low-volume air particulate sampling station locations were selected based on the historical air sampling locations and Regulatory Guide 4.14 guidance, including consideration for the locations of plant facilities, prevailing wind directions, available electrical power, and practical access. Initially, only two of the four air sampling stations had available hard-line electrical power. The other two stations were set up using solar/wind generation equipment to supply electrical power to the air samplers. Locations of the air particulate monitoring stations are shown in Figure 2.9-25 of the previous section of this report.

2.9.6.1 Methods

The air particulate monitoring program is being conducted with Model DF-40L-8 electric powered air samplers from F&J Specialty Products, Inc. (Figure 2.9-29). These samplers are calibrated by the manufacturer and programmed to draw about 30 liters of air intake per minute through a 47 mm glass fiber air sampling filter. The air samplers are housed in protective coolers mounted on elevated steel platforms such that the intake and sample filter holder assembly is positioned at about 5 feet above the ground surface (Figure 2.9-30). This is intended to approximate an average breathing zone height.

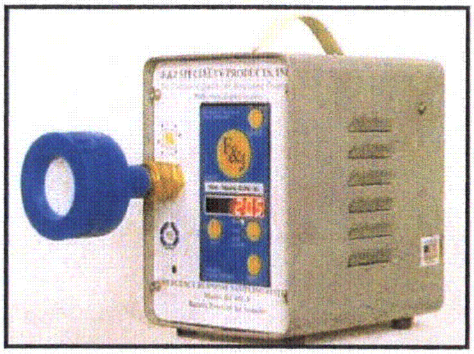


Figure 2.9-29: F&J air particulate sampler.

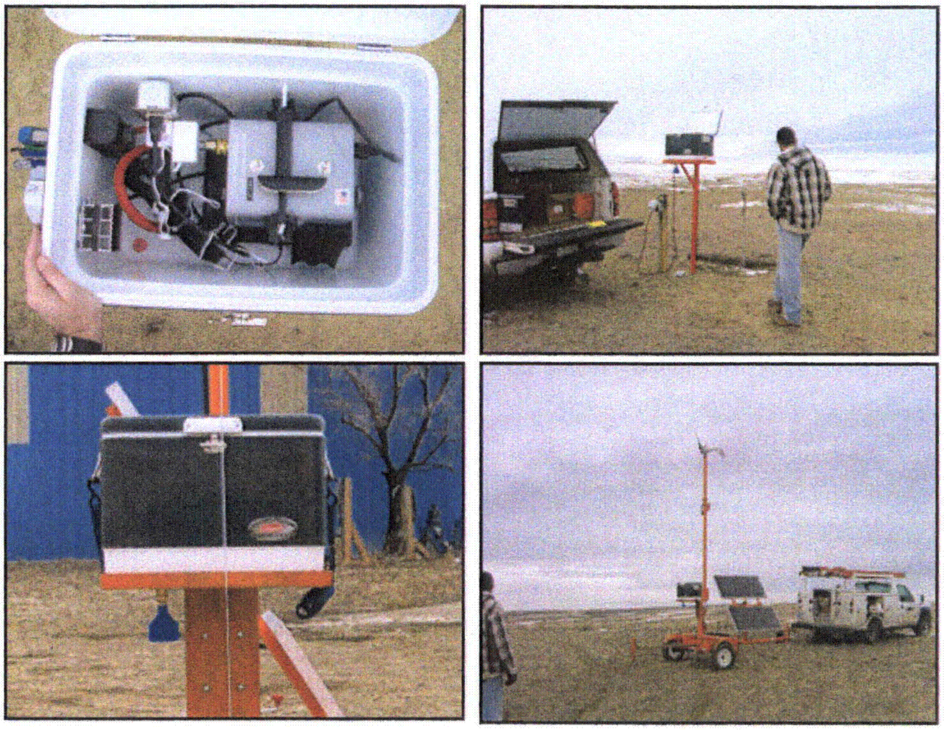


Figure 2.9-30: Air sampling station equipment and systems setup including hard-line and solar/wind powered units at Moore Ranch.

Filters are collected weekly to help prevent dust loading and are composited on an approximate quarterly basis to provide respective estimates of average radionuclide concentrations as specified in Regulatory Guide 4.14. Each quarterly batch of air filters from the four monitoring stations is submitted to ELI in Casper, WY for analysis of Ra-226, U-nat, Th-230, and Pb-210.

2.9.6.2 Air Particulate Sampling Results

Baseline air particulate sampling results to date are presented in Table 2.9-13 and are also graphically illustrated in Figure 2.9-31. In most cases, analytical results are above the lower limits of detection (LLD). The LLD values listed are those specified in Regulatory Guide 4.14. The effluent concentration values are provided by ELI as a relevant part of reporting for these data because they represent regulatory limits for each listed radionuclide in terms of doses to the public. This gives an indication of baseline conditions in this context and will help with evaluations of above background internal dose assessments via inhalation and ingestion pathways for data collected during ISL recovery operations.

Table 2.9-13: Air particulate monitoring data for quarter 1 (Feb 6 – May 9) and a subsequent 1-month period of monitoring (May 21 – June 28) at Moore Ranch.

Air Station ID	Monitoring Period	Air Volume Sampled (mL)	Radionuclide	Concentration (uCi/mL)	Error Estimate (uCi/mL)	LLD (uCi/mL)	Effluent Conc.* (uCi/mL)	% Effluent Concentration
MRA-1	2/6/07 - 5/9/07	2.83E+09	U-nat	4.24E-16	N/A	1.00E-16	9.00E-14	0.47
			Ra-226	3.18E-16	2.83E-16	1.00E-16	9.00E-13	0.04
			Pb-210	1.02E-14	2.19E-15	2.00E-15	6.00E-13	1.70
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.5
	5/21/07 - 6/28/07	3.08E+09	U-nat	1.62E-16	N/A	1.00E-16	9.00E-14	0.18
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	5.84E-15	1.92E-15	2.00E-15	6.00E-13	0.97
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50
MRA-2	2/6/07 - 5/9/07	2.32E+09	U-nat	5.60E-16	N/A	1.00E-16	9.00E-14	0.62
			Ra-226	4.74E-16	3.45E-16	1.00E-16	9.00E-13	0.05
			Pb-210	1.19E-14	2.63E-15	2.00E-15	6.00E-13	1.98
			Th-230	4.31E-16	3.02E-16	1.00E-16	2.00E-14	2.16
	5/21/07 - 6/28/07	1.71E+09	U-nat	3.51E-16	N/A	1.00E-16	9.00E-14	0.39
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	< 2.00E-15	N/A	2.00E-15	6.00E-13	< 0.33
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50
MRA-3	2/6/07 - 5/10/07	1.76E+09	U-nat	3.98E-16	N/A	1.00E-16	9.00E-14	0.44
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	9.32E-15	3.13E-15	2.00E-15	6.00E-13	1.55
			Th-230	1.93E-15	6.25E-16	1.00E-16	2.00E-14	9.66
	5/21/07 - 6/28/07	6.99E+08	U-nat	7.15E-16	N/A	1.00E-16	9.00E-14	0.795
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	2.02E-14	8.15E-15	2.00E-15	6.00E-13	3.36
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50
MRA-4	2/6/07 - 5/10/07	1.80E+09	U-nat	7.22E-16	N/A	1.00E-16	9.00E-14	0.80
			Ra-226	8.33E-16	4.44E-16	1.00E-16	9.00E-13	0.09
			Pb-210	1.22E-14	3.22E-15	2.00E-15	6.00E-13	2.03
			Th-230	5.56E-16	3.89E-16	1.00E-16	2.00E-14	2.78
	5/21/07 - 6/28/07	1.62E+09	U-nat	2.47E-16	N/A	1.00E-16	9.00E-14	0.27
			Ra-226	8.64E-16	6.79E-16	1.00E-16	9.00E-13	0.10
			Pb-210	< 2.00E-15	N/A	2.00E-15	6.00E-13	< 0.33
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50

Final prep volume is 0.95 liter
LLD's are from Reg. Guide 4.14
*Effluent concentration limit from 10 CFR Part 20 - Appendix B - Table 2
Solubility Class:
- Year for Natural Uranium
- Week for Radium-226
- Day for lead-210

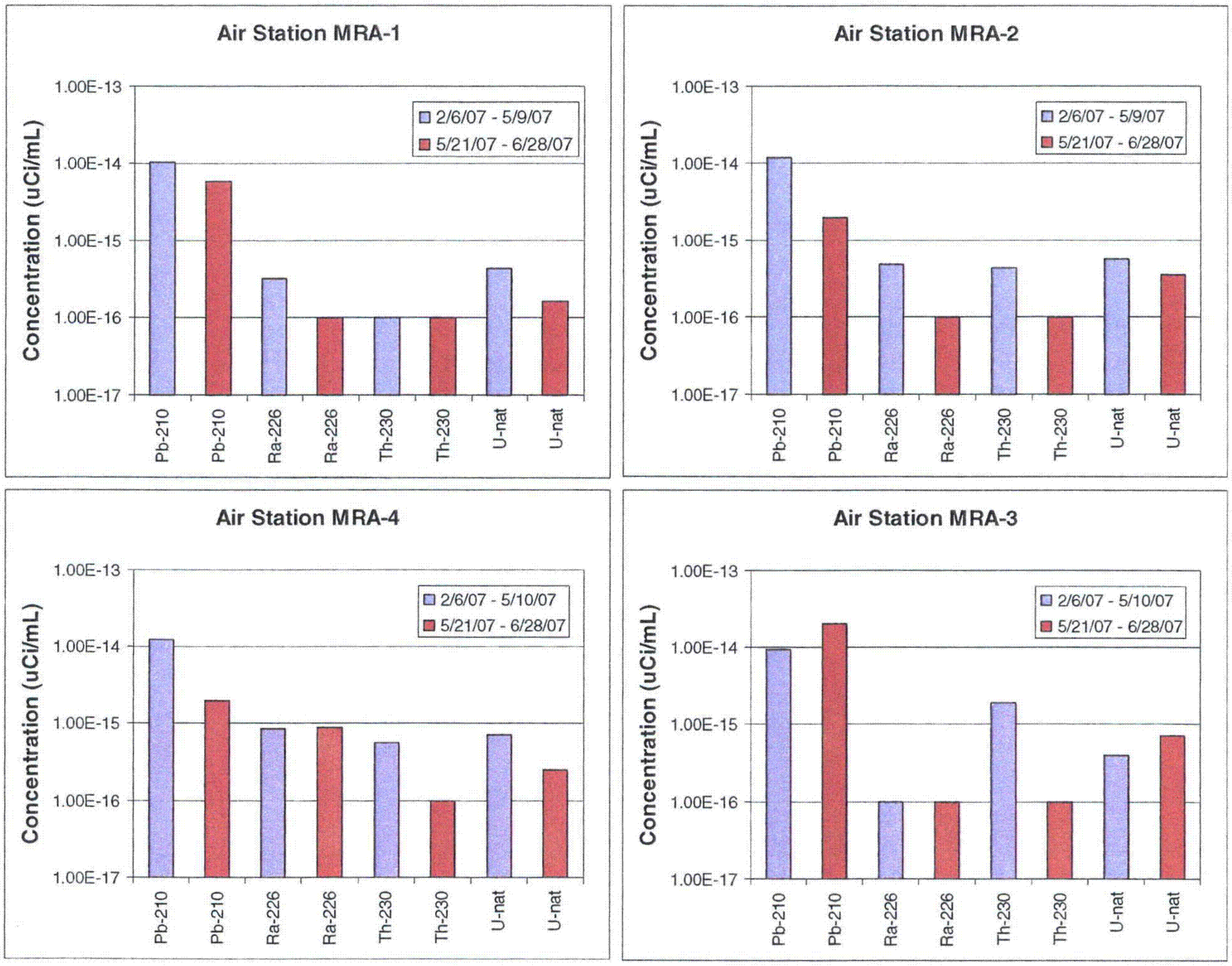


Figure 2.9-31: Air particulate results for quarter 1 and the subsequent month of sampling.

A comparison of average air particulate radionuclide concentrations to date at Moore Ranch with average corresponding concentrations at other nearby uranium recovery sites in this region of Wyoming (see Figure 2.2-2) is shown in Figure 2.9-32. In general, results are reasonably comparable for most radionuclides evaluated. In particular, data for Smith Ranch (about 37 miles SSW of the Moore Ranch site) and Christensen Ranch (about 19 miles NNW of the Moore Ranch site) are very similar to results to date for Moore Ranch. Lead-210 and U-nat results for the North Butte site (about 16 miles NNW of the site) are significantly lower than data from the other sites shown in Figure 2.9-32, but Ra-226 and Th-230 data are very similar across all of these sites. Real differences in background site characteristics could be responsible for lower Pb-210 and U-nat values at the North Butte site compared to other sites in the region, but differences in collection methods and analytical uncertainty could also contribute. In general, this comparison suggests that air particulate data for the remaining quarters of the baseline monitoring period are not likely to differ significantly from results to date, or with data from most nearby uranium recovery sites.

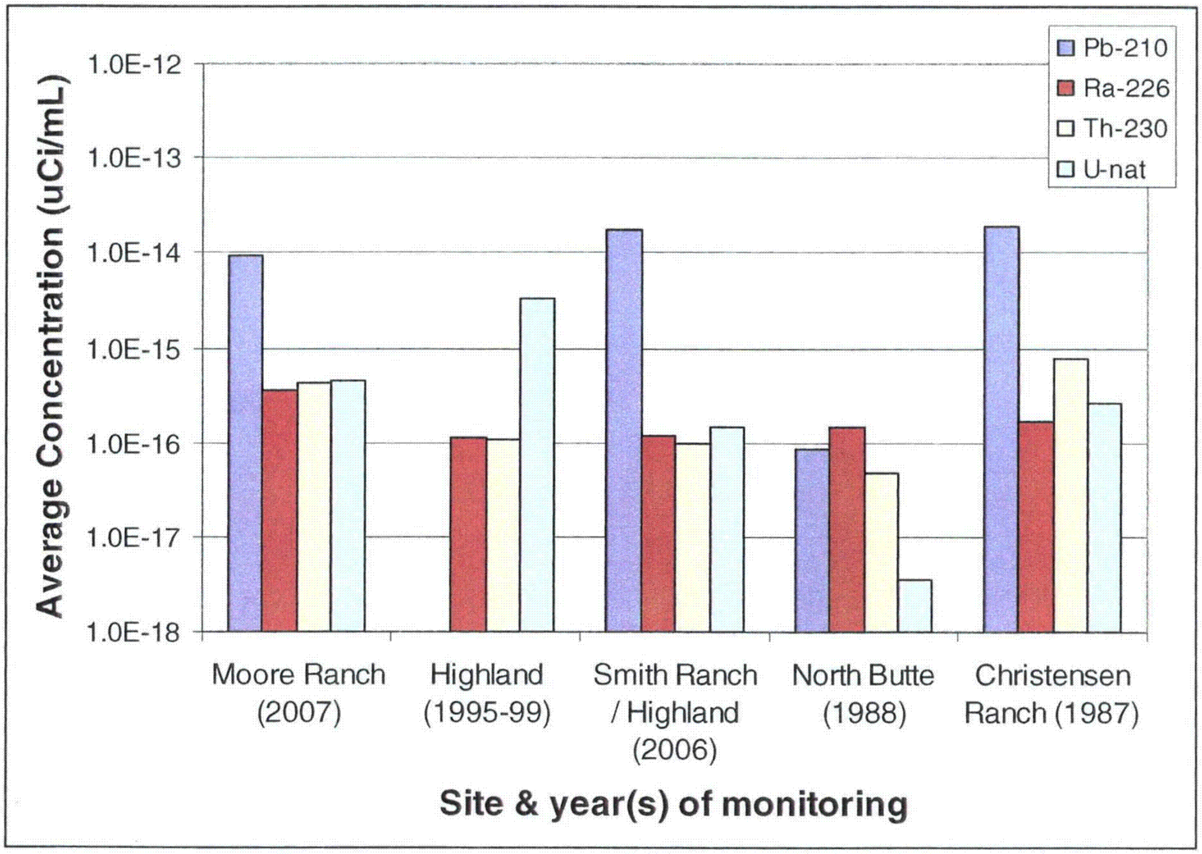


Figure 2.9-32: Average air particulate results to date for Moore Ranch compared to nearby uranium recovery sites in the region including Highland (NRC, 2004), Smith Ranch/Highland (NRC, 2004), North Butte (NRC, 2006) and Christensen Ranch (Cogema Mining, Inc 1996)

2.9.6.3 Conclusions

Baseline air particulate concentration data for the 2007 radiological survey of the Moore Ranch Uranium Project area are being collected and analyzed according to Regulatory Guide 4.14 protocols. To date, one quarter and one additional month of data are available and those results are presented in this section. The historical air particulate data as reported in the 1980 Conoco study are thought to be incorrect and thus were not used to augment this portion of radiological characterizations. Alternate comparisons with air particulate data from nearby uranium recovery sites in the region generally support a conclusion that remaining data for the 2007 monitoring program are likely to be similar to those collected to date and that the air particulate characterization of the Moore Ranch site should be deemed complete for purposes of administrative review of the application. Remaining data for the 2007 monitoring program will be submitted to the NRC and WDEQ/LQD as soon as they are available.

2.9.6.4 References

Cogema Mining, Inc, 1996. *Permit to Mine No. 478, A-2 Update and U.S. NRC License Renewal Application: Source Material License SUA-1341*, Irigary and Christensen Ranch Projects, January 1996.

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming.* Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 2004. *Reynolds Ranch Amendment Permit to Mine No. 1548 – Smith Ranch – Highland Uranium Project.* Volume I, Chapters 1-10. ADAMS Accession No. ML050390095

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2006. *North Butte ISL Satellite Project, Campbell County, Wyoming*, Power Resources, Inc., Volume I,, ADAMS Accession No. ML061740064

2.9.7 Radon Flux Measurements

Regulatory Guide 4.14 indicates that radon flux measurements should be conducted at eight locations within 1.5 km of the mill, during three separate months between spring and fall when the ground is thawed. Because there will be no tailings impoundments or evaporation ponds at the Moore Ranch Uranium Project, radon flux is unlikely to be an applicable radiological parameter for baseline characterization. There are historical data available from the Conoco study as provided below (Table 2.9-14 and Figure 2.9-33). Additional radon flux measurements are not planned at this time.

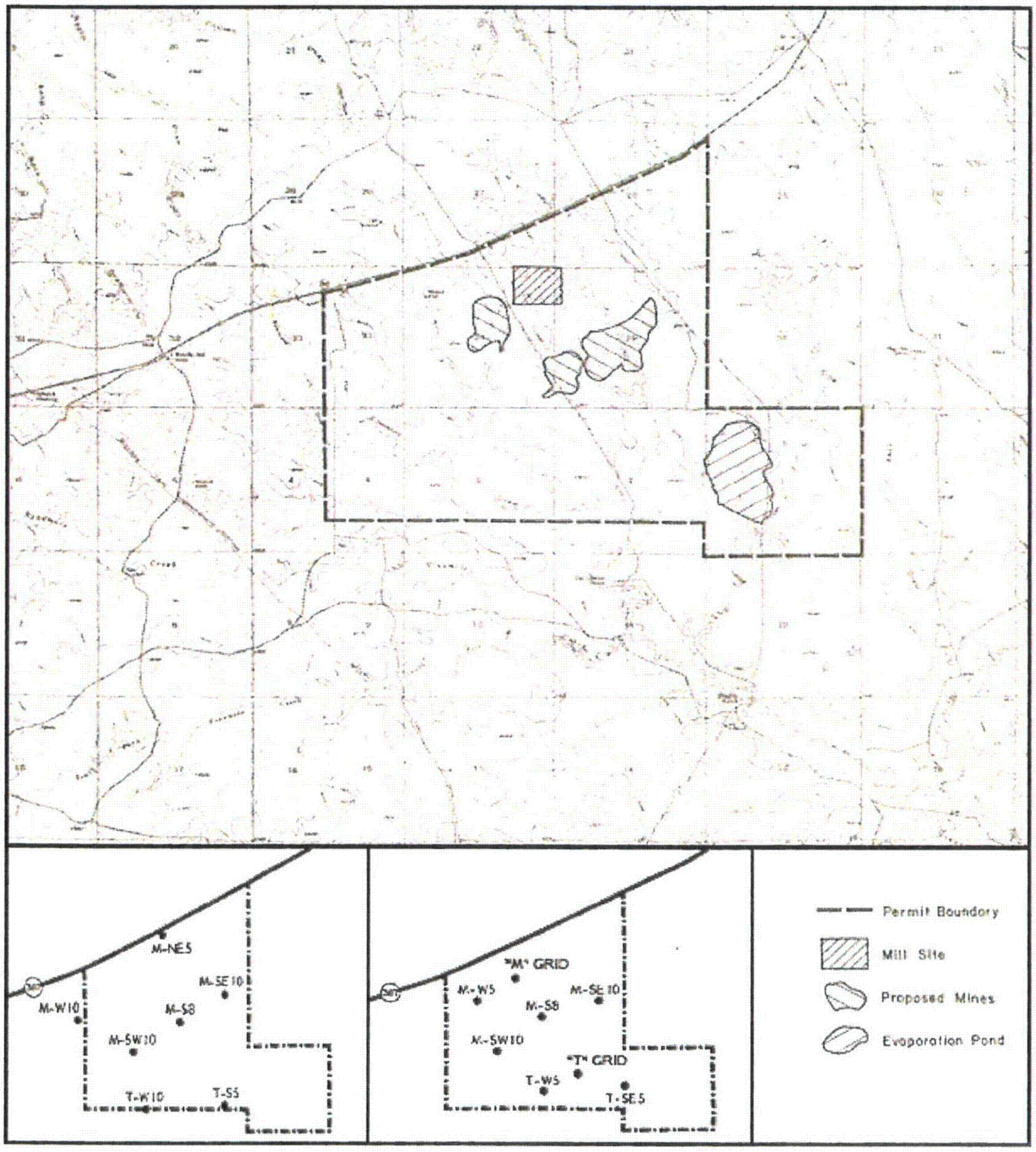


Figure 2.9-33: Historical radon flux measurement locations within the former mill site license area (adapted from Conoco, 1980).

Table 2.9-14: Historical radon flux data for the former Conoco mill site

Radon Emanation Charcoal Canister Technique [$pCi/m^2/sec$[a]]

Location ID	Set 1 8/31/79-9/6/79	Set 2 9/6/79-9/25/79	Set 3 9/25/79-10/11/79	Set 4 10/11/79-10/26/79
M-SW 10	1.9	0.8	1.2	1.3
M-S 8	-	0.9	2.6	1.6
M-NE 5	1.5	0.9	1.8	2.1
M-SE 10	1.4	-	1.3	1.4
M-W 10	2.3	-	0.9	0.9
T-W 10	2.0	0.7	1.4	-
T-S 5	2.3	-	2.9	1.3

Radon Emanation Drum Method [$pCi/m^2/sec$[a]]

Location ID	Set 1 8/31/79	Set 2 9/6/79	Set 3 9/15/79	Set 4 10/11/79
M-SW 10	1.25	-	0.7	0.7
M-W 5	0.8	-	0.8	0.7
M-SE 10	-	-	0.8	2.7
M-S 8	-	1.4	2.4	1.2
"M" Grid Center	1.4	-	2.2	0.4
T-W 5	0.9	0.4	0.4	0.4
T-SE 5	2.4	1.3	0.8	1.4
"T" Grid Center	0.6	1.0	0.8	1.2

(a) An overall uncertainty of ± 10% should be assigned at 2σ. Individual cumulative errors are less than this value.

2.9.7.1 References

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming*. Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills*. Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

2.9.8 Groundwater Sampling

Baseline groundwater sampling is being conducted at the Moore Ranch Uranium Project area in general accordance with Regulatory Guide 4.14 protocols (NRC, 1980). In this case, however, there are no tailings impoundments and respective guidance has been interpreted accordingly. Monitoring wells are located within mineralized areas, as well as at locations up and down hydrologic gradients from these areas. Wells that are or could be used for drinking, livestock watering, or crop irrigation have also been sampled. Quarterly sampling is continuing, with data for radiological parameters available to date presented in this section. A map of approximate well locations in the vicinity of proposed wellfields and the plant facility is shown in Figure 2.9-34. Comprehensive information on well locations and all water quality parameters is provided in sections of the licensing applications related specifically to groundwater (Section 2.9.2.7.2).

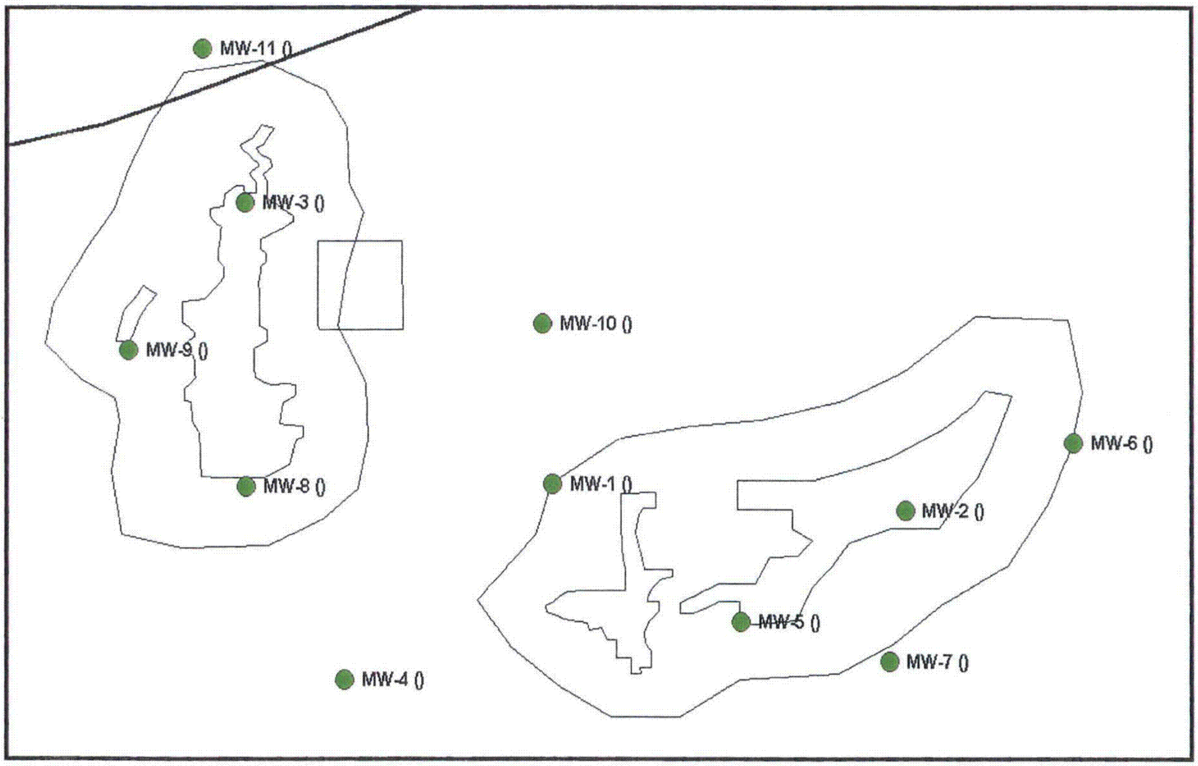


Figure 2.9-34: Groundwater monitoring wells at the Moore Ranch site near planned wellfields and central plant facilities.

With respect to historical groundwater monitoring, a map of well locations (Figure 2.9-35) and summary comparisons between radionuclide results from the current and historical data sets are presented. These comparisons may provide sufficient documentation of radiological groundwater parameters with respect to licensing applications prior to completion of the baseline groundwater monitoring program. As the monitoring program progresses, new data will be submitted to the NRC and WDEQ/LQD as they become available.

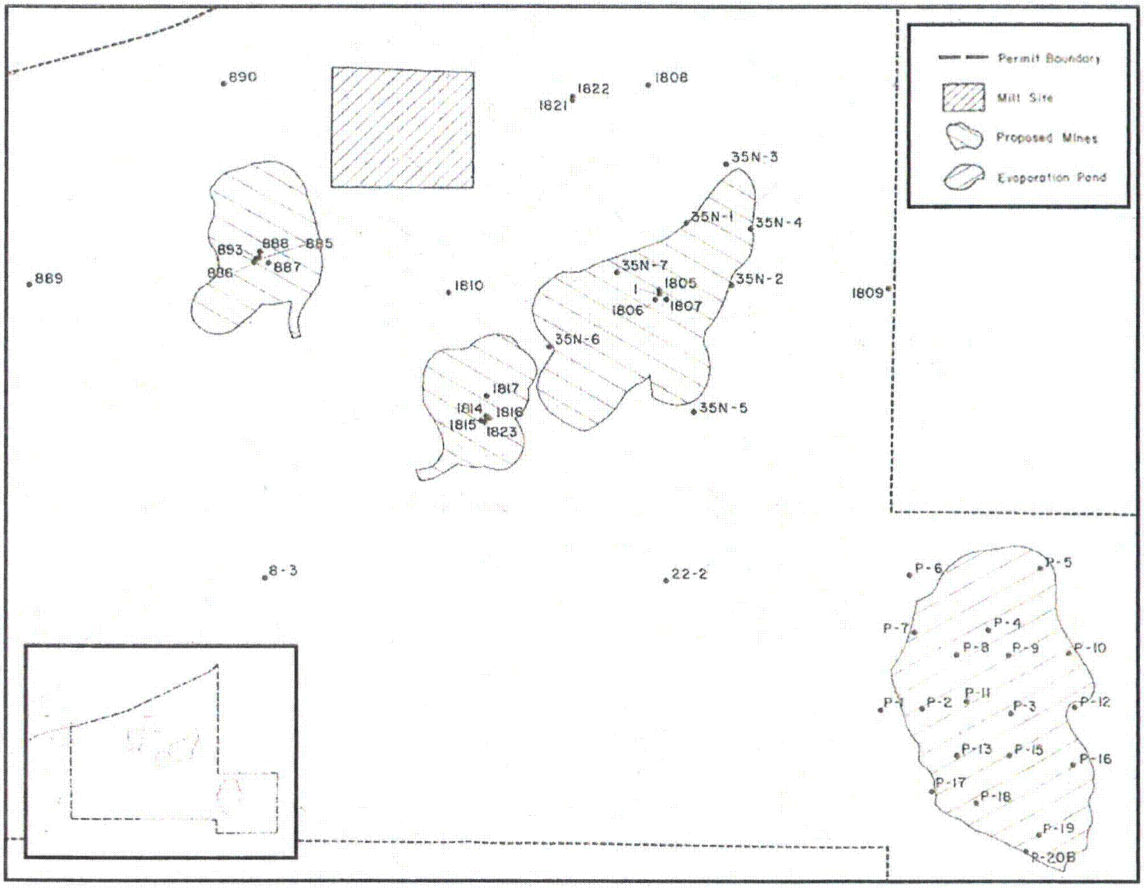


Figure 2.9-35: Historical groundwater monitoring wells at the Moore Ranch site near ore bodies (as estimated in 1980), and the formerly planned mill site and evaporation pond areas.

2.9.8.1 Methods

Prior to sampling a well, static water levels are monitored using an electrical measuring line (an "e-line"). All readings are reported to within at least one tenth of a foot and preferably to within a hundredth of a foot. After the static water level is measured, wells are purged at a sufficient volume induce the flow of formation water through the well screen. Wells with a high enough yield are purged for a minimum of three well volumes, and also until one or more indicator parameters are stable. Parameters monitored for stabilization include pH, temperature, and conductivity. For low yielding wells, the wells are pumped dry then allowed to recover. Samples are taken after sufficient well recovery. Accurate records of well purging are maintained to document the number of casing volumes purged from the well before sampling.

Groundwater field measurements and samples are taken as soon as the well is adequately purged. Sampling container(s) are completely filled, so all air is excluded from the container. Field measurements including pH, conductivity, and temperature are taken and recorded. Meters used to take field measurements are calibrated daily.

2.9.8.2 Groundwater Sampling Radiological Results

Results to date for dissolved radiological groundwater parameters are shown in Table 2.9-15. Parameters in suspended form were also evaluated, but all were below analytical reporting limits and are not presented here (those data, reporting limits, and other details can be found in Section 2.9.2.7.2 of the application pertaining specifically to groundwater).

Table 2.9-15: Analytical results to date for radiological parameters in groundwater samples collected during 2007 baseline surveys. Values with less-than qualifiers were all below analytical reporting limits.

Well No.	Gross Alpha pCi/L	Gross Beta pCi/L	Pb-210 pCi/L	Po-210 pCi/L	Ra-226 pCi/L	Ra-228 pCi/L	Th-230 pCi/L	Uranium pCi/L*
MR-PW-1	627	78.9	10	<1.0	82.6	2.1	<0.2	126
MR-OMW-1	3.5	20.4	<1.0	<1.0	0.8	2.8	<0.2	6.7
MR-UMW-1	13.3	25	<1.0	<1.0	0.8	<1.0	<0.2	6.4
MR-MW-2	1050	327	31	51	138	<1.0	<0.2	495
MR-OMW-2	9.6	8.6	<1.0	<1.0	1.1	2.5	1	1.8
MR-UMW-2	83.3	36.8	<1.0	1.8	1	<1.0	<0.2	75
MR-MW-3	370	162	69	34	280	<1.0	<0.2	56
MR-UMW-3	1.8	13.6	<1.0	<1.0	1.1	9.5	<0.2	0.9
MR-MW-4	201	53.8	<1.0	<1.0	45.7	1.7	<0.2	87
MR-OMW-4	3.5	14.4	<1.0	<1.0	1.8	2	<0.2	0.5
MR-UMW-4	53.4	18.4	<1.0	<1.0	1	3.3	<0.2	46
MR-MW-6	17	13.6	<1.0	<1.0	1.3	<1.0	<0.2	6.7
MR-MW-7	21.2	11.4	<1.0	1.6	1.1	<1.0	<0.2	6.7
MR-MW-9	47.1	24.6	<1.0	2	2.5	<1.0	<0.2	39
MR-MW-11	156	47.3	<1.0	<1.0	26	3.5	0.9	69
MR-885	293	147	41	31	309	1.8	<0.2	51
MR-1808	30.9	12.8	<1.0	<1.0	9.1	<1.0	0.4	0.8
MR-8-3	3.6	12.9	<1.0	<1.0	0.8	3	<0.2	1.3
Stockwell #1	68.2	24	<1.0	<1.0	0.8	1.6	<0.2	6.7
Stockwell #2	2	7.9	<1.0	<1.0	0.9	3.9	<0.2	6.7
Stockwell #3	24.3	16.5	<1.0	<1.0	3.3	3.5	<0.2	6.7
Stockwell #4	5.9	5.5	<1.0	<1.0	<0.2	<1.0	0.9	4.8

*Converted from units of mg/L to activity units of pCi/L using a conversion factor of 670 pCi/mg

Some groundwater sampling in 2007 is being conducted at or near historical wells as indicated in the 1980 Conoco study. All reported radiological analytes from the historical study, along with corresponding well ID location numbers from the current monitoring program, are shown in Table 2.9-16. To make comparisons between data sets, historical data were averaged in cases where multiple results at a given well location were provided for different sampling dates. In cases where reported results were listed as below reporting limits, the reporting limit was assigned to represent an approximate concentration.

In general, there is reasonable agreement among the two data sets, with the most notable exceptions being for uranium in historic wells 1808 and 8-3 (see Section 2.7). The results for these locations, corresponding to current wells MR-1808 and MR-8-3, suggest a two-orders-of-magnitude difference between current and historical samplings (Figure 2.9-36). Unless anthropogenic activities disturb groundwater system conditions, concentrations should not change significantly over a few decades as these systems are usually fairly well buffered geochemically.

Table 2.9-16: Historical analytical results for radiological parameters in groundwater samples as reported in the Conoco study (Conoco, 1980).

Historical Well No.	Pb-210 pci/L	Po-210 pci/L	Ra-226 pci/L	Th-230 pci/L	Uranium pCi/L	Corresponding 2007 Well No.
I			69 ± 10		338	MR-MW-2
I			27.6 ± 1.7		399	MR-MW-2
I	0 ± .2	0.2 ± .03	8.0 ± .4	0.0 ± .1	294 ± 15	MR-MW-2
1807			6.6 ± 2.3		3.4	MR-UMW-2
885			163 ± 20		38	MR-885
893			302		81	MR-885
893	10 ± .5	1.5 ± .1	126 ± 6	0.3 ± .1	58 ± 3	MR-885
1808	0 ± .6	0.12 ± .03	0.60 ± .07	0 ± .4	71 ± 4	MR-1808
8-3	0 ± 0.6	0.12 ± .03	0.60 ± .07	0 ± .4	71 ± 4	MR-8-3
T-1	0 ± .4	0.02 ± 0'01	0.41 ± 0.06	0.3 ± 0.1	44 ± 2	Stockwell #1
T-1			0.2 ± 0.2	0.6 ± 0.1	21 ± 2	Stockwell #1
P'-11						Stockwell #2
P'-9	1.6 ± 0.02	0.40 ± 0.05	2.0 ± 0.1	0.2 ± 0.1	32. ± 2.0	Stockwell #3
P'-9			2.1 ± 0.1	1.1 ± 0.1	22. ± 2.	Stockwell #3

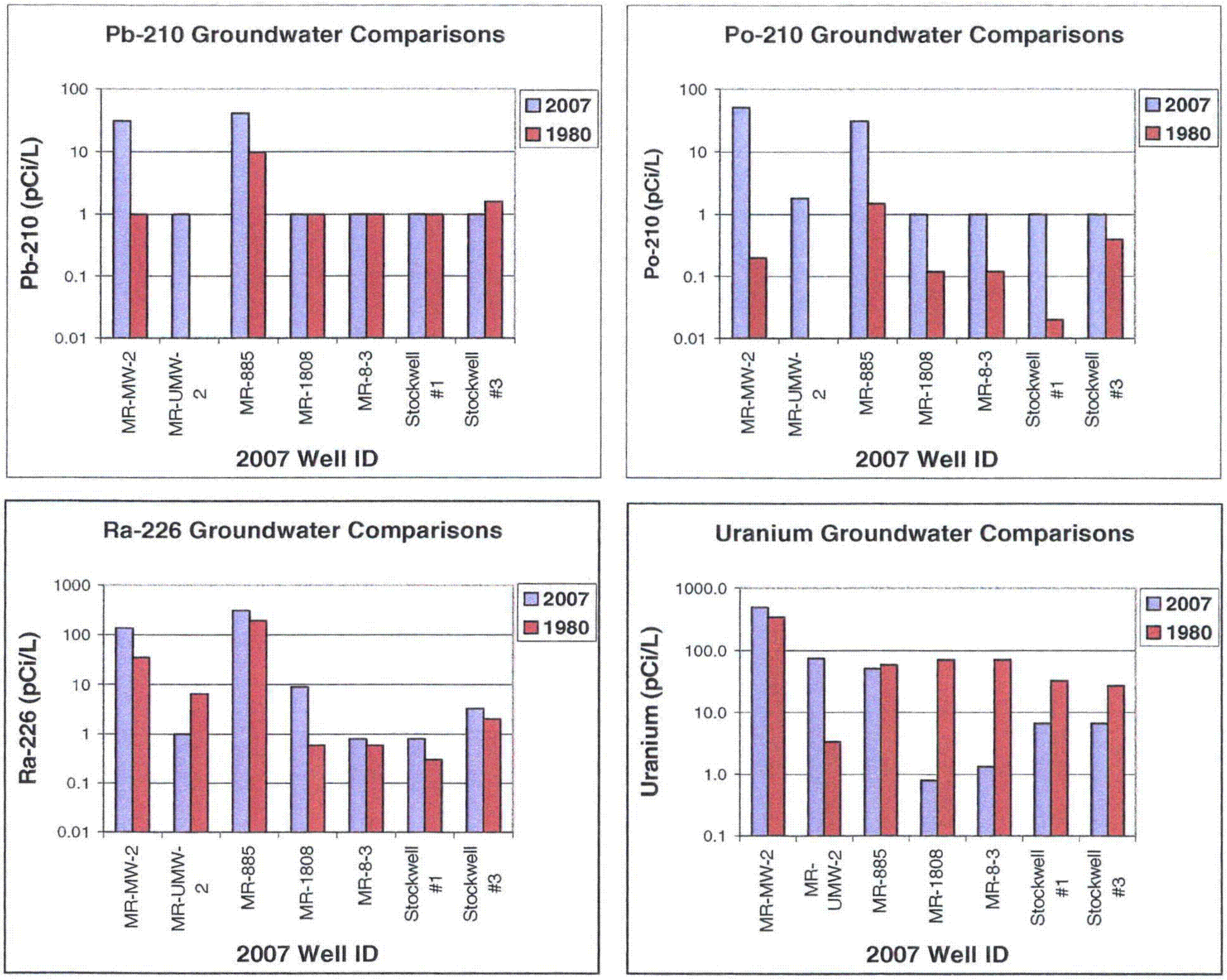


Figure 2.9-36: Comparisons of current (2007) and historical (1980) results for select radionuclide concentrations in groundwater samples collected at similar or identical well locations. The current well location ID numbers are given.

The most plausible explanation for the lack of agreement in uranium results for historic wells corresponding to current wells MR-8-3 and MR-1808 is error in data transcription in the historic Conoco report. Note that results for these two historic wells in Table 2.9-16 are listed as having identical results across all radionuclides. Clearly that is an analytical improbability. Thus it is suggested that these results are ignored and only the current data are considered valid at these two locations, particularly since both appear to be located well outside of currently estimated mineralized zones at the site (see Figure 2.9-35). Thorium-230 comparisons, not shown, were in good agreement as all results were near ELI's reporting limit of 0.2 pCi/g.

2.9.8.3 Conclusions

Radiological groundwater data for the Moore Ranch Uranium Project is being collected and analyzed according to Regulatory Guide 4.14 protocols. Results to date, along with historical groundwater data and summary comparisons of analytical results between the two data sets, are presented in this section. Current and historical data have reasonable agreement for most parameters. Uranium results deviate significantly in a few cases, two of which appear related to transcription errors in the historical report. Respective results for historic wells 8-3 and 1808 should not be considered. Remaining data for the current groundwater monitoring program will be submitted to the NRC and WDEQ/LQD as they become available. The combined data sets provide a reasonable characterization of radionuclide concentrations in groundwater and these parameters are unlikely to change significantly through the remainder of the baseline monitoring program. Based on this conclusion, the data should be considered complete for purposes of administrative review of the license and permit applications.

2.9.8.4 References

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming*. Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills*. Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

2.9.9 Surface Water Sampling

Baseline surface water sampling is being conducted at the Moore Ranch Uranium Project area in accordance with Regulatory Guide 4.14 protocols (NRC, 1980). Beginning in 2000, coal bed methane (CBM) production was introduced to the site and many ponds are now primarily fed by CBM groundwater discharge. (The CBM gas recovery method is discussed extensively in Section 7.2). As a result, during much of the year, surface water quality is a reflection of CBM discharge water. Historical data have not been analyzed or presented for comparison since they may not accurately represent current baseline conditions.

The year-long sampling program is continuing, with data for radiological parameters available to date presented in this section. New data will be submitted to the NRC and WDEQ/LQD as they become available. A map showing pond sampling locations relative to ore bodies and the proposed plant facility is presented in Figure 2.9-37. Comprehensive presentation of surface water sampling locations and all water quality parameters is provided in sections of licensing applications related specifically to surface water (see Section 2.7.1).

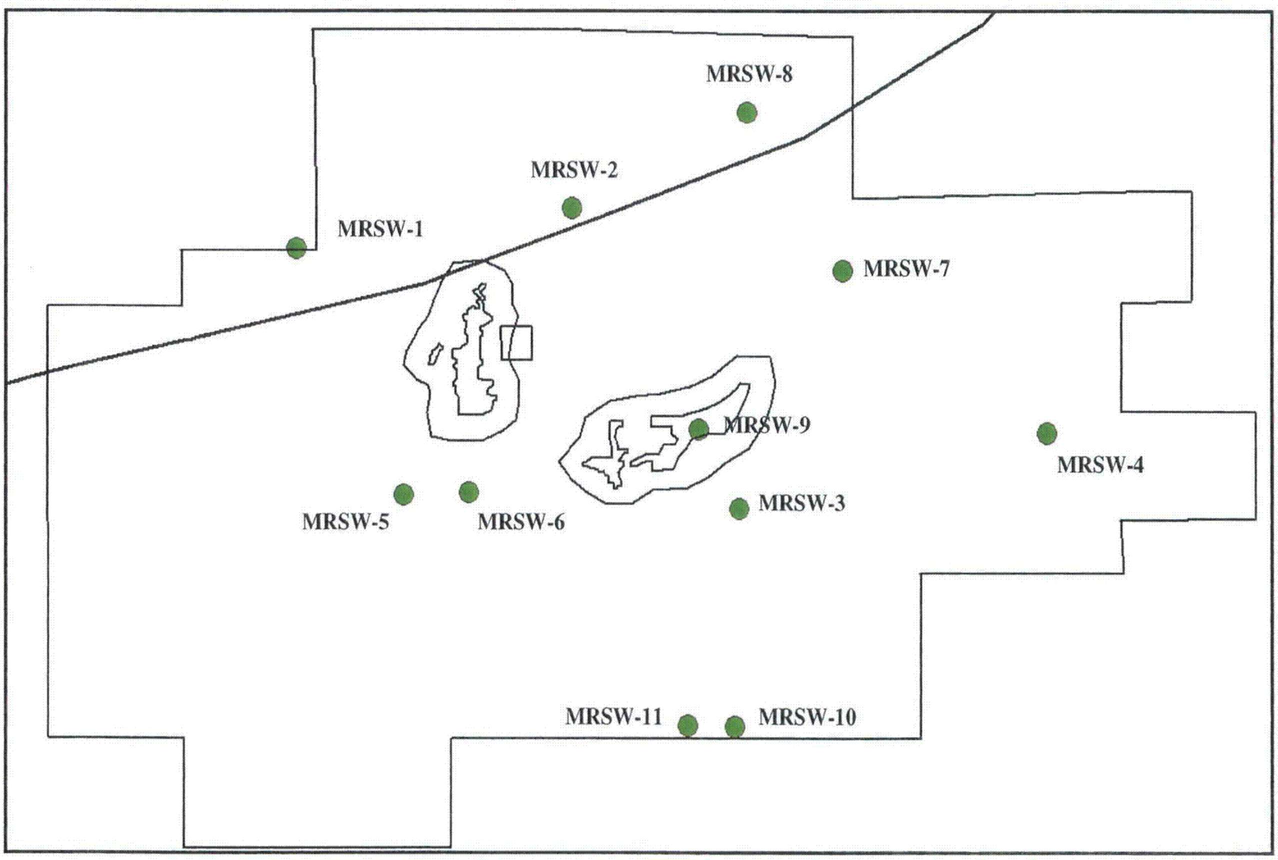


Figure 2.9-37: Surface water sampling locations at the Moore Ranch site.

2.9.9.1 Methods

Surface water samples are collected in the appropriate containers provided by the contract laboratory. Field meters were used to measure pH, specific conductance, and temperature of water samples and calibrated before each day's use as discussed in the Owner's Manual. Sample containers are flushed with the sample water in order to remove potential contaminants from the container. The bottle is then filled directly from the stream or pond with the with the sample bottle in a manner to prevent collecting debris or filled by using an alternate clean container. All samples analyzed by a contract laboratory are accompanied by a chain of custody to ensure proper analysis is performed and the sample is tracked.

2.9.9.2 Surface Water Sampling Results

Select results to date for dissolved radiological groundwater parameters are shown in Table 2.9-17. Parameters in suspended form were also evaluated, but virtually all were below analytical reporting limits and are not presented here (those data, reporting limits, and other details can be found in Section 2.7.1 of the application pertaining specifically to surface water)

Table 2.9-17: Analytical results to date for radiological parameters in surface water samples collected during 2007 baseline surveys. Values with less-than qualifiers were all below analytical reporting limits.

Surface Water Sampling ID	Sampling Date	Gross Alpha pCi/L	Gross Beta pCi/L	Pb-210 pCi/L	Po-210 pCi/L	Ra-226 pCi/L	Ra-228 pCi/L	Th-230 pCi/L	Uranium pCi/L*
MRSW-1	11/3/2006	6.8	21.8	170	<0.2	<0.2	<1.0	<0.2	3.5
	3/23/2007	1	10.3	<1.0	<1.0	<0.2	<1.0	<0.2	0.5
MRSW-2	10/25/2006	3	14	<1.0	<1.0	<0.2	<1.0	<0.2	13.4
	3/23/2007	1.5	9.7	<1.0	<1.0	<0.2	<1.0	<0.2	0.3
MRSW-3	10/25/2006	12.7	13.5	<1.0	<1.0	<0.2	<1.0	<0.2	8.7
	3/22/2007	7.9	9.7	<1.0	<1.0	<0.2	<1.0	<0.2	8.0
MRSW-4	10/25/2006	5.6	11.9	<1.0	<1.0	<0.2	<1.0	<0.2	4.6
	3/27/2007	2.5	7.6	<1.0	<1.0	<0.2	<1.0	<0.2	2.3
MRSW-5	11/3/2006	11	32.7	9.9	<1.0	<0.2	<1.0	<0.2	0.7
	3/22/2007	2.4	11	<1.0	<1.0	1.5	<1.0	<0.2	1.9
MRSW-6	3/22/2007	1.1	6.9	<1.0	<1.0	<0.2	<1.0	<0.2	<0.2
MRSW-7	10/25/2006	5.4	13.1	<1.0	<1.0	<0.2	<1.0	<0.2	0.4
MRSW-8	10/25/2006	4.3	20.9	<1.0	<1.0	<0.2	<1.0	<0.2	2.7
	3/23/2007	2.4	10.1	<1.0	<1.0	<0.2	<1.0	<0.2	0.6
MRSW-9	3/21/2007	1.7	3.9	8.6	<1.0	<0.2	<1.0	<0.2	1.1

*Converted from units of mg/L to activity units of pCi/L using a conversion factor of 670 pCi/mg

Locations MRSW-10 and MRSW-11 as shown in Figure 2.9-37 have not been sampled because surface water has yet to be observed in these impoundments. Most sample results to date for dissolved uranium are above analytical reporting limits, with a few values ranging between 40-70% of the U.S. Environmental Protection Agency's (EPA's) current 30 µg/L drinking water standard for uranium (EPA, 2000). Based on the conversion factor indicated in Table 2.9-17, an equivalent EPA uranium drinking water standard in units of specific activity is 20 pCi/L.

The fall 2006 sampling effort produced an unusually high result for Pb-210 in pond MRSW-1, as well as a slightly elevated Pb-210 result just downstream along the same drainage channel in pond MRSW-5. A second sampling of these two ponds in the spring of 2007 each had corresponding results below analytical reporting limits. In terms of drinking water standards, Pb-210 is not currently regulated by the EPA, though a standard of 1 pCi/L was proposed in 1999 (EPA, 2000). Most other radiological analytes specified in Regulatory Guide 4.14 have thus far been below analytical reporting limits across all sampling locations.

2.9.9.3 Conclusions

Radiological surface water data for the Moore Ranch Uranium Project area is being collected and analyzed according to Regulatory Guide 4.14 protocols. Results to date are presented in this section and remaining data will be submitted to the NRC and WDEQ/LQD as they become available. Comparisons with historical surface water data from the Conoco study (Conoco, 1980) are not appropriate as baseline conditions may have changed due to the introduction of coal bed methane groundwater discharges to surface water systems. In general, surface water concentrations of most radiological analytes specified in Regulatory Guide 4.14 are low, though the data suggest that baseline uranium levels can approach the current EPA drinking water standard at some locations. A possible explanation for the one unusually high Pb-210 result at pond location MRSW-1 in 2006 is not apparent based on the available data.

EMC believes that the 2007 surface water data meets the completeness criteria for administrative review of the license application, particularly since NUREG-1569 states that "...where perennial surface-water sources are present, surface-water quality measurements should be taken on a seasonal basis for a minimum of 1 year before implementation of in situ leach operations." All drainages at the Moore Ranch Uranium Project are ephemeral. Furthermore, during much of the year, surface water quality is a reflection of CBM discharge water.

2.9.9.4 References

U.S. Environmental Protection Agency (EPA). 2000. *National Primary Drinking Water Regulations; Radionuclides; Final Rule.* Federal Register: December 7, 2000 (Volume 65, Number 236).

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

2.9.10 Vegetation Sampling

Vegetation sampling at the Moore Ranch site was initiated in April of 2007. Regulatory Guide 4.14 calls for three rounds of sampling during the growing season (NRC, 1980). As of the effective date of this report, two of the three scheduled samplings are completed and those results are presented. Data from the remaining sampling event will be provided to the NRC and WDEQ/LQD as soon as available.

Historical vegetation data from the 1980 baseline survey (Conoco, 1980) are also summarized and compared to the available 2007 data. The historical data set for vegetation is also technically incomplete with respect to Regulatory Guide 4.14 specifications, however, the combined data sets might be considered by the NRC and WDEQ/LQD as meeting the completeness criteria for administrative review. Both early and later months during the growing season are represented between the two data sets.

Vegetation sampling locations for the 2007 survey were selected based on Regulatory Guide 4.14 guidance including three different areas near proposed facilities which have potential to be impacted by ISR operations. Locations of vegetation sampling areas in relation to processing plant facilities and ore deposits are shown in Figure 2.9-38.

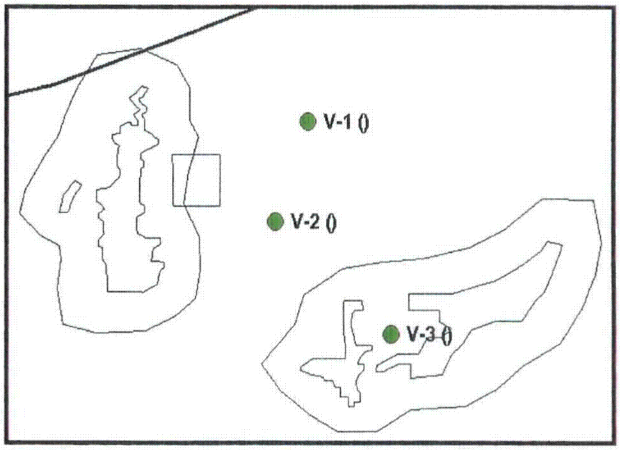


Figure 2.9-38: Vegetation sampling locations in relation to processing facilities area and subsurface ore deposits.

2.9.10.1 Methods

Vegetation samples were collected using ordinary gardening tools (hedge clippers, etc.) as mixed, above-ground growth across several hundred square meter areas at each sampling location. All varieties of vegetation present at each location were sampled and composited into a single sample. These varieties consisted mostly of short grasses and clover plants. At the first sampling event in April, new vegetation growth was limited resulting in difficulty in collecting sufficient volumes of sample for analysis (only 1-2 kilograms of total vegetation mass per sample were able to be collected). The second sampling event in June had considerably more vegetative growth and about 4-5 kilograms per sample were collected. All composited samples were collected in large plastic bags and hand delivered within 24 hours of collection, along with chain of custody forms, to ELI in Casper, WY. Analytes requested included all radiological parameters as recommended in Regulatory Guide 4.14.

2.9.10.2 Vegetation Sampling Results

For each Regulatory Guide 4.14 radionuclide, the second sampling had lower values than the first (Figure 2.9-39). The location with the highest average uranium content in vegetation was to the southeast of the proposed processing plant (V-3), otherwise, the location to the northeast of processing facilities (V-1) area had the highest mean radionuclide levels of the three sampling locations (Figure 2.9-40). Lead-210 had the greatest activity levels of the five radionuclides analyzed, which is likely due to a higher relative abundance of Pb-210 in air particulates from radon decay products. This latter observation is supported by the air particulate data presented in Section 2.9.6 (note in Table 2.9-18 that Pb-210 concentrations are 1-2 orders of magnitude higher than other radionuclides evaluated).

Table 2.9-18: Summary statistics for all vegetation samples collected to date (two of three scheduled samplings) for all sampling locations.

Analyte	Mean (uCi/kg)	Std. Dev. (uCi/kg)	Median (uCi/kg)	Max (uCi/kg)	Min (uCi/kg)	n
Pb-210	9.6E-05	5.9E-05	5.8E-05	1.7E-04	4.3E-06	6
Po-210	8.9E-06	9.2E-06	6.0E-06	2.7E-05	1.5E-06	6
Ra-226	2.2E-05	1.6E-05	1.7E-05	5.1E-05	1.3E-06	6
Th-230	5.2E-06	3.1E-06	4.9E-06	9.8E-06	1.1E-06	6
U-nat	2.2E-05	2.3E-05	5.2E-06	6.0E-05	0.0E+00	6

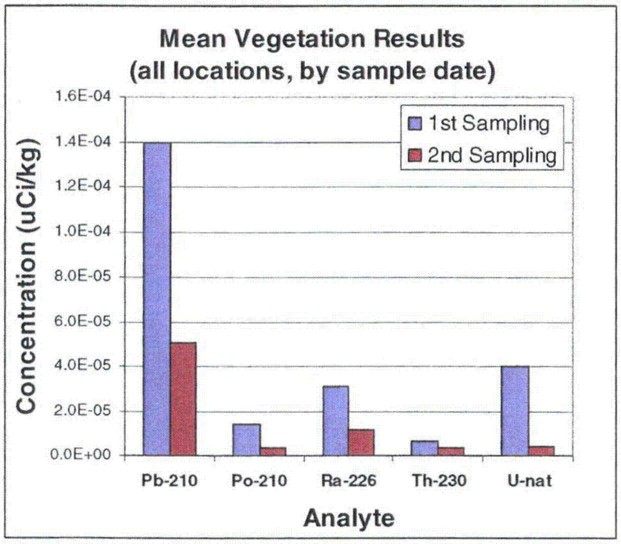


Figure 2.9-39: Analytical results for vegetation samples by sampling date for all locations.

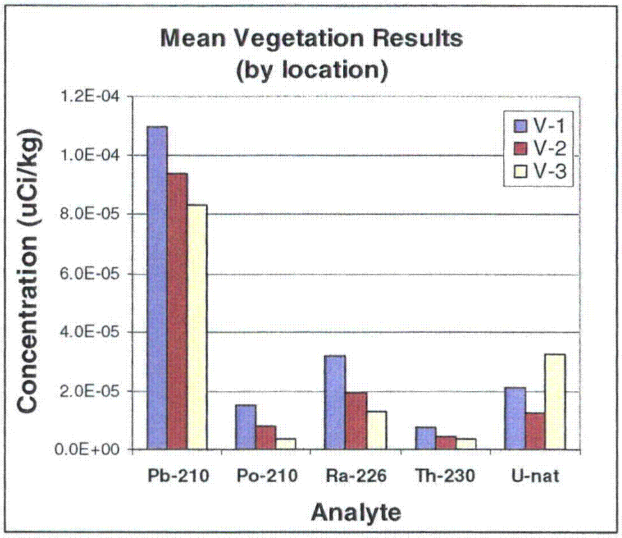


Figure 2.9-40: Analytical results for vegetation samples by sampling location.

Historical results consistently suggest higher radionuclide contents in vegetation at the site compared to the current data (Figure 2.9-41). As with other current/historical survey comparisons described in this report, uncertainty due to random analytical variability, or systematic uncertainty due to differences in analytical methods, are both possible contributors to such differences. Again, there was no information presented in the Conoco report of analytical methods used. For Ra-226 and uranium, there is reasonable agreement between the two data sets. Based on the historical data, there is no indication of significant differences in radionuclide concentrations by vegetation type (Figure 2.9-42). Thus, compositing of all vegetation types encountered at a given sampling location is likely to be generally representative of any given species.

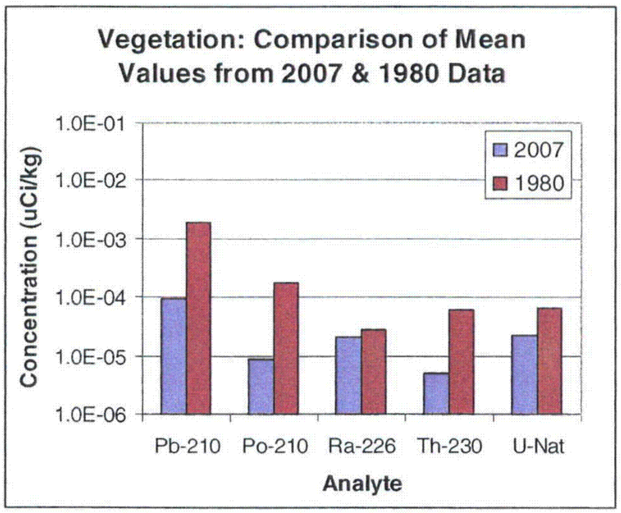


Figure 2.9-41: Mean results for vegetation samples from the 2007 survey compared to historical results (Conoco, 1980).

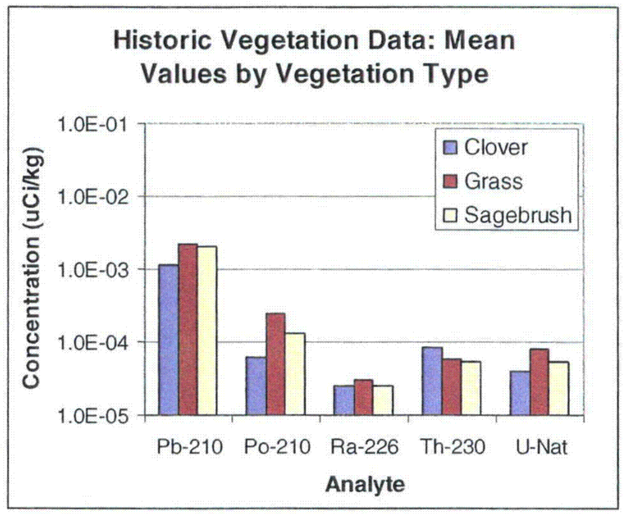


Figure 2.9-42: Mean historical results by vegetation type.

2.9.10.3 Conclusions

Baseline vegetation sampling data for the 2007 radiological survey of the Moore Ranch Uranium Project area are being collected and analyzed according to Regulatory Guide 4.14 protocols. To date, data from two of three scheduled sampling events are available and those results are presented in this section. The historical vegetation data as reported in the 1980 Conoco study are higher on average for each radionuclide analyzed, but data uncertainty due to differing analytical methods may be responsible for much of the difference. Remaining data for the final 2007 sampling (scheduled for late summer or early fall) will be submitted to the NRC and WDEQ/LQD as soon as they are available.

2.9.10.4 References

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming*. Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

2.9.11 Food Sampling

Sampling of food items from the site such as meat from local grazing livestock is not planned at this time. All radiological baseline parameters relevant to food chain dose pathways (e.g. soil, sediment, air particulate samples, water, and vegetation) are comprehensively characterized in this report. The historical Conoco baseline study included food pathway data for various locally raised agricultural products. Those data are provided in Table 2.9-19.

Table 2.9-19: Food sampling results from the historical baseline radiological survey (adapted from Conoco, 1980).

Sample Type	Collection Date	Analysis	Concentration (pCi/g)	± 2σ	Sample Type	Collection Date	Analysis	Concentration (pCi/g)	± 2σ
Squash Composite	9/22/1979	Ra-226	0.014	± 0.002	Sheep II Bone	10/15/1979	Ra-226	0.480	± 0.02
		Th-230	0	± 0.02			Th-230	0.10	± 0.05
		Pb-210	0	± 0.01			Pb-210	0.72	± 0.05
		Po-210	0.01	± 0.01			Po-210	0.16	± 0.02
		Total U-Nat	0.0	± 0.02			Total U-Nat	0.78	± 0.09
Leafy Vegetables Composit	9/22/1979	Ra-226	0.20	± 0.002	Steer I Meat	10/15/1979	Ra-226	0.001	± 0.0003
		Th-230	0	± 0.02			Th-230	0	± 0.05
		Pb-210	0.02	± 0.01			Pb-210	0.009	± 0.005
		Po-210	0.034	± 0.006			Po-210	0.003	± 0.001
		Total U-Nat	0.18	± 0.06			Total U-Nat	0.01	± 0.01
Root Vegetable Composite	9/22/1979	Ra-226	0.027	± 0.003	Steer I Kidney	10/15/1979	Ra-226	0.002	± 0.001
		Th-230	0.030	± 0.01			Th-230	0	± 0.01
		Pb-210	0	± 0.01			Pb-210	0.54	± 0.03
		Po-210	0.028	± 0.007			Po-210	0.131	± 0.01
		Total U-Nat	0.05	± 0.02			Total U-Nat	0.04	± 0.01
Sheep I Meat	10/15/1979	Ra-226	0	± 0.001	Steer II Meat	10/15/1979	Ra-226	< 0.01	
		Th-230	0.010	± 0.005			Th-230	0	± 0.01
		Pb-210	0	± 0.01			Pb-210	0.050	± 0.005
		Po-210	0.011	± 0.002			Po-210	0.023	± 0.005
		Total U-Nat	0	± 0.1			Total U-Nat	0.03	± 0.01
Sheep I Bone	10/15/1979	Ra-226	0.70	± 0.03	Steer II Kidney	10/15/1979	Ra-226	0	± 0.001
		Th-230	0	± 0.06			Th-230	0	± 0.01
		Pb-210	0.76	± 0.06			Pb-210	0.32	± 0.02
		Po-210	0.14	± 0.02			Po-210	0.09	± 0.01
		Total U-Nat	0.04	± 0.01			Total U-Nat	0.01	± 0.01
Sheep II Meat	10/15/1979	Ra-226	0.001	± 0.0003	Steer I and II Bone Composite	10/15/1979	Ra-226	0.008	± 0.007
		Th-230	0	± 0.01			Th-230	0	± 0.01
		Pb-210	0	± 0.001			Pb-210	0.99	± 0.08
		Po-210	0.021	± 0.002			Po-210	0.30	± 0.05
		Total U-Nat	0.020	± 0.01			Total U-Nat	0.13	± 0.03

2.9.11.1 References

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming*. Docket No. 40-8743. July, 1980.

2.9.12 Summary and Overall Conclusions

Comprehensive baseline radiological surveys of the Moore Ranch Uranium Project area in Campbell County, Wyoming are currently being conducted in accordance with Regulatory Guide 4.14 (NRC, 1980) as part of licensing/permitting application submittals to the USNRC and WDEQ/LQD. As of the effective date of this report, surveys of gamma exposure rates and radionuclide concentrations in soils and pond sediments are completed. Monitoring of air particulates, ambient radon/gamma dose rates, groundwater, and surface water continues, with 1-2 quarters of data collected to date. The final sampling event for stream sediments and vegetation have been completed and analysis is underway.

The current gamma exposure rate survey data, collected in the fall of 2006 using the latest GPS scanning system technologies, represent much higher survey coverage than was practical or possible at the time Regulatory Guide 4.14 was published. These data, combined with established analysis techniques and new mapping approaches, provides a very detailed characterization of the magnitude and spatial variability in background gamma exposure rates and soil Ra-226 concentrations across the entire site (about 8,000 acres). Soil/sediment sampling results generally corroborate applicable radiological characterizations based on the gamma survey, and support a conclusion that this approach will provide significant benefits to all stakeholders.

Although some data from current monitoring/sampling activities has yet to be collected, historical radiological survey data from the site (Conoco, 1980) have been compiled and compared to current data and where possible, incorporated into the overall assessment of baseline conditions across the site. The current data, when considered in conjunction with the historical data, provide a good characterization of expected results from remaining survey activities. This characterization should be considered complete for purposes of administrative review prior to completion of currently remaining radiological survey activities. All remaining baseline monitoring/sampling results will be provided to the NRC and WDEQ/LQD as they become available.

2.9.12.1 References

Conoco, Inc. 1980. *Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming.* Docket No. 40-8743. July, 1980.

U.S. Nuclear Regulatory Commission (NRC). 1980. Regulatory Guide 4.14. *Radiological Effluent and Environmental Monitoring at Uranium Mills.* Revision 1. Nuclear Regulatory Commission Office of Standards Development. Washington, D.C.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: DRAWING NO.: FIGURE 2.9-12, "MOORE RANCH KRIGING RESULTS: ESTIMATED 3 - FOOT HPIC EQUIVALENT GAMMA SCAN TACK DATA"

WITHIN THIS PACKAGE... OR, BY SEARCHING USING THE DOCUMENT/REPORT DRAWING NO. FIGURE 2.9-12

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WITHIN THIS PACKAGE... OR, BY SEARCHING USING THE DOCUMENT/REPORT DRAWING NO. FIGURE 2.9-13

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THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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WITHIN THIS PACKAGE... OR, BY SEARCHING USING THE DOCUMENT/REPORT DRAWING NO. FIGURE 2.9-16

D-05

3 DESCRIPTION OF PROPOSED FACILITY

The Moore Ranch Project will be developed by constructing wellfields and mining support facilities, as well as a central process facility to provide chemical makeup of recovery solutions, recovery of uranium by ion exchange, resin loading/unloading, elution and precipitation circuits, yellowcake drying capabilities, and groundwater restoration capabilities.

The proposed License Area for the Moore Ranch property contains approximately 7,110 acres. The total surface area to be affected by the proposed operation is within the License Area and will total less than 150 acres. The wellfields, central plant/offices/shop facilities, and two wastewater disposal wells are the primary surface features associated with the proposed ISR operations. There are no evaporation or holding ponds planned for the Moore Ranch Project at this time.

The proposed wellfield area to be used for the injection and recovery operations over the ten-year mine life will encompass approximately 150 acres. The wellfield areas will be fenced to limit access by livestock.

Other mineralized trends exist within the current proposed license area, but have not been extensively explored. If future exploration shows potential for development of these other existing trends, then appropriate baseline evaluations will be made at that time and submitted the NRC for approval.

3.1 IN SITU RECOVERY PROCESS

Production of uranium by ISR techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the recovery solution is pumped into the ore body. Corresponding recovery wells and pumps promote flow through the ore body and allow for the collection of uranium-rich recovery solution. Uranium is removed from the recovery solution by ion exchange, and then from the ion exchange resin by elution. The recovery solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluant) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium.

3.1.1 Orebody

The targeted mineralized zone for in situ uranium recovery at Moore Ranch is the 70 Sandstone at a depth that varies from 180 feet to 250 feet. The overall width of the mineralized area varies from 100 feet to 1000 feet. The orebody ranges in grade from less than 0.05% to greater than 0.5% U3O8, with an average grade estimated at 0.1% U3O8. Additional mining targets may exist in the area at greater depths. Additional future delineation will be needed to fully define any deeper targets.

Typical stratigraphic intervals to be mined are shown in the geologic cross sections contained in Section 2.6. For ISR wellfields, the production zone is the geological sandstone unit where the recovery solutions are injected and produced.

3.1.2 Well Construction and Integrity Testing

3.1.2.1 Well Materials of Construction

The well casing material will be polyvinyl chloride (PVC) with schedule 40 wall thickness and a nominal 5-inch outside diameter. However, if a larger pump size is necessary, larger diameter casing may be utilized. The table below shows the range of casing sizes that could be used at Moore Ranch, and the corresponding drill hole size to ensure adequate annular sealing. Each joint of the PVC casing will normally have a length of approximately 20 feet. Each joint will be connected either with glue and self-tapping screws or joined mechanically (with pipe threads or a water tight o-ring seal with a high strength nylon spline).

Casing	I.D.	O.D.	Bit size
4.5"	4.454	4.950	7-7/8
5.0"	5.047	5.563	8-3/4
6.0"	6.065	6.625	9-7/8

3.1.2.2 Well Construction Methods

Pilot holes for monitor, recovery, and injection wells are drilled to the bottom of the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole is logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. The cement is placed by pumping it down the casing and forcing it out the bottom of the casing and back up the casing-drill hole annulus. The pilot holes will be large enough in diameter to provide at least three inches of annulus space.

Typical well completion schematics for recovery wells, injection wells, and monitor wells are shown on Figure 3.1-1.

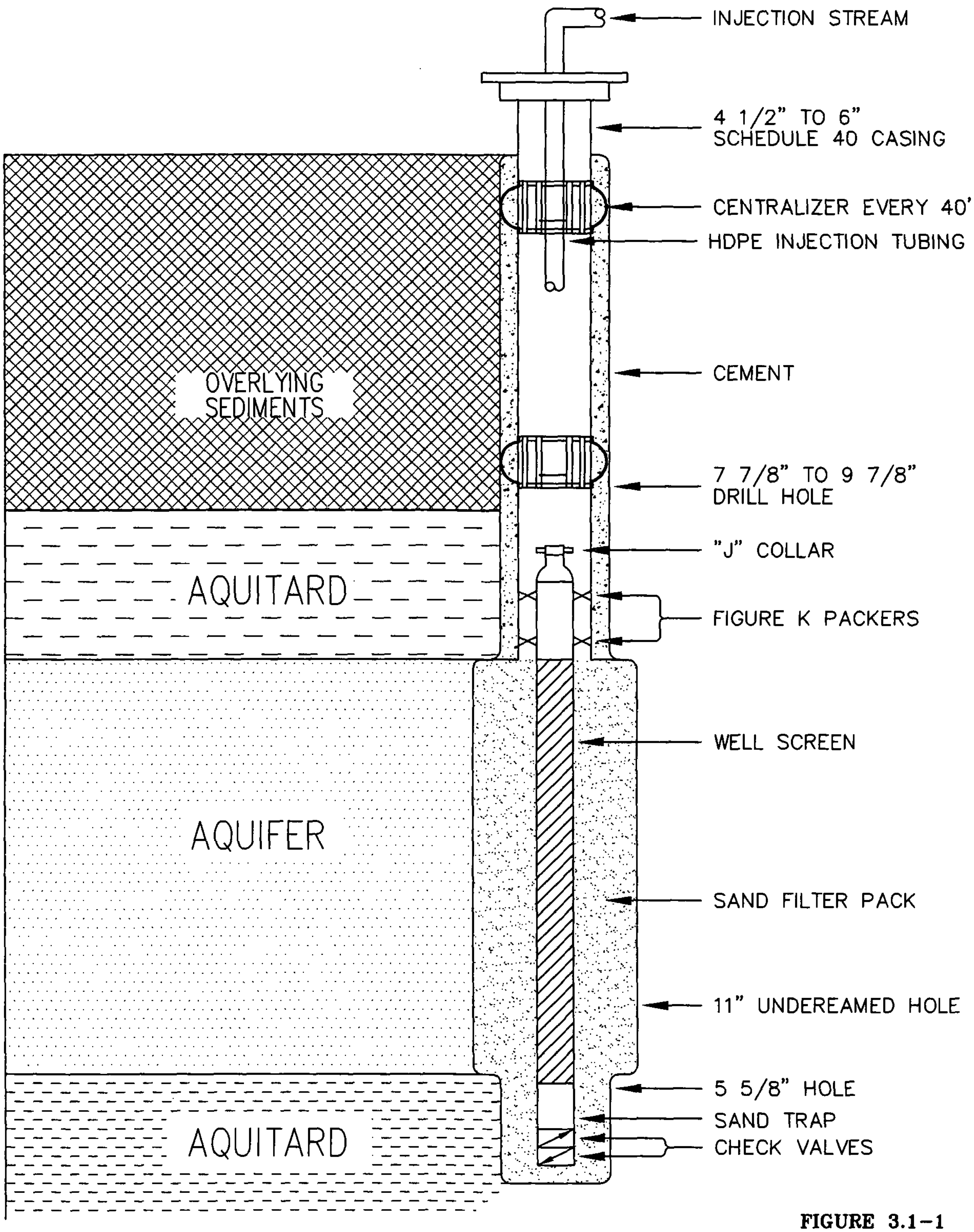

FIGURE 3.1-1

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MOORE RANCH
URANIUM PROJECT

TYPICAL WELL
COMPLETION

CAMPBELL COUNTY, WYOMING

Casing centralizers, located approximately every 40 feet above the casing shoe, are normally run on the casing to ensure it is centered in the drill hole. Effective sealing materials shall consist of neat cement slurry, sand-cement grout, or bentonite clay mixtures meeting State requirements described in Section 6, Chapter 11 of the Wyoming Land Quality Division (LQD) Non Coal Rules and Regulations or equivalent. The purpose of the cement or other sealing materials is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare instances, however, the drilling may result in a larger annulus volume than anticipated and cement may not return all the way to the surface. In these cases the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure may be performed by placement of a tremie pipe from the surface as far down into the annulus as possible to the nearest centralizer (40 feet), or by simply backfilling from the surface if use of a tremie pipe is impractical. Cement is pumped into the annulus until return to the surface is observed.

After the well is cemented to the surface and the cement has set, the well is drilled out and completed either as an open hole or it is fitted with a screen assembly (slotted liner), which may have a sand filter pack installed between the screen and the underreammed formation. The well is then air lifted to remove any remaining drilling mud and/or cuttings until well fluids are clear. A small submersible pump is frequently run in the well for final clean-up and sampling (where necessary).

A well completion report is completed on each well. These data are kept available on-site for review or submitted to the Land Quality Division upon request.

3.1.2.3 Well Development

Following construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using air lifting, swabbing or other accepted development techniques. Well development removes water and drilling fluids from the casing and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen. This process is necessary to allow representative samples of groundwater to be collected, and to ensure efficient injection and recovery operations.

Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling.

Final development is performed by pumping the well or swabbing for an adequate period to ensure that stable formation water is present. Monitoring for pH and conductivity is performed during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

3.1.2.4 Well Integrity Testing

Field-testing of all (i.e., injection, recovery, and monitor) wells is performed to demonstrate the mechanical integrity of the well casing. This mechanical integrity test (MIT) is performed using pressure-packer tests. In the MIT, the bottom of the casing adjacent to or below the confining layer above the production zone is sealed with a plug, downhole packer, or other suitable device. The top of the casing is then sealed in a similar manner or with a threaded cap, and a calibrated pressure gauge is installed to monitor the pressure inside the casing. The pressure in the sealed casing is then increased to 120% of the maximum operating pressure. A well must maintain 90% of this pressure for 10 minutes to pass the test. EMC will test all well casings at a pressure of 150 psi (maximum operating pressure) plus the 20% safety factor, for a total test pressure of 180 psi.

If there are obvious leaks, or the pressure drops by more than 10% during the 10 minute period, the seals and fittings on the packer system will be reset and/or checked and another test is conducted. If the pressure drops less than 10% the well casing is considered to have demonstrated acceptable mechanical integrity.

If a well casing does not meet the MIT criteria, the well will be taken out of service and the casing may be repaired and the well re-tested or plugged and abandoned. The WDEQ-LQD will be notified of any well that fails the MIT. If a repaired well passes the MIT, it will be employed in its intended service following approval from the LQD Administrator that the well has demonstrated mechanical integrity. If the well defect occurs at depth, the well may be plugged back and re-completed for use in a shallower zone provided it passes the MIT. If an acceptable test cannot be obtained after repairs, the well will be plugged and abandoned.

In addition to the initial testing after well construction, a MIT will be conducted on any well after any repair where a downhole drill bit or underreaming tool is used. Any injection well with evidence of suspected subsurface damage will require a new MIT prior to the well being returned to service. In accordance with WDEQ and EPA requirements, MITs are repeated once every five years for all wells.

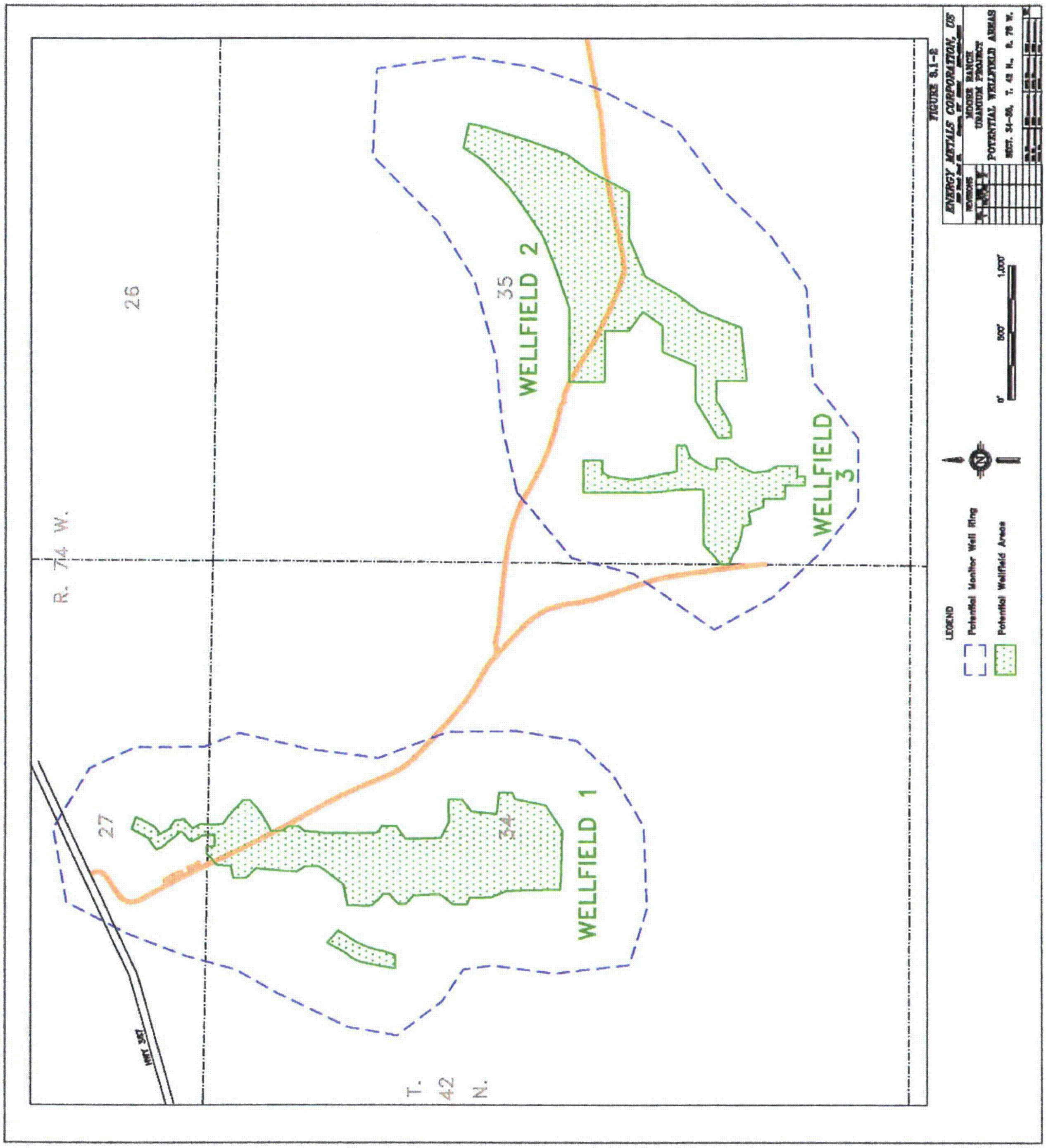
The MIT of a well will be documented to include the well designation, date of the test, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting the test. Results of the MITs are maintained on site and are available for inspection by NRC and WDEQ. In accordance with WDEQ and EPA requirements, the results of MITs are reported to the WDEQ on a quarterly basis.

3.1.3 Wellfield Design and Operation

The proposed Moore Ranch wellfield map is shown in Figure 3.1-2. The map is preliminary based on EMC's current knowledge of the area and the installation of three wellfields. As the Moore Ranch Project is developed, the wellfield map will be updated accordingly.

The wellfield injection/recovery pattern employed is based on the conventional square five spot pattern which is modified as needed to fit the characteristics of the orebody (see Figure 3.1-3). The standard production cell for the five spot pattern contains four injection wells surrounding a centrally located recovery well. The cell dimensions vary depending on the formation and the characteristics of the orebody. The injection wells in a normal pattern are expected to be between 75 feet and 150 feet apart. All wells will be completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. Other wellfield designs include alternating single line drives.

Within each wellfield, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient the natural groundwater movement from the surrounding area is toward the wellfield providing additional control of the recovery solution movement. The difference between the amount of water produced and injected is the wellfield "bleed."

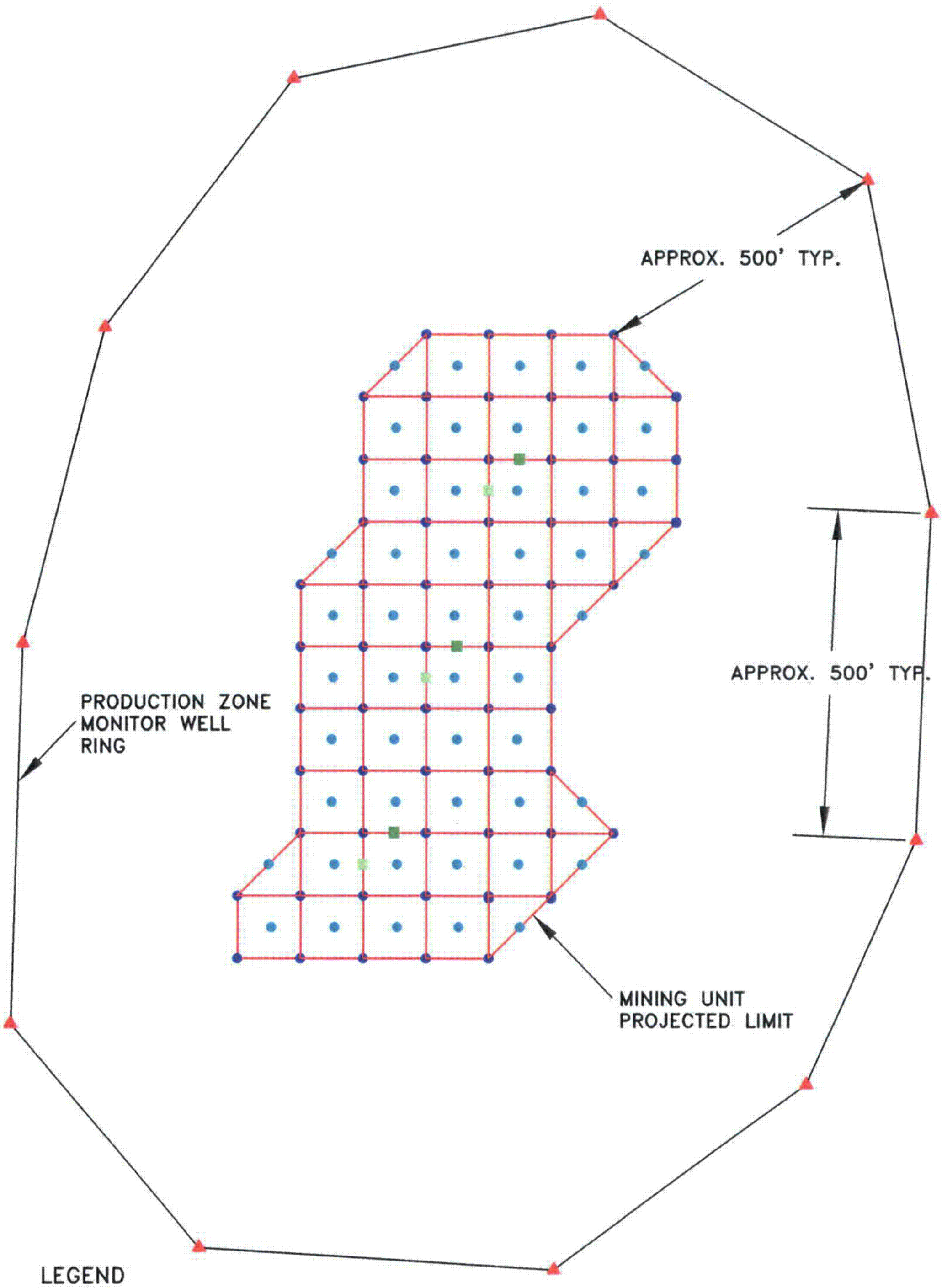

WELLFIELD 1
WELLFIELD 2
WELLFIELD 3
26
27
34
35
R. 74 W.
T. 42 N.
HWY 387
LEGEND
Potential Monitor Well Ring
Potential Wellfield Areas

The minimum over production or bleed rates will be a nominal 0.5% of the total wellfield production rate and the maximum bleed rate typically approaches 1.5%. Bleed rates will be adjusted as necessary to ensure that the wellfield cone of depression is maintained.

Each injection well and recovery well is connected to the respective injection or recovery manifold in a wellfield headerhouse building. The manifolds deliver the recovery solutions to the pipelines carrying the solutions to and from the ion exchange facilities. Flow meters and control valves are installed in the individual well lines to monitor and control the individual well flow rates and pressures. Wellfield piping is constructed of high density polyethylene (HDPE), polyvinyl chloride (PVC), and/or steel. The wellfield piping will typically be designed for an operating pressure of 150-300 psig, and it will be operated at pressures equal to or less than the rated operating pressure of the pipe and other in-line equipment. If a higher design pressure is needed, the pressure rating of the materials will be evaluated and if necessary, materials with a higher pressure rating will be used.

The individual well lines and the trunk lines to the ion exchange facility are buried to prevent freezing. The use of wellfield headerhouses and buried lines is a proven method for protecting pipelines. A typical wellfield development pattern is illustrated in Figure 3.1-3.

Monitor wells will be placed in the mining zone and in the first significant water-bearing sand above (overlying) the mining zone and below (underlying) the mining zone. All monitor wells will be completed using the well construction and testing methods discussed above and developed prior to recovery solution injection. Typical locations of the monitor well rings for the proposed wellfields are shown in Figure 3.1-2. As previously noted, the map is based on EMC's current knowledge of the area. As the project is developed, the wellfield map will be updated accordingly.



LEGEND

- INJECTION WELL
- PRODUCTION WELL
- PRODUCTION ZONE MONITOR WELL
- OVERLYING AQUIFER MONITOR WELL
- UNDERLYING AQUIFER MONITOR WELL

FIGURE 3.1-3

ENERGY METALS CORPORATION, US

MOORE RANCH URANIUM PROJECT

TYPICAL WELLFIELD LAYOUT

CAMPBELL COUNTY, WYOMING

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ENG. BY:	DATE:	APPR. BY:	DATE:
DRAFT. BY:	DATE:	SCALE:	FILE:

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Injection of solutions for mining will be at a maximum rate of approximately 3,000 gpm. A water balance for the proposed Moore Ranch Project is shown on Figure 3.1-4. The liquid waste generated at the central plant will be primarily the production bleed which is estimated at an average of 1% of the production flow. At 3,000 gpm, the average volume of liquid waste generated by production bleed is 30 gpm. EMC proposes to dispose of the liquid waste through deep disposal well injection.

As stated, a bleed rate of approximately 30 gpm from the 70 sand is anticipated during full scale operations. As demonstrated from the limited drawdown during the regional aquifer testing, this amount of consumptive use will generate negligible drawdown outside of wellfield areas. As a result, no impact to other users of groundwater is expected since there are no other existing users of groundwater in the 70-sand within the immediate proximity to the wellfield areas. For the same reasons, no impacts to water users outside of the proposed license boundary are expected. Impacts to groundwater from consumptive use are discussed in detail in Section 7.2. Furthermore, since coal bed methane (CBM) wells in the area are completed at far greater depths separated by several confining layers, there are no foreseen impacts to CBM operations as a result of the consumptive use of groundwater in the 70-sand.

Downhole injection pressures will be maintained below the formation fracture pressure. The formation fracture pressure gradient commonly used is 1.0 psi for every 1 foot of depth[1] to the top of the screened interval. At Moore Ranch, the depth to the top of the anticipated screened interval varies from approximately 160 feet in Wellfield 3 to 300 feet in Wellfield 1. Accordingly, injection pressures will range from 100 psi at the headerhouses located in shallower ore areas to no greater than 150 psi at the headerhouses located in deeper ore areas. Well casing integrity will be tested at 150 psi plus a 20% engineering factor, or 180 psi.

3.1.3.1 Wellfield Operational Monitoring

As discussed in Section 5.7 of this Technical Report, an extensive water-sampling program will be conducted prior to, during and following mining operations at the Moore Ranch project to identify any potential impacts to water resources of the area. The groundwater monitoring program is designed to establish baseline water quality prior to mining; detect excursions of lixiviant either horizontally or vertically outside of the production zone during mining; and determine when the production zone aquifer has been adequately restored following mining.

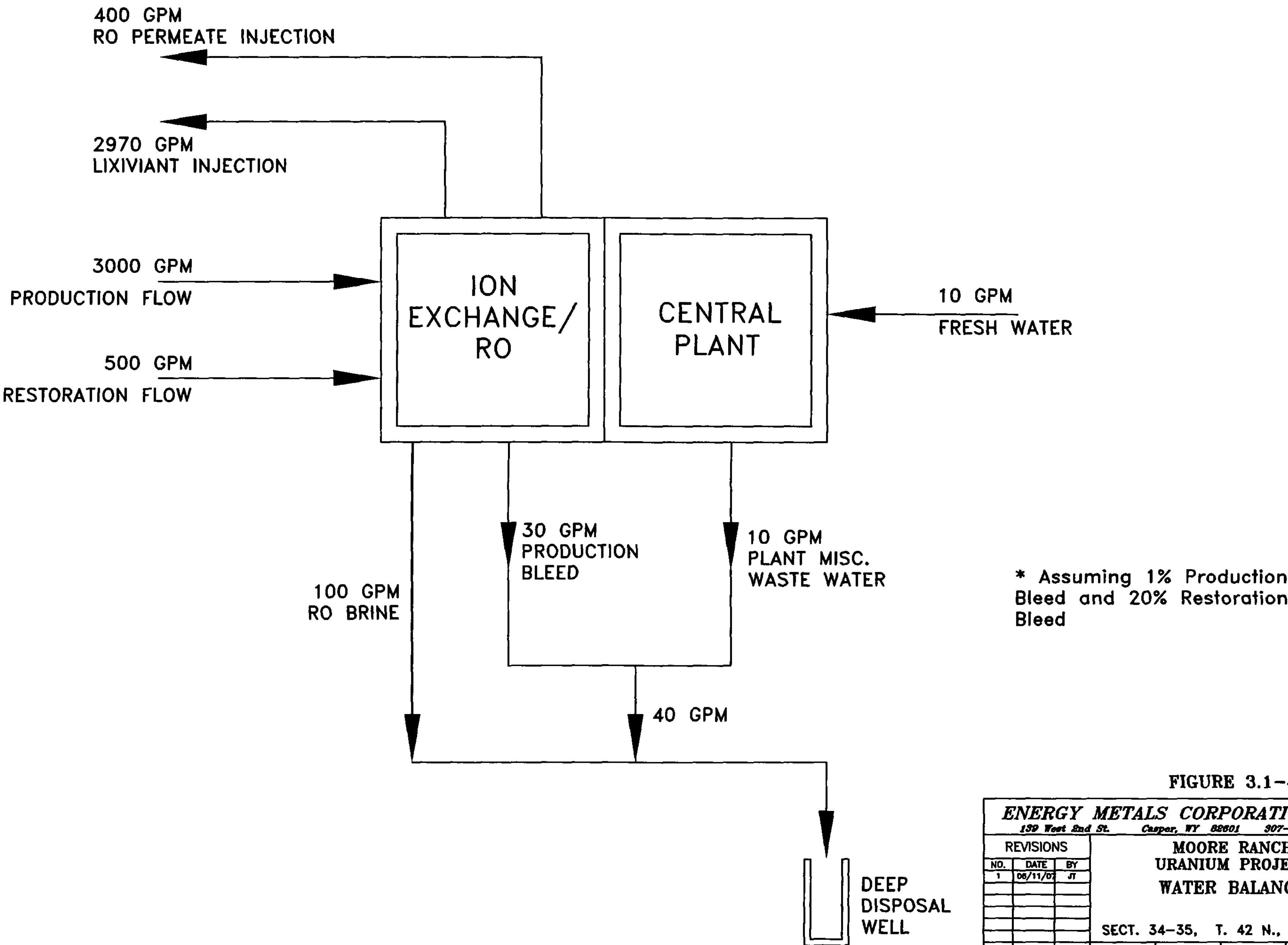

FIGURE 3.1-4

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139 West 2nd St. Casper, WY 82601 307-234-8235

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MOORE RANCH
URANIUM PROJECT
WATER BALANCE

SECT. 34-35, T. 42 N., R. 75 W.

3.1.4 Process Description

Uranium in situ recovery is a process that takes place underground, or in-place, by injecting lixiviant (recovery) solutions into the ore body and then recovering these solutions when they are rich in uranium. The uranium rich solutions (pregnant lixiviant) are then pumped from recovery wells (production wells) to the central plant ion exchange system for extraction. The uranium recovery process utilizes the following steps:

1. Injection of lixiviant: oxidation and complexation of the uranium underground;
2. Loading of uranium complexes onto an ion exchange resin;
3. Reconstitution of the recovery solution by addition of carbon dioxide and/or sodium bicarbonate and an oxidant;
4. Elution of uranium complexes from the resin;
5. Precipitation of uranium.

3.1.4.1 In Situ Reactions

The lixiviant is the recovery solution which is used to solubilize the uranium from the ore deposit. The composition is designed to reverse the natural geochemical conditions which led the to original uranium deposition. The project will use a carbonate/or bicarbonate recovery solution consisting of varying concentrations and combinations of sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), oxygen, and carbon dioxide (CO_2) added to the native groundwater to promote the dissolution of uranium as a uranyl carbonate complex. The lixiviant is typically made up on a batch basis in the plant and added continuously to the injection stream. The expected or typical lixiviant concentration and composition is shown in Table 3.1-1.

The chemistry of in situ recovery involves an oxidation step to convert the uranium in the solid state to a form that is easily dissolved by the recovery solution. The reactions representing these steps at a neutral or slightly alkaline pH are:

Oxidation: $UO_{2\,(solid)} + \frac{1}{2}\,O_{2\,(in\ solution)} + 2H^+ \longrightarrow UO_{3\,(at\ solid\ surface)}$

Dissolution: $UO_3 + 2\,HCO_3^{-1} \longrightarrow UO_2(CO_3)_2^{-2} + H_2O$

$$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \rightarrow UO_2(CO_3)_3^{-4} + H_2O$$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2(CO_3)_2^{--2}$, (UDC), and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$, (UTC). The relative abundance of each is a function of pH and total carbonate strength.

3.1.4.2 Uranium Extraction

The process flow sheet depicting the uranium extraction process as planned for the central plant is shown in Figure 3.1-5. The recovery of uranium from the pregnant lixiviant in the Moore Ranch Facility will take place in the ion exchange columns. The uranium bearing recovery solution enters the pressurized downflow ion exchange column and passes through the resin bed. A uranium specific ion exchange resin, such as Dowex 21K or equivalent, is used. The uranium complexes in solution are loaded onto the ion exchange resin in the column. This loading process is represented by the following chemical reaction:

$$2\,R\,HCO_3 + UO_2(CO_3)_2^{-2} \rightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

$$2\,RCl + UO_2(CO_3)_2^{-2} \rightarrow R_2UO_2(CO_3)_2 + 2Cl^{-}$$

$$R_2SO_4 + UO_2(CO_3)_2^{-2} \rightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate or sulfate ions.

The now barren lixiviant passes from the ion exchange columns to be reinjected into the formation. The solution is refortified with the sodium carbonate/bicarbonate based lixiviant as required and pumped to the wellfield for reinjection into the formation.

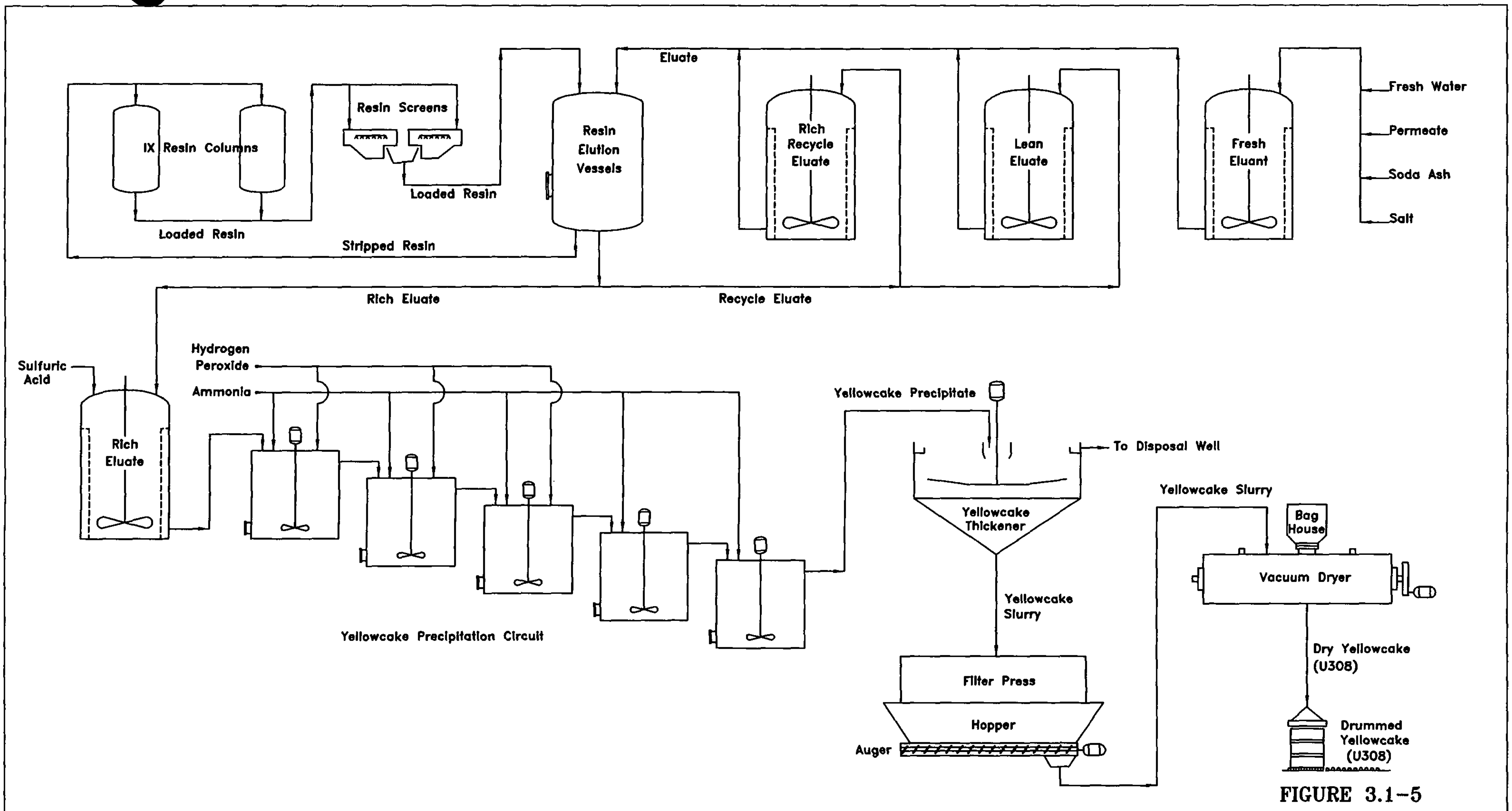

FIGURE 3.1-5

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MOORE RANCH
URANIUM PROJECT
PROCESS FLOW DIAGRAM

SECT. 34-35, T. 42 N., R. 75 W.

Table 3.1-1: Typical Lixiviant Concentrations

SPECIES	RANGE (mg/L)	
	Low	High
Na	≤ 400	6000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2500
HCO_3	≤ 400	5000
Cl	≤ 200	5000
SO_4	≤ 400	5000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12000
pH	< 6.0	8.0

* All values in mg/l except pH (units).

NOTE: The above values represent the concentration ranges that could be found in barren lixiviant or pregnant lixiviant and would include the concentration normally found in "injection fluid".

3.1.4.3 Resin Transfer and Elution

Once the ion exchange resin in an IX column is loaded to capacity with uranium complexes, the column will be taken out of service. The resin loaded with uranium will be transferred from the IX column to the elution circuit. Once the resin has been stripped of the uranium by the process of elution, the resin will be returned to the appropriate column for reuse in the ion exchange circuit. In the elution circuit the loaded resin will be stripped of uranium by a process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^- + CO_3^{-2} \longrightarrow 2\ RCl + UO_2(CO_3)_3^{-2}$$

After the uranium has been stripped from the resin, the resin may be rinsed with a sodium bicarbonate solution. This rinse removes the high chloride eluant physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the lixiviant can be controlled.

3.1.4.4 Precipitation

When a sufficient volume of pregnant eluant is held in storage, it is acidified with either sulfuric acid to break the uranyl carbonate complex ion and liberate carbonate ions as carbon dioxide. The solution is agitated to assist in removal of the resulting CO_2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\ CO_2\uparrow + 3H_2O$$

Anhydrous ammonia is then added to raise the pH to a level conducive for precipitating uranium crystals.

Hydrogen peroxide is then added to the solution to precipitate the uranium according to the following reaction:

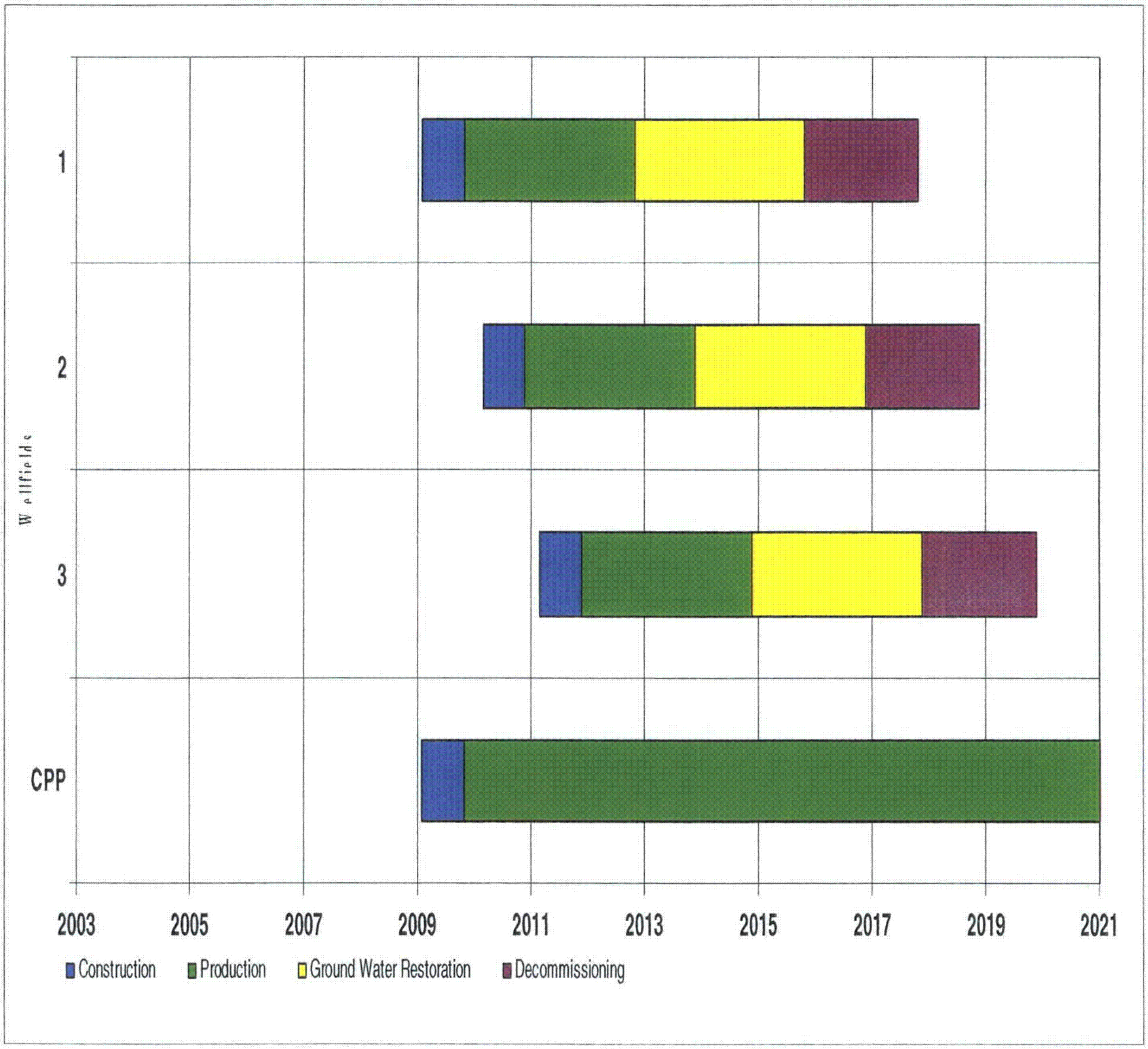
$$UO_2^{++} + H_2O_2 + 2H_2O \xrightarrow{NH_3} UO_4 \bullet 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is recirculated back to the barren makeup tank, sent to fresh salt brine makeup, or sent to waste. The thickened uranyl peroxide "slurry" is further dewatered and washed. The solids discharge is either sent to the vacuum dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or conversion facility.

3.1.5 Proposed Operating Schedule

The proposed Moore Ranch mine schedule is shown in Figure 3.1-6. The mine schedule is preliminary based on EMC's current knowledge of the area and the installation of three wellfields. As the Moore Ranch Project is developed, the mine schedule will be updated accordingly.

Figure 3.1-6: Proposed Moore Ranch Operations Schedule



3.2 CENTRAL PLANT AND CHEMICAL STORAGE FACILITIES; EQUIPMENT USED AND MATERIAL PROCESSED

The uranium recovery process described in the preceding section will be accomplished in several steps. Uranium recovery from the solution by ion exchange, subsequent processing of the loaded ion exchange resin to remove the uranium (elution), the precipitation of uranium, and the dewatering and packaging of solid uranium (yellowcake) will be performed at the central plant.

The central plant will not only serve production from Moore Ranch ISR operations, but is also planned to process resin from other potential EMC satellite projects in the area, or potential tolling arrangements with other in situ operations licensed under a different operator. The central plant will be initially designed and constructed to produce 2 million pounds of U_3O_8 per year (see Figure 3.2-1 for layout). Capacity is expected to be expanded to 4 million pounds per year as these other potential satellite projects are licensed and production increases (see Figure 3.2-2 for expanded facility layout).

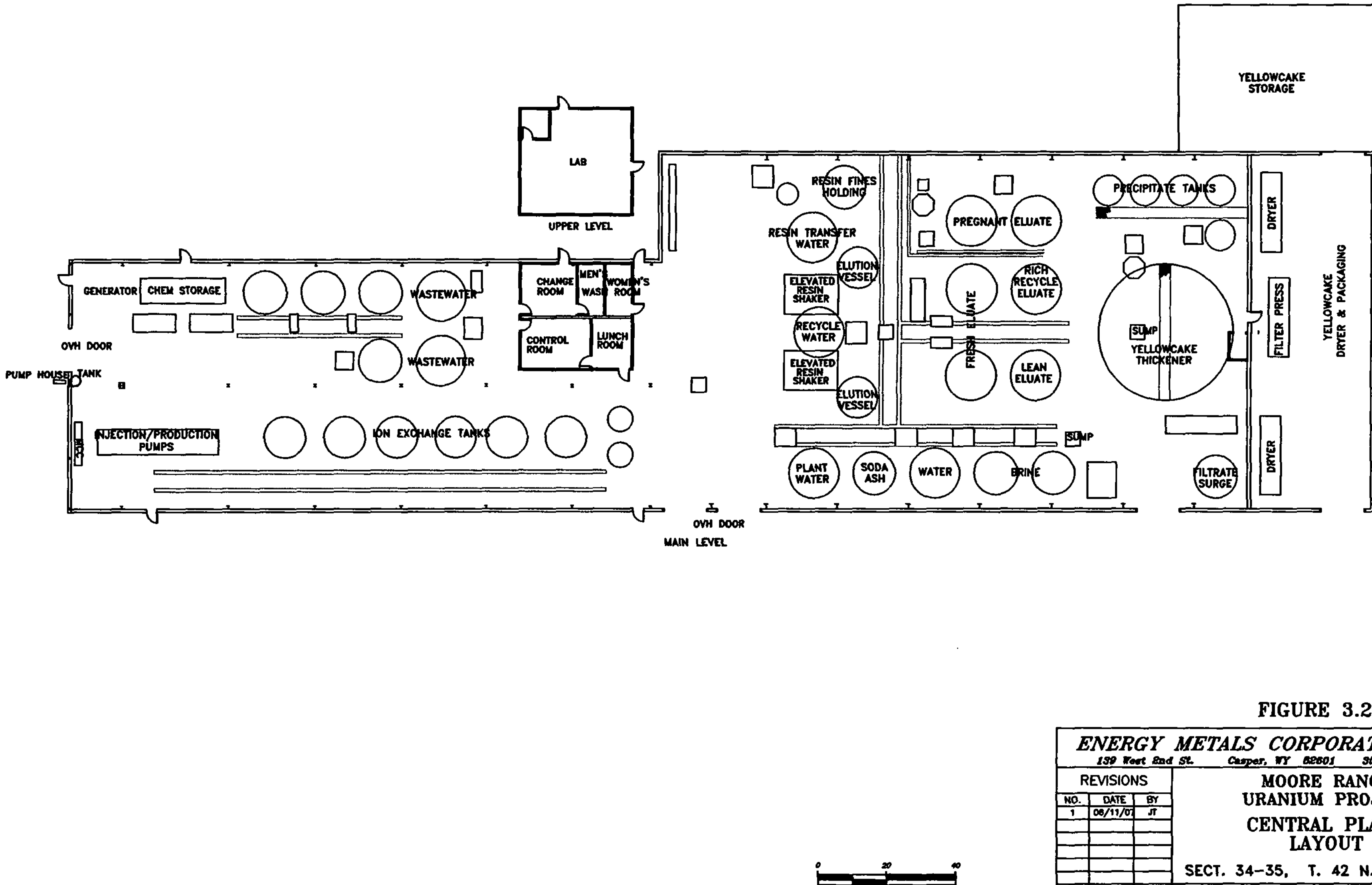


FIGURE 3.2-1

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MOORE RANCH
URANIUM PROJECT

CENTRAL PLANT
LAYOUT

SECT. 34-35, T. 42 N., R. 75 W.

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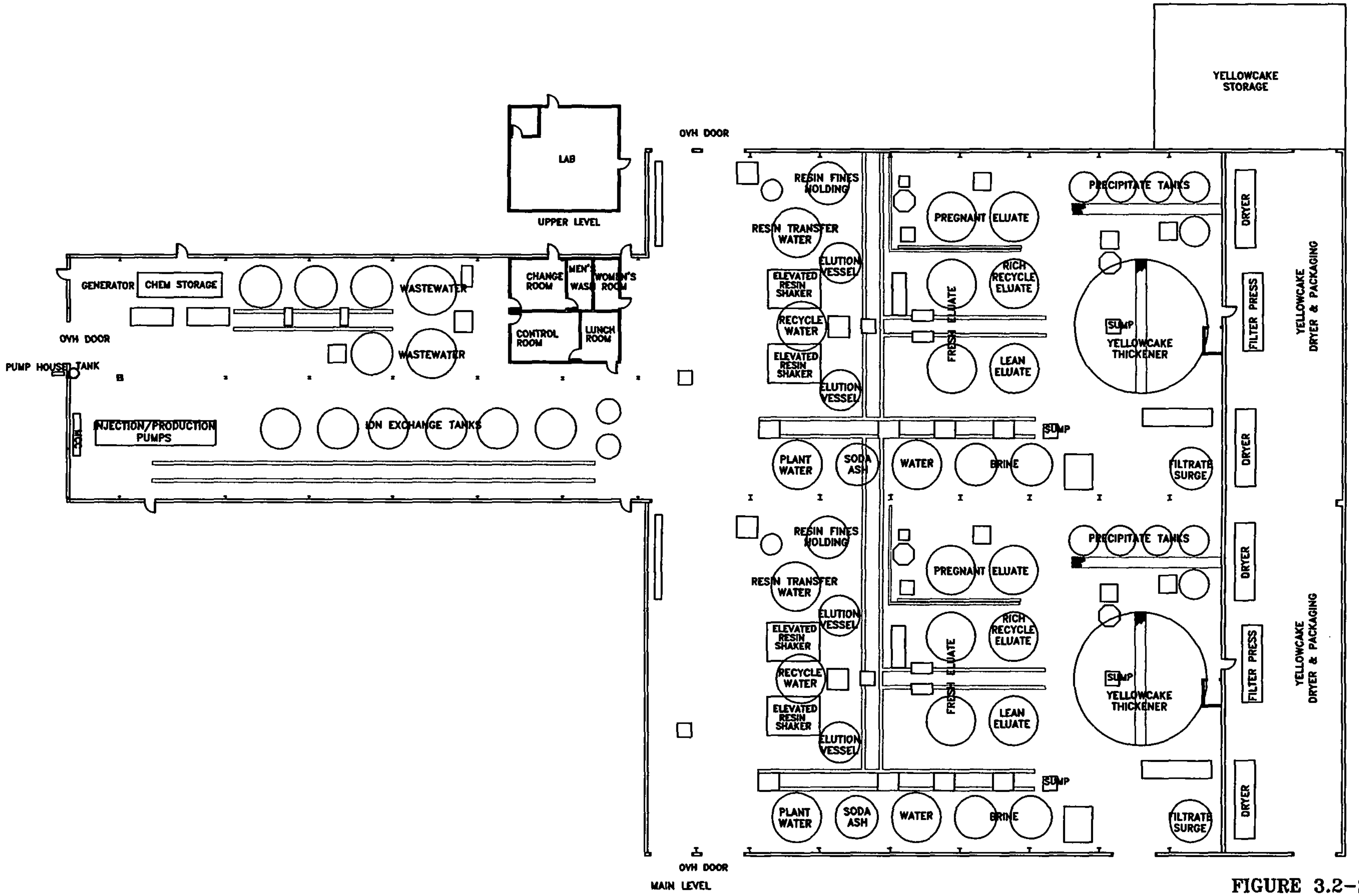

FIGURE 3.2-2

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MOORE RANCH
URANIUM PROJECT

EXPANDED CENTRAL PLANT LAYOUT

SECT. 34-35, T. 42 N., R. 75 W.

0 20 40

3.2.1 Moore Ranch Central Plant Equipment

The initial Moore Ranch central plant facilities will be housed in a building approximately 350 feet long by 100 feet wide. The building width (with the exception of the ion exchange area) will likely double to accommodate the future planned expansion. The central plant includes the following systems:

- Ion exchange;
- Resin transfer
- Chemical addition
- Filtration
- Elution Circuit
- Precipitation Circuit
- Product Filtering, Drying and Packaging, and
- Liquid Waste Stream Circuit.

Based on preliminary design and site geotechnical evaluations, the Moore Ranch central plant will be located within an 11 acre fenced area in the NW ¼¼, Section 34, T42N, R75W. This area will also contain the deep disposal well and chemical storage areas. Figure 3.2-2 shows the plan view of the expanded central plant.

3.2.1.1 Flow and Material Balance – Ion Exchange

The uranium-bearing solution or pregnant lixiviant pumped from the wellfield is piped to the ion exchange plant for extraction of the uranium by use of ion exchange units. The ion exchange system consists of eight fixed bed ion exchange vessels. The ion exchange vessels will be operated as three sets of two vessels in series with two vessels available for restoration. The ion exchange system is designed to process recovered solution at a rate of 3,000 gpm with each vessel sized for 500 cubic feet of resin operated in a pressurized downflow mode. As the solution passes through the IX resin in the IX vessels the uranyldicarbonate and uranyltricarbonate are preferentially removed from the solution. The barren solutions leaving the ion exchange units normally contain less than 2 mg/l of uranium.

After the barren lixiviant leaves the ion exchange vessels, carbon dioxide and/or carbonate/bicarbonate is added as necessary to return the carbonate/bicarbonate concentration to the desired operating level. The solution is then pumped back to the wellfield, with the oxidant (O_2 gas) added either as it leaves the central plant, or just before the solution is re-injected into the production zone.

Loaded resin from potential future EMC satellite operations or other projects will be transported to the central plant via tanker truck. A pressurized transfer system will be used to transfer resin from the truck to the plant.

3.2.1.2 Flow and Material Balance – Elution System

Using a three stage elution circuit, approximately 33,000 gallons of eluate will contact 500 cubic feet of resin. The first elution stage generates approximately 1,500 ft^3 (11,220 gallons) of pregnant eluate containing 10 to 20 grams per liter U_3O_8. Approximately 1,500 ft^3 (11,220 gallons) of fresh eluate will be required per elution batch. The fresh eluate is prepared by mixing the proper quantities of a saturated sodium chloride (salt) solution and saturated sodium carbonate (soda ash) solution and water to form a solution that is approximately 9% NaCl and 2% Na_2CO_3. The saturated salt solution will be generated in a brine generator and the saturated soda ash solution will be prepared by passing warm water (>105° F) through a bed of soda ash. The eluate is passed through a bank of 10 micron bag filters to remove entrained particulates prior to contacting the resin beds in the elution vessels.

In the three stage elution, the rich eluate is first passed through the elution vessels which contain the IX resin. The rich eluate strips approximately 84% of the uranyl carbonate ions from the resin and becomes pregnant eluate, which then contains approximately 15,500 mg/l of U_3O_8. Next, lean eluate is contacted with the resins and removes approximately 68% of the remaining uranyl carbonate to become rich eluate. Finally, fresh eluate is passed through the resins in the elution vessels and removes approximately 35% of the remaining uranyl carbonate from the resins. This final flush is the lean eluate. At this point, the resins have a residual uranyl carbonate concentration of approximately 3.33%. The resins are washed with fresh water and transferred back to the appropriate vessel or to a resin transfer trailer for transport back to any off-site satellite mining areas. Each batch of eluate will be transferred from the respective eluate storage tank through the elution vessel at a rate of approximately 210 gpm.

3.2.1.3 Flow and Material Balance – Precipitation System

Approximately 210 gallons of sulfuric acid is added to the pregnant eluate to break the uranyl carbonate complex, which liberates carbon dioxide and frees uranyl ions to form a uranyl sulfate ion complex. The acidic, uranium rich fluid is pumped to the first of five agitated tanks arranged in series. The fluid flows by gravity from one tank to the next. Hydrogen peroxide is added to the first two tanks to form an insoluble uranyl peroxide compound. Ammonia is then diffused into solution in the third tank. Compressed air is added to the ammonia stream prior to injection into the tank. Ammonia and air are also diffused into solution into the final tank in series. The addition of ammonia raises the pH of the precipitate solution to near neutral for optimum crystal growth and settling. The uranium precipitate solution is then pumped from the final precipitation tank to a 38-foot diameter gravity thickener.

3.2.1.4 Yellowcake Drying

The thickened yellowcake will be pumped into a plate and frame filter press. The yellowcake is washed by pumping fresh water through the solids in the filter press. Washing removes excess chlorides and other soluble contaminants from the yellowcake. The filtered yellowcake, which is approximately 60% solids, drops from the filter press into a live bottom hopper with a screw auger to move the pressed yellowcake slurry to a sump where a moyno-type positive displacement pump transfers the yellowcake to an indirect fired rotary vacuum dryer. Water is added to the yellowcake in the live bottom hopper to facilitate pumping the solids to the dryer.

The yellowcake will be dried at approximately 250°F. The off gases generated during the drying cycle are filtered through a baghouse, which is located on the top of the dryer, to remove particles down to approximately a 1 micron size fraction. The gases are then cooled and scrubbed in a surface condenser to further remove the smaller size fraction particulates and the water vapor during the drying process. Two rotary vacuum dryers (potentially 4 vacuum dryers after future plant expansion) will be located in a separate building attached to the central plant which will contain the dryers, the baghouses on the dryers and a condenser scrubber and vacuum pump system for each dryer. The dryers will be approximately 20 feet in length and 5 feet in diameter. The dryers will be heated with a heat transfer fluid (Dow-Therm® or equivalent) that circulates through the shell and the rotating central shaft, to which plows are affixed. The plows stir and mix the material in the dryer to facilitate even drying of the solids in the chamber. The heat transfer fluid (HTF) will be heated by two natural gas or propane fired HTF heaters, each provided with HTF pumps for circulating the HTF though the shell and central shaft of the dryer. The HTF heaters and pumps will be located in a shed structure attached to the back of the dryer building. The water-sealed vacuum pumps will provide the vacuum source while the dryer is being loaded and while the yellowcake is unloaded into drums. The major components of the system are described below:

1. Drying Chamber: A horizontal 316 stainless steel vessel heated externally and fitted with rotating plows to stir the yellowcake. The chamber will have a top port for loading

the wet yellowcake and a bottom port for unloading the dry powder. A third port will be provided for the venting through the baghouse during the drying procedure.

2. Bag House: This air and vapor filtration unit will be mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The bag house will be heated to prevent condensation of water vapor during the drying cycle. It will be kept under negative pressure by the vacuum system.

3. Condenser: This unit will be located downstream of the bag house and will be water cooled. It will be used to remove the water vapor from the non-condensable gases coming from the drying chamber. The gases are moved through the condenser by the vacuum system. Dust passing through the bag filters is wetted and entrained in the condensing moisture within this unit.

4. Vacuum Pump: The vacuum pump will be a rotary water sealed unit that provides a negative pressure on the entire system during the drying cycle. It will also be used to provide negative pressure during transfer of the dry powder from the drying chamber to fifty-five (55) gallon drums. The water seal of the rotary vacuum pump captures entrained particulate matter remaining in the gas streams.

5. Packaging: The system will be operated on a batch basis. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a bottom port into drums. A level gauge, a weigh scale, or other suitable device will be used to determine when a drum is full. Particulate capture will be provided by a sealed hood that fits on the top of the drum, which will be vented through a sock filter to the condenser and the vacuum pump system when the powder is being transferred.

6. Heating: The heat for drying will be supplied by indirect HTF such as Dow-Therm® or other suitable heat transfer fluids. The drying will be accomplished under 250°F and at pressures less than atmospheric.

7. Effluent Monitoring: The vacuum pump discharges to the atmosphere. The water that is collected from the condenser will be recycled to the precipitation circuit, eluant makeup or disposed with other process water. Room air will be monitored routinely for airborne dust.

8. Controls: The system will be instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures.

3.2.2 Yellowcake Packaging, Storage, and Shipment

The dried yellowcake will be removed from the rotary vacuum dryer by passing through a rotary valve into 55-gallon steel drums, which are placed under a hood for the drum loading. The vacuum pump for the dryer will be connected to the loading hood to minimize particulate emissions during drum loading.

The dried yellowcake product in the steel drums will be stored for shipment within a restricted storage area and shipped by truck to other licensed facilities for further processing. An enclosed warehouse, adjacent to the yellowcake drying area, will be provided for the storage of yellowcake. Onsite inventory of drummed yellowcake typically will be less than 200,000 lbs. However, in periods of inclement weather or other interruptions in product shipments, all production will be stored on-site in designated restricted storage areas.

The drummed yellowcake will be shipped by exclusive use transport to another licensed facility for further processing. All yellowcake shipments will be made in compliance with applicable DOT and NRC regulations.

A discussion of the areas in the proposed plant facility where fumes or gases could be generated can be found in Section 7.3. The potential sources are minimal in the ion exchange process area since the mining solutions contained in the process equipment are maintained under a positive pressure. Building ventilation in the process equipment area will be accomplished by the use of an exhaust system that draws in fresh air and sweeps the plant air out to the atmosphere.

3.2.3 Chemical Storage Facilities

Chemical storage facilities at the Moore Ranch Project will include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, will be stored outside and segregated from areas where licensed materials are processed and stored. Bulk storage of hazardous chemicals will be located as to provide adequate separation to avoid mixing of incompatible materials. Also, bulk hazardous materials will be stored outside in areas to provide adequate distance from facilities to minimize hazards to people during an accidental release. Other non-hazardous bulk process chemicals (e.g., sodium carbonate) that do not have the potential to impact radiological safety may be stored within the central plant facilities.

3.2.3.1 Process Related Chemicals

Process-related chemicals stored in bulk at the Moore Ranch Central Plant will include carbon dioxide, oxygen, sodium sulfide, ammonia, sulfuric acid, and/or hydrogen peroxide. Risk assessments completed by the NRC in NUREG-6733[2] for in situ recovery facilities identified anhydrous ammonia and bulk acid (sulfuric and hydrochloric) storage as the most hazardous chemicals with the greatest potential for impacts to chemical and radiological safety.

- Carbon Dioxide

Carbon dioxide will be stored adjacent to the central plant where it will be added to the lixiviant prior to leaving the central plant.

- Oxygen

Oxygen is typically stored near the central plant or within wellfield areas, where it is centrally located for addition to the injection stream in each headerhouse. Since oxygen readily supports combustion, fire and explosion are the principal hazards that must be controlled. The oxygen storage facility will be located a safe distance from the central plant and other chemical storage areas for isolation. The storage facility will be designed to meet industry standards in NFPA-50[3].

Oxygen service pipelines and components must be clean of oil and grease since gaseous oxygen will cause these substances to burn if ignited. All components intended for use with the oxygen distribution system will be properly cleaned using recommended methods in CGA G-4.1[4]. The design and installation of oxygen distribution systems is based on CGA-4.4[5].

- Chemical Reductants

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., sodium sulfide or hydrogen sulfide gas). To minimize the potential for accidents involving process chemicals to impact areas where licensed material is handled, these materials are stored outside of process areas. Sodium sulfide may be used as a chemical reductant during groundwater restoration. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory will be stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. There are no current plans to use hydrogen sulfide gas at the Moore Ranch Project. However, in the event that EMC determines that use of hydrogen sulfide as a chemical reductant is necessary, proper chemical safety precautions will be taken.

- Ammonia

The anhydrous ammonia storage and distribution system at the proposed Moore Ranch Central Plant will have an initial capacity of approximately 90,000 lbs with potential to double after expansion of the central plant. Administrative controls will limit ammonia storage in the tank to 80% of maximum capacity. Strict unloading procedures will be utilized to ensure that this limit is not exceeded and that other safety controls are in place during the transfer of anhydrous ammonia. Process safety controls will be in place at the central plant where anhydrous ammonia is added to the precipitation circuit. These safety controls include the installation of a process area ammonia detector and alarm and emergency shut off solenoid for isolation of the ammonia distribution system in the event of a major release.

The ammonia system at the central plant will be covered under the EPA's Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness. Storage and operation of the anhydrous ammonia system will be conducted in compliance with RMP regulations.

Additionally, anhydrous ammonia will have total storage exceeding the screening threshold contained in Appendix A of 6 CFR 27, Chemical Facility Anti-terrorism Final Interim Standards, Department of Homeland Security. As a result, EMC will be obligated to undergo initial screening requirements as required by the rule.

- Acid Storage

The sulfuric and/or hydrochloric acid storage and distribution systems at the central plant will have an initial capacity of approximately 6,000 gallons. Future capacity will double after expansion of the central plant. Strict unloading procedures are utilized to ensure that safety controls are in place during the transfer of these acids. Process safety controls are also in place at the central plant where sulfuric or hydrochloric acid is added to the precipitation circuit.

Initial anticipated hydrochloric acid storage (6,000 gallons) does not exceed the screening threshold (11,250 lbs) contained in Appendix A of 6 CFR 27, Chemical Facility Anti-terrorism Final Interim Standards, Department of Homeland Security. However, the threshold will be exceeded if capacity is doubled after plant expansion. As a result, EMC will be obligated to undergo initial screening requirements for hydrochloric acid as required by the rule at that time.

- Hydrogen Peroxide

Hydrogen peroxide will be stored outside in a 6,000-gallon tank constructed of aluminum during initial operations. This capacity will double after expansion of the central plant. The storage tank will be stored away from flammable sources, organic materials, and incompatible chemicals (including ammonia) to avoid adverse chemical reactions.

The use of hydrogen peroxide at concentrations greater than 52 percent is subject to the following regulatory programs:

- Process Safety Management of Highly Hazardous Chemicals standard contained in 29 CFR §1910.119 for TQs in excess of 7,500 pounds; and
- Threshold Planning Quantities (TPQs) contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities (TQs) in excess of 1,000 pounds.

The Moore Ranch design includes the use of hydrogen peroxide at a concentration of 50 percent contained in a hydrogen peroxide tank with an initial capacity of 6,000 gallons. With the design hydrogen peroxide concentration and capacity, EMC will not be subject to the aforementioned regulatory programs.

3.2.3.2 Non-Process Related Chemicals

Non-process related chemicals that will be stored at the Moore Ranch Central Plant include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the plant. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet EPA requirements.

3.3 INSTRUMENTATION AND CONTROL

The piping and metering system for production and injection solutions consists of buried trunk lines between the recovery plant and the operating wellfield areas with metering and flow distribution headers in the wellfield headerhouses. The individual well flows and pressures are adjusted and controlled within the headerhouses. Wellfield instrumentation will be provided to measure total production and injection flow. In addition, instrumentation will be provided to indicate the pressure which is being applied to the injection wells. Wellfield headerhouses will be equipped with water sensors and alarms to detect the presence of liquids in the wellfield headerhouses.

Instrumentation will be provided to monitor the total recovery flow into the central plant, the total injection flow leaving the plant, and the total waste flow leaving the plant. Instrumentation will be provided on each injection and production well to record an alarm in the event of a change in flow that might indicate a leak or rupture in the system. In the process areas, tank levels are measured in chemical storage tanks as well as process tanks.

Handheld radiation detection instruments and portable samplers will be used to monitor radiological conditions at the central plant. Specifications/ for this equipment are discussed in further detail in Section 5. The location of monitoring points and monitoring frequency for in-plant radiation safety is also discussed in Section 5.

3.4 REFERENCES

[1] Driscoll, F.G., *Groundwater and Wells, Second Edition*, (Johnson Division, 1986).

[2] Center for Nuclear Waste Regulatory Analyses, NUREG/CR–6733, *A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licenses*, 2001.

[3] National Fire Protection Association, NFPA-50, *Standard for Bulk Oxygen Systems at Consumer Sites*, (NFPA, 1996)

[4] Compressed Gas Association, CGA G-4.1, *Cleaning Equipment for Oxygen Service*, (CGA, 2000)

[5] Compressed Gas Association, CGA G-4.4, *Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems*, (CGA, 1993)

4 EFFLUENT CONTROL SYSTEMS

This section describes the effluent control systems used at the Moore Ranch Uranium Project. The effluents of concern at ISR operations include the release or potential release of radon gas (radon-222) and dried yellowcake. Yellowcake processing and drying operations will be conducted at the central plant.

The yellowcake drying facilities at the central plant will be comprised of vacuum dryers. By design, vacuum dryers do not discharge any uranium when operating. Effluent controls for yellowcake drying at the Moore Ranch Central Plant are discussed in this section and in detail in the process description in Section 3.1 of this Technical Report.

4.1 GASEOUS AND AIRBORNE PARTICULATES

The primary radioactive airborne effluent at the Moore Ranch Facility will be radon-222 gas. Radon-222 is found in the pregnant lixiviant that comes from the wellfield into the facility for separation of uranium. The uranium will be separated from the groundwater by passing the solution through fixed bed ion exchange (IX) units operated in a pressurized downflow mode. Vessel vents from the individual IX vessels will be directed to a manifold that is exhausted to atmosphere outside the building via an induced draft fan. Venting any released radon-222 gas to atmosphere outside the plant minimizes employee exposure. Small amounts of radon-222 may be released via solution spills, filter changes, IX resin transfer, reverse osmosis (RO) system operation during groundwater restoration, and maintenance activities. These are minimal radon gas releases on an infrequent basis. The exhaust system in the plant will further reduce employee exposure. The air in the plant is sampled for radon daughters (see Section 5.0) to assure that concentration levels of radon and radon daughters are maintained as low as reasonably achievable (ALARA).

This section describes the gaseous effluent control systems that will be installed in the Moore Ranch Facility.

4.1.1 Gaseous Effluents-Tank and Process Vessel, and Work Area Ventilation Systems

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks. Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. The design of the fans will be such that the system will be capable of limiting employee exposures with the failure of any single fan. Discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in Regulatory Guide 8.31[1]. Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. Separate ventilation systems may be used as needed for the functional areas within the plant. Tank ventilation systems of this type have been successfully utilized at other ISR facilities and have proven to be an effective method for minimizing employee exposure.

The work area ventilation system will be designed to force air to circulate within the plant process areas. The ventilation system will exhaust outside the building, drawing fresh air in. During favorable weather conditions, open doorways and convection vents in the roof will provide satisfactory work area ventilation. The design of the ventilation system will be adequate to ensure that radon daughter concentrations in the facility are maintained below 25 percent of the derived air concentration (DAC) from 10 CFR Part 20.

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic. Impacts from potential emissions from process chemicals that will be used at the plant is described in Section 7. There are no significant combustion related emissions from the process facility as commercial electrical power is available at the site.

4.1.2 Air Particulate Effluents

Potential radiological air particulate effluents consist primarily of dried yellowcake in the drying and processing areas of the central plant. The yellowcake drying facilities at the Moore Ranch Central Plant will be comprised of vacuum dryers. By design, vacuum dryers do not discharge any uranium when operating. The vacuum drying system is proven technology, which is being used successfully in several ISR sites where uranium oxide is being produced. Air particulate controls of the vacuum drying system include a bag house, condenser, vacuum pump, and packaging hood.

The bag house is an air and vapor filtration unit mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The bag house is heated to prevent condensation of water vapor during the drying cycle. It is kept under negative pressure by the vacuum system.

The condenser unit is located downstream of the bag house and is water cooled. It is used to remove the water vapor from the non-condensable gases coming from the drying chamber. The gases are moved through the condenser by the vacuum system. Any particulates that pass through the bag filters are wetted and entrained in the condensing moisture within this unit.

The vacuum pump is a rotary water sealed unit that provides a negative pressure on the entire system during the drying cycle. It is also used to provide ventilation during transfer of the dry powder from the drying chamber to fifty-five (55) gallon drums. The water seal of the rotary vacuum pump captures entrained particulate matter remaining in the gas streams.

The packaging system is operated on a batch basis. When the yellowcake is dried sufficiently, it is discharged from the drying chamber through a bottom port into drums. A level gauge, a weigh scale, or other suitable device will be used to determine when a drum is full. Particulate capture is provided by a sealed hood that fits on the top of the drum, which is vented through a sock filter to the condenser and the vacuum pump system when the powder is being transferred.

The system will be instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures. The system will alarm if there is an indication that the emission control system is not performing within operational specifications. If the system is alarmed due to the emission control system, the operator will follow standard operating procedures to recover from the alarm condition, and the dryer will not be unloaded as part of routine operations, if currently loaded, or reloaded, if currently empty, until the emission control system is returned to service within specified operational conditions.

To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed that signal an audible alarm if the air pressure (i.e. vacuum level) falls below specified levels, and the operation of this system is checked and documented during dryer operations. In the event this system fails, the operator will perform and document checks of the differential pressure or vacuum every four (4) hours. Additionally, during routine operations, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

4.2 LIQUID WASTE

4.2.1 Sources of Liquid Waste

As a result of in-situ recovery mining, there are several sources of liquid waste that are collected. The potential water sources that exist at the Moore Ranch Facility include the following.

4.2.1.1 Liquid Process Waste

The operation of the ion exchange process generates production bleed, the primary source of liquid waste as previously discussed in Section 3.0. This bleed will be routed to the deep disposal well(s) for disposal. Other liquid waste streams from the central plant include plant wash down water and bleed stream from the elution and precipitation circuits. However, these other liquid waste streams make up a very small portion of the total liquid waste stream.

4.2.1.2 Aquifer Restoration

Following mining operations, restoration of the affected aquifer commences which results in the production of wastewater. The current groundwater restoration plan consists of three activities:

1. Groundwater Transfer,
2. Groundwater Sweep, and
3. Groundwater Treatment.

Only the groundwater sweep and groundwater treatment activities will generate wastewater.

During groundwater sweep, water is extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A reverse osmosis (RO) unit will be used to reduce the total dissolved solids of the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is injected back into the formation and the brine is sent to the wastewater disposal system. Chemical reducing agents such as sodium sulfide or biological reducing agents may also be employed during the groundwater treatment phase.

4.2.1.3 Water Collected from Wellfield Releases

This water is injection lixiviant or recovery fluids recovered from areas where a liquid release has occurred from a well or pipeline. The water will be placed into the wastewater disposal system for deep well injection.

4.2.1.4 Stormwater Runoff

A final source of water is storm runoff. Stormwater management is controlled under NPDES permits issued by the WDEQ-WQD. Facility drainage will be designed to route storm runoff water away or around the plant, ancillary building and parking areas, and chemical storage. The design of the Moore Ranch facilities and procedural and engineering controls contained in a Best Management Practices (BMP) Plan will be implemented such that runoff is not considered to be a potential source of pollution.

4.2.2 Liquid Waste Disposal

EMC expects that the liquid waste stream generated at the Moore Ranch Facility will be chemically and radiologically similar to the waste disposed in the current disposal wells in operation at existing ISR sites in the Powder River Basin. It is anticipated that the maximum volume of liquid waste stream for disposal will be approximately 45 gpm during normal operations and approximately 100 gpm additional flow from restoration. The average disposal waste stream over the project (operations and restoration) will be approximately 105 gpm.

EMC plans to install two or more deep disposal wells at the Moore Ranch Facility as the primary liquid waste disposal method. EMC believes that permanent deep disposal is preferable to evaporation in evaporation ponds or land application methods. All compatible liquid wastes at the Moore Ranch Facility will be disposed in the planned deep wells. An application is currently in development and will be submitted to the WDEQ-WQD for a Class I UIC Permit for the Moore Ranch Facility in the late summer of 2007.

4.2.3 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the Moore Ranch facility, existing regulatory requirements from the NRC and WDEQ, and provisions of EMC's Environmental Management Programs have established a framework that significantly reduces the possibility of an occurrence. Extensive training of all personnel is standard policy for EMC operations and will be implemented at the Moore Ranch Facility. Frequent inspections of waste management facilities and systems will be conducted. Detailed procedures will be included in EMC's Environmental Management Programs, which will be adapted for use at the Moore Ranch Facility.

Potential sources of pollution include the following:

4.2.3.1 Spills from Wellfield Buildings, Pipelines, and Well Heads

Wellfield buildings or pipelines are not considered to be a potential source of pollutants during normal operations, as there will be no process chemicals or effluents stored within them. The only instance in which these wellfield features could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe or well failure. The possibility of such an occurrence is considered to be minimal as the piping will be leak checked first. In addition, the flows through the pipe will be at a relatively low pressure and can quickly be stopped, thus any release would not migrate far. Wellfield headerhouses will also be equipped with wet alarms for early detection of leaks. Piping from the wellfields will generally be buried, minimizing the possibility of an accident. Large leaks in the pipe would quickly become apparent to the plant operators due to a decrease in flow and pressure, thus any release could be mitigated rapidly. All piping will be leak checked prior to operation.

In general, piping from the plant, to and within the wellfield will be constructed of PVC or high density polyethylene pipe (HDPE) with butt welded joints or the equivalent. All pipelines will be pressure tested before final operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from a major cause of potential failure which is vehicles driving over the lines causing breaks. Typically, the only exposed pipes will be at the central plant, at the wellheads, and in the headerhouses in the wellfield. Trunkline flows and manifold pressures will be monitored for process control.

Engineering and administrative controls will be in place at the Central Plant to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur.

4.2.3.2 Central Plant

The central plant will serve as a central hub for the mining operations in the Moore Ranch Project. Therefore, the central plant area will have the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result from a release of process chemicals from bulk storage tanks, piping failure, or a process storage tank failure.

The design of the central plant building will be such that any release of liquid waste would be contained within the structure. A concrete curb will be built around the entire process building. This pad will be designed to contain the contents of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system will immediately shut down, limiting any release. Liquid inside the building, both from a spill or from washdown water, will be drained through a sump and sent to the liquid waste system.

4.2.3.3 Deep Well Pumphouses and Wellheads

The design of the deep well pumphouses and wellheads will be such that any release of liquids will be contained within the building or in a bermed containment area surrounding the facilities. Liquid inside the building will be contained and managed as appropriate.

4.2.3.4 Domestic Liquid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the State of Wyoming. These systems are in common use throughout the United States and the effect of the system on the environment is known to be minimal.

4.3 TRANSPORTATION VEHICLES

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve either vehicles delivering bulk chemical products, transport of resin to the Moore Ranch facility from satellite plants, transport of radioactive contaminated waste from Moore Ranch to an approved disposal site, or from vehicles carrying yellowcake slurry or dried yellowcake product from Moore Ranch Central Plant.

All chemicals and products delivered to or transported from the site will be transported in accordance with DOT regulations. Emergency response procedures will be developed and implemented as part of EMC's Environmental Management Programs to insure a rapid response to the situation. All appropriate personnel will be trained to the level required in the emergency response procedures to facilitate proper response from EMC employees.

4.4 SOLID WASTE AND CONTAMINATED EQUIPMENT

Solid waste generated at the site is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe, pumps and fittings, and domestic trash, construction debris, and is separated into the following two categories.

4.4.1 Uncontaminated Solid Waste

Waste which is not contaminated with radioactive material or which can be decontaminated and re-classified as uncontaminated waste includes solid waste, piping, valves, instrumentation, equipment and any other items that are not contaminated or which may be successfully decontaminated. If decontamination of waste material is possible, surveys for residual surface contamination will be made before releasing the material. Decontaminated materials must have activity levels lower than those specified in NRC guidance[2]. Methods for decontamination and release of contaminated equipment are discussed in further detail in Section 5.

EMC estimates that the proposed Moore Ranch Project will produce approximately 2,000 cubic yards (yd^3) of uncontaminated solid waste per year. Uncontaminated solid waste will be collected on the site on a regular basis and disposed of in the nearest sanitary landfill.

4.4.2 Byproduct Material

All contaminated items that cannot be decontaminated to meet release criteria will be properly packaged, transported, and disposed at a disposal site licensed to accept 11e.(2) byproduct material. Solid wastes generated by this project that may become contaminated with radioactive materials consist of items such as rags, trash, packing material, worn or replaced parts from equipment, piping, filters, protective clothing, and solids removed from process pumps and vessels. Radioactive solid waste that has a contamination level requiring controlled disposal will be isolated in drums or other suitable containers. EMC estimates that the proposed Moore Ranch Project will produce approximately 100 yd^3 of 11e.(2) byproduct material per year. These materials will be stored on site inside the restricted area until such time that a full shipment can be shipped to a licensed waste disposal site or mill tailings facility.

4.4.3 Septic System Solid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the WDEQ for Class V UIC wells. Disposal of solid materials collected in septic systems must be performed in accordance with WDEQ Solid Waste Management rules and regulations.

4.4.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). In the State of Wyoming, hazardous waste is governed by WDEQ Hazardous Waste Rules and Regulations. Based on preliminary waste determinations conducted by EMC in consideration of the processes and materials that will be used on the project, EMC will likely be classified as a Conditionally Exempt Small Quantity Generator (CESQG), defined as a generator that generates less than 100 kg of hazardous waste in a calendar month and that complies with all applicable hazardous waste program requirements. EMC expects that only used waste oil and universal hazardous wastes such as spent batteries will be generated at Moore Ranch.

4.5 REFERENCES

[1] U. S. Nuclear Regulatory Commission, Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002).

[2] U. S. Nuclear Regulatory Commission, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source or Special Nuclear Material* (May 1987).

5 OPERATIONS

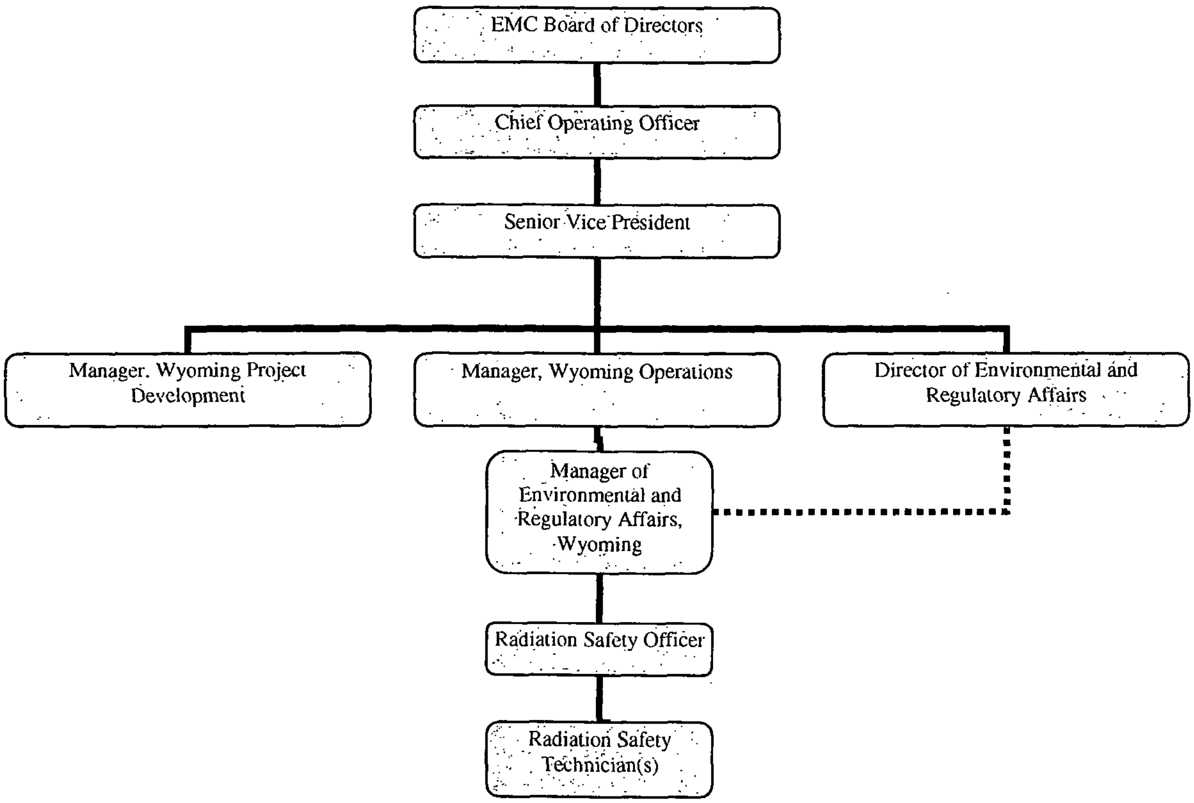
Energy Metals Corporation, US (EMC) is committed to conducting all operations in conformance with applicable laws, regulations and requirements of the various regulatory agencies. The responsibilities described below have been designed to ensure compliance and further implement EMC's policy for providing a safe working environment with cost effective incorporation of the philosophy of maintaining radiation exposures as low as is reasonably achievable (ALARA).

5.1 CORPORATE ORGANIZATION AND ADMINISTRATIVE PROCEDURES

EMC will maintain a performance-based approach to the management of the environment and employee health and safety, including radiation safety. Figure 5.1-1 is a partial organization chart for EMC with respect to the operation of the Moore Ranch Uranium Project and associated operations and represents the management levels that play a key part in the Radiation Protection Program (RPP). The personnel identified are responsible for the development, review, approval, implementation, and adherence to operating procedures, programs, environmental and groundwater monitoring programs as well as routine and non-routine maintenance activities. These individuals may also serve a functional part of the Safety and Environmental Review Panel (SERP) described under Section 5.2.5.

Specific responsibilities in the organization are provided below.

Figure 5.1-1: EMC Moore Ranch Organizational Chart



5.1.1 Board of Directors

The Board of Directors has the ultimate responsibility and authority for radiation safety and environmental compliance for EMC. The Board of Directors sets corporate policy and provides procedural guidance in these areas. The Board of Directors provides operational direction to the Chief Operating Officer of EMC.

5.1.2 Chief Operating Officer

The Chief Operating Officer (COO) is responsible for interpreting and acting upon the Board of Director's policy and procedural decisions. The COO is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at all EMC facilities. The COO is directly responsible for ensuring that EMC personnel comply with industrial safety, radiation safety, and environmental protection programs as established in the EMC Program. The COO is also responsible for company compliance with all regulatory license conditions/stipulations, regulations and reporting requirements. The COO has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations.

5.1.3 Senior Vice President

The Senior Vice President (Sr. VP) is responsible for management of all company operations including those in Wyoming. In this role, the Sr. VP has the responsibility and authority for the radiation safety and environmental compliance programs. The Sr. VP is responsible for ensuring that EMC personnel comply with industrial safety, radiation safety, and environmental protection programs as established in the EMC Program. The Sr. VP is also responsible for compliance with all regulatory license conditions/stipulations, regulations and reporting requirements. The Sr. VP has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations.

5.1.4 Manager of Wyoming Operations

The Manager of Wyoming Operations is responsible for all uranium production activity at the Wyoming project sites. All site operations, maintenance, construction, environmental health and safety, and support groups report directly to the Manager of

Wyoming Operations. In addition to production activities, the Manager of Wyoming Operations is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations. The Manager of Wyoming Operations is authorized to immediately implement any action to correct or prevent hazards. The Manager of Wyoming Operations has the responsibility and the authority to suspend, postpone or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The Manager of Wyoming Operations reports directly to the Senior Vice President.

5.1.5 Director of Environmental and Regulatory Affairs

The Director of Environmental and Regulatory Affairs is responsible for all radiation protection, health and safety, and environmental programs for EMC. The Director is responsible for ensuring that all company operations comply with all applicable regulatory requirements. The Director of Environmental and Regulatory Affairs reports directly to the Senior Vice President. This position is responsible for the development and review of radiological, health and safety, and environmental protection programs.

5.1.6 Manager of Environmental and Regulatory Affairs, Wyoming

The Manager of Environmental and Regulatory Affairs, Wyoming is responsible for all radiation protection, health and safety, and environmental programs in the State of Wyoming as stated in the EMC Program and for ensuring that EMC complies with all applicable regulatory requirements. The Manager of Environmental and Regulatory Affairs, Wyoming reports directly to the Manager of Wyoming Operations and supervises the Radiation Safety Officer (RSO) to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements. This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs.

5.1.7 Radiation Safety Officer

The RSO is responsible for the development, administration, and enforcement of all radiation safety programs. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The RSO is responsible for the implementation of all on-site environmental programs, including emergency procedures. The RSO inspects facilities to verify compliance with all applicable requirements in the areas of radiological health and safety. The RSO works closely with all supervisory personnel to review and approve new equipment and changes in processes and procedures that may affect radiological safety and to ensure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure related monitoring, including data from radiological safety. The RSO makes recommendations to improve any and all radiological safety related controls. The RSO has no production-related responsibilities. The RSO reports directly to the Manager of Environmental and Regulatory Affairs, Wyoming.

5.1.8 Radiation Safety Technician

The Radiation Safety Technician (RST) assists the RSO with the implementation of the radiological and industrial safety programs. The RST is responsible for the orderly collection and interpretation of all monitoring data, to include data from radiological safety and environmental programs. The RST reports directly to the RSO.

5.1.9 ALARA Program Responsibilities

The purpose of the ALARA (As Low As Reasonably Achievable) Program is to keep exposures to all radioactive materials and other hazardous material as low as possible and to as few personnel as possible, taking into account the state of technology and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest.

In order for an ALARA Program to correctly function, all individuals including management, supervisors, health physics staff, and workers, must take part in and share responsibility for keeping all exposures as low as reasonably achievable. This policy addresses this need and describes the responsibilities of each level in the organization.

5.1.10 Management Responsibilities

Consistent with Regulatory Guide 8.31[1], EMC senior management is responsible for the development, implementation, and enforcement of applicable rules, policies, and procedures as directed by regulatory agencies and company policies. These responsibilities include the following:

1. The development of a strong commitment to and continuing support of the implementation and operations of the ALARA program;
2. An Annual Audit Program which reviews radiation monitoring results, procedural, and operational methods;
3. A continuing evaluation of the Radiological Protection Program including adequate staffing and support; and
4. Proper training and discussions that address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors.

5.1.10.1 Radiation Safety Officer ALARA Responsibility

The RSO is responsible for ensuring the technical adequacy of the radiation protection program, implementation of proper radiation protection measures, and the overall surveillance and maintenance of the ALARA program. The RSO is assigned the following:

1. The responsibility for the development and administration of the ALARA program;
2. Enforcement of regulations and administrative policies that affect the Radiological Protection Program;
3. Assist with the review and approval of new equipment, process changes or operating procedures to ensure that the plans do not adversely affect the Radiological Protection Program;
4. Maintain equipment and surveillance programs to assure continued implementation of the ALARA program;
5. Assist with conducting an Annual ALARA Audit as discussed in Section 5.3.2 to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy;
6. Review annually all existing operating procedures involving or potentially involving any handling, processing, or storing of radioactive materials to ensure the procedures are ALARA and do not violate any newly established or instituted radiation protection practices; and
7. Conduct daily inspections of pertinent facility areas to observe that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle.

5.1.10.2 Supervisor Responsibility

Supervisors have front line responsibility for implementing all safety programs including the ALARA program. Each supervisor will be trained and instructed in the general radiation safety practices and procedures. Their responsibilities include:

1. Adequate training to implement the general philosophy behind the ALARA program;
2. Provide direction and guidance to subordinates in ways to adhere to the ALARA program;
3. Enforcement of rules and policies as directed by the Radiological Protection Program, which implement the requirements of regulatory agencies and company management; and
4. Seek additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside their sphere of training.

5.1.10.3 Worker Responsibility

Because success of both the radiation protection and ALARA programs are contingent upon the cooperation and adherence to those policies by the workers themselves, the facility employees must be responsible for certain aspects of the program in order for the program to accomplish its goal of keeping exposures as low as possible. Worker responsibilities include:

1. Adherence to all rules, notices, and operating procedures as established by management and the RSO through the Radiological Protection Program;
2. Making valid suggestions which might improve the radiation protection and ALARA programs;
3. Reporting promptly, to immediate supervisor, any malfunction of equipment or violation of procedures which could result in an unacceptable increased radiological hazard;
4. Proper use of protective equipment;
5. Proper performance of required contamination surveys.

5.2 MANAGEMENT CONTROL PROGRAM

5.2.1 Operating Procedures

EMC will develop procedures consistent with the corporate policies and standards and regulatory requirements to implement these management controls. The Radiological Protection Program will consist of written operating procedures for all process activities including those activities involving radioactive materials for the Moore Ranch Uranium Project. Where radioactive material handling is involved, pertinent radiation safety practices will be incorporated into the operating procedure. Additionally, written operating procedures will be developed for non-process activities including environmental monitoring, radiological protection procedures, emergency procedures, and industrial safety.

The procedures will provide pertinent radiation safety procedures to be followed. A copy of the written procedure will be kept in the area where it is used. All procedures involving radiation safety will be reviewed and approved in writing by the RSO or another individual with similar qualifications prior to being implemented. The RSO will also perform a documented review of the operating procedures annually.

5.2.2 Radiation Work Permits

In the case that employees are required to conduct activities of a nonroutine nature where there is the potential for significant exposure to radioactive materials and for which no operating procedure exists, a Radiation Work Permit (RWP) will be required. The RWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The RWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

The RSO may also issue Standing Radiation Work Permits (SRWPs) for periodic tasks that require similar radiological protection measures (e.g., maintenance work on a specified plant system). The SRWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The SRWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

5.2.3 Record Keeping and Retention

Specific instructions for the proper maintenance, control, and retention of records will be developed and will be consistent with the requirements of 10 CFR 20 Subpart L and 10 CFR §40.61 (d) and (e). Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, and transportation accidents will be maintained on site until license termination. Records containing information pertinent to decommissioning and reclamation such as descriptions of spills, excursions, contamination events, etc. as well as information related to site and aquifer characterization and background radiation levels will be maintained on site until license termination. Duplicates of all significant records will be maintained in the corporate office or other offsite locations.

5.2.4 Performance Based License Condition

With this license application EMC is requesting a Performance Based License (PBL). Under a license containing a PBL Condition, EMC will be allowed, without prior NRC approval or the need to obtain a License Amendment, to:

1. Make changes to the facility or process, as presented in the license application (as updated).
2. Make changes in the procedures presented in the license application (as updated).
3. Conduct tests or experiments not presented in the license application (as updated).

A License Amendment and/or NRC approval will be necessary prior to implementing a proposed change, test or experiment if the change, test or experiment would:

1. Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated);
2. Result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the license application (as updated);
3. Result in any appreciable increase in the consequences of an accident previously evaluated in the license application (as updated);
4. Result in any appreciable increase in the consequences of a malfunction of an SSC previously evaluated in the license application (as updated);
5. Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);
6. Create a possibility for a malfunction of an SSC with a different result than previously evaluated in the license application (as updated);
7. Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report (FSER) or the environmental assessment (EA) or technical evaluation reports (TERs) or other analysis and evaluations for license amendments.
8. For purposes of this paragraph as applied to this license, SSC means any SSC that has been referenced in a staff SER, TER, EA, or environmental impact statement (EIS) and supplements and amendments thereof.

Additionally, EMC will be required to obtain a license amendment unless the change, test, or experiment is consistent with the NRC conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TERs, and EIS or EA. This would include all supplements and amendments, and TERs, EAs, and EISs issued with amendments to the license.

5.2.5 Safety and Environmental Review Panel (SERP)

A Safety and Environmental Review Panel (SERP) will make the determination of compliance concerning the conditions discussed in Section 5.2.4. The SERP will consist of a minimum of three individuals. One member of the SERP will have expertise in management and will be responsible for managerial and financial approval for changes; one member will have expertise in operations and/or construction and will have expertise in implementation of any changes; and one member will be the Radiation Safety Officer (RSO), or equivalent. Other members of the SERP may be utilized as appropriate, to address technical aspects of the change, experiment or test, in several areas, such as health physics, groundwater hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The SERP will be responsible for monitoring any proposed change in the facility or process, making changes in procedures, and conducting tests or experiments not contained in the current NRC license. As such, the SERP will be responsible for insuring that any such changes result in no degradation in the essential safety or environmental commitments of EMC.

5.2.5.1 Safety and Environmental Review Panel Review Procedures

The EMC SERP will implement the following review procedures for the evaluation of all appropriate changes to the facility operations. The SERP may delegate any portion of these responsibilities to a committee of two or more members of the SERP. Any committees so constituted will report their findings to the full SERP for a determination of compliance with Section 5.2.4 of this chapter. In their documented review of whether a potential change, test, or experiment (hereinafter called the change) is allowed under the PBL (or Performance Based License Condition (PBLC)) without a license amendment, the SERP will consider the following:

- Current NRC License Requirements

The SERP will conduct a review of the most current NRC license conditions to assess which, if any, conditions will have an impact on or be impacted by the potential SERP action. If the SERP action will conflict with a specific license requirement, then a license amendment will be necessary before initiating the change. This review will include information included in the approved license application.

- Ability to Meet NRC Regulations

The SERP will determine if the change, test, or experiment conflicts with applicable NRC regulations (example: 10 CFR Parts 20 and 40 requirements). If the SERP action conflicts with NRC regulations, a license amendment will be necessary.

- Licensing Basis

The SERP will review whether the change, test, or experiment is consistent with NRC's conclusions regarding actions analyzed and selected in the licensing basis. Documents that the SERP must review in conducting this evaluation include any SERs, TERs, EAs, or EISs prepared to support issuance of or amendments to the license. The RSO will maintain a current copy of all pertinent documents for review by the SERP during these evaluations.

- Financial Surety

The SERP will review the proposed action to determine if any adjustment to the financial surety arrangement or approved amount is required. If the proposed action will require an increase to the existing surety amount, the financial surety instrument must be increased accordingly. The surety estimate must be approved through a license amendment by the NRC.

- Essential Safety and Environmental Commitments

The SERP will assure that there is no degradation in the essential safety or environmental commitment in the license application.

5.2.5.2 Documentation of SERP Review Process

After the SERP conducts the review process for a proposed action, it will document its findings, recommendations, and conclusions in a written report format. All members of the SERP shall sign concurrence on the final report. If the report concludes that the action meets the appropriate PBL or PBLC requirements and does not require a license amendment, the proposed action may then be implemented. If the report concludes that a license amendment is necessary before implementing the action, the report will document the reasons why, and what course EMC plans to pursue. The SERP report shall include the following:

- A description of the proposed change, test, or experiment (proposed action);

- A listing of all SERP members conducting the review and their qualifications (if a consultant or other member not previously qualified);

- The technical evaluation of the proposed action including all aspects of the SERP review procedures listed above;

- Conclusions and recommendations;

- Signatory approvals of the SERP members; and

- Any attachments such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

All SERP reports and associated records of any changes made pursuant to the PBL or PBLC shall be maintained through termination of the NRC license.

On an annual basis, EMC will submit a report to the NRC that describes all changes, tests, or experiments made pursuant to the PBL or PBLC. The report will include a summary of the SERP evaluation of each change. In addition, EMC will annually submit replacement pages of the License Application or supplementary information. Each replacement page will include both a change indicator for the area of change, (e.g., bold marking vertically in the margin adjacent to the portion actually change), and a page change identification, (date of change or change number, or both).

5.3 MANAGEMENT AUDIT AND INSPECTION PROGRAM

The following internal inspections, audits and reports will be performed for the Moore Ranch Uranium Project operations.

5.3.1 Radiation Safety Inspections

5.3.1.1 Daily Inspections

The RSO, RST or a qualified designee will conduct a daily walkthrough inspection of the plant. The inspection will entail a visual examination of compliance or other problems, which will reviewed with the Manager, Wyoming Operations.

5.3.1.2 Weekly RSO Inspections

On a weekly basis, the RSO and Manager, Wyoming Operations (or designees in their absence) will conduct an inspection of all facility areas to observe general radiation control practices and review required changes in procedures and equipment.

5.3.1.3 Monthly RSO Reports

The RSO will provide a written summary of the month's radiological activities at the Moore Ranch Uranium Project facilities. The report will include a review of all monitoring and exposure data for the month, a summary of worker protection activities, a summary of all pertinent radiation survey records, a discussion of any trends in the ALARA program, and a review of adequacy of the implementation of the NRC license conditions. Recommendations will be made for any corrective actions or improvements in the process or safety programs.

5.3.2 Annual ALARA Audits

EMC will conduct annual audits of the radiation safety and ALARA programs. The Director of Environmental and Regulatory Affairs may conduct these audits. Alternatively, EMC may use qualified personnel from other uranium recovery facilities or an outside radiation protection auditing service to conduct these audits. The purpose of the audits will be to provide assurance that all radiation health protection procedures and license condition requirements are being conducted properly at the Moore Ranch Uranium Project. Any outside personnel used for this purpose will be qualified in radiation safety procedures as well as environmental aspects of solution mining operations. Whether conducted internally or through the use of an independent audit service, the auditor will meet the minimum qualifications for education and experience for the RSO as described in Section 5.4.

The audit of the radiation protection and ALARA program will be conducted in accordance with the recommendations contained in Regulatory Guide 8.31. A written report of the results will be submitted to corporate management. The RSO may accompany the auditor but may not participate in the conclusions.

The annual ALARA audit report will summarize the following data:

1. Employee exposure records
2. Bioassay results

3. Inspection log entries and summary reports of mine and process inspections
4. Documented training program activities
5. Applicable safety meeting reports
6. Radiological survey and sampling data
7. Reports on any overexposure of workers
8. Operating procedures that were reviewed during this time period

The ALARA audit report will specifically discuss the following:

1. Trends in personnel exposures
2. Proper use, maintenance and inspection of equipment used for exposure control
3. Recommendations on ways to further reduce personnel exposures from uranium and its daughters.

The ALARA audit report will be submitted to and reviewed by the Senior Vice President and the Manager, Wyoming Operations. Implementations of the recommendations to further reduce employee exposures, or improvements to the ALARA program, will be reviewed with the ALARA auditor.

An audit of the Quality Assurance/Quality Control (QA/QC) program will also be conducted on an annual basis. An individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited will perform the audit. The results of the QA/QC audit will be documented with the ALARA Audit.

5.4 RADIATION SAFETY STAFF QUALIFICATIONS

The EMC project staff is highly experienced in the management of uranium project development, mining and operations. The following minimum personnel specifications and qualifications for the radiation safety staff will be strictly adhered to.

5.4.1 Radiation Safety Officer Qualifications

The minimum qualifications for the Radiation Safety Officer (RSO) are as follows:

- Education - A Bachelor's Degree or an Associate Degree in the physical sciences, industrial hygiene, environmental technology or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium mill/solution mining radiation protection.

- Health Physics Experience - A minimum of 1 year of work experience relevant to uranium mill/solution mining operations in applied health physics, radiation protection, industrial hygiene or similar work.

- Specialized Training - A formalized, specialized course(s) in health physics specifically applicable to uranium milling/solution mining operations, of at least 4 weeks duration. The RSO attends refresher training on uranium mill health physics every two years.

- Specialized Knowledge - The RSO, through classroom training and on-the-job experience, possesses a thorough knowledge of the proper application and use of all health physics equipment used in the operation, the procedures used for radiological sampling and monitoring, methods used to calculate personnel exposures to uranium and its daughters, and a thorough understanding of the solution mining process and equipment used and how hazards are generated and controlled during the process.

5.4.2 Radiation Safety Technician Qualifications

The RST will have one of the following combinations of education, training and experience:

1. Education - An associate degree or 2 years or more of study in the physical sciences, engineering or a health-related field, or high school diploma and a combination of experience and training.

   Training - At least a total of 4 weeks of generalized training in radiation health protection applicable to uranium mills/solution mining operations.

Experience - One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium mill/solution mining operation.

2. Education - A high school diploma.

   Training - A total of at least 3 months of specialized training in radiation protection relevant to uranium mills of which up to 1 month may be on-the-job training.

   Experience - Two years of relevant work experience in applied radiation protection.

5.5 RADIATION SAFETY TRAINING

All site employees and contractor personnel at the Moore Ranch Uranium Project will participate in a training program covering radiation safety, radioactive material handling, and radiological emergency procedures. The training program will be administered in keeping with standard radiological protection guidelines and the guidance provided in USNRC Regulatory Guide 8.29[2], USNRC Regulatory Guide 8.31, and USNRC Regulatory Guide 8.13[3]. The technical content of the training program will be under the direction of the RSO. The RSO or a qualified designee will conduct all radiation safety training.

5.5.1 Radiation Safety Training Program Content

5.5.1.1 Visitors

Visitors to the Moore Ranch Uranium Project facilities who have not received training will be escorted by on site personnel properly trained and knowledgeable about the hazards of the facility. At a minimum, visitors will be instructed specifically on what they should do to avoid possible hazards in the area of the facilities that they are visiting.

5.5.1.2 Contractors

Any contractors having work assignments at the Moore Ranch Uranium Project will be given appropriate radiation safety training. Contract workers who will be performing work on heavily contaminated equipment will receive the same training normally required of Moore Ranch workers as discussed in Section 5.5.1.3.

5.5.1.3 Radiation Worker Training

All EMC employees (and some contractors as noted in Section 5.5.1.2) will receive training as radiation workers. The program will incorporate the following topics recommended in USNRC Regulatory Guide 8.31:

Fundamentals of health protection

- Using respirators when appropriate.
- Eating, drinking and smoking only in designated areas.
- Using proper methods for decontamination.

Facility-provided protection

- Cleanliness of working space.
- Safety designed features for process equipment.
- Ventilation systems and effluent controls.
- Standard operating procedures.
- Security and access control to designated areas.

Health protection measurements

- Measurements of airborne radioactive material.
- Bioassay to detect uranium (urinalysis and in vivo counting).
- Surveys to detect contamination of personnel and equipment.
- Personnel dosimetry.

Radiation protection regulations

- Regulatory authority of NRC, OSHA and state.

- Employee rights in 10 CFR Part 19.
- Radiation protection requirements in 10 CFR Part 20.

Emergency procedures

All new workers, including supervisors, will be given instruction on the health and safety aspects of the specific jobs they will perform. This instruction is done in the form of individualized on-the-job training. Retraining is performed annually and documented.

5.5.2 Testing Requirements

A written test with questions directly relevant to the principals of radiation safety and health protection in the facility covered in the training course is given to each worker. The instructor reviews the test results with each worker and discusses incorrect answers to the questions with the worker until worker understanding is achieved. Workers who fail the exam are retested and test results remain on file.

5.5.3 On-The-Job Training

5.5.3.1 Health Physics Technician

On-the-job training will be provided to RSTs in radiation exposure monitoring and exposure determination programs, instrument calibration, plant inspections, posting requirements, respirator programs and radiation safety procedures.

5.5.4 Refresher Training

Following initial radiation safety training, all permanent employees and long-term contractors will receive on-going radiation safety training as part of the annual refresher training program and, if determined necessary by the RSO, during monthly safety meetings. This on-going training will be used to discuss problems and questions that have arisen, any relevant information or regulations that have changed, exposure trends and other pertinent topics.

5.5.5 Training Records

Records of training will be kept until license termination for all employees trained as radiation workers (i.e., occupationally exposed employees).

5.6 SECURITY

EMC is committed to:

- Providing employees with a safe, healthful, and secure working environment;
- Maintaining control and security of NRC licensed material;
- Ensuring the safe and secure handling and transporting of hazardous materials; and
- Managing records and documents that may contain sensitive and confidential information.

The NRC requires licensees to maintain control over licensed material (i.e., natural uranium ("source material") and byproduct material defined in 10 CFR §40.4). 10 CFR 20, Subpart I, *Storage and Control of Licensed Material*, requires the following:

§20.1801 Security of Stored Material

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§20.1802 Control of Material not in Storage

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Stored material at the Moore Ranch Uranium Project would include uranium packaged for shipment from the facility or byproduct materials awaiting disposal. Examples of material not in storage would include yellowcake slurry or loaded ion exchange resin removed from the restricted area for transfer to other areas.

5.6.1 License Area and Plant Security

The active mining areas will be controlled with fences and appropriate signs. All areas where source or byproduct materials are handled will be fenced. The main access road will be equipped with a locking gate. A 24-hour per day 7-day per week staff will be on duty at the Moore Ranch facility.

Plant operators will perform an inspection to ensure the proper storage and security of licensed material at the beginning of each shift. The inspection will determine whether all licensed material is properly stored in a restricted area or, if in controlled or unrestricted areas, is properly secured. In particular, operators will ensure that loaded ion exchange resin, slurry, drummed yellowcake, and byproduct material is properly secured. If licensed material is found outside a restricted area, the operator will ensure that it is secured, locked, moved to a restricted area, or kept under constant surveillance by direct observation by site personnel. The results of this inspection will be properly documented.

There will be a reception area located at the main entrance into the office building. All other entrances will be locked during off-shift hours. Visitors entering the office will be greeted by a receptionist. All visitors will be required to sign the access log and indicate the purpose of their visit and the employee to be visited. The person being visited will be responsible to supervise the visitor(s) at all times when they are on site. Visitors will only be allowed at the facility during regular working hours unless prior approval is obtained from the Manager, Wyoming Operations or the Manager of Environmental and Regulatory Affairs, Wyoming.

5.6.2 Transportation Security

EMC will routinely receive, store, use, and ship hazardous materials as defined by the U.S. Department of Transportation (DOT). In addition to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR), 49 CFR 172, Subpart I, *Security Plans*, requires that persons that offer for transportation or transport certain hazardous materials develop a Security Plan. Shipments may qualify for this DOT requirement under the following categories:

> §172.800(b)(4) A shipment of a quantity of hazardous materials in a bulk package having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids;
>
> §172.800(b)(5) A shipment in other than a bulk packaging of 2,268 kg (5,000 pounds) gross weight or more of one class of hazardous material for which placarding of a vehicle, rail car, or freight container is required;
>
> §172.800(b)(7) A quantity of hazardous material that requires placarding under the provisions of subpart F.

DOT requires that Security Plans assess the possible transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must take measures to provide personnel security by screening applicable job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment, and provide for en route security. Companies must also train appropriate personnel in the elements of the Security Plan.

Transport of licensed/hazardous material by EMC employees will generally be restricted to moving ion exchange resin from a Satellite facility to the Moore Ranch Central Plant or transferring contaminated equipment between company facilities. This transport will generally occur over short distances through remote areas. Therefore, the potential for a security threat during transport by EMC vehicle is minimal. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel;
- Providing the means and methods of protecting the drivers, vehicles, and customer's cargo while on the road; and
- Establishing consistent security guidelines and procedures that shall be observed by all personnel.

For the security of all tractors and trailers, the following will be adhered to:

- If material is stored in the vehicle, access must be secured at all openings with locks and/or tamper indicators;
- Off site tractors will always be secured when left unattended with windows closed, doors locked, the engine shut off, and no keys or spare keys in or on the vehicle;
- The unit is to be kept visible by an employee at all times when left unattended outside a restricted area.

The security guidelines and procedures apply to all transport assignments. All drivers and non-driving personnel will be expected to be knowledgeable of, and adhere to, these guidelines and procedures when performing any load-related activity.

5.7 RADIATION SAFETY CONTROLS AND MONITORING

EMC has a strong corporate commitment to and support for the implementation of the radiological control program at the Moore Ranch Uranium Project facilities. This corporate commitment to maintaining personnel exposures as low as reasonably achievable (ALARA) will be incorporated into the radiation safety controls and monitoring programs described in the following sections.

5.7.1 Effluent Control Techniques

5.7.1.1 Gaseous and Airborne Particulate Effluents

Under routine operations, the only radioactive effluent at the Moore Ranch facility will be radon-222 gas from the production solutions. Final processing of uranium to produce yellowcake will be performed in a vacuum dryer. As described in Section 4, there are no emissions from these systems.

The radon-222 is found in the pregnant lixiviant that will come from the wellfield into the Moore Ranch facility. The production flow will be directed to the process plant for separation of the uranium. The uranium will be separated by passing the recovery solution through pressurized downflow ion exchange units. The vents from the individual vessels will be connected to a manifold that will be exhausted outside the plant building through the plant stack.

Venting to the atmosphere outside of the plant building minimizes personnel exposure. Small amounts of radon-222 may be released in the plant building during solution spills, filter changes, ion exchange resin transfer operations and maintenance activities. The plant building will be equipped with exhaust fans to remove any radon that may be released in the building. No significant personnel exposure to radon gas is expected based on operating experience from similar facilities. Ventilation and effluent control equipment will be inspected for proper operation as recommended in USNRC Regulatory Guide 3.56[4]. Ventilation and effluent control equipment inspections will be conducted during radiation safety inspections as discussed in Section 5.3.1.

5.7.1.2 Liquid Effluents

The liquid effluents from the Moore Ranch Uranium Project facilities can be classified as follows:

- <u>Liquid Process Waste</u>

The operation of the ion exchange process generates production bleed, the primary source of liquid waste as previously discussed in Section 3.0. This bleed is routed to the deep disposal well for disposal. Other liquid waste streams from the central plant include plant wash down water and bleed stream from the elution and precipitation circuits. However, these other liquid waste streams make up a very small portion of the total liquid waste stream.

- <u>Aquifer Restoration</u>

Following mining operations, restoration of the affected aquifer commences which results in the production of wastewater. The current groundwater restoration plan consists of four activities:

1. Groundwater Transfer,
2. Groundwater Sweep,
3. Groundwater Treatment, and
4. Wellfield Circulation.

Only the groundwater sweep and groundwater treatment activities will generate wastewater.

During groundwater sweep, water is extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A reverse osmosis (RO) unit will be used to reduce the total dissolved solids of the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the waste disposal system. The brine is sent to the wastewater disposal system. Chemical reducing agents such as sodium sulfide or biological reducing agents may also be employed during the groundwater treatment phase.

EMC proposes to handle liquid effluents from the Moore Ranch Uranium Project using deep well injection.

5.7.1.3 Spill Contingency Plans

The RSO will be charged with the responsibility to develop and implement appropriate procedures to handle potential spills of radioactive materials. Personnel representing the engineering and operations functions of the Moore Ranch Uranium Project facility will assist the RSO in this effort. Basic responsibilities will include:

- Assignment of resources and manpower.
- Responsibility for materials inventory.
- Responsibility for identifying potential spill sources.
- Establishment of spill reporting procedures and visual inspection programs.
- Review of past incidents of spills.
- Coordination of all departments in carrying out goals of containing potential spills.
- Establishment of employee emergency response training programs.
- Responsibility for program implementation and subsequent review and updating.
- Review of new construction and process changes relative to spill prevention and control.

Spills can take two forms within an in-situ uranium mining facility: 1) surface spills such as tank failures, piping ruptures, transportation accidents, etc., and 2) subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield resulting in a subsurface release.

Engineering and administrative controls will be in place to prevent both surface and subsurface releases to the environment and to mitigate the effects should a release occur.

- Surface Releases

  Failure of process tanks - Potential failures of process tanks will be contained within the central plant building. The entire plant building will drain to a sump that will allow transfer of the spilled solutions to appropriate tankage or the waste disposal system.

  Surface Releases - The most common form of surface releases from in-situ mining operations occurs from breaks, leaks, or separations within the piping system that transfers mining fluids between the central plant and the wellfield. These are generally small releases due to engineering controls that detect pressure changes in the piping systems and alert the Plant Operators through system alarms.

In general, piping within the wellfield will be constructed of PVC or high-density polyethylene (HDPE) pipe with butt welded joints or an equivalent. All pipelines will be pressure tested at operating pressures prior to operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from vehicles driving over the lines, which could cause breaks. The only exposed pipes will be at the wellheads and in the headerhouses. Trunkline flows and wellhead pressures will be monitored for process control. Spill response will be specifically addressed in Emergency Procedures.

- Releases Associated With Transportation

EMC will prepare an emergency action plan for responding to a transportation accident involving a radioactive materials shipment. The plan will provide instructions for proper packaging, documentation, driver emergency and accident response procedures and cleanup and recovery actions.

- Sub-surface releases

Well Excursions - Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the monitor well ring will be to detect any mining solutions that may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with ISR mining. At Moore Ranch, an undetected excursion will be highly unlikely. A ring of perimeter monitor wells located no further than 500 feet from the wellfield and screened in the ore-bearing aquifer will surround all wellfields. Additionally, shallow monitor wells will be placed in the first overlying and underlying aquifers for each wellfield segment. Sampling of these wells will be done on a biweekly basis. Past experience at other ISR mining facilities has shown that this monitoring system is effective in detecting lixiviant migration. The total effect of the close proximity of the monitor wells, the low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion extremely remote.

Migration of fluids to overlying and underlying aquifers has also been considered. Several controls will be in place to prevent this. EMC will plug all exploration holes to prevent commingling of the ore zone, overlying, and underlying aquifers and to isolate the mineralized zone. In addition, prior to placing a well in service, a well mechanical integrity test (MIT) will be performed. This requirement of the

WDEQ UIC Program ensures that all wells be constructed properly and capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying and underlying aquifer will be sampled on a regular basis for the presence of recovery solution.

In addition to the spills described above, the accumulation of sediment or erosion of existing soils can lead to potential releases of pollutants. The likelihood of significant sediment or erosion problems is greatest during construction activities. If rain, producing runoff, occurs during construction a small amount of the fill may be carried away from the construction area. Significant precipitation during plant facility construction may also produce the same effect. Plant cover for erosion control will be established as soon as possible on exposed areas. Little additional suspendable material should be produced during mining operations and restoration activities. Site reclamation in the future with grading the plant site and replacing the topsoil will also expose unsecured soil for suspension in runoff waters. The sediment load as a result of precipitation during future construction or reclamation activities should not significantly affect the quality of any watercourses since the projected plant location is not crossed by any streams.

Runoff from precipitation events should be controlled to minimize any exposure to pollutants on the site. Runoff should not be a major issue given the engineering design of the facilities as well as engineering and administrative controls. Should there be high runoff concurrent with a pipeline failure, some contamination could be spread depending upon the relative saturation of the soils beneath the leaking area. In any event, only minimal releases of solutions would occur in the event of a pipeline failure and migration of pollutants due to runoff would be minimal.

5.7.2 EXTERNAL RADIATION EXPOSURE MONITORING PROGRAM

5.7.2.1 Gamma Surveys

External gamma radiation surveys will be performed routinely at the Moore Ranch Uranium Project. The required frequency will be quarterly in designated Radiation Areas and semiannually in all other areas of the plant. Surveys will be performed at worker occupied stations and areas of potential gamma sources such as tanks and filters. EMC will establish a Radiation Area if the survey indicates that gamma radiation levels exceed the action level of 5.0 mRem per hour for worker occupied stations. An investigation will be performed to determine the probable source and survey frequency for areas exceeding 5.0 mRem per hour is increased to quarterly. Records will be maintained of each investigation and the corrective action taken. If the results of a gamma survey identified areas where gamma radiation is in excess of levels that delineate a "radiation area", access to the area will be restricted and the area will be posted as required in 10 CFR §20.1902 (a).

External gamma surveys will be performed with survey equipment that meets the following minimum specifications:

1. Range - Lowest range not to exceed 100 microRoentgens per hour (μR/hr) full-scale with the highest range to read at least 5 milliRoentgens per hour (mR per hour) full scale;

2. Battery operated and portable;

Examples of satisfactory instrumentation that meets these requirements are the Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent. Gamma survey instruments will be calibrated at the manufacturer's suggested interval or at least annually and will be operated in accordance with the manufacturer's recommendations. Instrument checks will be performed each day that an instrument is used.

Gamma exposure rate surveys will be performed in accordance with standard operating procedures. Proposed survey locations for the Moore Ranch Central Plant are shown on Figure 5.7-1. Gamma survey instruments will be checked each day of use in accordance with the manufacturer's instructions. Surveys will be performed in accordance with the guidance contained in USNRC Regulatory Guide 8.30[5].

Beta surveys of specific operations that involve direct handling of large quantities of aged yellowcake are recommended in USNRC Regulatory Guide 8.30, Section 1.4. Beta evaluations may be substituted for surveys using radiation survey instruments.

5.7.2.2 Personnel Dosimetry

10 CFR §20.1502 (a)(1) requires exposure monitoring for "Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in §20.1201 (a)". Ten percent of the dose limit would correspond to a Deep Dose Equivalent (DDE) of 0.500 Rem.

EMC will determine monitoring requirements in accordance with the guidance contained in USNRC Regulatory Guide 8.34[6]. EMC believes that it is not likely that any employee working at the Moore Ranch Plant will exceed 10 percent of the regulatory limit (i.e., 500 mrem/yr). Although monitoring of external exposure may not be required in accordance with §20.1201(a), EMC will issue dosimetry to all process employees and will exchange them on a quarterly basis.

Dosimeters will be provided by a vendor that is accredited by National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology as required in 10 CFR § 20.1501. The dosimeters will have a range of 1 mR to 1000 R. Dosimeters will be exchanged and read on a quarterly basis.

Results from personnel dosimetry will be used to determine individual Deep Dose Equivalent (DDE) for use in determining Total Effective Dose Equivalent (TEDE).

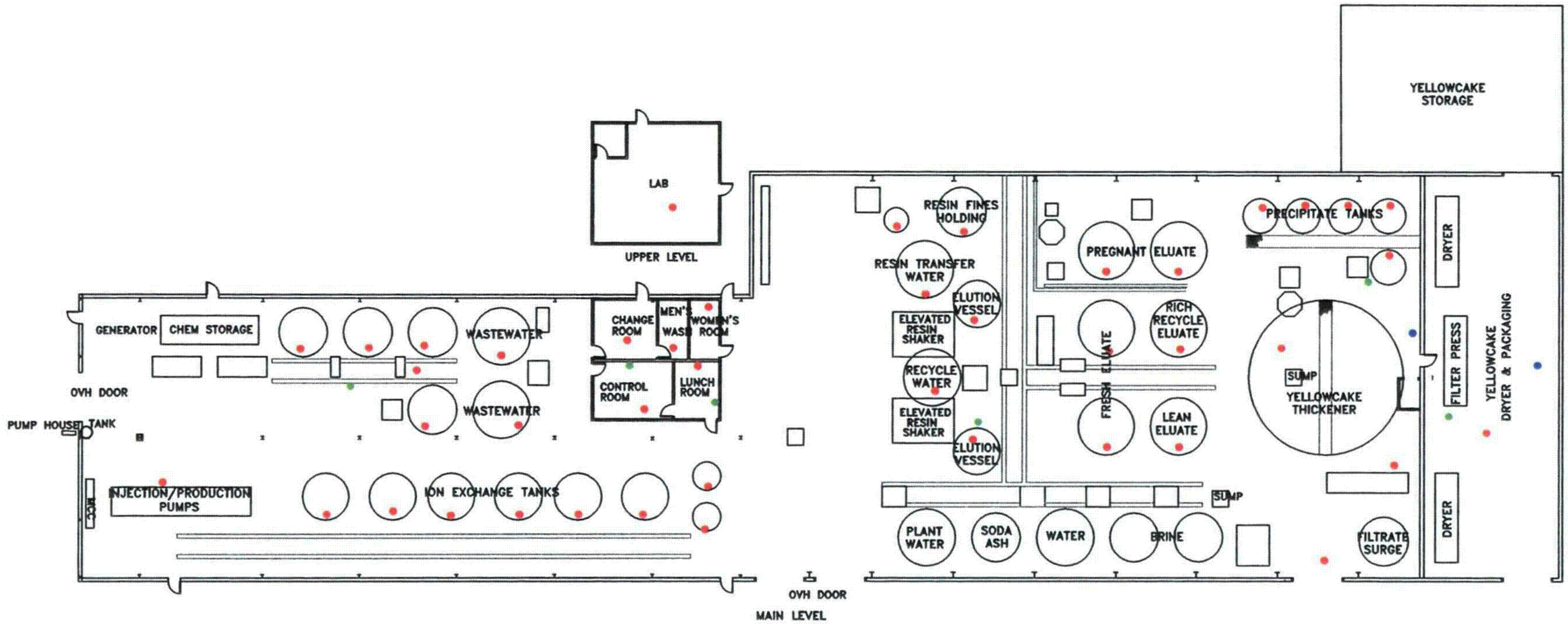


FIGURE 5.7-1

LEGEND

- RADON TESTING LOCATIONS
- GAMMA SURVEY LOCATIONS
- AIR PARTICULATE MONITORING LOCATIONS

0 20 40

ENERGY METALS CORPORATION, US
139 West 2nd St. Casper, WY 82601 307-234-8235

REVISIONS		
NO.	DATE	BY

MOORE RANCH
URANIUM PROJECT
CENTRAL PLANT
RADIOLOGICAL SURVEY
LOCATIONS

SECT. 34-35, T. 42 N., R. 75 W.

5.7.3 IN-PLANT AIRBORNE RADIATION MONITORING PROGRAM

5.7.3.1 Airborne Uranium Particulate Monitoring

Airborne particulate levels at solution mines that employ vacuum dryers are very low since there are no emissions. The primary potential source of airborne uranium is during yellowcake packaging. This operation will be confined to the dryer room. The room will be closed and posted as an airborne radioactivity area during packaging. The proposed airborne uranium sampling locations for the Moore Ranch Central Plant are shown on Figure 5.7-1.

Area samples will be taken in accordance with standard operating procedures. These procedures will implement the guidance contained in USNRC Regulatory Guide 8.25[7]. Samples will be taken with a glass fiber filter and a regulated air sampler such as an Eberline RAS-1 or equivalent. Sample volume will be adequate to achieve the lower limits of detection (LLD) for uranium in air. Samplers will be calibrated at the manufacturer's suggested interval or semiannually with a digital mass flowmeter or other primary calibration standard.

Breathing zone sampling will be performed to determine individual exposure to airborne uranium during certain operations. Sampling will be performed with a lapel sampler or equivalent. The air filters will be counted and compared to the Derived Air Concentration (DAC) using the same method used for area sampling. Air samplers will be calibrated at the manufacturer's recommended frequency or at least every six months using a primary calibration standard. Air sampler calibration will be performed in accordance with standard operating procedures.

Measurement of airborne uranium will be performed by gross alpha counting of the air filters using an alpha scaler such as a Ludlum Model 2000 or equivalent. The DAC for soluble (D classification) natural uranium of $5x10^{-10}$ µCi/ml from Appendix B to 10 CFR §§20.1001 - 20.2401 will be used. This is a conservative method because the gross alpha results include Uranium-238 and several of its daughters (notably Ra-226 and Th-230), which are also alpha emitters. An action level of 25% of the DAC for soluble natural uranium will be established at the Moore Ranch Plant. If an airborne uranium sample exceeds the DAC, the RSO will investigate the cause.

5.7.3.2 Radon Daughter Concentration Monitoring

Surveys for radon daughter concentrations will be conducted in the operating areas of the Moore Ranch Plant on a monthly basis. Sampling locations will be determined in accordance with the guidance contained in USNRC Regulatory Guide 8.25. Proposed radon daughter sampling locations for the Moore Ranch Plant are shown on Figure 5.7-1.

Samples will be collected with a low volume air pump (e.g., lapel sampler) and then analyzed with an alpha scaler using the Modified Kusnetz method described in ANSI-N13.8-1973. Routine radon daughter monitoring will be performed in accordance with standard operating procedures. Samplers will be calibrated at the manufacturer's suggested interval or semiannually with a digital mass flowmeter or other primary calibration standard. Air sampler calibration will be performed in accordance with standard operating procedures.

Results of radon daughter sampling are expressed in Working Levels (WL) where one WL is defined as any combination of short-lived radon-222 daughters in one liter of air without regard to equilibrium that emit 1.3×10^5 MeV of alpha energy. The DAC limit from Appendix B to 10 CFR §§ 20.1001 - 20.2402 for radon-222 with daughters present is 0.33 WL. EMC will establish an action level of 25% of the DAC or 0.08 WL. Radon daughter results in areas with an average concentration in excess of the action level will result in an investigation of the cause and an increase in the sampling frequency to weekly until the radon daughter concentration levels do not exceed the action level for four consecutive weeks.

5.7.3.3 Respiratory Protection Program

Respiratory protective equipment will be supplied by EMC for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials or toxic materials. Use of respiratory equipment at Moore Ranch Uranium Project will be in accordance with a respiratory protection program designed to implement the guidance contained in USNRC Regulatory Guide 8.15[8] and USNRC Regulatory Guide 8.31. The respirator program will administered by the RSO as the Respiratory Protection Program Administrator (RPPA).

5.7.4 EXPOSURE CALCULATIONS

Employee internal exposure to airborne radioactive materials at the Moore Ranch Plant will be determined based upon the requirements of 10 CFR § 20.1204 and the guidance contained in USNRC Regulatory Guides 8.30 and 8.7[9]. Following is a discussion of the exposure calculation methods and results.

5.7.4.1 Natural Uranium Exposure

Exposure calculations for airborne natural uranium will be perfromed using the intake method from USNRC Regulatory Guide 8.30, Section 2. The intake is calculated using the following equation:

$$I_u = b \sum_{i=1}^{n} \frac{X_i \times t_i}{PF}$$

where:

I_u	=	uranium intake, µg or µCi
t_i	=	time that the worker is exposed to concentrations X_i (hr)
X_i	=	average concentration of uranium in breathing zone, µg/m^3, µCi/m^3
b	=	breathing rate, 1.2 m^3/hr
PF	=	the respirator protection factor, if applicable
n	=	the number of exposure periods during the week or quarter

The intake for uranium will be calculated and recorded. The intakes will be totaled and entered onto each employee's Occupational Exposure Record.

The data required to calculate internal exposure to airborne natural uranium will be determined as follows:

Time of Exposure Determination

The results of periodic time studies for each classification of worker or 100% occupancy time will be used to determine routine worker exposures. Exposures during non-routine work (i.e., work requiring an RWP) will be based upon actual time.

Airborne Uranium Activity Determination

Airborne uranium activity will be determined from surveys performed as described in Section 5.7.3.1.

Exposures to airborne uranium will be compared to the DAC for the "D" solubility class for natural uranium from Appendix B of 10 CFR §§20.1001 - 20.2401 (i.e., 5×10^{-10} µCi/ml).

5.7.4.2 Radon Daughter Exposure

Exposure calculations for airborne radon daughters will be performed using the intake method from USNRC Regulatory Guide 8.30, Section 2. The radon daughter intake will be calculated using the following equation:

$$I_r = \frac{1}{170} \sum_{i=1}^{n} \frac{W_i \times t_i}{PF}$$

where:

I_r	=	radon daughter intake, working-level months
t_i	=	time that the worker is exposed to concentrations W_i (hr)
W_i	=	average number of working levels in the air near the worker's breathing zone during the time (t_i)
170	=	number of hours in a working month
PF	=	the respirator protection factor, if applicable

n = the number of exposure periods during the year

The data required to calculate exposure to radon daughters will be determined as follows:

Time of Exposure Determination

The results of periodic time studies for each classification of worker or 100% occupancy time will be used to determine routine worker exposure times. Exposures during non-routine work (i.e., work requiring an RWP) will be based upon actual time.

Radon Daughter Concentration Determination

Radon-222 daughter concentrations will be determined from surveys performed as described in Section 5.7.3.2. The working-level months for radon daughter exposure will be calculated and recorded. The working-level months will be totaled and entered onto each employee's Occupational Exposure Record.

Exposures to radon daughters will be compared to the DAC for radon daughters from Appendix B of 10 CFR §§20.1001 - 20.2401 (i.e., 0.33 WL).

5.7.4.3 Prenatal and Fetal Exposure

10 CFR §20.1208 requires that licensees ensure that the dose to an embryo/fetus during the entire pregnancy from occupational exposure of a declared pregnant woman does not exceed 0.5 Rem (500 mRem). Licensees are also required to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman that would satisfy the 0.5 Rem limit. The dose to the embryo/fetus is calculated as the sum of (1) the deep-dose equivalent to the declared pregnant woman and (2) the dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

The dose equivalent to the embryo/fetus is determined by the monitoring of the declared pregnant woman. 10 CFR §20.1502(a)(2) requires monitoring the exposure of a declared pregnant woman when the external dose to the embryo/fetus is likely to exceed a dose from external sources in excess of 10% of the embryo/fetus dose limit (i.e., 0.05 Rem/yr). 10 CFR 20.1502(b)(2) also requires that the licensee monitor the occupational intakes of radioactive material for the declared pregnant woman if her intake is likely to exceed a committed effective dose equivalent in excess of 0.05 Rem/yr. Based on this 0.05 Rem threshold, the dose to the embryo/fetus must be determined if the intake is likely to exceed 1% of ALI during the entire period of gestation.

Prior to declaration of pregnancy, the woman may not have been subject to monitoring based on the conditions specified in 10 CFR 20.1502. In this case, EMC will estimate the exposure during the period monitoring was not provided, using any combination of surveys or other available data (e.g., air monitoring, area monitoring, and bioassay). Exposure calculations will be performed as recommended in USNRC Regulatory Guide 8.36[10]:

- External Dose to the Embryo/Fetus

The deep-dose equivalent to the declared pregnant woman during the gestation period will be taken as the external dose for the embryo/fetus. The determination of external dose will consider all occupational exposures of the declared pregnant woman since the estimated date of conception and will be based on the methods discussed in Section 5.7.2.

- Internal Dose to the Embryo/Fetus

The internal dose to the embryo/fetus will consider the exposure to the embryo/fetus from radionuclides in the declared pregnant woman and in the embryo/fetus. The dose to the embryo/fetus will include the contribution from any radionuclides in the declared pregnant woman (body burden) from occupational intakes occurring prior to conception. The intake for the declared pregnant woman will be determined as discussed in Sections 5.7.3.1 and 5.7.3.2.

5.7.5 BIOASSAY PROGRAM

EMC will implement a urinalysis bioassay program at the Moore Ranch Uranium Project that meets the guidelines contained in USNRC Regulatory Guide 8.22[11]. The primary purpose of the program will be to detect uranium intake in employees who are regularly exposed to uranium. The bioassay program will consist of the following elements:

1. Prior to assignment to the facility, all new employees will be required to submit a baseline urinalysis sample. Upon termination, an exit bioassay will be required from all employees.

2. During operations, urine samples will be collected from workers on a quarterly basis. Employees who have the potential for exposure to dried yellowcake will submit bioassay samples on a monthly basis or more frequently as determined by the RSO. Samples will be analyzed for uranium content by a contract analytical laboratory. Blank and spiked samples will also be submitted to the laboratory with

employee samples as part of the Quality Assurance program. The minimum measurement sensitivity for the analytical laboratory will be 5 μg/l.

3. Action levels for urinalysis will be established based upon Table 1 in USNRC Regulatory Guide 8.22.

Elements of the quality assurance requirements for the Bioassay Program will be based upon the guidelines contained in USNRC Regulatory Guide 8.22. These elements include the following:

1. Each batch of samples submitted to the analytical laboratory will be accompanied by two blind control samples. The control samples will be from persons that have not been occupationally exposed and are spiked to a uranium concentration of 10 to 20 μg/l and 40 to 60 μg/l. Alternatively, synthetic control samples may be used. The results of analysis for these samples are required to be within ± 30% of the spiked value

2. The analytical laboratory spikes 10 to 30% of all samples received with known concentrations of uranium and the recovery fraction is determined. Results will be reported to EMC.

5.7.6 CONTAMINATION CONTROL PROGRAM

EMC will perform surveys for surface contamination in operating and clean areas of the Moore Ranch Plant in accordance with the guidelines contained in USNRC Regulatory Guide 8.30. Surveys for total alpha contamination in clean areas will be conducted weekly. In designated clean areas, such as lunchrooms, offices, change rooms, and respirator cabinets, the target level of contamination is nothing detectable above background. If the total alpha survey indicates contamination that exceeds 250 dpm/100 cm^2 (i.e., 25% of the removable limit) a smear survey will be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 250 dpm/100 cm^2, the area will be promptly cleaned and resurveyed.

All personnel leaving the restricted area will be required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area such as in the wellfields will be required to monitor themselves prior to leaving the area. All personnel will receive training in the performance of surveys for skin and personal contamination. All contamination on skin and clothing is considered removable, so the limit of 1,000 dpm/100 cm^2 will be applied to personnel monitoring. Personnel will also be allowed to conduct contamination monitoring of small, hand-carried items for use in wellfield and controlled areas as long as all surfaces can be reached with the instrument probe and the item does not originate in yellowcake areas. All other items are surveyed as described below.

The RSO, the radiation safety staff, or properly trained employees will perform surveys of all items removed from the restricted areas with the exception of small, hand-carried items described above. The release limits will be set as specified in *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses For Byproduct or Source Materials"*, USNRC, May 1987.

Surveys will be performed with the following equipment:

1. Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.

2. Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/cm^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent.

3. Swipes for removable contamination surveys as required.

Survey equipment will be calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments will be checked daily when in use. Alpha survey meters for personnel surveys will be response checked before each use.

As recommended in USNRC Regulatory Guide 8.30, EMC will conduct quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. The purpose of the spot check surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

5.7.7 AIRBORNE EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAMS

Radon

The radon gas effluent released to the environment will be monitored at the same air monitoring locations (MR-1 through MR-10) that were used for baseline determination of radon concentrations as described in Section 2.9. Sampling locations are shown on Figure 5.7-2. Monitoring will be performed using Track-Etch radon cups. The cups will be exchanged on a semiannual basis in order to achieve the required lower limit of detection (LLD). In addition to the manufacturer's Quality Assurance program, EMC will expose one duplicate radon Track Etch cup per monitoring period.

In addition to the environmental monitoring, the release of radon from process operations will be estimated using the source term method described in Section 7.3 and will be reported in the semi-annual effluent reports required by 10 CFR § 40.65.

Surface Soil

Surface soil has been sampled as described in Section 2.9.3. Surface soil samples will be taken at the monitoring locations described in Section 2.9.3 following conclusion of operations and will be compared to the results of the preoperational monitoring program.

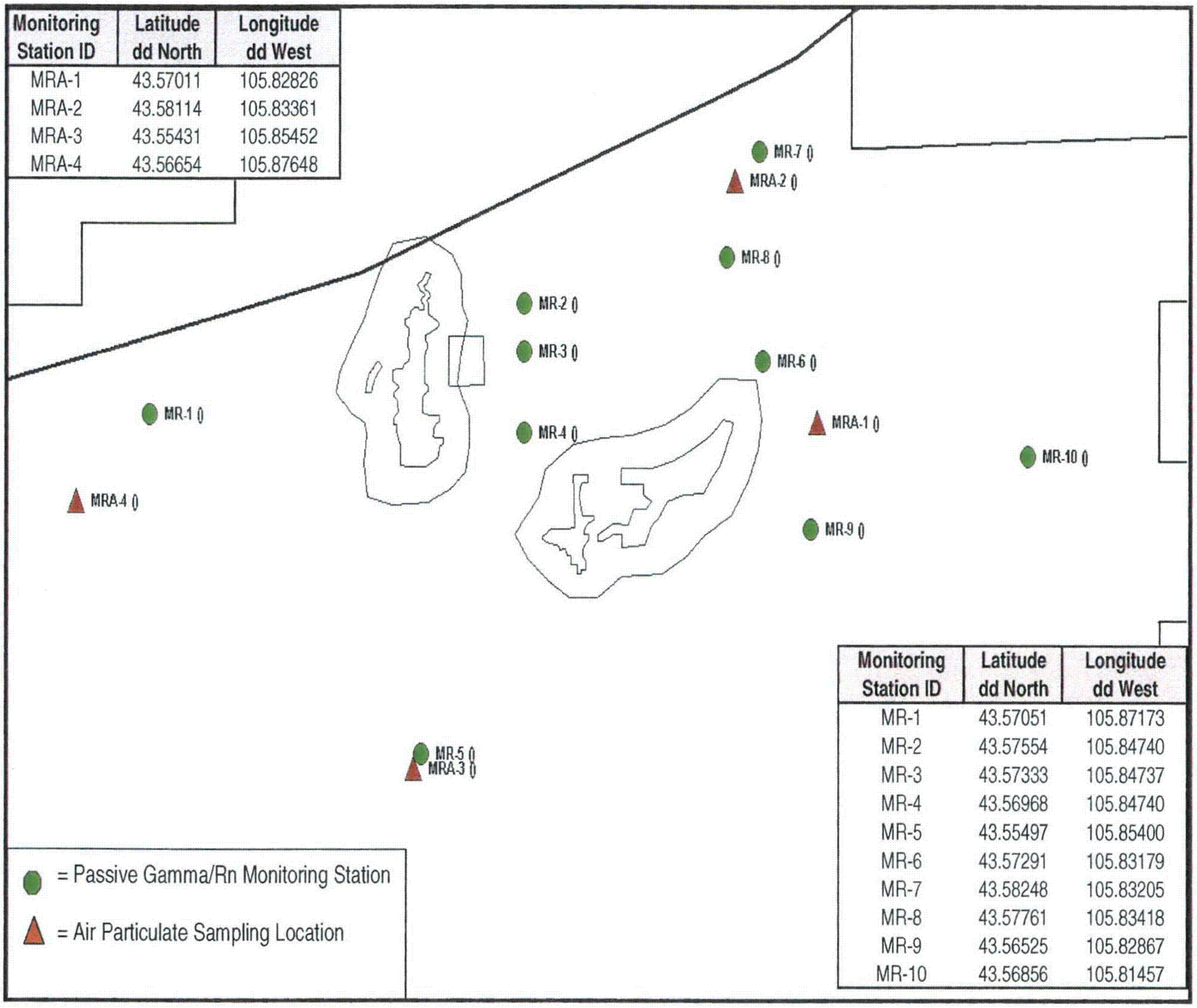
Surface soil will also be sampled at the plant location as described in Section 2.9. Post operational surface soil samples will be taken following conclusion of operations and will be compared to the results of the preoperational monitoring program.

Subsurface Soil

Subsurface soil will be sampled at the plant location as described in Section 2.9. Post operational subsurface soil samples will be taken following conclusion of operations and will be compared to the results of the preoperational monitoring program.

Figure 5.7-2

Proposed Moore Ranch Uranium Project Operational Environmental Monitoring Locations



Monitoring Station ID	Latitude dd North	Longitude dd West
MRA-1	43.57011	105.82826
MRA-2	43.58114	105.83361
MRA-3	43.55431	105.85452
MRA-4	43.56654	105.87648

Monitoring Station ID	Latitude dd North	Longitude dd West
MR-1	43.57051	105.87173
MR-2	43.57554	105.84740
MR-3	43.57333	105.84737
MR-4	43.56968	105.84740
MR-5	43.55497	105.85400
MR-6	43.57291	105.83179
MR-7	43.58248	105.83205
MR-8	43.57761	105.83418
MR-9	43.56525	105.82867
MR-10	43.56856	105.81457

Vegetation

Preoperational vegetation samples from the Moore Ranch Uranium Project site were collected in 2007 at the locations described in Section 2.9.

EMC does not propose to perform operational vegetation sampling at the environmental monitoring stations. In accordance with the provisions of USNRC Regulatory Guide 4.14[12], Footnote (o) to Table 2 requires that "*vegetation and forage sampling need be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway...*" defined as a pathway which would expose an individual to a dose in excess of 5% of the applicable radiation protection standard. This pathway was evaluated by MILDOS-Area and is discussed further in Section 7.3.

Direct Radiation

Environmental gamma radiation levels will be monitored continuously at the air monitoring stations (MR-1 through MR-10). Gamma radiation will be monitored through the use of environmental dosimeters obtained from a NVLAP certified vendor. Dosimeters will be exchanged on a quarterly basis.

Deep Disposal Well Monitoring

Monitoring of liquid effluent disposed of through the deep disposal well(s) will be conducted in accordance with the Class 1 Underground Injection Control Permit(s) issued by the Wyoming Department of Environmental Quality-Water Quality Division.

5.7.8 GROUNDWATER/SURFACE WATER MONITORING PROGRAM

5.7.8.1 Program Description

During operations at the Moore Ranch Uranium Project, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. EMC's operational water monitoring program will include the evaluation of groundwater on a regional basis, groundwater within the licensed area, and surface water on a regional and site specific basis.

5.7.8.2 Groundwater Monitoring

The groundwater monitoring program is designed to detect excursions of lixiviant outside of the wellfield under production and into the overlying and/or underlying water bearing strata.

- Private Well Monitoring

All private wells within one kilometer of the wellfield area boundary will be sampled on a quarterly basis with the landowner's consent. Groundwater samples will be analyzed for natural uranium and radium-226.

- Wellfield Baseline Sampling

Production zone wells (injection and production pattern area) will be sampled four times with a minimum of 2 weeks between samplings during baseline characterization. Wells will be selected based on a density of one well per three acres of mine unit. The first and second sample events will include analyses for all WDEQ LQD Guideline 8, Appendix 1, parts III and IV parameters as shown in Table 5.7-1. The third and fourth sampling events will be analyzed for a reduced list of parameters as defined by the results of the previous sample events. If certain elements are not detected during the first and second sampling events, then those elements will not be analyzed during the third and fourth sample events.

Data for each parameter are averaged. If the data collected for the entire mine unit indicate that waters of different underground water classes (WDEQ-WQD Rules and Regulations, Chapter VIII) exist together, the data are not averaged together, but treated as sub-zones. Data within specific sub-zones are averaged. Boundaries of sub-zones, where required, are delineated at half-way between the sets of sampled wells which define the sub-zones. The Restoration Target Values (RTV's) are determined from the baseline water quality data and are used to assess the effectiveness of ground water restoration activities. The average and range of baseline values determined for the wells completed in the Production Zone within the wellfield area constitute the RTV's.

- Monitor Well Baseline Water Quality

Monitor well ring wells are installed within the Production Zone, outside the mineralized portion of the ore zone and production pattern area in a "ring" around the mine area. These wells are used to obtain baseline water quality data and characterize the area outside the production pattern area. Upper Control Limits (UCL's) are determined for these wells from the baseline water quality data used in operational excursion monitoring. As determined from the modeling described in Addendum 5.7-A, the distance between these monitor wells will be no more than 500 feet and the distance between these monitor wells and the production patterns will be approximately 500 feet. The acceptable distance between the monitor wells and the production patterns was determined using a ground water flow model and estimated hydraulic properties for the proposed production area. The acceptable distance between monitor wells and the production patterns also took into account the demonstration that if an excursion were to occur, production fluids could be controlled within 60 days, as required by WDEQ requirements.

Monitor wells will be installed within the overlying aquifer (72-Sand) and underlying aquifer (68-sand) at a density of one well per every four acres of pattern area. These wells will be used to obtain baseline water quality data to be used in the development of UCL's for these zones.

After completion, wells will be developed (by air flushing or pumping) until water quality in terms of pH and specific conductivity appears to be stable and consistent with the anticipated water quality of the area. After development, wells will be sampled to obtain baseline water quality. Wells will be purged before sample collection to ensure that representative water is obtained. All monitor wells including ore zone and overlying and underlying monitor wells will be sampled four times at least two weeks apart. The first sample will be analyzed for the parameters shown in Table 5.7-1. Subsequent samples will be analyzed for the UCL parameters only (i.e., chloride, conductivity, and total alkalinity). Results from the samples will be averaged arithmetically to obtain a baseline mean value determination of upper control limits for excursion detection. If the data collected for the monitor well ring unit indicate that waters of different underground water classes (WDEQ-WQD Rules and Regulations, Chapter VIII) exist together, the data are not averaged together, but treated as sub-zones. Data within specific sub-zones are averaged. Boundaries of sub-zones, where required, are delineated at half-way between the sets of sampled wells which define the sub-zones.

Table 5.7-1
Baseline Water Quality Parameters
WDEQ LQD Guideline 8

Constituents (reported in mg/l unless noted)	*Analytical Method*
Ammonia Nitrogen as N	EPA 350.1
Nitrate + Nitrite as N	EPA 353.2
Bicarbonate	EPA 310.1/310.2
Boron	EPA 212.3/200.7
Carbonate	EPA 310.1/310.2
Fluoride	EPA 340.1/340.2/340.3
Sulfate	EPA 375.1/375.2
Total Dissolved Solids (TDS) @ 180ºF	EPA 160.1/SM2540C
Dissolved Arsenic	EPA 206.3/200.9/200.8
Dissolved Cadmium	EPA 200.9/200.7/200.8
Dissolved Calcium	EPA 200.7/215.1/215.2
Dissolved Chloride	EPA 300.0
Dissolved Chromium	EPA 200.9/200.7/200.8
Total and Dissolved Iron	EPA 236.1/200.9/200.7/200.8
Dissolved Magnesium	EPA 200.7/242.1
Total Manganese	EPA 200.9/200.7/200.8/243.1/243.2
Dissolved Molybdenum	EPA 200.7/200.8
Dissolved Potassium	EPA 200.7/258.1
Dissolved Selenium	EPA 270.3/200.9/200.8
Dissolved Sodium	EPA 200.7/273.1
Dissolved Zinc	EPA 200.9/200.7/200.8
Radium-226 (pCi/l)	DOE RP450/EPA 903.1/SM 7500-R-AD
Radium-228 (pCi/l)	SM 7500-R-AD
Gross Alpha (pCi/l)	DOE RP710/CHEMTA-GP B1/EPA 900
Gross Beta (pCi/l)	DOE RP710/CHEMTA-GP B1/EPA 900
Uranium	DOE MM 800/EPA 200.8
Vanadium	EPA 286.1/286.2/200.7/200.8

- Wellfield Hydrologic Data Package

Following completion of the field data collection, the Wellfield Hydrologic Data Package is assembled and submitted to the WDEQ for review. In accordance with NRC Performance Based Licensing requirements, the Wellfield Hydrologic Data Package is reviewed by a Safety and Environmental Review Panel (SERP) to ensure that the results of the hydrologic testing and the planned mining activities are consistent with technical requirements and do not conflict with any requirement stated in NRC regulations or in the NRC license. A written SERP evaluation will evaluate safety and environmental concerns and demonstrate compliance with applicable NRC license requirements as previously discussed in Section 5.2.4. The written SERP evaluation will be maintained at the site.

The Wellfield Hydrologic Data Package contains the following:

1. A description of the proposed mine unit (location, extent, etc.).

2. A map(s) showing the proposed production patterns and locations of all monitor wells.

3. Geologic cross-sections and cross-section location maps.

4. Isopach maps of the Production Zone sand, overlying confining unit and underlying confining unit.

5. Discussion of how the hydrologic test was performed, including well completion reports.

6. Discussion of the results and conclusions of the hydrologic test including pump test raw data, drawdown match curves, potentiometric surface maps, water level graphs, drawdown maps and when appropriate, directional transmissivity data and graphs.

7. Sufficient information to show that wells in the monitor well ring are in adequate communication with the production patterns.

8. Baseline water quality information including proposed UCLs for monitor wells and average production zone/restoration target values.

9. Any other information pertinent to the area tested will be included and discussed.

- Operational Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, upper control limits (UCLs) are set for chemical constituents which would be indicative of a migration of lixiviant from the well field. The constituents chosen for indicators of lixiviant migration and for which UCLs will be set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process (uranium is exchanged for chloride on the ion exchange resin). Chloride is also a very mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion as bicarbonate is the major constituent added to the lixiviant during mining. Water levels are obtained and recorded prior to each well sampling. However, water levels are not used as an excursion indicator. Upper control limits will be set at the baseline mean concentration plus five standard deviations for each excursion indicator. For chloride with a low baseline mean and little noted variation during baseline sampling, the UCL may be determined by adding 15 mg/l to the baseline mean if that value is greater than the baseline mean plus five standard deviations.

Operational monitoring consists of sampling the monitor wells at least twice monthly and at least 10 days apart and analyzing the samples for the excursion indicators chloride, conductivity, and total alkalinity. EMC requests that in the event of certain situations such as inclement weather, mechanical failure, or other factors that may result in placing an employee at risk or potentially damaging the surrounding environment, NRC allow a delay in sampling of no more than five days. In these situations, EMC will document the cause and the duration of any delays.

To assure that water within the well casing has been adequately displaced and/or formation water is sampled, wells will be purged before sample collection to ensure that representative water is obtained. Samples will be taken when field water quality parameters such as pH and specific conductivity appear to be stable and consistent with the anticipated water quality of the area. Low flow purging may also be used in certain instances to prevent pulling of mining fluids to the monitor well from excessive purging and ensure only formation water is sampled.

Water level and analytical monitoring data for the UCL parameters are reported to the WDEQ-LQD on a quarterly basis. This data is retained on site for review by the NRC.

- Excursion Verification and Corrective Action

During routine sampling, if two of the three UCL values are exceeded in a monitor well, , the well is resampled within 24 hours of the determination that a sample has exceeded two of the three UCL values and analyzed for the excursion indicators. The verification sample is split and analyzed in duplicate to assess analytical error. If results of the confirmatory sampling are not complete within 30 days of the initial sampling event, then the excursion will be considered confirmed for the purpose of meeting the reporting requirements described below. If the second sample does not exceed the UCLs, a third sample is taken within 48 hours. If neither the second or third sample results exceeded the UCLs, the first sample is considered in error.

If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the USNRC Project Manager and the WDEQ-LQD is notified by telephone or email within 24 hours and notified in writing within thirty (30) days. A written report describing the excursion event, corrective actions, and corrective action results will be submitted to the NRC within 60 days of the excursion confirmation.

If an excursion is verified, the following methods of corrective action will be instituted (not necessarily in the order given) dependent upon the circumstances:

- A preliminary investigation will be completed to determine the probable cause.

- Production and/or injection rates in the vicinity of the monitor well will be adjusted as necessary to increase the net bleed, thus forming a hydraulic gradient toward the production zone.

- Individual wells will be pumped to enhance recovery of mining solutions.

- Injection into the well field area adjacent to the monitor well may be suspended. Recovery operations continue, increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, sampling frequency of the monitor well on excursion status will be increased to once every seven days.

If an excursion is not controlled within 30 days following confirmation of the excursion, the WDEQ requires that a sample must be collected from each of the affected monitoring wells and analyzed for the following parameters: ammonia; antimony; arsenic; barium; beryllium; bicarbonate; boron, cadmium, calcium, carbonate; chloride; chromium;

conductivity; copper; fluoride; gross alpha; gross beta; iron; lead; magnesium; manganese; mercury; molybdenum; nitrate + nitrite; pH; potassium; selenium; sodium; sulfate; radium-226 and 228; thallium; TDS; uranium; vanadium; and zinc.

If the concentration of the UCL parameters detected in the monitor well(s) does not begin to decline within 60 days after the excursion is verified, injection into the production zone adjacent to the excursion will be suspended to further increase the net water withdrawals. Injection will be suspended until a declining trend in the concentration of the UCL parameters is established. Additional measures will be implemented if a declining trend does not occur in a reasonable time period. After a significant declining trend is established, normal operations will be resumed with the injection and/or production rates regulated such that net withdrawals from the area will continue. The declining trend will be maintained until the concentrations of excursion parameters in the monitor well(s) have returned to concentrations less than respective UCLs.

If an excursion is controlled, but the fluid which moved out of the production zone during the excursion has not been recovered within 60 days following confirmation of the excursion, the operator will submit to the WDEQ-LQD and the NRC within 90 days following confirmation of the excursion a plan and compliance schedule meeting the requirements of LQD Rules and Regulations, Chapter 13, Section 13(b).

A monthly report on the status of an excursion shall be submitted to the LQD administrator beginning the first month the excursion is confirmed and continuing until the excursion is over. The monthly report shall contain the requirements described in LQD Rules and Regulations, Chapter 12, Section 12(e). An excursion will be considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion, or if only one excursion indicator exceeds its respective UCL by less than 20%.

5.7.8.3 Surface Water Monitoring

Pre-operational surface water quality monitoring was performed as discussed in Sections 2.7 and 2.9. The proposed license area does not contain perennial streams and all surface water features are ephemeral and only contain natural runoff during heavy rainfall and snowmelt events. Current coal-bed methane operations contribute a small amount of surface discharge, which maintains some ponding at select locations across the site for portions of the year. Upstream and downstream samples from all pre-operational surface water locations will be obtained quarterly when water is present. Surface water samples will be analyzed for Pb-210; Ra-226; Th-230; Unat; and Po-210. Surface water monitoring results will be submitted in the semi-annual environmental and effluent reports submitted to NRC.

5.7.9 QUALITY ASSURANCE PROGRAM

A quality assurance program will be implemented at the Moore Ranch Uranium Project for all relevant operational monitoring and analytical procedures. The objective of the program will be to identify any deficiencies in the sampling techniques and measurement processes so that corrective action can be taken and to obtain a level of confidence in the results of the monitoring programs. The QA program will provide assurance to the regulatory agencies and the public that the monitoring results are valid.

The QA program will address the following:

- Formal delineation of organizational structure and management responsibilities. Responsibility for both review/approval of written procedures and monitoring data/reports will be provided.
- Minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QA program.
- Written procedures for QA activities. These procedures will include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting.
- Quality control (QC) in the laboratory. Procedures will cover statistical data evaluation, instrument calibration, duplicate sample programs and spike sample programs. Outside laboratory QA/QC programs are included.
- Provisions for periodic management audits to verify that the QA program is effectively implemented, to verify compliance with applicable rules, regulations and license requirements, and to protect employees by maintaining effluent releases and exposures ALARA.

QA procedures will include:

1. Environmental monitoring procedures.
2. Testing procedures.

3. Exposure procedures.

4. Equipment operation and maintenance procedures.

5. Employee health and safety procedures.

6. Incident response procedures.

5.8 REFERENCES

[1] USNRC Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002).

[2] USNRC Regulatory Guide 8.29, *Instructions Concerning Risks From Occupational Radiation Exposure* (Revision 1, February 1996).

[3] USNRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* (Revision 3, June 1999).

[4] USNRC Regulatory Guide 3.56, *General Guidance For Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills* (May 1986).

[5] USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities* (Revision 1, May 2002).

[6] USNRC Regulatory Guide 8.34, *Monitoring Criteria and Methods To Calculate Occupational Radiation Doses* (July 1992).

[7] USNRC Regulatory Guide 8.25, *Air Sampling in the Workplace* (Revision 1, June 1992).

[8] USNRC Regulatory Guide 8.15, *Acceptable Programs For Respiratory Protection* (Revision 1, October 1999).

[9] USNRC Regulatory Guide 8.7, *Instructions For Recording and Reporting Occupational Radiation Exposure Data* (Revision 1, June 1992).

[10] USNRC Regulatory Guide 8.36, *Radiation Exposure to the Embryo/Fetus* (July 1992).

[11] USNRC Regulatory Guide 8.22, *Bioassay at Uranium Mills* (Revision 1, August 1988).

[12] USNRC Regulatory Guide 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills* (Revision 1, April 1980).

Addendum 5.7-1

Groundwater Modeling to Assess Monitor Well Ring Spacing
Wellfield 1, Moore Ranch Uranium ISR Project

Groundwater Modeling to Assess Monitor Well Ring Spacing
Wellfield 1, Moore Ranch Uranium ISR Project

Prepared by
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Introduction

A groundwater flow model was developed for the Moore Ranch Uranium Project to assess the spacing of monitor wells around the uranium ISR wellfield. This memorandum briefly describes key features of the model development including the conceptual model and the numerical model code, domain, grid, boundary conditions, and simulation results. A 500-foot monitor well ring spacing is proposed for the Moore Ranch ISR Wellfield 1. Results of the model simulations indicate that the proposed spacing is adequate to allow for recovery of excursions related to operation of the ISR mine.

Conceptual Model

A conceptual hydrologic model for the Moore Ranch Project area is briefly summarized here. Details of the geology and hydrogeology of the site can be found in the NRC Source Materials License application that is submitted concurrently with this document.

The aquifer simulated is the 70 Sand, which is the proposed uranium production zone for the Moore Ranch Project. The 70 Sand averages approximately 80 feet in thickness within the area of Wellfield 1 and dips north-northwesterly at approximately 0.5 to 1 degree. In the vicinity of Wellfield 1, the 70 Sand aquifer is predominately a confined system. The 70 Sand aquifer transitions to an unconfined system toward the south where the sand crops out. Groundwater flow within the 70 Sand is toward the north under a hydraulic gradient of 0.004 ft/ft. Transmissivity of the aquifer is 300 to 400 ft^2/d (2,250 to 3,000 gpd/ft). The hydraulic conductivity determined from a recent pumping test at well MW3 was 4.5 ft/d. Porosity of the 70 Sand is estimated at 26 percent. Within the vicinity of Wellfield 1, the 70 Sand is bounded above and below by low permeability clays and silts that act as confining units.

Recharge occurs to the 70 Sand within a few miles to the south where this hydrostratigraphic unit crops out. There are no known discharge areas from the 70 Sand within the Permit Area.

Groundwater velocity under ambient, non-pumping conditions can be estimated using the Darcy equation:

$$v = \frac{k * i}{\varnothing}$$

where v = interstitial groundwater velocity (ft/d)
k = hydraulic conductivity (ft/d)
i = hydraulic gradient (ft/ft)
∅ = porosity (unitless)

Using site-specific values of 4.5 ft/d (from the MW3 pumping test), 0.004 ft/ft (potentiometric surface map of the 70 Sand) and 0.26 (estimated) for the k, i, and ∅ terms, respectively, the groundwater velocity under natural (background) conditions is calculated as 0.072 ft/d, or approximately 26.3 ft/yr. The modeling demonstrates that if mining related fluids reach the monitor well ring, changes in the localized pumping rates within the wellfield are capable of recovering those fluids, and then keeping them within the monitor well ring (the proposed aquifer exemption area).

Model Code

The model used was MODFLOW, a finite difference numerical simulator developed by the USGS (McDonald & Harbaugh 1988). MODFLOW was selected for simulating groundwater flow at the Moore Ranch site because it is capable of a wide array of boundary conditions, in addition to being a public domain code that is well accepted in the scientific community. The code simulates groundwater flow using a block-centered, finite-difference approach. Modeled aquifers can be simulated as unconfined, confined, or a combination of confined and unconfined. MODFLOW also supports variable thickness layers (i.e. variable aquifer bottoms and tops. Documentation of all aspects of the code is provided in the users manual (McDonald & Harbaugh 1988).

A particle-tracking code also was utilized that could easily incorporate information collected from the MODFLOW groundwater flow model. The code chosen was MODPATH (Pollock, 1994), which was designed to use the output head files from MODFLOW to calculate particle velocity changes over time in three dimensions. MODPATH was used to provide computations of groundwater seepage velocities and groundwater flow directions at the site. MODPATH is also a public domain code that is well accepted in the scientific community.

The pre/post-processor Groundwater Vistas (Environmental Simulations, Version 4, 2004) was used to assist with input of model parameters and output of model results. Groundwater Vistas serves as a direct interface with MODFLOW and MODPATH. Groundwater Vistas provides an extensive set of tools for developing, modifying and calibrating numerical models and allows for ease of transition between the groundwater flow and particle tracking codes.

Model Domain and Grid

The model domain assigned for this assessment encompasses nearly two square miles with a north-south dimension of 8,200 ft and an east-west dimension of 6,300 ft. The model grid is centered over Wellfield 1 of the Moore Ranch Project. The wellfield is approximately 3,000 feet long and 600 feet wide and is oriented with the long axis along a north-south trend. The model extends approximately 2,500 feet beyond each side of the wellfield. The model consists of 328 rows and 254 columns. Each cell in the model has uniform dimensions of 25 ft by 25 ft. Because of the presence of overlying and underlying confining units, only the 70 Sand was simulated, so the model contains a single layer. The base of the model and the top of the model are simulated as no flow boundaries that approximate the overlying and underlying confining units. The domain of the model is illustrated in Figure 1.

Boundary Conditions

Boundary conditions imposed on a numerical model define the external geometry of the groundwater flow system being studied as well as internal sources and sinks. Boundary conditions assigned in the model were determined from observed conditions. Descriptions of the types of boundary conditions that can be implemented with the MODFLOW code are found in McDonald & Harbaugh (1988). Boundary conditions used to represent hydrologic conditions at the Moore Ranch Project included general-head (GHB) and wells. The locations of boundary conditions within the model are illustrated in Figure 1. Discussion of the placement and values for these boundary conditions is provided below.

The GHB was used in the Moore Ranch model to account for inflow and outflow from the model domain. GHBs were assigned along the edges of the model domain where available water-level data suggest the aquifer is being recharged from, or discharging to, a source external to the model domain. GHBs were used because the groundwater elevation at those boundaries can change in response to simulated stresses. In the Moore Ranch model, GHBs were assigned to the south, west, north and east boundaries of the model. The values of head assigned to the GHB ranged from 5196.4 ft along the south edge of the model 5163.6 ft, along the north edge. This resulted in simulated background potentiometric surface with a hydraulic gradient of 0.004 ft/ft.

The model domain was extended a suitable distance from the limits of the wellfield outline to eliminate perimeter boundary effects on the interior of the model. The conductance term for the GHB cells was set to a relatively large value ($2x10^6$) so that groundwater flow in and out of the cells was not constricted and the boundary conditions would not limit the response of the aquifer to internal stresses (primarily from the wells).

The MODFLOW well package was used to simulate injection and extraction (production) wells within proposed Wellfield 1. As shown in Figure 1, the wellfield configuration includes a series of five spot patterns with an extraction well located in the center, surrounded by four injection wells. The distance between injectors is 100 feet. The distance from each injector to any extraction well is 70.7 feet. When the well patterns are placed adjacent to one another, the injector wells may supply fluids to as many as four different extraction wells. Using this well configuration to cover the area of Wellfield 1 required 131 extraction wells and 174 injection wells. Figure 2 shows the distribution of injection and extraction wells within the wellfield (note that a potential inclusion area to Wellfield 1, and parts of Wellfield 2 are shown, but have no impact on this analysis. A monitor well ring was placed around the wellfield approximately 500 feet from the outermost injection wells. The monitor well ring roughly approximates the minimum extent of the aquifer exemption area.

Aquifer Properties

Input parameters used in the model to simulate aquifer properties are consistent with site-derived data including; hydraulic conductivity, storativity, hydraulic gradient, saturated thickness and porosity. Hydraulic conductivity determined from the MW3 pumping test was 4.5 ft/d. As previously described under the boundary conditions, a hydraulic gradient of 0.004 ft/ft was imposed on the model using the GHB cells along the perimeter of the model. The top and bottom of the 70 Sand were simulated as dipping to the north at 0.004 ft/ft to coincide with the hydraulic gradient of the potentiometric surface to maintain a constant aquifer saturated thickness of 80 feet. Storativity was estimated from other pumping tests conducted in the area. The storativity value used in the model simulations was 0.0006. Similarly, porosity of the aquifer was estimated from other ISR operations in the region. A value of 25 percent was used in the simulation.

Model Simulations

The model was set up to initially simulate non-pumping, pre-mining conditions. Results of this simulation generally replicate the baseline conditions in the aquifer prior to ISR mining with northward groundwater flow direction at a hydraulic gradient of 0.004 ft/ft. Figure 3 shows the results of the non-pumping simulation.

A simulation was then run in which the wellfield is operational. In this simulation, 131 extraction wells are pumping at a combined rate of 2,977 gpm of groundwater and 173 injection wells are injecting at a combined total of 2,939 gpm. This ratio provides a one percent bleed (over pumpage) such that there is net inward flux of groundwater into the wellfield (Figure 4). The pumping rate was the same for each of the extraction wells (22.7 gpm). For the injection wells, higher rates were simulated for the interior pattern wells in the central portion of the wellfield (19.8 gpm) and lower rates were simulated for wells along the edges of the wellfield (ranging from 6.2 to 15.6 gpm).

Particle tracking was used to evaluate if all lixiviant injected into the injection wells was recovered by the production wells (Figure 5). Particles were placed over the location of the perimeter injection wells to determine the flowpaths from those wells. The figure illustrates that all of the flowpaths from the injection wells are captured by the site extraction wells, although in some cases there is appreciable flare. In some cases, injected water moves out away from the wellfield and is not captured by the five-spot pattern it came from, but is eventually captured further northward by other well patterns Figure 6 shows the particle tracking results in greater detail without the potentiometric surface. The amount of potential flare shown on these figures is not a concern as wellfield balancing will be performed during operations.

The next simulations were run to determine if an excursion detected at the site monitoring ring wells could be recovered by adjusting operating rates within the wellfield. Any number of hypothetical scenarios could be developed for obtaining mining-derived fluids out to the monitor well ring. Rather than attempt to develop scenarios that would require failure of the wellfield configuration to retain ISR related fluids within the monitor well ring, the model was used to evaluate whether or not ISR related fluids detected at the monitor well ring could be recovered by altering the wellfield production/injection rates.

Sampling of the monitor ring wells will occur every 14 days. Therefore, the longest period that an ISR-derived constituent could move beyond the monitor well ring undetected would be 14 days. It is assumed that it could take a week (7 days) for a corrective action plan to be developed and implemented. Therefore, the maximum travel time for an ISR-derived constituent to move beyond the monitor well ring is assumed to be 21 days in the simulation. The model simulation of this scenario is set up by placing particles at the monitor wells located directly north of the orebody. The particles represent an ISR-derived fluid that has managed to reach the monitor well ring. The model is initially run for a period of 21 days under the normal operating rates to determine how far beyond the monitor well ring the particle would travel.

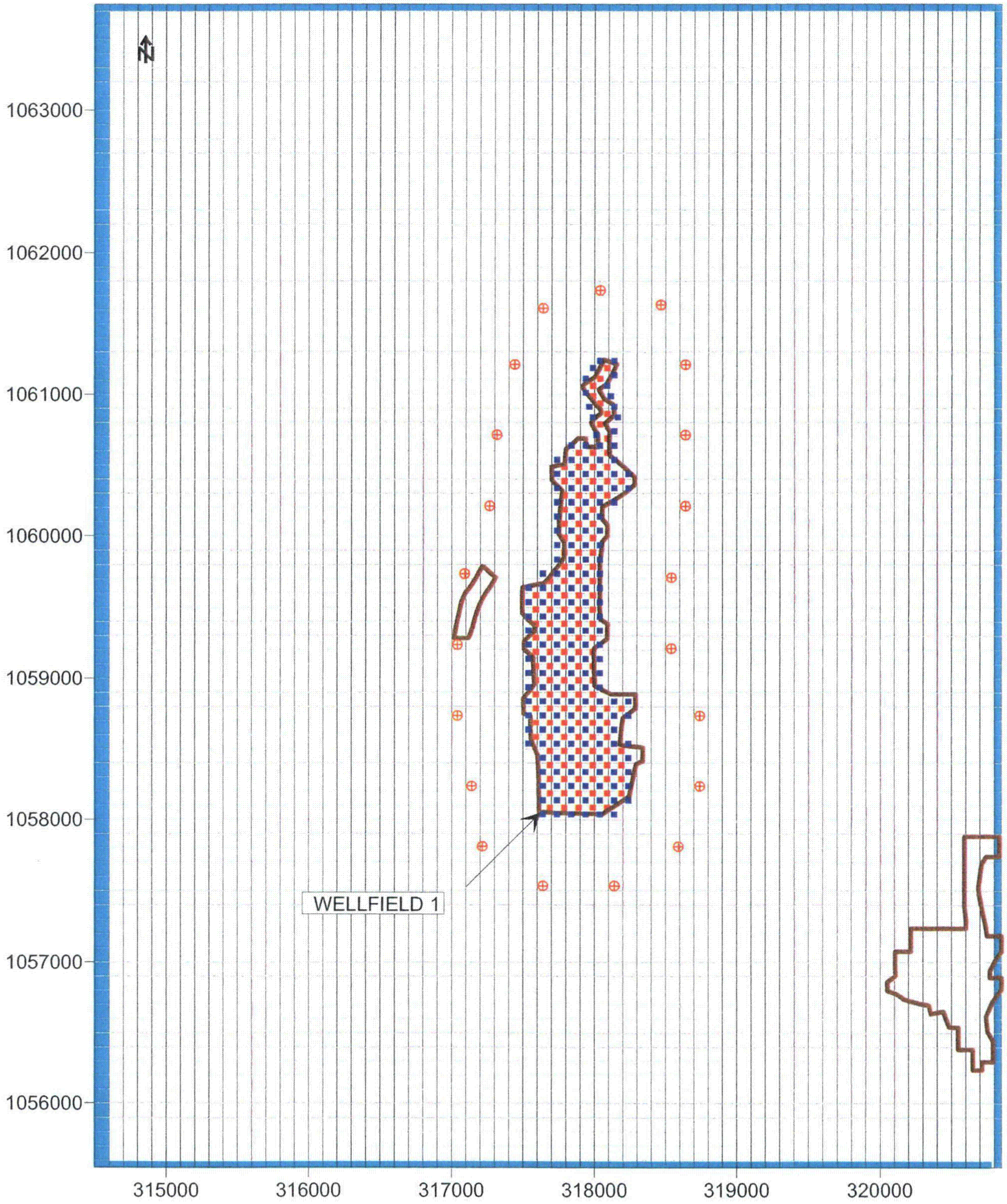
The area north of the wellfield is the most critical with respect to monitoring and potential excursions because it is directly downgradient of the wellfield and has the greatest potentiometric difference that has to be overcome in order to recover groundwater after a hypothetical excursion. Areas upgradient of the wellfield will naturally flow toward the wellfield. Monitor wells located along the east and west sides of the wellfield are generally crossgradient of the wellfield and would not require as much hydraulic control to capture. Therefore, the focus of the modeling effort is on the area and monitor wells directly north of Wellfield 1.

Results of the first stress period (21 days of normal operation) indicate that the particle placed in the monitor well that is directly downgradient 500 feet north of the wellfield traveled a total distance of approximately one foot. This is consistent with the previous calculation of groundwater velocity under non-pumping conditions (0.72 ft/d x 21 days = 1.51 ft). The travel distance under the pumping scenario is slightly less than the non-pumping scenario because of the net drawdown and subsequent depression in the potentiometric surface within the wellfield

The corrective action simulated with the model was to turn off the six northernmost injection wells, but maintain the normal operation rates for the extraction wells. The model was run under these conditions for a simulated period of 100 days. Results of this second stress period of the model are shown in Figure 7. There is a significant cone of depression centered around the northern edge of the wellfield. The capture zone from the potentiometric surface resulting from the corrective action pumping scenario is shown in Figure 8. For purposes of clarity, the capture zone only includes the four northernmost extraction wells. As shown on the figure, all of the monitor wells fall within the capture zone that develops under this scenario. Note that this pumping scenario did not involve an increased pumping rate at the extraction wells, only a reduction in the injection rate for selected neighboring wells. During the 100 days of excursion recovery pumping, the particle that had moved 1 foot north of the monitor well would move 8 feet back toward the wellfield and be inside of the monitor well ring. Obviously, excursion recovery can be achieved in a shorter time frame if more injection wells are shut off, or if the rate of production is increased. In this regard, the assumptions shown herein are conservative.

Conclusions

The groundwater model developed for the EMC Moore Ranch Uranium Project indicates that the proposed pumping/injection plan is suitable for ISR mining. Maintenance of a one percent bleed effectively captures all of the lixiviant introduced into the injection wells. In the event that an excursion occurs resulting in ISR-derived fluids reaching the monitor well ring, feasible alteration to the production/injection rates within reasonable operating ranges will be sufficient to bring those fluids back into the monitor well ring.



- General Head Boundary
- Production Well
- Injection Well
- Monitor Well

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 1. MOORE RANCH PROJECT
MODEL DOMAIN AND BOUNDARY CONDITIONS

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG1.SRF	BY: EPL CHECKED: HPD

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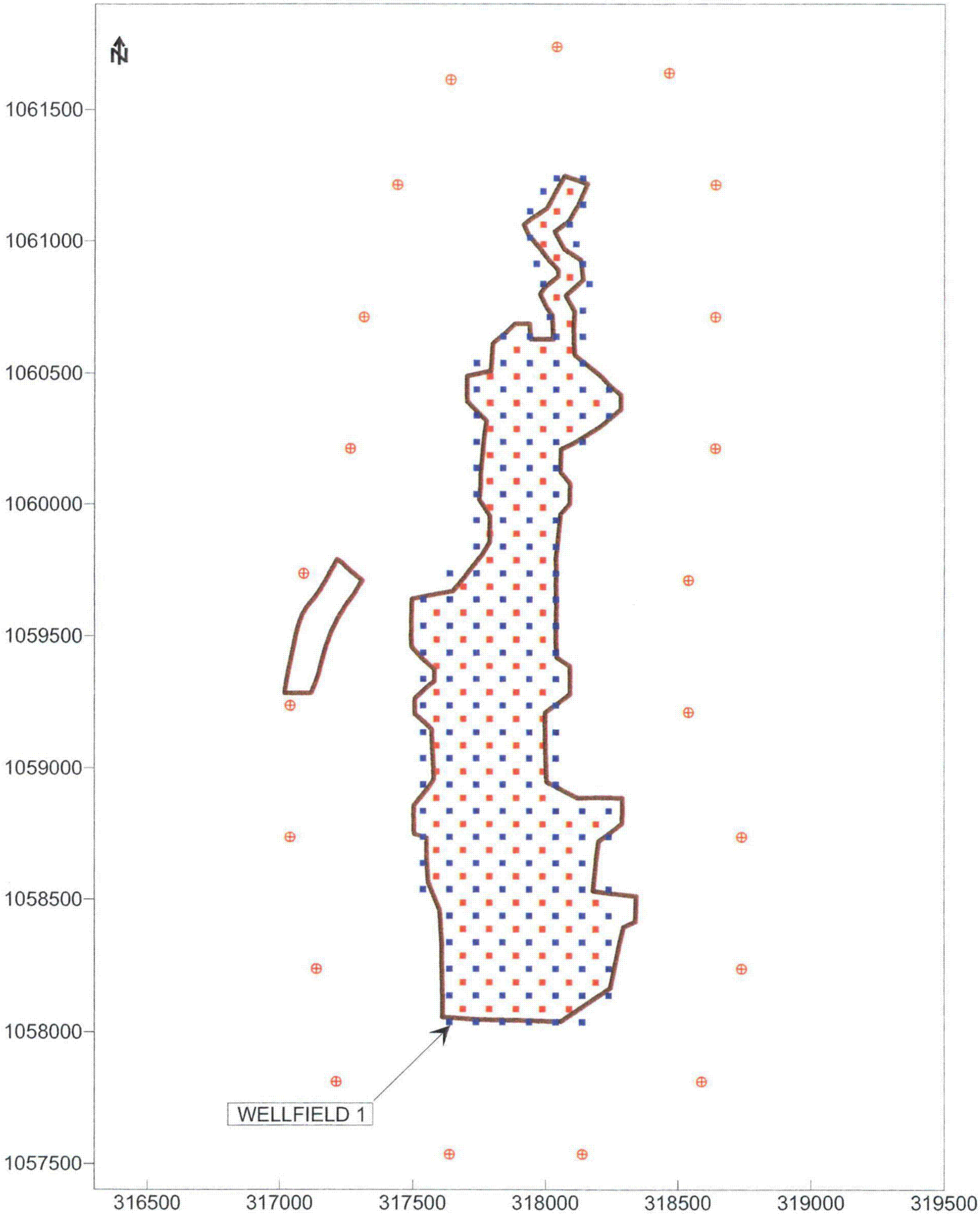

General Head Boundary
Production Well
Injection Well
Monitor Well

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 2. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE DETAIL-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007	
DWG: EMCMRWSMFIG2.SRF	BY: EPL	CHECKED: HPD

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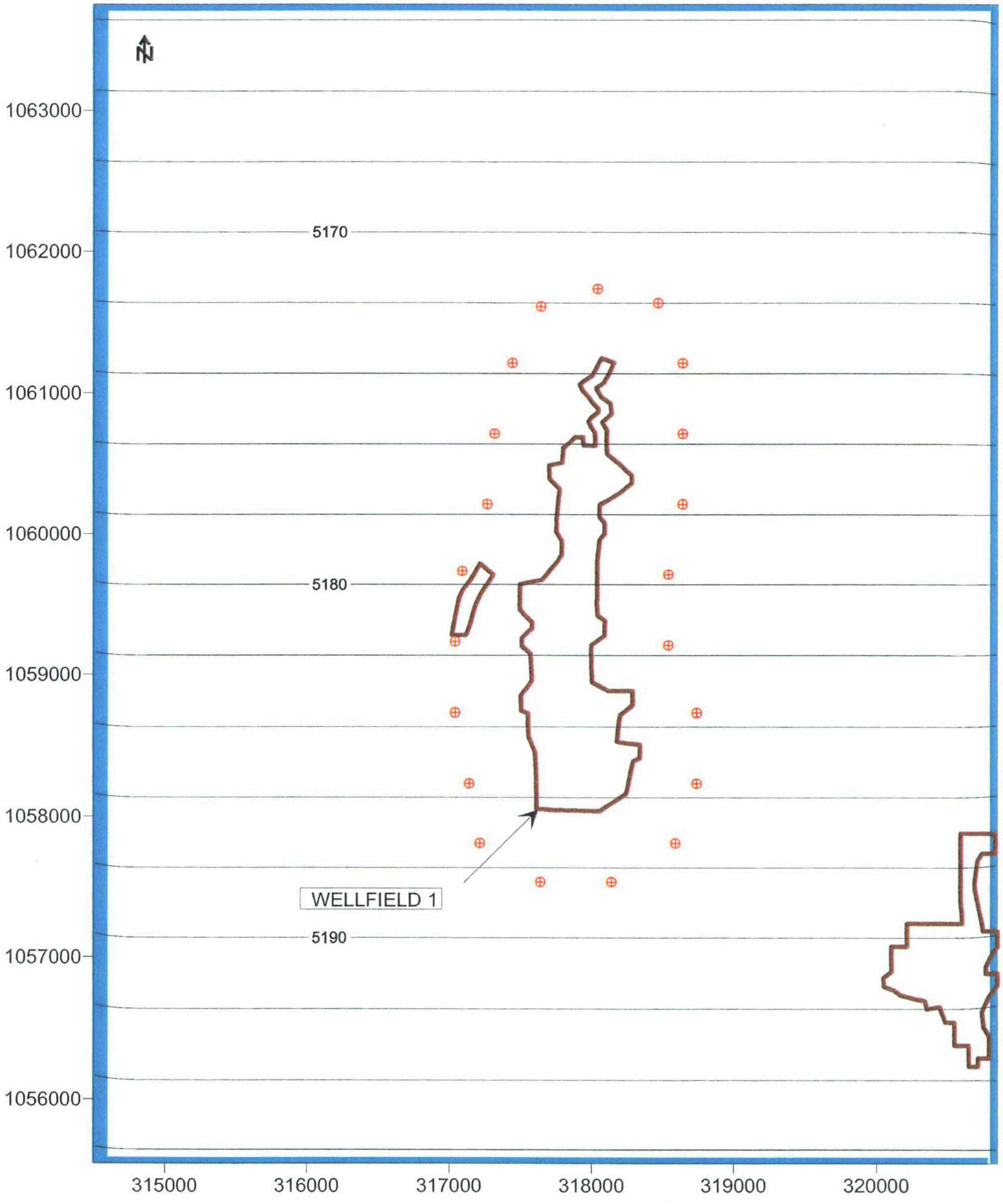

Monitor Well

Potentiometric surface
Contour interval = 2 feet

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FIGURE 3. MOORE RANCH PROJECT
SIMULATED POTENTIOMETRIC SURFACE-NO PUMPING

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG3.SRF	BY: EPL CHECKED: HPD

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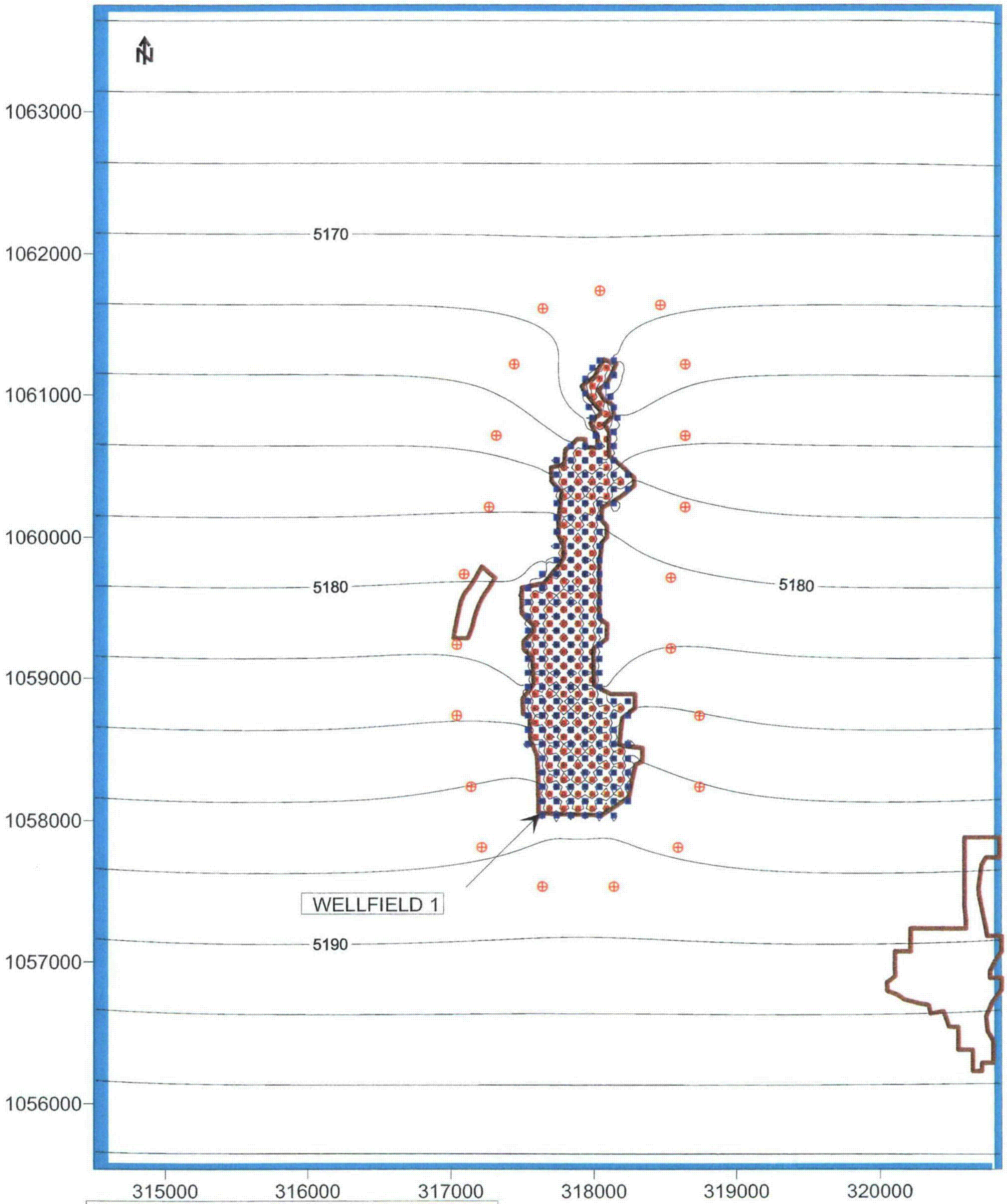

- General Head Boundary
- Production Well
- Injection Well
- Monitor Well

Potentiometric surface
Contour interval = 2 feet

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 4. MOORE RANCH PROJECT
SIMULATED POTENTIOMETRIC SURFACE-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG4.SRF	BY: EPL CHECKED: HPD

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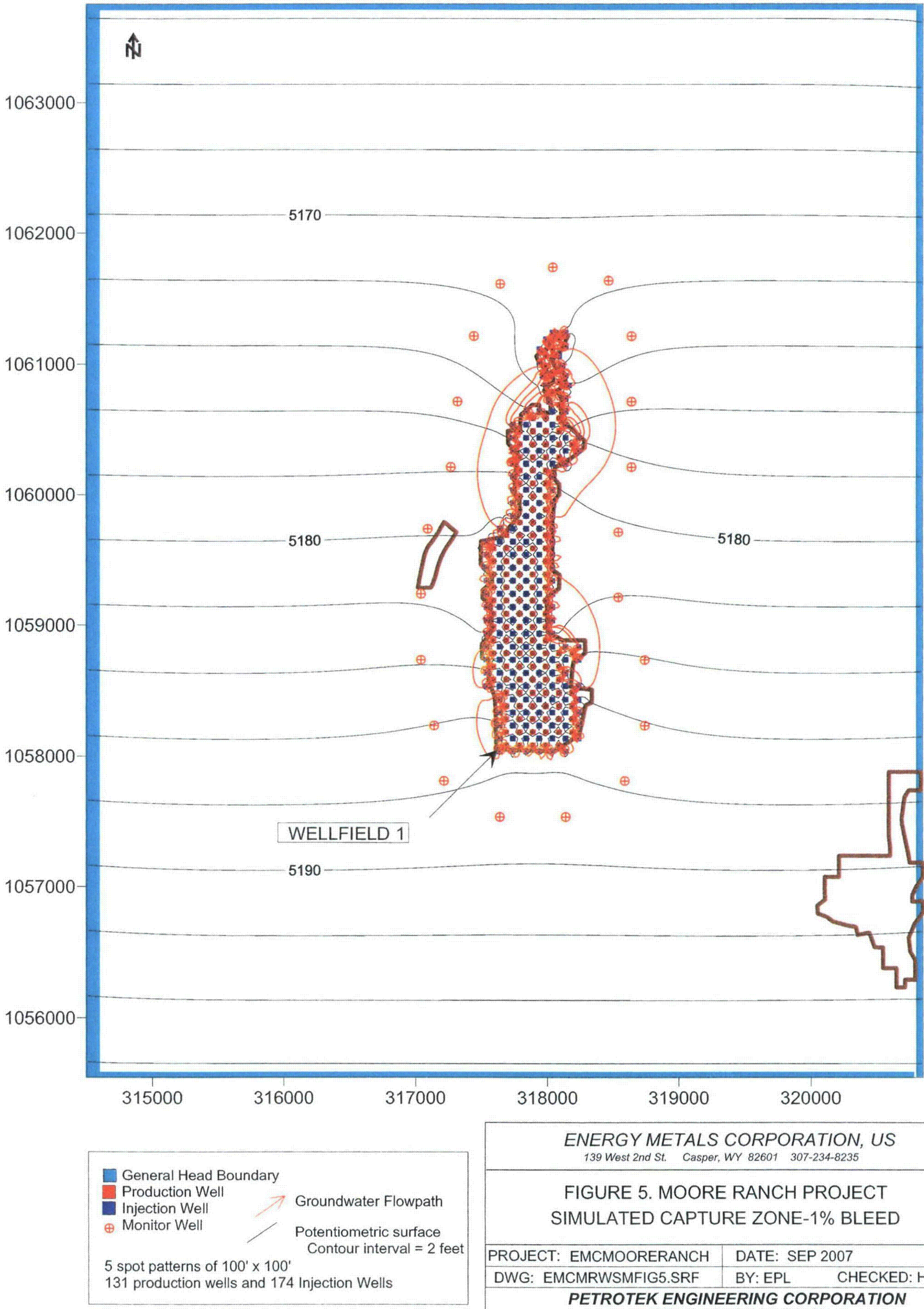

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FIGURE 5. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG5.SRF	BY: EPL CHECKED: HPD

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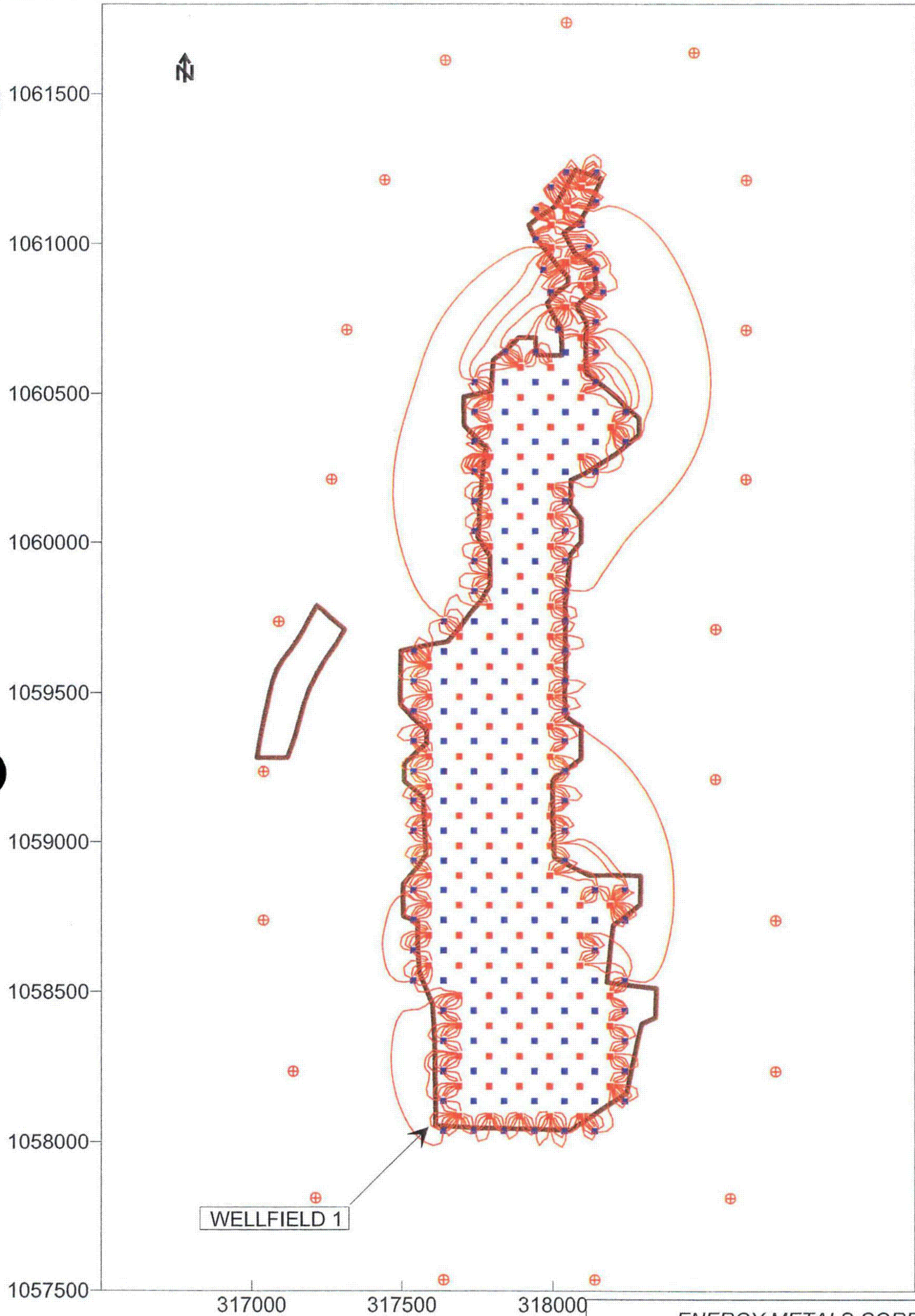

General Head Boundary
Production Well
Injection Well
Monitor Well
Groundwater Flowpath

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 6. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE DETAIL-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG6.SRF	BY: EPL CHECKED: HPD

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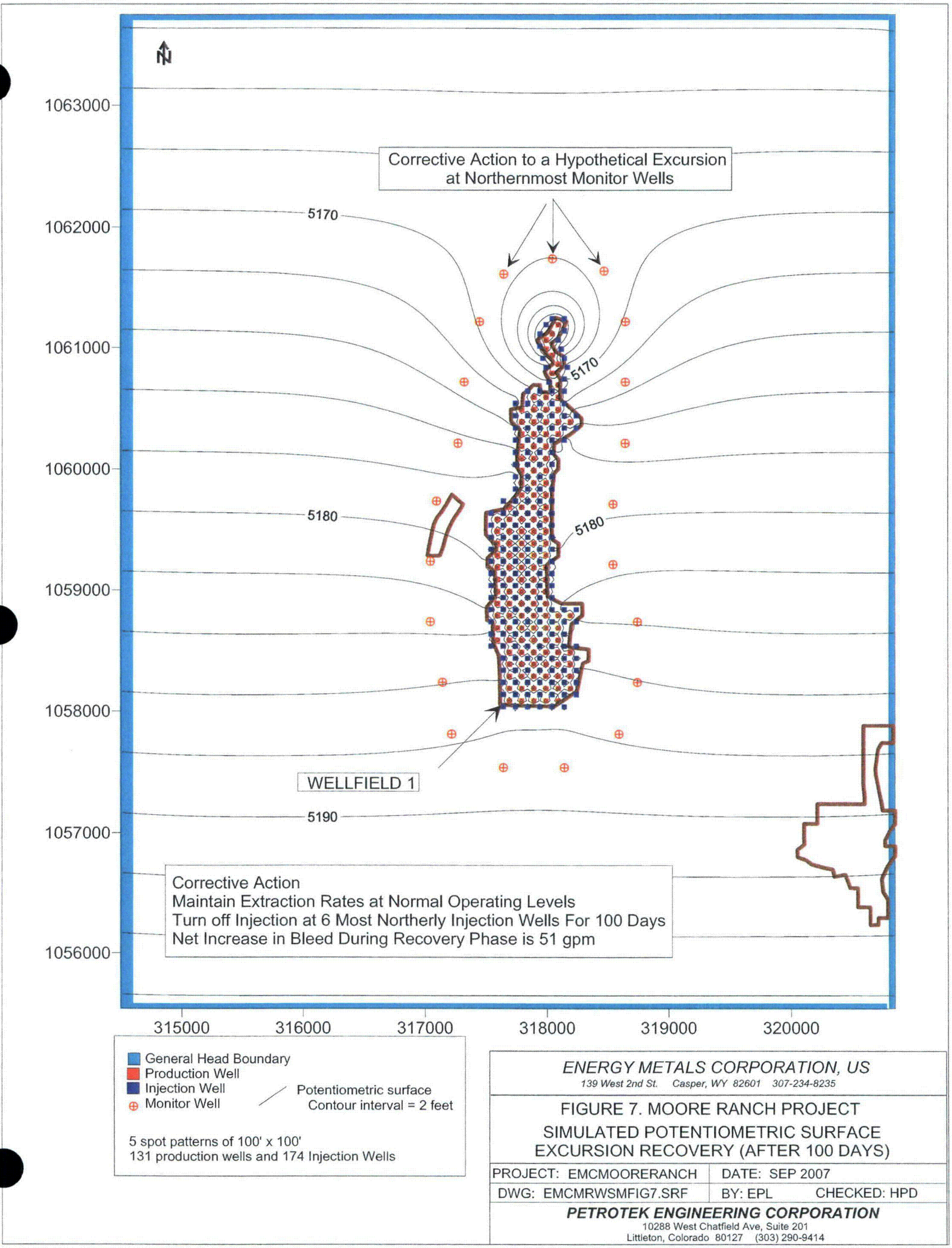

Corrective Action to a Hypothetical Excursion at Northernmost Monitor Wells
5170
5180
5190
WELLFIELD 1
1063000
1062000
1061000
1060000
1059000
1058000
1057000
1056000
315000
316000
317000
318000
319000
320000
Corrective Action
Maintain Extraction Rates at Normal Operating Levels
Turn off Injection at 6 Most Northerly Injection Wells For 100 Days
Net Increase in Bleed During Recovery Phase is 51 gpm
General Head Boundary
Production Well
Injection Well
Monitor Well
Potentiometric surface
Contour interval = 2 feet
5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells
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FIGURE 7. MOORE RANCH PROJECT
SIMULATED POTENTIOMETRIC SURFACE
EXCURSION RECOVERY (AFTER 100 DAYS)
PROJECT: EMCMOORERANCH
DATE: SEP 2007
DWG: EMCMRWSMFIG7.SRF
BY: EPL
CHECKED: HPD
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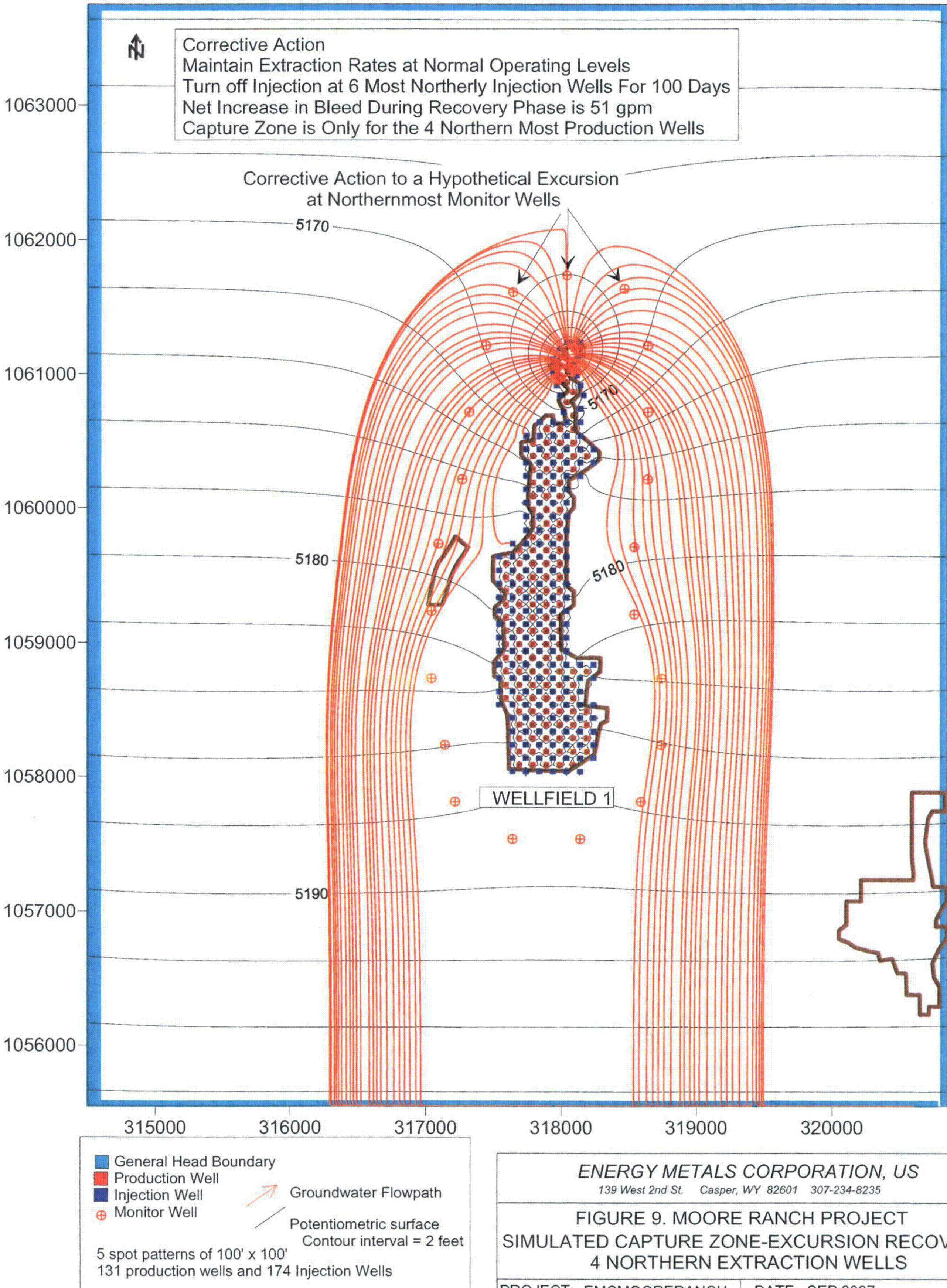

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FIGURE 9. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE-EXCURSION RECOVERY
4 NORTHERN EXTRACTION WELLS

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG8.SRF	BY: EPL CHECKED: HPD

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6 GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

The objective of groundwater restoration, surface reclamation, and facility decommissioning is to return the affected environment (groundwater and land surface) to conditions such that they are suitable for uses for which they were suitable prior to mining. The methods to achieve this objective for both the affected groundwater and the land surface are described in the following sections.

6.1 PLANS AND SCHEDULES FOR GROUNDWATER QUALITY RESTORATION

6.1.1 Groundwater Restoration Criteria

The purpose of groundwater restoration is to protect groundwater adjacent to the mining zone. Approval of an aquifer exemption by the WDEQ and the EPA is required before mining operations can begin. The aquifer exemption removes the mining zone from protection under the Safe Drinking Water Act (SDWA). Approval is based on existing water quality, the ability to commercially produce minerals, and the lack of use as an underground source of drinking water (USDW). Groundwater restoration prevents any mobilized constituents from affecting aquifers adjacent to the ore zone.

The goal of the groundwater restoration efforts will be to return the groundwater quality of the production zone, on a wellfield average, to the standard of pre-mining class of use or better using Best Practicable Technology (BPT) as defined in §35-11-103(f)(i) of the Wyoming Environmental Quality Act, 2006. The pre-mining class of use will be determined by the baseline water quality sampling program which is performed for each wellfield, as compared to the use categories defined by the WDEQ, Water Quality Division (WQD). Baseline, as defined for this project, shall be the mean of the pre-mining baseline data after outlier removals. Restoration shall be demonstrated in accordance with Chapter 11, Section 5(a)(ii) of the WDEQ, Land Quality Division Rules and Regulations.

The evaluation of restoration of the groundwater within the production zone shall be based on the average baseline quality over the production zone. Baseline water quality will be collected for each wellfield from the wells completed in the planned production zone (i.e., MP-Wells). The evaluation of restoration will be conducted on a parameter by parameter basis. Restoration Target Values (RTVs) are established for the list of baseline water quality parameters. The RTVs for the wellfields will be the average of the pre-mining values. Table 6.1-1 entitled Baseline Water Quality Parameters lists the parameters included in the RTVs.

Baseline values will not be changed unless the operational monitoring program indicates that baseline water quality has changed significantly due to accelerated movement of groundwater, and that such change justifies redetermination of baseline water quality. Such a change would require resampling of monitor wells and review and approval by the WDEQ.

Table 6.1-1 Baseline Water Quality Parameters

Parameter (units)
Dissolved Aluminum (mg/l)
Ammonia Nitrogen as N (mg/l)
Dissolved Arsenic (mg/l)
Dissolved Barium (mg/l)
Boron (mg/l)
Dissolved Cadmium (mg/l)
Dissolved Chloride (mg/l)
Dissolved Chromium (mg/l)
Dissolved Copper (mg/l)
Fluoride (mg/l)
Gross Alpha (pCi/l)
Gross Beta (pCi/l)
Total and Dissolved Iron (mg/l)
Dissolved Mercury (mg/l)
Dissolved Magnesium (mg/l)
Total Manganese (mg/l)
Dissolved Molybdenum (mg/l)
Dissolved Nickel (mg/l)
Nitrate + Nitrite as N (mg/l)
Dissolved Lead (mg/l)
Radium-226 (pCi/L)

Table 6.1-1 Baseline Water Quality Parameters

Parameter (units)
Radium-228 (pCi/L)
Dissolved Selenium (mg/l)
Dissolved Sodium (mg/l)
Sulfate (mg/l)
Uranium (mg/l)
Vanadium (mg/l)
Dissolved Zinc (mg/l)
Dissolved Calcium (mg/l)
Bicarbonate (mg/l)
Carbonate (mg/l)
Dissolved Potassium (mg/l)
Total Dissolved Solids (TDS) @ 180°F (mg/l)

Source: WDEQ LQD Guideline 8, Hydrology, March 2005

6.1.2 Estimate of Post-Mining Groundwater Quality

EMC has estimated the post-mining water quality based on the experience of COGEMA Mining, Inc. in Production Units 1 through 9 at the Irigaray ISR project located in the Powder River Basin near the proposed Moore Ranch Uranium Project[1]. The Irigaray data was selected because of the proximity and similar geologic conditions to Moore Ranch. Cogema employed ammonium bicarbonate with hydrogen peroxide as the oxidant during early mining operations. In May 1980, the lixiviant system for the entire site was converted to sodium bicarbonate chemistry with gaseous oxygen as the oxidant. The water quality database is extensive because it represents nine production units located in a 30 acre site.

The water quality of the Irigaray ore zone after mining was established by sampling each of the designated restoration wells. The post-mining mean of the analytical results from Production Units 1 through 9 is presented in Table 6.1-2. The chemical alteration of the ore zone aquifer can be observed through comparison of the post-mining mean concentrations with the baseline concentrations.

Table 6.1-2 Irigaray Post-Mining Water Quality

Parameter (units)	Irigaray Baseline Range	Irigaray Post-Mining Mean
Dissolved Aluminum (mg/l)	<0.05 – 4.25	<1.037
Ammonia Nitrogen as N (mg/l)*	<0.05 – 1.88	23
Dissolved Arsenic (mg/l)	<0.001 – 0.105	<0.601
Dissolved Barium (mg/l)	<0.01 – 0.12	<1.067
Boron (mg/l)	<0.01 – 0.225	<0.442
Dissolved Cadmium (mg/l)	<0.002 – 0.013	<0.979
Dissolved Chloride (mg/l)*	5.3 – 15.1	277
Dissolved Chromium (mg/l)	<0.002 – 0.063	<1.018
Dissolved Copper (mg/l)	<0.002 – 0.04	<0.828
Fluoride (mg/l)	0.11 – 0.66	<1
Total and Dissolved Iron (mg/l)	0.02 – 11.8	<1.098
Dissolved Mercury (mg/l)	<0.0002 - <0.001	<0.971
Dissolved Magnesium (mg/l)	0.02 – 9.0	45.7
Total Manganese (mg/l)	<0.005 – 0.190	1.249
Dissolved Molybdenum (mg/l)	<0.02 - <0.1	<1.067
Dissolved Nickel (mg/l)	<0.01 - <0.2	<1.018
Nitrate + Nitrite as N (mg/l)	<0.2 – 1.0	<3
Dissolved Lead (mg/l)	<0.002 - <0.050	<1.018
Radium-226 (pCi/L)	0 – 247.7	200.5
Dissolved Selenium (mg/l)	<0.001 – 0.416	0.247
Dissolved Sodium (mg/l)	95 - 280	827
Sulfate (mg/l)	136 - 824	639
Uranium (mg/l)	<0.0003 – 18.8	7.411
Vanadium (mg/l)	<0.05 – 0.55	<1.067
Dissolved Zinc (mg/l)	<0.01 – 0.200	<0.065
Dissolved Calcium (mg/l)*	1.6 – 33.5	199.2
Bicarbonate (mg/l)*	5 - 144	1343
Carbonate (mg/l)	0 - 96	<2

Table 6.1-2 Irigaray Post-Mining Water Quality

Parameter (units)	Irigaray Baseline Range	Irigaray Post-Mining Mean
Dissolved Potassium (mg/l)	0.4 – 17.5	9
Total Dissolved Solids (TDS) @ 180°F (mg/l)	308 - 1054	2451

* Parameters with RTV other than baseline

EMC expects similar baseline and post-mining water quality at the Moore Ranch site. The success of groundwater restoration at the Irigaray site is discussed in Section 6.1.5.

6.1.3 Groundwater Restoration Method

The commercial groundwater restoration program consists of two stages, the restoration stage and the stability monitoring stage. The restoration stage typically consists of three phases:

1) Groundwater transfer;
2) Groundwater sweep;
3) Groundwater treatment.

These phases are designed to optimize restoration equipment used in treating groundwater and to minimize the volume of groundwater consumed during the restoration stage. EMC will monitor the quality of groundwater in selected wells as needed during restoration to determine the efficiency of the operations and to determine if additional or alternate techniques are necessary. Online production wells used in restoration will be sampled for uranium concentration and for conductivity to determine restoration progress on a pattern-by-pattern basis.

The sequence of the activities will be determined by EMC based on operating experience and waste water system capacity. Not all phases of the restoration stage will be used if deemed unnecessary by EMC.

A reductant may be added at any time during the restoration stage to lower the oxidation potential of the mining zone. Either a sulfide or sulfite compound may be added to the injection stream in concentrations sufficient to establish reducing conditions within the mining zone. EMC may also employ bioremediation as a reduction process.

Reductants are beneficial because several of the metals, which are solubilized during the leaching process, are known to form stable insoluble compounds, primarily as sulfides.

Dissolved metal compounds that are precipitated under reducing conditions include those of arsenic, molybdenum, selenium, uranium and vanadium.

6.1.3.1 Groundwater Transfer

During the groundwater transfer phase, water may be transferred between a wellfield commencing restoration and a wellfield commencing mining operations. Also, a groundwater transfer may occur within the same wellfield, if one area is in a more advanced state of restoration than another.

Baseline quality water from the wellfield commencing mining will be pumped and injected into the wellfield in restoration. The higher TDS water from the wellfield in restoration will be recovered and injected into the wellfield commencing mining. The direct transfer of water will act to lower the TDS in the wellfield being restored by displacing affected groundwater with baseline quality water.

The goal of the groundwater transfer phase is to blend the water in the two wellfields until they become similar in conductivity. The water recovered from the restoration wellfield may be passed through ion exchange (IX) columns and/or filtered during this phase if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens.

For the groundwater transfer between wellfields to occur, a newly constructed wellfield must be ready to commence mining. Therefore this phase may be initiated at any time during the restoration process. If a wellfield is not available to accept transferred water, groundwater sweep or some other activity will be utilized as the first phase of restoration.

The advantage of using the groundwater transfer technique is that it reduces the amount of water that must ultimately be sent to the waste water disposal system during restoration activities.

6.1.3.2 Groundwater Sweep

Groundwater sweep may be used as a stand-alone process where groundwater is pumped from the wellfield without injection causing an influx of baseline quality water from the perimeter of the mining unit, which sweeps the affected portion of the aquifer. The cleaner baseline water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The plume of affected water near the perimeter of the wellfield is also drawn inside the boundaries of the wellfield. Groundwater sweep may also be used in conjunction with the groundwater treatment phase of restoration. The water produced during groundwater sweep is disposed of in an approved manner.

The rate of groundwater sweep will be dependent upon the capacity of the waste water disposal system and the ability of the wellfield to sustain the rate of withdrawal.

6.1.3.3 Groundwater Treatment

Either following or in conjunction with the groundwater sweep phase water will be pumped from the mining zone to treatment equipment at the surface. Ion exchange (IX), reverse osmosis (RO) or Electro Dialysis Reversal (EDR) treatment equipment will be utilized during this phase of restoration.

Groundwater recovered from the restoration wellfield will be passed through an IX system prior to RO/EDR treatment, as part of the waste disposal system or it will be re-injected into the wellfield. The IX columns exchange the majority of the contained soluble uranium for chloride or sulfate. Additionally, prior to or following IX treatment, the groundwater may be passed through a de-carbonation unit to remove residual carbon dioxide that remains in the groundwater after mining.

At any time during the process, a reductant (either biological or chemical), which will be used to create reducing conditions in the mining zone, may be metered into the restoration wellfield injection stream. The concentration of reductant injected into the formation is determined by how the mining zone groundwater reacts with the reductant. The goal of reductant addition is to decrease the concentrations of redox sensitive elements.

All or some portion of the restoration recovery water can be sent to the RO unit. The use of an RO unit 1) reduces the total dissolved solids in the affected groundwater, 2) reduces the quantity of water that must be removed from the aquifer to meet restoration limits, 3) concentrates the dissolved contaminates in a smaller volume of brine to facilitate waste disposal, and 4) enhances the exchange of ions from the formation due to the large difference in ion concentration. The RO passes a high percentage of the water through the membranes, leaving 60 to 90 percent of the dissolved salts in the brine water or concentrate. The clean water, called permeate, will be re-injected or stored for use in the mining process. The permeate may also be de-carbonated prior to re-injection into the wellfield. The brine water that is rejected contains the majority of dissolved salts in the affected groundwater and is sent for disposal in the waste system. Make-up water, which may come from water produced from a wellfield that is in a more advanced state of restoration, water being exchanged with a new mining unit, water being pumped from a different aquifer, the purge of an operating wellfield or a combination of these sources, may be added prior to the RO or wellfield injection stream to control the amount of "bleed" in the restoration area.

The reductant (either biological or chemical) added to the injection stream during this stage will scavenge any oxygen and reduce the oxidation-reduction potential (Eh) of the aquifer. During mining operations, certain trace elements are oxidized. By adding the reductant, the Eh of the aquifer is lowered thereby decreasing the solubility of these elements. Regardless of the reductant used, a comprehensive safety plan regarding reductant use will be implemented.

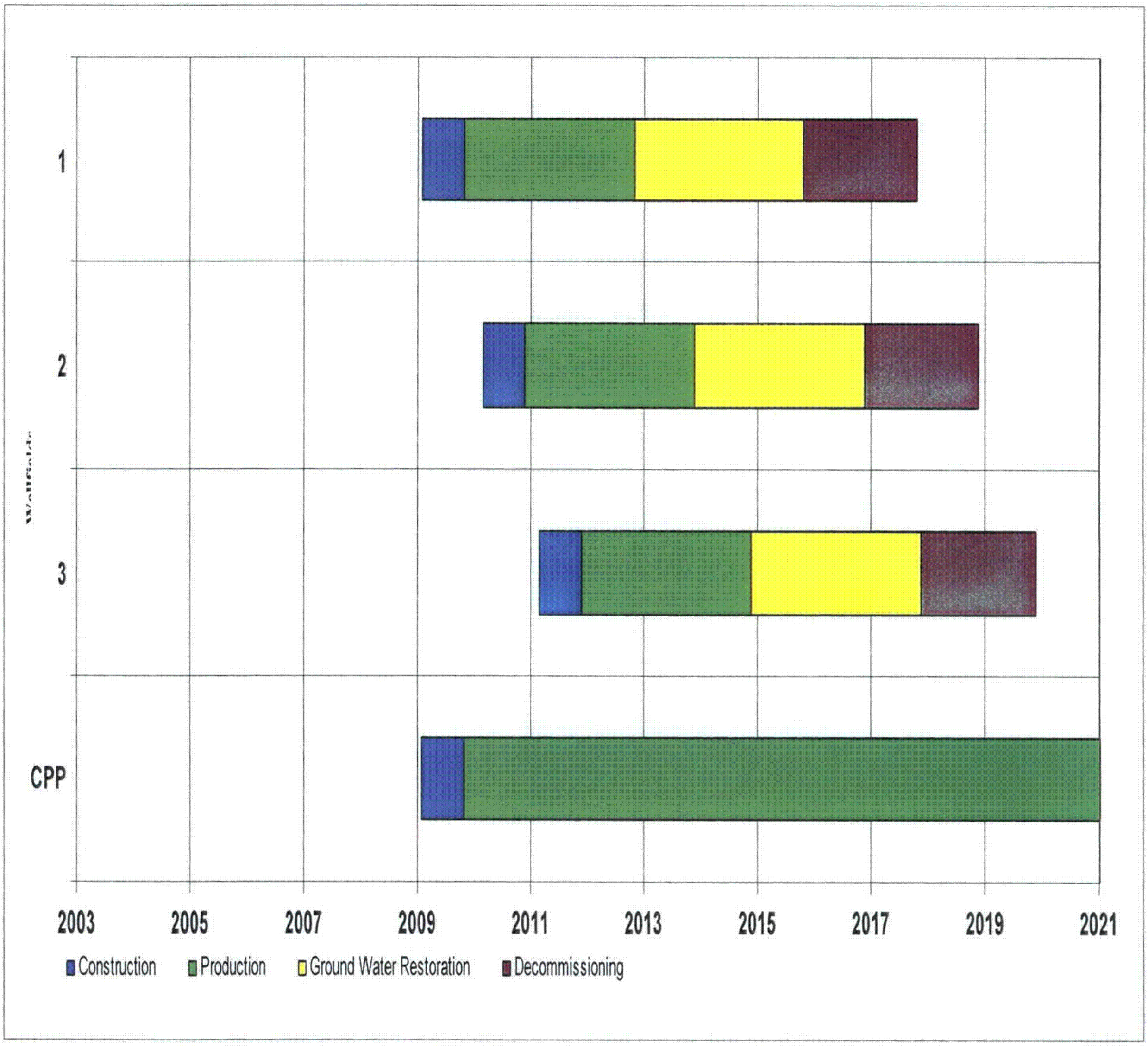
If necessary, sodium hydroxide may be used during the groundwater treatment phase to return the groundwater to baseline pH levels. This will assist in immobilizing certain parameters such as trace metals.

The number of pore volumes treated and re-injected during the groundwater treatment phase will depend on the efficiency of the RO in removing Total Dissolved Solids (TDS) and the success of the reductant in lowering the uranium and trace element concentrations. Estimates of the number of pore volumes required for each restoration phase are discussed in Section 6.6.

6.1.4 Restoration Schedule

The proposed Moore Ranch mine schedule is shown in Figure 6.1-1 showing the estimated schedule for restoration. The restoration schedule is preliminary based on EMC's current knowledge of the area and are based the completion of mining activities for the three wellfields. As the Moore Ranch Project is developed, the restoration schedule will be defined further.

Figure 6.1-1 Proposed Moore Ranch Operations and Restoration Schedule



6.1.5 Effectiveness of Groundwater Restoration Techniques

The groundwater restoration methods described in this application have been successfully applied at other uranium ISR facilities in the Powder River Basin as well as in Nebraska and Texas. A number of uranium ISR mines in Wyoming, Nebraska, and Texas have successfully restored groundwater and obtained regulatory approval of restoration using these techniques. The following two ISR facilities are located in the Powder River Basin near the proposed Moore Ranch Project.

- Smith Ranch/Highland Uranium Project

Groundwater restoration activities at the Smith Ranch-Highland Uranium Project currently operated by Power Resources, Inc. (PRI) have been approved by the NRC and the WDEQ for the R&D operations and for the A-Wellfield during commercial operations. In 1987, the NRC confirmed successful restoration of the Q-sand project. Although one well exhibited uranium and nitrate levels above the target restoration values, the wellfield averages on a whole were below the targets.

In 2004, the NRC concurred with the WDEQ's determination that the A-wellfield at Highland had been restored in accordance with the applicable regulatory requirements[2]. Not all of the parameters were returned to baseline conditions, but the groundwater quality was consistent with the pre-mining class of use.

- Irigaray/Christensen Ranch Uranium Project

Groundwater restoration activities at the Irigaray/Christensen Ranch Uranium Project operated by Cogema Mining, Inc. have been approved by the NRC and the WDEQ for Wellfields 1 through 9 following commercial operations and groundwater restoration. Post-mining water quality in the nine production units was described in Section 6.1.2. The WDEQ determined that twenty-seven of twenty-nine constituents were restored below the restoration target values. Only bicarbonate and manganese did not meet the baseline range. WDEQ determined that these two constituents met the criteria of pre-mining class of use. Based on this, the WDEQ determined that the groundwater, as a whole, had been returned to its pre-mining class of use and that the post restoration groundwater conditions did not significantly differ from the background water quality.

In 2006, the NRC concurred with the WDEQ's determination that wellfields 1 through 9 at Irigaray had been restored in accordance with the applicable regulatory requirements[3]. NRC determined that Cogema used best practicable technology and agreed that the WDEQ class-of-use standards were met.

6.1.6 Environmental Effects of Groundwater Restoration

Based on the effectiveness of groundwater restoration at other ISR mines in the Powder River Basin, EMC expects that the proposed groundwater restoration techniques will successfully return the mining zone at Moore Ranch to the restoration target values. As discussed in Section 6.1.1, the purpose of restoring the groundwater to these restoration target values is to protect adjacent groundwater that is outside the production zone. If a constituent cannot technically or economically be restored to its restoration target value within the exploited production zone, WDEQ and NRC will require that EMC demonstrate that leaving the constituent at a higher concentration will not be a threat to public health and safety or the environment or produce an unacceptable impact to the use of adjacent groundwater resources. EMC believes that the application of proven best practicable technology for groundwater restoration and the regulatory requirements that are in place at the State and federal level will ensure that there is no adverse impact on the water quality of groundwater outside the production zone.

The proposed restoration methods consume groundwater. Groundwater recovered during groundwater sweep is generally directly disposed in the waste water system. Approximately 20 to 25 percent of the groundwater treatment flow through the RO system is disposed as RO brine. This consumption of groundwater is an unavoidable consequence of groundwater treatment. Impacts and water usage during operations and restoration are discussed in more detail in Section 7.2.5.1.

6.1.7 Groundwater Restoration Monitoring

6.1.7.1 Monitoring During Active Restoration

During restoration, lixiviant injection is discontinued and the quality of the groundwater is constantly being improved, thereby greatly diminishing the possibility and relative impact of an excursion. Therefore, the monitor ring wells (M-Wells), overlying aquifer wells (MO or MS-Wells), and underlying aquifer wells (MU or MD-Wells) are sampled once every 60 days and analyzed for the excursion parameters, chloride, total alkalinity and conductivity. Water levels are also obtained at these wells prior to sampling.

In the event that unforeseen conditions (such as snowstorms, flooding, equipment malfunction) occur, the WDEQ will be contacted if any of the wells cannot be monitored within 65 days of the last sampling event.

6.1.7.2 Restoration Stability Monitoring

A minimum six month groundwater stability monitoring period will be implemented to show that the restoration goal has been adequately maintained. The following restoration stability monitoring program will be performed during the stability period:

- The monitor ring wells will be sampled once every two months and analyzed for the UCL parameters, chloride, total alkalinity (or bicarbonate) and conductivity; and

- At the beginning, middle and end of the stability period, the MP-Wells will be sampled and analyzed for the parameters in Table 6.1-1.

In the event that unforeseen conditions (such as snowstorms, flooding, equipment malfunction) occur, the WDEQ will be contacted if any of the M-Wells or MP-Wells cannot be monitored within 65 days of the last sampling event.

6.1.8 Well Plugging and Abandonment

Wellfield plugging and surface reclamation will be initiated once the regulatory agencies concur that the groundwater has been adequately restored and that groundwater quality is stable. All production, injection and monitor wells and drillholes will be abandoned in accordance with WS-35-11-404 and Chapter VIII, Section 8 of the WDEQ-LQD Rules and Regulations to prevent adverse impacts to groundwater quality or quantity.

Wells will be plugged and abandoned in accordance with the following program.

- When practicable, all pumps and tubing will be removed from the well.
- All wells will be plugged from total depth to within 23 feet of the collar with a nonorganic well abandonment plugging fluid of neat cement or bentonite based grout mixed in the recommended proportion of 20 lbs per barrel of water, to yield an abandonment fluid with a 10 minute gel strength of at least 20 lbs/100 sq ft and a filtrate volume not to exceed 13.5 cc.
- The casing is cut off at least three feet below the ground surface. Abandonment fluid is topped off to the top of the cut-off casing. A steel plate is placed atop the sealing mixture showing the permit number, well identification, and date of plugging.
- A cement plug is placed at the top of the casing (if cement is not within three feet of the surface), and the area is backfilled, smoothed, and leveled to blend with the natural terrain.

As an alternative method of well plugging, a dual plug procedure may be used where a cement plug will be set using slurry of a weight of no less than 12 lbs/gallon into the bottom of the well. The plug will extend from the bottom of the well upwards across the first overlying aquitard. The remaining portion of the well will be plugged using a bentonite/water slurry with a mud weight of no less than 9.5 lbs/gallon. A 10-foot cement top plug will be set to seal the well at the surface.

6.1.9 Restoration Wastewater Disposal

EMC plans to install deep disposal wells (EPA UIC Class I non-hazardous wells) at the Moore Ranch Uranium Project as the primary liquid waste disposal method. EMC believes that permanent deep disposal is preferable to evaporation in evaporation ponds. Disposal in a Class I well permanently isolates the waste water from the public and the environment. Alternatives assessed by EMC for waste water disposal are discussed in Section 8.

Based on the expected post mining concentrations of groundwater quality constituents discussed in Section 6.1.2 and the proposed groundwater restoration techniques discussed in Section 6.1.3, EMC projects that the restoration injection stream will exhibit the range of characteristics shown in Table 6.1-3.

Table 6.1-3 Projected Moore Ranch Restoration Injection Stream Water Quality

Parameter	Units	Min	Max
Calcium	mg/l	350	700
Magnesium	mg/l	50	150
Sodium	mg/l	400	950
Potassium	mg/l	40	90
Carbonate	mg/l	0	0.3
Bicarbonate	mg/l	200	1250
Sulfate	mg/l	900	2500
Chloride	mg/l	300	1000
Nitrate	mg/l	0.01	0.5
Fluoride	mg/l	0.01	2
Silica	mg/l	10	65
Total Dissolved Solids	mg/l	1000	6500
Conductivity	µmho/cm	1000	5500
Alkalinity	mg/l	165	1025
pH	Std. Units	6	12
Arsenic	mg/l	0.01	1
Cadmium	mg/l	0.0001	0.001
Iron	mg/l	0.5	15
Lead	mg/l	0.01	0.04
Manganese	mg/l	0.01	1.5
Mercury	mg/l	0.0001	0.001
Molybdenum	mg/l	0.1	1.5
Selenium	mg/l	0.01	0.5
Uranium	mg/l	0.05	15
Ammonia	mg/l	0.1	0.5
Radium-226	pCi/l	500	5000

All compatible liquid wastes generated during groundwater restoration at Moore Ranch will be disposed in the planned deep wells. An application is under preparation for submittal to the WDEQ for a Class I UIC Permit for the Moore Ranch Uranium Project.

6.2 PLANS AND SCHEDULES FOR RECLAIMING DISTURBED LANDS

6.2.1 Introduction

All lands disturbed by the mining project will be returned to their pre-mining land use of livestock grazing and wildlife habitat unless an alternative use is justified and is approved by the state and the landowner, i.e. the rancher desires to retain roads or buildings. The objectives of the surface reclamation effort is to return the disturbed lands to production capacity of equal to or better than that existing prior to mining. The soils, vegetation and radiological baseline data will be used as a guide in evaluating final reclamation. This section provides a general description of the proposed facility decommissioning and surface reclamation plans for the Moore Ranch Project. The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in Section 6.1.8.
- Determination of appropriate cleanup criteria for structures (Section 6.3) and soils (Section 6.4).
- Radiological surveys and sampling of all facilities, process related equipment and materials on site to determine their degree of contamination and identify the potential for personnel exposure during decommissioning.
- Removal from the site of all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocation to an operational portion of the mining operation as discussed in Section 6.3.
- Decontamination of items to be released for unrestricted use to levels consistent with the requirements of NRC.
- Survey excavated areas for contamination and remove contaminated materials to a licensed disposal facility.
- Perform final site soil radiation surveys.

- Backfill and recontour all disturbed areas.
- Establish permanent revegetation on all disturbed areas.

The following sections describe in general terms the planned decommissioning activities and procedures for the Moore Ranch facilities. EMC will, prior to final decommissioning of an area, submit to the NRC a detailed Decommissioning Plan for their review and approval at least 12 months before planned commencement of final decommissioning.

6.2.2 Surface Disturbance

The primary surface disturbances associated with ISR mining are the sites containing the central processing plant, maintenance and office areas. Surface disturbances also occur during the well drilling program, pipeline and well installations, and road construction. These more superficial disturbances involve relatively small areas or have very short-term impacts.

Disturbances associated with the central processing plant, office and maintenance buildings, and field header buildings, will be for the life of those activities and topsoil will be stripped from the areas prior to construction. Disturbance associated with drilling and pipeline installation is limited, and is reclaimed and reseeded as soon as weather conditions permit. Vegetation will normally be reestablished over these areas within two years. Surface disturbance associated with development of access roads will occur at the Moore Ranch site and topsoil will be stripped from the road areas prior to construction and stockpiled.

Surface reclamation in the wellfield production units will vary in accordance with the development sequence and the mining/reclamation timetable. Final surface reclamation of each wellfield production unit will be completed after approval of groundwater restoration stability and the completion of well abandonment activities. Surface preparation will be accomplished as needed so as to blend any disturbed areas into the contour of the surrounding landscape.

Wellfield decommissioning will consist of the following steps:

- The first step of the wellfield decommissioning process will involve the removal of surface equipment. Surface equipment primarily consists of the injection and production feed lines, wellhouses, electrical and control distribution systems, well boxes, and wellhead equipment. Wellhead equipment such as valves, meters or control fixtures will be salvaged to the extent possible.

- Removal of buried wellfield piping.

- The wellfield area may be recontoured, if necessary, and a final background gamma survey conducted over the entire wellfield area to identify any contaminated earthen materials requiring removal to disposal.

- Final revegetation of the wellfield areas will be conducted according to the revegetation plan.

- All piping, equipment, buildings, and wellhead equipment will be surveyed for contamination prior to release in accordance with the NRC guidelines for decommissioning.

It is estimated that a significant portion of the equipment will meet release limits, which will allow disposal at an unrestricted area landfill. Other materials that are contaminated will be decontaminated until they are releasable. If the equipment cannot be decontaminated to meet release limits, it will be disposed of at a NRC licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence. Once a production unit has been mined out and groundwater restoration and stability have been accepted by the regulatory agencies, the wellfield will be scheduled for decommissioning and surface reclamation.

6.2.3 Topsoil Handling and Replacement

In accordance with WDEQ-LQD requirements, topsoil is salvaged from building sites, permanent storage areas, main access roads, graveled wellfield access roads and chemical storage sites. Conventional rubber-tired, scraper-type earth moving equipment is typically used to accomplish such topsoil salvage operations. The exact location of topsoil salvage operations is determined by wellfield pattern emplacement and designated wellfield access roads within the wellfields, which will be determined during final wellfield construction activities.

As described in Section 2.6, topsoil thickness varies within the permit area from non-existent to several feet in depth. However, typical topsoil stripping depths are expected to range from 3 to 6 inches.

Salvaged topsoil is stored in designated topsoil stockpiles. These stockpiles will be generally located on the leeward side of hills to minimize wind erosion. Stockpiles will not be located in drainage channels. The perimeter of large topsoil stockpiles may be bermed to control sediment runoff. Topsoil stockpiles will be seeded as soon as possible after construction with the permanent seed mix. In accordance with WDEQ-LQD requirements, all topsoil stockpiles will be identified with a highly visible sign with the designation "Topsoil."

During mud pit excavation associated with well construction, exploration drilling and delineation drilling activities, topsoil is separated from subsoil with a backhoe. When use of the mud pit is complete, all subsoil is replaced and topsoil is applied. Mud pits only remain open a short time, usually less than 30 days. Similarly, during pipeline construction, topsoil is stored separate from subsoil and is replaced on top of the subsoil after the pipeline ditch is backfilled.

6.2.4 Final Contouring

Recontouring of land where surface disturbance has taken place will restore it to a surface configuration that will blend in with the natural terrain and will be consistent with the post mining land use. Since no major changes in the topography will result from the proposed mining operation, a final contour map is not required.

6.2.5 Revegetation Practices

Revegetation practices will be conducted in accordance with WDEQ-LQD regulations and the mine permit. During mining operations the topsoil stockpiles, and as much as practical of the disturbed wellfield areas will be seeded to establish a vegetative cover to minimize wind and water erosion. After topsoiling prior to final reclamation, an area will normally be seeded with a nurse crop to establish a standing vegetative cover along with the permanent seed mix. A long term temporary seed mix may be used in the wellfields and other areas where the vegetation will be disturbed again prior to final decommissioning and final revegetation. This long term seed mix typically consists of one or more of the native wheat grasses (i.e. Western Wheatgrass, Thickspike Wheatgrass).

Permanent seeding is accomplished with a seed mix approved by the WDEQ-LQD. The permanent mix typically contains native wheat grasses, fescues, and clovers. Typical seeding rates will be 12-14 lbs of pure live seed per acre.

The success of permanent revegetation in meeting land use and reclamation success standards will be assessed prior to application for bond release by utilizing the "Extended Reference Area" method as detailed in WDEQ-LQD Guideline No. 2 - Vegetation (March 1986). This method compares, on a statistical basis, the reclaimed area with adjacent undisturbed areas of the same vegetation type.

The Extended Reference Areas will be located adjacent to the reclaimed area being assessed for bond release and will be sized such that it is at least half as large as the area being assessed. In no case will the Extended Reference Area be less than 25 acres in size.

The WDEQ-LQD will be consulted prior to selection of Extended Reference Areas to ensure agreement that the undisturbed areas chosen adequately represent the reclaimed areas being assessed. The success of permanent revegetation and final bond release will be assessed by the WDEQ-LQD.

6.3 PROCEDURES FOR REMOVING AND DISPOSING OF STRUCTURES AND EQUIPMENT

6.3.1 Preliminary Radiological Surveys and Contamination Control

Prior to process plant decommissioning, a preliminary radiological survey will be conducted to characterize the levels of contamination on structures and equipment and to identify any potential hazards. The survey will support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities. In general, the contamination control program used during mining operations (as discussed in Section 5.7) will be appropriate for use during decommissioning of structures.

Based on the results of the preliminary radiological surveys, gross decontamination techniques will be employed to remove loose contamination before decommissioning activities proceed. This gross decontamination will generally consist of washing all accessible surfaces with high-pressure water. In areas where contamination is not readily removed by high-pressure water, a decontamination solution (e.g., dilute acid) may be used.

6.3.2 Removal of Process Buildings and Equipment

The majority of the process equipment in the process building will be reusable, as well as the building itself. Alternatives for the disposition of the building and equipment are discussed in this section.

All process or potentially contaminated equipment and materials at the process facility including tanks, filters, pumps, piping, etc., will be inventoried, listed and designated for one of the following removal alternatives:

- Removal to a new location for future use;
- Removal to another licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release, sale or other unrestricted use by others.

EMC believes that process buildings will be decontaminated, dismantled and released for use at another location. If decontamination efforts are unsuccessful, the material will be sent to a permanent licensed disposal facility. Cement foundation pads and footings will be broken up and trucked to a solid waste disposal site or to a NRC-licensed disposal facility if contaminated.

6.3.2.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Salvageable building materials, equipment, pipe and other materials to be released for unrestricted use will be surveyed for alpha contamination in accordance with NRC guidance. Release limits for alpha radiation are as follows:

- Removable alpha contamination of 1,000 dpm/100cm^2
- Average total alpha contamination of 5,000 dpm/100 cm^2 over an area no greater than one square meter
- Maximum total alpha contamination of 15,000 dpm/100 cm^2 over an area no greater than 100 cm^2.

Decontamination of surfaces will be guided by the ALARA principle to reduce surface contamination to levels as far below the limits as practical. Non-salvageable contaminated equipment, materials, and dismantled structural sections will be sent to an NRC-licensed facility for disposal. In most cases, the byproduct material will be shipped as Low Specific Activity (LSA-I) material, UN2912, pursuant to 49 CFR 173.427.

6.3.2.2 Preparation for Disposal at a Licensed Facility

If facilities or equipment are to be moved to a facility licensed for disposal of 11e.(2) byproduct material, the following procedures may be used.

- Flush inside of tanks, pumps, pipes, etc., with water or acid to reduce interior contamination as necessary for safe handling.

- The exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated the equipment will be washed down and decontaminated to permit safe handling.

- The equipment will be disassembled only to the degree necessary for transportation. All openings, pipe fittings, vents, etc., will be plugged or covered prior to moving equipment from the plant building.

- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in lined roll off containers or covered dump trucks or drummed in barrels for delivery to the receiving facility.

- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.

6.3.3 Waste Transportation and Disposal

Materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed at a disposal site licensed by the NRC or an Agreement State to receive 11e.(2) byproduct material. EMC is investigating alternatives for disposal at existing sites licensed to receive 11e.(2) byproduct material including Pathfinder Mines, Kennecott Uranium Company, and Denison Mines. An agreement for disposal of 11e.(2) byproduct material will be in place before construction of the Moore Ranch project commences. A current disposal agreement will be maintained at a minimum of one licensed disposal facility throughout licensed operations.

Transportation of all contaminated waste materials and equipment from the site to the approved licensed disposal facility or other licensed sites will be handled in accordance with the Department of Transportation (DOT) Hazardous Materials Regulations (49 CFR Part 173) and the NRC transportation regulations (10 CFR 71).

6.4 METHODOLOGIES FOR CONDUCTING POST-RECLAMATION AND DECOMMISSIONING RADIOLOGICAL SURVEYS

6.4.1 Cleanup Criteria

Surface soils will be cleaned up in accordance with the requirements of 10 CFR Part 40, Appendix A, including a consideration of ALARA goals and the chemical toxicity of uranium. The proposed limits and ALARA goals for cleanup of soils are summarized in Table 6.4-2.

On April 12, 1999, the NRC issued a Final Rule (64 FR 17506) that requires the use of the existing soil radium standard to derive a dose criterion for the cleanup of byproduct material. The amendment to Criterion 6(6) of 10 CFR Part 40, Appendix A was effective on June 11, 1999. This "benchmark approach" requires that NRC licensees model the site-specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determinations must then be submitted to NRC with the site reclamation plan or included in license applications. This section documents the modeling and assumptions made by EMC to derive a standard for natural uranium in soil for the proposed Moore Ranch Project.

Concurrent with publication of the Final Rule, NRC published draft guidance (64 FR 17690) for performing the benchmark dose modeling required to implement the final rule. Final guidance was published as Appendix E to NUREG-1569[4]. This guidance discusses acceptable models and input parameters. This guidance, guidance from the RESRAD Users Manual[5], the Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil[6] and site-specific parameters were used in the modeling as discussed in the following sections.

6.4.1.1 Determination of Radium Benchmark Dose

RESRAD Version 6.3 computer code was used to model the Moore Ranch site and calculate the annual dose from the current radium cleanup standard.

The following supporting documentation for determination of the radium benchmark dose is attached in Appendix C:

- The RESRAD Data Input Basis (Appendix C-1) provides a summary of the modeling performed with RESRAD and the values that were used for the input parameters. A sensitivity analysis was performed for parameters which are important to the major component dose pathways and for which no site specific data was available.
- Selected graphs produced with RESRAD that present the results of the sensitivity analysis performed on the input parameters are attached (Appendix C-2).
- A full printout of the final RESRAD modeling results for the resident farmer scenario with the chosen input values is attached (Appendix C-3 and Appendix C-4.). The printout provides the modeled maximum annual dose for calculated times

for the 1,000- year time span and provides a breakdown of the fraction of dose due to each pathway.

- Graphs produced by RESRAD in Appendix C-5 provide the modeling results for the maximum dose during the 1,000 year time span for both radium-226 and natural uranium. A series of graphs depicts the summed dose for all pathways and the component pathways that contribute to the total dose.

The maximum dose from Ra-226 contaminated soil at the 5 pCi/g above background cleanup standard, as determined by RESRAD, for the residential farmer scenario at Moore Ranch was 39.5 mrem/yr. This dose was based upon the 5 pCi/g surface (0 to 6-inch) Ra-226 standard and was noted at time, t = 0 years. The two major dose pathways were external exposure and plant ingestion (water independent). For these two pathways, a sensitivity analysis was performed for important parameters for which no site specific information was available. The 39.5 mrem/yr dose from radium is the level at which the natural uranium radiological end point soil standard will be based as described in Section 6.4.1.2.

6.4.1.2 Determination of Natural Uranium Soil Standard

RESRAD was used to determine the concentration of natural uranium in soil distinguishable from background that would result in a maximum dose of 39.5 mrem/yr. The method involved modeling the dose from a set concentration of natural uranium in soil. This dose was then compared to the radium benchmark dose and scaled to arrive at the maximum allowable natural uranium concentration in soil.

For ease of calculations, a preset concentration of 100 pCi/g natural uranium was used for modeling the dose. The fractions used were 48.9 percent (or pCi/g) U-234, 48.9 percent (or pCi/g) U-238 and 2.2 percent (or pCi/g) U-235. The distribution coefficients that were selected for each radionuclide were RESRAD default values. A sensitivity analysis was performed using a range of distribution coefficients to evaluate potential effects of not using site specific data. All other input parameters were the same as those used in the Ra-226 benchmark modeling. The RESRAD output showing the input parameters is provided in Appendix C-3.

Using a natural uranium concentration in soil of 100 pCi/g, RESRAD determined a maximum dose of 7.5 mrem/yr. at time, t = 0 years. The printout of the RESRAD data summary is provided in Appendix C-4.

To determine the uranium soil standard, the following formula was used:

$$\text{Uranium Limit} = \left(\frac{\text{100 pCi/g natural uranium}}{\text{7.5 mrem/yr. natural uranium dose}} \right) \text{x 39.5 mrem/yr radium benchmark dose}$$

$$\text{Uranium Limit} = \text{526 pCi/g natural uranium}$$

The natural uranium limit is applied to soil cleanup with the Ra-226 limit using the unity rule. To determine whether an area exceeds the cleanup standards, the standards are applied according to the following formula:

$$\left(\frac{\text{Soil Uranium Concentration}}{\text{Soil Uranium Limit}} \right) + \left(\frac{\text{Soil Radium Concentration}}{\text{Soil Radium Limit}} \right) < 1$$

This approach will be used to determine the radiological impact on the environment at Moore Ranch from releases of source and byproduct materials.

6.4.1.3 Uranium Chemical Toxicity Assessment

The chemical toxicity effects from uranium exposure are evaluated by assuming the same exposure scenario as that used for the radiation dose assessment. In the Benchmark Dose assessment for the resident farmer scenario, it was assumed that the diet consisted of 25 percent of the meat, fruits, and vegetables grown at the site. No intake of contaminated food through the aquatic or milk pathways was considered probable. Also, the model showed that the contamination would not affect the groundwater quality. Therefore, the same model will be used in assessing the chemical toxicity. The intake from eating meat was shown to be negligible compared to the plant pathway and therefore is not shown here. This is confirmed by the results of the RESRAD calculations shown in Appendix C-4.

The method and parameters for estimating the human intake of uranium from ingestion are taken from NUREG/CR-5512 Vol. 1[7]. The uptake of uranium in food is a product of the uranium concentration in soil and the soil-to-plant conversion factor. The annual intake in humans is then calculated by multiplying the annual consumption by the uranium concentration in the food. Since the soil-plant conversion factor is based on a dry weight, the annual consumption must be adjusted to a dry-weight basis by multiplying by the dry-weight to wet-weight ratio. Parameters for these calculations are given in Section 6.5.9 of the NUREG/CR-5512. Table 6.4-1 provides the parameters used in these calculation and results for leafy vegetables, other vegetables, and fruit.

Annual intakes of 14 kg/year and 97 kg/year were assumed for leafy vegetables and other vegetables and fruit, respectively. Consistent with Appendix C-3 dose calculations, it was assumed that 25 percent of the food was grown on the site. It was also assumed that the uranium concentration in the garden or orchard was 526 pCi/g. This corresponds to the uranium Benchmark Concentration for surface soils. Using a conversion factor for natural uranium of 1 mg = 677 pCi, then 526 pCi/g is equivalent to 777 mg/kg. The human intake shown in the first column of Table 6.4-1 is equal to the product of the parameters given in the subsequent columns. Table 6.4-1 shows that the total annual uranium intake from all food sources from the site is 51 mg/yr.

The two-compartment model of uranium toxicity in the kidney from oral ingestion was used to predict the burden of uranium in the kidney following chronic uranium ingestion[8]. This model allows for the distribution of the two forms of uranium in the blood, and consists of a kidney with two compartments, as well as several other compartments for uranium distribution, storage and elimination including the skeleton, liver, red blood cells (macrophages) and other soft tissues.

Table 6.4-1: Annual Intake of Uranium from Ingestion

Human Intake (mg/yr)	*Soil Concentration (mg/kg)*	*Soil to Plant Ratio (mg/kg plant to mg/kg soil)*	*Annual Consumption (kg)*	*Dry Weight Wet Weight Ratio*	*Food Source*
9.2	777	1.7E-2	3.5	0.2	Leafy Vegetables
35	777	1.4E-2	13	0.25	Other Vegetables
6.7	777	4.0E-3	12	0.18	Fruit
51					Total

The total burden to the kidney is the sum of the two compartments. The mathematical representation for the kidney burden of uranium at steady state can be derived as follows:

$$Q_P = \frac{IR \times f_1}{\lambda_P \left(1 - f_{ps} - f_{pr} - f_{pl} - f_{pk} - f_{pk1}\right)}$$

Where:

Q_P	=	uranium burden in the plasma, µg
IR	=	dietary consumption rate, mg U/d
f_1	=	fractional transfer of uranium from GI tract to blood, unit less
f_{ps}	=	fractional transfer of uranium from plasma to skeleton, unit less
f_{pr}	=	fractional transfer of uranium from plasma to red blood cells, unit less
f_{pl}	=	fractional transfer of uranium from plasma to liver, unit less
f_{pt}	=	fractional transfer of uranium from plasma to soft tissue, unit less
f_{pk1}	=	fractional transfer of uranium from plasma to kidney, compartment 1, unit less;
λ_p	=	biological retention constant in the plasma, d-1.

The burden in kidney compartment 1 is:

$$Q_{k1} = \lambda_P \times Q_P \times \frac{f_{pk1}}{\lambda_{k1}}$$

Where:

Q_{k1}	=	uranium burden in kidney compartment 1, mg;
λ_{k1}	=	biological retention constant of uranium in kidney compartment 1, d-1.

Similarly, for compartment 2 in the kidney, the burden is:

$$Q_{k2} = \lambda_P \times Q_P \times \frac{f_{pk2}}{\lambda_{k2}}$$

Where:

Q_{k2}	=	uranium burden in kidney compartment 2, µg;
λ_{k2}	=	biological retention constant of uranium in kidney compartment 2, d-1;
f_{pk2}	=	fractional transfer of uranium from plasma to kidney compartment 2, unit less.

The total burden to the kidney is then the sum of the two compartments is:

$$Q_{k1}+Q_{k2}=\frac{IR\times f_1}{\left(1-f_{ps}-f_{pr}-f_{pl}-f_{pt}-f_{pk1}\right)}\times\left(\frac{f_{pk1}}{\lambda_{k1}}+\frac{f_{pk2}}{\lambda_{k2}}\right)$$

The parameter input values for the two-compartment kidney model include the daily intake of uranium estimated for residents at this site, and the ICRP 69 values recommended by the ICRP as listed below. The daily uranium intake rate was estimated to be 0.14 mg/day (51 mg/year) from ingestion while residing at this site.

IR	=	0.14 mg/day
f_1	=	0.02
f_{ps}	=	0.105
f_{pr}	=	0.007
f_{pl}	=	0.0105
f_{pt}	=	0.347
f_{pk1}	=	0.00035
f_{pk2}	=	0.084
λ_{k1}	=	ln(2)/5 yrs
λ_{k2}	=	ln(2)/7 days

where ln(2) = 0.693…

Given a daily uranium intake of 0.14 mg/day at this site and the above equation, the calculated uranium in the kidneys is 0.0093 mg U, or a concentration of 0.03 µg U/g kidney. This is three percent of the 1.0 µg U/g value that has generally been understood to protect the kidney from the toxic effects of uranium. Some researchers have suggested that mild effects may be observable at levels as low as 0.1 µg U/g of kidney tissue. Using 0.1 µg U/g as a criterion, then the intake is thirty percent of the level where mild effects may be observable.

The EPA evaluated the chemical toxicity data and found that mild proteinuria has been observed at drinking water levels between 20 and 100 μg/liter. Assuming water intake of 2 liters/day, this corresponds to an intake of 0.04 to 0.2 mg/day. Using animal data and a conservative factor of 100, the EPA arrived at a 30 μg/liter limit for use as a National Primary Drinking Water Standard (Federal Register/Vol.65, No.236/ December 7, 2000). This is equivalent to an intake of 0.06 mg/day for the average individual. Naturally, since large diverse populations are potentially exposed to drinking water sources regulated using these standards, the EPA is very conservative in developing limits.

This analysis indicates that a soil limit of 526 pCi/g of natural uranium would result in an intake of approximately 0.14 mg/day. Using the most conservative daily limit corresponding to the National Primary Drinking Water standard, a soil limit of 225 pCi/g corresponds to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day. Therefore exposure to soils containing 225 pCi/g of natural uranium should not result in chemical toxicity effects. Since the roots of a fruit tree would penetrate to a considerable depth, limiting subsurface uranium concentrations to 225 pCi/g will be considered appropriate as well.

ALARA considerations require that an effort be made to reduce contaminants to as low as reasonably achievable levels. The ALARA goals are normally based on a cost-benefit analysis. For the cleanup of gamma-emitting radionuclides, the cost of cleanup becomes excessively high as soil concentrations and/or gamma emission rates become indistinguishable from background.

Cleanup of uranium mill sites has demonstrated that conservatively derived gamma action levels along with appropriate field survey and sampling procedures result in near background radium-226 concentrations for the site. In addition, the presence of a mixture of radium-226 and uranium will tend to drive the cleanup to even lower radium-226 concentrations. It is therefore believed that no specific ALARA goal is required for surface radium-226.

EMC proposes an ALARA goal of limiting the natural uranium concentration in the top 15 cm soil layer to 150 pCi/g, averaged over 100 m^2. The uranium concentration should be limited to 225 pCi/g for all soil depths because of chemical toxicity concerns (Table 2.4-2).

Table 6.4-2
Soil Cleanup Criteria and Goals

	Radium-226 (pCi/gm)		Natural Uranium (pCi/gm)	
Layer Depth	*Limit*	*Goal*	*Limit*	*Goal*
Surface (0-15 cm)	5	5	225	150
Subsurface (15 cm layers)	15	15	225	225

6.4.2 Excavation Control Monitoring

EMC will use hand-held and GPS-based gamma surveys to guide soil remediation efforts. Field personnel will monitor excavations with hand-held detection systems to guide the removal of contaminated material to the point where there is high probability that an area meets the cleanup criteria. Support will be provided by GPS-based gamma surveys periodically to more accurately assess the progress of excavation.

6.4.3 Surface Soil Cleanup Verification and Sampling Plan

Cleanup of surface soils will be restricted to a few areas where there are known spills and, potentially, small spills near wellheads. Final GPS-based gamma surveys will be conducted in potentially contaminated areas. Areas will be divided into 100 m^2 grid blocks. Soil samples will be obtained from grid blocks with gamma count rates exceeding the gamma action level. The samples will be five-point composites and will be analyzed at an offsite laboratory for radium-226 and natural uranium.

6.4.4 Quality Assurance

Verification soil samples will be sent to a commercial laboratory for analysis of radium-226 and natural uranium. The commercial laboratory will be required to have a well-defined quality assurance program that addresses the laboratory's organization and management, personal qualifications, physical facilities, equipment and instrumentation, reference materials, measurement traceability and calibration, analytical method validation, standard operating procedures (SOPs), sample receipt, handing, storage, records, and appropriate licenses. EMC will maintain a laboratory QA file that will include, at a minimum, the laboratory's Quality Assurance Manual (QAM) and audit reports.

6.5 DECOMMISSIONING HEALTH PHYSICS AND RADIATION SAFETY

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels will be kept as low as reasonably achievable during decommissioning. The Radiation Safety Officer, Radiation Safety Technician or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in Section 5 will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of Regulatory Guide 8.30[9] or other applicable standards at the time.

6.5.1 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC. Records of all contaminated materials transported to a licensed disposal site will be maintained for a period of five years or as otherwise required by applicable regulations at the time of decommissioning.

6.6 FINANCIAL ASSURANCE

EMC will maintain surety instruments to cover the costs of reclamation including the costs of groundwater restoration, the decommissioning, dismantling and disposal of all buildings and other facilities, and the reclamation and revegetation of affected areas. Additionally, in accordance with NRC and WDEQ requirements, an updated Annual Surety Estimate Revision will be submitted to the NRC and WDEQ each year to adjust the surety instrument amount to reflect existing operations and those planned for construction or operation in the following year. After review and approval of the Annual Surety Estimate Revision by the NRC and WDEQ, EMC will revise the surety instrument to reflect the revised amount.

Groundwater restoration costs are based on treatment of 1 pore volume for groundwater sweep and 5 pore volumes for reverse osmosis and reductant/bioremediation. Wellfield pore volumes are determined using the following equation:

Wellfield Pore Volume = (Affected Ore Zone Area) x (Average Completed Thickness) x (Flare Factor) x (Porosity)

Flare factor has been determined for PRI's Smith Ranch wellfields to be approximately 1.5 to 1.7. This flare factor was estimated using a three dimensional groundwater flow model (MODFLOW) in conjunction with an advective particle tracking technique (MODPATH). Horizontal and vertical flare factors of 1.5 and 1.3, respectively, have been approved by the US Nuclear Regulatory Commission for the Hydro Resources, Inc. Churchrock licensing action in New Mexico. COGEMA Mining, Inc., at the Irigaray/Christensen Ranch sites, uses an overall flare factor of 1.44. Accordingly, EMC is using a flare factor of 1.5 for the surety estimate attached in Appendix D.

6.7 REFERENCES

[1] COGEMA Mining, Inc., *Wellfield Restoration Report, Irigaray Mine*, June 2004.

[2] U.S. Nuclear Regulatory Commission, *Review of Power Resources, Inc.'s A-Wellfield Ground Water Restoration Report for the Smith Ranch-Highland Uranium Project*, June 29, 2004.

[3] U.S. Nuclear Regulatory Commission, *Technical Evaluation Report, Review of Cogema Mining, Inc.'s Irigaray Mine Restoration Report, Production Units 1 through 9, Source Materials License SUA-1341*, September 2006.

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

[5] Argonne National Laboratory, C. Yu, A. J. Zielen, J.-J. Cheng, D. J. LePoire, E. Gnanapragasam, S. Kamboj, J. Arnish, A. Wallo III, W. A. Williams, and H. Peterson. *User's Manual for RESRAD Version 6.* 2001.

[6] Argonne National Laboratory, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil*, 1993.

[7] U.S. Nuclear Regulatory Commission, NUREG/CRR-5512 (PNL-7994) Vol. 1, *Residual Radioactive Contamination from Decommissioning*, 1992.

[8] International Commission on Radiation Protection (ICRP), ICRP Publication 69. *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 3 Ingestion Dose Coefficients*. 1995.

[9] U.S. Nuclear Regulatory Commission, Regulatory Guide No. 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, May 2002.

7 ENVIRONMENTAL EFFECTS

This section discusses and describes the degree of unavoidable environmental impacts that are associated with construction and operations of the Moore Ranch Project. Environmental impacts can be direct, indirect, and/or cumulative in nature and can be temporary (short term) or permanent (long term).

7.1 ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND CONSTRUCTION

The site preparation and construction associated with the Moore Ranch Project will include the following activities:

- Construction of the central plant, office and maintenance facilities.
- Construction of deep injection well(s) and associated building(s).
- Grading and construction of access roads, as required.

Site preparation and construction activities will include topsoil salvaging, site clearing and leveling, building erection, and access road construction. The impacts from wellfield construction activities including the construction of injection, production, and monitor wells are discussed in section 7.2 since these are ongoing activities at an ISR facility. This section strictly discusses the short term impacts of initial site preparation and plant construction where they differ from the impacts of operations.

Environmental impacts of construction projected for the Moore Ranch Project are based on the studies of the existing environment conducted by EMC and discussed in Section 2. The total area impacted by initial construction activities is approximately 11 acres. All areas disturbed will be reclaimed during final decommissioning activities as described in Section 6. The planned schedule for construction, production, restoration, and decommissioning was presented in Section 1.

7.1.1 Air Quality Effects of Construction

Construction activities at the Moore Ranch Project will cause minimal short term effects on local air quality. Increased suspended particulates from vehicular traffic on unpaved roads, fugitive dust caused by wind erosion of areas cleared of vegetation, and diesel emissions from construction equipment would be the primary air quality impacts. The application of water to unpaved roads would reduce the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from construction equipment are expected to be short term only, ceasing once the operational phase begins.

7.1.2 Land Use Impacts of Construction

As discussed in Section 2.2, rangeland is the primary land use within the Moore Ranch License Area and the surrounding 2.0-mile review area. Oil and gas production facilities and infrastructure are also located on rangeland throughout the review area. The review area also contains pastureland to the west. Based on a site reconnaissance conducted in May 2007 and a 2006 aerial photo, there are no occupied housing units in the License Area. Figure 2.2-1 depicts land use in the review area.

Construction of the Moore Ranch Central Plant and associated structures will encompass approximately 11 acres. As a result of site preparation and construction, use of the land as rangeland will be excluded from the area that is under development. Oil and gas production facilities will not be affected. Considering the relatively small size of the area impacted by construction, the exclusion of grazing from this area over the course of the Moore Ranch project will have an insignificant impact on local livestock production.

7.1.3 Surface Water Impacts of Construction

7.1.3.1 Surface Water Impacts from Sedimentation

Construction activities for the Central Plant have the potential to increase the sediment yield of the disturbed areas. The impacted area during construction of the Central Plant is relatively small in comparison to the overall area that will be impacted during wellfield construction. Therefore, surface water impacts from sedimentation are discussed in Section 7.2.6.2.

7.1.4 Population, Social, and Economic Impacts of Construction

The construction phase of the Moore Ranch Project will cause a moderate impact to the local economy resulting from the purchases of goods and services directly related to construction activities. Impacts to community services in rural Campbell County or the nearby towns of Midwest and Edgerton in Natrona County, and Wright in Campbell County, such as roads, housing, schools, and energy costs will be minor or non-existent and temporary.

An estimated 50 percent (25 workers) of the construction work force would be based in Campbell County, which contains the Project site. The workforce hired outside of the County would likely be based in Casper, located in the neighboring Natrona County, as Casper is a regional economic hub that provides a variety of construction services and labor for projects located throughout Wyoming.

Most construction work available to the local construction labor pool consists of temporary contract work that varies in duration, depending on the scope of each construction project. Further, the number of unemployed construction workers does not represent the number of workers that would be available to the proposed project from the local construction labor pool. The number is an annual average that does not take into account monthly variations in the available construction labor pool from construction start-ups and completions. Contractors for projects located throughout northeastern Wyoming typically hire the local construction labor pool. The actual number of construction workers available for the proposed project would potentially draw from the entire construction labor pool of 6,268 (2005 estimate; the construction labor pool as of 2007 is likely to be larger), as construction activities from some active projects would conclude so that workers would be available for future projects.

7.1.5 Noise Impacts of Construction

There are no occupied housing units in the vicinity of the proposed Moore Ranch Project. Open rangeland is the primary land use within and in the surrounding 2.0-mile area. Other land uses include oil and gas and coal bed methane production facilities, as well as pastureland located to the west of the Project area. As a result of the remote location of the Project and the low population density of the surrounding area, impact to noise or congestion within the Project area or in the surrounding 2.0-mile area are not anticipated. Additionally, given the maximum increase in population due to migrant workers is insignificant, noise and congestion impacts are not anticipated in Campbell or other neighboring counties.

7.2 ENVIRONMENTAL EFFECTS OF OPERATIONS

This section describes the environmental impacts of operation of the Moore Ranch Project. Operational activities will include the following:

- Ongoing wellfield construction activities including well drilling and construction, access road construction, installation of pipelines and utilities, and construction of headerhouses;
- Plant and wellfield production operations;
- Groundwater restoration activities as wellfields are removed from production; and

- Final site reclamation activities.

Potential environmental concerns from the operation of the Moore Ranch Project addressed in the following sections are air quality impacts, land use and water quality impacts, soil impacts, impacts to cultural resources, ecological impacts, and cumulative impacts from existing coal bed methane (CBM) development within the proposed License Area.

7.2.1 Air Quality Impacts of Operations

EMC estimated fugitive dust emissions from operation of the Moore Ranch Project based on projected activity levels and emission factors supplied by the WDEQ. Projected activities impacting dust emissions included ongoing wellfield construction activities, routine site traffic related to operations and maintenance, heavy truck traffic delivering chemicals and material and shipping product, and employee traffic to and from the site. Based on these activities, the projected total PM_{10} emissions is 15.5 tons per year. This level of emissions is small relative to surface mines and other industrial operations that generate dust from vehicles and disturbed areas. The larger surface mines in the Powder River Basin show PM_{10} emissions inventories in the thousands of tons per year. Sections of unpaved county roads can also exceed this 15 tons per year emission rate by an order of magnitude or more. Viewed another way, atmospheric dispersion modeling generally shows that fugitive PM_{10} emissions on the order of 15 tons per year result in insignificant impacts to ambient air beyond a distance of a few hundred yards from the sources. Significant impact for PM_{10} is defined as 1.0 μg/m3 or more. For reference purposes, the national ambient standard for annual average PM_{10} is 50 μg/m3.

It is important to note that no control factors were assumed for the emission calculations. Periodic watering or chemical treatment of the unpaved roads will reduce emission factors by half or more.

7.2.2 Land Use Impacts of Operations

As discussed in Section 2.2 and 7.1.2, rangeland is the primary land use within the Moore Ranch License Area and within the surrounding 2.0-mile area. Oil and gas production facilities and infrastructure are also located on rangeland throughout the review area. Operation of the Moore Ranch Project will ultimately encompass approximately 150 acres. As with site preparation and construction, use of the land as rangeland will be excluded from this area during the life of the project. Oil and gas production facilities will not be affected. Considering the relatively small size of the area impacted by operations, the exclusion of grazing from this area over the course of the Moore Ranch project will have an insignificant impact on local livestock production.

7.2.3 Geologic and Soil Impacts of Operations

7.2.3.1 Geologic Impacts of Operations

Geological impacts from operations are expected to be minimal, if any. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the target sandstone will be on the order of 1 percent or less. Further, once mining and restoration operations are completed, groundwater levels will return to near original conditions under a natural gradient.

7.2.3.2 Soil Impacts of Operations

Based on the soil mapping unit descriptions in Section 2.6, the hazard for water erosion within the Moore Ranch Project varies from slight to severe and the hazard from wind erosion varies from moderate to severe. The potential for wind and water erosion is mainly a factor of surface characteristics of the soil, including texture and organic matter content. Given the fine-loamy and sandy texture of the surface horizons throughout the majority of the Moore Ranch Project and the semi-arid climate, the soils are more susceptible to erosion from wind than water. See Table 2.6-7 in Section 2.6 for a summary of wind and water erosion hazards within the Moore Ranch Project.

The 11 acre fenced controlled area is underlain by soils with a slight potential for water erosion and a severe potential for wind erosion. The soils underlying the proposed wellfields are at a moderate to severe risk of erosion from both wind and water. Though no topsoil will be stripped from the wellfields, construction may result in an increase in the erosion hazard from both wind and water due to the removal of vegetation and the physical disturbance from heavy equipment.

Soil erosion mitigation will be implemented in accordance with WDEQ-LQD Rules and Regulations, Chapter 3, Environmental Protection Performance Standards. Typical erosion protection measures that may be implemented at the Moore Ranch Project include the following:

- Temporary diversion of surface runoff from undisturbed areas around the disturbed areas and the use of water velocity dissipation structures;
- Retaining sediment within the disturbed areas through the use of best management practices such as silt fencing, retention ponds, or other effective means;
- Salvage and stockpiling of topsoil from the central plant facility area and from secondary wellfield access roads in a manner to avoid wind and/or water erosion.

7.2.4 Archeological Resources Impacts of Operations

As discussed in Section 2.4, the Class II Inventory investigations found seven sites, 48CA6691-48CA6697, and 25 Isolate Resources/Artifacts, including artifacts from the Paleo-Indian, Middle Archaic, Late Archaic and Historic periods. Two sites, 48CA6694 and 48CA6696, are considered eligible for nomination to the National Register of Historic Places (NRHP). All sites and artifacts are described in detail in the Class III Inventory Report in Appendix A. Six previously recorded sites were also revisited during this investigation. None of the previously recorded sites have been affected by CBM development or exploratory drilling activities associated with uranium development. Only two sites, 48CA965 and 48CA966, which are listed as not eligible for nomination to the NRHP, are at or near any current development areas (near the monitor well ring). No sites are located within planned wellfield areas (see report in Appendix A).

None of the sites eligible for nomination are located within areas currently planned for in situ development, and in fact, are located well over a mile away from any planned development. If exploration and development plans are subsequently expanded near those areas, then all associated ground-disturbing activities will avoid impacting sites 48CA6694 and 48CA6696. If avoidance is not feasible, then a testing/data recovery plan will need to be implemented and completed prior to commencement of any ground disturbing activities to mitigate the adverse affects to the eligible sites.

As concluded in the Class III Inventory Report in Appendix A, the currently proposed Moore Ranch Project will not affect any known significant cultural resources and additional archaeological work is not considered necessary.

7.2.4.1 Visual and Scenic Impacts

The visible surface structures proposed for the Moore Ranch Project include wellhead covers, wellhouses, electrical distribution lines, and the central plant facility. The project will use existing and new roads to access each wellhouse and the central plant.

Each wellhead cover typically consists of a weatherproof structure placed over the well. These covers are approximately 3 feet high and 2 feet in diameter. Each wellhouse is a small metal building. The central plant building will be approximately 400 feet by 100 feet in size for the initial phase. In addition, maintenance, warehouse, and office structures are planned. A disturbance area around each wellhouse is necessary to provide an adequate area for operations and maintenance vehicles to turn around. Electric distribution lines would connect wellhouses to existing electric distribution lines. The distribution poles are approximately 20 feet high and are wooden so that their natural color harmonizes with the landscape.

Temporary and short-term visual effects during the construction period in each wellfield would result from wellhouse construction, well drilling, and construction of access roads and electric distribution lines. Following completion of wellfield installation, temporarily disturbed areas will be reclaimed. Only long-term effects associated with operations and maintenance will remain following post-construction reclamation.

Long-term effects will result from the addition of structures to the landscape, such as the central plant and associated structures, wellhouses, wellhead covers, access roads, and electric distribution lines. Effects from long-term activities will occur over the life of the project.

Project development is planned for an area where extensive CBM development has already occurred and where additional development is planned. CBM installations are similar in visual impact to those associated with ISR uranium mining. CBM wells are installed in a network of approximately eight wells per square mile. These wells are connected by underground pipelines to collection and pumping structures that appear similar to ISR wellhouses. Overhead power lines are installed to each well.

As noted in Section 2.4, the total score of the scenic quality inventory for the Moore Ranch License Area is 4. According to NUREG-1569, if the visual resource evaluation rating is 19 or less, no further evaluation is required. Therefore, no further evaluation of changes to scenic resources from the proposed Moore Ranch Project is required.

Despite the existing visual impacts from CBM development and the low scenic quality rating for the proposed project site, EMC intends to implement measures to lessen the visual impact from the project. Mitigation measures are meant to minimize adverse contrasts of project facilities with the existing landscape. One method to minimize these contrasts is the selection of paint colors for structures that harmonize with the surrounding landscape. To the extent possible, topographic features may be used to screen wellheads, plant facilities, and roads. Roads may be aligned with the contours of the topography, although this measure may result in a greater area of disturbance. Construction debris will be removed from new construction areas as soon as possible.

7.2.5 Groundwater Impacts of Operations

The potential groundwater impacts of ISR mining are related to the consumption of groundwater and short-and long-term changes to groundwater quality. Perhaps the most significant environmental impact that can occur as a result of ISR mining is the degradation of water quality in the ore-bearing aquifer.

7.2.5.1 Groundwater Consumption

Based on a bleed of 0.5% to 1.5% which has been successfully applied at other ISR operations, the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 99%) of groundwater used in the mining process will be treated and re-injected. Potential impacts on groundwater due to consumptive use outside the proposed License Area are expected to be negligible.

To generally quantify the potential impact of drawdown due to mining and restoration operations, the following assumptions were used:

Mining/restoration and plant life:	12.5 years
Average net consumptive use:	105 gpm
Location of pumping centroid:	NE ¼ of Section 34
Observation radius:	Variable based on water use
	5,000 feet (nearest stock well)
	6,500 feet (nearest permit boundary)
	16,000 feet (nearest water supply well)
Formation transmissivity	586 ft^2/d (preliminary pump test results)
Formation thickness	80 feet
Formation hydraulic conductivity	7.3 ft/d
Formation storativity	4.0 x 10^{-3} (pump test results)

The data were used to predict drawdown over time with a Theis semi-steady state analytical solution, which includes the following assumptions:

- The aquifer is confined and has apparent infinite extent;

- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping;
- The piezometric surface is horizontal prior to pumping;
- The well is pumped at a constant rate;
- No recharge to the aquifer occurs;
- The pumping well is fully penetrating; and,
- Well diameter is small, so well storage is negligible.

Based on these assumptions and results from the Moore Ranch Pump Test, drawdown after 12.5 years of operation at various distances from the centroid of pumping (e.g., the center of the NE ¼ of Section 34) were estimated to be 11.3, 9.8 and 5.1 feet, respectively. This amount of drawdown is approximately 10 to 15 percent of the available drawdown (approximately 70 feet, depending on location) in the 70 Sand.

As shown in Figure 2.2-3 few water wells are present in the vicinity of Moore Ranch. There is little use of shallow ground water in the immediate vicinity of Moore Ranch. The closest industrial well is approximately 2,900 feet from the centroid of pumping (NE ¼ of Section 34). The closest stock well is approximately 5,000 feet from the centroid of pumping; the closest domestic well is approximately 16,000 feet. The limited drawdown that likely will be induced from mining, groundwater restoration and plant operations will have little if any impact on local water users.

To assess the impacts from mining and restoration operations on local groundwater, the following monitoring will be performed:

- Measure background water levels in the private domestic or livestock water wells surrounding the project area before mining and every three months during operations; and,
- Measure background water levels in regional monitoring wells installed by EMC before mining and every three months during operations

It is likely that the wells surrounding the Moore Ranch License Area may provide stock water for private or public (BLM) leases. If significant impacts to those wells are observed (e.g., water levels drop to a point that impairs the usefulness of the wells), the following mitigation measures would be considered:

- Lowering the pump level in the wells, if possible;
- Deepening the wells, if possible; or,
- Replacing the wells with new wells completed in deeper sands that are not impacted by ISR operations.

7.2.5.2 Impacts on Ore Zone Groundwater Quality

During ISR mining operations, water quality impacts are usually of greater concern than water consumption impacts because water consumption during mining is relatively small. Contamination of groundwater from the proposed lixiviant is caused by (1) the addition of sodium bicarbonate and oxygen to the groundwater, (2) the addition of chloride to the groundwater by the processing plant, and (3) the interaction of these chemicals with the mineral and chemical constituents of the aquifer being mined. The result is that during mining, the concentration of most of the naturally occurring dissolved constituents will be appreciably higher than their concentrations in the original groundwater.

EMC has estimated the post-mining water quality based on the experience of Cogema Mining, Inc. in Production Units 1 through 9 at the Irigaray ISR project located in the Powder River Basin near the proposed Moore Ranch Project[1]. The Irigaray data was selected because of the proximity and similar geologic conditions to Moore Ranch. Cogema employed ammonium bicarbonate with hydrogen peroxide as the oxidant during early mining operations. In May 1980, the lixiviant system for the entire site was converted to sodium bicarbonate chemistry with gaseous oxygen as the oxidant. The water quality database is extensive because it represents nine production units located in a 30 acre site.

The water quality of the Irigaray ore zone after mining was established by sampling each of the designated restoration wells. The post-mining mean of the analytical results from Production Units 1 through 9 is presented in Table 7.2-1. The chemical alteration of the ore zone aquifer can be observed through comparison of the post-mining mean concentrations with the baseline concentrations. Thirty-five of the thirty-six parameter concentrations in the post-mining means exceeded the baseline means. Twenty-two of these parameters did not meet Restoration Target Values (of the twenty-nine with established RTVs).

Table 7.2-1 Irigaray Post-Mining Water Quality

Parameter (units)	Irigaray Baseline Range	Irigaray Post-Mining Mean
Dissolved Aluminum (mg/l)	<0.05 – 4.25	<1.037
Ammonia Nitrogen as N (mg/l)*	<0.05 – 1.88	23
Dissolved Arsenic (mg/l)	<0.001 – 0.105	<0.601
Dissolved Barium (mg/l)	<0.01 – 0.12	<1.067
Boron (mg/l)	<0.01 – 0.225	<0.442
Dissolved Cadmium (mg/l)	<0.002 – 0.013	<0.979
Dissolved Chloride (mg/l)*	5.3 – 15.1	277
Dissolved Chromium (mg/l)	<0.002 – 0.063	<1.018
Dissolved Copper (mg/l)	<0.002 – 0.04	<0.828
Fluoride (mg/l)	0.11 – 0.66	<1
Total and Dissolved Iron (mg/l)	0.02 – 11.8	<1.098
Dissolved Mercury (mg/l)	<0.0002 - <0.001	<0.971
Dissolved Magnesium (mg/l)	0.02 – 9.0	45.7
Total Manganese (mg/l)	<0.005 – 0.190	1.249
Dissolved Molybdenum (mg/l)	<0.02 - <0.1	<1.067
Dissolved Nickel (mg/l)	<0.01 - <0.2	<1.018
Nitrate + Nitrite as N (mg/l)	<0.2 – 1.0	<3
Dissolved Lead (mg/l)	<0.002 - <0.050	<1.018
Radium-226 (pCi/L)	0 – 247.7	200.5
Dissolved Selenium (mg/l)	<0.001 – 0.416	0.247
Dissolved Sodium (mg/l)	95 - 280	827
Sulfate (mg/l)	136 - 824	639
Uranium (mg/l)	<0.0003 – 18.8	7.411
Vanadium (mg/l)	<0.05 – 0.55	<1.067
Dissolved Zinc (mg/l)	<0.01 – 0.200	<0.065
Dissolved Calcium (mg/l)*	1.6 – 33.5	199.2
Bicarbonate (mg/l)*	5 - 144	1343
Carbonate (mg/l)	0 - 96	<2
Dissolved Potassium (mg/l)	0.4 – 17.5	9
Total Dissolved Solids (TDS) @ 180°F (mg/l)	308 - 1054	2451

* Parameters with RTV other than baseline

In general, these post-mining concentrations are within the range of those projected by NRC for ISR operations at the Crownpoint Uranium Project[2]. EMC expects similar baseline and post-mining water quality at the Moore Ranch site.

7.2.5.3 Potential Groundwater Quality Impacts from Accidents

7.2.5.3.1 Lixiviant Excursions

Water quality impacts in adjacent aquifers from ISR mining activities are related to the identification, control, and clean-up of excursions. During production, injection of the lixiviant into the wellfield results in a temporary degradation of water quality compared to pre-mining conditions. Movement of this water out of the wellfield results in an excursion. Excursions of contaminated groundwater in a wellfield can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone, poor well integrity, or hydrofracturing of the ore zone or surrounding units. Past experience from other commercial scale in-situ recovery projects in the Powder River Basin has shown that when proper steps are taken in monitoring and operating a wellfield, excursions, if they do occur, can be controlled and recovered and that serious impacts on the groundwater are prevented.

Excursions of lixiviant at ISR facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the mining zone of the ore-body aquifer. A vertical excursion is a movement of solutions into overlying or underlying aquifers.

The historical experience at other ISR uranium operations indicates that the selected excursion indicator parameters and UCLs allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected.

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers.

The State of Wyoming and the NRC require restoration of affected groundwater in the mining zone following production activities. EMC will be required to return the groundwater in the mining zone to baseline water quality conditions as a primary goal or to class of use standards. The mining aquifer must be exempted by the WDEQ and the EPA from protection under the Safe Drinking Water Act (SDWA) before mining can occur. One of the criteria for exemption is that the water is not currently used as an underground source of drinking water (USDW) and will not be used as a USDW in the future. By restoring the exempted aquifer, EMC ensures that adjacent, non-exempted aquifers will not be affected in the future.

Successful groundwater restoration has been demonstrated using the same methods proposed by EMC as discussed in Section 6. Therefore, long term impacts on groundwater quality are expected to be minimal.

7.2.5.4 Potential Groundwater Impacts from Spills

Potential impacts to groundwater and surface water may occur during operations as a result of an uncontrolled release of process liquids due to a wellfield leak. Should an uncontrolled wellfield release occur, there would be a potential for contamination of the shallow aquifer as well as surrounding soil. With a slow leak that remains undiscovered or a catastrophic failure, a shallow excursion is one potential impact.

The potential environmental impacts from spills and mitigative measures are discussed in further detail in Section 7.5.

7.2.6 Surface Water Impacts of Operations

7.2.6.1 Surface Waters and Wetlands

EMC plans to construct three wellfields and a central plant facility for the Moore Ranch Project. No wetlands will be impacted due to the construction of the central plant facility and the two western wellfield sites (Wellfields #1 and #3). Wetlands or surface water channels may be impacted in the easternmost wellfield site (Wellfield #2), which is located in Section 35. The second tributary to Simmons Draw runs north to south in the northern half of the eastern wellfield site. The section of the tributary is between waypoint 70 (a CBM outfall location) and W37. There is a small POW stock pond (0.02 acres) at W36. The tributary in the eastern wellfield area is considered PUB on the drainage bottom and is approximately 1.66 acres. As previously noted in Section 2.7 wetlands located within the Moore Ranch boundaries are recommended as non-jurisdictional.

No drainages or bodies of water will be significantly modified or altered within the Moore Ranch Project area during project construction or operations. If significant changes or alterations were to occur, the impact to the second tributary to Simmons Draw wetlands would be minimal as the disturbance is short-term and the draw is ephemeral. The potential for erosion is present due to the construction of the wells near the drainage; however, disturbance is short-term and disturbed areas will be reseeded soon after the wellfields are constructed.

7.2.6.2 Surface Water Impacts from Sedimentation

Normal construction activities within the wellfields, process plant, and along the pipeline courses and roads have the potential to increase the sediment yield of the disturbed areas. However, the relative size of these disturbances is small when compared to the size of the overall areas and to the size of the watersheds, and also have a short term impact. Since well field decommissioning and reclamation activities will be on-going throughout the life of the project, the area to be reclaimed at the conclusion of operations will be reduced, although a slight increase in sediment yields and total runoff can still be expected. Since all natural flow within the project boundaries is ephemeral with no intermittent or perennial streams, potential impacts to surface water from construction and decommissioning activities are also limited to uncommon precipitation or runoff events.

The physical presence of the surface facilities including wellfields and associated structures, access roads, office buildings, pipelines, facilities and other structures associated with ISR mining and processing of uranium are not expected to significantly change peak surface water flows because of the relatively flat topography of the drainages at the site, the low regional precipitation, the absorptive capacity of the soils, and the small area of disturbance relative to the large drainage within and adjacent to the proposed License Area. In areas where these structures may affect surface water drainage patterns, diversion ditches and culverts will be used to prevent excessive erosion and control runoff. In areas where runoff is concentrated, energy dissipaters are used to slow the flow of runoff to minimize erosion and sediment loading in the runoff.

Construction and industrial stormwater National Pollutant Discharge Elimination System (NPDES) permits will be obtained in accordance with WDEQ - Water Quality Division regulations. Best management practices will be implemented to reduce erosion impacts according to storm water management plans developed for those permits.

7.2.6.3 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as excessive rainwater or runoff in impacted soil areas or failure or an uncontrolled release of process liquids due to a wellfield leak. Section 7.5 discusses measures to prevent and control wellfield spills. Process buildings and chemical storage areas will be constructed with sumps or secondary containments, and a regular program of inspections and preventive maintenance will be implemented.

7.2.7 Ecological Impacts of Operations

7.2.7.1 Vegetation

Wellfield and production facilities will be constructed within upland grassland vegetation communities. Direct impacts include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types). Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; reduction in livestock forage; and changes in visual aesthetics. An estimated 150 acres of upland grassland would be affected by construction disturbance under current development plans.

Construction activities, increased soil disturbance, and higher traffic volumes could stimulate the introduction and spread of undesirable and invasive, non-native species within the project area. Non-native species invasion and establishment has become an increasingly important result of previous and current disturbance in Wyoming. These species often out-compete desirable species, including special-status species, rendering an area less productive as a source of forage for livestock and wildlife. Additionally, sites dominated by invasive, non-native species often have a different visual character that may negatively contrast with surrounding undisturbed vegetation. The presence of two State-designated weeds, Canada thistle and field bindweed, was observed in the Moore Ranch area during the baseline surveys along with other undesired annual grass species such as cheat grass brome. EMC will conduct weed control as needed to limit the spread of undesirable and invasive, non-native species on disturbed areas.

No threatened or endangered vegetation species were observed within the Moore Ranch Project area; therefore, no impacts are anticipated.

Mitigation of vegetation impacts will consist of temporary and permanent surface revegetation of disturbed areas. Revegetation practices will be conducted in accordance with WDEQ-LQD regulations and the mine permit. Disturbed areas will be seeded to establish a vegetative cover to minimize wind and water erosion and the invasion of undesired plant species. A long term temporary seed mix may be used in wellfield and other areas where the vegetation will be disturbed again prior to final decommissioning and final revegetation. This long term seed mix typically consists of one or more of the native wheat grasses (e.g., Western Wheatgrass and Thickspike Wheatgrass). Permanent seeding is accomplished with a seed mix approved by the WDEQ-LQD. The permanent mix typically contains native wheat grasses, fescues, and clovers. Wellfield areas may be fenced as necessary to prevent livestock access, which will enhance the establishment of temporary vegetation.

7.2.7.2 Wildlife and Fisheries

ISR uranium mining differs from conventional surface mining by using less intrusive extraction methods that are more efficient and, thus, have less impact on the surrounding area. In situ operation use a series of injection and production wells that extract the uranium from the ore body without physically removing the ore or overburden from the ground. The mine area consists of a series of wells within a systematic pattern with a single processing facility to remove the uranium from the lixiviant.

ISR uranium mining can have direct and indirect impacts on local wildlife populations. These impacts are both short-term (lasting until successful reclamation is achieved) and long-term (persisting beyond successful completion of reclamation). However, long term impacts are not expected to be substantial due to the relatively limited habitat disturbance associated with this mining method. The direct impacts of ISR mining on wildlife include injuries and mortalities caused by collisions with project-related traffic or habitat removal actions such as topsoil stripping, particularly for smaller species with limited mobility such as some rodents and herptiles, and restrictions on wildlife movement due to construction of fences. The likelihood for the impacts resulting in injury or mortality is greatest during the construction phase due to increased levels of traffic and physical disturbance during that period. Traffic will persist during production, but should occur at a reduced, and possibly more predictable level. Speed limits will be enforced during all construction and maintenance operations to reduce impacts to wildlife throughout the year, but particularly during the breeding season.

Because ISR mining has a much smaller impact footprint than conventional surface mining, topsoil stripping and habitat destruction are restricted to relatively small areas needed for the processing facility and access roads. Surface disturbance associated with the Moore Ranch Project is expected to consist of a 236-acre well field, an 11-acre central plant facility, approximately 1.0 mile of new access road, and a permanent working staff of approximately 60 individuals. Total surface disturbance from this new infrastructure would be approximately 150 non-contiguous acres. As indicated, most of that habitat disturbance will consist of scattered, confined drill sites for wells that will not result in large expanses of habitat being dramatically transformed from its original character as in other surface mining operations. Therefore, most indirect impacts would relate to the displacement of wildlife due to increased noise, traffic, or other disturbances associated with the development and operation of the Moore Ranch Project, as well as from small reductions in existing or potential cover and forage due to habitat alteration, fragmentation, or loss. Indirect impacts typically persist longer than direct impacts. However, the nature of ISR mining decreases the occurrence of large-scale habitat alterations and, thus, the need for reclamation efforts that can result in dramatic differences between pre-construction and post-construction vegetative communities.

Repeated surveys over multiple, consecutive years in the project area have documented that three wildlife species of particular concern do not occur in the Moore Ranch Project area: the bald eagle, greater sage-grouse (Centrocercus urophasianus), and mountain plover. Suitable habitat for all three species (trees, sagebrush, and sparse, low-growth vegetation, respectively) is extremely limited, further minimizing the potential for both direct and indirect impacts for those species, and others that require similar habitats. Other wildlife species of concern, such as ferruginous hawks (Buteo regalis), that do occur in the area may experience indirect impacts from increased travel and noise in the area during project construction and operation. However, the combination of documented nesting despite existing CBM facilities, the presence of potential alternate nesting and foraging habitat in the immediate vicinity, and the mobility of this species reduces impacts to ferruginous hawks and other such species.

Some vegetative communities currently present in the project area can be difficult to reestablish through artificial plantings, and natural seeding of those species would likely take many years. Consequently, wildlife species associated with specific habitats such as blue grama (Bouteloua gracilis) grasslands, birdsfoot sagebrush (Artemisia pedatifida), and big sagebrush (Artemisia tridentata) could be reduced in number or replaced by generalist species with broader habitat requirements until natural reseeding of certain vegetation occurs or reclamation matures to its target mix. Again, because the proposed Moore Ranch Project area is dominated by mid-grass species, the species using these three habitat types do not occur in the project area, and because the actual surface disturbance will be relatively limited (approximately 150 non-contiguous acres), negative impacts to these wildlife species are expected to be minimal.

7.2.7.3 Medium-Sized and Small Mammals

Medium-sized mammals (such as lagomorphs, coyotes, and foxes) may be temporarily displaced to other habitats during the initial uranium mining activities. Direct losses of some small mammal species (e.g., voles, ground squirrels, mice) may be higher than for other wildlife due to their more limited mobility and likelihood that they would retreat into burrows when disturbed, and thus be impacted by topsoil scraping or staging activities. However, given the limited area expected to be disturbed (approximately 150 non-contiguous acres) by the Moore Ranch Project, such impacts would not be expected to result in major changes or reductions in mammalian populations for small or medium-sized animals. The species known to be, or potentially, present in the project area have shown an ability to adapt to human disturbance in varying degrees, as evidenced by their presence in CBM developments and residential areas of similar, or greater, disturbance. Additionally, small mammal species in the area have a high reproductive potential and tend to re-occupy and adapt to altered and/or reclaimed areas quickly.

7.2.7.4 Big Game Mammals

Beginning in 2000, the Wyoming Game and Fish Department (WGFD) and WDEQ/LQD no longer required surface mining operations in Wyoming to conduct surveys for big game.

Under the proposed action, big game could be displaced from portions of the Moore Ranch Project to adjacent areas, particularly during construction of the wellfield and facilities, when disturbance activities would be greatest. Disturbance levels would decrease during actual production and restoration operations and would consist primarily of vehicular traffic on improved and unimproved (two-track) roads throughout the project area. Similar disturbance is already present in the area due to existing CBM operations. Pronghorn would be most affected, as they are more prevalent in the area. However, no areas classified as crucial pronghorn habitat occur on or within several miles of the Moore Ranch Project area and this species is not as common in the general analysis area as elsewhere within the region due to the limited presence of sagebrush in the area. Mule deer would not be substantially impacted given their infrequent use of these lands, the paucity of winter forage and security cover, and the availability of suitable habitat in adjacent areas. The WGFD does not consider the general area to be within the "use range" of any other big game species. Sightings of those species in that vicinity are rare, if they occur at all.

7.2.7.5 Upland Game Birds

ISR uranium mining in the Moore Ranch Project area would affect approximately 150 non-contiguous acres of potential foraging and nesting habitat for mourning doves, though such disturbance is not expected to have any marked impacts on doves. While woody corridors are not abundant in the general area, they also are not unique to the Moore Ranch Project area. Similar habitat is present immediately south of the area, where mining is not projected to occur in the near future. Additionally, doves are not restricted to treed habitats, nor are they subject to any special mitigation measures for habitat loss.

Annual monitoring studies conducted by private and agency biologists in the Moore Ranch Project area since at least 2003 have repeatedly demonstrated that sage-grouse do not inhabit that locale. As described previously in Section 2.8, those surveys encompassed most of the proposed License Area and its one-mile perimeter through 2006, and the entire area in 2007. The nearest known sage-grouse lek is approximately 3.0 miles northwest of the Moore Ranch Project area (WGFD records obtained from D. Thiele, Regional Biologist, WGFD, Buffalo, WY). Given the lack of sage-grouse observations in the area, and the minimal quantity and marginal quality of potential sage-grouse habitat, implementation of the proposed action is not likely to negatively impact any existing or potential sage-grouse leks, or important sagebrush habitats.

Baseline monitoring studies have repeatedly demonstrated that sage-grouse do not inhabit the license area. As described previously in Section 2.8, those surveys encompassed most of the proposed license area and its one-mile perimeter for much of that period. No sage-grouse leks were observed in that region during any survey year. WGFD records and USDA-FS records also failed to document any sage-grouse leks within the area that encompasses the general analysis area (i.e., proposed Moore Ranch boundary and a one-mile perimeter). Given the lack of sage-grouse observations in the area, and the minimal quantity and marginal quality of potential sage-grouse habitat, EMC does not plan to conduct operational monitoring for sage-grouse at this time.

7.2.7.6 Other Birds

The Moore Ranch Project could impact 14 avian species of concern (8 Level I and 6 Level II) known to occur or potentially present as seasonal or year-round residents. Direct impacts could include injury or mortality due to encounters with vehicles or heavy equipment during construction or maintenance operations. Indirect impacts could include habitat loss or fragmentation and increased noise and activity that may deter use of the area by some species. Surface disturbance would be relatively minimal (total of approximately 150 non-contiguous acres) and would be greatest during construction. Enforced speed limits during all phases of the Moore Ranch Project would reduce impacts to wildlife throughout the year, particularly during the breeding season.

7.2.7.7 Raptors

ISR uranium mining in the Moore Ranch Project area would not impact regional raptor populations, though individual birds or pairs may be affected. Mining activity could cause raptors to abandon nests proximate to disturbance, particularly if mining encroaches on active nests during a given breeding season. The Wyoming Ecological Services Office of the US Fish and Wildlife Service (FWS) recommends a one-mile buffer around all ferruginous hawk nests. Nests of most other raptor species (including all of the others present in the project area) are typically buffered by a one-quarter- or one-half-mile radius. Thirteen intact ferruginous hawk nests were known to be present within the portions of the Moore Ranch Project area monitored during 2007. Eleven were located within the proposed license boundary and two were located within a one-mile radius. Three documented great horned owl nest sites (one-quarter mile buffer or less) are located within the license area. Only one of four intact red-tailed hawk nest sites (one-half mile buffer) occurred within that boundary in 2007. Other potential direct impacts to these species are limited to injury or mortality due to collisions with mine-related vehicular traffic.

Typically, approval from the leading regulatory agency is required before disturbance activities can occur within buffer zones for active raptor nests. All three species represented on the Moore Ranch Project have successfully nested near active surface coal mining and other energy development areas throughout the Powder River Basin for many years as documented in Annual Reports from various coal mines submitted to the WDEQ/LQD. Efforts to maintain viable raptor territories and protect nest productivity have succeeded due to a combination of the raptors becoming acclimated to the gradual encroachment of mine operations and the successful execution of state-of-the-art mitigation techniques.

Construction activities associated with the Moore Ranch Project that occur within or near active raptor territories would temporarily impact the availability of foraging habitat for nesting birds. However, equipment yards associated with mining provide additional habitat for prey species such as cottontails and raptors have been documented voluntarily nesting quite near those areas. As at other surface mines throughout the region, including nearby uranium projects, nesting raptors at the Moore Ranch project have likely been influenced primarily by natural factors such as prey abundance and availability of nesting substrates. Due to the paucity of woody vegetation and river cliffs, raptors that nest in trees or on high cliffs are not as abundant as those that either nest on the ground or are adaptable to nesting on mine facilities or other man-made structures (platform nests, etc.). During active mining, new nesting habitat can be created through enhancement efforts (nest platforms, nest boxes, and tree plantings) to mitigate any negative impacts associated with the project.

Wildlife studies on the Moore Ranch Project will include annual raptor surveys. It is not anticipated that mining related activities will adversely affect a raptor nest, or disturb a nesting raptor as there is a lack of nesting raptors on and near the plant and wellfield areas due to the lack of trees and other nesting sites. Additionally, mining related activities are limited to relatively small areas for limited periods of time. According to surveys summarized in Section 2.8, eight raptor nests were observed within the proposed Moore Ranch License Area including 5 ferruginous hawks, 2 great horned owls, and one red-tailed hawk. Seventy five other nests were observed within one mile of the license area,

In accordance with WDEQ-LQD requirements, a raptor nest survey is conducted in late April or early May each year to identify any new nests and assess whether known nests are being utilized. The survey covers all areas of planned activity for the life of mine (i.e., wellfields and central plant facility) and a one mile area around the activity. Status and production at known nests will be determined, if possible. This survey program is primarily intended to protect against unforeseen conditions such as the construction of a new nest in an area where operations may take place.

No raptor nests were observed within one-half-mile of the proposed central plant facilities in the 2007 survey. As a result, it is very unlikely that any raptor nests will be disturbed in the future. In the very unlikely event that it is necessary to disturb a raptor nest, a mitigation plan and appropriate permit will be acquired from the U.S. Fish and Wildlife Service, Wyoming Field Office, in Cheyenne, Wyoming.

7.2.7.8 Fish and Macroinvertebrates

No aquatic habitat exists on the Moore Ranch Project that will support fish or macroinvertebrates. Therefore, no impacts from construction or operations to fish or macroinvertebrates can occur.

7.2.7.9 Threatened and Endangered Species

7.2.7.9.1 Bald Eagle (Federal Threatened)

ISR mining at the Moore Ranch Project may affect, but is not likely to adversely affect, bald eagles. As bald eagle nests and winter roost sites are absent in the study area, potential hazards for this species would be limited to foraging individuals during winter.

Direct impacts to bald eagles would include the potential for injury or mortality to individual birds foraging in the project area due to collisions with mine-related equipment during construction or operation of the Moore Ranch Project. The increased human presence and noise associated with construction activities, if conducted while eagles are wintering within the area, could displace individual eagles from using the area during that period. As bald eagles have not been documented in the project area, impacts of the proposed action would be limited to occasional foraging individuals rather than a large segment of the population. If necessary, the majority of direct impacts could be mitigated if construction activities were conducted outside the winter and early spring months, or outside the daily roosting period, should eagles be present during construction. Any bald eagles that might roost or nest in the area once the mine is operational would be doing so in spite of continuous and on-going human disturbance, indicating a tolerance for such activities.

Indirect impacts such as area avoidance could result from increased noise and human presence associated with mining related operations. Potential winter foraging habitat could be further fragmented by linear disturbances such as fences and new roads associated with the project. Given the size of the proposed project, those disturbances would occur within narrow corridors over relatively short distances.

Due to the lack of potential nesting or roosting sites and the lack of concentrated sources of prey, both the direct and indirect effects of the proposed action to bald eagles are expected to be minimal.

7.2.7.9.2 Reptiles, Amphibians, and Fish

Potential habitat for reptiles, amphibians, and aquatic species is quite limited within the proposed license area, and occurs primarily as ephemeral or intermittent habitat associated with small, scattered stock ponds or drainages in the area. Portions of Pine Tree Draw, Simons Draw, and Ninemile Creek, and their ephemeral tributaries, occur within the proposed license area, but do not represent reliable water sources.

Activities associated with the Moore Ranch Project are not expected to disturb existing surface water or alter the topography in the area. Furthermore, under natural conditions, such habitat is limited in the project area and few observations of aquatic species have been recorded there over time. Impacts to surface water flow and channels are expected to be minimal, as no significant alterations to these features would result from construction and operations. Additionally, any primary channels and surface water flow affected during mining would be restored during reclamation.

7.2.7.10 Waterfowl and Shorebirds

Construction and operation of the Moore Ranch Project would have a negligible effect on migrating and breeding waterfowl and shorebirds. Little existing habitat is present in the area, so it does not currently support large groups or populations of these species. Ponding of water from fluid releases during operations will be immediately removed, minimizing any contact of released fluids with waterfowl or shorebirds. Any new treated water sources would enhance current habitat conditions for these species, though such effects may be ephemeral and temporary in nature. Habitat disturbance in drainages or other potential water sources would be reclaimed once productive operations have ceased. Replacement of any impacted jurisdictional wetlands would be required in accordance with Section 404 of the Clean Water Act.

7.2.8 Noise Impacts of Operations

As noted in section 7.1.5, there are no occupied housing units in the vicinity of the proposed Project. Open rangeland is the primary land use within and in the surrounding 2.0-mile area. Other land uses include oil and gas production facilities, as well as pastureland located to the west of the Project area.

7.2.9 Cumulative Impacts of Coal Bed Methane Development Projects

The Powder River Basin has been developed since the mid-1980's for the recovery of coal bed methane (CBM). With advancements in technology, development and production of CBM has been increasing substantially since the mid-1990s. Development has been centered in all or parts of Campbell, Converse, Johnson, and Sheridan counties. The target coal zones are contained in the Fort Union formation.

The following discussion of CBM recovery methods (Section 7.2.9.1) and environmental impacts (Section 7.2.9.2) is based on a Final Environmental Impact Statement (FEIS) prepared by the Bureau of Land Management (BLM) for the Powder River Basin[3]. The proposed Moore Ranch License Area includes existing CBM recovery facilities which are discussed in Section 7.2.9.3. Cumulative environmental impacts of existing CBM development and the Moore Ranch Project are discussed in Section 7.2.9.4.

7.2.9.1 Coal Bed Methane Recovery Method

Recovery of CBM involves installation of facilities including access roads, pipelines for gathering gas and produced water, electrical utilities, facilities for measuring and compressing recovered gas, facilities for treating, discharging, disposing of, containing, or injecting produced water, and pipelines to transport gas to high-pressure transmission pipelines. Several coal beds may occur together. Standard practice in these areas is to drill a separate well to develop each coal bed. Where possible, wells are collocated on the same well pad. Wells and well pads are generally installed on an 80-acre spacing pattern (eight pads per square mile).

Typically, the CBM operators use a truck-mounted water well type of drilling rig to drill CBM wells. A well is drilled to a depth of 350 feet to 1,500 feet or deeper to the top of a coal zone. When the target coal is reached, the well production casing is placed and cemented. Placement of production casing includes insertion of a steel pipe into the drill hole from the bottom of the hole to the surface. Casing is set into the hole one joint at a time and is threaded at one end with a collar located at the other end to connect each joint. The casing is then cemented into place by pumping a slurry of dry cement and water into the casing head, down through the casing string to the bottom, and then up through the annulus between the casing and the well. A plug and water flush is then pumped to the bottom of the well to remove any residual cement from the inside walls of the casing. Sufficient cement is pumped into the annulus to fill the space, where it is allowed to harden. If indications of inadequate primary cementing exist such as lost returns, cement channeling, or mechanical failure of equipment, the operator evaluates the adequacy of the cementing by pressure testing the casing shoe, running a cement bond log, cement evaluation tool log, or a combination.

Cementing the annulus around the casing pipe restores the original isolation of formations by creating a barrier to the vertical migration of fluids and gas between rock formations within the borehole. It also protects the well by preventing pressure in the formation from damaging the casing and retards corrosion by minimizing contact between the casing and corrosive formation waters.

After the coal zone is drilled, the open hole is flushed with clean chlorinated water to remove the coal fines from the hole. Steel tubing is then inserted inside the casing and in the open hole. A submersible electric pump is attached to the bottom end of the tubing to pump water from the coal. The size and capacity of the submersible pump depends on the coal's thickness and the rate of production expected from the well. Most pumps are rated at 10 to 20 gallons per minute. The pump is necessary because water pressure in the coal zone must be reduced before gas (methane) will flow to the open hole. The water is pumped up the tubing to the surface where, generally, it is gathered in a pipeline for disposal. When the gas is released from the coal, it flows up the space between the tubing and the steel casing to the gas-gathering system and compressors at the surface.

After well productivity is established, a small area of about 5 to 6 feet square is leveled and a weatherproof covering or box is placed over the wellhead. Enclosures for wellheads and metering facilities are vented. Usually, a metal fence or rail is installed immediately around the box and electrical panel to protect them from livestock. Meters to measure pressure and rates of water production may be placed in the box. Injection facilities, including some treatment facilities, may be collocated at CBM wells. The power lines for the submersible water pumps are laid in trenches, usually with water pipelines, to minimize surface disturbance and the visual impact of operations.

Three types of pipelines are generally constructed. These pipelines gather gas and produced water and deliver gas at high pressure. The gathering pipelines convey gas from the wells to compressor facilities and the produced water to discharge or disposal points. The high-pressure gas pipelines connect compressor facilities to transmission pipelines. The pipelines to gather gas and produced water are constructed of high density polyethylene (HDPE) pipe with an outside diameter of 2 to 12 inches. The high-pressure pipelines are constructed of steel pipe with an outside diameter of 12 to 16 inches. Rights-of-way for the pipelines vary from 20 to 50 feet for HDPE pipeline and 100 feet for steel pipelines. All pipelines are generally installed along access roads to minimize disturbance.

Produced water is brought to a point of discharge into a natural drainage or into containment for disposal. The average rate of water production per well is about 10 gpm. This rate for an individual well may rise as deeper, thicker coals are produced. Historically, the rate of water production drops to one-half its initial level after the first year of production in a new area where the water pressure is being reduced before gas production begins.

The method of handling produced water varies as the water quality, water volumes, and desires of the surface owner change. Typical water handling methods include direct surface discharge, passive or active treatment of produced water followed by direct surface discharge, infiltration or containment impoundments for produced water, land application using irrigation equipment, and injection of produced water through disposal wells. Presently, the primary method of disposal is to convey the water in an underground pipe to a surface discharge location mutually selected by the operator and the surface owner or lessee. WDEQ permits these surface discharges through the State NPDES program.

Gas-gathering pipelines for an average of 10 wells are tied together in a central measuring facility (CMF). At the CMF, gas is commingled into the gas-gathering system, which transports it to a compressor station. Two types of compressor stations are constructed: central reciprocating and booster stations. Produced natural gas under pressure from the wellhead moves through the low-pressure gas-gathering system to a booster compressor station. Typical pressure in the gathering line is less than 50 psi. At booster stations, low horsepower (350 HP) natural gas or electric-powered boosters or blowers enhance the flow of gas through the pipelines. Gas from the booster compressor stations then flows through medium-pressure pipelines (50 to 125 psi) to a central reciprocating compressor station. High horsepower (1,650 HP) compressors at these stations increase the pressure of natural gas to an estimated 700 to 1,450 psi to facilitate transmission of the natural gas to high-pressure transmission pipelines.

As production areas deplete, surface facilities are removed. Depleted production holes are plugged and abandoned in accordance with Onshore Oil and Gas Order No. 2 and Wyoming Oil and Gas Conservation Commission (WOGCC) rules. Once the well is conditioned as a static column, the well is decommissioned by pouring redundant plugs, a slurry of cement and water at strategic locations in the well bore. These locations are based on each well's configuration to prevent migration of fluids or gas up the well bore or any uncemented paths. A mixture of bentonite and water is placed between the cement plugs. Well pads are recontoured, plowed, and seeded. Wells may also be assigned to the landowner consistent with the terms of the surface use agreement. When the well is assigned, all rights and responsibilities, including reclamation, pass to the landowner, unless otherwise specified. The underground pipelines are cleaned, disconnected, and then abandoned in place to avoid any unnecessary surface disturbance. Underground electric lines are disconnected and are also abandoned in place to avoid any unnecessary surface disturbance. Aboveground lines are disconnected and the power poles are removed from the sites.

The productive life of each well is expected to be about 7 years. Final reclamation of these wells occurs during the 2 to 3 years after production ends, resulting in an overall average life of 10 years.

7.2.9.2 Environmental Impacts of CBM Recovery in the Powder River Basin

In 2003, the BLM issued a Final Environmental Impact Statement (FEIS) and a Record of Decision[4] (ROD) for a proposed expansion of CBM production in the Powder River Basin. The following sections describe the environmental impacts of the alternative approved by the BLM in the ROD. This review is limited to CBM impacts that may contribute to a cumulative impact when considered with the environmental impacts of the Moore Ranch Project as discussed in Sections 7.1 and 7.2.1. through 7.2.8 above. It should be noted that the environmental impacts associated with CBM development discussed in this section were associated with a large project (51,000 total CBM wells) located in a large area within the Powder River Basin (approximately 8 million acres). The cumulative impacts of development in the Moore Ranch Project area will be based on the actual and planned CBM development within that area and are discussed in detail in Section 7.2.9.4.

7.2.9.2.1 Groundwater Impacts

CBM recovery requires the removal of large volumes of groundwater from the coal zone in order to depressurize the zone and release the gas. The BLM estimated that development of CBM in the Powder River Basin through 2018 would remove about 3 million acre-feet, less than 0.3 percent of the total recoverable groundwater (nearly 1.4 billion acre-feet) in the Wasatch and Fort Union Formations within the Powder River Basin. An estimated 15 to 33 percent of the groundwater removed will infiltrate the surface and recharge the shallow aquifers above the coals. Redistribution of pressure within the coals after water production ends would allow the hydraulic pressure head to recover within approximately 50 feet or less of pre-project levels within 25 years after the project end. Complete recovery of water levels likely would take tens to hundreds of years, depending on the location.

BLM models indicated that Wasatch aquifers that overlie the coals also would be affected by development. As the coal is de-pressurized by water removal during mining or development of CBM, water contained in deep Wasatch sands would leak into the coals. Water levels in the deep Wasatch sands would be lowered, but BLM estimated that the drawdown likely would be less than 10 percent of the level that would occur in the coal. Conversely, in some areas BLM estimated that water levels in very shallow Wasatch sands likely would rise initially, up to 50 feet in the immediate vicinity of infiltration impoundments and up to 10 feet at distances of several hundred feet from impoundments or surface drainages that receive CBM discharge. This rise would occur through enhanced recharge from infiltration of CBM produced water.

BLM projected that the infiltration of produced water would not noticeably affect groundwater quality.

Wells completed in developed coals that are located within the areal extent of the 100-foot drawdown contour created by a CBM well could experience drops in water level and possibly methane occurrence. Flowing artesian wells and springs that emanate from coals in these areas would likely experience a decrease in flow rate. BLM estimated that recovery of artesian conditions likely would not occur unless recovery of the last five percent or so of hydraulic head occurs.

7.2.9.2.2 Surface Water Impacts

An estimated 9 to 52 percent of CBM produced water would contribute to surface flows. Perennial flows would be likely to develop in formerly ephemeral channels. The preferred alternative included management of surface water discharges of produced water by sub-watersheds and the emphasized use of infiltration for produced water management. The Moore Ranch Project is located in the BLM Upper Belle Fourche River watershed. Under modeled conditions, the amount of produced water assumed to reach the main stem of the Upper Belle Fourche River sub-watershed during the peak year of CBM water production (2006) was about 61 cfs (44,168 acre-feet/year).

BLM expects noticeable changes in water quality of main stems during periods of low flow. The key water quality parameters of concern due to their impacts on water use for irrigation are sodicity (as measured by the sodium absorption ratio or SAR) and salinity (as measured by conductivity). NPDES permit conditions provide enforceable assurance that water quality standards and designated uses would not be degraded from discharges of CBM produced water. Under modeled conditions, the BLM estimated that the resultant water quality in the Upper Belle Fourche River sub-watershed at Moorcroft, Wyoming, during all months of the year would be adequate to meet the Most Restrictive Proposed Limit (MRPL) for both conductivity and SAR that the WDEQ has adopted in its NPDES permitting process to be protective of downstream irrigation. Under some flow conditions, the modeled SAR values and concentrations of sodium may inhibit the use of irrigation on some tributaries in the Upper Belle Fourche River sub-watershed. However, BLM noted that samples collected since the onset of CBM production in the Upper Belle Fourche River sub-watershed had not detected changes in ambient stream water quality which were predicted by the mass balance model.

BLM projected that concentrations of suspended sediment in surface waters would be likely to rise above baseline levels as a result of increased flows and runoff from disturbed areas. BLM requires site-specific Water Management Plans (WMPs) as an integral part of mitigation planning to control and monitor the potential effects from increased flows in surface drainages.

As a positive impact of CBM development, the discharge of produced water would result in the increased availability of surface water for irrigation and other downstream beneficial uses. Numerous impoundments are constructed to temporarily store CBM produced water for beneficial use. BLM estimated that between 8 to 25 percent of CBM produced water would be held in storage.

7.2.9.2.3 Air Quality Impacts

Fugitive dust and exhaust from construction activities, along with air pollutants emitted during operation (i.e., well operations, injection well and pipeline compressor engines, etc.), are potential causes of decreases in air quality related to CBM development and production. BLM performed air pollutant dispersion modeling to quantify potential PM_{10} and SO_2 impacts during construction based on the individual pollutant's period of maximum potential emissions. Construction emissions would occur during potential road and well pad construction, well drilling, and well completion testing. During well completion testing, natural gas may be flared and exhausted. Maximum air pollutant emissions from each well would be temporary (i.e., occurring during a short construction period) and would occur in isolation. Air quality impacts would occur during production including non-CBM well production equipment and booster and pipeline compression engine exhausts. The amount of air pollutant emissions during construction is controlled by watering disturbed soils, and by air pollutant emission limitations imposed by the WDEQ. Before actual development can occur, the WDEQ must review the specific air pollutant emissions pre-construction permit application that examines the source-specific air quality impacts. As part of these permits (depending on source size), the WDEQ may require additional air quality impacts analyses or mitigation measures.

7.2.9.3 CBM Development at Moore Ranch

Two companies (Barrett Resources Corporation and Devon Energy Corporation) have CBM claims located within the proposed Moore Ranch License Area. EMC has met with representatives of both companies to discuss current and planned CBM operations within he proposed license area and coordination with EMC activities. Currently existing CBM facilities operated by Devon located within the proposed Moore Ranch License Area are shown in Figure 7.2-1. Barrett has plans for future development within the license area. The producing interval is the Anderson/Big George coal at depths of between 1,000 and 1,200 feet below ground surface.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:
DRAWING NO.: FIGURE 7.2-1,
"MOORE RANCH URANIUM PROJECT EXISTING AND PROPOSED SITE FEATURES"

WITHIN THIS PACKAGE... OR, BY SEARCHING USING THE DOCUMENT/REPORT DRAWING NO. FIGURE 7.2-1

D-06

Existing Devon installations were installed approximately seven years ago and will be nearing the end of their operational life at the time EMC expects to begin construction. Reclamation activities for these Devon wells and facilities will likely occur during the operational phase of the Moore Ranch Project.

Barrett plans to install new facilities within the next several years in Sections 2, 3, 4, 33 and the NW ¼ of Section 34. These planned facilities are located outside EMC wellfields.

Based on discussions with both CBM operators and experience with concurrent CBM and uranium recovery development in other locations in the Powder River Basin, EMC believes that these activities can be coordinated to maintain health, safety, and environmental controls.

7.2.9.4 Cumulative Environmental Impacts of the Moore Ranch Project and CBM Development

The only potential cumulative environmental impact of CBM and ISR operation would be hydrologic. As previously mentioned, the producing interval for CBM is the Anderson/Big George coal at depths of between 1,000 and 1,200 feet below ground surface. The Anderson/Big George Coal is within the Fort Union Formation and is separated from the uranium-producing 70 Sand in the Wasatch Formation by over 700 feet of interbedded clays, siltstone, and discontinuous sands. As a result, no hydrologic impacts from coal bed methane production are expected on sandstone and clay aquitards relevant to in situ mining at Moore Ranch.

The potential effect of accidents due to collocation of ISR and CBM projects are discussed in Section 7.5.6.

7.2.10 Cumulative Impacts of Other Uranium Development Projects

The Powder River Basin has been historically developed for the recovery of uranium using ISR and conventional (underground and pit) mining. The only existing licensed uranium projects currently located in the Powder River Basin are the Smith Ranch/Highland Uranium Project (operated by Power Resources, Inc.) and the Irigaray/Christensen Ranch Project (operated by Cogema Mining, Inc). These ISR projects are located approximately 37 miles south-southeast and 19 miles north-northwest of the Moore Ranch Project, respectively. Considering the distance between the existing projects and the proposed Moore Ranch Project, cumulative environmental impacts are not expected.

EMC is aware that several companies are actively investigating the potential for ISR mining in areas near the Moore Ranch Project. These projects are in various stages of development.

Licensing and permitting applications have not been submitted to the regulatory agencies at the time of this application. As such, it is not possible for EMC to accurately predict the cumulative environmental impacts should these uranium projects seek and ultimately gain regulatory approval and be developed.

7.3 RADIOLOGICAL EFFECTS

EMC is proposing to develop a uranium in-situ recovery facility with a production and restoration flow of approximately 3000 and 500 gallons per minute (gpm) respectively. An assessment of the radiological effects of the Moore Ranch facility (the facility) must consider the types of emissions, the potential pathways present, and an evaluation of potential consequences of radiological emissions.

The facility will use fixed bed pressurized down flow ion exchange columns to separate uranium from the pregnant production fluid and to treat restoration solutions. The uranium contained in the eluant from the production ion exchange columns will be precipitated and subsequently vacuum dried.

In addition to ion exchange treatment, the groundwater restoration process will also use reverse osmosis to remove the dissolved solids. Liquid waste disposal will be via direct deep well injection. No evaporation ponds are planned at this time.

The facility will also receive uranium-loaded ion exchange resin from various satellite facilities around the region. An average of 6 resin transfers per day from these satellite facilities is anticipated.

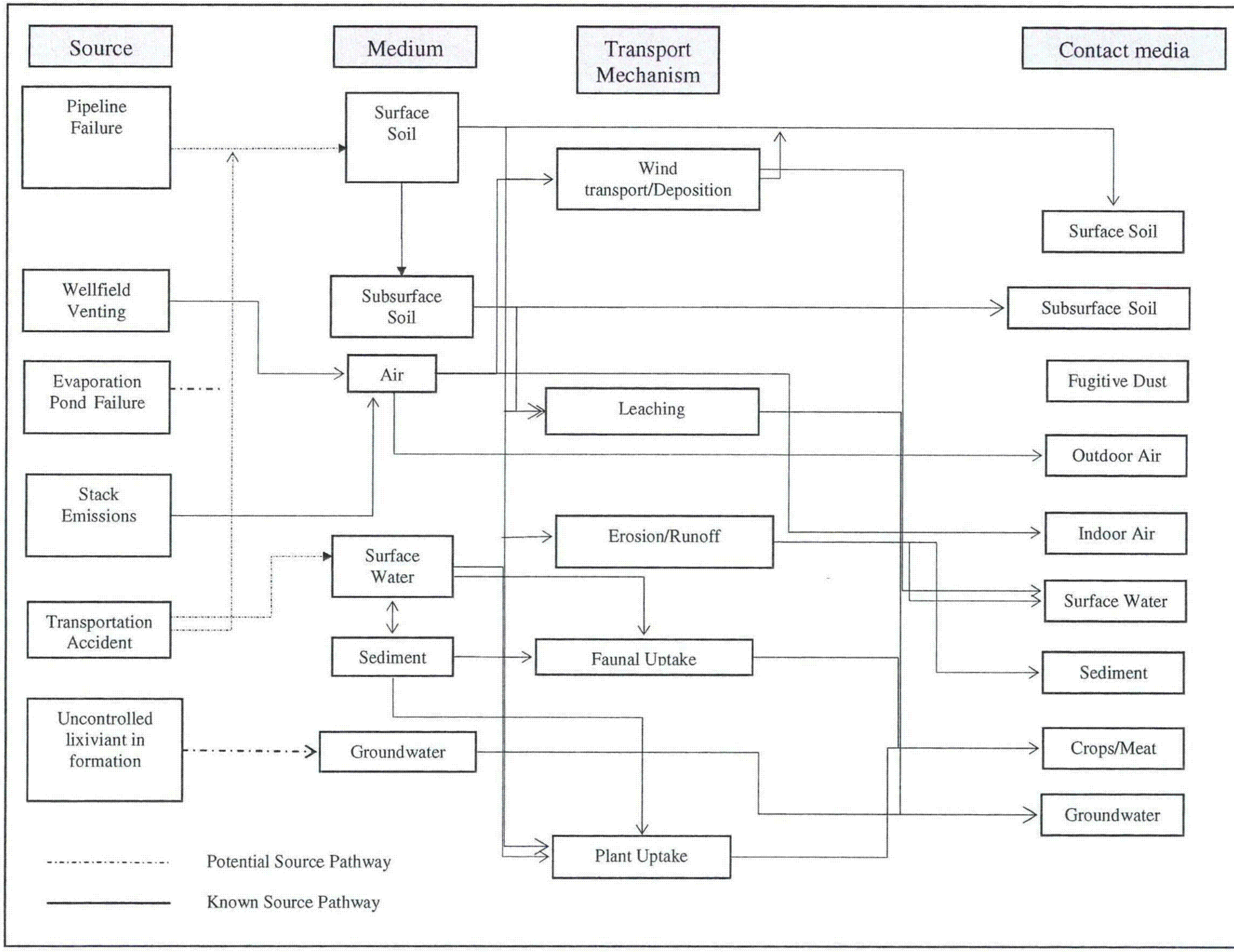
Since the drying and packaging operation is conducted under vacuum, the only expected routine emission at the facility will be radon-222 gas. Radon-222, a decay product of radium-226, is dissolved in the lixiviant as it travels through the ore to a production well where it is brought to the surface. The concentration of radon-222 in the production solution and estimated releases are calculated using the methods found in USNRC Regulatory Guide 3.59[5]. The details of and assumptions used in these calculations are found in Section 7.3.3.

MILDOS-AREA[6] is used to model radiological impacts on human and environmental receptors (e.g. air and soil) using site specific radon-222 release estimates, meteorological and population data, and other parameters. The estimated radiological impacts resulting from routine site activities will be compared to applicable public dose limits as well as naturally occurring background levels.

7.3.1 Exposure Pathways

Figure 7.3-1 presents exposure pathways from all potential sources at the Moore Ranch facility. The predominant pathways for planned and unplanned releases are identified. As mentioned earlier, atmospheric radon-222 is expected to be the predominant pathway for impacts on human and environmental media. Impacts of radon-222 releases can be expected in all quadrants surrounding the facility, the magnitude of which is driven predominantly by wind direction and atmospheric stability. As a noble gas, radon-222 itself has very little radiological impact on human health or the environment. Radon-222 has a relatively short half-life (3.2 days) and its decay products are short lived, alpha emitting, nongaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. As Figure 7.3-1 shows, all exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to air emissions of radon-222 are evaluated by MILDOS-AREA. MILDOS-AREA modeling output is contained in Appendix E.

Figure 7.3-1 Human Exposure Pathways for Known and Potential Sources from the Moore Ranch Area



Contact media	Ingestion	Inhalation	Direct Exposure	Absorption
Surface Soil	X		X	
Subsurface Soil	X		X	
Fugitive Dust	X	X	X	X
Outdoor Air		X	X	
Indoor Air		X	X	
Surface Water	X			X
Sediment				
Crops/Meat	X			
Groundwater	X			

x Predominant Path

7.3.2 Exposures from Water Pathways

The mining solutions in the ore zone will be controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

The primary method of waste disposal at the facility will be by deep well injection. The deep well(s) will be completed at depths significantly deeper than zones planned for mining and current CBM operations and will be isolated geologically from underground sources of drinking water. The well(s) will be constructed under a permit from the Wyoming Department of Environment Quality (WDEQ) and all requirements of the Underground Injection Control (UIC) program for Class I wells will be met.

The uranium ion exchange, precipitation, drying and packaging facilities will be located on curbed concrete pads to prevent any liquids from entering the environment. Solutions used to wash down equipment drain to a sump and are either pumped back into the processing circuit or to the disposal well. The pads will be of sufficient size to contain the contents of the largest tank in the event of a rupture.

No routine liquid environmental discharges, other than waste disposal via deep well injection, are planned and as such, no definable water related pathways for routine operations exist.

7.3.3 Exposures from Air Pathways

The only source of radionuclide emissions is radon-222 released into the atmosphere through a vent system in the main plant area or from the wellfields. As shown in Figure 7.3-1, atmospheric releases of radon-222 can result in radiation exposure via three pathways; inhalation, ingestion, and external exposure. The Total Effective Dose Equivalent (TEDE) to nearby residents in the region around the facility was estimated using MILDOS-AREA.

7.3.3.1 Source Term Estimates

The source terms used to estimate radon-222 releases from the facility include three well fields in production, one restoration well field, new well field development, operation of the central process plant, and resin transfers from neighboring satellite processing facilities. The parameters used to characterize and estimate releases are provided in Table 7.3-1.

Table 7.3-1 Parameters used to estimate and characterized source terms at the Moore Ranch In-Situ Recovery facility.

Parameter	Value	Unit	Source
Average Ore Grade	0.1	%	Application
Ore radium-226 Concentration	282	pCi g^{-1}	Reg. Guide 3.59
Mined Area	3.12E+05	m^2 y^{-1}	Application
Average Lixiviant Flow	1.14E+04	L m^{-1}	Application
Average Restoration Flow	1.89E+03	L m^{-1}	Application
Operating days per year	365	days	
Ore formation thickness	6.1	meters	Application
Ore formation porosity	0.2	NA	Application
Ore formation rock density	2.65	g cm^{-3}	Application
Average residence time for lixiviant	7	days	Application
Average residence time for restoration solutions	35	days	Application
Average mass of ore material in mud pit	1.02E+07	g	Estimate based on planned activities
Number of mud pits generated per year	300	NA	Estimate based on planned activities
Storage time in mud pits	14	days	Estimate based on planned activities
Radon-222 emanating power	0.2	NA	Reg. Guide 3.59
Radon-222 release rates	0.1	y^{-1}	Estimate based on process
Resin Porosity	0.4	NA	NUREG 1569
Ion Exchange Column Volume	1.42E+04	L	Estimate based on planned activities
Number of Resin Transfers per day	6	NA	Estimate based on planned activities
Stack Height	16	m	Application
Stack Diameter	0.3	m	Application
Stack Velocity	11	m s^{-1}	Application

7.3.3.1.1 Production Releases

Currently EMC plans to have up to three wellfield areas at Moore Ranch that could potentially be mined concurrently. The potential radon-222 releases from the production well fields were estimated using methods described in Regulatory Guide 3.59 as follows:

Radon released (equilibrium condition) to production fluid from leaching is calculated using Equation 1:

$$G = R\rho E \frac{(1-p)}{p} x10^{-6} \qquad \text{(Equation 1)}$$

Where:

G	=	radon released (Ci/m^3)
R	=	radium content of ore (pCi/g)
E	=	emanating power
ρ	=	rock density (g cm^{-3})
p	=	formation porosity

The yearly radon released to the production fluid is calculated using Equation 2:

$$Y = 1.44GMD(1 - e^{-\lambda t}) \qquad \text{(Equation 2)}$$

Where:

Y	=	yearly radon released to production fluid (Ci yr^{-1})
G	=	radon released at equilibrium (Ci m^{-3})
M	=	lixiviant flow rate (L min^{-1})
D	=	production days per year (d)
λ	=	radon-222 decay constant (d^{-1})
t	=	lixiviant residence time
1.44	=	unit conversion factor

Using Equations 1 and 2 and the parameters in Table 7.3-1, the yearly radon released to production fluid is 2563 Ci yr^{-1}. Regulatory Guide 3.56 assumes all the radon-222 that is released to the production fluid is ultimately released to the atmosphere, which is the case for ion exchange columns operating at atmospheric pressure in an open system and is an appropriate conservative assumption for this type of ion exchange system. In cases where pressurized downflow ion exchange columns are used and wellfields are operated under pressure, the majority of radon released to the production fluid stays in solution and is not released. The radon which is released is from occasional well field venting for sampling events, small unavoidable leaks in well field and ion exchange equipment, and maintenance of well field and ion change equipment. For this reason, an estimated annual release of 10% of the radon-222 in the production fluid from the wellfields and an additional 10% in the ion exchange circuit was assumed. Given this assumption, the annual radon-222 released from production in the wellfield and at the central plant facility is 256 and 230 Ci yr^{-1}, respectively. For purposes of MILDOS-AREA model simulations, the wellfield release of 256 Ci yr^{-1} was distributed equally among the three proposed well fields at the site.

7.3.3.1.2 Restoration Releases

Radon-222 releases resulting from wellfield restoration activities were estimated in the same manner as the production activities above (i.e., using Equation 2) but modified for the lower restoration flow rate and the longer restoration fluid residence time, both of which are listed in Table 7.3-1. The estimate of a 10% release in the well field and treatment facility results in releases of 59 and 53 Ci yr^{-1} respectively. For purposes of the MILDOS-AREA model simulations, the wellfield release of 59 Ci yr^{-1} was distributed equally among the three proposed well fields at the site.

7.3.3.1.3 New Wellfield Releases

Radon-222 releases resulting from new wellfield development activities were estimated using methods described in NUREG-1569 as follows:

$$Rn_{nw} = EL[Ra]TmNx10^{-12} \qquad \text{(Equation 3)}$$

Where:

Rn_{nw}	=	Radon-222 release rate from new well field (Ci yr^{-1})
E	=	emanating power
[Ra]	=	concentration of radium-226 in ore (pCi g^{-1})
L	=	decay constant of radon-222
T	=	storage time in mud pit (d)
m	=	average mass of ore material in the pit (g)
N	=	number of mud pits generated per year
10^{-12}	=	unit conversion factor (Ci pCi^{-1})

Using Equation 3 and the parameters in Table 7.3-1, the yearly radon released from new wellfield development is 0.43 Ci yr^{-1}. For purposes of the MILDOS-AREA model simulations, the new wellfield release was assumed to occur at the central plant location.

7.3.3.1.4 Resin Transfer Releases

Radon-222 releases resulting from resin transfers from neighboring satellite facilities were estimated using methods described in NUREG-1569 as follows:

$$Rn_x = 3.65x10^{-10} F_i C_{Rn} \qquad \text{(Equation 4)}$$

Where:

Rn_x	=	Radon release rate from resin transfers (Ci yr^{-1})
F_i	=	water discharge rate from resin unloading (L d^{-1})
C_{Rn}	=	Steady state radon-222 concentration in process water (pCi L^{-1})
$3.65x10^{-12}$	=	unit conversion factor (Ci pCi^{-1})(d yr^{-1})

The steady state radon-222 concentration in process water (C_{Rn}) can be estimated from the following expression:

$$C_{Rn} = \frac{Y * 1.9E6}{M} \qquad \text{(Equation 5)}$$

Where:

C_{Rn}	=	Steady state radon-222 concentration in process water (pCi L^{-1})
Y	=	yearly radon released to production fluid (Ci $yr-^{1}$)
M	=	lixiviant flow rate (L min^{-1})
1.9E6	=	unit conversion factor (pCi Ci^{-1})(yr min^{1})

The water discharge rate from resin unloading (Fi) can be estimated from the following expression:

$$F_i = N_i * V_i * P_i \qquad \text{(Equation 6)}$$

Where:

F_i = water discharge rate from resin unloading (L d^{-1})
N_i = Number of resin transfers per day
V_i = volume of resin in transfer (L)
P_i = porosity of resin

Using Equations 4-6 and the parameters in Table 7.3-1, the yearly radon released from resin transfers from satellite facilities development is 5.3 Ci yr^{-1}. This estimate assumes the ore grade mined at the satellite facilities would yield the same radon concentration in production fluid as the Moore Ranch facility. For purposes of the MILDOS-AREA model simulations, the resin transfer release was assumed to occur at the central plant location.

7.3.3.1.5 Radon-222 Release Summary

A summary of estimated radon-222 releases from the Moore Ranch Facility is presented in Table 7.3-2. The source coordinates in Table 7.3-2 are relative to the main plant area.

Table 7.3-2 Estimated Radon-222 Releases (Ci yr^{-1}) from the Moore Ranch Facility

Location	X (km)	Y (km)	Production	Restoration	Drilling	Resin Transfer	Total
Well Field 1	-0.42	0.07	85.3	20	0	0	105.3
Well Field 2	0.89	-0.53	85.3	20	0	0	105.3
Well Field 3	0.47	-0.64	85.3	20	0	0	105.3
Main Plant Stack	0	0	230	53	0	5.3	288.3
New Well Field	0	0	0	0	0.43	0	0.43
Total			486	113	0.43	5.3	604.7

7.3.3.2 Receptors

The receptors used in the MILDOS-AREA simulations are presented in Table 7.3-3 and include the property boundary in 16 compass directions, 2 residences, and the town of Wright.

Table 7.3-3 Moore Ranch Receptor Names and Locations

Location	X (km)	Y (km)	Distance (km)
1. Property Boundary- N	0.00	2.60	2.60
2. Property Boundary- NNE	1.09	2.63	2.85
3. Property Boundary- NE	1.96	1.96	2.77
4. Property Boundary- ENE	3.64	1.50	3.94
5. Property Boundary- E	6.71	0.00	6.71
6. Property Boundary- ESE	4.27	-1.96	5.11
7. Property Boundary- SE	2.31	-2.31	3.27
8. Property Boundary- SSE	1.19	-2.87	3.11
9. Property Boundary- S	0.00	-2.85	2.85
10. Property Boundary- SSW	-1.51	-3.64	3.94
11. Property Boundary- SW	-2.85	-2.85	4.03
12. Property Boundary- WSW	-3.02	-1.25	3.27
13. Property Boundary- W	-2.77	0.00	2.77
14. Property Boundary- WNW	-2.17	0.90	2.35
15. Property Boundary-NW	-1.42	1.42	2.01
16. Property Boundary- NNW	-1.09	2.63	2.85
17. Nearest Resident East	4.50	0.00	4.50
18. Nearest Resident South	0.00	-13.4	13.4
19. Wright	26.1	18.9	32.2

7.3.3.3 Miscellaneous Parameters

The metrological data used in the MILDOS-AREA model is from the Joint Frequency Distribution data presented in Section 2.5 of this application.

The population distribution used in the MILDOS-AREA model to estimate population doses is from the demographic information presented in Section 2.3 of this application.

7.3.3.4 Total Effective Dose Equivalent (TEDE) to Individual Receptors

In order to show compliance with the annual dose limit found in 10 CFR §20.1301, EMC has demonstrated by calculation that the TEDE to the individual most likely to receive the highest dose from the Moore Ranch uranium in-situ recovery operation is less than

100 mrem per year. The results of the MILDOS-AREA simulation for each receptor in Table 7.3-3 are presented in Table 7.3-4.

An evaluation of the TEDE follows:

1) The maximum TEDE of 0.8 mrem/yr, located at the northwest property boundary, is 0.8 percent of the public dose limit of 100 mrem.

2) Receptor #17 is the closest resident to the Moore Ranch facility. The estimated TEDE at this location is 0.7 mrem/yr, which is 0.7 percent of the regulatory limit.

3) The effect of the Moore Ranch operation on any potential resident is less that 1 mrem/yr.

4) Since radon-222 is the only radionuclide emitted, public dose requirements in 40 CFR part 190 and the 10 mrem/y constraint rule in 10 CFR §20.1101 do not apply.

5) Even if 100% of the radon-222 contained in restoration and production fluids were released to the atmosphere (i.e. 100% released instead of 10%), the impacts to potential residents surrounding the facility would be less than the 100 mrem public dose limit.

Table 7.3-4 Estimated Total Effective Dose Equivalent (TEDE) to Receptors near the Moore Ranch Processing Facility

Receptor	Distance from Main Plant (km)	TEDE (mrem/y)
1. Property Boundary- N	2.60	0.43
2. Property Boundary- NNE	2.85	0.32
3. Property Boundary- NE	2.77	0.34
4. Property Boundary- ENE	3.94	0.41
5. Property Boundary- E	6.71	0.45
6. Property Boundary- ESE	5.11	0.45
7. Property Boundary- SE	3.27	0.54
8. Property Boundary- SSE	3.11	0.50
9. Property Boundary- S	2.85	0.48
10. Property Boundary- SSW	3.94	0.22
11. Property Boundary- SW	4.03	0.15
12. Property Boundary- WSW	3.27	0.22
13. Property Boundary- W	2.77	0.41
14. Property Boundary- WNW	2.35	0.74
15. Property Boundary-NW	2.01	0.80
16. Property Boundary- NNW	2.85	0.46
17. Nearest Resident East	4.50	0.69
18. Nearest Resident South	13.4	0.08
19. Wright	32.2	0.03

7.3.3.5 Population Dose

The annual population dose commitment to the population in the region within 80 km of the Moore Ranch facility is also predicted by the MILDOS-AREA code. The results are contained in Table 7.3-5 where TEDE is expressed in terms of person-rems. For comparison, the dose to the population within 80 km of the facility due to background radiation has been included in the table. Background radiation doses are based on a North American population of 346 million and an average TEDE of 360 mrem.

The atmospheric release of radon also results in a dose to the population on the North American continent. This continental dose is calculated by comparison with a previous calculation based on a 1 kilocurie release near Casper, Wyoming, during the year 1978. The results of these calculations are included in Table 7.3-5 and also combined with dose to the region within 80 km (50 mi) of the facility to arrive at the total radiological effects of one year of operation at the Moore Ranch project.

The maximum radiological effect of the Moore Ranch operation would be to increase the TEDE of continental population by 0.000045 percent.

Table 7.3-5 Total Effective Dose Equivalent to the Population from One Year's Operation at the Moore Ranch Facility

Criteria	TEDE (person rem/yr)
Dose received by population within 80 km of the facility	0.09
Dose received by population beyond 80 km of the facility	5.3
Total Continental Dose	5.4
Background North American Dose	1.2 E8
Fractional increase to background dose	4.5 E-8

7.3.3.6 Exposure to Flora and Fauna

To estimate potential radiological impacts to flora and fauna, the most important pathway for exposure should be identified. Since the only planned emissions from the facility is radon-222 to the atmosphere, the most important pathway for exposure to flora and fauna is deposition of radon-222 decay products on surface water, surface soils, and vegetation. MILDOS-AREA estimates surface deposition rate as a function of distance from the source for the radon-222 decay products and calculates surface concentrations. Table 7.3-6 presents the highest surface concentrations of radon-222 decay products predicted by MILDOS-AREA over a 100 year period. Soil concentrations were calculated based on a conservative assumption of 1.5 g cm^{-3} bulk soil density.

Table 7.3-6 Highest Surface Concentrations of Radon-222 Decay Products Resulting from Moore Ranch ISR Operations

Radionuclide	Distance from site (km)	Direction	Surface Concentration (pCi/m^2)	Soil Concentration in upper 0.5 cm (pCi/g)
Polonium-218	1.5	E	25	3 E^{-3}
Lead-214	1.5	E	25	3 E^{-3}
Bismuth-214	1.5	E	25	3 E^{-3}
Lead-210	35	E	50	6 E^{-3}

Lead-210 represents the radionuclide with the highest concentration (6 E^{-3} pCi/g) which is at least an order of magnitude below most analytical laboratories detection limits. Recent site specific surface soil (0-5 cm) data previously discussed in Section 2.9.3 show that lead-210 ranges from 1.1 to 4.6 with a mean of 2.8 ± 1.6 pCi/g. The increase in soil radioactivity projected by MILDOS over a 100-year period is insignificant compared to site specific background concentrations.

It is likely that soil re-suspension from background soils would be the predominant source of lead-210 concentration in vegetation surrounding the site since lead-210 concentrations in vegetation would be similar to that of soil.

From this evaluation, the radiological impact of operations at the Moore Ranch Project would be minimal and indistinguishable from current baseline conditions.

7.4 NON-RADIOLOGICAL EFFECTS

NUREG-1569[6] requires that applicants provide estimates of concentrations of nonradioactive constituents in effluents at the points of discharge and provide a comparison with natural ambient concentrations and applicable discharge standards. There are two effluents expected from the Moore Ranch Project.

- A gaseous and airborne effluent will consist of air ventilated from the plant building ventilation system and vented from process vessels and tanks. This gaseous effluent will contain radon gas as previously discussed in sections 4 and 7.3. The gaseous and airborne effluent will not contain any non-radiological effluents. Nonradioactive airborne effluents at the Moore Ranch Project will be limited to fugitive dust from access roads and wellfield activities. Fugitive dust emissions will be minimal and dust suppressants will be used if conditions warrant their use. Air quality impacts of construction and operation of the Moore Ranch Project were discussed in detail in Sections 7.1.1 and 7.2.1, respectively.

- The liquid effluent will be managed in the deep disposal wells. The deep disposal wells will permanently dispose of liquid wastes and will be permitted under a Class I UIC Permit issued by the WDEQ. There are no non-radiological impacts expected due to the liquid effluents from the Moore Ranch Project.

7.5 EFFECTS OF ACCIDENTS

Accidents involving human safety associated with the ISR uranium mining technology typically have far less severe consequences that accidents associated with underground and open pit mining methods. In-situ mining provides a higher level of safety for employees and neighboring communities when compared to conventional mining methods or other energy related industries. Accidents that may occur would generally be considered minor when compared to other industries. Radiological accidents that might occur would typically manifest themselves slowly and are therefore easily detected and mitigated. The remote location of the Moore Ranch facility and the low level of radioactivity associated with the process combine to decrease the potential hazard of an accident to the general public.

NRC has previously evaluated the effects of accidents at conventional uranium milling facilities in NUREG–0706[7] and specifically at ISR uranium facilities in NUREG/CR-6733[8]. These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures and properly trained personnel are used. The proposed Moore Ranch facilities are consistent with the operating assumptions, site features, and designs examined in the NRC analyses in NUREG/CR-6733. EMC will develop emergency management procedures to implement the recommendations contained in the NRC analyses. Training programs will be developed to ensure that EMC personnel are adequately trained to respond to all potential emergencies. These training programs were discussed in detail in Section 5.

NUREG-0706 considered the environmental effects of accidents at single and multiple uranium milling facilities. Analyses were performed on incidents involving radioactivity and classified these incidents as trivial, small, and large. NUREG-0706 also considered transportation accidents. Some of the analyses in NUREG-0706 are applicable to ISR facilities, such as transportation accidents. NUREG/CR-6733 specifically addressed risks at ISR facilities and identified the "risk insights" that are discussed in the following sections.

7.5.1 Chemical Risk

NUREG/CR-6733 noted that the scope of the NRC mission includes hazardous chemicals to the extent that mishaps with these chemicals could affect releases of radioactive materials. Industrial safety aspects associated with the use of hazardous chemicals at Moore Ranch is regulated by the Wyoming State Mine Inspector.

7.5.1.1 Sulfuric Acid

Sulfuric acid is used to split the uranyl carbonate complex from rich eluate into carbon dioxide gas and uranyl ions in preparation for precipitation using hydrogen peroxide. The sulfuric acid will be stored in a tank located outdoors and piped to the central plant for use in the precipitation circuit. The concentration of sulfuric acid fumes that are immediately dangerous to life and health (IDLH) is 15 mg/m^3. In the risk analysis from NUREG/CR-6733, a spill of 93 percent sulfuric acid was not deemed a significant inhalation hazard to workers as long as normal air dilution is available from the facility ventilation system. NUREG/CR-6733 also noted that sulfuric acid reacts vigorously with ammonia, sodium carbonate, and water, all of which will be present at Moore Ranch. To minimize the potential for chemical reactions in the unlikely event of simultaneous tank leaks, the sulfuric acid storage tank will be located away from other process tanks.

The use of sulfuric acid is subject to Threshold Planning Quantities (TPQs) contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities (TQs) in excess of 1,000 pounds. As discussed in Section 3, the Moore Ranch design includes a sulfuric acid tank with a capacity of 6,000 gallons. Based on the design capacity, EMC will be subject to the Emergency Response Plan requirements.

7.5.1.2 Anhydrous Ammonia

Anhydrous ammonia is used for pH adjustment during the precipitation process. The ammonia will be stored in a tank located outdoors and piped to the Central Plant for use in the precipitation circuit. Ammonia in the liquid form is not the primary hazard. The liquid will evaporate to a gaseous state. The IDLH concentration of ammonia is 300 parts per million (ppm). NUREG/CR-6733 identified an ammonia leak as a significant risk factor within a plant structure because ventilation rates adequate to dilute ammonia fumes in a localized area to maintain concentrations below the IDLH in the event of a leak would not be feasible. An additional hazard associated with ammonia is that it reacts vigorously with sulfuric acid, which will also be present in the precipitation circuit.

To minimize the probability and consequence of an ammonia accident, the EMC system design and operating procedures will be consistent with American National Standards Institute (ANSI) recommendations[9]. These recommendations include 1) providing an excess flow valve located as close to the storage tank as possible that automatically closes if the flow rate exceeds a specific value; 2) the use of appropriate ANSI and American Society of Material Evaluation (ASME) standard codes for norrefrigerated pressure piping; and 3) provision of positive pressure, self-contained, full face respirators in the immediate vicinity of the ammonia piping and process operations. The ammonia piping will be placed so as to minimize the potential for impact from vehicles or other objects that might cause ruptures.

The use of anhydrous ammonia is subject to various regulatory programs including the following:

- Risk Management Planning (RMP) required in 40 CFR Part 68 for threshold quantities (TQs) in excess of 10,000 pounds;
- Threshold Planning Quantities (TPQs) contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities (TQs) in excess of 500 pounds; and
- Reportable Quantities (RQs) for spills from the Comprehensive Environmental, Response, Compensation and Liability Act (CERCLA) in 40 CFR § 302.4 for spills in excess of 100 pounds.

As discussed in Section 3, the Moore Ranch design includes an anhydrous ammonia tank with a capacity of 90,000 pounds with the potential for expansion to correspond to expansion of the central plant. Based on this design capacity, EMC will be subject to all of the aforementioned regulatory programs.

In addition to the listed regulatory programs, the Process Safety Management (PSM) of Highly Hazardous Chemicals standard contained in 29 CFR §1910.119 applies to anhydrous ammonia for TQs in excess of 10,000 pounds. In the State of Wyoming, industrial safety at ISR mines is regulated by the Wyoming State Mine Inspector and OSHA's PSM standard does not apply. However, EMC will consider the PSM standard during the development of the ammonia system design and operating procedures.

7.5.1.3 Hydrogen Peroxide

Hydrogen peroxide will be used in the precipitation phase at Moore Ranch. A 50-percent solution of hydrogen peroxide will be added to the acidified uranium-rich eluant to form an insoluble uranyl peroxide compound. Hydrogen peroxide is a strong oxidizer and is a reactive, easily decomposable compound. Its hazardous decomposition products include oxygen and hydrogen gas, heat, and steam. Decomposition can be caused by mechanical shock, incompatible materials including alkalies, light, ignition sources, excess heat, combustible materials, strong oxidants, rust, dust, and a pH above 4.0. When sealed in strong containers, the decomposition of hydrogen peroxide can cause excessive pressure to build up which may then cause the container to burst explosively.

As noted in NUREG/CR-6733, a hydrogen peroxide piping system leak in a process building has the potential to result in localized vapor concentrations in excess of the IDLH value of 75 ppm within several minutes. A leak in a confined space has the potential to generate lethal concentrations of vapor at an even faster rate. EMC will incorporate recommendations concerning materials of construction for tanks and piping systems and the use of local ventilation with explosion-proof fans to control vapors in the event of a leak of hydrogen peroxide.

The use of hydrogen peroxide at concentrations greater than 52 percent is subject to the following regulatory programs:

- Process Safety Management of Highly Hazardous Chemicals standard contained in 29 CFR §1910.119 for TQs in excess of 7,500 pounds; and
- Threshold Planning Quantities (TPQs) contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities (TQs) in excess of 1,000 pounds.

As discussed in Section 3, the Moore Ranch design includes the use of hydrogen peroxide at a concentration of 50 percent contained in a hydrogen peroxide tank with a capacity of 6,000 gallons. With the design hydrogen peroxide concentration and capacity, EMC will not be subject to the aforementioned regulatory programs.

7.5.1.4 Oxygen

Oxygen presents a substantial fire and explosion hazard. The design and installation of the oxygen storage facility is typically performed by the oxygen supplier and meets applicable industry standards. The oxygen will be delivered to Moore Ranch by truck and stored on site under pressure in a cryogenic tank in liquid form. The oxygen will be allowed to evaporate and will be added to the barren lixiviant upstream of the injection manifold. The design and installation of underground and above-ground gaseous oxygen piping at Moore Ranch including material specifications, velocity restrictions, location and specifications for valves, and design specifications for metering stations and filters will be in accordance with industry standards contained in CGA G-4.4[10]. Headerhouses will be equipped with an exhaust ventilation system.

Combustibles such as oil and grease will burn in oxygen if ignited. EMC will ensure that all oxygen service components are cleaned to remove all oil, grease, and other combustible material before putting them into service. Acceptable cleaning methods are described in CGA G-4.1[11].

EMC will develop procedures that implement emergency response instructions for a spill or fire involving oxygen systems.

7.5.1.5 Carbon Dioxide

The primary hazard associated with the use of carbon dioxide is concentration in confined spaces, presenting an asphyxiation hazard. Bulk carbon dioxide facilities are typically located outdoors and are subject to industry design standards. Floor level ventilation and carbon dioxide monitoring at low points will be performed to protect workers from undetected leaks of carbon dioxide within the central plant.

7.5.1.6 Sodium Carbonate and Sodium Chloride

Sodium carbonate and sodium chloride are primarily inhalation hazards. Soda ash and carbon dioxide will be used to prepare sodium carbonate for injection in the wellfield. Sodium carbonate and sodium chloride are also used for regeneration of ion exchange resin. Dry storage and handling systems will be designed to industry standards to control the discharge of dry material.

7.5.1.7 Sodium Sulfide

Sodium sulfide may be used as a reductant during groundwater restoration. Sodium sulfide is corrosive and will cause severe eye and skin burns. Routes of entry into the body include inhalation, ingestion, and contact with the skin. Under low pH conditions, sodium sulfide can react with water to liberate hydrogen sulfide gas. Sodium sulfide can be flammable and contact with heat, flame, or other sources of ignition will be avoided. Sodium sulfide will be stored separately from hydrogen peroxide and sulfuric acid.

7.5.2 Radiological Risk

7.5.2.1 Tank Failure

A spill of the materials contained in the process tanks at the Moore Ranch Project will present a minimal radiological risk. Process fluids will be contained in vessels and piping circuits within the central plant. The tanks at Moore Ranch will contain injection and production solutions, ion exchange resin, pregnant eluant, yellowcake, and liquid waste.

The plant will be designed to control and confine liquid spills from tanks should they occur. The central plant building structure and concrete curb will contain the liquid spills from the leakage or rupture of a process vessel and will direct any spilled solution to a floor sump. The floor sump system will direct any spilled solutions back into the plant process circuit or to the waste disposal system. Bermed areas, tank containments, and/or double-walled tanks will perform a similar function for any process chemical vessels located outside the central plant building.

All tanks will be constructed of fiberglass or steel with the exception of the hydrogen peroxide storage tank, which will typically be constructed of aluminum. Instantaneous failure of a tank is unlikely. Tank failure would more likely occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary.

NUREG/CR-6733 analyzed the potential impacts of a failure of a yellowcake thickener resulting in a release of 20% of the contents outside the plant structure. This postulated accident scenario was based on an event at the Irigaray ISR facility in 1994. The event in question was caused by the failure of an inadequate concrete pad supporting the thickener. The subsequent release from the building was a result of the proximity of the thickener to the plant wall. NUREG/CR-6733 concluded that, based on conservative calculations of this unlikely event, the dose to the public would be below the limits in 10 CFR Part 20. The calculations resulted in a dose to an unprotected worker in excess of the exposure limits from 10 CFR Part 20 (i.e., 5 rem). However, this dose estimate was based on a number of unlikely, conservative assumptions. The scenario made the unrealistic assumption that no efforts would be made to clean up the spill, allowing the yellowcake to dry and become transportable. The dose was based on lung clearance class Y uranium, which produces the highest dose estimates. No allowance in the dose calculation was made for the use of protective equipment, including protection factors from the use of respiratory protection equipment.

NUREG/CR-6733 also assessed the potential dose from a catastrophic spill from an ion exchange column resulting in the release of the entire contents of the vessel and the resultant release of radon gas. Based on a number of assumptions, the predicted dose was 1.3 rem in a 30-minute period to a worker in the area. Any change to the Rn-222 concentration or exposure time has a linear affect on dose. For example, if the room size is doubled or the exposure time is halved, then the dose will be halved. NUREG/CR-6733 recommended that the use of ventilation or atmosphere-supplying respirators designed to protect against gases would be sufficient to mitigate doses, that unprotected personnel should evacuate spill areas near ion-exchange columns, and that ISR facilities maintain proper equipment, training, and procedures to respond to large lixiviant spills or ion-exchange column failure.

The Moore Ranch Central Plant will be designed in accordance with standard industry building codes and will incorporate containment adequate to contain the contents of the largest tank in the facility at a minimum. As discussed in Section 4.1, area ventilation will be provided to control concentrations of airborne radioactive material in the central plant. Finally, EMC will prepare spill response procedures, provide spill response equipment and materials, require the use of protective equipment, and will train employees in proper spill response methods.

7.5.2.2 Plant Pipe Failure

The rupture of a pipe within the central plant will be easily detected by operating staff and can be quickly controlled. Spilled solution will be contained and managed in the same fashion as for a tank failure.

7.5.3 Groundwater Contamination Risk

7.5.3.1 Lixiviant Excursion

Excursions of lixiviant at ISR facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the mining zone of the ore-body aquifer. A vertical excursion is a movement of solutions into overlying or underlying aquifers.

EMC will control the lateral movement of lixiviant by maintaining well field production flow at a rate slightly greater than the injection flow. This difference between production and injection flow is referred to as process bleed. The bleed solution will either be recycled in the plant or sent to the liquid waste disposal system. When process bleed is properly distributed among the many mining patterns within the wellfield, mining solutions are contained within the monitor well ring.

EMC will monitor for lateral movement of lixiviant using a horizontal excursion monitoring system. This system consists of a ring of monitor wells completed in the same aquifer and zone as the injection and production wells. Monitor wells will be installed as discussed in Section 5.7.8. Monitor wells will be sampled biweekly for approved excursion indicators.

The historical experience at other ISR uranium operations indicates that the selected indicator parameters and UCLs allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected.

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers. EMC will prevent vertical excursions through aquifer testing programs and rigorous well construction, abandonment, and testing requirements. Aquifer testing is conducted before mining wells are installed to detect any leaks in the confining layers. Aquifer test reports are submitted to the WDEQ for review and approval before well construction activities may proceed. Well construction and integrity testing will be conducted in accordance with WDEQ regulations and methods approved by NRC and WDEQ. Construction and integrity testing methods were discussed in detail in Section 3.1. Well abandonment is conducted in accordance with methods approved and monitored by the WDEQ and discussed in detail in Section 6.2.

EMC will monitor for vertical excursions in the overlying aquifer using shallow monitor wells. These wells will be located within the wellfield boundary at a density of one well per four acres. Shallow monitor wells will be sampled biweekly for approved excursion indicators.

7.5.4 Wellfield Spill Risk

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the central plant, would result in a release of injection or production solution which would contaminate the ground in the area of the break. All piping from the central plant, to and within the wellfield will be buried for frost protection. Pipelines will be constructed of high density polyethylene (HDPE) with butt welded joints, or equivalent. All pipelines will be pressure tested at operating pressures prior to final burial and production flow and following maintenance activities that may affect the integrity of the system.

Each wellfield will have a number of headerhouses where injection and production wells will be continuously monitored for pressure and flow. Individual wells may have high and low flow alarm limits set. All monitored parameters and alarms will be observed in the control room via the computer system. In addition, each headerhouse will have a "wet building" alarm to detect the presence of any liquids in the building sump. High and low flow alarms have been proven effective in detection of significant piping failures (e.g., failed fusion weld).

Occasionally, small leaks at pipe joints and fittings in the headerhouses or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. EMC will implement a program of continuous wellfield monitoring by roving wellfield operators and will require periodic inspections of each well that is in service. Small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in soil contamination. Following repair of a leak, EMC will require that the affected soil be surveyed for contamination and the area of the spill documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Contamination may be removed as appropriate.

7.5.5 Transportation Accident Risk

Transportation of hazardous materials to and from the Moore Ranch Project can be classified as follows:

- Shipments of uranium-laden resin from the Moore Ranch Central Plant to a licensed facility for toll "milling" and return shipments of barren, eluted resin. Resin will be transported in tank trucks to a nearby licensed facility for elution, precipitation, and drying.

- Shipments of dried yellowcake. Yellowcake will be transported in 208-L (55-gal.) drums to a distant conversion facility for refining and conversion. Conversion facilities are currently located in Metropolis, Illinois and Port Hope, Ontario, Canada.

- Shipments of process chemicals or fuel from suppliers to the site.

- Shipment of radioactive waste from the site to a licensed disposal facility.

Accident risks involving potential transportation occurrences and mitigating measures are discussed in the following sections.

7.5.5.1 Accidents Involving Ion Exchange Resin Shipments

A potential transportation risk associated with operation of the Moore Ranch Project as a uranium extraction plant using toll "milling" at another licensed processing facility is the transfer of the ion exchange resin to and from the plant. Loaded ion exchange resin would be transported from the Moore Ranch Project in a 4,000 gallon capacity tanker trailer. It is currently anticipated that up to four loads of uranium-laden resin may be transported for elution and up to four loads of barren eluted resin may be returned on a daily basis. The transfer of resin will occur on a combination of private, county and State roads. For shipments of ion exchange resin to a central processing facility, NRC determined that the probability of an accident involving such a truck was 0.009 in any year[12].

Resin or eluate shipments will be treated similarly to yellowcake shipments in regards to Department of Transportation (DOT) and USNRC regulations. Shipments will be handled as Low Specific Activity (LSA) material for both uranium-laden and barren resin. General shipping procedures are outlined as follows:

- The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond signs.

- A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified shall be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index and the package identification number.

- Before each shipment of loaded or barren eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.

- Properly licensed and trained drivers will transport the resin between the Moore Ranch Project and the toll "milling" facility.

EMC will develop an emergency response plan for yellowcake and other transportation accidents to or from the Moore Ranch Project. EMC personnel will receive training for responding to a transportation accident.

The worst case accident scenario involving resin transfer transportation would be an accident involving the transport truck and tanker trailer when carrying uranium-laden resin where all of the tanker contents were spilled. Because the uranium is ionically-bonded to the resin and the resin is in a wet condition during shipment, the radiological and environmental impacts of such a spill are minimal. The radiological and environmental impact of a similar accident with barren, eluted resin would be less significant. The primary environmental impact associated with either accident would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. Areas impacted by the removal of soil would be revegetated.

In the event of a transportation accident involving the resin transfer operation, EMC will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

- Each truck will be equipped with a communication device that will allow the driver to communicate with either the shipper or receiver. In the event of an accident and spill, the driver will be able to communicate with either site to obtain help.

- A check-in and check-out procedure will be instituted where the driver will notify the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, an emergency response team will respond and search for the vehicle. This system will assure reasonably quick response time in the case that the driver is incapacitated in the accident.

- Each resin transport vehicle will be equipped with an emergency spill kit which the driver can use to begin containment of any spilled material. The kit will include plastic sheeting to cover spilled material until cleanup operations can begin.

- Both the shipping and receiving facilities will be equipped with emergency response kits to quickly respond to a transportation accident.

- Personnel and truck drivers will have specialized training to handle an emergency response to a transportation accident.

7.5.5.2 Accidents Involving Yellowcake Shipments

NUREG-0706 concluded that the probability of a truck accident involving shipments of yellowcake in any year is 11 percent for each uranium extraction facility. This calculation used average accident probabilities (4.0 x 10^{-7}/km for rural interstate, 1.4 x 10^{-6}/km for rural two-lane road, and 1.4 x 10^{-6}/km for urban interstate) that NUREG/CR-6733 determined were conservative.

As with resin shipments, yellowcake shipments will be made in accordance with DOT and USNRC regulations. Shipments will be handled as Low Specific Activity (LSA) material and will follow the same general shipping procedures as outlined for ion exchange resin shipments in Section 7.5.5.1.

The worst case accident scenario involving yellowcake transportation would be an accident involving the transport truck where the integrity of one or more drums containing yellowcake was breached, resulting in a release to the environment. Unlike ion exchange resin shipments, ISR operators do not typically transport their own yellowcake to conversion facilities but rather contract with transport companies that specialize in shipments of yellowcake. These companies have extensive emergency response programs including spill response equipment on board, drivers trained in radiological emergency response, constant monitoring of truck location and operating parameters, and standing contracts with environmental emergency response contractors for cleanup of spills. As with ion exchange resin, the primary environmental impact associated with an accident involving the spill of yellowcake would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure.

7.5.5.3 Accidents Involving Shipments of Process Chemicals

It is estimated that approximately 4 bulk chemical, fuel, and supply deliveries will be made per working day throughout the operational life of the project. Types of deliveries will include carbon dioxide, oxygen, salt, soda ash, hydrogen peroxide, ammonia, sulfuric acid, and fuel. All shipment will be made in accordance with the applicable DOT hazardous materials shipping provisions.

7.5.5.4 Accidents Involving Radioactive Wastes

Low level radioactive 11(e).2 by-product material or unusable contaminated equipment generated during operations will be transported to a licensed disposal site. Because of the low levels of radioactive concentration involved, these shipments are considered to have minimal potential environmental impact in the event of an accident. Shipments are generally made bulk in sealed roll off containers in accordance with the applicable DOT hazardous materials shipping provisions.

7.5.6 Accident Risk Associated with Coal Bed Methane Development

The presence of CBM development on the Moore Ranch Project site presents accident risks that are not commonly associated with ISR mining. These additional accident risks, the control methods that the CBM operators currently have in place, additional control measures proposed by EMC, and the potential effect of accidents on the health and safety of EMC employees and the public and the security of licensed material are discussed in the following sections. The potential accident scenarios that could impact EMC operations are based on those analyzed by the BLM in the 2003 FEIS for the Powder River Basin.

7.5.6.1 Methane Migration and Seepage

CBM development includes potentially increased risks of methane seepage, fires, or explosions. Methane is not biologically toxic, but high concentrations in confined spaces can displace oxygen and present a danger of fire or explosion.

Methane gas can reach the surface by naturally occurring seepage along fault lines, fractures, or sandstone layers in areas where coal beds are shallow. Gas migration could also be enhanced during CBM development in areas along a coal outcrop, which are not present on the Moore Ranch site. Non-CBM wells that penetrate the coal seam may provide pathways for migration of methane if the casings or plugs are inadequate or faulty or lack isolation through the coal horizons.

The potential for migration of methane in CBM wells is minimized or prevented by the use of the current CBM industry standards for cementing and casing wells that isolate or protect all zones from gas or fluid migration. Well construction methods for CBM wells were discussed in detail in Section 7.2.9.1.

Risks from methane associated with oil and gas wells, including CBM wells, are controlled through the BLM-mandated conditions of approval for the Application for Permit to Drill (APD) that address well conditions, casing, ventilation, and plugging procedures appropriate to site-specific CBM development plans. In addition, CBM operators must have emergency plans and employee training programs that address fire prevention and control measures.

BLM reported in the 2003 FEIS that experience in the Powder River Basin has shown that few cases of methane seeps that involve potentially explosive concentrations of gas have occurred.

7.5.6.2 Pipeline Ruptures

CBM development involves the potential for leaks or ruptures of gas flowlines or pipelines. Most ruptures occur when heavy equipment accidentally strikes the pipeline while operating in close proximity. These ruptures may result in a fire or explosion if a spark or open flame ignites the escaping gas.

Materials used in the pipelines are designed and selected in accordance with applicable standards to minimize the potential for a leak or rupture. Pipeline markers are posted at frequent intervals along the pipelines to warn excavators and to reduce the risk of accidental rupture from excavating equipment. EMC will work with CBM operators located on the proposed license area to ensure that all gas collection and transmission lines within proposed development areas are adequately marked to prevent accidental rupture by EMC activities.

The CBM operators monitor the pipeline flows by either remote sensors or daily inspections of the flow meters. Routine monitoring reduces the probability of effects to health and safety from ruptures by facilitating the prompt detection of leaks. If pressure losses are detected, the wells are shut in until the problem is isolated and addressed.

The projected development area of the Moore Ranch Project includes approximately 2,100 feet of gas pipeline. Based on a statistical average of one significant safety incident per year per 4,154 miles of total pipeline[13], 0.0001 additional pipeline safety incidents (including ruptures) may occur within the license area per year over the life of the project.

Based on the low incident rate, location of pipelines, and the preventative measures planned for the Moore Ranch Project, there is an insignificant increase in risks to human health and safety and control of licensed material associated with potential pipeline ruptures from CBM-related facilities.

7.5.7 Natural Disaster Risk

NUREG/CR-6733 considered the potential risks to an ISR facility from natural disasters. Specifically, the risk from an earthquake and a tornado strike were analyzed. NRC determined that the primary hazard from these natural events was from dispersal of yellowcake from a tornado strike and failure of chemical storage facilities, resulting in the possible reaction of process chemicals. NUREG/CR-6733 recommended that licensees follow industry best practices during design and construction of chemical facilities. EMC is committed to following these standards.

The Moore Ranch Project is located in Campbell County Wyoming, in which 69 tornadoes touch downs were recorded in a period from 1950 through 2003[14]. Of those, 65 tornadoes were classified as F0 (with wind speeds of 40-72 miles per hour and described as a gale tornado) or F1 tornadoes (described as moderate with wind speeds of 73-112 miles per hour). Four of the 69 tornadoes were classified as F2 with wind speeds of 113-157 miles per hour and described as significant tornadoes. Based on the Fujita Scale, the type of damage that can be expected from an F2 tornado is roof damage, unsecured mobile homes pushed off foundations, and light structures severely damaged or destroyed. Based on maximum wind speed probability, the eastern third of the state can expect a tornado between 10,000 and 100,000 years,

NUREG-0706 estimated the probability of occurrence of a tornado in the area in which the project is located is about 3 x 10^{-4} per year. The area was categorized as Region 3 in relative tornado intensity. For this category, the wind speed of the design tornado was 240 mph (F4 tornado), of which 190 mph is rotational and 50 mph is translational. The Moore Ranch structures are not designed to withstand a tornado of this intensity.

The nature of the operation is such that little more could be done to secure the facility with advance warning than without it. NUREG-0706 postulated a "no warning" tornado. It was conservatively assumed that a maximum inventory of 50 short tons of yellowcake was onsite when the tornado strikes, and that 15% of the contained material was released. In this analysis, NRC assumed that the tornado lifts about 25,100 lb of yellowcake (equivalent to the contents of twenty-six 55-gallon drums). The conservative model assumed that all of the yellowcake was in a respirable form, was entrained as the vortex passed over the site and upon reaching the site boundary, was dispersed by the trailing winds. The model predicted a maximum exposure at a distance of approximately 2.5 miles from the mill, where the 50-year dose commitment to the lungs of an individual was estimated to be 8.3 x 10^{-7} rem (0.8 mrem). NUREG/CR-6733 reviewed this model scenario and found it to be valid for ISR operations.

NUREG/CR-6733 concluded that tornado risk is very low at uranium ISR facilities and that no design or operational changes were required to mitigate the risk. One recommendation was that chemical storage tanks be located sufficiently far apart that leaks caused by tornado damage would not result in chemical reactions. EMC will institute procedures and provide instructions to operating personnel for response and mitigation of natural disasters and any associated spills of radioactive materials.

7.6 ECONOMIC AND SOCIAL EFFECTS OF CONSTRUCTION AND OPERATION

7.6.1 Construction

The construction phase would cause a moderate impact to the local economy, resulting from the purchases of goods and services directly related to construction activities. Impacts to community services in rural Campbell County or the nearby towns of Midwest and Edgerton in Natrona County, and Wright in Campbell County, such as roads, housing, schools, and energy costs would be minor or non-existent and temporary.

An estimated 50 percent (25 workers) of the construction work force would be based in Campbell County, which contains the Project site. The workforce hired outside of the County would likely be based in Casper, located in the neighboring Natrona County, as Casper is a regional economic hub that provides a variety of construction services and labor for projects located throughout Wyoming.

Most construction work available to the local construction labor pool consists of temporary contract work that varies in duration, depending on the scope of each construction project. Further, the number of unemployed construction workers does not represent the number of workers that would be available to the proposed project from the local construction labor pool. The number is an annual average that does not take into account monthly variations in the available construction labor pool from construction start-ups and completions. Contractors for projects located throughout northeastern Wyoming typically hire from the local construction labor pool. The actual number of construction workers available for the proposed project would potentially draw from the entire construction labor pool of 6,268 (2005 estimate; the construction labor pool as of 2007 is likely to be larger), as construction activities from some active projects would conclude so that workers would be available for future projects.

7.6.2 Operations Workforce

An estimated 40 to 60 people would be required for the operation of the proposed Moore Ranch Project. It is not known how many of the required operations workforce would be hired from outside of Campbell and Natrona Counties. In the event that the entire operations workforce and their families relocated to the counties, the population increase would be a maximum of 150, based on the 2005 average household size of 2.52 in Wyoming. This increase would account for 0.1 percent of the population of Campbell and Natrona Counties, and is smaller than the projected annual growth rate. Therefore, there would be little to no effect to the vacancy rates of any type of housing in Gillette area or Campbell County.

7.6.3 Effects to Housing

The Moore Ranch License Area lies within commuting distance of Gillette and Wright, in Campbell County; and Casper in Natrona County, so that workers from these counties would likely commute from their homes. There would be no impact to temporary housing located within commuting distance (an estimated 1 to 2 hours) of the License Area.

In the event that workers from outside the local area are hired for construction, temporary housing such as motel/hotel rooms and RV sites located within commuting distance would be required, as no on-site housing (man camp) would be available. The available stock of motel/hotel rooms would accommodate relocating workers.

It is recognized, however, that the coal bed methane gas and mineral industries are presently a dominating factor for temporary housing availability in the area, and the workforce employed in these industries occupy much of the temporary housing that becomes available.

It is anticipated that few of the construction work force during any phase of the proposed Project would purchase or rent housing of any type. Therefore, there would be no effects on the costs of any type of housing in the counties. Because rental housing usually require a long-term lease (generally a minimum of 6 months), only operations employees would likely enter into this type of lease agreement. Under a hiring scenario that assumes all of the proposed operations workforce would need to relocate to the area, 40 to 60 housing units would be required over the life of the project. In 2006, there were a total of 60 vacant housing units in Campbell and Natrona Counties, which would not meet the future demand for housing in the counties from anticipated population growth. Therefore, there would be little to no effect to the rental rates of any type of housing in Gillette or Campbell County.

Household projections estimate an increase in households from 2000 to 2030 as 140 percent in Campbell County and 73 percent in Natrona County. The existing housing stock would not accommodate the projected households. Local communities in general are aware of the pressing need for the new residential development.

7.6.4 Effects to Services

It is likely that both the construction and operating work force would be from the Campbell and Natrona Counties, or other nearby counties in northeast Wyoming, and would not require permanent or temporary housing. In the event that up to 50 percent of the construction and operating workforce are non-local workers, it is anticipated that there would be a less than one percent increase in the population of Campbell and Natrona Counties from the permanent relocation of the workers and their families. Most non-local workers would utilize temporary housing. Because existing mobile home and RV parks will be used for a majority of the temporary housing, the Project will not require new water, sewer, electrical lines, or other infrastructure. There will be no additional demands of increases in service levels for local infrastructure, such as police, fire, water, or utilities. In addition, there would be little measurable increase in non-basic employment, as these jobs are generated from ongoing employment of the existing base of construction workers, and would be maintained through the continued employment of local construction workers. Therefore, construction and operation of the Project would not significantly affect the various public and non-public facilities and services described above from the in-migration of workers for non-basic employment opportunities.

7.6.5 Effects to Traffic

The most heavily used public road segment would be State Highway 387 between I-25 to the west and State Highway 59 to the east. Access to Moore Ranch from Gillette would be from State Highway 59, and from Casper would be from I-25. Construction traffic, the construction workforce, and the operations workforce would converge on Moore Ranch on State Highway 387 from the east and the west. The existing traffic levels on the highway are low. The highest levels of project-related traffic would be from the operations workforce, and assuming there would be an average of one employee per vehicle, per one-way vehicle trip, there could be an increase of 5.4 percent in daily traffic along the highway. This 5.4 percent (10.8 percent for two trips per day) increase is well below the 25 percent threshold generally used for predicting significant effects to a transportation system.

Equipment needed for construction and installation of the proposed facility would include heavy equipment (cranes, bulldozers, graders, track hoes, trenchers, and front-end loaders), and heavy- and light-duty trucks. It is anticipated that heavy equipment will be transported primarily to the site during off-peak traffic hours.

7.6.6 Economic Impact Summary

Economic impacts are summarized in the benefit-cost analysis in Section 9.

7.7 ENVIRONMENTAL JUSTICE

The U.S Census 2000 Decennial Population program provides race and poverty characteristics for Census Tracts and Block Groups, which are subdivisions of Census Tracts. The Moore Ranch License Area and the surrounding 2-mile buffer are contained within five Census Tracts and one additional Block Group that encompass portions of Campbell, Converse, Johnson, and Natrona Counties.

As summarized in Table 7.7-1, the combined population of the surrounding Census Tracts was 4,799. Minority populations accounted for a small percentage of the total population, with percentages of minorities generally similar to or smaller than those of the state as a whole.

The State of Wyoming was selected to be the geographic area to compare the demographic data for the population in the affected Census Tracts. This determination was based on the need for a larger geographic area encompassing affected area Census Tracts in which equivalent quantitative resource information is provided. The population characteristics of the affected Census Tracts are compared with Wyoming population characteristics to determine whether there are concentrations of minority or low-income populations in the Census Tracts relative to the state.

The data in Table 7.7-1 show that minority populations in the affected Tracts account for an overall smaller proportion of the population than the proportion of minority populations at the state level. No concentrations of minority populations were identified as residing near the proposed Project facilities, as residents nearest to the Moore Ranch Area are rural populations, while most of the minority population lives in Gillette and communities along the I-25 corridor to the south. There would be no disproportionate impact to minority population from the construction and implementation of the Moore Ranch Project.

With the exception of Census Tracts 9551 in Johnson County and 14.01 in Natrona County, the populations within the Tracts exhibit lower rates of people living below the poverty level than the state. Census Tracts 9551 and 14.01 contain rural populations; therefore, there is no concentration of people living below the poverty level in these Tracts. No disproportionate adverse environmental impacts would occur in populations living below the poverty level within the Census Tracts from proposed Project activities.

Table 7.7-1 Race and Poverty Level Characteristics of the Population in the Moore Ranch Permit Area Census Tracts

	State of Wyoming	Percent of Total State Population	Census Tract 1, Campbell County	Percent of Census Tract 1	Census Tract 9566, Converse County	Percent of Census Tract 9566	Block Group 1, Census Tract 9566, Converse County	Percent of Block Group 1, Census Tract 9566	Census Tract 9551, Johnson County	Percent of Census Tract 9551	Census Tract 14.01, Natrona County	Percent of Census Tract 14.01	Census Tract 18, Natrona County	Percent of Census Tract 18	Total
Total	493,782	100.0	4,779	100.0	2,944	100.0	1,412	100.0	1,918	100.0	3,478	100.0	3,285	100.0	**17,816**
Urban:	322,073	65.2	418	8.7	0	0.0	0	0.0	0	0.0	0	0.0	9	0.3	**427**
Inside urbanized areas	125,706	25.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	0.3	**9**
Inside urban clusters	196,367	39.8	418	8.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	**418**
Rural	171,709	34.8	5,615	117.5	2,944	100.0	1,412	100.0	1,918	100.0	3,478	100.0	3,276	99.7	**18,643**
White alone	454,095	92.0	4,671	97.7	2,805	95.3	1,331	94.3	1,877	97.9	3,284	94.4	3,150	95.9	**17,118**
Black or African American alone	3,126	0.6	1	0.0	6	0.2	3	0.2	1	0.1	11	0.3	8	0.2	**30**
American Indian and Alaska Native alone	11,363	2.3	22	0.5	18	0.6	13	0.9	8	0.4	41	1.2	45	1.4	**147**
Asian alone	2,972	0.6	4	0.1	12	0.4	5	0.4	3	0.2	8	0.2	6	0.2	**38**
Native Hawaiian and Other Pacific Islander alone	232	0.0	2	0.0	1	0.0	1	0.1	0	0.0	8	0.2	2	0.1	**14**
Some other race alone	12,595	2.6	24	0.5	60	2.0	46	3.3	11	0.6	47	1.4	28	0.9	**216**
Two or more races	9,399	1.9	55	1.2	42	1.4	13	0.9	18	0.9	79	2.3	46	1.4	**253**
People who are Hispanic or Latino	31,384	6.4	88	1.8	113	3.8	73	5.2	52	2.7	106	3.0	78	2.4	**510**
Median household income in 1999	37,892	-	55,233	-	47,250	-	44,821	-	40,053	-	38,629	-	45,481	-	na
Per capita income in 1999	19,134	-	21,886	-	22,673	-	19,598	-	20,595	-	15,601	-	21,084	-	na
Population with income in 1999 below poverty level:	54,777	-	398	-	157	-	85	-	241	-	571	-	191	-	**1,643**
Percent below poverty level	11.1%	-	8.3%	-	5.3%	-	6.0%	-	12.6%	-	16.4%	-	5.8%	-	**9.2%**

7.8 REFERENCES

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8 ALTERNATIVES TO PROPOSED ACTION

8.1 NO-ACTION ALTERNATIVE

Under the provisions of the National Environmental Policy Act (NEPA), one alternative that must be considered in each environmental review is the no-action alternative. In this case, the no-action alternative would mean that the NRC would not approve the Moore Ranch application and would not issue a Source Materials License. ISR uranium mining would not occur in the Moore Ranch area and the associated environmental impacts would not occur.

8.1.1 Impacts of the No-Action Alternative

The no-action alternative would result in significant financial impacts to EMC and to Campbell County, Wyoming and the surrounding area. EMC has invested significant resources to develop the Moore Ranch Uranium Project that would be irretrievably lost under the no action alternative. In addition, the no action alternative would adversely affect the economic growth of Campbell County. As discussed in further detail in Section 9, the Moore Ranch Uranium Project is expected to provide a significant economic impact to the local economy.

A decision to not issue a Source Materials License to EMC would leave a large resource unavailable for energy production supplies. Although EMC is continuing to develop estimates of the reserves at Moore Ranch, the current estimated resource is 5.8 million pounds U_3O_8.

In 2006, total domestic U.S. uranium production was approximately 4.7 million pounds U_3O_8[1]. During the same year, domestic U.S. uranium consumption was approximately 67 million pounds U_3O_8[2]. The Moore Ranch project represents an important new source of domestic uranium supplies that are essential to provide a continuing source of fuel to power generation facilities.

In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this license application would result in adverse economic affects on the individuals that have surface leases with EMC and own the mineral rights in the Moore Ranch Project Area.

8.2 PROPOSED ACTION

The proposed Moore Ranch Uranium Project contains a licensed area of approximately 7,110 acres. Of this potential licensed area, the surface area to be affected by mining operations will be less than 150 acres for the central plant and facilities including the wellfields. The Moore Ranch Uranium Project is located in Campbell County, Wyoming within Township 42 North, Range 75 West, Sections 26, 27, 33, 34, 35, 36 and Township 41 North, Range 75 West, Sections 1, 2, 3, and 4, and Township 42 North, Range 74 West, Section 31 between the towns of Wright and Edgerton with access to the project site from Wyoming State Highway 387. The proposed action will consist of construction, operation, and ultimately decommissioning of wellfields, an ion exchange facility, wastewater disposal well(s), and a processing and drying facility.

Commercial production of the reserves at the Moore Ranch Project and subsequent groundwater restoration activities are projected to extend over the next ten years. The minimum projected life of the central plant is projected to be 25 years since EMC plans to use the facility to process ion exchange resin from satellite facilities operated by EMC or others. Aquifer restoration and reclamation at Moore Ranch will be accomplished concurrent with operations to the extent feasible plus an additional two years at the end of the project for final decommissioning of the central plant facilities and surface reclamation in these areas. More detailed schedules were provided in Section 1.

The in-situ process consists of an oxidation step and a dissolution step. The oxidants utilized in the facility are hydrogen peroxide and/or gaseous oxygen. A sodium bicarbonate lixiviant is used for the dissolution step. The uranium-bearing solution is recovered from the wellfield and piped to the central plant for extraction. The central plant process utilizes the following steps:

- Loading of uranium complexes onto an ion exchange resin;
- Reconstitution of the solution before reinjection by the addition of sodium bicarbonate and oxygen;
- Elution, precipitation, drying, and packaging of yellowcake in the central plant; and
- Restoration of groundwater following mining activities.

The operation of the Moore Ranch Project will result in a number of effluent streams. Airborne effluents are limited to the release of radon-222 gas during the uranium recovery process. Liquid wastes are handled through deep well injection.

Groundwater restoration activities consist of three steps:

- Groundwater transfer;
- Groundwater sweep; and
- Groundwater treatment;

Groundwater restoration will take place concurrently with development and production activities. The goal of the groundwater restoration is to return the water quality of the affected zone to a chemical quality consistent with baseline conditions or, as a secondary goal, to the class of use standards specified by the WDEQ.

Following groundwater restoration activities, all injection and recovery wells will be reclaimed using appropriate plugging and abandonment procedures. In addition, a sequential land reclamation and revegetation program will be implemented on the site. This reclamation will be performed on all disturbed areas, including the plant, wellfields, ponds and roads.

EMC will maintain financial responsibility for groundwater restoration, plant decommissioning and surface reclamation. Financial surety is discussed in Section 6.

The environmental impacts of the requested action will be minimal as discussed in Section 7. The only radiological air impacts will be from the release of radon gas during production. The release of radon will be minimized by the use of pressurized downflow ion exchange columns. In addition, radon gas quickly dissipates in the atmosphere and results in a minimal additional exposure to the public as discussed in Section 7. All drying and packaging performed at the Moore Ranch Central Plant will use a vacuum drying system, so there are no additional radioactive air particulate releases.

In situ recovery mining of uranium alters the geochemistry and the water quality in the mining zone. Other operating ISR facilities have proven that impacts to groundwater can be controlled through stringent well construction techniques, wellfield operating methodologies that minimize excursions, and the use of best practicable technologies to restore the groundwater after mining activities are complete. The success of the groundwater protection practices proposed by EMC was discussed in Section 6.

The impacts discussed in Section 7 include short-term and long-term impacts. However, it should be noted that in situ recovery mining technique allows the entire mine site to be decommissioned and returned to unrestricted use within a relatively short time so there are no long-term impacts.

8.3 REASONABLE ALTERNATIVES

8.3.1 Process Alternatives

8.3.1.1 Lixiviant Chemistry

EMC proposes to use a sodium bicarbonate lixiviant that is an alkaline solution. Where the groundwater contains carbonate, an alkaline lixiviant will mobilize fewer hazardous elements from the ore body and will require less chemical addition than an acidic lixiviant. Also, test results at other projects indicate only limited success with acidic lixiviants, while the sodium bicarbonate has proven highly successful at commercial mining operations in the Powder River Basin to date. Alternate leach solutions include ammonium carbonate solutions and acidic leach solutions. These solutions have been used in solution mining programs in other locations. However, operators have experienced difficulty in restoring and stabilizing the aquifer. Therefore these solutions were excluded from consideration.

8.3.1.2 Groundwater Restoration

The success of the groundwater restoration techniques proposed by EMC has been shown at other ISR mining operations in the Powder River Basin. Groundwater sweep, permeate/reductant injection and groundwater treatment have successful restored the groundwater to pre-mining quality. No feasible alternative groundwater restoration method is currently available. The NRC and the WDEQ consider the method currently employed as the Best Practicable Technology (BPT) available.

8.3.1.3 Waste Management

Liquid wastes generated from production and restoration activities are generally managed at ISR facilities by solar evaporation ponds, deep well injection, and/or land application. The use of deep waste disposal well(s) is considered by EMC to be the best alternative to dispose of these types of wastes. The Moore Ranch deep well(s) will isolate liquid wastes generated by the project from any underground source of drinking water (USDW). These wells must be authorized by the State of Wyoming under a Class I UIC Permit. EMC has considered and rejected using solar evaporation ponds and land application as a disposal method at Moore Ranch due to required treatment, monitoring and reclamation costs, and the potential environmental impacts from a surface discharge.

All solid wastes will be properly managed. Non-contaminated solid waste will be disposed in an off site solid waste landfill permitted by the county in which it is located. Contaminated wastes will be shipped to a NRC-approved facility for disposal.

8.4 ALTERNATIVES CONSIDERED BUT ELIMINATED

As a part of the alternatives analysis conducted by EMC, several mining alternatives were considered. Due to the significant environmental impacts and cost associated with these alternative mining methods in relation to the Moore Ranch ore body, they were eliminated from further consideration.

8.4.1 Mining Alternatives

Underground and open pit mining represent the two currently available alternatives to solution mining for the uranium deposits in the project area. In the southern Powder River Basin uranium ore has been mined with open pits in the past. This activity occurred from 1970 to 1984 at the Exxon Highland facility and from the mid-1970s to 1986 at Union Pacific Resources Bear Creek site, both located south of the Moore Ranch site. Ore was also mined with underground mining at the Exxon Highland site, in addition to the open pit method. The Moore Ranch project was originally investigated by Conoco in the late 1970's as an open pit mine. Neither of these methods is economically viable for producing the Moore Ranch reserves at this time.

From an environmental perspective, open pit mining or underground mining and the associated milling process involve higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased not only from the mining process but also from milling and the resultant mill tailings. The milling process generates a significant amount of waste relative to the amount of ore processed. Extensive mill tailings ponds are needed for the disposal of these wastes. The environmental impacts associated with open pit and underground mining are generally recognized as being considerably greater than those associated with in-situ recovery mining.

In a comparison of the overall impacts of ISR mining of uranium compared with conventional mining, an NRC evaluation[3] concluded that environmental and socioeconomic advantages of in situ recovery include the following:

1. Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much less.

2. No mill tailings are produced and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by ISR methods is generally less than 1% of that produced by conventional milling methods (more than 948 kg (2090 lb) of tailings usually result from processing each metric ton (2200 lb) of ore).

3. Because no ore and overburden stockpiles or tailings pile(s) are created and the crushing and grinding ore-processing operations are not needed, the air exposure problems caused by windblown dusts from these sources are eliminated.

4. The tailings produced by conventional mills contain essentially all of the uranium daughter products including radium-226 that are originally present in the ore. By comparison, less than 5% of the radium in an ore body is brought to the surface when ISR methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings and the potential for radiation exposure is significantly less than that associated with conventional mining and milling.

5. By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire mine site can be returned to unrestricted use within a relatively short time.

6. Solution mining results in significantly less water consumption than conventional mining and milling.

7. The socioeconomic advantages of ISR include:

   - The ability to mine a lower grade ore,
   - A lower capital investment,
   - Less risk to the miner,
   - Shorter lead time before production begins, and

- Lower manpower requirements.

8.5 CUMULATIVE EFFECTS

8.5.1 Future Development

EMC has other potential resource areas identified in the Powder River Basin that may be developed as satellite facilities to the Moore Ranch Central Plant. Development of these facilities is dependent upon further site investigations by EMC and the future of the uranium market. If conditions warrant, EMC may submit license amendment requests to permit development of these additional resources. EMC currently projects that development of these areas would be primarily intended to maintain production allowed under the proposed license as reserves in the Moore Ranch site deplete.

8.6 COMPARISON OF THE PREDICTED ENVIRONMENTAL IMPACTS

Table 8.6-1 provides a summary of the environmental impacts for the no-action alternative (Section 8.1), the preferred alternative (Section 8.2), and the process alternatives (Section 8.3). The predicted impacts for the mining alternatives discussed in Section 8.4 are not included for comparison because these alternatives were rejected due to significant environmental and economic impacts. Environmental impacts were discussed in greater detail in Section 7.

Table 8.6-1: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Land Surface Impacts	None	Minimal temporary impacts in wellfield areas; Significant surface and subsurface disturbance confined to a portion of the Central Plant site.	Same as Preferred Alternative.	Same as Preferred Alternative. Potential additional impacts from land application of treated waste water.
Land Use Impacts	None	Loss of agricultural production (livestock grazing) in the impacted area for duration of project.	Same as Preferred Alternative.	Same as Preferred Alternative plus additional land use impact from installation of evaporation ponds and/or land application areas.
Transportation Impacts	None	Minimal impact on current traffic levels.	Same as Preferred Alternative.	Same as Preferred Alternative.
Geology and Soil Impacts	None	No geologic impacts. Minimal temporary soil impacts in disturbance areas from wind and water erosion.	Same as Preferred Alternative.	Same as Preferred Alternative. Potential additional impacts to soils from land application of treated waste water.
Surface Water Impacts	None	None	None	None
Groundwater Impacts	None	Consumption of mining zone groundwater for control of mining solutions and restoration	Same as Preferred Alternative. Increased difficulty with groundwater restoration and stabilization.	Same as Preferred Alternative.

Table 8.6-1: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Ecological Impacts	None	No substantive impairment of ecological stability or diminishing of biological diversity.	Same as Preferred Alternative.	Same as Preferred Alternative.
Air Quality Impacts	None	Additional total dust emissions of 15.5 tons per year due to vehicle traffic on gravel roads.	Same as Preferred Alternative.	Same as Preferred Alternative.
Noise Impacts	None	Barely perceptible increase over background noise levels in the area.	Same as Preferred Alternative.	Same as Preferred Alternative.
Historic and Cultural Impacts	None	None	None	None
Visual/Scenic Impacts	None	Moderate impact; noticeable minor industrial component.	Same as Preferred Alternative.	Same as Preferred Alternative plus additional visual and scenic impacts installation of evaporation ponds and/or land application areas.
Socioeconomic Impacts	Loss of positive economic impact of $28.8M and 601 temporary and permanent jobs to Campbell County and the surrounding area	Annual direct economic impact of $28.8M and 601 temporary and permanent jobs to local area	Same as Preferred Alternative.	Same as Preferred Alternative.
Nonradiological Health Impacts	None	None	None	None

Table 8.6-1: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Radiological Health Impacts	None	Estimated maximum dose from radon gas released at Moore Ranch at the project boundary is 0.8 mrem/yr or 0.8% of the public dose limit.	Same as Preferred Alternative.	Same as Preferred Alternative.
Waste Management Impacts	None	Generation of additional liquid and solid waste for proper disposal.	Same as Preferred Alternative. Mobilization of additional hazardous elements in lixiviant requiring disposal.	Generation of additional 11e.(2) byproduct material from decommissioning evaporation ponds.
Mineral Resource Recovery Impacts	Loss of a valuable domestic energy resource. EMC estimated reserves are under development but the current estimated recoverable resource is 5.8 million pounds with a current spot market value of $522 million (based on $90/lb).	Recovery and use of a domestic energy resource.	Same as Preferred Alternative.	Same as Preferred Alternative.

REFERENCES

[1] Energy Information Administration, *Summary Production Statistics of the U.S. Uranium Industry*, www.eia.doe.gov/cneaf/nuclear/dupr/usummary.html accessed August 14, 2007.

[2] Energy Information Administration, *2006 Uranium Market Annual Report*, www.eia.doe.gov/cneaf/nuclear/umar/umar.html, accessed August 14, 2007.

[3] U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to the Operation of the Teton Project*, NUREG-0925, June 1982. Para. 2.3.5.

9 BENEFIT-COST ANALYSIS

9.1 BENEFIT-COST ANALYSIS GENERAL BACKGROUND

Benefit-cost analysis (BCA) has established that the proposed development of a new uranium in-situ recovery facility at the Moore Ranch Project is potentially a cost-effective project to undertake and will provide a net economic benefit to the State of Wyoming.

This analysis has been specifically tailored to meet the requirements established by the Nuclear Regulatory Commission (NRC) NUREG 1569, and includes a description of the economic benefits from the construction and operation of the proposed Moore Ranch Project and a discussion of the temporary and long-term external costs. Where possible, benefit and cost estimates are monetized; however, reliable monetary estimates for some potential impacts are not readily available so the narrative examines several factors in non-monetary or qualitative terms.

The following analyses use IMPLAN (IMpact Analysis for PLANning), a standard industry software package that models the economic impacts of capital intensive projects, to calculate the potential economic impacts to the county. It was originally developed by the United States Department of Agriculture (USDA) Forest Service in cooperation with the Federal Emergency Management Agency (FEMA) and the United States Department of the Interior (USDI) Bureau of Land Management (BLM) for land and resource management planning (IMPLAN 2004). Currently, it is being managed by the Minnesota IMPLAN Group, Inc. (MIG).

9.2 ALTERNATIVES AND ASSUMPTIONS

BCA is widely used analytical tool for helping decision makers determine whether the cost of a project today will result in sufficient benefits to justify expenditure on a capital intensive project (Brown 2003; Zerbe and Bellas 2006). To provide value and to assist in the decision process, the BCA needs to be clear about the alternatives being considered and the underlying assumptions including quantities of goods, labor costs, market conditions and discount rates used to compute net present value. The following discussion briefly identifies alternatives and key assumptions used throughout the analysis.

9.2.1 Development Alternatives

This BCA evaluates the benefits and costs of building the Moore Ranch Project and all the costs and benefits resulting from its ongoing operation in Campbell County, Wyoming. The BCA tradeoff under consideration involves comparing a future with the proposed Moore Ranch Project to a future that represents a continuance of the no action.

9.2.1.1 No Action Alternative

Under the no action alternative, there would be no change in the current land cover or land and water uses at the site; therefore, there would be no change in the existing underlying socioeconomic and demographic trends.

9.2.1.2 Proposed Action

The proposed action involves the construction and operation of a uranium in-situ recovery (ISR) facility. ISR involves leaving the ore where it is in the ground and using liquids which are pumped through it to recover the minerals out of the ore. Consequently, the proposed action involves limited surface disturbance at the Moore Ranch Project and no tailings or waste rock would be generated.

9.2.2 Key Assumptions and Limitations

Key assumptions about the costs and benefits associated with the proposed Moore Ranch Project involve: (1) The Operating Life of the project; (2) the Discount Rate used; (3) the Scope of the Impact; and (4) Non-monetary Impacts. Each of these is described in more detail below.

9.2.2.1 Operating Life of Moore Ranch Project

The Moore Ranch Project will be a single unit of analysis including the wellfields, central plant, and outlying related structures. For this analysis, the total effective life of the Project is assumed to be 27 years. Within this time frame, there are three distinct phases of operation with a distinct suite of costs and benefits:

- 2 years of site development and facility construction (1 year for initial construction and 1 year for construction related to plant expansion during operations some time in the future)

- 10 years of wellfields and central plant operation
- 15 years of the central plant continuing operation after decommissioning the wellfields.

9.2.2.2 Discount Rate

Computing the net present value (NPV) of the proposed Moore Ranch Project requires that future benefits and costs be discounted. This discounting reflects the time value of money that benefits and costs are worth more if they are expected sooner. Following guidelines established by circular A-94 from the United States Office of Management and Budget (OMB), net present value estimates of benefits and costs are reported using a real discount rate of 7 percent (OMB 1992). Circular A-94 was revised in 1992 based on extensive review and public comment and currently reflects the best available guidance on standardized measures of costs and benefits. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years.

9.2.2.3 Scope of impact

A critical step in any BCA is establishing a viable scope of impact and thus establishing who will be affected by the Moore Ranch Project (Zerbe and Bellas 2006). As a practical matter the proposed project would be limited to the potential impact it may have on Campbell County.

9.2.2.4 Non-monetary Impacts and Benefit-Cost Ratio

Conventional BCA uses monetary values to compare goods and services derived from a project or program. The values of goods and services represent their relative importance so that if the total value of the benefits is greater than the total value of the costs, the Moor Ranch Project is desirable. The standard result is a quantified benefit-cost ratio (BCR), equal to a project's total net benefits divided by its total cost. BCR's above one have positive net economic impacts. While many inputs in the Moore Ranch Project BCR are goods and services (skilled labor, construction material) that are regularly traded in markets at well known and predictable prices, others (changes to land or water, aesthetic impacts) are not directly traded and are more difficult to value. Where reliable monetary values are not available a qualitative approach based on the best available information is required.

9.3 ECONOMIC BENEFITS OF PROJECT CONSTRUCTION AND OPERATION

This section considers the potential economic impacts resulting from construction and operation-related activities over the life of the Moore Ranch Project. Economic benefits are those that have the potential to affect the local economy, including the number of jobs created and state and local tax revenues generated from project related business activities.

These analyses use IMPLAN to calculate the potential economic impacts to Campbell County. IMPLAN allows the user to build an input-output model tailored to model the potential impact of a proposed project on a specific community or region. The system is flexible and contains a database of over 500 industrial sectors gathered from counties throughout the United States. By identifying the location and industrial sector of the project (i.e., construction and mining), the analyst can therefore estimate the total potential economic impact of a given project. The model requires labor and capital expenditures data as inputs in order to evaluate the potential economic impacts of the project. The output is the potential direct and indirect employment impacts and generated tax revenue.

This analysis focuses on Campbell County, Wyoming and two economic sectors most closely associated with the distinct phases of the proposed Moore Ranch Project: new construction (IMPLAN code 41) and support activities for mining (IMPLAN code 29). Unfortunately, IMPLAN does not currently have a uranium mining sector for Campbell County, so all tax revenue estimates drawn from IMPLAN should be treated as lower-bound estimates given that ad valorem and severance taxes will likely differ for different mining sectors.

9.3.1 INPLAN Input Data

This analysis assumes that the Moore Ranch Project begins in 2009 for initial construction and construction activities take place through late 2009. The second year of construction will occur at a later time during operations for plant expansion and is not included in this analysis. The total estimated number of construction workers employed directly by the applicant is 50 per year, of which 25 (50 percent) would likely be from Campbell County. Construction capital expenditures are estimated at $50 million (including initial construction and future plant expansion), or $25 million per year for the duration of the initial construction period (Table 9.3-1).

Following one year of facility construction, the wellfields and central plant would be fully-operational, employing 60 full-time workers per year for the first 10 years. After completion of mining and restoration activities, 40 full-time workers will be required for continuing plant operations, accepting loaded ion exchange resin from satellite facilities for processing. Approximately 30 (50 percent) of workers would be located in Campbell County. The Moore Ranch Project has the potential to incur up to $12 million in non-payroll-related operating costs annually for the first 10 years, and $1.8 million thereafter.

Table 9.3-1 Input Data for the Moore Ranch Project

Activities	IMPLAN Code	Per Year		
		2008 - 2009	2010 - 2019	2020 - 2034
Construction Expenditures				
Non-payroll[1]	41	$25 M	NA	NA
Payroll[2]	41	25 workers	NA	NA
Operations Expenditures				
Non-payroll	29	NA	$12 M	$1.8 M
Payroll	29	NA	30 workers	20 workers

[1] Does not include land purchase cost
[2] Limited to Campbell County

9.3.2 Employment Benefits

Using the above assumptions, Table 9.3-2 summarizes the potential employment-related effects generated by the Moore Ranch Project. IMPLAN defines employment as total wage and salary employees, including self-employed jobs that are related to the proposed project. It also includes both full-time and part-time workers and is measured in annual average jobs.

Table 9.3-2 also shows the potential direct, indirect and induced effects on county-wide employment. The direct employment effects refer to the employment directly generated by the Moore Ranch Project. For the initial construction phase in years 2008 to 2009, the model estimated 285 additional non-payroll workers hired in Campbell County per year based on the 25 payroll workers engaged directly in construction activities, and the $25 million of non-wage capital expenditures incurred by the Moore Ranch Project per year.

Potential indirect effects pertain to the inter-industry effects from the direct effects and could include increased labor demand, goods and services required to support the Moore Ranch Project (such as restaurant and hotel staff). In addition, new workers living within Campbell County would spend their income locally which induces additional income and employment. Construction workers living in the county for the construction period would purchase local goods and services which help generate additional employment. The sum of potential direct, indirect and induced effects represents the total potential employment impacts of the Moore Ranch Project.

These results indicate that the Moore Ranch Project is expected to create 401 additional jobs per year for the first year of intensive construction, 147 additional jobs per year in the next 10 years during full operation, and 53 additional jobs per year in the last 15 years of operation. It is important to note that the total potential economic impacts from the Moore Ranch Project could extend to the surrounding areas of Converse, Natrona and Johnson counties. As a result, the total potential employment impacts predicted by this analysis are conservative.

Table 9.3-2 Employment Effects of the Moore Ranch Project in Campbell County

Years	Employment per Year			
	Direct	Indirect	Induced	Total
2008 - 2009	285	59	57	401
2010 - 2019	75	38	34	147
2020 - 2034	27	14	12	53

9.3.3 State and Local Tax Revenue Benefits

In addition to aggregate employment effects, IMPLAN provides an estimate of expected state and local tax revenue impacts over the life of the Moore Ranch Project associated with mining activities. In order to remain consistent with the scope of impact, Federal taxes are not included in this analysis. The results standardized to 2007 dollar equivalents using the OMB recommended real discount rate of 7 percent are presented in Table 9.3-3.

Potential state and local tax implications associated with the proposed Project are presented in Table 9.3-3. While IMPLAN includes employee and employer social insurance taxes as well as personal tax items like income tax, property tax and motor vehicle license tax, these tax revenues are not reported here because they are paid by county workers and their families and thus represent a transfer of wealth rather than a net economic gain. Conversely, corporate dividend taxes and the indirect business tax category associated with the proposed Project consist of tax items such as property tax, sales tax and a state-levied severance tax on uranium production. These revenues stem directly from the construction and operation of the Moore Ranch Project, are paid by the operator of the proposed Moore Ranch Project, and therefore can be counted as net economic gains when compared to the no action alternative.

As table 9.3-3 shows, the results from the IMPLAN analysis show that the construction and operation of the Moore Ranch Project is expected to generate a net present value of approximately $8.0 million in total enterprise and business tax revenues over the life of the Moore Ranch Project.

Table 9.3-3 State and Local Tax Revenue IMPLAN Projections

	Net Present Value ($ Millions) *		
Activities	**Enterprise (Corporate) Tax**	**Indirect Business Tax**	**Total Taxes**
Construction	0.2	1.2	1.4
Operations	1.3	5.3	6.6
Total	1.5	6.5	**8.0**

*2007 DOLLAR EQUIVALENTS

Additionally, severance taxes associated with uranium mining in Campbell County are levied by the State of Wyoming, Mineral Tax Division of the Department of Revenue. The current uranium severance tax is 4% of taxable market value coming from mining operations (Wyoming Department of Revenue—Mineral Tax Division 2007). Current resource estimates for the proposed project are 5.8 million lbs (43-101 compliant). This does not include reserve estimates as these projections are not yet complete. Assuming that the identified 5.8 million lbs were sold at current market prices of approximately $90 per pound, the severance tax would yield approximately $20,800,000 in net economic benefits over the life of the operation.

In sum, the results show that $28.8 million net quantifiable economic benefits can be linked to the proposed project. It is noted that this figure represents a lower bound estimate as it excludes potential reserve resources and does not include potential benefits derived from taxes on royalties or lease payments to local landowners stemming from the operation of the proposed Moore Ranch Project.

9.4 EXTERNAL COSTS OF PROJECT CONSTRUCTION AND OPERATION

In this section of the analysis, external costs of the proposed Moore Ranch Project are identified and compared to the no action alternative. Both short-term and long-term external costs that may affect the interest of people other than the owners and operators of the proposed Moore Ranch Project are also identified and described.

9.4.1 Short Term External Costs

9.4.1.1 Housing Shortages

Approximately 50 percent of the total construction and operating work force for the proposed Moore Ranch Project would likely come from Campbell County. The remaining workforce would likely be based in Casper, located in neighboring Natrona County. The IMPLAN model results show that in 2008-2009, the Moore Ranch Project is expected to generate 401 new jobs due to construction-related activities. In 2010, 147 new jobs are generated for operations-related activities, which are expected to continue until 2019. In 2020, 53 jobs would be needed for central plant operations.

Since the Moore Ranch Project lies within commuting distance of Natrona County, no impacts on the housing situation in nearby cities or towns are anticipated. In the event that workers from out-of-state are hired for the short-term construction phase of the Moore Ranch Project, the present available stock of motel/hotel rooms would accommodate the temporary workers.

In the event that the entire direct payroll and non-payroll workforce relocated to Campbell County, the population increase would be a maximum of 718 for the first phase, 189 for the second phase and 68 for the final phase of operation, based on the 2005 average household size of 2.52 in Wyoming. This increase would account for 2.5 percent of the population of Campbell County as of 2006, thereby posing little or no change from the no action alternative on housing needs in the area.

9.4.1.2 Impacts on Schools and Other Public Services

Two schools are located in Campbell County approximately 22 miles northeast of the Moore Ranch Project area: Cottonwood Elementary School and Cottonwood High School. The total enrollment in the elementary school increased by only 13 percent from 2002 to 2006. The total enrollment for the high school decreased by 15 percent over the same period. The elementary school currently has a student-to-teacher ratio of 12.5 to 1, while the high school has a ratio of 9.7 to 1. In the neighboring Natrona County, the Midwest School provides classes for students from preschool through grade 12. It has a student to teacher ratio of 9.4 to 1.

Families moving into the Campbell County School District as a result of the proposed Moore Ranch Project are not expected to significantly stress the current school system because it is presently under-capacity. Likewise, there is no significant change anticipated from the no action alternative in the demand for other public services such as fire, police, water and utilities. The maximum population increase resulting from the permanent migration of workers into Campbell County represents only 2.5 percent of the population.

9.4.1.3 Impacts on Noise and Congestion

There are no occupied housing units in the vicinity of the proposed Project. Open rangeland is the primary land use within and in the surrounding 2.0-mile area. Other land uses include oil and gas production facilities, as well as pastureland located to the west of the Project area. As a result of the remote location of the Project and the low population density of the surrounding area, impact to noise or congestion within the Project area or in the surrounding 2.0-mile area are not anticipated. Additionally, given the maximum increase in population due to migrant workers is insignificant, noise and congestion impacts are not anticipated in Campbell or other neighboring counties.

9.4.2 Long Term External Costs

9.4.2.1 Impairment of Recreational and Aesthetic Values

While opportunities for developed and dispersed recreation exist throughout the five-county region surrounding the Moore Ranch Project, there are currently no recreational uses within the Moore Ranch Project area or in the surrounding 2.0-mile area, and no developed recreation opportunities are provided on federal and state lands within a 50 mile radius of the proposed Moore Ranch Project. Most developed recreation opportunities offered by the private sector are community facilities in townships or urban areas for tourist services and facilities.

The physical remoteness of the proposed Moore Ranch Project and its lack of proximity to any well recognized federal or state sites of recreational interest indicated that there are no significant long-term impairments to recreational values from developing the Moore Ranch Project.

9.4.2.2 Land Disturbance

The Moore Ranch Project area has been used historically for grazing, prospecting and oil and gas development; therefore, it is unlikely that any undisturbed land area currently exists within the proposed Moore Ranch Project area. A significant, pre-existing human footprint on the landscape is evident in existing grazing activities and facilities (stock tanks, fences), oil production facilities, natural gas production facilities, and infrastructures that support these activities. Oil and gas field infrastructure within the Moore Ranch Project area and the surrounding 2.0-mile review area includes access roads, overhead electric distribution lines, and cleared rights-of-way for underground utilities, which are generally found along access roads. There would be negligible changes in land cover or land use from existing conditions outside of the 2.0-mile review area.

As the proposed Project would use in-situ recovery instead of conventional surface mining techniques, there would be limited land surface disturbance associated with the wellfield development and operation of the site. Land surface disturbance associated with wellfield development would also be short term as interim stabilization with native vegetation species is implemented as soon as construction activities are complete and maintained through the life of the wellfield. No tailings or waste rock would be generated. The Central Plant and private access roads would be confined to clearly delineated areas within the Moore Ranch Project area. While there would be some land use changes from the existing condition within the Moore Ranch Project area, potential impacts will be minimal.

9.4.2.3 Habitat Disturbance

Currently, there is no federally or state designated wildlife habitat located within the proposed Moore Ranch Project area. As the Moore Ranch Project area has been historically used extensively for livestock grazing and oil and gas development, there are no anticipated long-term losses to wildlife or wildlife habitat relative to the existing conditions resulting from the construction and operation of the proposed Moore Ranch Project.

9.4.3 Groundwater Impacts

It is unlikely that any future irrigation development would occur within the proposed Moore Ranch Project area due to limited water supplies, topography, and climate. Irrigation within the 2.0-mile review area is anticipated to be consistent with the past. Based on population projections, future water use within the 2.0-mile review area would likely be a continuation of present use; therefore, it is anticipated that there would be no significant changes from the existing conditions for public water supply in the area.

Following standard mining practice, any impacted water drawn from the aquifer on site would either be treated before re-injection or disposed through deep well injection. Upon decommissioning, wells would be sealed and remaining groundwater would be restored as discussed in Section 6. The goal of the groundwater restoration program would be to return the groundwater to a quality consistent with pre-mining use. Prior to mining in each mining unit, baseline groundwater quality would be determined. This data would be established for each wellfield at the minimum density of one production or injection well per four acres. Upon completion of restoration, a groundwater stabilization monitoring program would begin in which the restoration wells and any monitor wells on excursion status during mining operations would be sampled and analyzed for the restoration parameters.

Given the historically limited irrigation, the lack of domestic groundwater use, and the groundwater restoration program associated with the proposed Moore Ranch Project, there would be no permanent commitment of water resources required and any potential long-term changes from the no action groundwater conditions would be limited to those identified and addressed in the groundwater restoration program.

9.4.4 Radiological Impacts

As the proposed Moore Ranch Project would be using in-situ recovery techniques, most of the identified radioactivity in the orebody would remain permanently underground. Following standard ISR procedures, routine operational monitoring of air, dust and surface contamination would be undertaken by EMC as discussed in Section 5. Prior to central plant decommissioning, a preliminary radiological survey would be conducted to identify any potential radiological hazards. The survey will also support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities.

Decommissioning of process facilities would be scheduled only after agency approval. This would be accomplished in accordance with an approved decommissioning plan and the most current applicable USNRC rules and regulations, permit and license stipulations and amendments in effect at the time of the decommissioning activity.

All process or potentially contaminated equipment and materials at the process facility including tanks, filters, pumps, piping, etc., would be designated for one of the following removal alternatives:

- Removal to a new location within the Moore Ranch Project area for further use or storage;
- Removal to another licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release, sale or other non-restricted use by the landowners and others.

It is likely that process buildings would be dismantled and moved to another location or to a permanent licensed disposal facility. Cement foundation pads and footings would be broken up and trucked to a local disposal site or to a licensed facility if contaminated. The landowners may request that a building or other structures be left on site for future use. In that case, the building would be decontaminated to meet unrestricted use criteria. At the present time, burial of non-contaminated wastes on site is not anticipated.

Under the proposed operating and decommissioning conditions, the potential long-term external radiological impacts at the Moore Ranch Project are anticipated to be negligible compared to the existing background no action conditions.

9.5 BENEFIT-COST SUMMARY

A primary economic benefit of the Moore Ranch Project is the creation of 601 new job opportunities within the county, including the direct, indirect and induced employment effects over the construction and operating life of the Moore Ranch Project (Table 9.5-1). Additionally, the Moore Ranch Project may generate up to $28.8 million in total state and local business tax revenues over the life of the Moore Ranch Project, which is a significant economic gain compared to the no action alternative.

Table 9.5-1 further shows that the short-terms effects on housing, schools and public facilities and the increased potential for noise and congestion in the county involve little or no change compared to the current conditions. Based on the historical land uses, physical remoteness and proposed reclamation practices, no potential quantifiable long-term impairments appear to significantly offset the benefits of the proposed Moore Ranch Project.

The proposed Moore Ranch Project is likely to place negligible short-term or long-term cost burdens on the county, while providing increased revenue and employment opportunities; therefore, the development and operation of the proposed Moore Ranch Project would provide a net economic benefit to Campbell County when compared to the no action alternative.

Table 9.5-1 Summary of Benefits and Costs for the Moore Ranch Project

Benefits	Costs
• **Tax revenue** $28.8 million • **Temporary and permanent jobs** 601 jobs	• **Housing impacts** Little or no change • **Schools and Public Facilities** Negligible • **Noise and Congestion** None • **Impairment of recreational and Aesthetic values** Negligible • **Land Disturbance** Minor • **Groundwater impacts** Controlled through mitigation • **Radiological Impacts** Controlled through mitigation

9.6 REFERENCES

Campbell, H. and R. Brown. 2003. Benefit-Cost Analysis: Financial and Economic Appraisal Using Spreadsheets. New York: Cambridge University Press.

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U.S. Office of Management and Budget (OMB). 1992. Circular No. A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs.

Wyoming Department of Revenue—Mineral Tax Division 2007. Severance Tax Report for Uranium Form 5200.

Zerbe, R. O. and A.S. Bellas. 2006. A Primer for Benefit-Cost Analysis. Northampton, MA: Edward Elgar.

10.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

Various permits and approvals from numerous Federal and State agencies will be required for the Moore Ranch Project to operate. Section 10.1 identifies the issuing agencies, a description of the type of permit(s), license or approvals needed, and the current status of securing these approvals.

10.1 APPLICABLE REGULATORY REQUIREMENTS, PERMITS, AND REQUIRED CONSULTATIONS

As stated above, Table 10.1-1 lists the necessary environmental approvals from Federal and State Agencies required for the Moore Ranch Project. The NRC Licensing process for a source materials license represents the longest lead-time approval; therefore, the majority of the remaining approvals are in-progress or will be initiated with in the next year. All necessary approvals must be secured prior to commencement of commercial production at the site.

Table 10.1-1: Environmental Approvals for the Moore Ranch Uranium Project

Issuing Agency	Description	Status
Wyoming Department of Environmental Quality 122 West 25th St Herschler Building Cheyenne, Wyoming 82001	Underground Injection Control Class III Permit (WDEQ Title 35-11)	Class III UIC Permit application under preparation; expected submittal to WDEQ in November 2007
	Aquifer Exemption (WDEQ Title 35-11)	Aquifer exemption application under preparation; expected submittal to WDEQ in first quarter 2008
	Underground Injection Control Class I (WDEQ Title 35-11)	Class I UIC Permit application under preparation; expected submittal to WDEQ in first quarter 2008
	Industrial Stormwater NPDES Permit (WDEQ Title 35-11)	An Industrial Stormwater NPDES will be required for the Central Plant Area. Expected submittal second quarter 2008
	Construction Stormwater NPDES Permit (WDEQ Title 35-11)	Construction Stormwater NPDES authorizations are applied for and issued annually under a general permit based on projected construction activities. The Notice of Intent will be filed at least 30 days before construction activities begin in accordance with WDEQ requirements.

Table 10.1-1: Environmental Approvals for the Moore Ranch Uranium Project

Issuing Agency	Description	Status
	Mineral Exploration Permit (WDEQ Title 35-11)	Mineral Exploration Permit 342DN Approved: August 22, 2006
	Underground Injection Control Class V (WDEQ Title 35-11)	The Class V UIC permit will be applied for following installation of an approved site septic system during facility construction.
U.S. Nuclear Regulatory Commission Washington, DC 20555	Source Materials License (10 CFR 40)	Application Submitted herein
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW, Washington, DC 20460	Aquifer Exemption (40 CFR 144, 146)	Aquifer exemption application forwarded to EPA following WDEQ action

10.2 ENVIRONMENTAL CONSULTATION

During the course of the preparation of this license application, consultations were conducted with several agencies:

Ecological Resources

Preparation of the ecological resources discussion (Sections 2.0) required consultations with the following individuals and agencies:

- Wetlands — Mike Burgan US Army Corps of Engineers
  2232 Del Range Blvd. Suite 210
  Cheyenne, WY 82009
- Soils — Jon Sweet – Soils Scientist – WDEQ-LQD, District III
  1866 South Sheridan Ave.
  Sheridan, WY 82801
- Vegetation — Stacy Page – WDEQ-LQD, District III
  1866 South Sheridan Ave.
  Sheridan, WY 82801

- Wildlife
  Vern Stetler - Coordinator
  Statewide Habitat Protection
  Wyoming Game and Fish Department
  5400 Bishop Rd.
  Cheyenne, WY 82006

  Scott Covington - Terrestrial Biologist
  Wyoming Game and Fish Department
  5400 Bishop Rd.
  Cheyenne, WY 82006

  Brian Kelly
  US Fish and Wildlife Service
  4000 Airport Parkway
  Cheyenne, WY 82801

- Archaeology
  Wyoming State Historic Preservation Office
  2301 Central Ave.
  Cheyenne, WY 82002

- Hydrology
  Mark Taylor, PG Hydrogeologist
  WDEQ-LQD, District III
  1866 South Sheridan Ave.
  Sheridan, WY 82801