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Addendum 6-A: Quality Assurance Plan

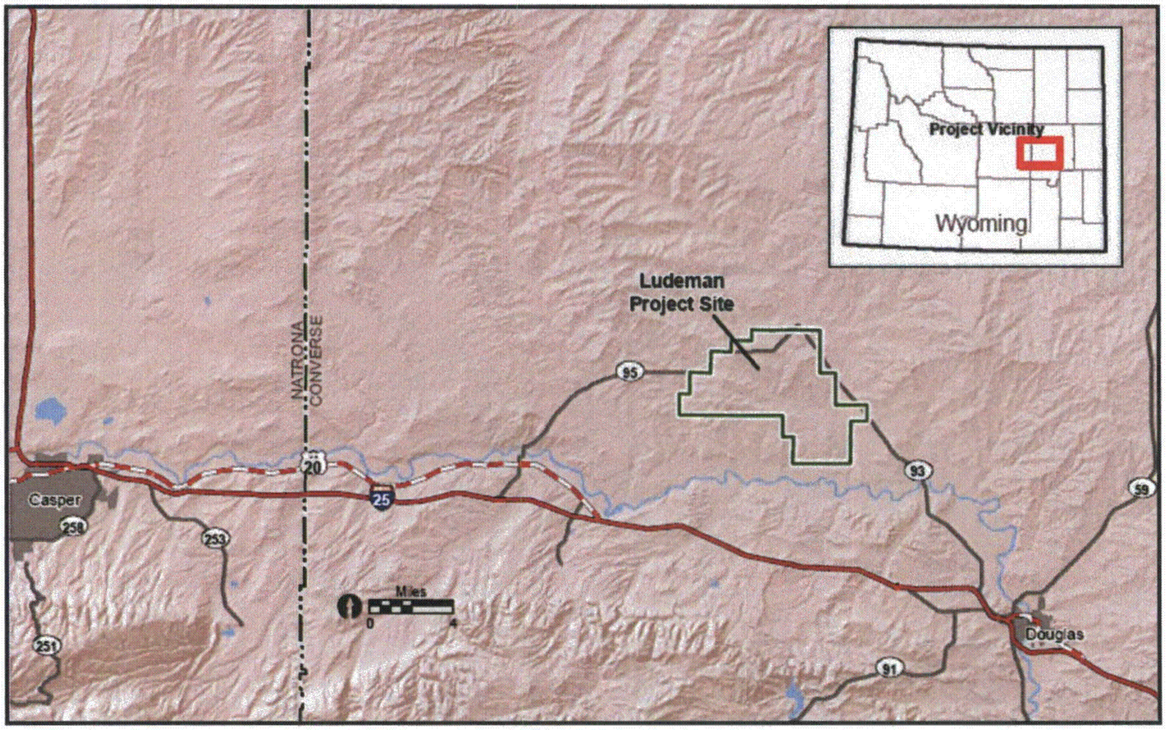
6 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 RADIOLOGICAL MONITORING

6.1.1 Introduction

Radiological baseline studies and monitoring results for the proposed Ludeman Project (proposed project) area in Converse County, Wyoming are provided in this Section. The baseline studies were conducted by Tetra Tech. Various radiological parameters in different environmental media have been surveyed according to applicable regulatory guidance. The site is situated on approximately 20,000 acres of private lands (Figure 6-1). Because the deposits are distributed across considerable distances within the proposed project area boundaries, three Satellite recovery facility locations are proposed and baseline radiological surveys were designed accordingly.

Figure 6-1: Location of the Proposed Ludeman Project Area and vicinity locations.



Basic guidance for radiological surveys at uranium recovery sites can be found in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 4.14 (NRC, 1980).

Although Regulatory Guide 4.14 does not address special considerations associated with ISR uranium recovery sites, the 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; WDEQ/LQD, 2007).

Radiological baseline surveys of the proposed project site were initiated by Uranium One and Tetra Tech in 2008. Relevant planning was developed under the assumption that all phases of the uranium extraction and processing cycle could potentially be performed at any of the three recovery facility sites.

Topography at the site is comprised primarily of low rolling hills, relatively flat areas, and small ephemeral drainages (Figure 6-2). Vegetation includes a mixture of short grass prairie varieties including occasional copse of sagebrush. The predominant land uses are livestock grazing and wildlife habitat. There is currently one residential ranch site within the project area and a number of residential dwellings near the northern boundaries of the site along Highway 95.

Figure 6-2: Select photos of portions of the Proposed Ludeman Project Area.

Although these radiological baseline surveys were conducted primarily based on Regulatory Guide 4.14 protocols (NRC, 1980), some aspects of survey approaches were enhanced or modified to address site- and project-specific issues along with more recent ISR specific regulatory guidance as referenced in the applicable sections of this report. Data from these baseline studies are presented in this report for consideration by the U.S.

Nuclear Regulatory Commission (NRC) and the Wyoming Department of Environmental Quality / Land Quality Division (WDEQ/LQD) with respect to licensing/permitting applications. The following sections describe methods, activities, and results to date of radiological baseline surveys for the proposed project area.

6.1.2 Gamma Survey

A survey of baseline gamma exposure rates and respectively estimated soil radionuclide concentrations at the proposed project area was conducted by Tetra Tech (Fort Collins, Colorado) on September 16 through 22, 2008 on behalf of Uranium One (Casper, Wyoming). The purpose of the survey was to establish baseline levels and spatial distributions of these radiological parameters prior to proposed in-situ recovery (ISR) operations at the site. This information is an important component of overall radiological baseline characterizations as required for licensing/permitting applications by the NRC and WDEQ/LQD.

NRC Regulatory Guide 4.14 calls for a pre-operational gamma survey with up to 80 individual radial grid-based gamma exposure rate measurements for each processing facility location (NRC, 1980). Consistent with ISR license application guidelines described in Regulatory Guide 3.46 (NRC, 1982) and NUREG-1569 (NRC, 2003), as well as with radiological survey guidelines outlined in MARSSIM, the Multi-Agency Radiation Survey and Site Investigation Manual (NRC, 2000), Tetra Tech used modern GPS-based scanning system technologies for this project.

Unlike discrete grid-based measurements as recommended in NRC Regulatory Guide 4.14, these scanning systems are able to quickly and efficiently provide a more thorough characterization of the spatial distribution of gamma exposure rates across very large areas (Whicker et al., 2008). The basic gamma scanning system developed by Tetra Tech can be mounted in various configurations including backpacks, off-highway vehicles (OHVs), or trucks, and has been used for remedial support at a number of uranium mill site decommissioning projects, as well as for numerous radiological baseline surveys of proposed uranium recovery sites (Whicker et al., 2008 & 2006; Johnson et al., 2006).

Tetra Tech has used OHV-mounted versions of this scanning system for previous ISR baseline surveys at many sites in Wyoming, with results from several of these studies presented in licensing/permitting applications to the NRC and the WDEQ/LQD (Uranium One, 2008; EMC, 2007; Lost Creek ISR, LLC, 2007). The method should meet or exceed minimum guidelines outlined in NRC Regulatory Guide 4.14 and other applicable regulatory guidance documents. This system is considered current state-of-the-art technology for conducting gamma surveys. Associated analysis methods, including gamma-based estimation of certain soil radionuclide concentrations, have been further developed in recent years (Whicker et al., 2008).

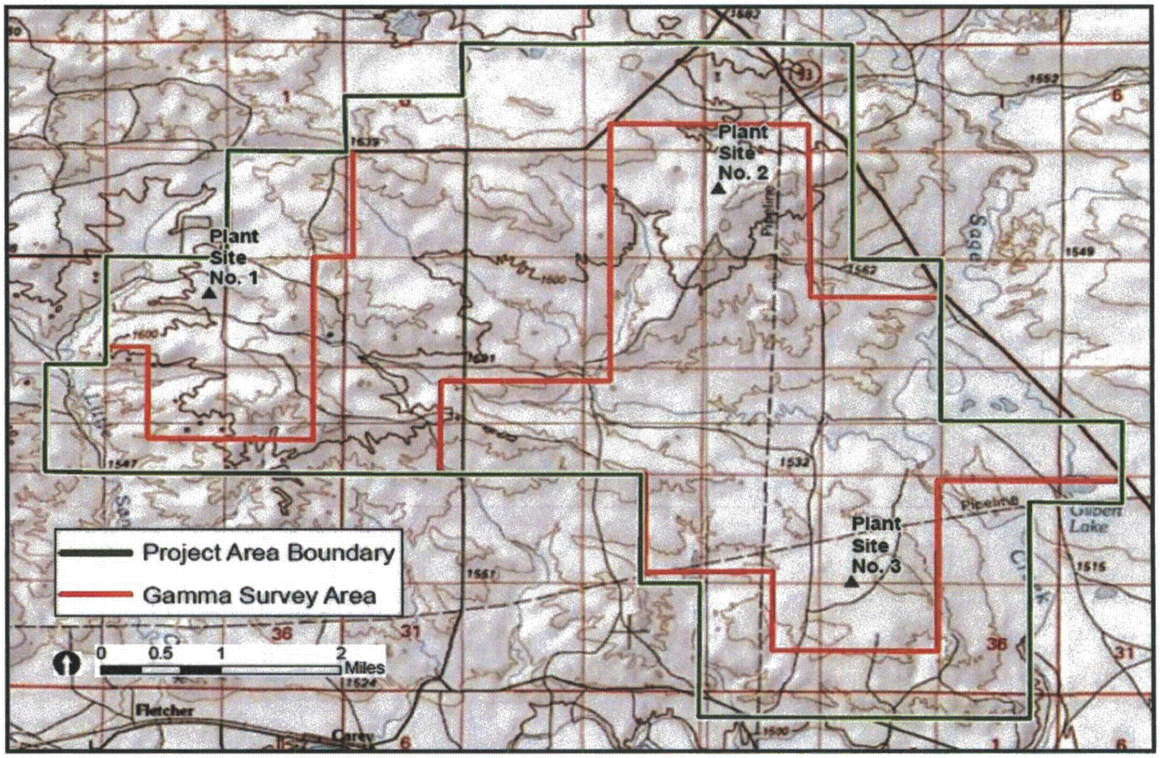
The objectives of this survey were to characterize the spatial distribution of gamma exposure rates across areas scanned (corrected for the energy dependence of sodium iodide (NaI) gamma detectors) and if possible, to estimate approximate Ra-226 and natural uranium (U-nat) concentrations in surface soils using statistical correlations between NaI-based gamma readings and concentrations of these radionuclides in surface soils. Data and analyses from this study are presented in this report for consideration by the NRC and WDEQ/LQD with respect to licensing/permitting applications.

6.1.2.1 Methods

6.1.2.1.1 Gamma Scanning

This survey consisted of gamma scans of select areas of the site along with targeted composite sampling of surface soils and static exposure rate measurements using a high-pressure ionization chamber (HPIC). The site layout and general survey areas are shown in Figure 6-3. The planned survey areas, comprising about 11,000 acres, were selected to establish baseline conditions in probable ISR wellfield areas, and to provide about 1.5 kilometers of survey coverage in any direction from proposed facility locations. Portions of Sections 35/36, T34N R73W were later determined to be wellfield areas and will be surveyed prior to development.

Figure 6-3: Site layout and gamma survey areas



For the proposed project survey, the most recently developed Yamaha Rhino-mounted scanning system configuration was used (Figure 6-4). Given the large size of the site, along with occasional rugged terrain and sagebrush vegetation, these two-seater Rhino OHVs with roll bar cages and conventional driver control systems (steering wheel, foot-controlled gas and brake pedals) were well suited for the project. Equipped with special extra-wide tires, these vehicles are well suited to safely negotiating sites like Ludeman while minimizing environmental impact.

Figure 6-4: 3-detector GPS-based scanning systems mounted on Rhino OHVs

In addition to addressing safety considerations, roll bar cages on Rhino OHVs provide 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 OHV cargo bed. Simultaneous GPS and gamma exposure rate data are recorded every 1 to 2 seconds using an onboard PC with data acquisition software developed by Tetra Tech (Tetra Tech, 2007).

System configuration involves about 8-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 given site conditions. Experimental measurements were later performed to determine statistically equivalent readings as measured by a high-pressure ionization chamber (HPIC) at 3 feet above the ground surface (discussion to follow).

Based on previous observations and experience in the field under similar scanning geometries, lateral NaI detector response to significantly elevated planar (non-point) gamma sources at the ground surface is estimated to be 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 gamma 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 25 feet across, perpendicular to the direction of travel. Vehicle scanning speeds ranged between 2 and 15 mph depending on the roughness of the terrain, with an estimated average speed of 8-10 mph.

In most portions of the proposed license area, 10-15 percent was the targeted scan coverage though practical considerations such as safety, terrain, and natural obstructions and other factors 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 separation between vehicles is estimated to provide ground coverage of about 15 percent. In terrain deemed unsafe for OHV scanning, efforts were made to scan as closely as possible along the perimeters of such terrain.

Data was downloaded daily into a project database and plotted with special field mapping software (Tetra Tech Inc., 2006). Daily quality control (QC) measurements were performed to evaluate instrument performance and insure data quality (discussed later). Daily scan results were evaluated in terms of general agreement between onboard detectors and QC measurements 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.

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

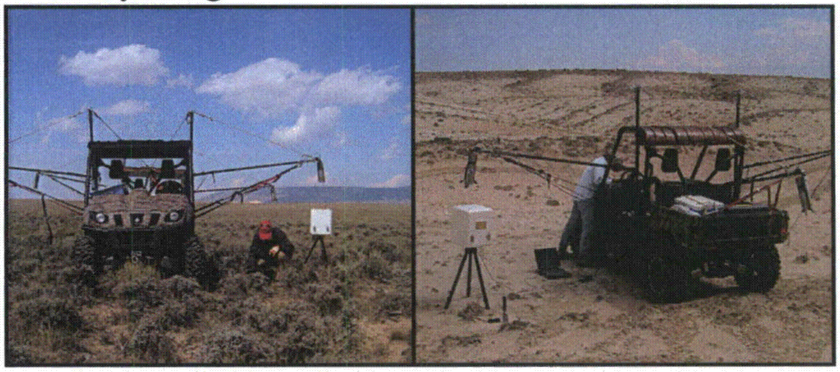
Gamma exposure rates measured by NaI detectors represent only relative measurements as response characteristics of NaI detectors are energy dependent. True gamma exposure rates are best measured with a less energy dependent system such as a HPIC. Depending on the radiological characteristics of a given site, NaI detectors can have measurement values significantly different from corresponding HPIC measurement values.

NaI systems are useful for ISR recovery 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, 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 site. These locations were identical to those used for gamma/Ra-226 correlation plot measurements (discussed in the next section). At each cross-calibration measurement location, 10 individual HPIC readings were recorded and averaged. The center of the sensitive volume for the HPIC is about 3 feet above the ground surface. The ground directly below the HPIC was marked to identify the exact measurement location for subsequent NaI measurements. Up to three of the same NaI detectors used for scanning the Ludeman site were located directly above this same location when taking measurements. For each NaI detector, 10 to 20 individual NaI readings at a 4.5-foot detector height were collected and averaged. Overall mean NaI values from each location were recorded to pair with corresponding mean HPIC readings for regression analysis and determination of a cross-calibration equation.

Pictures of the cross-calibration measurement process being conducted at other ISR sites in Wyoming are shown in Figure 6-5. The validity of applying a single cross-calibration equation to all data, based on measurements involving only a subset of the NaI detectors used for scanning the site can be linked to data quality control measurements showing acceptable consistency in readings between all detectors used for the gamma survey (discussed later).

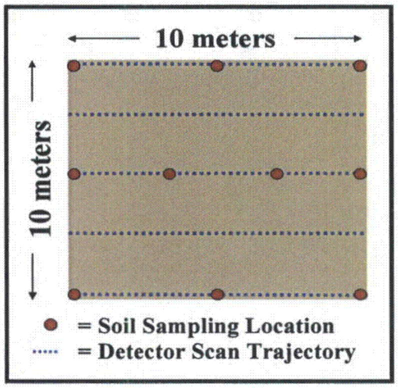
Figure 6-5: Photos of NaI/HPIC cross-calibration measurements being performed at other ISR sites in Wyoming



6.1.2.1.3 Gamma / Soil Radionuclide Correlations

NRC Regulatory Guide 4.14 recommends that 40 baseline surface soil samples should be collected at 5-cm depths, extending in a radial grid pattern up to 1.5 kilometers away 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 proposed project area and previous success with correlation techniques, prompted a number of gamma/soil radionuclide correlation plots to be sampled. Depending on the statistical strength of the relationship between gamma readings and radionuclide concentrations in surface soils, such correlations can be used to estimate approximate soil concentrations (to a 15-cm depth) across the entire site based on gamma survey results. As specified in the regulatory guidance, uranium and associated decay series products are important with respect to baseline radiological soil characterizations.

Figure 6-6: Diagram of soil sampling and gamma measurement design for correlation plots



Correlation soil sampling was conducted as composite sampling over 10×10 meter plots (Figure 6-6). Within each plot, 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 plot and recorded. Samples were sent to Energy Laboratories Incorporated (ELI) in Casper, Wyoming for analysis of Ra-226 and natural uranium (U-nat) concentrations. Samples were dried, crushed, and thoroughly homogenized prior to analysis to insure a representative average radionuclide concentration over each 100 m^2 plot. Samples were then canned, sealed, and held 21 days prior to counting. This allows for sufficient ingrowth of radon and short-lived progeny before Ra-226 analyses were performed using high-purity germanium (HPGe) gamma spectroscopy (method E901.1). Separate aliquots were analyzed for U-nat by ICP-MS (method SW6020).

Following methods described in Johnson et al. (2006), each 100 m^2 soil sampling plot was also scanned using the same OHV systems used to scan the entire site. One difference from the methods described in Johnson et al. (2006), was that the NaI detectors used for the survey were not shielded (collimated). The average NaI gamma reading over each plot was calculated and recorded to pair with the corresponding average Ra-226 or U-nat concentration. The general sampling/scanning design for correlation plot measurements is depicted in Figure 6-6.

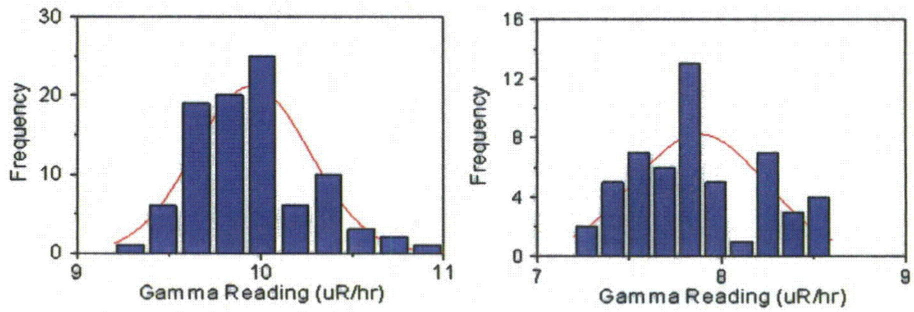
6.1.2.1.4 Data Quality Assurance / Quality Control

Data quality assurance and quality control issues for gamma surveys of the Ludeman Project 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 enables estimation of data uncertainty (e.g. accuracy and precision).

Quality control documentation for this project includes the following:

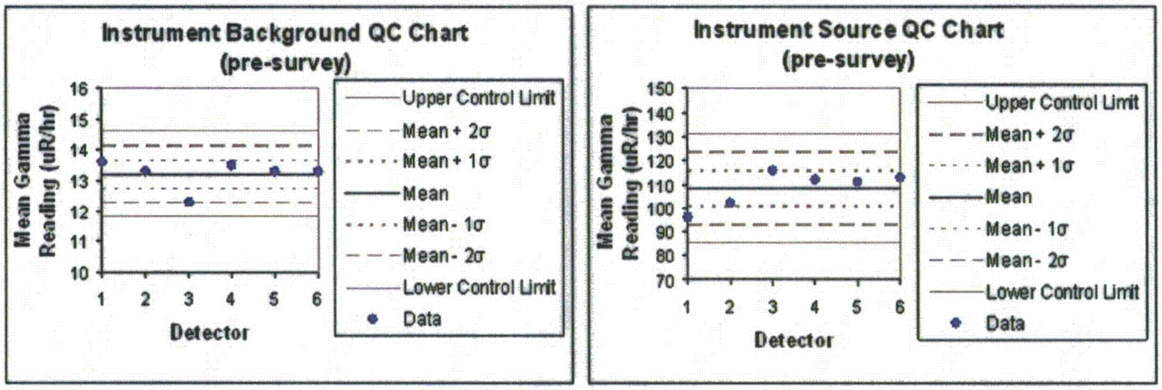
- Just prior to the survey, instrument QC measurements were performed at a designated indoor location (in Fort Collins, Colorado) for each NaI detector used to survey the site. This was done to quantify the consistency of readings between detectors under controlled measurement conditions prior to the survey. The mean of 20 individual QC measurements of ambient background, as well as from a Cs-137 check-source, were determined indoors under identical counting geometries. Under these conditions, all data from any given set of properly calibrated and correctly functioning NaI scanning detectors should approximate a normal (Gaussian) distribution (Fig. 6-7);

Figure 6-7: Example frequency histograms for two series of QC measurements from different NaI detector sets used for two separate gamma survey projects. Each series was taken indoors under controlled measurement geometries. The red lines represent theoretical normal distributions



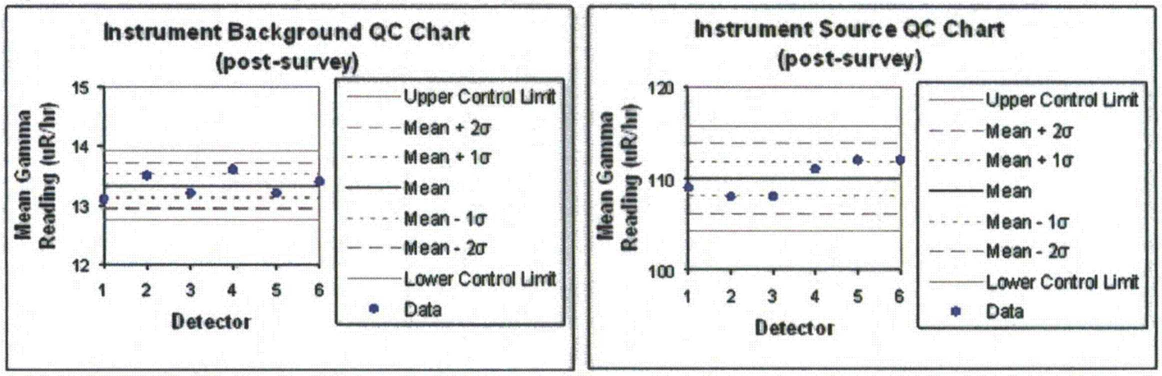
- For normally distributed data, over 99 percent of measurements are expected to fall within ± 3 standard deviations from the mean. Any instrument with a QC measurement result falling outside ± 3 standard deviations from the mean of all QC measurements on the applicable control chart warrants investigation. If a detector exceeds control limits on both background and check-source control charts, it is replaced with a factory-calibrated spare detector and sent back to the manufacturer for repair and recalibration. Prior to the survey, this set of detectors performed well within all applicable QC limits under these criteria (Figure 6-8);

Figure 6-9: Pre-survey instrument control charts



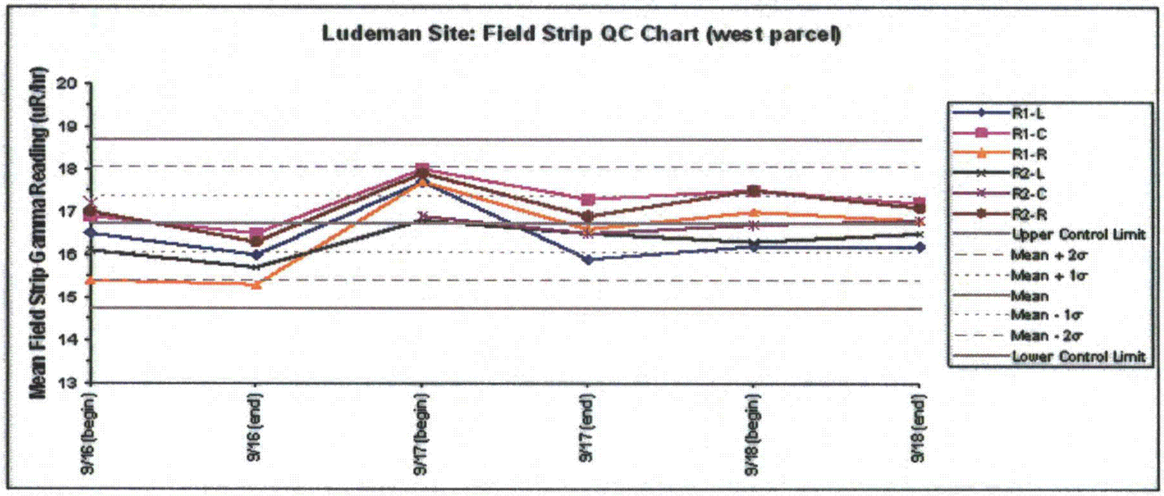
- Immediately after the survey, instrument QC measurements of background and a Cs-137 source were again performed under a controlled geometry (at the same designated indoor location as pre-survey QC measurements) for each NaI detector in use at the end of project survey activities. This was done to again quantify the consistency of readings between detectors under identical measurement geometries, and to also compare against pre-survey instrument control charts. This detector set also performed within acceptable QC limits (Figure 6-9), and results were similar to pre-survey QC measurements (Figure 6-8);

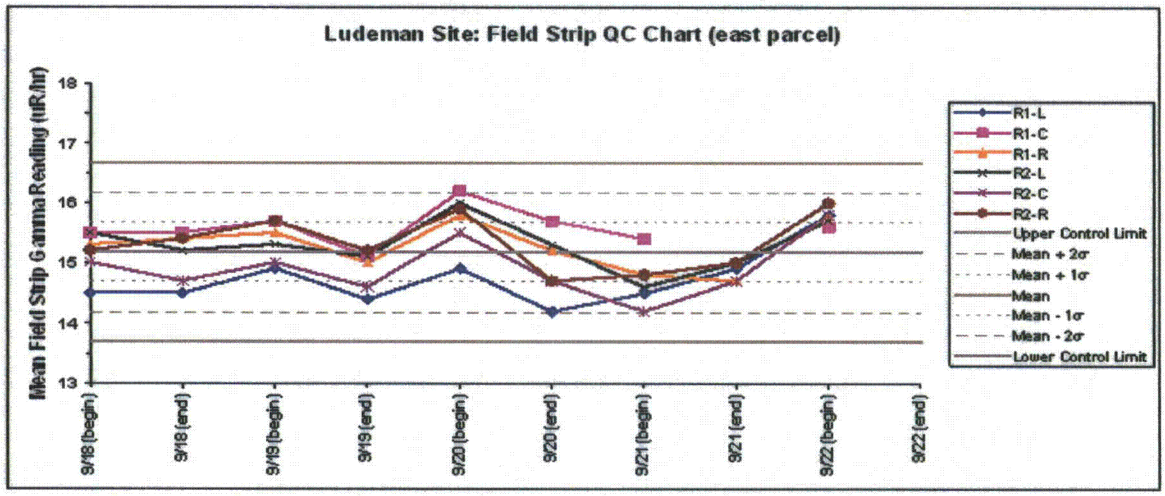
Figure 6-8: Post-survey instrument control charts



- During the survey, the actual performance of each scanning system was tested in the field each day by scanning along a designated strip near the vehicle staging area. These "field strip" scans were conducted before and after each day's scanning. There were two field strips for the project: one for the west scan parcel, one for the east scan parcel. The day that operations were moved from the west parcel to the east parcel (Sept. 18, 2008), field strip measurements were conducted at each of the two different locations with the same scanning detectors. This ties the two field strips together in terms of verification of system performance at the two different locations. Under actual field conditions, scanning systems performed within acceptable QC limits throughout the project (Figure 6-10). In cases where a detector developed suspect performance during the day's scanning (i.e. following morning QC measurements), the subject data files were eliminated from the project data base and the detector in question was replaced with a factory calibrated spare, itself then subject to routine field strip QC measurements to show consistency with the other detectors in use. In all such cases, replacement detectors demonstrated acceptable performance relative to all other properly functioning detectors in field strip QC tests;

Figure 6-10: Field strip control charts for west scan parcel (top) and east scan parcel (bottom)





- 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, stationary measurements across the site (collected as part of HPIC cross-calibration and gamma/Ra-226 correlation activities) with original scan data. In general, these stationary measurement data showed good agreement with original continuous scan data; and

- With respect to confirmatory soil sample analysis results from Energy Laboratories Inc. (Casper, WY), no flags or analytical problems were noted with respect to quality control assessments (e.g. duplicate sample analyses, laboratory control samples, etc.). 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 proposed project site, along with the HPIC, were calibrated by the manufacturer within one year prior to the date of use on this project;
- A field log book of daily measurements, activities and problems was maintained;
- Chain-of-custody protocols were followed for soil sampling and contract laboratory analyses;
- Tetra Tech's Radiological Health Group staff has extensive qualifications and over 100 years worth of combined experience in performing radiological measurements and related site assessments (CV's provided on request);
- 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., 2008; Whicker et al., 2006); and
- Daily scan results for each vehicle were reviewed for consistency along track paths for all onboard detectors. Obvious inconsistencies prompted further investigation. In cases where technical problems were discovered or where the data were otherwise clearly incorrect, the affected data were eliminated from the project database.

6.1.2.2 Gamma Survey Results

6.1.2.2.1 Baseline Gamma Survey Results

Descriptive statistics for raw gamma survey data from the proposed project site are shown in Figure 6-11. After thorough QC assessment of the scan data, nearly 350,000 individual gamma and paired GPS readings were included in the official final database of raw NaI measurements. The frequency histogram shows a highly right skewed distribution due to a few relatively small areas with pronounced sources of terrestrial radiation. Raw gamma survey data are mapped in Figure 6-12.

Figure 6-11: Frequency histogram and descriptive statistics for raw NaI-based

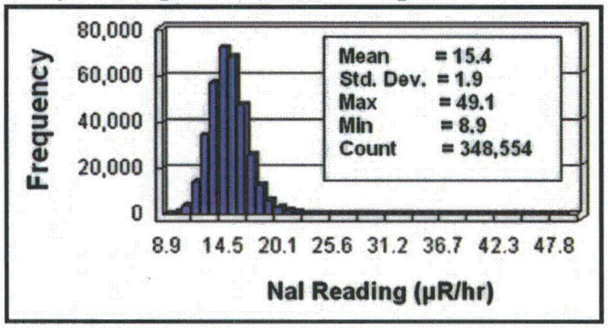


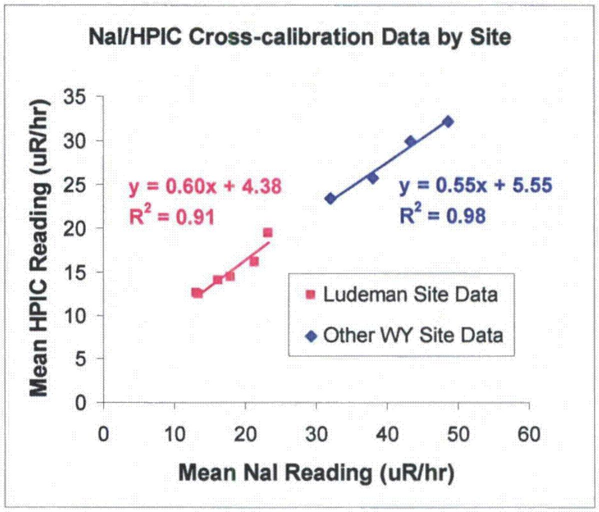
Figure 6-12: Raw, NaI-based gamma survey results for the Proposed Ludeman Project area

The vast majority of gamma readings in scanned areas were below 20 µR/hr. Data trends in a number of areas show several distinct regions with slightly higher gamma readings, indicative of higher levels of naturally occurring terrestrial radionuclides at or near the ground surface. Regions of significantly elevated gamma readings are very limited, and represent less than 1 percent of the survey area that possess gamma readings in excess of 25 μR/hr. In some cases, areas with higher readings have certain geomorphologic features that appear to be associated with higher gamma exposure rates (e.g. hill tops, eroded areas, outcrops of exposed rocks or unusually colored soils). In other cases, there are no obvious features associated with the higher observed readings.

6.1.2.2.2 HPIC / NaI Cross-calibration Results

Due to complications from the weather, only 6 of the planned 10 correlation plot/cross-calibration locations at the proposed project site were successfully measured and sampled during the scheduled field work. However, immediately following this work, 4 additional pairs of cross-calibration measurements were collected (using the same detectors) in conjunction with a separate project that was being conducted at a similar site in Wyoming. Linear regressions for data from the proposed project and the alternate site in Wyoming were plotted on the same graph for qualitative comparison, and the two curves appear nearly identical to one another in terms of slope and intercept (Figure 6-13).

Figure 6-13: Linear regression results for cross-calibration measurements collected at the Ludeman (pink) and an alternate ISR site in Wyoming (blue)



To statistically test for coincidence of the two regression lines in Figure 6-13, a multiple regression analysis was performed using a basic method as described in Dawson & Trapp (2004). The full regression model for this test is as follows:

$$Y = \alpha + \beta_1 X + \beta_2 Z + \beta_3 XZ$$

<u>Where</u>:

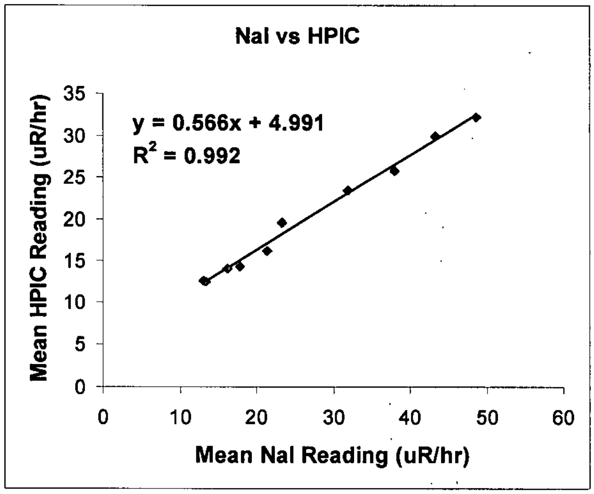
Y = µrem-meter reading (the dependent variable)
X = NaI reading (an independent variable)
Z = Location (an independent dummy variable where 1=Ludeman, 0=other WY site)
XZ = independent variable to test for interaction between X and Z
α = regression intercept coefficient
$\beta_{1,2,3}$ = regression slope coefficients for each independent variable in the model

The two regression lines in Figure 6-13 would have equal slopes and be parallel if $\beta_3 = 0$ (no interaction between NaI reading and location). If $\beta_2 = \beta_3 = 0$, then the two lines are statistically coincident. This latter equality serves as the relevant null hypothesis to be evaluated with t-tests in the multiple regression analysis. The key results from this analysis are the p-values for the regression coefficients as shown in Figure 6-14. Based on these p-values, the null hypothesis cannot be rejected at the 95 percent confidence level and the two lines are considered coincident. A similar analysis was conducted to specifically test for any confounding effects of location (without an interaction term in the full model, and using a null hypothesis of $\beta_2 = 0$). The results showed no statistical evidence of confounding effects from location when both NaI reading and location were included in the regression model.

Figure 6-14: Multiple regression analysis results to test for coincidence of cross-calibration curves from Ludeman and the alternate site

```
                Multiple Regression Analysis Results
     =======================================================

Number of Points      = 10
Number of Variables   = 3
Dependent Variable    = HPIC
Independent Variable  = NaI
Independent Variable  = Location
Independent Variable  = NaI_x_Location

 Regression equation:
    HPIC        = 5.4943
                  +0.552741*NaI
                  -1.15059*Location
                  +0.0514303*NaI_x_Location

                   Regression Statistics
           --------------------------------------

           R-Squared            = 0.99213441
    Adjusted R-Squared          = 0.98820161
Standard error of estimation    = 0.79499764
  Durbin-Watson statistics      = 2.44273006
      Mean absolute error       = 0.50221231
     Sum of squared error       = 3.79212753
      Mean squared error        = 0.63202126

    Estimate    Standard Errors    t-Value        P-Value
---------------+---------------+---------------+---------------
     5.4943         2.6220          2.0955         0.0810
     0.5527         0.0642          8.6164         0.0001
    -1.1506         3.0369         -0.3789         0.7178
     0.0514         0.1070          0.4809         0.6476
---------------+---------------+---------------+---------------
```

Figure 6-15: Cross-calibration curve for the HPIC versus NaI detectors positioned at a 4.5 foot detector height



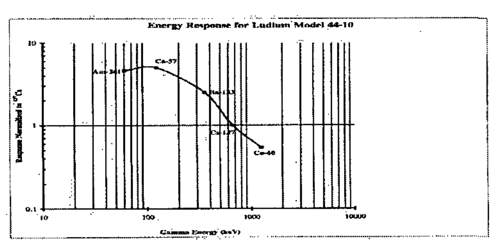
This statistical analysis indicates that the relationships between HPIC and NaI readings at the proposed project and at the alternate measurement site in Wyoming are essentially identical. This provides scientific justification for combining the two data sets to determine a single cross-calibration curve that spans most of the range of gamma data collected at the proposed project site. Results of this overall cross-calibration between the HPIC (at 3 feet above the ground surface) and NaI detectors (at 4.5 feet above the ground surface) are shown in Figure 6-15. Regression coefficients from the combined data set are consistent with those measured by Tetra Tech at other uranium recovery sites, including a number of sites in nearby regions of Wyoming. As is normal, the ratio of HPIC to NaI readings was inversely proportional to the magnitude of measured exposure rates. HPIC/NaI ratios ranged from 0.66 to 0.97, corresponding to locations with the highest and lowest measured readings.

Cross-calibration measurement locations with the lowest measured NaI readings (near 13 μR/hr) demonstrated only a slight difference between mean HPIC and NaI measurement values. As can be observed in Figure 6-11, about 10 percent of the survey data fell below this level. Scan data exceeding the upper range of cross-calibration measurements was well under 1 percent. Although extrapolation of the cross-calibration curve was necessary for conversion of all NaI data to approximate HPIC equivalents, the strength of the relationship (R^2 value of nearly 1) is highly significant. Tetra Tech has found NaI/HPIC cross-calibration relationships (from both direct measurements in the field as well as in the literature) to demonstrate linear characteristics (e.g. Whicker et al., 2008, Schiager, 1974). The slope and intercept can vary somewhat by site and by instrument, but across all ranges of observed values, a highly linear relationship between NaI and HPIC readings appears to be characteristic of such measurements. Extrapolation for the relatively small fraction of data outside the range of measured cross calibration values is thus unlikely to introduce significant error into the converted data set.

As with many sites, this regression model predicts a cross-over point in the statistical relationship where NaI and HPIC readings are essentially identical (in this case, at about 11.5 μR/hr). Below this value HPIC readings are slightly higher than NaI readings. This kind of relationship has been confirmed by direct field measurements at a number of project sites and is believed to be related to the ratio of cosmic to terrestrial sources of gamma radiation combined with the energy response characteristics of NaI detectors.

Ludlum Model 44-10 NaI detectors are calibrated against a Cs-137 source (Ludlum, 2006). At photon energies close to that of Cs-137 (662 keV), detector response will be close to 100 percent (Figure 6-16). In the case of Ra-226, the associated decay series product Bi-214 has similar photon emission energy (609 keV) while photon emission energies for Pb-214 are significantly lower (295 and 352 keV respectively). More importantly, the majority of all terrestrial gamma radiation that interacts with the NaI detector, including that from other gamma emitters such as K-40, involves scattered secondary photons of energies well below 662 keV. Thus, in areas where photons from terrestrial sources exceed a certain minimum percentage of the total ambient gamma field, detector response relative to Cs-137 will be greater than 100 percent and the detectors will over-predict true exposure rates. In areas where terrestrial radionuclide concentrations are very low, higher energy cosmic sources can dominate detector response and result in a slight under-prediction of true exposure rates.

Figure 6-16: Energy response characteristics of the Ludlum Model 44-10 NaI detector (Ludlum, 2006)



6.1.2.2.3 Final Gamma Exposure Rate Mapping

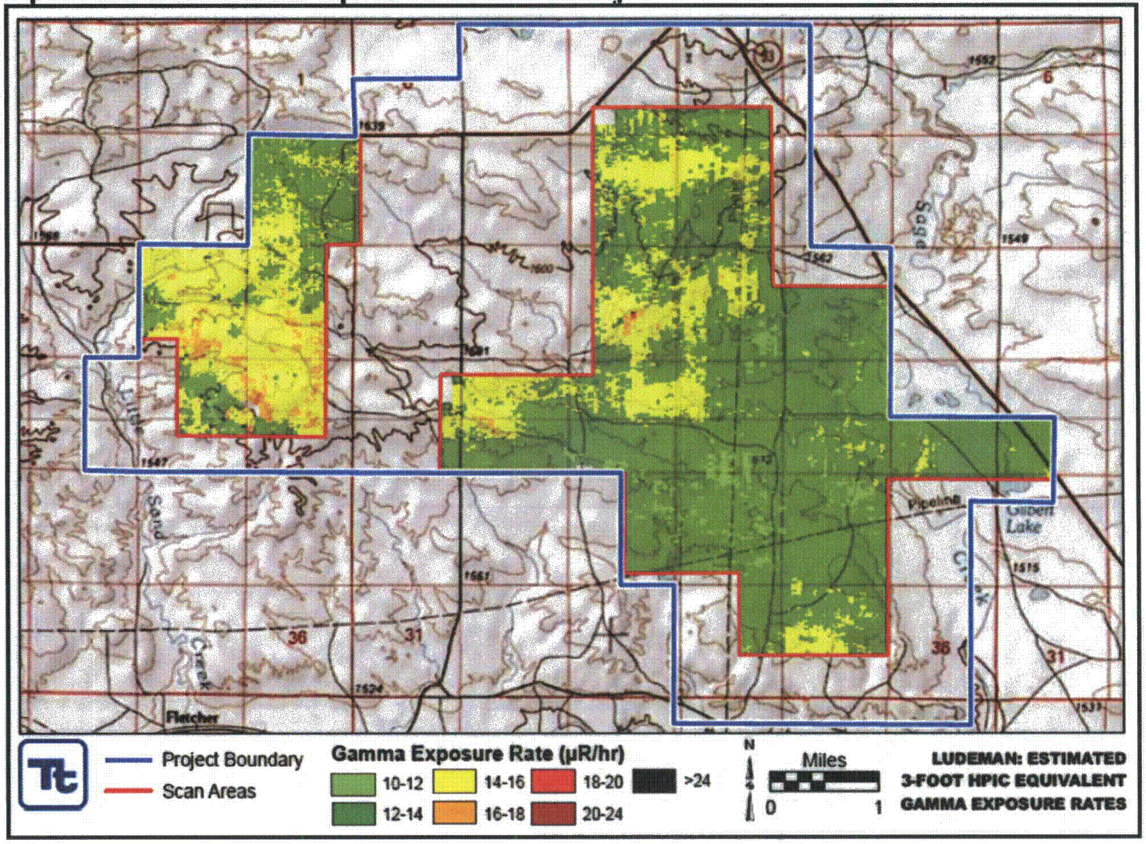
Using regression equation shown in Figure 6-15, all baseline gamma scan data collected with NaI detectors at the proposed project site were normalized to 3-foot HPIC equivalent measurements to produce the best possible estimate of true gamma exposure rate for each individual NaI reading. This converted data set, along with a special data kriging program in ArcGIS (ESRI, 2008), was used to develop continuous estimates of true gamma exposure rates at 3 feet above the ground surface (3-foot HPIC equivalent values) across all scanned areas.

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:	400 feet
Semivariogram model:	Exponential
Number of nearest data points:	10

A map of estimated 3-foot HPIC equivalent gamma exposure rates across the survey areas is shown in Figure 6-17.

Figure 6-17: Continuous, kriged estimates of 3-foot HPIC equivalent gamma exposure rates at the Proposed Ludeman Project site.

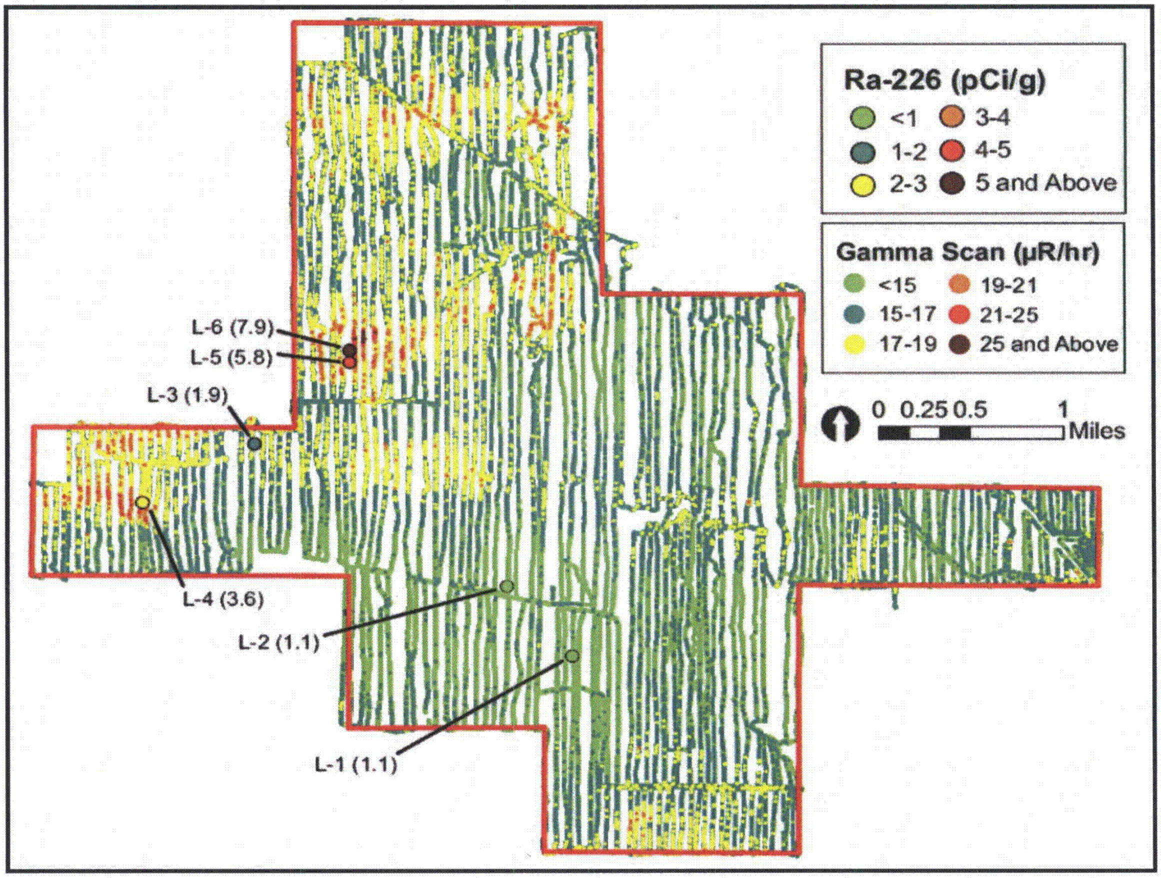


Note that the gamma scale legend increments differ between the raw NaI-based gamma scan track map shown in Figure 6-12, and the final official map of gamma survey results provided in Figure 6-17. This is because the data in the final map of official gamma survey results have been converted to 3-foot HPIC equivalent values and the range of values differs slightly.

6.1.2.2.4 NaI/Ra-226 Correlation Results

Overlays of correlation plot sampling locations, color-coded and annotated to show soil Ra-226 results on corresponding portions of the raw NaI gamma scan map, are shown in Figure 6-18. Soil sampling results represent average Ra-226 concentrations over 100 m^2 sampling plots to a depth of 15 cm.

Figure 6-18: Correlation plot measurement locations and annotated soil Ra-226 concentration results (pCi/g, in parentheses) overlain on the NaI scan track map.



The data in Figure 6-18 indicate a clear spatial association between the levels of measured soil Ra-226 concentrations and gamma scan readings in corresponding locations. Statistical regression analysis of the correlation plot data revealed a highly significant linear relationship between mean Ra-226 soil concentration and mean NaI gamma reading (Figure 6-19). Although only 6 correlation plots were sampled for reasons previously indicated, the variability about the regression line is very small, the R^2 value is nearly one, and the range of gamma values measured at these plots is evenly distributed across a range of values that includes nearly 90 percent of the scan data collected at the site. Assuming normal distributional characteristics and representativeness of correlation plot locations, the limits of the 2σ (95 percent) prediction band shown indicate that 95 percent of the time, local average Ra-226 in surface soils should be within about ± 1 pCi/g of a value predicted based on gamma readings and use of this correlation. The gamma/Ra-226 relationship observed at the Moore Ranch ISR site (EMC, 2007), located about 45 miles NNW of the proposed project, is remarkably similar (Figure 6-20), suggesting that this basic relationship is consistent across this region of Wyoming.

Figure 6-19: Linear correlation between Ra-226 soil concentration and NaI-based gamma exposure rate reading. Prediction band limits [1σ (68%) and 2σ (95%)] are shown

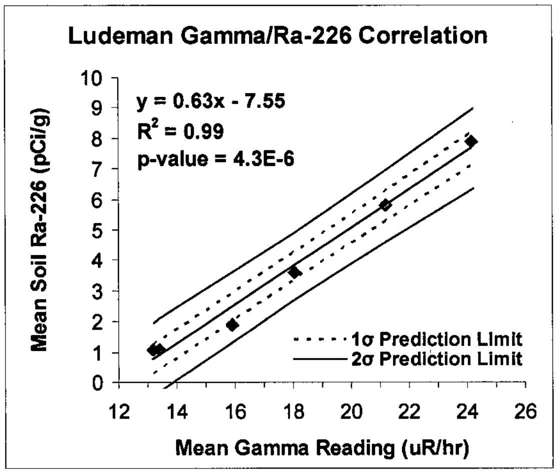
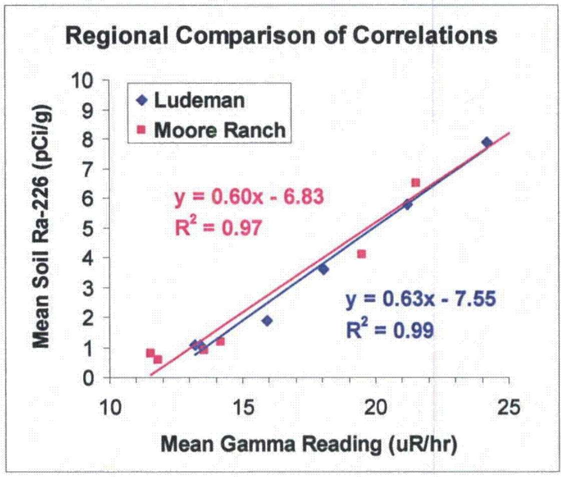


Figure 6-20: Comparison of gamma/Ra-226 correlations developed at Ludeman and Moore Ranch (about 45 miles NNW of Ludeman)



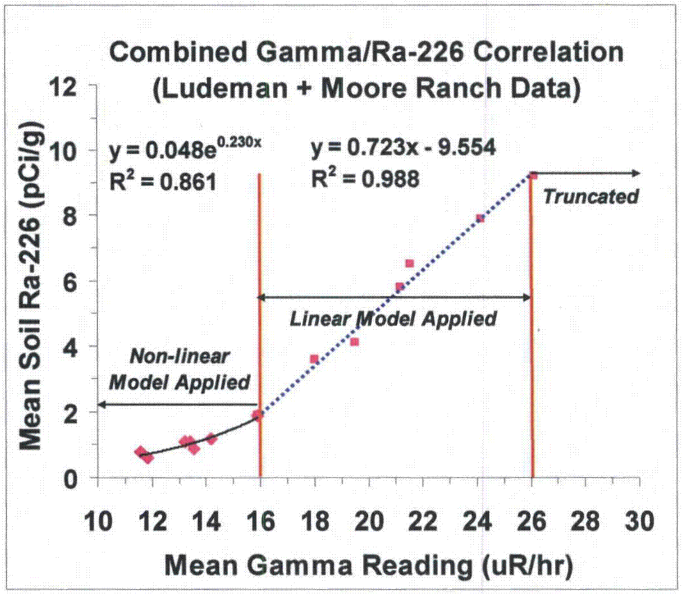
To test for any statistical differences between correlation curves for the two sites as shown in Figure 6-20, multiple regression analyses were performed using the same statistical methods presented in Section 6.2.2.2. The results indicated that these two regression lines are statistically indistinguishable from one another (i.e. coincident) at the 95 percent confidence level, and revealed no statistical evidence of a confounding effect of location due to data collected at the two different sites. These results provide reasonable scientific justification for combining the two data sets in order to achieve a more robust estimate of an average relationship between gamma readings and Ra-226 concentrations in surface soils at the proposed project site.

Although a linear regression of the combined Ludeman/Moore Ranch correlation data set is highly significant (p-value < 0.001, $R^2 = 0.98$), the data falling below about 16 μR/hr, suggest a slight non-linearity relative to the data above this range. This feature, though somewhat subtle, is apparent in the data shown in Figure 6-20, and is consistent with similar observations at a number of other sites in Wyoming (EMC, 2007; Uranium One, 2008; Whicker et al., 2008). This phenomenon is believed to be related to use of gross gamma measurements, the relative influences of cosmic and terrestrial sources of gamma radiation, and the energy dependence of NaI detectors (Whicker et al., 2008).

When soil Ra-226 concentrations are very low, cosmic radiation, direct and scattered photons from all terrestrial sources, will dominate detector response. In a context of gamma/Ra-226 correlation measurements, this is analogous to instrument background "noise". As soil Ra-226 concentrations increase, the signal to noise ratio gradually increases at an increasing rate (i.e. in a non-linear fashion), until a certain threshold is reached and a more significant (and generally linear) correlative impact on gross gamma readings becomes apparent. The level at which this "threshold" occurs at a given site may be related to the energy dependence of NaI detectors and the ratio of cosmic to terrestrial sources at the site.

Other soil radionuclides including Th-232 and its decay products, including K-40, may have an impact on such a threshold as well; or even on the effectiveness of the correlation itself, if levels relative to Ra-226 are high and/or are highly variable. At other Wyoming ISR sites sampled by Tetra Tech, soil radionuclides other than those radiologically linked to Ra-226, have been moderately variable, with average concentrations in the range of 1-2 pCi/g for Th-232, and 15-25 pCi/g for K-40. To date, such levels and associated variability have not previously demonstrated a significant confounding effect on the general reliability of gamma/Ra-226 correlations.

Figure 6-21: Partitioned correlation model for predicting Ra-226 concentrations in surface soils based on gamma readings at the Proposed Ludeman site.



When gamma/Ra-226 correlation data have non-linear properties, non-linear correlation models have generally demonstrated slightly better accuracy for predicting soil Ra-226, particularly in the low to mid ranges of gamma readings found at the site (EMC, 2007; Uranium One, 2008; Whicker et al., 2008). The combined data set was carefully evaluated and ultimately partitioned into several data categories for modeling, resulting in a partitioned overall model for predicting Ra-226 concentrations in surface soils based on gamma readings (Figure 6-21).

A gamma reading of 16 μR/hr was selected as a reasonable partition boundary line between use of a non-liner model for lower values, and a linear model for higher values. Above 26 μR/hr, estimates of soil Ra-226 based on the gamma survey data were artificially truncated at soil Ra-226 value of 9.3 pCi/g, to avoid model extrapolation on the highest end of the scale. On the lowest end of the scale, truncation was not considered necessary in terms of its potential to significantly impact kriging results. Issues and rationale for truncation are further discussed in Section 6.2.2.5.

In addition to Ra-226, correlation plot soil samples from the proposed project site were also analyzed for natural uranium (U-nat) by acid leaching followed by metals analysis via inductively coupled plasma mass spectrometry (ICP-MS). The mean ratio of U-nat/Ra-226 ($\pm\ \sigma$) for reported activity concentrations was 1.1 ± 0.7. Based on natural isotopic abundances and relative half lives, U-238 is responsible for about 49 percent of total radioactivity contained in U-nat, U-234 contributes about 49 percent, and U-235 contributes about 2 percent (NCRP, 1987). The mean U-238/Ra-226 activity ratio of for the correlation soil samples thus appears to be about 0.5 ± 0.3.

Despite considerable variability in U-nat/Ra-226 ratios for these samples, a linear correlation between U-nat and Ra-226 was statistically significant (Figure 6-22), and the regression should provide a reasonable estimate of an average relationship between the two parameters at the soil surface. Baseline estimates of Ra-226 at the soil surface could be converted into rough estimates of U-nat using this relationship, though such predictions are specific to the analytical methods used to measure each parameter in the correlation samples. Natural uranium itself does not have a significant gamma signature, but because of the radiological association with Ra-226 it can sometimes be significantly correlated with gamma exposure rates. The gamma/U-nat relationship for correlation plot data from the proposed project is shown in Figure 6-23.

Figure 6-22: Statistical relationship between mean U-nat and Ra-226 soil concentrations at correlation plot locations.

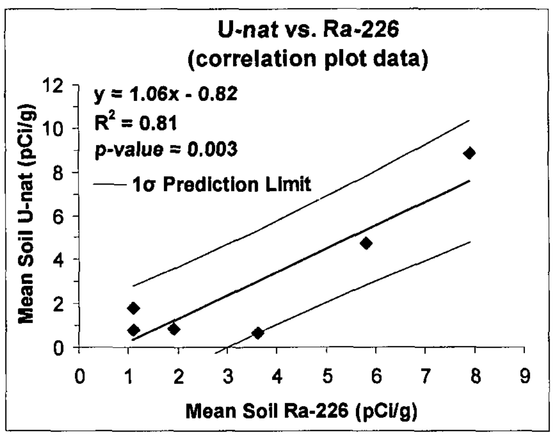
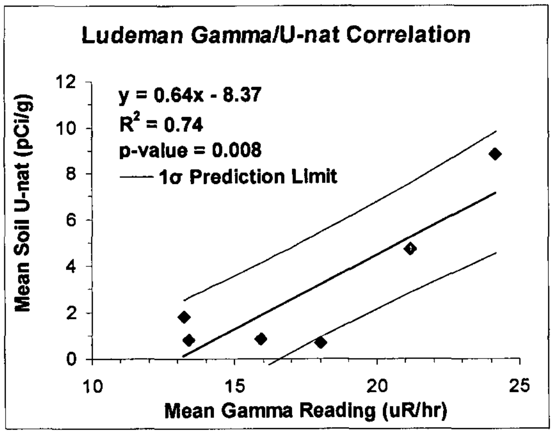


Figure 6-23: Statistical relationship between gamma readings and U-nat soil concentrations at correlation plot locations.

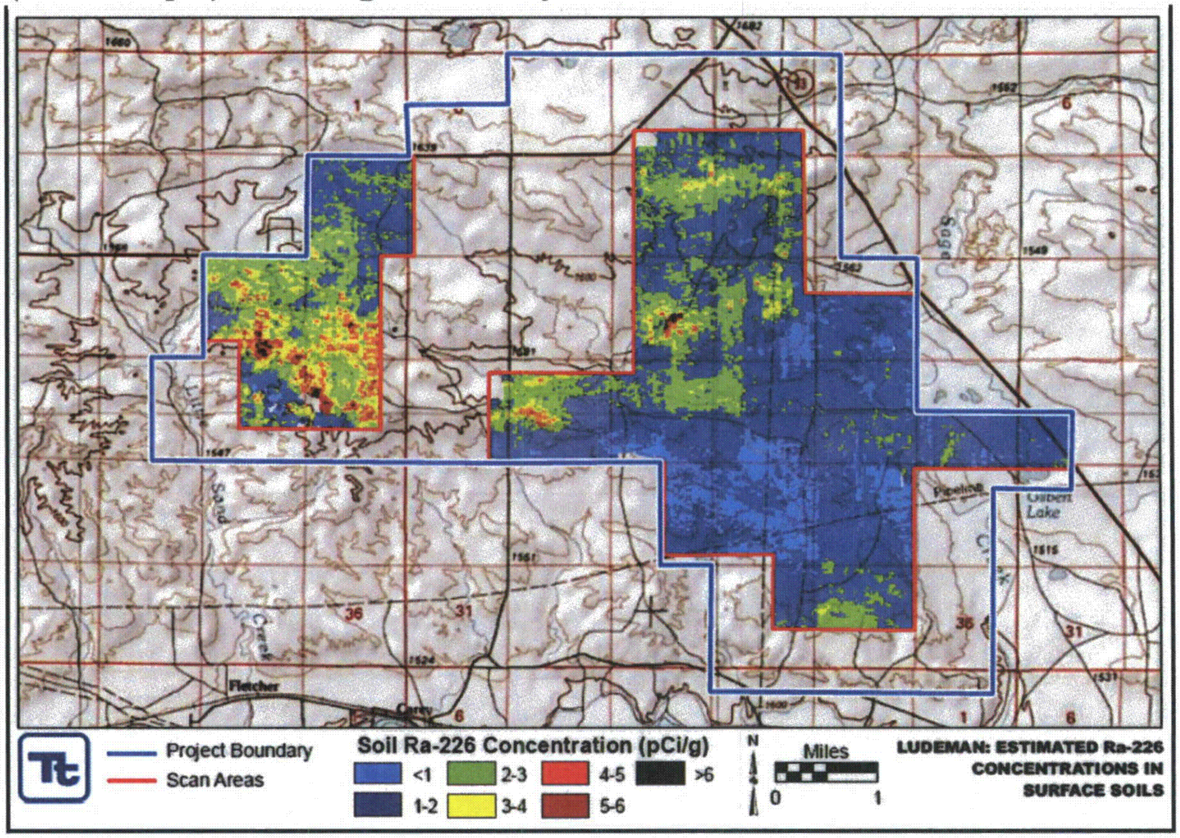


Under natural undisturbed soil conditions, U-238 and Ra-226 are often found in approximate secular equilibrium with one another; though some depletion of U-238, due to higher uranium mobility, can sometimes be indicated by the data. It is not uncommon to see considerable variability in U-238/Ra226 ratios, though apparent disequilibrium can result from analytical error and differing analytical methods (e.g. radiochemical separation versus gamma spectroscopy), particularly at low concentrations. For this reason, it would be questionable to conclude from this data that significant disequilibrium between U-238 and its decay series products occurs in soils at this site.

6.1.2.2.5 Soil Radionuclide Concentration Mapping

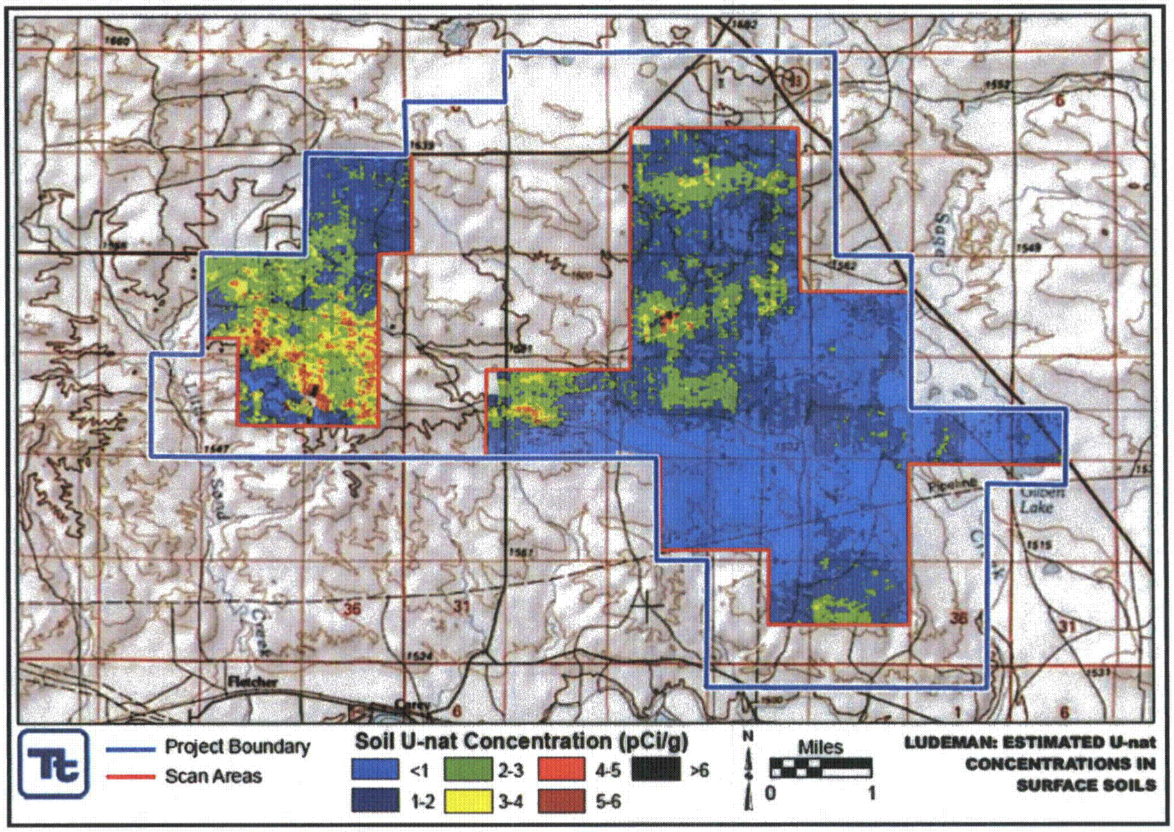
The partitioned gamma/Ra-226 correlation model shown in Figure 6-21, was used to convert raw NaI gamma scan readings from the site into estimates of Ra-226 concentrations in surface soils. Once converted, the resulting data set was kriged to provide continuous estimates of Ra-226 in surface soils (Figure 6-24).

Figure 6-24: Continuous, kriged estimates of Ra-226 concentrations in surface soils (0-15 cm depth) based on gamma survey results.



As previously indicated, conversion of scan data beyond the upper limit of gamma correlation plot data (26 μR/hr) involved artificial truncation at a fixed value (9.3 pCi/g), to avoid extrapolation of the predictive model. Above this range, the relationship is uncertain and model extrapolation has the potential to introduce localized spatial inaccuracies into respective kriging results. Though specific quantitative predictions regarding soil Ra-226 concentrations at gamma readings greater than 26 μR/hr are unjustified, this is unlikely to be problematic in a context of assessing impacts from site operations. While radiologically elevated, these locations are well delineated in terms of spatial extent and they represent only a tiny fraction of the overall survey area (Figure 6-24). Below the range of correlation plot data, truncation was not deemed necessary as the model decreases only slightly with decreasing readings and low-end extrapolation was not expected to significantly influence the spatial reliability of kriging results. Using similar data conversion protocols as described for estimation of soil Ra-226, the gamma/U-nat correlation equation (Figure 6-23) was used to convert raw NaI gamma scan readings into estimates of U-nat concentrations in surface soils. Converted data were then kriged to provide continuous estimates of U-nat in surface soils (Figure 6-25).

Figure 6-25: Continuous, kriged estimates of U-nat concentrations in surface soils (0-15 cm depth) based on gamma survey results.



As expected, the general spatial distribution of gamma-based estimates of soil U-nat concentrations across the surveyed areas is very similar to that of soil Ra-226.

6.1.2.3 Data Utility

The estimates of baseline gamma exposure rates provided in Figure 6-17 can be used to help assess respective changes due to operational activities at the site. If the same or similar models of NaI scintillation detectors are used for future gamma survey activities (e.g. factory calibrated Ludlum 44-10 detectors), the HPIC cross calibration regression model shown in Figure 6-15 can be used to convert field gamma readings to estimates of true exposure rate for direct comparison with the baseline estimates in corresponding areas as shown in Figure 6-17. If different types of gamma detectors are used, the HPIC cross calibration model provided in this report may not apply, as instrument energy dependence characteristics can differ.

The gamma-based estimates of baseline Ra-226 concentrations in surface soils provided in Figure 6-24, can be used to help assess potential changes in Ra-226 soil concentrations due to operational activities at the site. An important caveat is that future laboratory analysis of soil samples used for such comparisons should employ the same analytical method used to develop this baseline information (HPGe-based gamma spectroscopy by a qualified laboratory). Sodium iodide (NaI) based gamma scintillation detectors can be used as a field screening tool to help define the extent of potential contamination relative to the baseline estimates in corresponding areas as shown in Figure 6-24. If different types of gamma detectors are used, or if the suspected magnitude of potential contamination being surveyed is well above baseline conditions, the correlation model presented in this report may not apply as instrument energy dependence characteristics can differ. Another caveat is that a number of baseline soil samples from areas possessing higher gamma readings, had Ra-226 results that were significantly lower than indicated by gamma readings in the field, and a relatively small overall bias exists between the two estimation methods. These issues are discussed in more detail in Section 6.2.4.2.

Potential impacts from future site operations on soil U-nat concentrations can be assessed by comparison of soil sampling results against gamma-based estimates of baseline U-nat concentrations (Figure 6-25) in corresponding areas. However, the same analytical method employed for measuring U-nat in correlation plot samples (ICP-MS) should be used. Once ISR operations have commenced, gamma measurements are unlikely to be a reliable tool for evaluating uranium contamination in soil, since the correlation used for baseline estimation only applies to baseline soil conditions. Uranium itself has no significant gamma signature, and operational releases may involve different physical/chemical properties and different relative amounts of Ra-226 and U-nat.

All of the above options for assessment of potential radiological impacts from future site operations relative to the baseline radiological information generated by the proposed project gamma survey must consider data uncertainty in both the estimated baseline values and any future analytical information used for such comparisons. In all cases, analytical methods and instruments should be comparable to those used in this study. Use of several available assessment options should reduce overall potential for misidentification or erroneous quantification of possible future contamination.

6.1.2.4 Data Uncertainty

For comparison of operational/post-operational survey measurements against baseline survey data, it is necessary to take into account the degree of uncertainty in survey measurements. Sources of measurement uncertainty include (but may not be limited to):

- Instrument variability within and between gamma detectors;
- Variations in count data associated with the random nature of radioactive decay;
- Small-scale spatial variability in gamma exposure rates (differences in readings due to small differences in measurement geometry or location);

- Temporal variability in gamma exposure rates associated with:
    - Changes in natural shielding factors for terrestrial or cosmic sources such as changes in soil moisture or barometric pressure
    - Diurnal fluctuations in ambient radon concentrations in air
- Small inaccuracies in GPS readings; and
- Errors associated with soil sampling and laboratory analyses

Each radiological baseline parameter characterized in association with the gamma survey is evaluated in a context of total estimation uncertainty in the following sections.

6.1.2.4.1 Gamma Exposure Rates

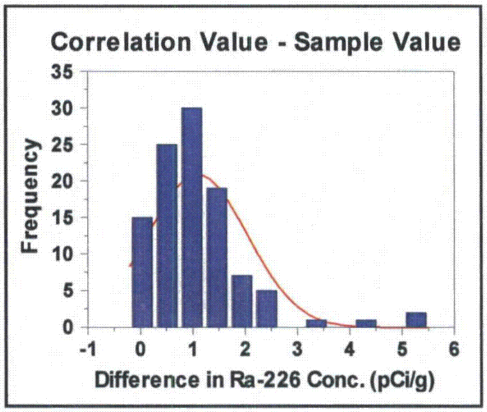
In general, scanning system measurements along QC field strips at the site provide an indication of total gamma measurement uncertainty including most of the above sources of variability in gamma exposure rate readings. Based on the data shown in Figure 6-10, the total range of potential uncertainty in NaI scanning measurements at field strip locations was about ± 2 μR/hr. Approximately the same amount of uncertainty should be applicable to 3-foot HPIC equivalent data at these locations. The field strips were located in areas having ambient gamma exposure rate readings in the range of 15-18 μR/hr (close to the average of all readings found at the site). In areas of significantly higher gamma exposure rates (e.g. above 25 μR/hr), the degree of uncertainty in measurements is likely to be somewhat higher; but again, these areas represent a very small fraction of the total area surveyed.

Given the general density of scan coverage attained at the proposed project site (on the order of 10-15 percent), larger-scale distributional characteristics are more likely to be accurately characterized as smaller-scale spatial variability in exposure rates between scan tracks from each survey vehicle is not measured. The kriging process for continuous estimation of overall baseline conditions is believed to "smooth" some variability associated with certain sources of data uncertainty in areas along individual gamma scan tracks (e.g. variability in response characteristics of different detectors, small inaccuracies in GPS readings). Although this smoothing effect is believed to improve estimation precision (reproducibility) along scan tracks, the accuracy of interpolated values between scan tracks is dependent on the degree of spatial uniformity in soil radionuclide concentrations.

6.1.2.4.2 Gamma-Based Soil Ra-226 Estimates

Gamma-based estimates of soil Ra-226 (Figure 6-24) were compared with independent soil sampling results at corresponding locations to help assess data uncertainty. Past results for estimating Ra-226 concentrations using these same characterization techniques have generally demonstrated differences between estimated and measured values in the range of ± 2 pCi/g (EMC, 2007; Uranium One, 2009; Whicker et al., 2008).

Figure 6-26: Frequency histogram of numerical differences between gamma-based estimates of Ra-226 in surface soils (correlation value) minus radial grid soil sampling results (sample value) at corresponding locations.

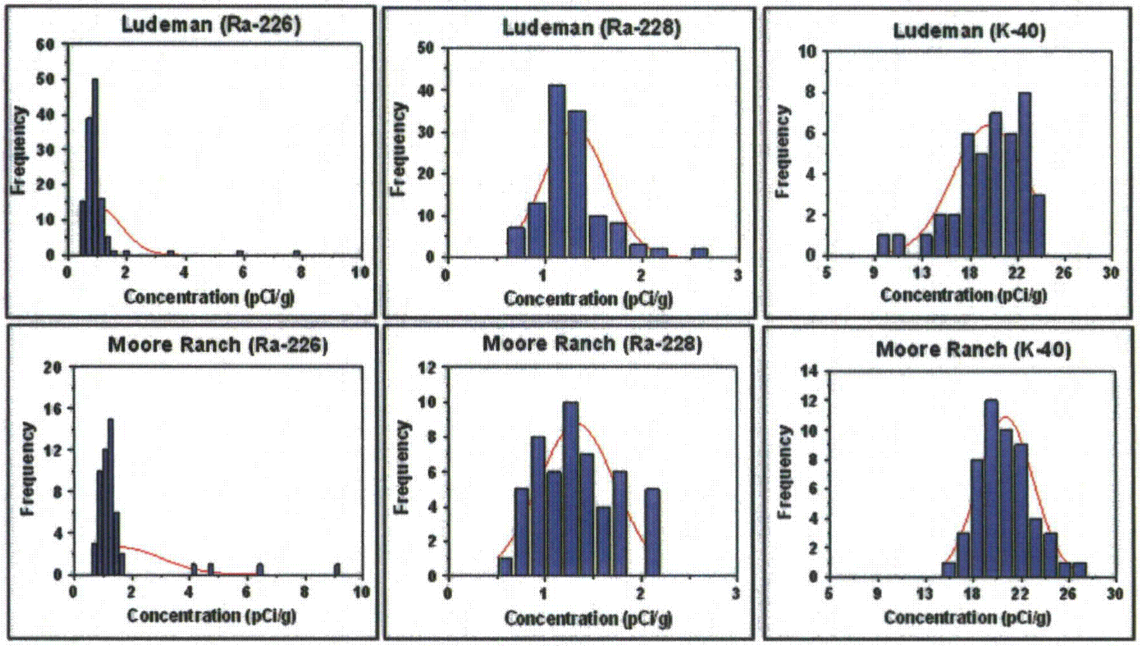


One hundred eighteen surface soil samples at the proposed project were collected along radial sampling grids among the three proposed Satellite facility locations according to Regulatory Guide 4.14 protocols. Radium-226 results for these samples were superimposed on the kriged map of gamma-based Ra-226 concentration estimates for surface soils and corresponding values were numerically compared. The vast majority of gamma-based estimates (correlation values) were within + 2 pCi/g of corresponding soil sampling results (Figure 6-26). Considerably larger differences are apparent in a few locations where higher gamma readings are present, and on average, an overall bias of about ± 1 pCi/g is evident between the two characterization parameters.

To evaluate apparent discrepancies and potential bias in either the gamma-based estimates or the soil sampling results, frequency histograms of analytical results for Ra-226, Ra-228, and K-40 in surface soils from the radial grid samples were generated (Figure 6-27). These histograms provide an indication of relative levels and variability for naturally occurring sources of terrestrial gamma radiation (U-238/Th-232 decay series and K-40). Because the gamma/Ra-226 correlation for Ludeman was essentially identical to that of Moore Ranch, corresponding frequency distributions for surface soil samples from the nearby Moore Ranch site are also shown for comparison.
Assuming approximate equilibrium conditions for decay series products associated with Ra-226 and Ra-228 (the U-238 and Th-232 decay series respectively), average levels and variability for naturally occurring gamma emitting radionuclides (including K-40) are very similar at both sites. At Moore Ranch, soil sample results for Ra-226 were generally within ± 1 pCi/g of corresponding gamma-based estimates (EMC, 2007) despite this

amount of variability in Ra-228 and K-40 values. As previously indicated, differences at most Wyoming sites have been within ± 2 pCi/g under similar conditions.

Figure 6-27: Frequency histograms of Ra-226, K-40 and Ra-228 results for surface soil samples from Ludeman (top) and Moore Ranch (bottom). Values for both radial grid samples and correlation plot samples are included.

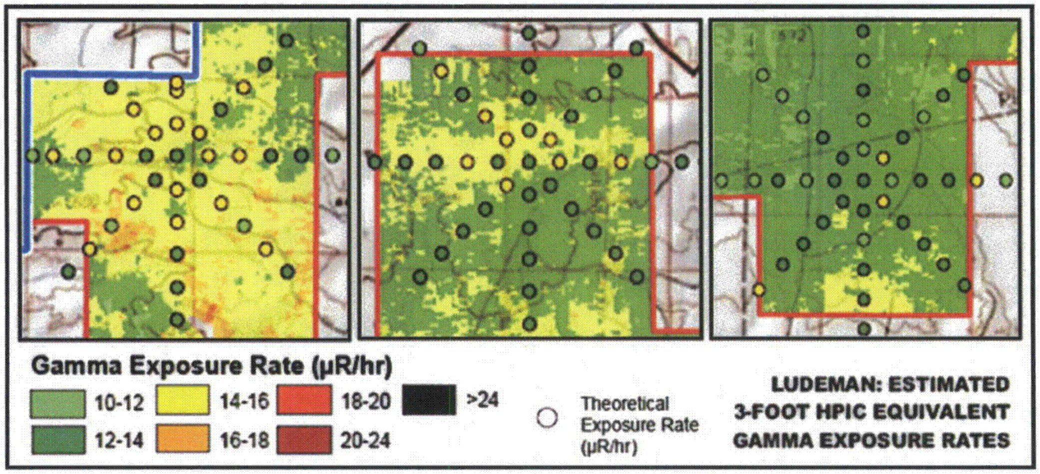


Gamma measurements and composite soil sampling at each correlation plot are designed to be spatially precise and highly representative of average conditions for each parameter. The correlation between field gamma readings and Ra-226 concentrations in surface soils at the proposed project demonstrated a very strong statistical relationship. Figure 6-18 clearly shows the spatial associations between these two parameters. The r-squared of 0.99 for the gamma/Ra-226 regression (Figure 6-19) suggests only a 1 percent probability that the observed statistical correlation was a result of random chance or a coincidental artifact of sampling/analytical error. The prediction limits on this regression indicate that 95 percent of the total estimation uncertainty associated with the correlation data is equivalent to about ± 1 pCi/g. This level of uncertainty and the regression coefficients are both nearly identical to corresponding parameters observed in the gamma/Ra-226 correlation for the nearby Moore Ranch site (Figure 6-20).

On the other hand, analytical laboratory results for soil Ra-226 concentrations in radial grid samples from the proposed project were generally low relative to Moore Ranch and other sites in Wyoming and showed little variation in association with the spatial distributions of measured gamma exposure rates. The average Ra-226 concentration among radial grid samples (0.9 pCi/g) was low relative to the average value across the site as predicted by field gamma measurements (1.9 pCi/g), and is also low relative to the average value for directly measured soil samples from Moore Ranch (1.5 pCi/g). It is also slightly low relative to national averages reported in the literature (1-2 pCi/g as cited in Myrick et al., 1983 and NCRP, 1987).

These soil sampling results prompted calculation of a theoretical gamma exposure rate at each radial grid location based on expected contributions to the total gamma radiation field from both cosmic and terrestrial sources. The cosmic component was modeled based on elevation (Stone et al. 1999). Terrestrial components were calculated based on measured radionuclides in the Ludeman radial grid soil samples and use of conversion factors given in NCRP Report 94 (NCRP, 1987). Results for Ra-226 and Ra-228 (analogs for the U-238 and Th-232 decay series, assuming equilibrium) along with K-40 were used for these calculations under an assumption that these soil parameters (and associated decay series products) are the primary terrestrial sources at Ludeman and that each discrete sampling result reflects uniform soil radionuclide concentrations in the area. Calculated total theoretical gamma exposure rates at radial grid soil sampling locations were then plotted on the kriged, HPIC-equivalent gamma exposure rate map for comparison (Figure 6-28).

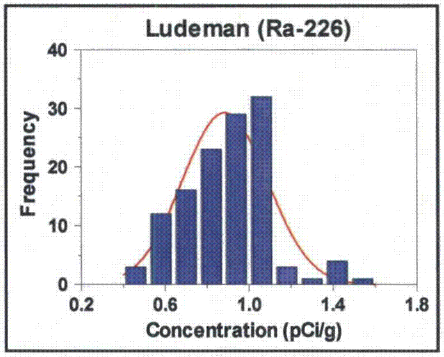
Figure 6-28: Calculated theoretical gamma exposure rate based on elevation and soil radionuclide concentrations at each radial grid sampling location, superimposed on the HPIC equivalent gamma survey map. Legend increments and color coding apply to both calculated theoretical values and kriged values based on the gamma survey.



In general, there is reasonably good spatial/quantitative agreement in many areas between theoretical gamma exposure rates at radial grid sampling locations and kriged, HPIC-equivalent estimates based on gamma survey measurements. However, there is an apparent trend of low theoretical values relative to kriged values at a significant number of locations, particularly in areas of consistently higher measured gamma readings. This suggests that soil radionuclide results for discrete soil samples collected in these areas may commonly under-represent average local concentrations. For example, if the average soil Ra-226 concentration in the vicinity of a given radial grid sampling location were underestimated by 1 pCi/g based on the point sample result, the calculated theoretical exposure rate could underpredict the actual exposure rate by as much as 1.8 μR/hr (due to this single source of terrestrial gamma radiation).

Radionuclide histograms for radial grid soil samples indicate that both Ra-228 and K-40 have roughly normal distributional characteristics, similar to those shown in Figure 6-27. Neither distribution is right-skewed (i.e. lognormal) and there was essentially no statistical correlation between the two radionuclides ($R^2 < 0.1$), thus neither source (alone or combined) is likely to be consistently responsible for higher gamma exposure rates in certain areas as identified and delineated by the gamma survey. This suggests that Ra-226 must be primarily responsible and should thus have at least a somewhat right skewed histogram, similar in nature to that shown in Figure 6-27 for all samples collected at the site (including the correlation plot samples).

Figure 6-29: Frequency histogram of analytical results for Ra-226 at radial grid soil sampling locations.



However, the histogram of Ra-226 values for radial grid samples is not right skewed. Instead, this distribution is unusual with an increasing frequency of occurrences building towards a value of 1.1 pCi/g, followed by an abrupt truncation above this value and only a few instances of slightly higher concentrations represented (Figure 6-29). This result is believed to be at least partly responsible for the low theoretical exposure rate values in areas of consistently higher measured gamma readings, and can thus potentially be linked to a low bias in soil sampling results versus gamma-based soil Ra-226 estimates.

Based on all available quantitative and qualitative evidence, the most likely explanations for apparent discrepancies and bias between gamma-based estimates of soil Ra-226 concentrations and directly measured Ra-226 concentrations in discrete radial grid soil samples include:

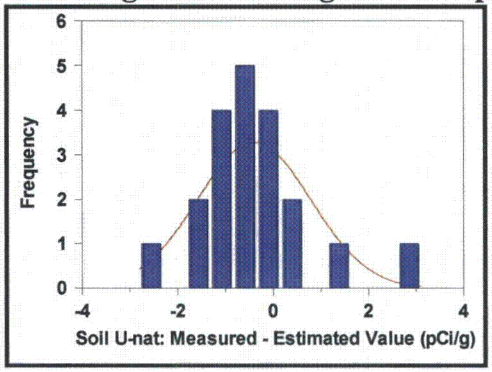
- Spatial heterogeneity in actual soil radionuclide concentrations relative to smoothly interpolated estimates between gamma survey tracks.
- Errors related to discrete point sampling versus composite sampling across more spatially representative areas (also a heterogeneity issue).
- Error in mapping the precise location where each radial grid sample was collected (GPS readings were recorded only at radial grid centers).
- Potential low bias in analytical laboratory results.

In general, the evidence tends to support an estimate of uncertainty in gamma based predictions of Ra-226 in surface soils that is consistent with values from other study sites in Wyoming (on the order of ± 2 pCi/g). Areas with the highest gamma readings at the site could have uncertainties that exceed this range, but such areas represent only small portions of the site and these areas are still well defined as being naturally elevated with respect to terrestrial sources of gamma radiation. In all cases, is important to recognize that kriged, gamma-based estimates of radionuclide concentrations in surface soils are based on the preponderance of gamma readings in any given area, and are thus most likely to reflect average soil concentrations across larger source areas.

6.1.2.4.3 Gamma-Based Soil U-nat Estimates

Regarding uncertainty in gamma-based estimates of soil U-nat concentrations (Figure 6-25), direct comparison between estimated and measured values demonstrate results that are consistent with the correlation results as well as with past results for this characterization technique. U-nat results for all soil and sediment samples (provided later in this report) are reasonably consistent with corresponding results from the nearby Moore Ranch site (EMC, 2008).

Figure 6-30 Histogram of differences between measured U-nat in soil samples and estimated U-nat values based on gamma readings in corresponding locations.



Comparisons of U-nat results from direct soil sampling against gamma-based estimates in corresponding locations suggests about ± 3.5 pCi/g of total estimation uncertainty (Figure 6-30). This amount of uncertainty is higher than indicated by the prediction limits on the gamma/U-nat correlation (Figure 6-23), likely due to variability in U-nat/Ra-226 ratios and the fact that the krig map involves interpolation between scan tracks where no actual measurements were collected.

Although a slight relative bias is apparent between estimated and measured U-nat values (about ± 0.5 pCi/g from an ideal mean difference of zero), the average difference is reasonably close to zero and the majority of individual differences are within ± 1 pCi/g of the mean. It is not clear whether the apparent bias is slightly high for estimated values, or slightly low for measured values.

6.1.2.5 Data Uncertainty Implications

Although the estimated total data uncertainty for gamma-based estimates of Ra-226 and U-nat in surface soils (± 2 pCi/g and 3.5 pCi/g respectively) appears high relative to the range of concentrations present, correlations generate the most probable statistical estimate of an equivalent measured concentration value at a given gamma reading based on average relationships from the correlation plot data. Assuming consistency in the analytical method used for soil sample analyses, the majority of measured concentration values should thus be closer to the estimated values versus respective bounds on estimated data uncertainty. This theoretical expectation is supported by the frequency histograms shown in Figures 6-26 and 6-30.

Because uncertainty is inherent in any type of survey data, statistical methods must be used to help account for such uncertainty when evaluating whether operational/post operational survey data are different from estimated baseline values at a given level of confidence, or whether they exceed applicable regulatory criteria relative to estimated baseline values. In addition to use of the kriged soil radionuclide concentration maps to help ascertain respective changes in radiological conditions (operationally or post operationally), the final kriged map of estimated baseline gamma exposure rates (Figure 6-17) should also be used. Gamma exposure rate results (cross-calibrated against the HPIC) are believed to be reliable and reproducible within a slightly smaller relative range of total data uncertainty.

When both spatial and quantitative aspects are considered, gamma based estimates of soil radionuclide concentrations across the site should result in considerably less overall uncertainty relative to direct soil sampling alone. This gamma survey methodology produces a spatial density of information on terrestrial sources of gamma radiation that is orders of magnitude greater than can be achieved by grid-based sampling or measurement approaches. Grid-based approaches rely more heavily on an assumption of spatial uniformity in soil concentrations. Survey data for this site, as well as for many other uranium recovery sites, demonstrate that baseline soil radionuclide concentrations can vary significantly across small areas. Grid-based survey approaches have a higher probability of missing or mischaracterizing the spatial distribution and extent of such features.

Direct, grid-based soil sampling data, however, are a necessary and important component of this overall characterization approach. Grid-based soil sampling is indicated in applicable regulatory guidance documents and also enables evaluation of the degree of uncertainty in gamma-based estimates (assuming consistency in analytical laboratory methods) as well as factors that may influence such uncertainty (e.g. heterogeneity, representativeness, etc.). The combination of both forms of radiological survey information is significantly more effective than either form alone.

6.1.2.6 Conclusions

The 2008 baseline gamma survey of the proposed project site in Converse County, Wyoming provides a detailed characterization of natural background gamma exposure rates and associated radionuclide soil concentrations at the site. The survey included high density gamma scanning using six independent (factory-calibrated) detectors, robust daily quality control measurements, NaI/HPIC cross calibrations, gamma/soil radionuclide correlations, in-depth statistical assessments, and geostatistical spatial analysis techniques in an effort to provide the most thorough characterization possible for a number of important baseline radiological parameters.

Gamma exposure rates and gamma-based estimates of soil radionuclide concentrations are similar to those observed at the nearby Moore Ranch site (EMC, 2007). Baseline gamma exposure rate characterization results along with gamma-based estimates of Ra-226 and U-nat concentrations in surface soils should meet regulatory standards for baseline characterizations. This information will help facilitate effective identification and assessment of any potential radiological contamination that could result from ISR activities. Future measurements of these parameters should use analytical methods consistent with the methods used in this survey. The technology and approaches used for this gamma survey have resulted in a level of understanding of radiological baseline characteristics at the proposed project site that is likely to benefit all stakeholders.

6.1.3 Soil Sampling

Soil sampling was conducted at the proposed project site in the fall of 2008 in accordance to NRC Regulatory Guide 4.14 protocols. Data from NRC Regulatory Guide 4.14, soil sampling represents discrete, systematic locations involving 5-cm sampling depths for surface soils, and incremental soil profile sampling to a depth of 1 meter for subsurface soils (NRC, 1980). Because gamma-based estimates of soil radionuclides were based on 15-cm surface soil depths, baseline soil radionuclide concentration data for both 5-cm and 15-cm soil depths are represented in this report in accordance with NRC Regulatory Guide 4.14 protocols and NUREG-1569 application review recommendations (NRC, 2003).

6.1.3.1 Methods

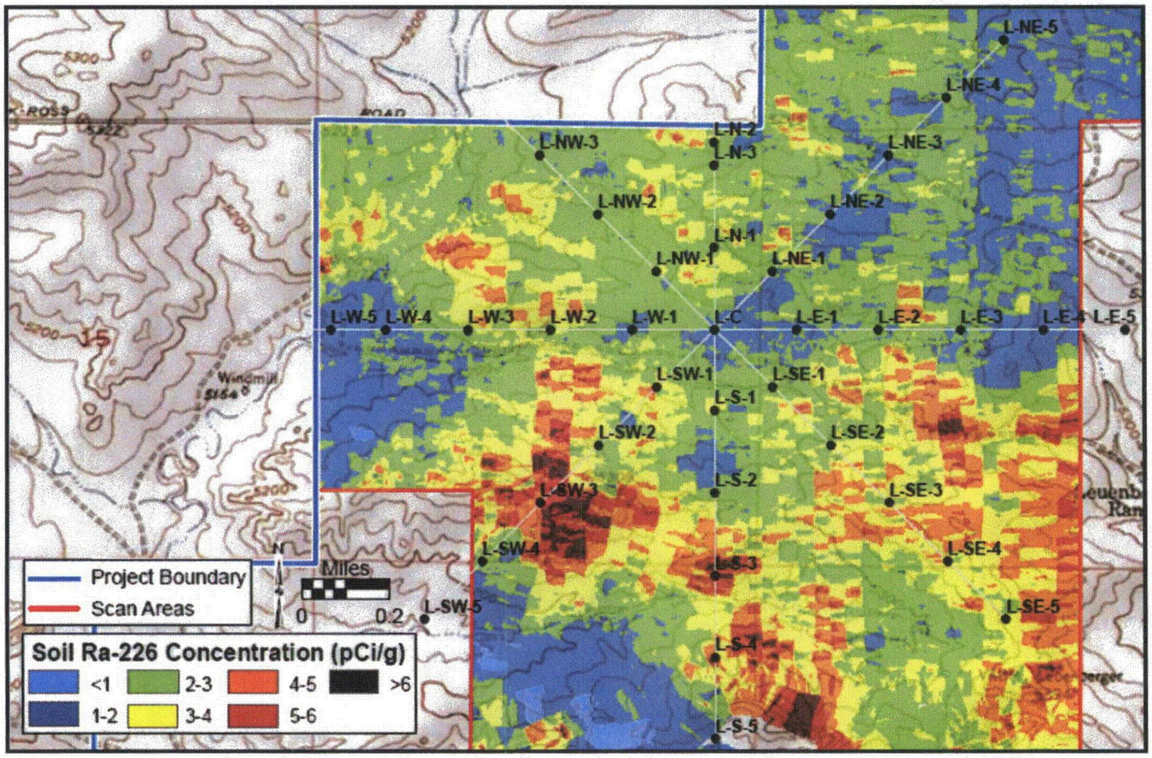
6.1.3.1.1 Surface Soil Sampling

The surface soil sampling design indicated in NRC Regulatory Guide 4.14 involves a radial grid pattern with the center of the grid located at the proposed processing facility. In this case, there are three proposed Satellite facility sites within the project area boundaries, each of which is separated by considerable distances (Figure 6-3). Discrete soil samples were collected along transects radiating in 8 compass directions from each of these facility locations at 300 meter intervals as is illustrated in Figure 6-31 for Facility Site 1 (the "Leuenberger" Facility Site).

Each radial grid sampling transect was about 1,500 meters long, resulting in the collection of 5 samples per transect for a total of 41 radial grid samples per Satellite facility. In a few cases, there were necessary omissions or spatial modifications to the radial sampling grid as planned locations were located off-site on private property, or in areas disturbed by pipeline installations. Soil samples were sent to ELI (Casper, Wyoming) for analysis of all analytes as specified in NRC Regulatory Guide 4.14.

Analytes included Ra-226 for all samples, with about 11 percent of the samples being further analyzed for natural uranium (U-nat), Th-230, and Pb-210. Additional surface soil samples were collected at each air particulate monitoring station and were analyzed per NRC Regulatory Guide 4.14 specifications. All radial grid and air station surface soil samples were collected with a shovel or hand trowel to a depth of 5 cm, double bagged, and labeled. Sampling tools were cleaned before each subsequent collection. A systematic location ID number (Facility Site name, transect compass heading, and transect sample number) for each sampling location, along with the collection date, were recorded in the field log book. GPS coordinates were taken at the center of each sampling grid. Sampling locations along each radial grid transect were determined in the field at approximate 300-meter intervals. Individual GPS coordinates or gamma readings were not taken at each location. Samples were sent to ELI in Casper, Wyoming along with chain of custody / analysis request forms. After receipt by ELI, samples were dried, crushed, ground, and thoroughly homogenized prior to analysis.

Figure 6-31 NRC Regulatory Guide 4.14 radial grid surface soil sampling locations (black dots) with annotated sample ID scheme for Satellite Plan Site 1 (the "Leuenberger" Facility Site). Gamma-based estimates of soil Ra 226 concentrations are also shown to illustrate the spatial distribution of local sources of terrestrial gamma radiation relative to grid locations.



6.1.3.1.2 Subsurface Soil Sampling

Five subsurface depth profile sampling locations in the vicinity of each Satellite facility were also selected based on NRC Regulatory Guide 4.14 recommendations. One location was at the approximate center of each planned Satellite facility location, with the other four samples collected along the same radial transects used for surface soil sampling, at 750 meters from the facility and in the four primary compass headings (N, E, S, and W).

Subsurface soil samples were collected with a 2-man gas powered auger with a 4-inch diameter bit with a 3-foot extension. At each location, three depth-integrated samples were successively collected at 33-cm increments, the final sample culminating at a total depth of 1 meter. After a sample was taken, the hole was cleaned out before going to the next required depth. Sample collection, lab delivery, chain of custody, sample preparation, and analysis protocols were the same as those described in the preceding section for surface soil samples. All soil depth profile samples were analyzed for Ra-226 by gamma spectroscopy (Method 901.1). At each of the three Satellite Site radial depth sampling grids, all samples from one location were further analyzed for natural U-nat, Th-230, and Pb-210 by wet radiochemical methods.

6.1.3.2 Soil Sampling Results

Annotated maps of Ra-226 concentration results from all radial grid surface soil samples collected at the site have been superimposed on the kriged gamma-based estimates of soil Ra-226 and are provided in this Section. Tabular summary statistics for all surface soil sampling results are also provided. The subsequent section provides tabular summary statistics for subsurface soil samples. Results for all radionuclides are reasonably consistent with results from Moore Ranch (EMC, 2008) though Ra-226 results for radial grid samples were generally low as discussed in Section 6.2.4.2.

6.1.3.2.1 Surface Soil Sampling Results

Color-coded, annotated soil Ra-226 results for all surface soil samples (0-5 cm depths) are provided for each radial sampling grid illustrated in Figures 6-32 through 6-34. Summary statistics for all radiological surface soil parameters as recommended in NRC Regulatory Guide 4.14 are shown in Table 6-1.

Figure 6-32: Facility Site 1 (Leuenberger) radial grid surface soil sampling results: annotated Ra-226 concentrations (pCi/g) for discrete samples collected at a 5-cm soil depth, superimposed on the gamma-based Ra-226 estimation map.

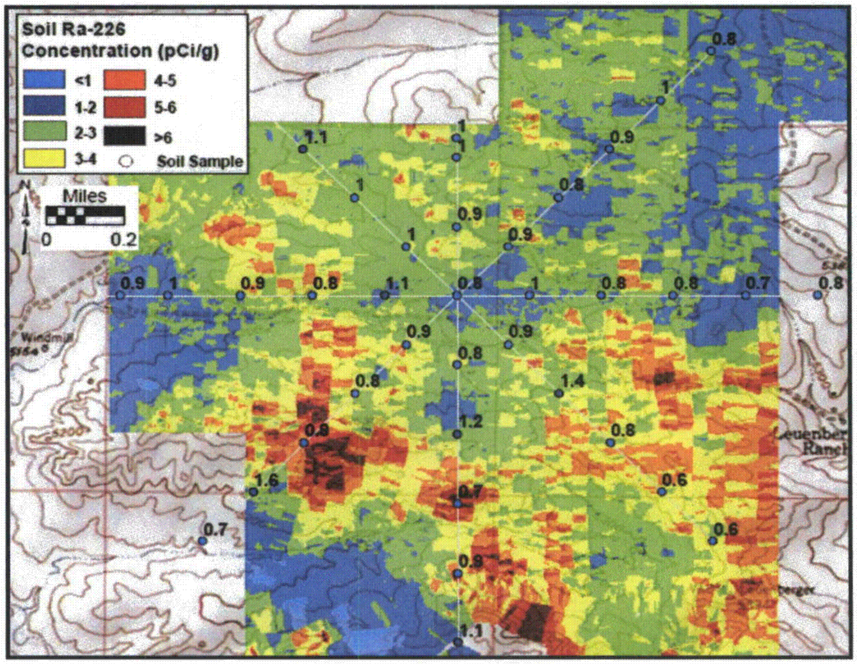


Figure 6-33: Facility Site 2 (North Platte) radial grid surface soil sampling results: annotated Ra-226 concentrations (pCi/g) for discrete samples collected at a 5-cm soil depth, superimposed on the gamma-based Ra-226 estimation map.

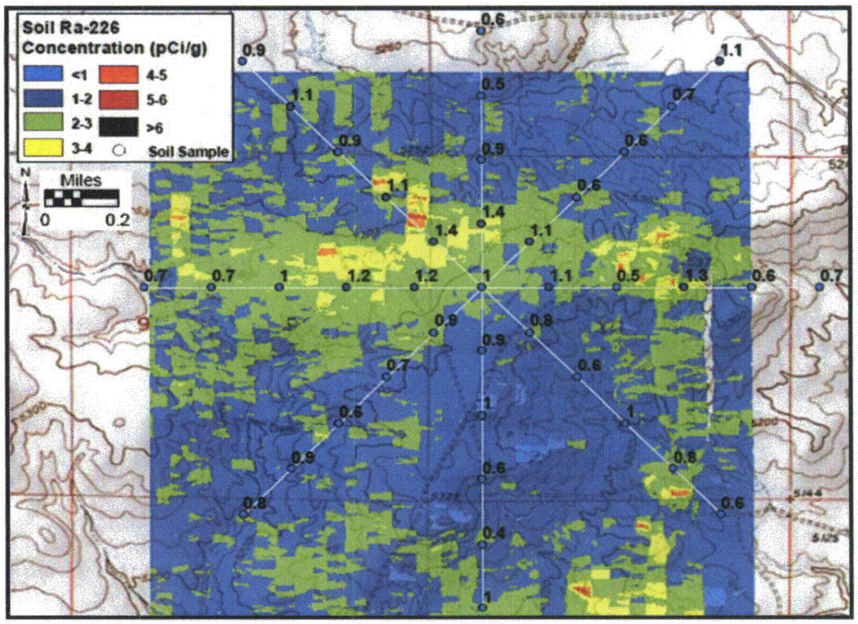


Figure 6-34: Facility Site 3 (Peterson) radial grid surface soil sampling results: annotated Ra-226 concentrations (pCi/g) for discrete samples collected at a 5-cm soil depth, superimposed on the gamma-based Ra 226 estimation map.

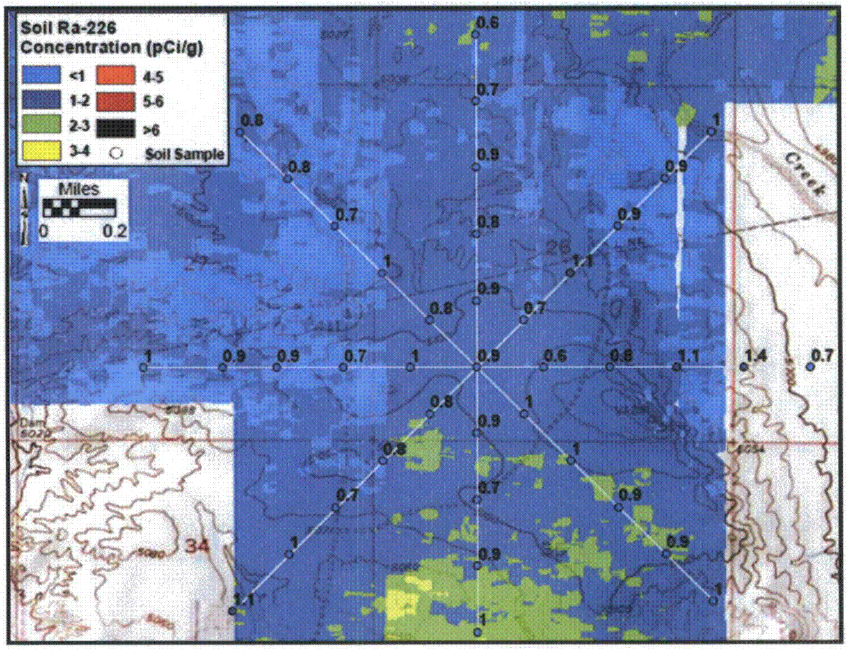


Table 6-1: Summary statistics for surface soil samples collected along the radial grids and at air particulate monitoring stations (discrete samples collected at 5-cm sampling depths).

Surface Soil Sample Series	Mean	Std. Dev.	Median	Max	Min	n
Ra-226 (pCi/g)						
Plant 1 (Leuenberger) Radial Samples	0.9	0.2	0.9	1.6	0.6	37
Plant 2 (North Platte) Radial Samples	0.9	0.3	0.9	1.4	0.4	41
Plant 3 (Peterson) Radial Samples	0.9	0.2	0.9	1.4	0.6	41
Air Particulate Station Samples	0.8	0.1	0.8	0.9	0.7	5
All Samples	0.9	0.2	0.9	1.6	0.4	124
U-nat (pCi/g)						
Plant 1 (Leuenberger) Radial Samples	0.9	0.2	0.9	1.0	0.7	3
Plant 2 (North Platte) Radial Samples	0.8	0.3	0.7	1.2	0.5	4
Plant 3 (Peterson) Radial Samples	0.6	0.1	0.6	0.8	0.5	4
Air Particulate Station Samples	0.8	0.2	0.7	1.1	0.7	5
All Samples	0.8	0.2	0.7	1.2	0.5	16
Th-230 (pCi/g)						
Plant 1 (Leuenberger) Radial Samples	0.3	0.1	0.3	0.4	0.2	4
Plant 2 (North Platte) Radial Samples	0.2	0.1	0.2	0.4	0.1	4
Plant 3 (Peterson) Radial Samples	0.4	0.1	0.4	0.5	0.3	4
Air Particulate Station Samples	0.3	0.1	0.3	0.4	0.1	5
All Samples	0.3	0.1	0.3	0.5	0.1	17
Pb-210 (pCi/g)						
Plant 1 (Leuenberger) Radial Samples	0.8	0.8	0.6	1.7	0.2	3
Plant 2 (North Platte) Radial Samples	1.6	0.6	1.5	2.3	1.0	4
Plant 3 (Peterson) Radial Samples	0.6	0.5	0.6	1.2	0.1	4
Air Particulate Station Samples	0.5	0.9	0.9	1.2	-0.9	5
All Samples	0.5	0.8	1.0	2.3	-0.9	16

Apparent discrepancies between soil sampling results for Ra-226 and gamma-based estimates in corresponding locations are discussed at length in Section 6.2.4.2. The evidence suggests that considerable heterogeneity in soil radionuclide concentrations may be responsible for such discrepancies. Given that gamma survey measurements define averages from terrestrial sources across larger source areas (e.g. 100 m^2), while discrete soil samples give only a point estimate. There is also evidence of a potentially low bias in soil sampling results for Ra-226, given the measured levels of other radionuclides such as Ra-228 and K-40 relative to the total gamma field at these locations. Gamma-based soil Ra-226 estimates are believed to provide a reliable characterization of average surface concentrations in the general vicinity of any given location.

6.1.3.2.2 Subsurface Soil Sampling Results

Summary statistics for subsurface samples by radionuclide and sampling depth increment across all subsurface sampling locations are shown in Table 6-2. There was no indication of any trends in soil concentration with depth at any of the radial sampling grids. This result suggests that soil concentration is generally independent of depth over the top 1 meter of the soil profile in most locations, and that surface soil sampling results and gamma-based estimates of soil radionuclides provide a reasonable indication of expected concentrations over this depth in the soil profile.

Table 6- 2: Summary statistics for all subsurface (depth profile) soil samples collected along NRC Regulatory Guide 4.14 radial grids (includes grids for all three Satellite facility locations).

Soil Sampling Depth (cm)	Mean	Std. Dev.	Median	Max	Min	n
Ra-226 (pCi/g)						
0-33	1.0	0.2	0.9	1.2	0.7	15
33-66	0.9	0.2	1.0	1.3	0.5	15
66-100	1.0	0.3	0.9	1.7	0.6	15
U-nat (pCi/g)						
0-33	0.7	0.2	0.7	0.9	0.5	3
33-66	0.7	0.2	0.7	0.9	0.5	3
66-100	0.9	0.2	0.9	1.0	0.6	3
Th-230 (pCi/g)						
0-33	0.4	0.2	0.5	0.5	0.2	3
33-66	0.0	0.3	-0.2	0.4	-0.2	3
66-100	0.1	0.4	0.1	0.4	-0.3	3
Pb-210 (pCi/g)						
0-33	0.1	0.7	0.4	0.5	-0.7	3
33-66	0.1	1.1	-0.3	1.3	-0.8	3
66-100	-0.3	0.9	-0.7	0.7	-1.0	3

6.1.3.3 Conclusions

Baseline radiological soil sampling data for the proposed project site were collected in accordance with NRC Regulatory Guide 4.14 protocols. These data sets, combined with correlated soil sampling results and continuous kriged estimates of Ra-226 and U-nat soil concentrations based on gamma survey data (Section 6.2.2.5) provide a comprehensive characterization of existing soil radionuclide concentrations across the site. This information should meet respective baseline characterization requirements as indicated by the U.S. Nuclear Regulatory Commission and the Wyoming Department of Environmental Quality / Land Quality Division for ISR licensing/permitting applications.

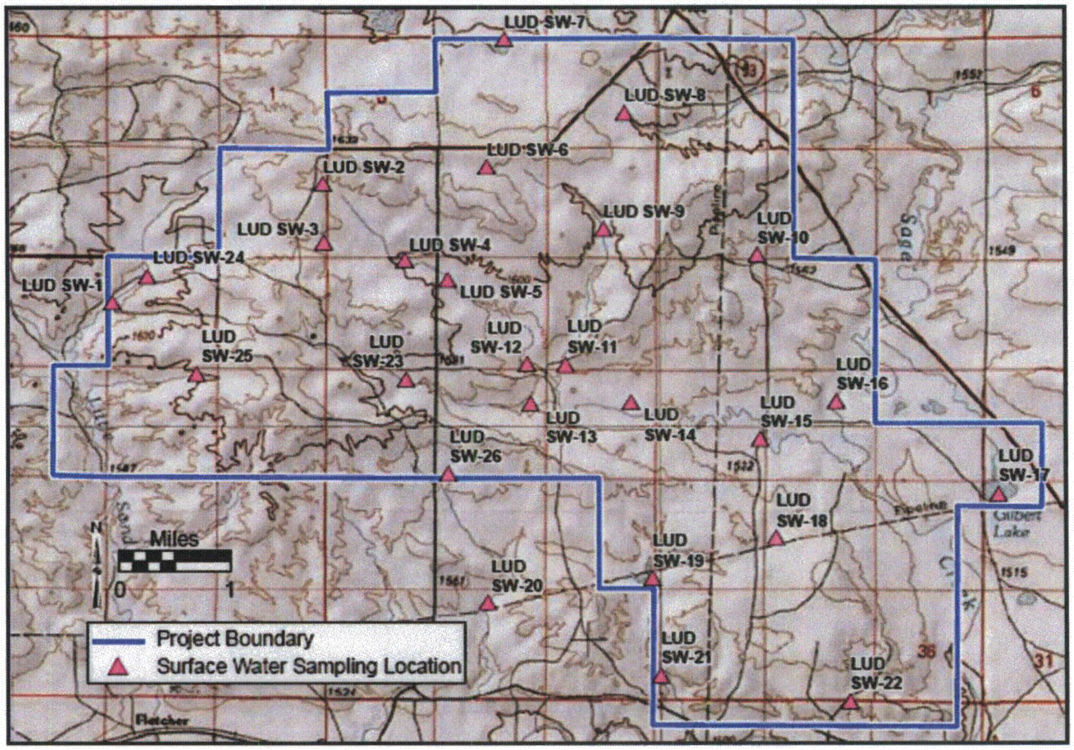
6.1.4 Sediment Sampling

In August of 2008, baseline sediment sampling was conducted at the proposed project site in general accordance with NRC Regulatory Guide 4.14 protocols (NRC, 1980). Although this guidance calls for two separate sampling events (spring and fall) for stream sediments, respective sediment sampling at other ISR sites in the region show that measured differences in sediment radionuclide concentrations between runoff season (spring) and low-flow (fall) hydrologic conditions are very similar, generally falling within the range of normal sampling and analytical variability (EMC, 2008; Uranium One, 2009).

Figure 6-35: Example of an ephemeral stream drainage channel at the Ludeman Project.

Selected sediment sampling locations were the same as those used for surface water sampling locations (Figure 6-35). This included stock ponds, small natural impoundments and ephemeral stream drainage channels. These locations are widely distributed across the site, including locations generally upstream and downstream from proposed Satellite facility locations (Figure 6-36).

Figure 6-36: Surface water / sediment sampling locations.



6.1.4.1 Methods

At each sediment sampling location, a soil sample was collected with a hand trowel to a depth of 5 cm. Location ID numbers, date, and GPS coordinates for each sampling location were recorded in the field log book. Samples were sent to Energy Laboratories, Inc. in Casper, Wyoming along with chain of custody / analysis request forms. Samples were dried, crushed, ground, and thoroughly homogenized prior to analysis. Sediment samples were analyzed for Ra-226 content by gamma spectroscopy (Method 901.1). Other analytes were measured by standard wet radiochemical methods.

6.1.4.2 Sediment Sampling Results

Individual sampling locations and respective Ra-226 results are shown in Figure 6-37. Individual results for all radionuclides by location are shown in Figure 6-38. Descriptive summary statistics of all sediment data are provided in Table 6-3. On average, baseline sediment radionuclide results are slightly higher compared to surface soil data (Section

6.3.2.1), and considerably higher for Pb-210. One unusually high U-nat value was reported.

Figure 6-37: Sediment sampling locations (same as surface water sampling locations) and annotated sediment Ra-226 concentration results.

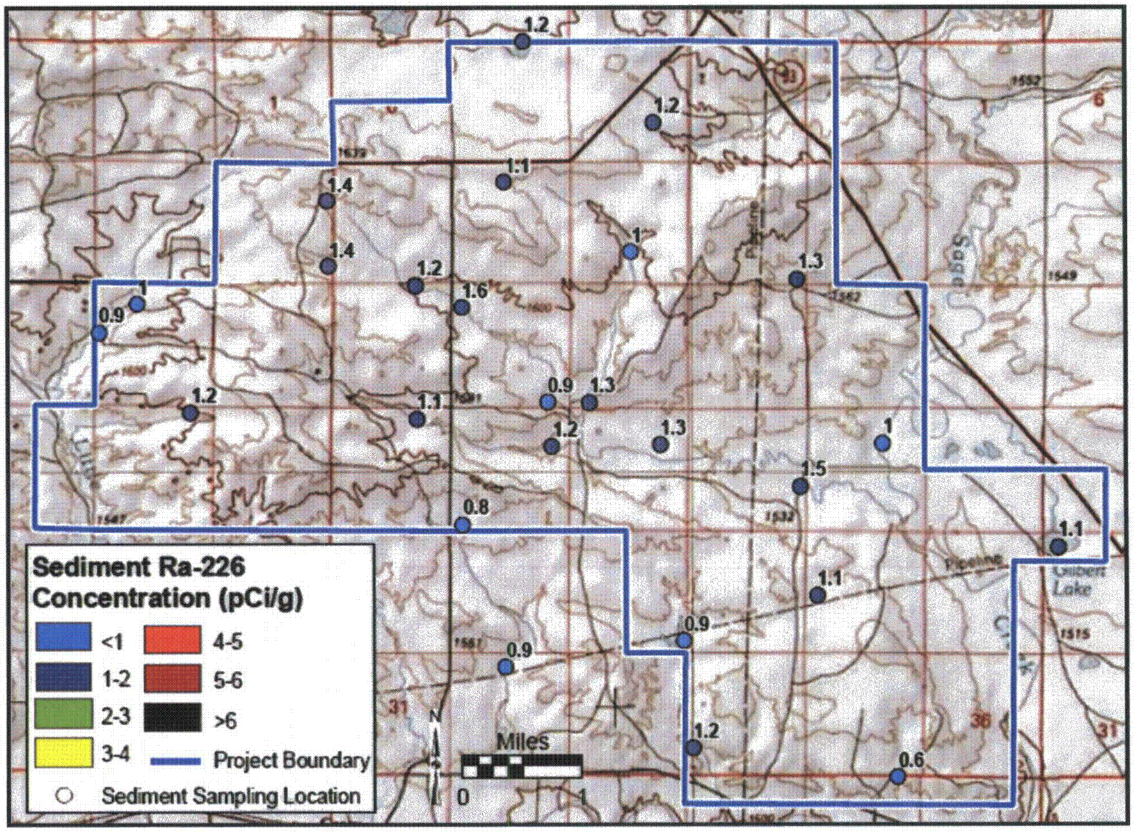


Figure 6- 38: Individual sediment sampling results by radionuclide and location.

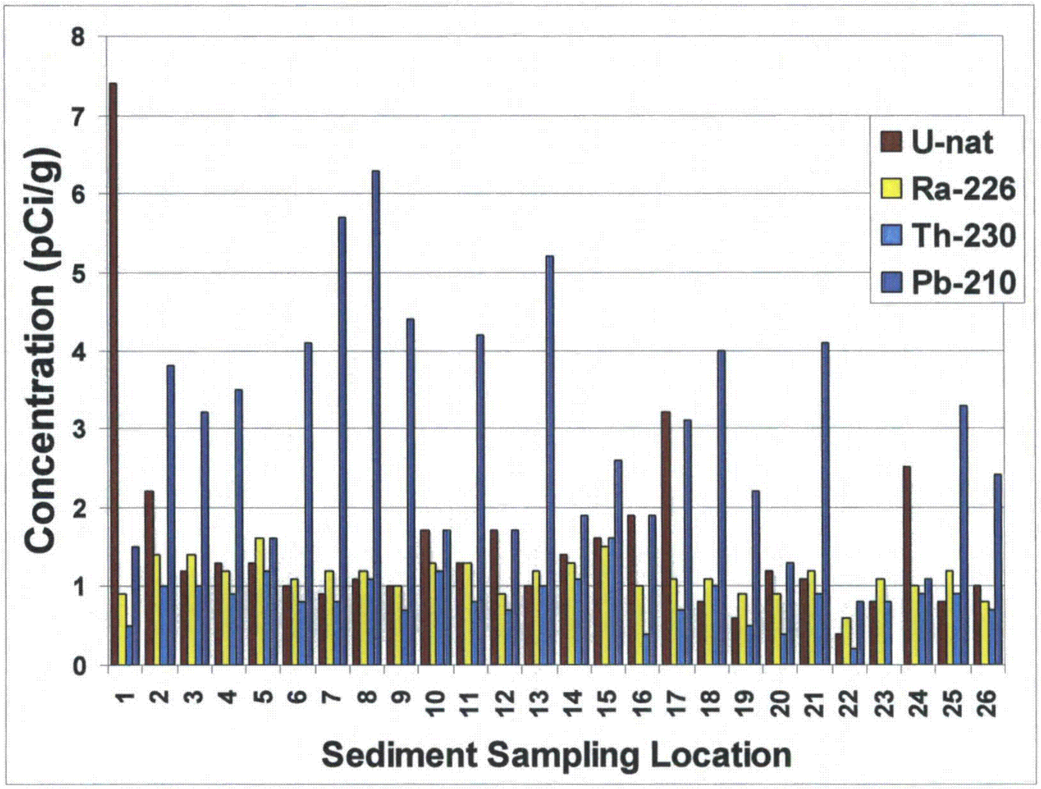


Table 6-3: Descriptive Statistics for Stream Sediment Samples.

Analyte	Mean	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.1	0.2	1.2	1.6	0.6	26
U-nat	1.6	1.3	1.2	7.4	0.4	26
Th-230	0.8	0.3	0.9	1.6	0.2	26
Pb-210	3.0	1.5	3.1	6.3	0.8	25

The high uranium concentration detected in sediment at location 1 (LUD SW-1), appears to be a legitimate analytical result, as surface water samples collected at this same location at different times also yielder higher uranium concentrations (see Section 6.9).

6.1.4.3 Conclusions

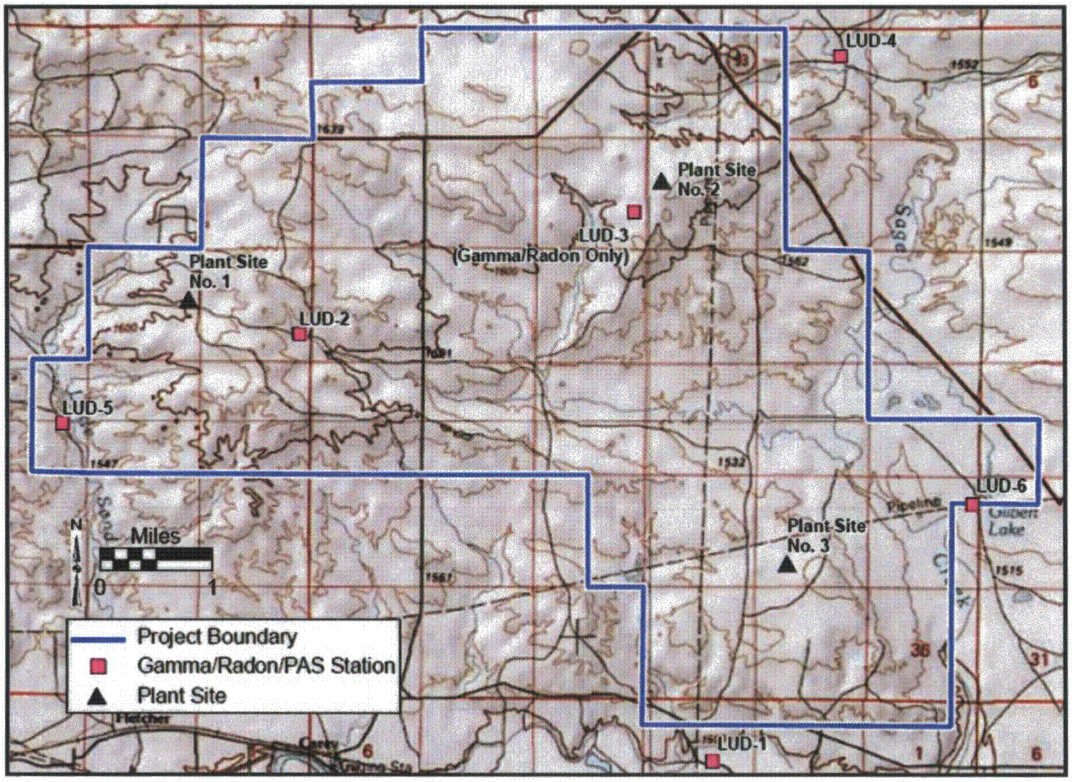
Baseline sediment radionuclide data for the proposed project site were collected and analyzed according to NRC Regulatory Guide 4.14 protocols. This information should be sufficient to meet respective baseline survey requirements as indicated by the U.S. Nuclear Regulatory Commission and the Wyoming Department of Environmental Quality / Land Quality Division with respect to ISR licensing/permitting applications.

6.1.5 Ambient Gamma Dose Rate and Radon Monitoring

Continuous passive monitoring of ambient gamma dose rates and radon concentrations within the project area was initiated in March 2008. NRC 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). This data was collected and reported on a quarterly basis.

Passive devices for monitoring average ambient gamma dose rates and radon levels are housed within each monitoring station. Station locations were selected based on NRC Regulatory Guide 4.14, including locations of Satellite facilities, prevailing wind directions, corresponding locations with air particulate monitoring stations, adjacent residences, practical access, and consideration for continued monitoring during operational phases of the project. In all, 6 of these stations were installed, one at each particulate air sampling (PAS) location. Locations of passive gamma/radon and PAS monitoring stations are shown in Figure 6-39.

Figure 6-39: Approximate station locations for combined monitoring of ambient baseline gamma dose rate, radon, and air particulates (Gamma/Radon/PAS stations



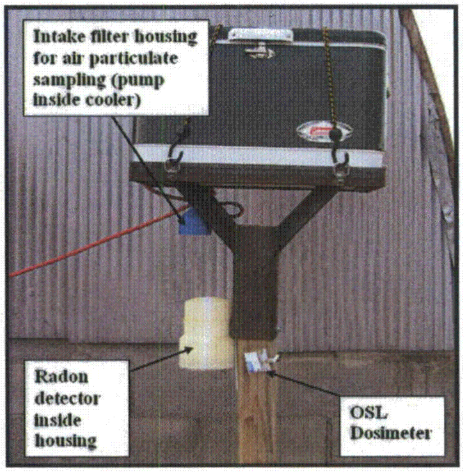
6.1.5.1 Methods

6.1.5.1.1 Ambient Gamma Dose Rate Monitoring

Passive monitoring of gamma dose rates at the site is being conducted with optically stimulated luminescent dosimeters (OSLs) supplied by Landauer, Incorporated. The OSLs are attached to air particulate monitoring stations (Figure 6-40).

Each batch of OSLs contains a "transit" and "deploy" control OSL badge to account for background doses received by field badges when not actually deployed at the site. Both control badges were stored at Uranium One's office in Casper, Wyoming (away from any radioactive sources), except while in transit to and from Landauer; and as applicable, to and from the site during quarterly field badge change outs. One of the control badges is taken into the field during quarterly field dosimeter change-outs to account for any additional dose exposure to field badges during this period. However in this case, the distance and time required for this to occur was negligible, relative to the overall monitoring period; and thus, slight differences between transit and deploy control badge dose results are not considered a reliable measure of this dose, particularly in a context of potential uncertainties in such measurements.

Figure 6-40: Passive gamma/radon monitoring station equipment attached to air particulate sampling station.



Landauer reports a "net" dose result, calculated by subtracting the deploy control badge result from each field badge result. This gives a 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 representing the amount of time the field badges are not actually deployed at the site. For this project, 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 OSL issuance to OSL analysis by the dosimetry vendor.
2. Determine the total dose to the field dosimeter while not deployed at the site:
   - 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 while not deployed at the site as: (Result from step 1 above) × (number of days from OSL issuance to OSL analysis, minus the number of days the field badge was actually deployed at the site)

3. Calculate the total dose received by the field OSL while deployed at the site:
   - Assume additional background dose received by the field badge during deployment to and from the site is negligible relative to the overall monitoring period.
   - Subtract the result in step 2 above from the gross result for the field OSL as reported by the vendor.

6.1.5.1.2 Ambient Radon-222 Monitoring

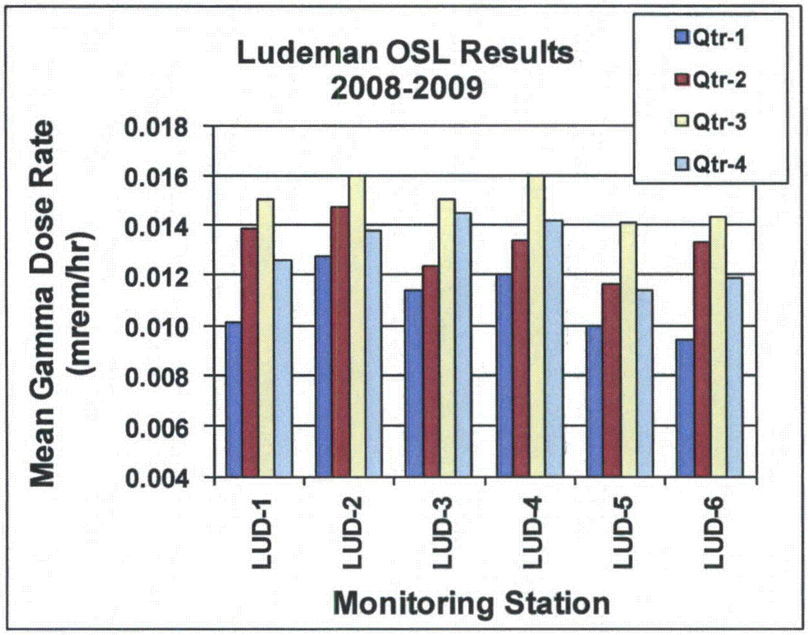
Passive monitoring of average Rn-222 air concentrations at the site is being conducted with Radtrak® alpha-track radon gas detectors supplied by Landauer. These radon detectors, also attached to air particulate stations, are housed in special plastic containers from the OSL dosimetry provider (Figure 6-40). The radon detectors are supplied by the vendor in special sealed packages designed to prevent detector radon exposures prior to the beginning of the monitoring period. Upon completion of the site monitoring period, film-foil 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).

6.1.5.2 Ambient Gamma Dose Rate and Radon Results

6.1.5.2.1 Ambient Gamma Dose Rate Results

Passive gamma dose monitoring results are presented graphically in Figure 6-41 and in tabular format in Table 6-4. In general, measured dose rates ranged between 0.009 and 0.015 mrem/hr. Assuming a radiation weighting factor of 1 for photons, these dose rates are generally consistent with the gamma survey results, which averaged 13.7 μR/hr (HPIC-normalized) across the areas surveyed.

Figure 6-41: Mean gamma dose rate results by quarter for each monitoring station



The OSL data suggest that quarterly differences in average gamma dose rates at a given location can vary significantly (over ± 0.004 mrem/hr in one case). In addition to actual temporal variability in background sources of gamma radiation, measurement error may have contributed to this apparent degree of temporal variation.

Table 6-4: Average ambient gamma dose rate monitoring results by quarter.

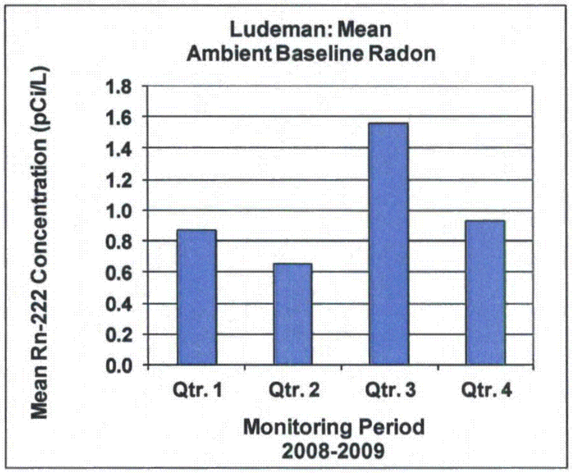
Passive Monitoring Station ID	OSL Issue Date	Field Installation Date	Monitoring End Date	Landauer GROSS Result (mrems)	Estimated Field Dose During Monitoring Period (mrem)	Estimated Daily Field Dose (mrem)	Estimated Field Dose Rate (mrem/hr)
QUARTER 1 (2008)							
LUD-1	1/1/2008	3/4/2008	4/14/2008	30.1	8.5	0.208	0.009
LUD-2	1/1/2008	3/4/2008	4/14/2008	34.9	13.3	0.325	0.014
LUD-3	1/1/2008	3/4/2008	4/14/2008	32.2	10.6	0.259	0.011
LUD-4	1/1/2008	3/4/2008	4/14/2008	33.5	11.9	0.291	0.012
LUD-5*	1/1/2008	-	-	34.8	-	-	-
LUD-6*	1/1/2008	-	-	34.1	-	-	-
Transit control	1/1/2008		4/14/2008	34.6	-	-	-
Deploy control	1/1/2008		4/14/2008	34.6	-	-	-
QUARTER 2 (2008)							
LUD-1	4/1/2008	4/14/2008	7/1/2008	35.1	28.3	0.295	0.012
LUD-2	4/1/2008	4/14/2008	7/1/2008	39.0	32.2	0.335	0.014
LUD-3	4/1/2008	4/14/2008	7/1/2008	34.9	28.1	0.293	0.012
LUD-4	4/1/2008	4/14/2008	7/1/2008	37.6	30.8	0.321	0.013
LUD-5*	4/1/2008	-	-	39.5	-	-	-
LUD-6*	4/1/2008	-	-	39.9	-	-	-
Transit control	4/1/2008		7/1/2008	36.3	-	-	-
Deploy control	4/1/2008		7/1/2008	36.9	-	-	-
QUARTER 3 (2008)							
LUD-1	7/1/2008	7/1/2008	10/2/2008	35.4	33.4	0.341	0.014
LUD-2	7/1/2008	7/1/2008	10/2/2008	37.1	35.1	0.359	0.015
LUD-3	7/1/2008	7/1/2008	10/2/2008	35.4	33.4	0.341	0.014
LUD-4	7/1/2008	7/1/2008	10/2/2008	37.7	35.7	0.365	0.015
LUD-5	7/1/2008	7/1/2008	10/2/2008	32.1	30.1	0.308	0.013
LUD-6	7/1/2008	7/1/2008	10/2/2008	35.4	33.4	0.341	0.014
Transit control	7/1/2008		10/2/2008	38.3	-	-	-
Deploy control	7/1/2008		10/2/2008	37.0	-	-	-
QUARTER 4 (2008)							
LUD-1	10/1/2008	10/2/2008	1/9/2009	34.0	31.7	0.302	0.013
LUD-2	10/1/2008	10/2/2008	1/9/2009	37.1	34.8	0.331	0.014
LUD-3	10/1/2008	10/2/2008	1/9/2009	38.8	36.5	0.347	0.014
LUD-4	10/1/2008	10/2/2008	1/9/2009	38.1	35.8	0.341	0.014
LUD-5	10/1/2008	10/2/2008	1/9/2009	31.1	28.8	0.274	0.011
LUD-6	10/1/2008	10/2/2008	1/9/2009	32.3	30.0	0.286	0.012
Transit control	10/1/2008		1/9/2009	40.6	-	-	-
Deploy control	10/1/2008		1/9/2009	37.7	-	-	-

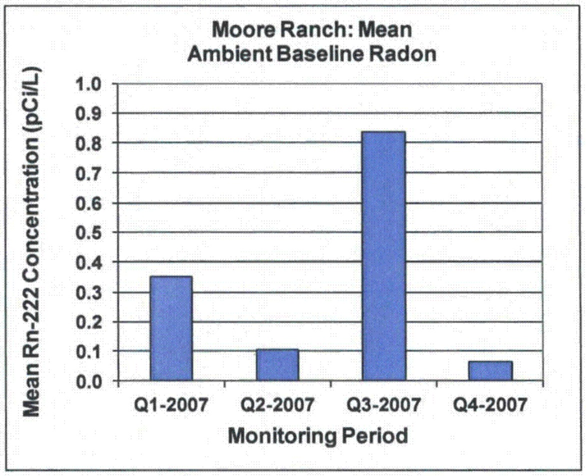
*Station not installed until quarter 3, 2008

6.1.5.2.2 Ambient Rn-222 Monitoring Results

A summary of average baseline Rn-222 results by quarter is shown in Figure 6-42. Tabular data for individual stations are presented in Table 6-5. Ambient baseline radon concentrations were generally slightly higher than an estimated national average value (about 0.4 pCi/L as reported by Foster, 1993), but apparent differences may be within the range of normal measurement uncertainty. Given analytical uncertainties, the reported values are reasonably consistent with findings at the nearby Moore Ranch ISR site in Wyoming (Figure 6-42, right). The measured annual average baseline Rn-222 concentration at Ludeman was 0.8 ± 0.3 pCi/L.

Figure 6-42: Average ambient baseline Rn-222 results across all stations by quarter for Ludeman (left), and for the Moore Ranch ISR site (right; EMC, 2008) which is located approximately 45 miles NNW of Ludeman.





Passive Monitoring Station ID	Field Installation Date	Quarter End (seal) Date	Quarterly Result (pCi-days/l)	Quarterly Results (pCi/l)
		QUARTER 1 (2008)		
LUD-1	3/4/2008	4/14/2008	30	0.7
LUD-2	3/4/2008	4/14/2008	30	0.7
LUD-3	3/4/2008	4/14/2008	41	1
LUD-4	3/4/2008	4/14/2008	47	1.1
LUD-5	Not Sampled	-	-	-
LUD-6	Not Sampled	-	-	-
		QUARTER 2 (2008)		
LUD-1	4/14/2008	7/1/2008	30	0.4
LUD-2	4/14/2008	7/1/2008	30	0.4
LUD-3	4/14/2008	7/1/2008	30	0.4
LUD-4	4/14/2008	7/1/2008	30	0.4
LUD-5	Not Sampled	-	-	-
LUD-6	Not Sampled	-	-	-
		QUARTER 3 (2008)		
LUD-1	7/1/2008	10/2/2008	31.7	0.3
LUD-2	7/1/2008	10/2/2008	70.4	0.8
LUD-3	7/1/2008	10/2/2008	130.7	1.4
LUD-4	7/1/2008	10/2/2008	84.7	0.9
LUD-5	8/4/2008	10/2/2008	35.7	0.6
LUD-6	8/4/2008	10/2/2008	83.7	1.4
		QUARTER 4 (2008)		
LUD-1	10/2/2008	1/9/2009	55.1	0.6
LUD-2	10/2/2008	1/9/2009	70.7	0.7
LUD-3	10/2/2008	1/9/2009	128.3	1.3
LUD-4	10/2/2008	1/9/2009	126.2	1.3
LUD-5	10/2/2008	1/9/2009	65.5	0.7
LUD-6	10/2/2008	1/9/2009	107.4	1.1
		QUARTER 1 (2009)		
LUD-1	1/9/2009	4/1/2009	30	0.4
LUD-2	1/9/2009	4/1/2009	30	0.4
LUD-3	1/9/2009	4/1/2009	117.4	1.4
LUD-4	1/9/2009	4/1/2009	62.5	0.8
LUD-5	1/9/2009	4/1/2009	156.8	1.9
LUD-6	1/9/2009	4/1/2009	47.5	0.6
		QUARTER 2 (2009)		
LUD-1	4/1/2009	7/14/2009	42.4	0.4
LUD-2	4/1/2009	7/2/2009	74.9	0.7
LUD-3	4/1/2009	7/14/2009	122.3	1.2
LUD-4	4/1/2009	7/14/2009	162.9	1.8
LUD-5	4/1/2009	7/14/2009	55.2	0.5
LUD-6	4/1/2009	7/14/2009	71.9	0.7
		QUARTER 3 (2009)		
LUD-1	7/14/2009	9/1/2009	30.9	0.6
LUD-2	7/14/2009	9/1/2009	30.9	0.6
LUD-3	7/14/2009	9/1/2009	66.5	1.4
LUD-4	7/2/2009	9/1/2009	102.3	1.7
LUD-5	7/14/2009	9/22/2009	514.9	7.4
LUD-6	7/14/2009	9/1/2009	75.7	1.5

6.1.5.3 Conclusions

Baseline ambient gamma dose rate and radon-222 air concentration data for the proposed project was collected and analyzed according to NRC Regulatory Guide 4.14 protocols. Gamma dose rate results are consistent with gamma exposure rate survey data. In a context of possible sampling and measurement uncertainties, ambient radon concentration results were consistent with the reported national average as well as with results from the nearby Moore Ranch ISR site.

6.1.6 Air Particulate Monitoring

Continuous monitoring of baseline air particulate radionuclide concentrations was initiated in late April 2008. NRC 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). This data was collected and reported on a quarterly basis.

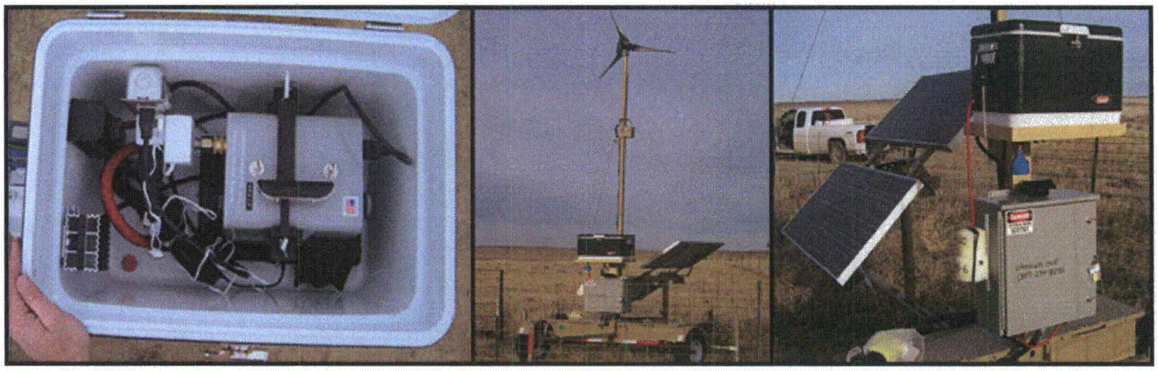
Low-volume air particulate sampling station locations were selected based on NRC Regulatory Guide 4.14, including consideration for the locations of Satellite facilities, prevailing wind directions, adjacent residences, hard line power availability, and practical access for both baseline and future operational monitoring programs. An off-site location is also part of the air particulate monitoring program. In cases where existing power supply was unavailable, stations were set up using solar/wind generation equipment to supply electrical power to the air samplers. Locations of air particulate monitoring stations at each site are shown in Figure 6-39 of the previous section of this report.

6.1.6.1 Methods

The air particulate monitoring program is being conducted with the Model DF-40L-8 electric powered air sampler from F&J Specialty Products, Inc. (Figure 6-43). These samplers are calibrated by the manufacturer and programmed to draw approximately 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, so that the intake and sample filter holder assembly is positioned at about 5 feet above the ground surface (Figure 6-44). This is intended to approximate an average breathing zone height.

Figure 6-43: F&J air particulate sampler.

Figure 6-44: Air sampling station equipment and solar/wind powered system setup.



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 NRC Regulatory Guide 4.14. Each quarterly batch of air filters from the four monitoring stations is submitted to ELI in Casper, Wyoming for analysis of Ra-226, U-nat, Th-230, and Pb-210.

6.1.6.2 Air Particulate Sampling Results

A graphical summary of baseline air particulate sampling results by quarter for the Ludeman site is shown in Figure 6-45. Historical mean values at other uranium recovery sites in this region of Wyoming are shown in Figure 6-46. In general, baseline air particulate radionuclide concentrations at the Ludeman site appear consistent with baseline values measured at other sites in the region.

Figure 6-45: Mean baseline radionuclide levels (error bars represent + 1σ from the mean) in air particulate samples from the Ludeman Project. Negative values were excluded for this graphical data summary, and for results below detection limits, the detection limit

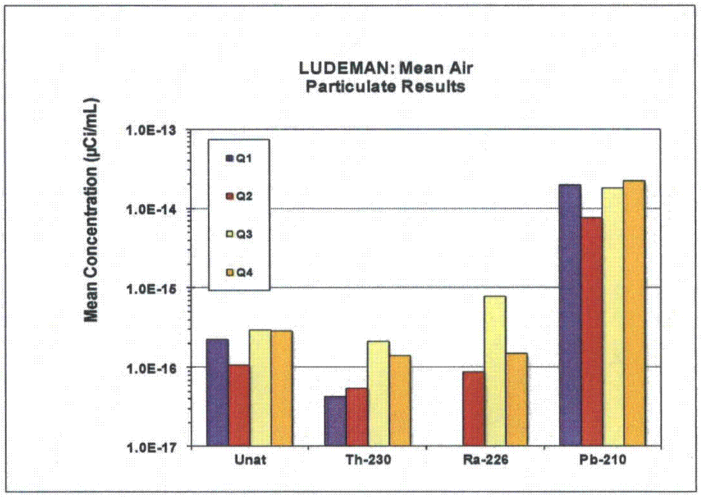
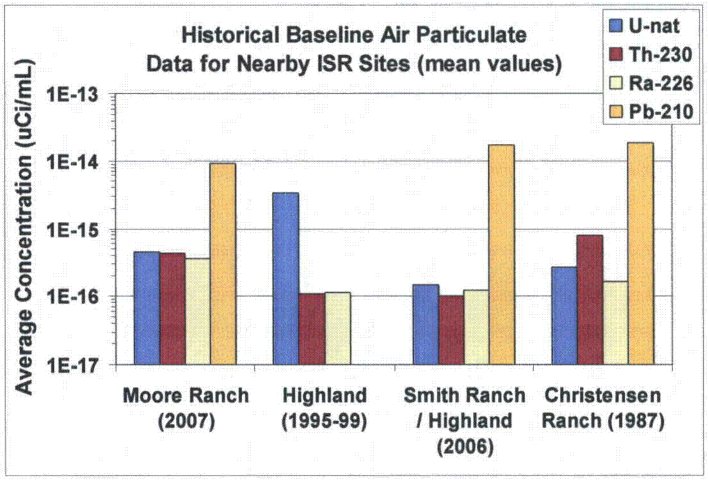


Figure 6-46: Average air particulate results for nearby uranium recovery sites in the region (adapted from EMC, 2007).



All individual air particulate monitoring station results to date for the proposed project site are provided in Table 6-6. Baseline monitoring continues, and remaining data will be provided to regulatory agencies when available. In most cases, analytical results are above the lower limits of detection (LLD). The LLD values listed in Table 6-6 are those specified in NRC 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; and in this context, will help with evaluations of above background internal dose assessments via inhalation and ingestion pathways for data collected during ISR recovery operations.

Table 6-6: Air particulate radionuclide data for the Ludeman Project

Air Station ID	Qtr - Collection Date	Air Volume Sampled (mL)	Radionuclide	Concentration (µCi/mL)	Error Estimate (µCi/mL)	LLD (µCi/mL)	Effluent Conc. (µCi/mL)	% Effluent Concentration
LUD-1	Qtr2 - 2008	2.35E+09	U-nat	1.00E-16	N/A	1.00E-16	9.00E-14	1.11E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	1.00E-16	N/A	1.00E-16	9.00E-13	1.11E-02
			Pb-210	1.11E-14	8.51E-15	2.00E-15	6.00E-13	1.85E+00
	Qtr3 - 2008	1.94E+09	U-nat	1.55E-16	N/A	1.00E-16	9.00E-14	1.72E-01
			Th-230	2.47E-16	9.79E-17	1.00E-16	3.00E-14	8.23E-01
			Ra-226	6.70E-16	6.70E-16	1.00E-16	9.00E-13	7.44E-02
			Pb-210	1.60E-14	1.08E-14	2.00E-15	6.00E-13	2.67E+00
	Qtr4 - 2008	2.54E+09	U-nat	1.18E-16	N/A	1.00E-16	9.00E-14	1.31E-01
			Th-230	3.03E-16	3.46E-16	1.00E-16	3.00E-14	1.01E+00
			Ra-226	1.00E-16	N/A	1.00E-16	9.00E-13	1.11E-02
			Pb-210	1.22E-14	9.45E-15	2.00E-15	6.00E-13	2.03E+00
	Qtr1 - 2009	2.28E+09	U-nat	2.84E-16	N/A	1.00E-16	9.00E-14	3.16E-01
			Th-230	-4.08E-16	2.44E-16	1.00E-16	3.00E-14	-1.36E+00
			Ra-226	1.04E-17	3.60E-16	1.00E-16	9.00E-13	1.15E-03
			Pb-210	1.71E-14	7.54E-15	2.00E-15	6.00E-13	2.85E+00
	Qtr2 - 2009	2.30E+09	U-nat	1.12E-16	N/A	1.00E-16	9.00E-14	1.24E-01
			Th-230	2.15E-16	1.26E-16	1.00E-16	3.00E-14	7.17E-01
			Ra-226	-1.10E-16	2.86E-17	1.00E-16	9.00E-13	-1.22E-02
			Pb-210	1.06E-14	5.91E-15	2.00E-15	6.00E-13	1.77E+00
	Qtr3 - 2009	1.57E+09	U-nat	1.01E-16	N/A	1.00E-16	9.00E-14	1.12E-01
			Th-230	-3.19E-16	1.68E-16	1.00E-16	3.00E-14	-1.06E+00
			Ra-226	6.36E-17	1.54E-16	1.00E-16	9.00E-13	7.07E-03
			Pb-210	2.22E-14	7.75E-15	2.00E-15	6.00E-13	3.70E+00
LUD-2	Qtr2 - 2008	1.66E+09	U-nat	1.00E-16	N/A	1.00E-16	9.00E-14	1.11E-01
			Th-230	3.42E-16	3.43E-16	1.00E-16	3.00E-14	1.14E+00
			Ra-226	1.00E-16	N/A	1.00E-16	9.00E-13	1.11E-02
			Pb-210	2.00E-15	N/A	2.00E-15	6.00E-13	3.33E-01
	Qtr3 - 2008	4.44E+09	U-nat	1.00E-16	N/A	1.00E-16	9.00E-14	1.11E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	1.35E-16	2.93E-16	1.00E-16	9.00E-13	1.50E-02
			Pb-210	3.83E-15	4.73E-15	2.00E-15	6.00E-13	6.38E-01
	Qtr4 - 2008	2.77E+09	U-nat	2.89E-16	N/A	1.00E-16	9.00E-14	3.21E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	1.00E-16	N/A	1.00E-16	9.00E-13	1.11E-02
			Pb-210	1.70E-14	9.03E-15	2.00E-15	6.00E-13	2.83E+00
	Qtr1 - 2009	2.56E+09	U-nat	1.49E-16	N/A	1.00E-16	9.00E-14	1.66E-01
			Th-230	2.37E-16	2.73E-16	1.00E-16	3.00E-14	7.89E-01
			Ra-226	-2.27E-17	2.89E-16	1.00E-16	9.00E-13	-2.52E-03
			Pb-210	1.99E-14	6.75E-15	2.00E-15	6.00E-13	3.32E+00
	Qtr2 - 2009	2.36E+09	U-nat	8.30E-17	N/A	1.00E-16	9.00E-14	9.22E-02
			Th-230	-1.89E-16	8.86E-17	1.00E-16	3.00E-14	-6.29E-01
			Ra-226	4.63E-18	3.92E-17	1.00E-16	9.00E-13	5.14E-04
			Pb-210	5.51E-15	1.17E-15	2.00E-15	6.00E-13	9.19E-01
	Qtr3 - 2009	1.30E+09	U-nat	1.80E-16	N/A	1.00E-16	9.00E-14	2.00E-01
			Th-230	-5.12E-17	2.19E-16	1.00E-16	3.00E-14	-1.71E-01
			Ra-226	7.80E-17	1.88E-16	1.00E-16	9.00E-13	8.67E-03
			Pb-210	1.91E-14	3.80E-15	2.00E-15	6.00E-13	3.18E+00
LUD-4	Qtr2 - 2008	9.25E+08	U-nat	1.00E-16	N/A	1.00E-16	9.00E-14	1.11E-01
			Th-230	1.08E-16	2.05E-16	1.00E-16	3.00E-14	3.60E-01
			Ra-226	1.00E-16	N/A	1.00E-16	9.00E-13	1.11E-02
			Pb-210	2.00E-15	N/A	2.00E-15	6.00E-13	3.33E-01
	Qtr3 - 2008	2.46E+09	U-nat	2.03E-16	N/A	1.00E-16	9.00E-14	2.26E-01
			Th-230	2.32E-16	1.18E-16	1.00E-16	3.00E-14	7.73E-01
			Ra-226	6.91E-16	5.69E-16	1.00E-16	9.00E-13	7.68E-02
			Pb-210	1.83E-14	8.54E-15	2.00E-15	6.00E-13	3.05E+00
	Qtr4 - 2008	2.40E+09	U-nat	2.50E-16	N/A	1.00E-16	9.00E-14	2.78E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	1.00E-16	N/A	1.00E-16	9.00E-13	1.11E-02
			Pb-210	2.58E-14	1.04E-14	2.00E-15	6.00E-13	4.30E+00
	Qtr1 - 2009	2.26E+09	U-nat	2.84E-16	N/A	1.00E-16	9.00E-14	3.16E-01
			Th-230	3.68E-16	4.05E-16	1.00E-16	3.00E-14	1.23E+00
			Ra-226	3.86E-16	4.22E-16	1.00E-16	9.00E-13	4.28E-02
			Pb-210	2.79E-14	7.69E-15	2.00E-15	6.00E-13	4.64E+00
	Qtr2 - 2009	2.27E+09	U-nat	9.11E-17	N/A	1.00E-16	9.00E-14	1.01E-01
			Th-230	1.02E-16	1.19E-16	1.00E-16	3.00E-14	3.39E-01
			Ra-226	-2.12E-17	4.09E-17	1.00E-16	9.00E-13	-2.26E-03
			Pb-210	1.41E-14	5.98E-15	2.00E-15	6.00E-13	2.36E+00
	Qtr3 - 2009	1.26E+09	U-nat	1.60E-15	N/A	1.00E-16	9.00E-14	1.78E+00
			Th-230	1.91E-15	6.14E-16	1.00E-16	3.00E-14	6.37E+00
			Ra-226	9.48E-17	2.29E-16	1.00E-16	9.00E-13	1.05E-02
			Pb-210	1.60E-14	9.50E-15	2.00E-15	6.00E-13	2.67E+00

Table 6-7: Air particulate radionuclide data for the Ludeman Project (Cont.)

Air Station ID	Qtr - Collection Date	Air Volume Sampled (mL)	Radionuclide	Concentration (µCi/mL)	Error Estimate (µCi/mL)	LLD (µCi/mL)	Effluent Conc. (µCi/mL)	% Effluent Concentration
LUD-5	Qtr3 - 2008	1.41E+09	U-nat	2.13E-16	N/A	1.00E-16	9.00E-14	2.37E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	2.13E-16	7.80E-16	1.00E-16	9.00E-13	2.37E-02
			Pb-210	2.06E-14	1.49E-14	2.00E-15	6.00E-13	3.43E+00
	Qtr4 - 2008	2.57E+09	U-nat	4.28E-16	N/A	1.00E-16	9.00E-14	4.76E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	3.50E-16	5.06E-16	1.00E-16	9.00E-13	3.89E-02
			Pb-210	2.49E-14	9.73E-15	2.00E-15	6.00E-13	4.15E+00
	Qtr1 - 2009	2.34E+09	U-nat	1.90E-16	N/A	1.00E-16	9.00E-14	2.11E-01
			Th-230	-7.14E-17	4.35E-16	1.00E-16	3.00E-14	-2.38E-01
			Ra-226	-1.41E-16	3.18E-16	1.00E-16	9.00E-13	-1.57E-02
			Pb-210	2.02E-14	7.39E-15	2.00E-15	6.00E-13	3.36E+00
	Qtr2 - 2009	2.09E+09	U-nat	8.21E-17	N/A	1.00E-16	9.00E-14	9.12E-02
			Th-230	-1.09E-16	9.76E-17	1.00E-16	3.00E-14	-3.64E-01
			Ra-226	-4.94E-17	3.61E-17	1.00E-16	9.00E-13	-5.49E-03
			Pb-210	7.27E-15	1.32E-15	2.00E-15	6.00E-13	1.21E+00
	Qtr3 - 2009	1.48E+09	U-nat	8.48E-17	N/A	1.00E-16	9.00E-14	9.42E-02
			Th-230	-3.21E-17	1.16E-16	1.00E-16	3.00E-14	-1.07E-01
			Ra-226	5.78E-16	2.85E-16	1.00E-16	9.00E-13	6.42E-02
			Pb-210	1.67E-14	3.27E-15	2.00E-15	6.00E-13	2.78E+00
LUD-6	Qtr3 - 2008	1.75E+09	U-nat	1.71E-16	N/A	1.00E-16	9.00E-14	1.90E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	5.14E-15	7.43E-16	1.00E-16	9.00E-13	5.71E-01
			Pb-210	1.83E-14	1.20E-15	2.00E-15	6.00E-13	3.05E+00
	Qtr4 - 2008	2.41E+09	U-nat	3.32E-16	N/A	1.00E-16	9.00E-14	3.69E-01
			Th-230	1.00E-16	N/A	1.00E-16	3.00E-14	3.33E-01
			Ra-226	1.00E-16	N/A	1.00E-16	9.00E-13	1.11E-02
			Pb-210	2.99E-14	1.04E-14	2.00E-15	6.00E-13	4.98E+00
	Qtr1 - 2009	2.41E+09	U-nat	2.12E-16	N/A	1.00E-16	9.00E-14	2.36E-01
			Th-230	9.27E-17	3.21E-16	1.00E-16	3.00E-14	3.09E-01
			Ra-226	-3.78E-16	2.35E-16	1.00E-16	9.00E-13	-4.19E-02
			Pb-210	1.19E-14	7.06E-15	2.00E-15	6.00E-13	1.98E+00
	Qtr2 - 2009	1.61E+09	U-nat	1.96E-16	N/A	1.00E-16	9.00E-14	2.18E-01
			Th-230	-1.35E-16	2.23E-16	1.00E-16	3.00E-14	-4.50E-01
			Ra-226	5.69E-16	9.89E-17	1.00E-16	9.00E-13	6.32E-02
			Pb-210	8.08E-15	1.71E-15	2.00E-15	6.00E-13	1.35E+00
	Qtr3 - 2009	9.85E+08	U-nat	1.03E-16	N/A	1.00E-16	9.00E-14	1.14E-01
			Th-230	-1.91E-16	3.47E-16	1.00E-16	3.00E-14	-6.37E-01
			Ra-226	1.84E-16	3.26E-16	1.00E-16	9.00E-13	2.04E-02
			Pb-210	2.52E-14	5.02E-15	2.00E-15	6.00E-13	4.20E+00

6.1.6.3 Conclusions

Baseline air particulate concentration data for the proposed project site were collected and analyzed based on NRC Regulatory Guide 4.14 recommendations, along with other considerations in a context of both pre-operational and operational phases of the project. This information should be sufficient for review by the NRC and WDEQ/LQD.

6.1.7 Radon Flux Measurements

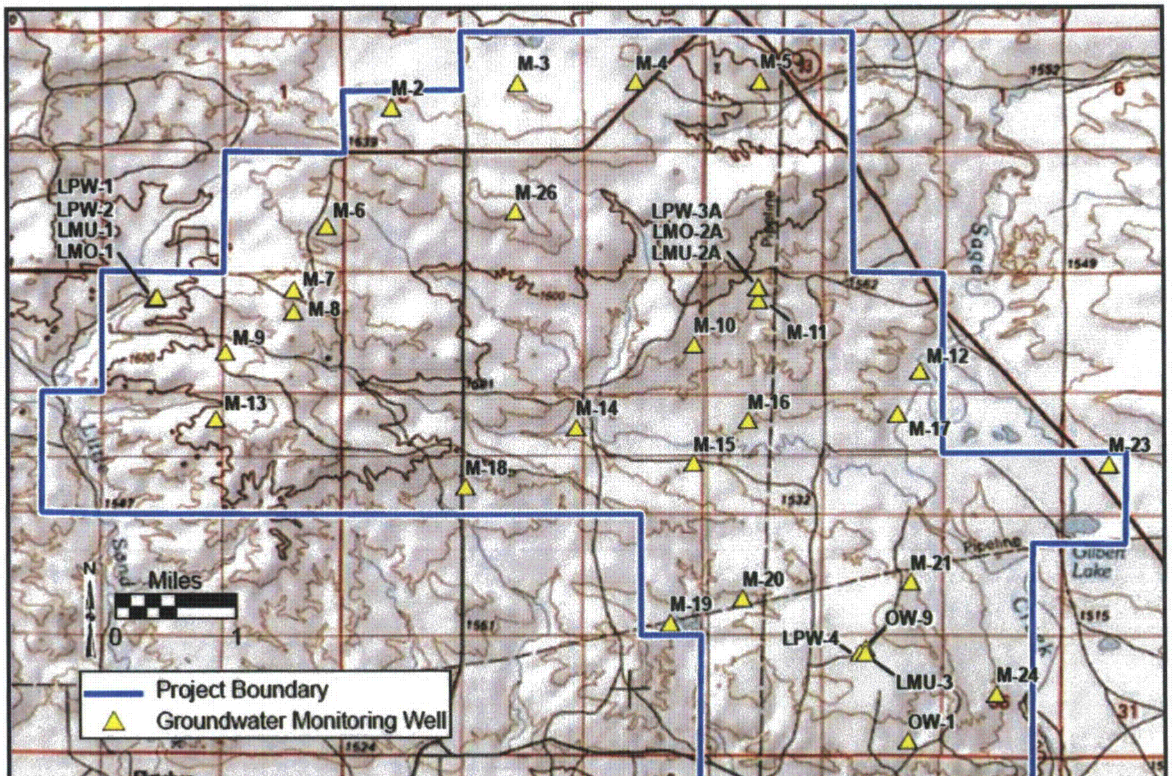
NRC Regulatory Guide 4.14 indicates that radon flux measurements should be conducted at eight locations within 1.5 km of the mill, during three separate months between spring and fall when the ground is thawed (NRC, 1980). Since there will be no tailings impoundments at this ISR site, radon flux is not an applicable radiological parameter for baseline characterization.

6.1.8 Groundwater Sampling

Baseline groundwater sampling was conducted at the proposed project area in accordance with NRC Regulatory Guide 4.14 protocols (NRC, 1980). In this case, however, there are no tailings impoundments and respective guidance has been interpreted accordingly. A map of approximate groundwater monitoring well locations is shown in Figure 6-47. The nomenclature and meaning of well ID numbers is as follows:

- M = Monitoring well for Production Zone
- LPW = Ludeman pump test well for Production Zone
- LMU = Ludeman monitoring well underlying Production Zone
- LMO = Ludeman monitoring well overlying Production Zone
- OW = Other well, previously existing (e.g. from historical pump testing)

Figure 6-47: Groundwater monitoring well locations.



Comprehensive information on well locations, depths, all groundwater quality parameters and respective detection limits is provided in various sections of this ISR licensing application that are related specifically to groundwater (Section 2.7). Sampling of existing wells used for livestock watering or other purposes has been initiated, though this sampling was delayed because these wells are turned off on a seasonal basis. Results from this additional groundwater sampling effort will be submitted to the NRC and WDEQ/LQD upon receipt of analytical data from the laboratory.

6.1.8.1 Methods

Prior to sampling a groundwater 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 to 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.

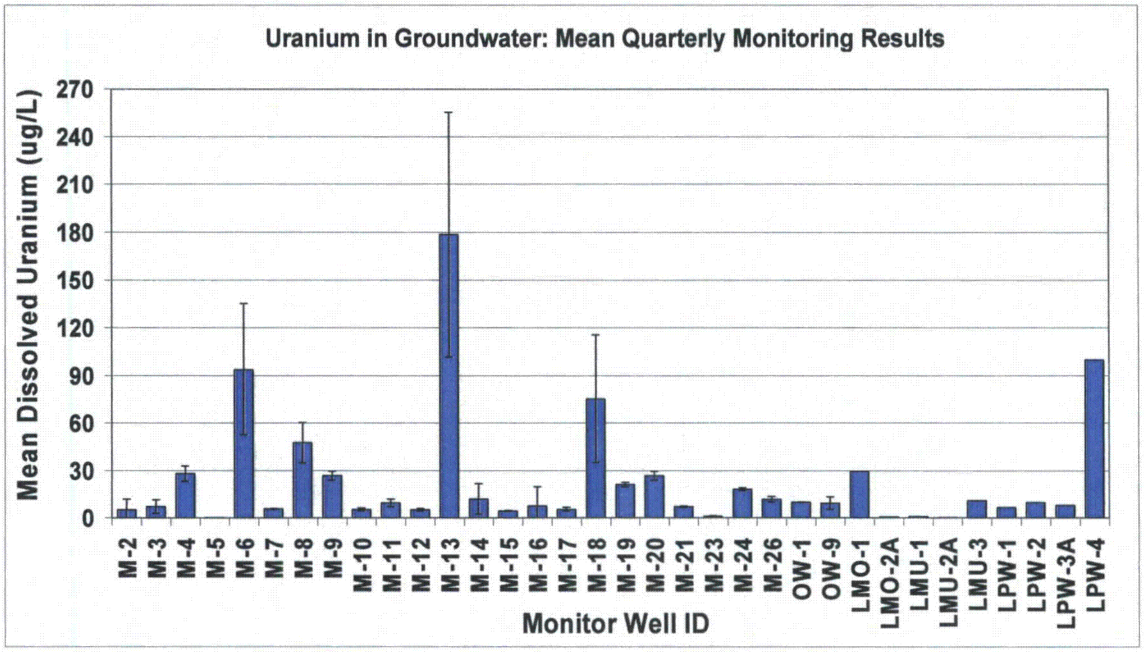
6.1.8.2 Groundwater Sampling Results

Summary statistics for dissolved radionuclides in groundwater across all individual quarterly samples collected to date are provided in Table 6-7. Average quarterly results ($\pm$ 1σ) to date by well location for dissolved radiological groundwater parameters are shown graphically in Figures 6-48 through 6-53. The error bars on the graphical data provide an indication of quarterly variability in analytical results for each parameter and well location. In some cases, log scales are also presented to better illustrate the range of mean values on the lowest end of the scale. Parameters in suspended form were also evaluated – results were generally similar and are not presented here (those data, reporting limits, and other details can be found in Section 2.7.2 of the application pertaining specifically to groundwater).

Table 6-8: Summary statistics for dissolved radionuclide's in groundwater across all individual quarterly samples collected to date within the Ludeman Project area.

Analyte	Mean	Std. Dev.	Median	Max	Min	n
U-nat (µg/L)	25	42	10.2	267	0.3	79
Th-230 (pCi/L)	0.04	0.10	0.0	0.60	-0.1	79
Ra-226 (pCi/L)	133	305	14.5	1490	0.3	73
Pb-210 (pCi/L)	14.3	31.3	2.8	213	-10.9	79
Po-210 (pCi/L)	1.1	1.9	0.5	12.4	-0.4	79
Ra-228 (pCi/L)	1.2	1.6	0.9	9.7	-2.0	79

Figure 6-48: Mean quarterly uranium results (± 1σ) by groundwater monitoring well location (top) and same results on a log scale (bottom).



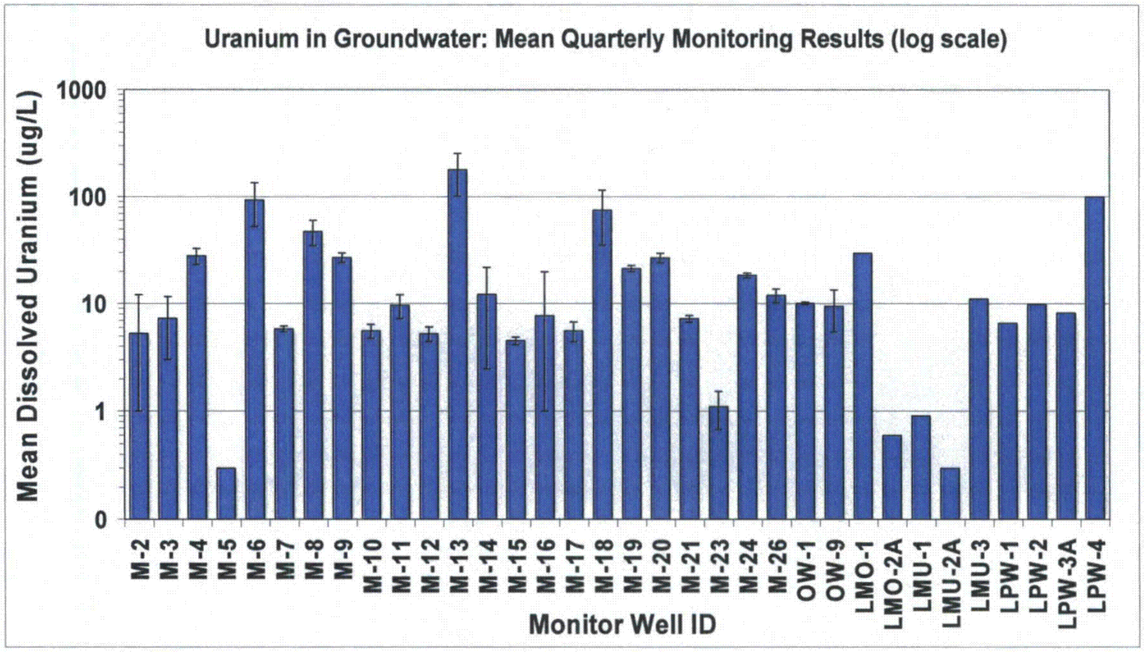
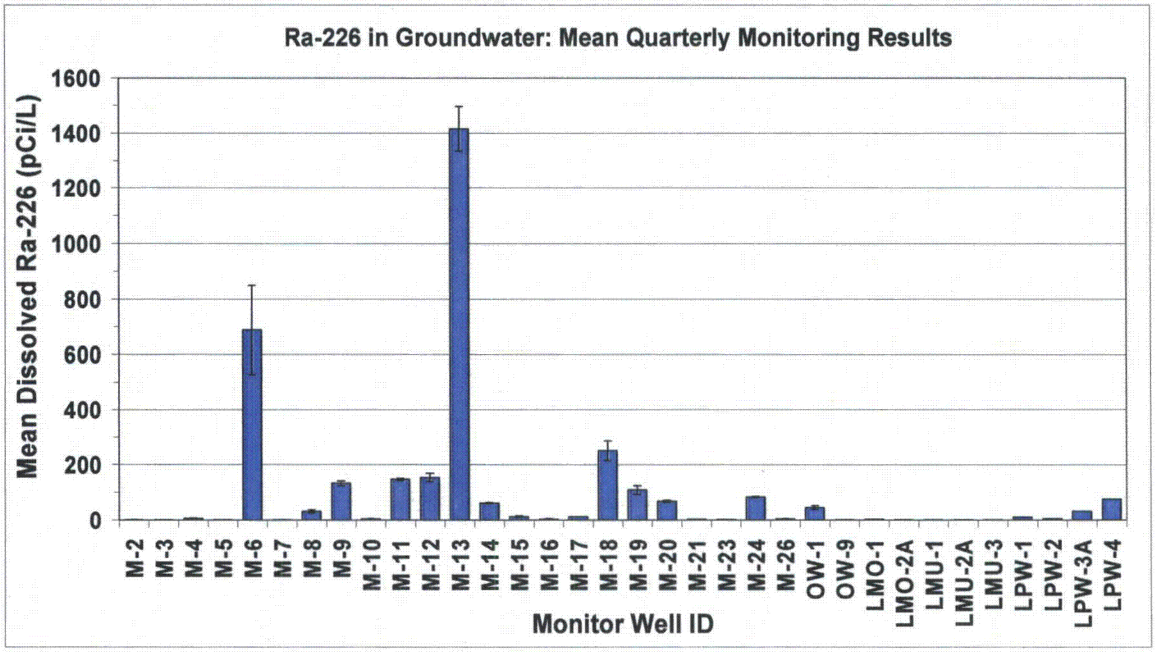


Figure 6-49: Mean quarterly Ra-226 results (± 1σ) by groundwater monitoring well location (top) and same results on a log scale (bottom)



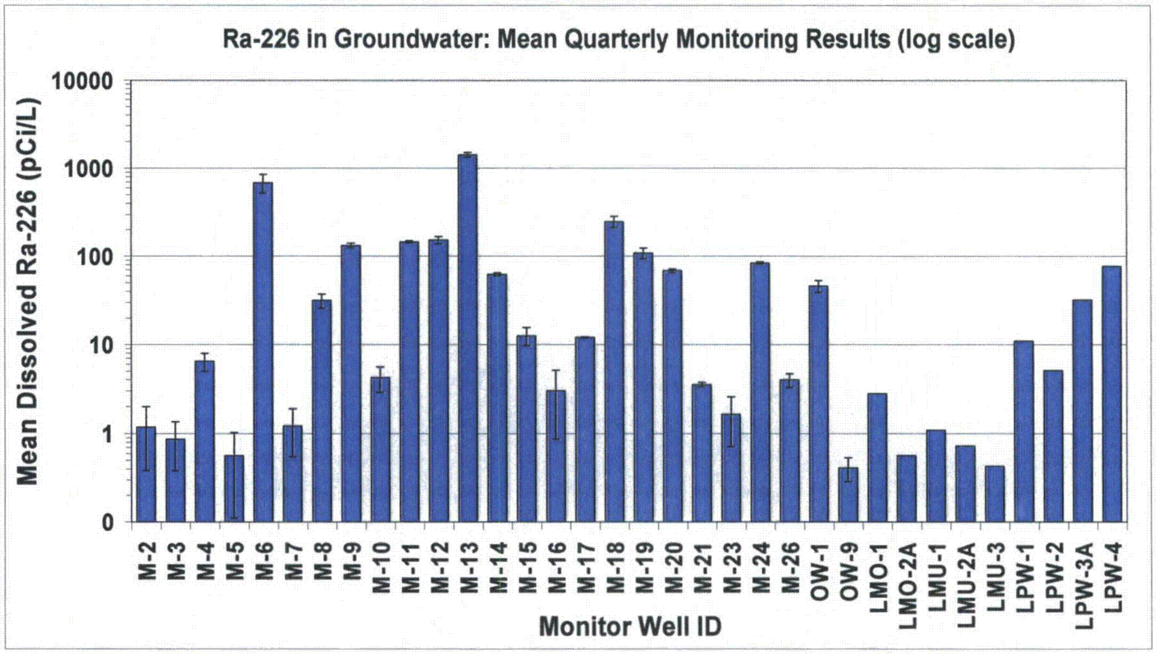


Figure 6- 50: Mean quarterly Th-230 results (± 1σ) by groundwater monitoring well location.

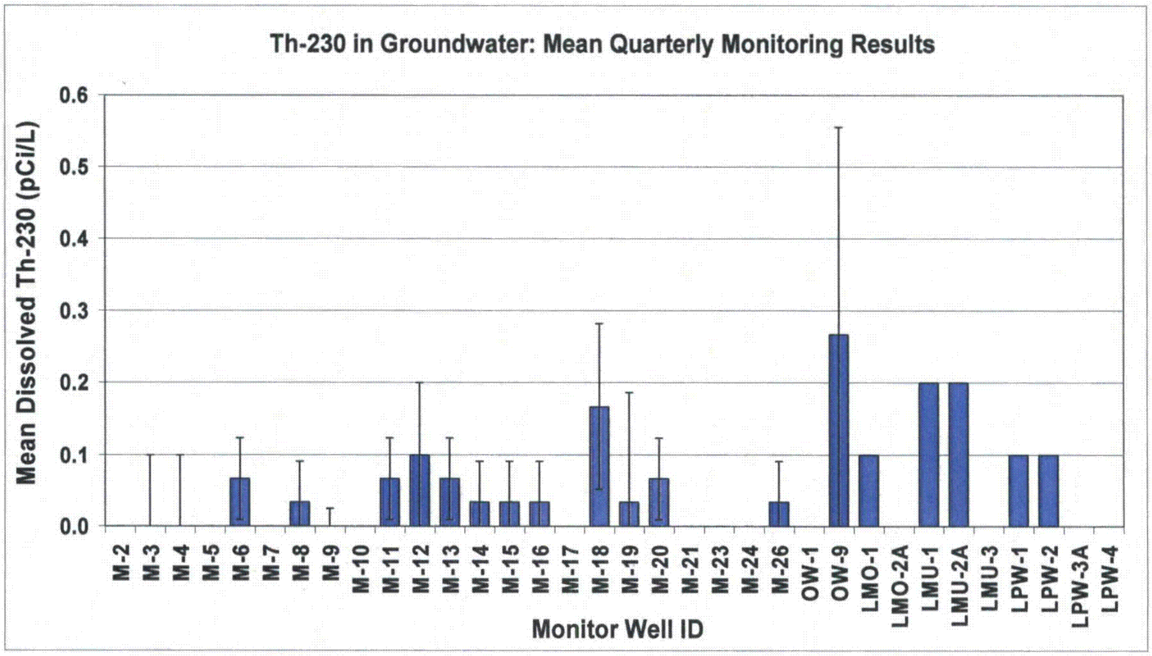

Th-230 in Groundwater: Mean Quarterly Monitoring Results
Mean Dissolved Th-230 (pCi/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
M-2
M-3
M-4
M-5
M-6
M-7
M-8
M-9
M-10
M-11
M-12
M-13
M-14
M-15
M-16
M-17
M-18
M-19
M-20
M-21
M-23
M-24
M-26
OW-1
OW-9
LMO-1
LMO-2A
LMU-1
LMU-2A
LMU-3
LPW-1
LPW-2
LPW-3A
LPW-4
Monitor Well ID

Figure 6-51: Mean quarterly Pb-210 results (± 1σ) by groundwater monitoring well location.

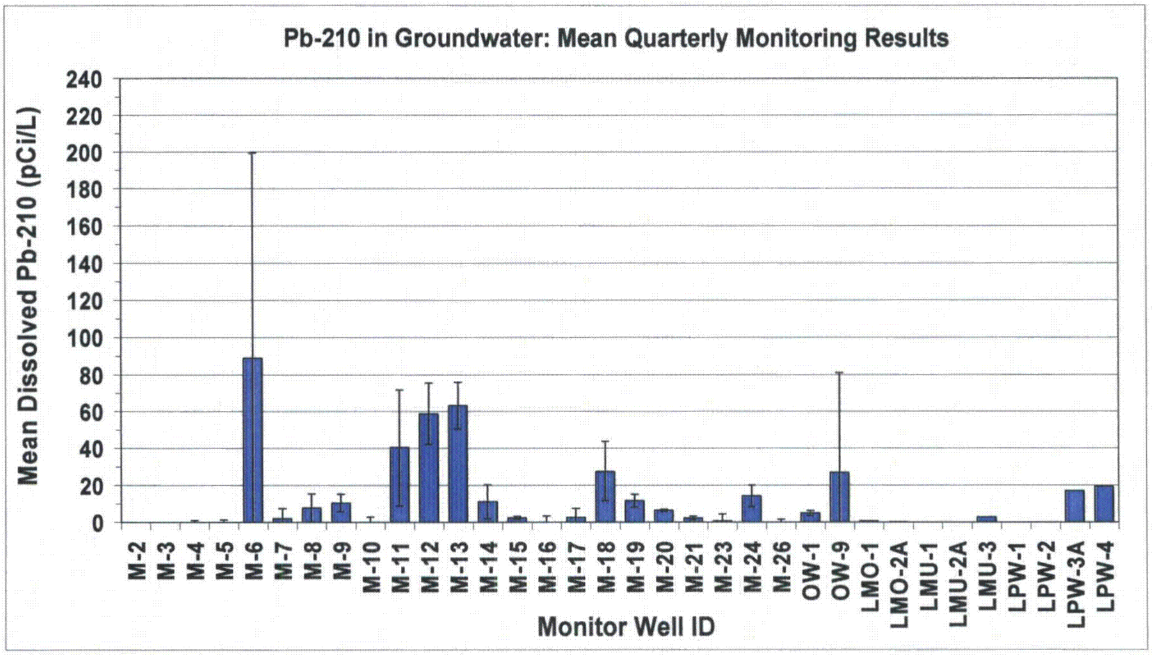


Figure 6-52: Mean quarterly Po-210 results (± 1σ) by groundwater monitoring well location.

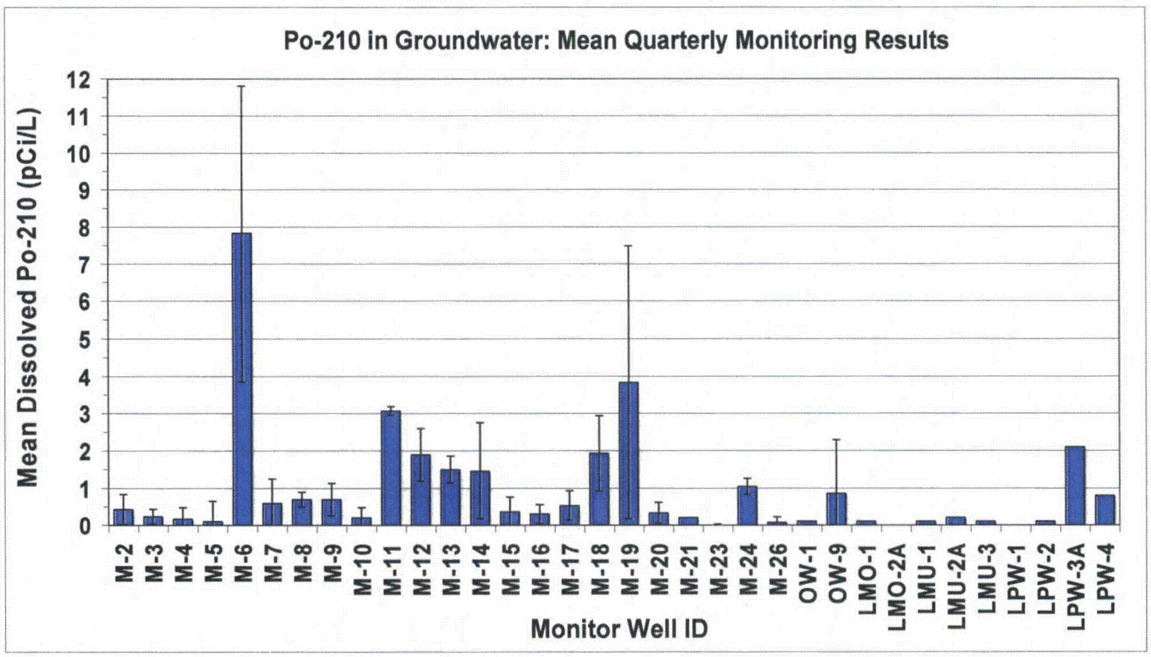
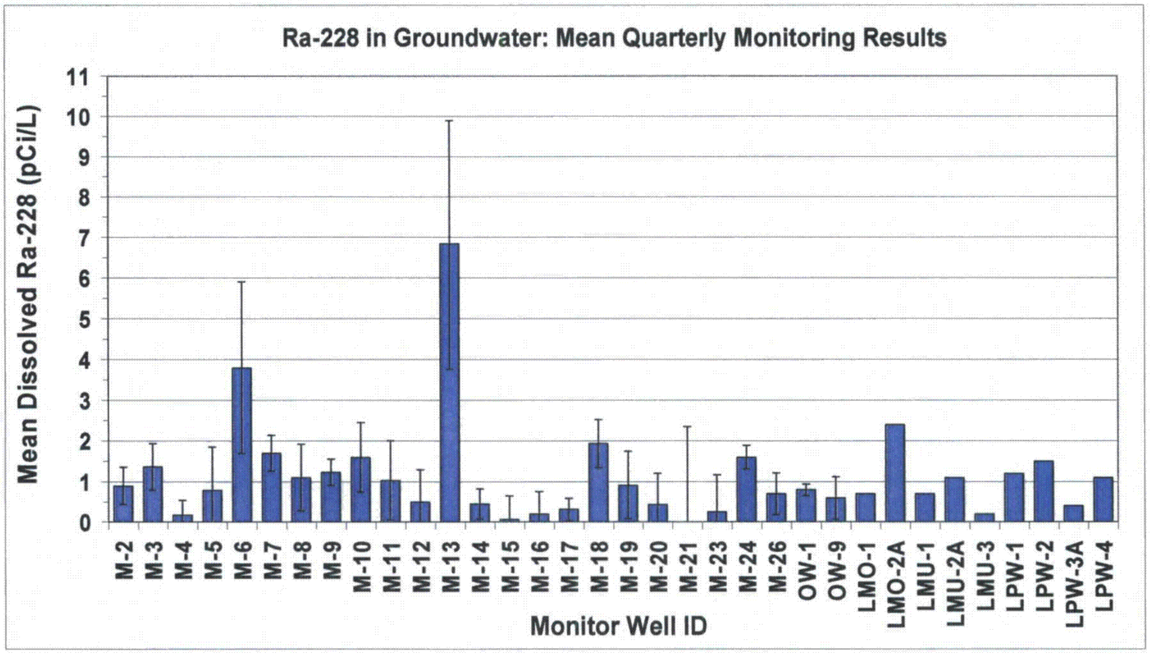


Figure 6-53: Mean quarterly Ra-228 results (± 1σ) by groundwater monitoring well location.



A number of wells had pre-operational baseline groundwater concentrations of uranium and/or combined Ra-226/Ra-228 that exceeded respective maximum contaminant levels (MCLs) listed by the U.S. Environmental Protection Agency (EPA) for drinking water (30 ug/L for uranium, 5 pCi/L for combined Ra-226/Ra-228; EPA, 2000). These include the following wells:

- Monitor wells, Production Zone (M): 4, 6, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 20, and 24;
- Pump test wells, Production Zone (LPW): 1, 3A, and 4;
- Other wells, Production Zone (OW): 1

Wells M-6, M-13, M-18, and LPW-4 had results that exceeded MCLs for both uranium and combined Ra-226/Ra-228. All results in excess of MCLs for uranium and/or combined Ra-226/Ra-228 represent natural, pre-existing conditions in the proposed Production Zone. This is not unexpected given the known natural mineralization of uranium and associated radionuclides within this zone. Baseline groundwater conditions in the proposed Production Zone at this site are not suitable for domestic uses.

None of the monitoring wells underlying or overlying the Production Zone had baseline groundwater results in excess of MCLs for uranium or combined Ra-226/Ra-228.

However, this doesn't necessarily mean that baseline groundwater conditions in aquifers above or below the Production Zone are below MCLs in all locations at the site. The gamma survey shows evidence of elevated uranium and Ra-226 at the ground surface in certain areas, and surface water results for one pond show significantly elevated levels (see Section 6.9). It is possible that pockets of naturally elevated concentrations of radionuclides outside the proposed Production Zone could influence localized baseline groundwater quality conditions in underlying or overlying aquifers.

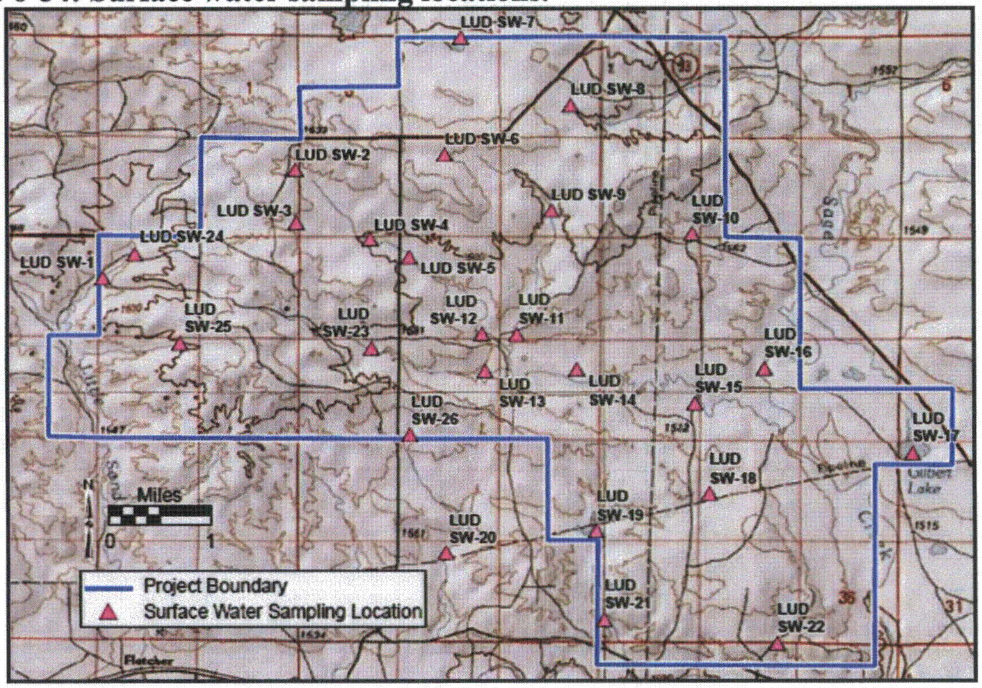
6.1.8.3 Conclusions

Radiological baseline groundwater data for the proposed project area presented in this section provide a characterization of baseline radionuclide concentrations in groundwater for review by the NRC and WDEQ/LQD with respect to licensing/permitting applications. Baseline groundwater conditions within the proposed Production Zone show elevated levels of uranium and/or Ra-226 and other radionuclides in many locations.

6.1.9 Surface Water Sampling

Baseline surface water sampling at the proposed project site is being conducted on a quarterly basis. Surface water sampling locations are shown in Figure 6-54. This sampling includes stock ponds, small natural impoundments and ephemeral stream drainage channels where surface waters are present at least part of the year. These locations are widely distributed across the site, including locations generally upstream and downstream from proposed processing Satellite facility locations. Data to date for radiological parameters are presented in this section. Data for all surface water quality parameters are provided in this ISR licensing application related specifically to surface water (Section 2.7.1).

Figure 6-54: Surface water sampling locations.



6.1.9.1 Methods

Surface water samples were 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 directed by the Owner's Manual. The bottle is then filled directly from the stream or pond in a manner to prevent collecting unwanted 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 that the sample is properly tracked and relinquished in the appropriate manner.

6.1.9.2 Surface Water Sampling Results

Summary statistics for dissolved radionuclide's in surface water across all individual quarterly samples collected to date are provided in Table 6-8. Average quarterly results ($\pm 1\sigma$) by sample location to date for dissolved radiological surface water parameters are presented graphically in Figures 6-55 through 6-60. The error bars in the graphs provide an indication of quarterly variability in analytical results for each parameter and sampling location. In some cases, log scales are also presented to better illustrate the range of mean values on the lowest end of the scale. Parameters in suspended form were also evaluated

– results are generally similar 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 6- 9: Summary statistics for dissolved radionuclides in surface water across all individual quarterly samples collected to date within the Ludeman Project area.

Analyte	Mean	Std. Dev.	Median	Max	Min	n
U-nat (µg/L)	11	25	1.1	123	0.3	73
Th-230 (pCi/L)	0.1	0.2	0.1	1.0	-0.6	73
Ra-226 (pCi/L)	0.9	1.1	0.5	5.0	-0.3	73
Pb-210 (pCi/L)	0.5	4.4	0.0	13	-9.9	73
Po-210 (pCi/L)	0.3	0.5	0.3	2.9	-0.4	73
Ra-228 (pCi/L)	0.6	0.8	0.5	2.9	-1.0	73

Figure 6-55: Mean quarterly Ra-226 results (± 1σ) by surface water sampling location.

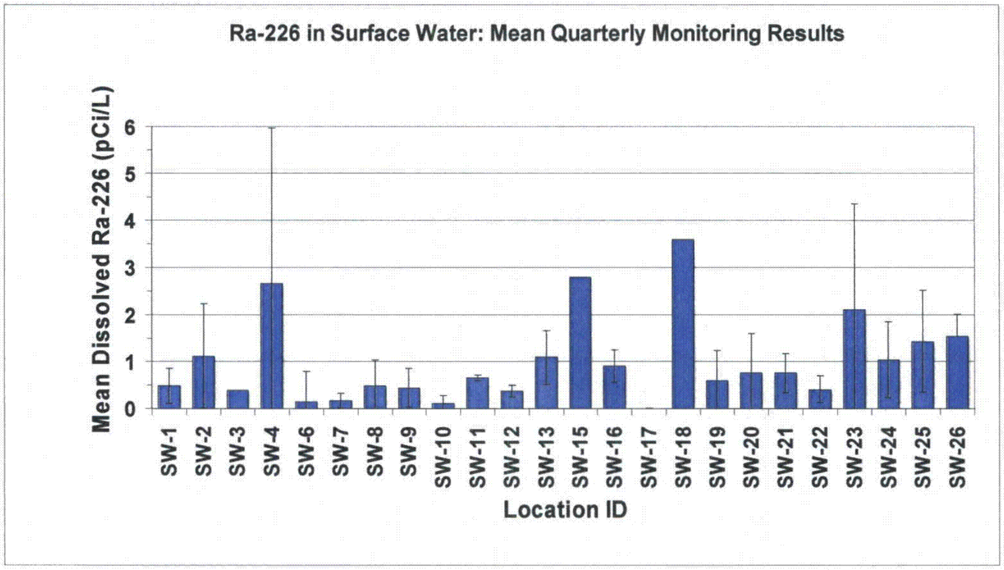
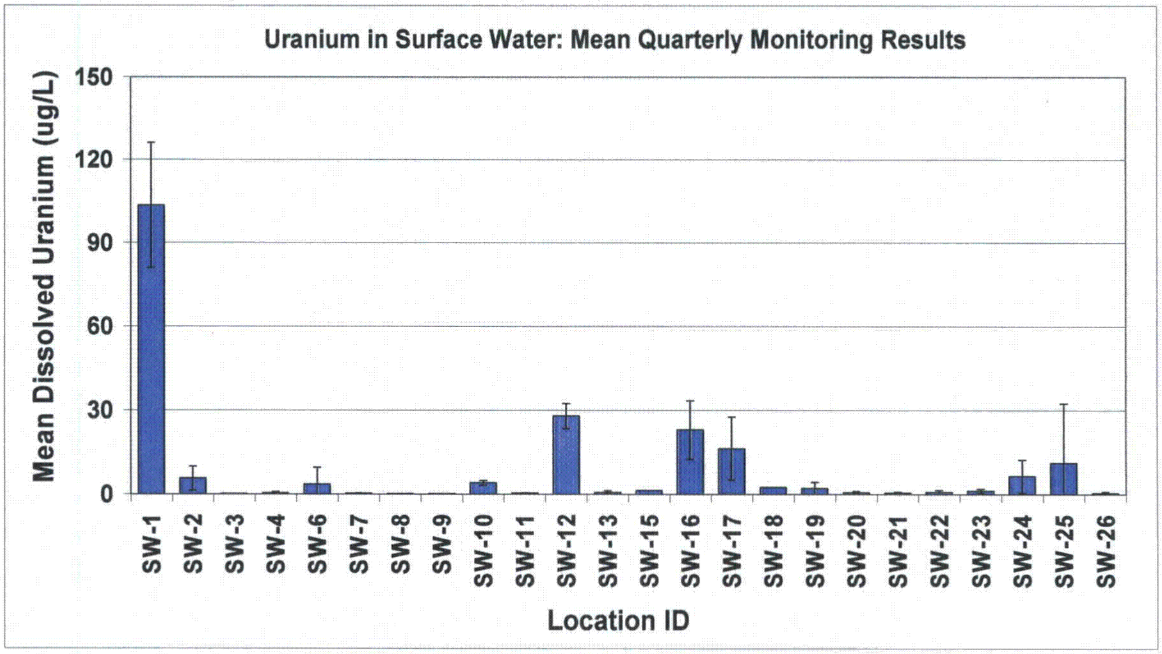


Figure 6-56: Mean quarterly uranium results (± 1σ) by surface water sampling location (top) and same results on a log scale (bottom).



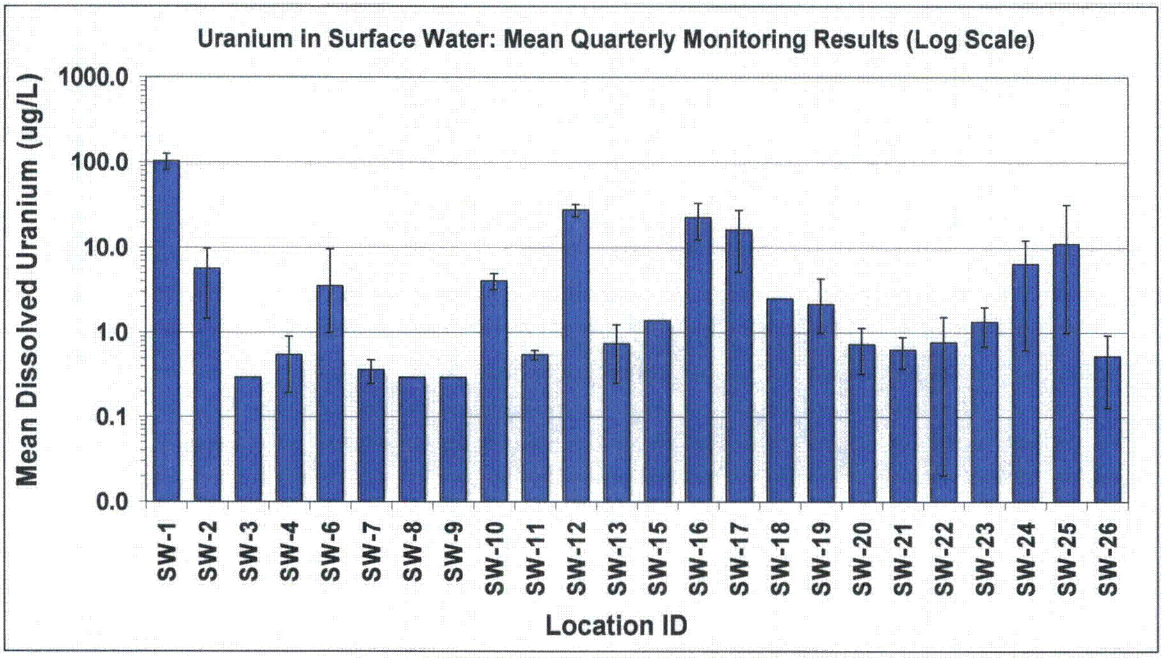


Figure 6-57: Mean quarterly Th-230 results (± 1σ) by surface water sampling location.

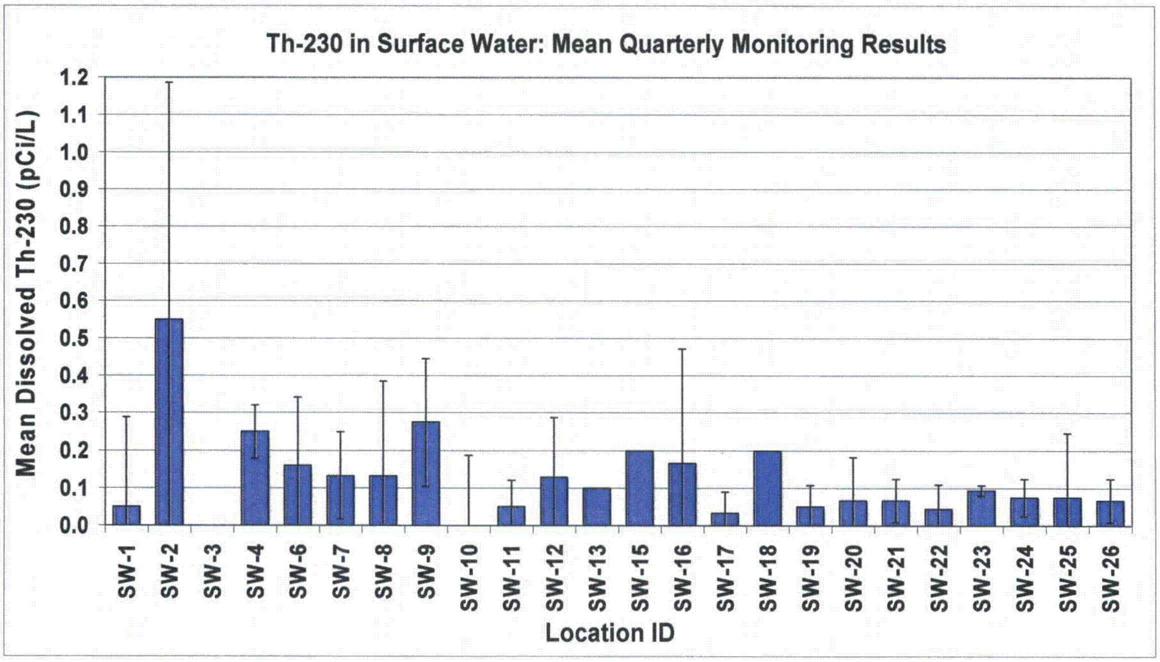


Figure 6-58: Mean quarterly Pb-210 results (± 1σ) by surface water sampling location.

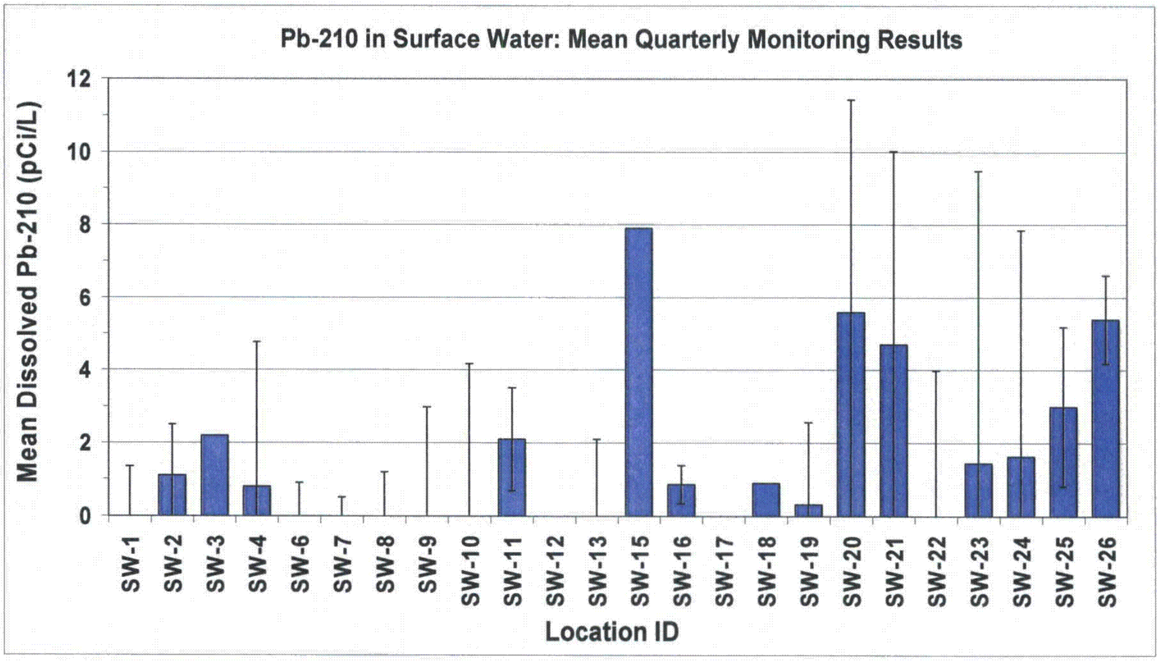


Figure 6- 59: Mean quarterly Po-210 results (± 1σ) by surface water sampling location.

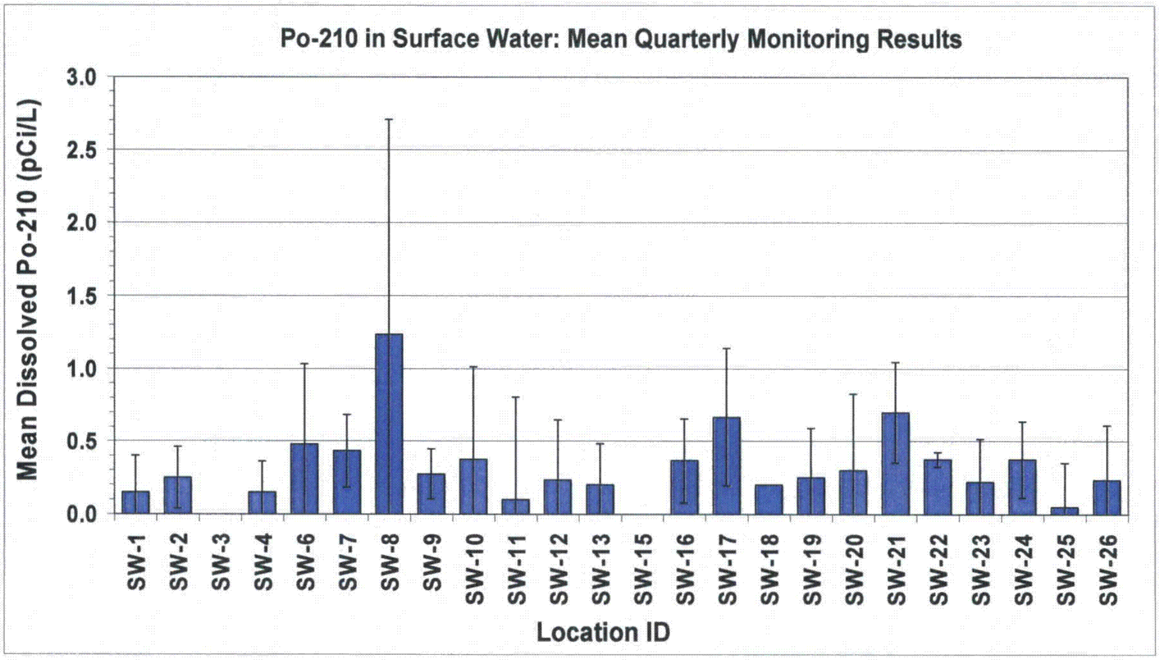
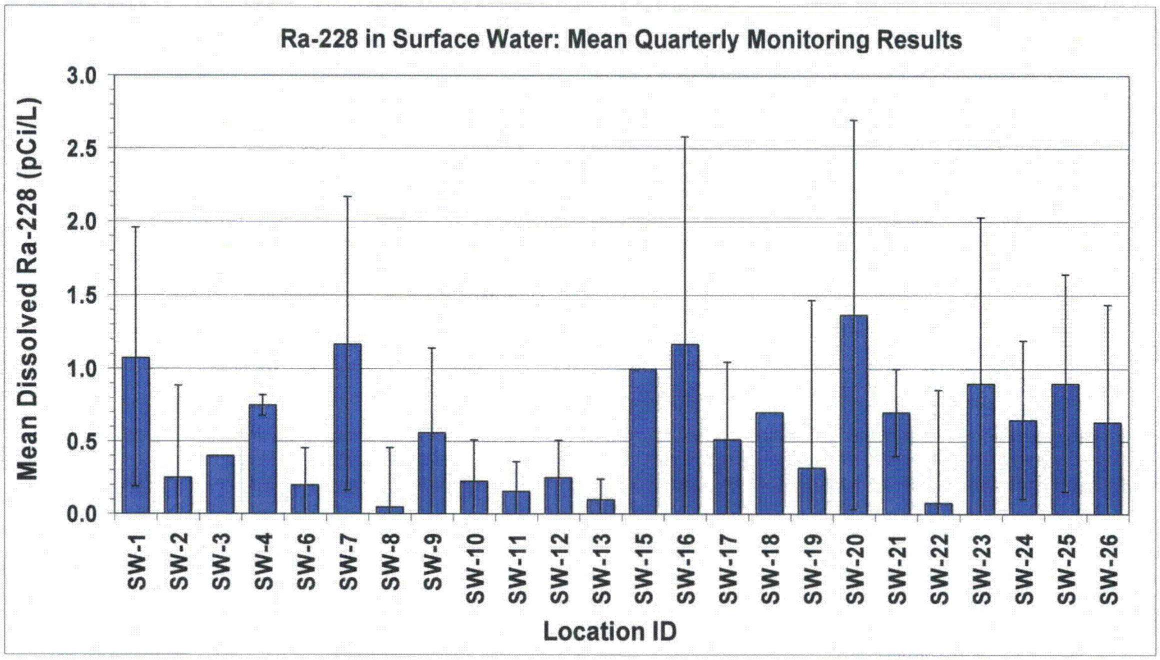


Figure 6-60: Mean quarterly Ra-228 results (± 1σ) by surface water sampling location.



A number of locations had baseline surface water samples with uranium and/or combined Ra-226/Ra-228 concentrations that exceeded respective MCLs listed by the EPA for drinking water (30 ug/L for uranium, 5 pCi/L for combined Ra-226/Ra-228; EPA, 2000). These include the following locations:

- SW-1, SW-4, SW-12, SW-16, and SW-23

The most notable case of elevated radionuclide concentrations in pre-operational baseline surface waters was observed at location SW-1, where elevated U-nat concentrations were also observed in sediment (see Section 6.4). Given the localized pockets of elevated uranium and Ra-226 in surface soils identified by the gamma survey, it is possible that accumulations of radionuclide-bearing sediments could occur in certain surface water impoundments. Source areas for such accumulations could potentially originate from outside the proposed project area boundaries; and thus would not be identified by the radiological baseline characterizations provided in this Section of the Technical Report.

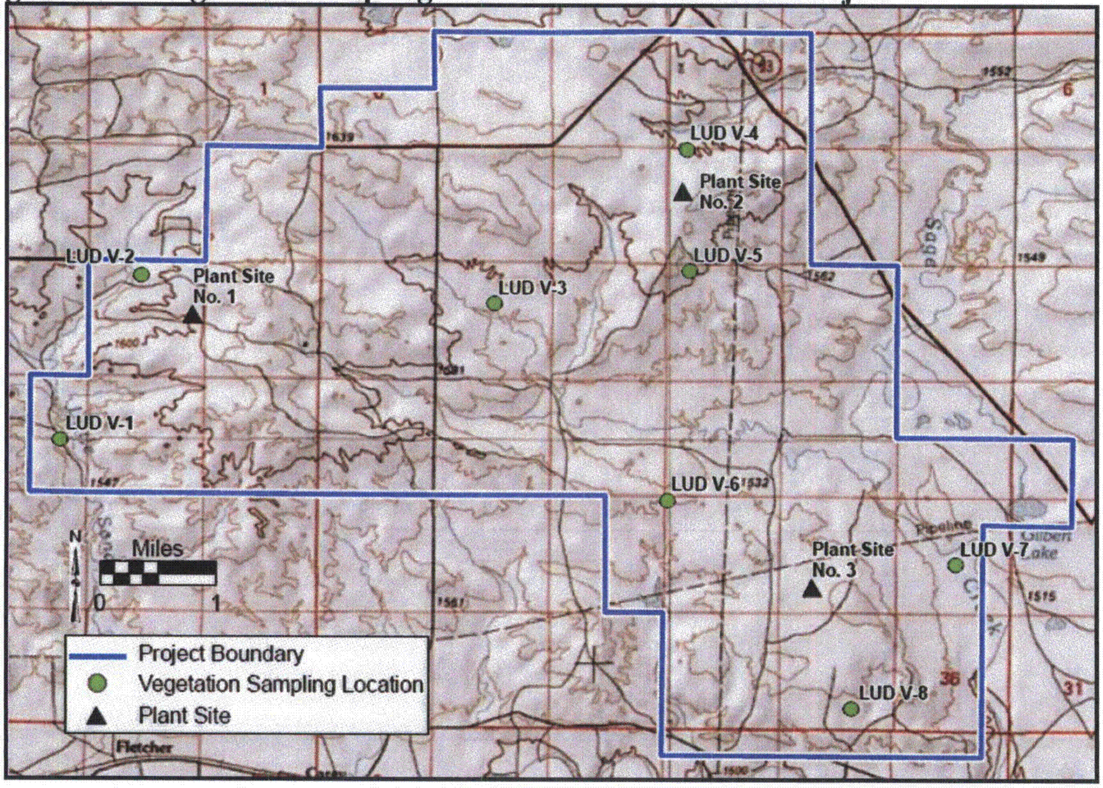
6.1.9.3 Conclusions

Radiological surface water data collected as part of baseline characterizations for the Ludeman ISR site are being collected on a quarterly basis. The data obtained to date should provide an adequate characterization of baseline radionuclide concentrations in surface waters for review by the NRC and WDEQ/LQD with respect to licensing/permitting applications.

6.1.10 Vegetation Sampling

NRC Regulatory Guide 4.14 calls for several vegetation sampling events during the growing season (NRC, 1980). Vegetation samples were collected in early July, August, and September of 2008. Data from these sampling events are presented in this section to complete a baseline radiological characterization of vegetation. Vegetation sampling locations (Figure 6-61) were selected based on proximity to potential wellfield areas and processing facilities, along with consideration for prevailing wind directions and convenient access.

Figure 6-61: Vegetation sampling locations at the Ludeman Project



6.1.10.1 Methods

Vegetation samples were collected using ordinary gardening tools (pruning shears, etc.) as mixed, above-ground growth across several hundred square meter areas at each sampling location. An estimated 3-5 kilograms of total vegetation biomass per sample was collected. Samples were collected in large plastic bags and were sent to ELI in Casper, Wyoming along with chain of custody forms. Analytes requested included all radiological parameters as recommended in NRC Regulatory Guide 4.14.

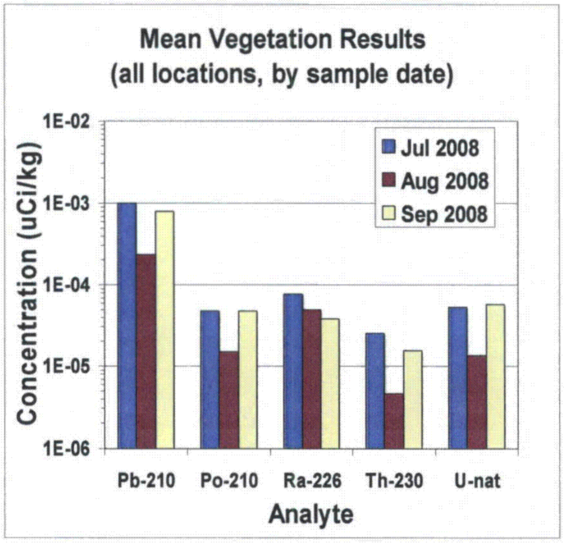
6.1.10.2 Vegetation Sampling Results

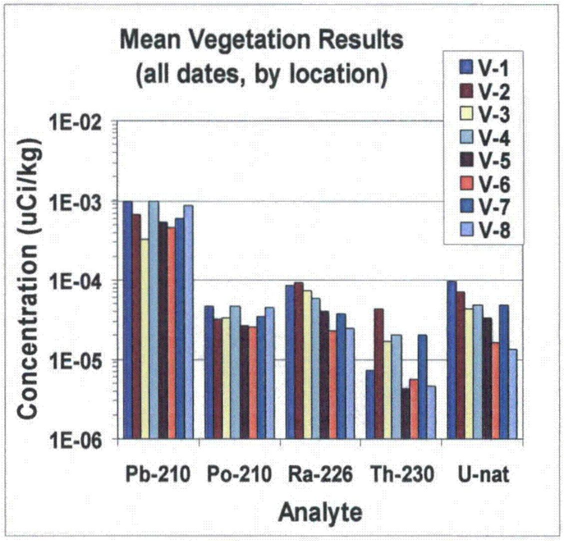
Summary statistics for baseline vegetation sampling results to date are presented in Table 6-9 and illustrated in Figure 6-62. There is an apparent trend for lower radionuclide concentrations in vegetation during the August 2008 sampling event (Figure 6-62), though such differences may be within a normal range of sampling and measurement variability. Similarly, some differences in mean radionuclide concentrations by sampling location may be attributed to sampling and measurement variability, as consistent trends are not apparent.

Table 6- 10: Summary statistics for radionuclide's in vegetation for all sampling dates and locations.

Analyte	Mean (uCi/kg)	Std. Dev. (uCi/kg)	Median (uCi/kg)	Max (uCi/kg)	Min (uCi/kg)	n
Pb-210	1.3E-03	4.5E-04	1.2E-03	1.9E-03	8.7E-04	6
Po-210	1.6E-04	6.5E-05	2.0E-04	2.1E-04	5.8E-05	6
Ra-226	2.3E-04	8.9E-05	2.2E-04	3.7E-04	1.0E-04	6
Th-230	6.5E-05	2.8E-05	6.4E-05	1.1E-04	2.3E-05	6
U-nat	1.2E-04	4.0E-05	1.3E-04	1.6E-04	4.3E-05	6

Figure 6-62: Mean analytical results for all vegetation samples by sampling date (left) and by location (right).





Across all vegetation samples, lead-210 has the greatest activity levels of the five radionuclide's 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 6.6.

6.1.10.3 Conclusions

Baseline vegetation sampling data for the proposed project site was collected and analyzed according to NRC Regulatory Guide 4.14 protocols. The results presented in this Section should complete relevant baseline characterization requirements for licensing/permitting evaluations by the NRC and WDEQ/LQD.

6.1.11 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 section. Changes in these parameters due to site operations could be used to model corresponding radiological changes in food items such as meat or milk from agricultural livestock. Respective radionuclide transfer factors can be found in the literature (e.g. IAEA, 1994; Yu, 2001). Larger game animals such as deer or pronghorn have extensive ranges, and the potential for bioaccumulation of radionuclide's in these animals due to site operations is unlikely to be significant, as they would likely derive only a small fraction of their total sustenance needs from the site.

6.1.12 Summary and Overall Conclusions

Comprehensive baseline radiological surveys of the proposed project area in Converse County, Wyoming, have been conducted in a manner consistent with NRC Regulatory Guide 4.14 recommendations (NRC, 1980) and other applicable regulatory guidance documents as part of licensing/permitting application submittals to the U.S. Nuclear Regulatory Commission and Wyoming Department of Environmental Quality / Land Quality Division. The data provided in this Section of the Technical Report is considered sufficient for complete review by applicable regulatory agencies.

The gamma exposure rate survey data, collected with the latest GPS-based scanning system technologies, represents increased survey coverage than was practical or possible at the time NRC Regulatory Guide 4.14 was published. This data, combined with established analysis techniques and state-of-the-art mapping approaches, provides a detailed characterization of the magnitude and spatial variability in background gamma exposure rates and associated soil radionuclide concentrations across the site. The approach of high-density gamma scanning, gamma/soil radionuclide correlations, HPIC cross-calibrations, and integrated use of GIS for spatial analyses and data presentation, should meet or exceed current regulatory guidelines for baseline characterizations. Respective results as presented in this Report are expected to benefit all stakeholders.

6.2 PHYSIOCHEMICAL GROUNDWATER MONITORING

6.2.1 Program Description

During operations at the proposed project, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. Uranium One's operational water monitoring program will include the evaluation of groundwater and surface water within the proposed project area. This section describes well development and sampling methods and proposed groundwater and surface water monitoring programs.

6.2.2 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.

6.2.2.1 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 wellfield. 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 6-10. 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 wellfield 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.

Table 6-10: 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) @ 180°F	*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*

6.2.2.2 Monitor Well Baseline Water Quality

Monitor well ring wells are installed within the Production Zone, outside the mineralized portion of the Production Zone and production pattern area in a "ring" around the production area. These wells are used to obtain baseline water quality data and characterize the area outside the production pattern area. Upper Control Limits (UCLs) are determined for these wells from the baseline water quality data for use during operational excursion monitoring. As described in Section 3, 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.

Monitor wells will be installed within the overlying aquifer and underlying aquifer 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 UCLs 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 6-10. 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.

6.2.2.3 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 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 of the Technical Report. The written SERP evaluation will be maintained at the site.

The Wellfield Hydrologic Data Package contains the following:

1. A description of the proposed wellfield (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 Upper Control Limits (UCLs) for monitor wells and average production zone/restoration target values; and
9. Any other information pertinent to the area tested will be included and discussed.

6.2.2.4 Operational Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular wellfield, UCLs are set for chemical constituents that would be indicative of a migration of lixiviant from the well field. The constituents chosen for indicators of lixiviant migration for the proposed project 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 IX 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 could be affected during an excursion because bicarbonate is the major constituent added to the lixiviant during mining. Although, groundwater levels are obtained and recorded prior to each well sampling, they are not used as an excursion indicator. UCLs 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, at least ten days apart, and analyzing the samples for the excursion indicators chloride, conductivity and total alkalinity. Uranium One 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, Uranium One will document the cause and the duration of any delays.

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.

6.2.2.5 Excursion Verification and Corrective Action

During routine sampling, if two of the three UCL values are exceeded in a monitor well, the well is re-sampled within 24 hours and analyzed for the excursion indicators. A verification sample is split and analyzed in duplicate to assess analytical error. If results of the confirmatory sampling are not complete within 24 hours 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 will be 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; and
- 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 corrective actions identified above, 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, Uranium One 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 WDEQ-LQD Rules and Regulations, Chapter 13, Section 13(b).

A monthly report on the status of an excursion will be submitted to the WDEQ-LQD administrator beginning the first month the excursion is confirmed and continuing until the excursion is over. The monthly report will 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.

6.3 ECOLOGICAL MONITORING

6.3.1 Wildlife

Annual wildlife monitoring surveys for the proposed project will be performed and will follow the same regimen as other ISR operations in the region to maximize comparisons among survey results and impact assessments. At a minimum, those surveys typically will include the following, as modified for site-specific habitats (e.g., no trees, so no bald eagle winter roost surveys):

1. Early spring surveys for new and/or occupied raptor territories and/or nests, monitoring of new sage-grouse leks within one mile of the proposed project area and T&E species on and within the proposed project area; and
2. Other surveys as required by regulating agencies.

Based on results from previous surveys, the WGFD recommended in late 1999 that big game monitoring be discontinued on all existing surface mine sites in Wyoming. Similarly, results from a three-year big game monitoring program conducted at the nearby Smith Ranch and Highland Uranium Projects during their respective permitting processes documented that those operations were having no significant negative impact on pronghorn or mule deer.

6.4 QUALITY ASSURANCE PROGRAM

A Quality Assurance (QA) program will be implemented at the proposed 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 Uranium One QA Plan for Wyoming ISR Operations is provided in Addendum 6-A.

The QA program addresses 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;
- Laboratory QC. Procedures will cover statistical data evaluation, instrument calibration, duplicate sample programs and spike sample programs. Outside laboratory QA/QC programs are included; and
- 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; and
6. Incident response procedures.

ADDENDUM 6-A

WYOMING ISR OPERATIONS QUALITY ASSURANCE PLAN

Wyoming In Situ Recovery Projects Quality Assurance Plan

Prepared by
Uranium One
Casper, Wyoming

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1 INTRODUCTION

This Quality Assurance Plan is applicable to the environmental monitoring program implemented by Uranium One at Wyoming ISR sites. The plan provides the quality requirements for field collection of samples and the subsequent analysis of those samples at a laboratory.

2 QUALITY PLAN REVIEW, REVISION AND DISTRIBUTION

This Quality Assurance Plan will be reviewed by affected project managers in accordance with the company policy for controlled documents. Revisions will be made at the direction of the Manager of Environmental and Regulatory Affairs, Wyoming to reflect changes in work scope, organizational interfaces or new regulatory requirements. This plan will be reviewed annually to ensure the content is valid and applicable to monitoring activities. Revisions to this plan will require approvals at the same level as the original document. At a minimum, copies of this QA Plan shall be available to all affected employees and support organizations.

3 REGULATORY REQUIREMENTS

This Quality Assurance Plan is designed to incorporate quality assurance/quality control requirements and guidance the following regulatory references:

– USNRC Regulatory Guide 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills*, Revision 1, April 1980.

– USNRC Regulatory Guide 4.15, *Quality Assurance for Radiological Monitoring Programs (Normal Operations) – Effluent Steams and the Environment*, Revision 1, February 1979.

4 ORGANIZATION

Administration of the environmental monitoring programs in Wyoming is assigned to the Manager of Environmental and Regulatory Affairs, Wyoming. The Manager may delegate the day-to-day implementation of the environmental monitoring program to other Uranium One employees or to outside contractors, but he may not delegate the ultimate responsibility. Such assignment shall be in writing.

Key positions within the Uranium One management system include:

Senior Vice President, ISR Operations – The Senior Vice President, ISR Operations has responsibility for overall management of Wyoming operations for Uranium One. The Senior Vice President, ISR Operations reports to the Executive Vice President, Uranium One.

General Manager, Wyoming Operations - The General Manager, Wyoming Operations is responsible for all uranium production activity at the project site. All site operations, maintenance, construction, environmental health and safety, and support groups report directly to the General Manager, Wyoming Operations. In addition to production activities, the General Manager, Wyoming Operations is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations.

Manager of Environmental and Regulatory Affairs, Wyoming – The Manager of Environmental and Regulatory Affairs, Wyoming has responsibility for the overall management of the environmental monitoring programs for Uranium One. The Manager of Environmental and Regulatory Affairs, Wyoming reports to the Senior Vice President, ISR Operations.

Radiation Safety Officer – The Radiation Safety Officer has responsibility for the overall management of the radiation safety program and the environmental monitoring programs for Uranium One including implementation of QA Program requirements related to radiation safety and environmental programs. The Radiation Safety Officer reports to the General Manager, Wyoming Operations and will coordinate with the Manager of Environmental and Regulatory Affairs, Wyoming.

5 QUALITY OBJECTIVES

Environmental data for the Wyoming ISR sites, derived through long-term monitoring and data interpretation, will be of sufficient quantitative and qualitative value to determine whether performance criteria are being met. The type and quality of data provided to the appropriate regulatory agencies will be used to document the performance of the uranium recovery operation and later attainment of reclamation and restoration goals.

Monitoring strategy for sampling and analytical QA objectives for data include:

- Data will be of sufficient quality to withstand scientific and legal scrutiny;
- Data will be acquired in accordance with procedures appropriate for their intended use;
- Data will be of known accuracy and precision; and

- Data will be complete, representative, and comparable.

5.1 FIELD QUALITY OBJECTIVES

The field and analytical methods chosen for use in completing the work are industry standards and are consistent with accepted standards for conducting environmental investigations.

5.2 LABORATORY QUALITY OBJECTIVES

The quality of data generated by the analytical laboratory is dependent on method precision, accuracy, and sensitivity and the basic nature of the analysis and type of equipment used to perform an analysis. Precision is a measure of the reproducibility of an analytical measurement, and accuracy is the difference between a measured value and a true or known value. These considerations are dependent upon the sample matrix and performance criteria, and method sensitivity may not be achieved in all sample matrices.

5.2.1 Precision

Precision is the agreement between a set of replicate measurements without assumption about or knowledge of the true value. Precision is assessed on the basis of repetitive measurements. Replicate field measurements of ground water are not needed because they are sequentially recorded during well purging. Evaluations will be performed to judge the precision of both field and laboratory measurement processes.

Duplicate sample analyses are used to monitor the overall precision that can be expected for a particular environmental medium within an analytical sample batch. Requirements for the collection frequency of QA samples will be specified in the site-specific environmental planning document sample events.

In the laboratory, precision is a measure of reproducibility and may be determined by repeated analysis of laboratory control samples (LCSs) or reference standards or by duplicate analysis. The laboratory will demonstrate precision through analysis of replicate standards and performance samples prior to analysis of investigative samples as required by the particular analytical method.

5.2.2 Bias

Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction. The analytical laboratory will analyze reference materials to verify that the analytical results are not biased. Calibration and operational checks of field instruments will verify that no bias is present in field measurements.

5.2.3 Accuracy

Accuracy is the nearness of a measurement or the mean of a set of measurements, to the true value and is usually expressed as the difference between the two values or the difference as a percentage of true value.

It is not possible to directly assess accuracy of field measurements and water levels because true values for these measurements are not known. To ensure accuracy of the field data, instruments and equipment used in surveying, sampling, or obtaining the measurements will be maintained and calibrated. Accuracy of surface water and ground water field measurements is addressed indirectly through instrument checks and calibrations, which will be documented in field logbooks or on field data sheets, as appropriate.

Accuracy will be assessed for analytical data by examining the results obtained from laboratory Quality Control (QC) samples. The primary means of determining the accuracy of an analytical method is to compare the results of repeated measurements of laboratory control samples and reference material with published known values. The secondary method of accessing accuracy is to analyze matrix spike samples. Accuracy requirements of routine analytical services are specified in the analytical methods. Accuracy for each analysis will be stated as a percent recovery in laboratory analytical reports.

5.2.4 Representativeness

Representativeness is generally ensured through the use of standard sampling protocols. Representativeness will be accomplished:

- Through extensive sampling that includes implementation of field QA/QC procedures;
- By careful and informed selection of sampling sites, sampling depths, and analytical parameters;

- Through the proper collection and handling of samples to avoid interferences and to minimize constituent loss;
- By monitoring field activities to ensure procedure compliance and adherence to sampling protocols; and
- By meeting sample care and custody requirements

5.2.5 Comparability

Comparability is the confidence with which one data set can be compared to another. Comparability is ensured by employing approved sampling plans, standardized field procedures, and experienced personnel using properly maintained and calibrated instruments. In the laboratory, sample handling and preparation procedures, analytical procedures, holding times, and QA protocols will be adhered to. All data in a particular data set will be obtained by the same methods and will use consistent units for reportable data. Prescribed QC procedures will be used to provide results of known quality. Data will be grouped and evaluated according to similar sampling methods, sampling media, and laboratory analytical methods.

5.2.6 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the analyte of interest. An evaluation of sensitivity is included in the analytical methods that are used to analyze samples.

6 PERSONNEL AND TRAINING

6.1 PERSONNEL REQUIREMENTS

6.1.1 Training

Personnel will be qualified to perform their assigned job through meeting basic job description requirements, education standards, experience, and ongoing performance reviews. Training will be provided when needed to maintain proficiency; to adapt to new technologies, equipment, or instruments; and to perform new assigned responsibilities.

The RSO is responsible for determining site-required training and communicating the requirements to appropriate managers. Managers are responsible for determining training needs of their staff. Personnel assigned to environmental monitoring activities are responsible for ensuring that their required training are documented and are maintained in a current status for their assignments. At a minimum, individual training requirements will be reviewed annually and updated as needed.

The RSO is responsible for ensuring that personnel assigned to environmental monitoring tasks are sufficiently familiar with the implementing documents (e.g., plans, procedures, and drawings) and the requirements established for environmental monitoring, sample collection, analysis, documenting and reporting activities, and demonstrating proficiency.

The RSO will ensure that personnel assigned to field sampling activities can demonstrate proficiency when performing the work or that they are properly supervised by a person who is proficient.

6.1.2 Certifications

QA staff that performs independent assessments of environmental monitoring activities or management systems will be qualified as lead assessors.

Laboratories used for analysis of samples collected for characterization, compliance, or other purposes will be required to pass an audit or be certified by the National Environmental Laboratory Accreditation Conference (NELAC).

7 DATA GENERATION AND ACQUISITION

This section addresses aspects of the measurement system design and implementation to ensure that appropriate methods for sampling, analysis, data handling, and QC are employed and will be thoroughly documented.

7.1 SAMPLING PROCESS DESIGN

The data obtained through monitoring site conditions will be of sufficient quantity and quality to achieve environmental monitoring objectives.

Monitoring procedures for the Wyoming ISR sites have been established. These monitoring programs are designed to ensure that monitoring data would satisfy applicable regulations and would ensure that there were no unacceptable risks to human health or the environment. The site-specific environmental monitoring plan defines the sample locations and sampling frequency and determines the types of analyses that will be conducted on the samples collected from these locations. The plans are reviewed every 5 years. Any updates to the monitoring plan that would eliminate or modify monitoring parameters, locations, or frequencies specified in the License Application will be made by license amendment. The RSO can initiate changes to environmental monitoring plans that do not require a license amendment. These changes will be managed as required by the Performance Based License Condition.

7.2 SAMPLING METHODS

Field measurements and sample collection will follow procedures attached to nationally recognized consensus standards such as EPA methods, American Society for Testing and Materials standards, or instrument manufacturer recommended procedures. Deviation from approved procedures requires approval by the RSO before the start of work.

7.2.1 Sample Collection Procedures

Sampling procedures used at Wyoming ISR sites will be managed as controlled documents and will be amended according to the requirements of this plan.

Procedures must be followed for documenting field activities and delivering the samples to the laboratory. Procedures will identify the methods employed to obtain representative field measurements and samples of specified media. The procedures will identify the equipment, instruments, and sampling tools that are needed and, where appropriate, performance criteria (e.g., special handling, operational checks, field calibrations) to ensure the quality of the field data.

The RSO is responsible for ensuring that inspections, operations and maintenance activities, field measurements, and specified samples are properly documented, occur at the prescribed frequency and locations, and are obtained in compliance with procedures and requirements specified in the project documents. Daily QC checks and data reviews will ensure that requirements have been met. If field conditions prevent inspections, required field measurements, and/or specified sample collection, the conditions will be fully documented in the field book as a field variance.

7.2.2 Field Measurements and Sampling Methods

Field measurements and sampling schedules are summarized in the environmental monitoring procedures. The data obtained through these activities will be used to monitor compliance with performance requirements. Field procedures used in well inspections, field measurements, sample collection methods, field data, equipment and supplies applicable to the field activities, sample preservation requirements, and QC sample requirements are described in the environmental monitoring procedures.

7.3 PREPARATION AND DECONTAMINATION REQUIREMENTS FOR SAMPLING EQUIPMENT

7.3.1 Requirements for Sample Containers, Preservation, and Holding Times

Non-dedicated equipment used in obtaining samples will be visually inspected and cleaned before use at each sample location. Measures will be taken (e.g., storage in trays, plastic bags, or boxes) to protect clean or decontaminated equipment while it is not being used. Sample containers will be inspected for integrity and cleanliness before being used. Suspect containers will be discarded in a manner that will preclude their inadvertent use, or they will be tagged and segregated for return to the supplier.

7.3.2 Container Requirements

Sample containers will be will be provided by the analytical laboratory or purchased. Containers will be of an adequate size to contain the required sample volume and of an approved material (e.g., amber/clear glass or HDPE) that does not promote sample degradation. As appropriate, supplier provided certificates of cleanliness will be retained with the project documentation.

7.3.3 Preservation and Holding Times

Efforts to preserve the integrity of the samples through prescribed chemical additives and/or temperature-controlled storage will be maintained as appropriate from the time the containers are received, throughout the sample collection and shipping process, and will continue until all analyses are performed. Procedures that will be employed to collect and preserve the integrity of the samples are described in the procedures. Holding times begin at the time the sample is collected, not when the sample is received by the laboratory.

7.3.4 Decontamination Procedures and Materials

Where practical, dedicated pumps will be installed in monitor wells and disposable materials will be used to minimize the decontamination requirements. The final rinse following equipment decontamination will be collected as an equipment blank QC sample.

7.4 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Sample handling, custody, and shipping procedures are addressed in the environmental monitoring procedures. A minimum number of individuals should be involved in sample collection and handling to ensure integrity of the sample and compliance with custody procedures. To maintain evidence of authenticity, the samples collected must be properly identified and easily discernable from like samples. To maintain the integrity of the sample, proper preservation, storage, and shipping methods will be used.

Unused sampling equipment, sample containers, and coolers that have been shipped or transported to a sampling location will be kept in a clean, temperature-controlled, and secure location to minimize damage, tampering, degradation, and possible cross-contamination.

7.4.1 Identification, Handling, Packaging, and Storage

7.4.1.1 Sample Identification

Environmental samples and associated QC samples will be assigned a unique identification number. In addition to the unique number, QC samples will be assigned a fictitious location identifier that is consistent with the sample location identification scheme.

Samples will be identified by a label or tag attached to the sample container that specifies, as appropriate, the project, sample location, unique identification number, preservatives added, date and time collected, and the sampler's name. Sample labels, tags, and/or container markings should be completed with indelible (waterproof) ink. Clear tape may be placed over each sample label for added protection, if needed.

7.4.1.2 Sample Handling and Storage

During field collection, sample containers may be stored in boxes, trays, or coolers, as dictated by protection and preservation needs. Samples that require refrigeration will be stored in coolers with sufficient ice to maintain the required temperature controls during field collection, packaging, and shipping. Samples that are not transported to the laboratory the day of collection must be stored in containers that will prevent damage or degradation of the sample. In addition, samples must be stored in locked containers or buildings when they are out of the direct control of the responsible custodian. Samples stored overnight or at locations where access is not solely controlled by the custodian will have custody seals placed on the outside of the container (cooler or box) as a measure of security.

7.4.1.3 Sample Custody

To ensure the integrity of the sample, the field custodian is responsible for the care, packaging, and custody of the samples until they are transferred to the laboratory.

Chain of Custody forms will be used to list all samples and transfers of sample possession to provide documentation that the samples were in constant custody between collection and analysis. The filled-in Chain of Sample Custody form, a copy of which is retained by the originator, will accompany samples that are sent or transported to the analytical laboratory.

7.4.1.4 Sample Packaging and Shipping

All samples will be handled, packaged, and transported or shipped in accordance with applicable U.S. Department of Transportation requirements. Sample storage containers (e.g., boxes or coolers) and sample containers will be securely packaged to protect the contents from damage, spilling, leaking, or breaking. Void space in shipping containers should be filled with an inert material or additional ice, if appropriate, to further protect and secure the contents.

Custody seals are not required for containers or samples that are transported directly to the analytical laboratory for analysis or interim storage. Custody seals are required for shipping containers (e.g., coolers or boxes) that are sent by common carrier. Clear tape should be placed over the seals as protection against tearing during shipment.

Mailed sample packages will be registered with return receipt requested. If packages are sent by common carrier, receipts are retained as part of the chain of custody documentation. Other commercial carrier documents shall be maintained with the chain of custody records.

7.4.2 Laboratory Requirements

7.4.2.1 Laboratory Sample Receipt

The subcontract analytical laboratory personnel are responsible for the care and custody of samples from the time they are received until the time the sample is analyzed and archive portions are discarded. On arrival at the laboratory, laboratory personnel must examine the container and document the receiving condition, including the integrity of custody seals, when applicable. When opening the shipping container, laboratory personnel will examine the contents and record the condition of the individual sample containers (e.g., bottles broken or leaking), the temperature (when applicable), method of shipment, carrier name(s), and other information relevant to sample receipt and log-in. Laboratory personnel verify that the information on the sample containers matches the information on the Chain of Sample Custody form.

7.4.2.2 Discrepancies Identified During Sample Receipt

If discrepancies are identified during the sample receiving process, laboratory personnel will attempt to resolve the problem by checking all available information (e.g., other markings on sample containers and type of sample), recording appropriate notes on the Chain of Sample Custody form, and contacting the RSO to resolve any questions.

If the laboratory judges the sample integrity to be questionable (e.g., samples arrive damaged or leaking, or the temperature range is exceeded), the RSO will be contacted and will bring in appropriate technical staff to make a decision regarding rejecting or flagging the data and/or re-sampling the location. Damaged samples will be rescheduled for collection and analysis, if necessary.

Discrepancies noted during sample receiving at a subcontracted laboratory or testing facility will be resolved in accordance with the procurement documents. In general, the RSO will be contacted to facilitate resolution of a problem.

7.4.2.3 Sample Disposition

When sample analyses and necessary QA/QC checks have been completed in the laboratory, the residual sample material and wastes generated as a result of the analytical process will be treated, shipped, and disposed of in accordance with all applicable federal, state, and local transportation and waste management requirements. When samples are stored, they will be protected to prevent damage or degradation. At a minimum, samples shall not be removed from the laboratory sooner than 60 days after the delivery of laboratory data reports.

7.4.3 Analytical Methods

Laboratories involved in the analysis of samples will have a written QA/QC program that provides rules and guidelines to ensure reliability and validity of the work conducted at the laboratory.
The analytical procedures to be used by subcontracted laboratory services will be specified in the procurement documents. These procedures typically consist of EPA methods. The use of these methods will ensure that required method detection limits and project reporting limits are achieved for each of the requested analytes.

Required analytical methods will be documented in appropriate site-specific documents.

7.4.3.1 Subcontracted Laboratory Requirements

The subcontracted laboratory will have a documented QA program in place, the implementation of which may be independently verified through proposal reviews, prior history, and/or pre-award survey. As appropriate, subcontracted laboratories will use EPA or EPA-approved methods or other methods specified and approved within the provisions of the procurement documents. Subcontracted laboratories are required to pass an audit or be certified by NELAC. Internal method requirements for analysis of spikes, duplicates, or replicates will be followed and may be used as performance indicators for these services.

Data turnaround times, sample disposition, and other requirements of the analytical laboratory are identified in procurement documents. The laboratory must obtain authorization from the RSO for changes to the procurement documents.

Work submitted to the laboratory may not be subcontracted by the laboratory without the prior consent of Uranium One.

7.4.4 Quality Assurance/Quality Control

7.4.4.1 Field QA/QC

A variety of instruments, equipment, sampling tools, and supplies will be used to collect samples and to monitor site conditions. Proper inspection, calibration, maintenance, and use of the instruments and equipment are required to ensure field data quality. In addition, field QA will be implemented through the use of approved procedures, proper cleaning and decontamination, protective storage of equipment and supplies, and timely data reviews during field activities. The QC objective of these data collection activities is to obtain reproducible and comparable measurements to a degree of accuracy consistent with the intended use of the data.

QC samples will consist of field duplicates, equipment rinsate blanks, and trip blanks, as appropriate, for the matrix and analytes involved. An additional volume of ground water for selected analyses will be collected for matrix spike/matrix spike duplicate (MS/MSD) use, as requested by the laboratory. Field QC samples will be used to quantitatively and qualitatively evaluate the analytical performance of the laboratory and to assess external and internal effects on the accuracy and comparability of the reported results. Field QC samples will be uniquely identified.

Where applicable, field measurement data will be compared to previous measurements obtained at the same location. Large variations (greater than 30 percent) in field measurement data at a location will be examined to evaluate whether general trends are developing. Variations in data that cannot be explained will be assigned a lower level of confidence through assignment of qualifiers or will be flagged for additional sampling or evaluation.

7.4.4.2 Laboratory QA/QC

Laboratory QC checks are internal system checks and control samples introduced by the laboratory into the sample analysis stream. These checks are used to validate data and calculate the accuracy and precision of the data. The objectives of the laboratory QA/QC program should be to:

- Ensure that procedures and any revisions are documented
- Ensure that analytical procedures are conducted according to sound scientific principals and have been validated
- Monitor the performance of the laboratory by a systematic inspection program and provide for corrective measures, as necessary.
- Collaborate with other laboratories in establishing quality levels, as appropriate
- Ensure that data are properly recorded and archived

Internal QA procedures for analytical services will be implemented by the laboratory in accordance with the laboratory's standard operating procedures. Data sheets, which also report the blank and spiked sample checks that have been performed, will be provided and will indicate when a QC check was performed. Analytical data that do not meet acceptance criteria will be qualified and flagged in accordance with standard operating procedures.

Laboratory quality control procedures are defined within the particular analytical method or are defined in procurement documents.

7.4.5 Instrument/Equipment Testing, Inspection, Calibration, and Maintenance

A variety of equipment, instruments, and sampling tools will be used to collect data and samples for the Wyoming ISR sites. Proper maintenance, calibration, and use of equipment and instruments are imperative to ensure the quality of all the data that are collected.

Field and laboratory equipment, instruments, tools, gauges, and other items used in performing work tasks that require preventive maintenance will be serviced in accordance with manufacturers' recommendations and instructions. When applicable, technical procedures will identify the manufacturers' instructions and recommended frequency for servicing the equipment. Preventive maintenance for calibrated measuring and test equipment will be performed either by field or laboratory personnel who are knowledgeable of the equipment, or by manufacturer's authorized service center as part of routine calibration tasks. Records of equipment calibration, repair, or replacement of controlled instruments will be filed and maintained in accordance with the applicable records management requirements.

Instruments that are not calibrated to the manufacturers' specifications will display a warning tag to alert the sampler and analyst that the instrument has only limited calibration.

7.4.5.1 Field Equipment and Instruments

Field equipment, instruments, and associated supplies used to obtain field measurements and collect samples are specified in sampling procedures.

Field personnel will conduct visual inspections and operational checks of field equipment and instruments before they are shipped or carried to the field and before using the equipment or instruments in field data collection activities. Whenever any equipment, instrument, or tool is found to be defective or fails to meet project requirements, it will not be used, and as appropriate, it will be tagged defective and segregated to prevent inadvertent use. Backup equipment, instruments, and tools should be available on site or within 1-day shipment to avoid delays in the field schedule.

The RSO or designee is responsible for the overall maintenance, operation, calibration, and repairs made to field equipment, instruments, and tools. The RSO or designee is also responsible for ensuring that the field book has adequate documentation that describes any maintenance, repairs, and calibrations performed in the field.

Equipment and instruments used to obtain data will be maintained and calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturers' specifications. Calibration of equipment and instruments will be performed at approved intervals, as specified by the manufacturer, or more frequently as conditions dictate. Calibration standards used as reference standards will be traceable to the National Institute of Standards and Technology or other recognized standards when available. Instruments found to be out of tolerance will be tagged defective and segregated to prevent inadvertent use.

In some instances, calibration periods will be based on usage rather than periodic calibration. Equipment will be calibrated or checked as a part of its operational use. Records of field calibration will be documented on forms provided for technical procedures or recorded in the field logbook. Calibration checks will be performed in accordance with procedures.

Procedures recommended by the manufacturer will be used for equipment preventive maintenance. Backup equipment, supplies, and critical spare parts (e.g., tape, bottles, filters, pH paper, tubing, probes, electrodes, and batteries) will be kept on site to minimize downtime. The RSO or designee is responsible for ensuring that routine maintenance is performed and that tools and spare parts used to conduct routine maintenance are available.

7.4.5.2 Laboratory Equipment and Instruments

As part of the QA/QC program for the analytical laboratory, routine preventive maintenance is conducted to minimize the occurrence of instrument failure and other system malfunctions. The laboratory will maintain a schedule for servicing critical items and will perform routine maintenance, scheduled maintenance and repair, or coordinate with a vendor to arrange for maintenance and repair service, as required. All laboratory instruments will be maintained in accordance with the manufacturers' specifications and the requirements of the specific method employed. Equipment will be tested during routine calibration, and deficiencies will be corrected as specified in procedures.

The concentration of standards and frequency of initial and continuing calibration of analytical instruments will be as specified in the laboratory procedures. Calibration data will be provided with the analytical data package. Calibration records pertaining to subcontracted laboratory services will be filed and maintained by the laboratory in accordance with internal procedures.

7.4.6 Instrument/Equipment Calibration and Frequency

Calibration of analytical laboratory equipment will be based on approved written procedures. The concentration of standards and frequency of initial and continuing calibration of analytical instruments will be as specified in the laboratory SOPs. The analytical laboratory will maintain calibration records. Calibration data will be provided with the analytical data package, as specified in the procurement documents.

7.4.7 Inspection/Acceptance of Supplies and Consumables

7.4.7.1 Sample Containers

Sample containers for water, soil, sediment, and other media will be provided by the subcontracted laboratory and will be new or pre-cleaned. As appropriate, supplier-provided certificates of cleanliness will be retained with field documentation.

Containers will be visually inspected for integrity and cleanliness before being used. Suspect containers will not be used and will be discarded in a controlled manner to prevent inadvertent future use. If sufficient quantities of containers are suspect, the laboratory will immediately be notified of the condition and requested to provide a sufficient quantity of replacement containers. Suspect containers will be collected, segregated, and tagged for return to the analytical laboratory. The RSO or designee will describe the situation in the field book as a field variance.

7.4.7.2 Supplies and Consumables

The RSO or designee is responsible for ensuring that supplies, materials, and consumable items used during field activities are properly inspected for integrity, cleanliness, and compliance with specified tolerances and that they are appropriate to the activity. Items with a specified shelf life or expiration date will be labeled. Expired materials will not be used and will be properly disposed of or returned to the laboratory for disposal, as appropriate. Supplies, materials, and equipment will be inventoried at the conclusion of the sampling event in preparation for the next scheduled event.

7.4.8 Data Management

Project data are generated mainly from routine sampling of monitor wells, routine operations system sampling, and occasional soil sampling events. The RSO or designee is responsible for managing project data in compliance with Uranium One requirements.
Field data books are assembled for most sampling events. These books contain information such as sample location identification (ID), date, QA sample ID, well purge method, sampling method, and field measurements. These are completed at the time of sample collection.

Data from samples submitted to an analytical laboratory are received as both hard copy and as electronic data. The hard copy analytical reports are archived in the project records along with the original field data forms and other relevant hard copy forms or documents containing project data. The hard copy forms are categorized in the project records according to the project filing procedures. Electronic data are also archived in the project records according to the project filing procedures.

7.5 DATA VALIDATION AND USABILITY

Technical data, including field data and results of laboratory analyses, will be routinely verified and validated to ensure that the data are of sufficient quality and quantity to meet the project's intended data needs. Results of data validation efforts will be documented and summarized in the site-specific validation reports. The person doing work is responsible for initiating the review, verification, validation, and screening associated with field and/or laboratory data.

7.5.1 Field Measurement Data

The objective of field data verification is to ensure that data are collected in a consistent manner and in accordance with procedures and schedules established in the Wyoming ISR environmental planning documents. Field data validation procedures include a review of raw data and supporting documentation generated from field investigations. The data are reviewed for completeness, transcription errors, compliance with procedures, and accuracy of calculations.

The person doing the validation (in consultation with the RSO or designee, if required) may correct problems that are found or noted in field documentation. Corrections to data forms will be made by lining through the incorrect entry, correcting the information, then initialing and dating the corrected information. The person validating the document, with the consent of the RSO or designee, may also determine that incorrect data should not be entered into a database or that the data should have an additional qualifier.

7.5.2 Laboratory Data

The laboratory performing the analyses will document the analytical data in accordance with standard procedures inherent in the analytical methods and as approved by the RSO or designee, if required.

Once the data package is received from the analytical laboratory, laboratory records and data package requirements will be checked to assess the completeness of the data package, and the data will be validated by personnel qualified and experienced in laboratory data validation.

The QC data provided by the laboratory (method blanks, matrix spikes, etc.) will be evaluated to see if they are within the acceptance range. If they are not, the data set affected by the QC samples will be evaluated to determine if corrective action is necessary.

7.5.2.1 Quality Control Samples

QC samples consisting of trip blanks, equipment rinsate blanks, field duplicate samples (replicated or co-located samples), laboratory spikes, laboratory blanks, laboratory duplicates, and laboratory control samples (including thermoluminescent dosimeters) are evaluated in the data validation process.

7.5.3 Qualification of Data and Corrective Actions

Qualification criteria are defined in the Uranium One procedures. In addition to the process of qualifying the data, other corrective actions may be used. These may include reanalysis of the data by the laboratory or re-sampling of the affected locations. Other corrective actions to prevent contamination of future samples may also be proposed.

7.5.4 Determination of Anomalous Data

The final aspect of data validation involves the screening of both field and laboratory analytical data for potentially anomalous data points.

7.5.4.1 Data Screening

The initial step in determining potentially anomalous data points consists of screening all data from a sampling event for values that fall outside a designated historical data range. The historical data range used for comparison will be from previous sampling events.

7.5.4.2 Technical Review

The next step involves a review of the screened data by a qualified individual experienced in data review. Each data point will be evaluated to determine if the data point is acceptable or if follow-up action is required. This evaluation will consider factors such as number of historical data points, analyte concentration, magnitude of the deviation from the historical data range, number of historical non-detects, variability of the historical data, location of the sample point relative to other potential interfering activities, and correlation with other analytes.

7.5.4.3 Follow-up Actions

Follow-up actions can include one or more of the following:

- Requesting a laboratory check of calculations and dilutions
- Sample reanalysis
- Re-sampling
- Comparison to results from the next sampling event
- Data qualification

Based on the results of the follow-up action, the RSO will make a final determination of validity of the data point. The data point will be considered acceptable or it will be qualified, and a record of the action will be made. A summary of any anomalous data will be included in the site-specific data validation report.

7.5.4.4 Data Qualification

After the RSO has determined that a data point is anomalous, the data point will be qualified as unusable in the database. Qualification of data will be noted with a brief justification for the qualification.

7.6 DOCUMENTATION AND RECORDS

The requirements for documentation and records management apply to the preparation, review, approval, issue, use, and revision of documents or forms that prescribe processes, specify requirements, or establish design. Records must be specified, prepared, reviewed, approved, and maintained as directed by Uranium One policy.

Field and laboratory data will be sufficiently documented to provide a scientifically defensible record of the activities and analyses performed. Records of field variance reports, internal reviews, field and laboratory records of tests and analyses, field logs, Chain of Custody forms, and project reports will be used in interpreting and assessing the usability of the data. Standardized forms and computer files, codes, programs, and printouts will be designed to eliminate errors made during data entry and reduction. Calculation steps are described in the technical and analytical procedures and software lists. Routine data-transfer and data-entry verification checks are performed.

7.6.1 Records Management Plan

A site-specific records management plan shall be prepared to identify the records to be generated, file locations, and retention schedule for the Wyoming ISR site. The records management plan establishes the requirements for preparing, preserving, and storing records. Project personnel will work with the RSO, or his designee, to ensure that environmental monitoring records are correctly identified and maintained in accordance with the plan. Modifications to the plan shall be submitted to the RSO and are subject to the RSO's review and approval. At a minimum the site record management plan will include the following requirements:

Records not utilized to determine occupational dose that require a 3 year retention period as specified in 10 CFR §20.2103:

- Area beta-gamma measurements and associated instrument calibrations not utilized to determine employee dose;
- Equipment release records and associated instrument calibrations
- Instrument daily function check records;
- Alpha contamination surveys eating areas; and
- Personnel contamination surveys frisking stations

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). The following specific records will be permanently maintained and retained until license termination:

- Records of disposal of byproduct material on site through deep disposal wells as required in 10 CFR §20.2002 and transfers or disposal off site of source or byproduct material;
- Records of surveys, calibrations, personnel monitoring, and bioassays as required in 10 CFR §20.2103;
- Records containing information pertinent to decommissioning and reclamation such as descriptions of spills, excursions, contamination events etc. including the dates, locations, areas, or facilities affected, assessments of hazards, corrective and cleanup actions taken, and potential locations of inaccessible contamination;
- Records of information related to site and aquifer characterization and background radiation levels;
- As-build drawings and photographs of structures, equipment, restricted areas, well fields, areas where radioactive materials are stored, and any modifications showing the locations of these structures and systems; and

- Records of the radiation protection program including program revisions, standard operating procedures, radiation work permits, training and qualification records, SERP proceedings and audits.

The RSO will be responsible for ensuring that the required records are maintained and controlled. Hard copies of all records will be maintained on site in a controlled environment to protect them from damage deterioration and will be available for inspection by regulatory agencies. Electronic copies may be maintained in addition to hard copies with backup protection. Duplicates of all records will be maintained in the Casper office or other offsite location(s).

7.6.2 Document Control and Changes

Uranium One policy and procedures will be followed to ensure that the preparation, issuance, and revisions to project documents and forms will be controlled so that current and correct information is available at the work location. These project documents (e.g., plans, procedures, drawings, and forms) and subsequent revisions will be reviewed for adequacy and approved before being issued for use. Written records and photo documentation will be handled in a manner that ensures association to the activity, the samples, and their locations. The RSO can authorize minor changes to project documents without requiring a formal review process.

At a minimum, personnel responsible for environmental monitoring activities at the Wyoming ISR site will have access to the applicable documents and will be knowledgeable of the contents before the associated work assignment.

Nonroutine sampling and field investigations will be documented in the file. The RSO will be briefed on and will approve all nonroutine field investigations before the work begins.

7.6.3 Corrections to Documents

When practical, correction of errors should be made by the individual who made the entry. The method used to make a correction is to draw a line through the error, enter the correct information, then initial and date the entry. The erroneous material must not be obscured.

When a document requires replacement due to illegibility or inaccuracies, the document will be voided, and a replacement document will be prepared. A notation will be made on the voided document that a replacement document was completed. The voided document will be retained with the field documentation.

7.6.4 Project Documents

Project documents are written materials that provide a background or history of the work, establish the basis for the work, give guidance to the work, and provide a summary of the work. They may be documents such as technical reports, technical and administrative plans, inspection or test documents, and design or as-built drawings. Documents prepared for the Wyoming ISR site that establishes instructions or procedures will be developed in accordance with the applicable requirements. Documents that are subject to revision will be managed and issued as controlled documents. These include, but are not limited to, the following documents:

- Quality Assurance Plans and Procedures
- Site-Specific Environmental Monitoring and Sampling Plans

7.6.5 Procedure Requirements

Uranium One personnel will comply with the requirements of all approved written procedures or other instructions. Any deviation from approved field procedures must be authorized by the RSO. Field changes to project plans or deviation from procedures will be documented in the field book as a field variance and communicated to the RSO as soon as possible.

The RSO will be notified of any changes to subcontract laboratory procedures. The RSO will be informed of and review changes to laboratory procedures. Impacts will be identified to the RSO. As appropriate, procedure changes that affect laboratory data will be identified and documented during the data review, verification, and validation activities. As appropriate, the RSO will inform Uranium One management of technical or other substantive changes to laboratory procedures that may affect reporting limits or analytical sensitivity.

7.6.6 Field Documentation

Field documentation requirements are specified in the sampling procedures. All entries in field documents will be made with indelible (waterproof) ink and will be legible, reproducible, accurate, complete, and traceable to the sample measurements and/or site location. These documents will be retained as project records. Field documents are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the field sampling activities. Field logbooks and forms (e.g., sample collection data sheets, field measurement data forms, Chain of Custody forms, and shipping forms) will be stored in a manner that protects them from loss or damage.

The sampler will adequately document and identify field measurements and each sample collected. Field records will be completed at the time the observation or measurement is made and when the sample is collected. Project documents and written procedures will be available at the work site. The RSO or designee will ensure that specified requirements are followed so that an accurate record of sample collection and transfer activities is maintained.

As appropriate, sample disposition will be specified to the subcontract laboratory in the appropriate procurement documents.

7.6.6.1 Field Variance and Nonconformance Documentation

Changes from specified field protocols established in planning documents or standard operating procedures must be authorized by the RSO and fully documented by the person doing the sampling. Field variances will be reported in a timely manner to evaluate the impact the variance has on the data or system operations. Field variance reporting applies to deviations from (1) prescribed field sampling and measurement requirements; (2) specified shipping, handling, or storage requirements; and (3) decontamination procedures.
A variance must be documented whenever an activity is performed or sample is obtained where:

- The activity performed or sample collection technique does not fall within the methods or protocols specified;
- The monitoring or measurement instrument that was used was out of calibration or had failed an operational check;
- Insufficient documentation results in the inability to trace the activity, measurement, or sample to the prescribed or selected location; and
- There is a loss of or damage to records that cannot be duplicated.

The variance should be fully described, and corrective action, if applicable, should be taken immediately. Comments describing the variance will be used during data evaluation to assess the use of associated results and validity of the data. Field variances should be noted in the field data sheet, on a general log sheet, or in the activity logbook. As appropriate, field variances will be summarized in the report at the conclusion of the activity.

7.6.6.2 Chain of Sample Custody

The custody of individual samples will be documented by recording each sample's identification, number of containers, and matrix on a standardized Chain of Custody form. This form will be used to list all transfers of sample possession.

7.6.7 Laboratory Documentation

The format and content of laboratory reports depend on contract requirements, regulatory reporting formats, and whether explanatory text is required. At a minimum, the laboratory data report will include the following items:

- Analytical method used;
- Date and time of analysis;
- The Chain of Custody form;
- Sample receiving documentation;
- QC data results and report;
- Sample data results by analysis, including method detection limits, reporting limits, and dilution factors;
- Summary of results (e.g., case narrative); and
- Certification by the laboratory that the analytical data meet applicable data quality requirements

Analytical data that do not meet specified criteria will be qualified and flagged to allow data evaluation before use. Any nonconformances or difficulties encountered during analyses will be documented with each data package.

7.6.8 Reports Received from Subcontractors

7.6.8.1 Laboratory or Other Data Reports

Reporting requirements and formats will be defined in procurement documents issued for subcontracted services. The RSO will be consulted regarding difficulties or nonconformance associated with subcontracted analytical services and will resolve disputes that could affect data quality.

7.6.8.2 Plans and Technical Reports

The criteria for technical reports received from subcontracted services may include a deliverable schedule for draft and final documents, required reviews, format, software type and version requirements, and contents of the document, including any supporting documents, data, and references.

7.7 QUALITY IMPROVEMENT, ASSESSMENT, AND OVERSIGHT

All personnel must continually seek to improve the quality of their work. This section addresses the activities for assessing the effectiveness of the implementation of the project and associated QA/QC requirements.

7.7.1 Quality Improvement

Management encourages innovation and continuous improvement in the work environment by fostering a "no fault" attitude to encourage the identification of problems and to create an atmosphere of openness to suggestions for improvement. All personnel are encouraged to identify and suggest improvements.

Personnel have the freedom and authority to stop work until effective corrective action has been taken. Work that is performed by subcontractors will be subject to oversight. The work may be suspended immediately for imminent threats to health, safety, environmental release, or significant adverse quality issues. Re-start of such work stoppages will be at the direction of the General Manager, Wyoming Operations.

7.7.1.1 Corrective Actions

Corrective actions are the process of identifying, recommending, approving and implementing measures to improve unacceptable procedures, and sampling practices that may affect data quality. All proposed and implemented corrective actions will be documented through the site SERP process. Items requiring immediate corrective actions will be implemented with the approval of the Radiation Safety Office and modifications documented through the SERP process.

If corrective actions are insufficient, the appropriate personnel may issue suspension of work until the problem can be resolved.

During any field sampling activity, the field personnel will be responsible for documenting and reporting all QA nonconformance's and suspected deficiencies associated with the sampling being conducted. All nonconformance's and or deficiencies will be documented in the field log book or sheets and reported to the RSO. If the problem is associated with field measurement sampling equipment, the field personnel will take the appropriate corrective actions. If the field corrective actions are not sufficient to correct the deficiency, personnel may suspend field activities until the problem can be resolved. Any time field activities have been suspended due to QA deficiencies the RSO shall be notified.

Field corrective actions could include:

- Repeating the measurement to check for errors;
- Checking, recharging or replacing batteries in sampling equipment;
- Re-calibration or function check of instrument or equipment to ensure proper operations; and
- Replacing meter or instruments not functions properly

Field corrective actions will be documented.

7.7.2 Assessment and Response Actions

Assessments of project activities will be planned and scheduled with the appropriate levels of management. The Manager of Environmental and Regulatory Affairs - Wyoming is responsible for scheduling and administering the internal assessment plan. When the assessment is conducted, results will be evaluated to measure the effectiveness of the implemented quality system. Assessment activities may include management assessments and independent assessments.

Assessment activities will be documented. Reports resulting from management assessments will be issued to the responsible manager and distributed internally to project management. Assessment activities involving subcontracted services will be coordinated with the appropriate levels of project management and will be documented.

The RSO will promptly define corrective actions and correct deficiencies identified through assessments. Corrective actions will be independently verified by staff not organizationally reporting to the RSO. Verification will be documented and retained in the assessment file.

7.7.2.1 Management Assessments

Included in the management assessments are human resource issues, operations issues, resource allocation, financial performance, financial controls, and quality control. The Senior Vice President, ISR Operations is responsible for ensuring that project staff supports these activities as delegated, that they observe firsthand the work in progress, communicate with those performing the work, identify potential or current problems, and identify good practices.

The Senior Vice President, ISR Operations shall determine the scope, schedule, and responsibilities for site-specific management assessment. All levels of management are responsible for responding to assessment findings and completing agreed-upon corrective actions.

7.7.2.2 Independent Assessments

Independent assessments (e.g., audits and surveillances) will be planned, performed, and documented in accordance with written instructions, procedures, or checklists.

Personnel who lead independent assessments (audits or surveillances) must be qualified, have reporting independence, and have access to the areas of inquiry. The Senior Vice President, ISR Operations or designee will track, report on the status, and verify closure of independent assessments and external assessment findings.

The Senior Vice President, ISR Operations is responsible for responding to assessment findings and ensuring that agreed-upon corrective actions are completed in a timely manner.

7.7.3 Reviews

Reviews are an integral component to the success of project activities. Reviews are conducted during planning and throughout the project to ensure that project objectives will be met. Reviews conducted at the project level may consist of:

- Management reviews—to ensure the adequacy of planning and availability of resources;
- Administrative and technical reviews—typically include reviews of project documents to ensure that project objectives are clearly described and sufficiently planned, scheduled, and managed in accordance with project management strategies;
- Procurement Reviews—typically Uranium One policies and procedures that apply to purchasing goods and services. Subcontracted analytical laboratories are required to have a documented QA program. Laboratory capability may be evaluated through review of the QA program description or through pre-award survey or vendor audit activities. The results of the survey are documented and provided to the laboratory;

- Independent Peer Reviews—May be conducted to solicit input for the planned technical approach and data quality objectives of the project or task; and
- Data Review—to ensure that the data collected and used for each activity of the project are of sufficient quality. The RSO will conduct data reviews as a quality measure to ensure the adequacy and completeness of field activities. In addition, data review, verification, and validation will be conducted after a sampling event. Analytical data will be reviewed and summarized in the laboratory report. The results will include an explanation of any laboratory problems and their possible effects on data quality.

7.7.4 Reports to Management

Management assessments, internal assessments, and external appraisal report findings are documented. The QA organization maintains the schedule and file for these reports that are typically issued to the responsible manager.

Quality improvement actions (e.g., planning, lessons learned, nonconformance reporting, tracking and follow-up, and reviews) will be documented and reported to management.

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7 BENEFIT-COST ANALYSIS

7.1 BENEFIT-COST ANALYSIS GENERAL BACKGROUND

Demand for uranium to fuel nuclear power facilities is set to grow rapidly as the nuclear industry expands. The world's appetite for energy is expanding at a fast pace, driven largely by modernization of the developing nations. At the same time as total energy demand is growing, there is a growing impetus to reduce the burning of carbon-based fuels. Currently, nuclear energy provides 6 percent of the world's total energy supply, including 15 percent of the world's electricity. Some countries rely heavily on the nuclear industry. In the United States nearly 20 percent of the electricity is produced from nuclear power compared to France where it is 78 percent (U.S. Energy Information Administration 2010a).

The general need for production of uranium is assumed in the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the energy produced are weighed against environmental costs, including a prorated share of the environmental costs of the uranium fuel cycle. This section summarizes costs and benefits of the proposed development of the proposed project. The Benefit-Cost Analysis (BCA) discussed in this section has established that the proposed development of a new uranium ISR facility at the proposed project is potentially a cost-effective effort to undertake and will provide a net economic benefit to the State of Wyoming.

The analysis described in this section has been tailored to meet the requirements established by the NRC NUREG-1569 (Section 9). It includes a description of economic costs and benefits resulting from construction, operation, restoration, reclamation, and decommissioning of the proposed facility and a discussion of 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. Results derived from IMPLAN software have been approved in applications for Uranium One's Moore Ranch facility (Uranium One USA, Inc. SUA-1596). IMPLAN was originally developed by the United States Department of Agriculture (USDA) 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).

7.2 ALTERNATIVES AND ASSUMPTIONS

BCA is a widely used analytical tool to help 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.

7.2.1 Development Alternatives

This BCA evaluates the benefits and costs of building the proposed project and all the costs and benefits resulting from its ongoing operation in Converse County, Wyoming. The BCA tradeoff under consideration involves comparing a future assuming the proposed project to a future that assumes the No Action Alternative.

7.2.1.1 No Action Alternative

Under the No Action Alternative, there would be no change in 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.

7.2.1.2 Proposed Action

The Proposed Action involves the construction and operation of a uranium ISR facility. The ISR technology involves leaving the ore where it is below the ground surface and pumping native ground water fortified with oxygen and carbon dioxide to recover the minerals from the ore. Consequently, the Proposed Action involves limited surface disturbance, no open mine pits, and no tailings or waste rock would be generated.

7.2.2 Key Assumptions and Limitations

Key assumptions about the costs and benefits associated with the proposed project involve: (1) The Operating Life of the project; (2) the Discount Rate used; (3) the potential Scope of the Monetary Impacts; and (4) Potential Non-monetary Impacts. Each of these is described in more detail below.

7.2.2.1 Operating Life of Project

For purposes of cost-benefit analysis, the proposed project includes wellfields, Satellite facilites, and outlying related structures. The total effective life of the project, based on initial calculations, is 13 years. This includes construction of Satellite facilities and wellfield infrastructure, operations, wellfield restoration, and Satellite plant decommissioning. The first year includes only construction costs, since operations will be limited to preparation work only during that first year. Decommissioning the last Satellite plant in the 13th year is the final phase. No operations staff or other operations costs were included in the analysis for that year. Those operations costs are, however, assumed to be minor compared to other years of construction and operation.

A total of seven wellfields and three Satellite facilities are projected over the life of the project. Figure 7-1 shows the projected schedule of construction, operations, and decommissioning for wellfields and Satellite facilities. Wellfield decommissioning is included in the Satellite plant decommissioning phase. As Figure 7-1 shows, in a single year there may be multiple construction, operation, and decommissioning activities.

It is possible that the proposed project life-span could be shorter than or exceed the projected 13 year period. This will depend on the amount of ore, recoverability of the ore, and market demand, among other factors.

7.2.2.2 Discount Rate

Computing the net present value (NPV) of the proposed project requires that future benefits and costs be discounted. This discounting reflects assumption that the time value of money reflected in benefits and costs is worth more if 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 seven percent (OMB 2011). Circular A-94 was revised in 2011 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.

7.2.2.3 Scope of Impact

A critical step in any BCA is establishing a viable scope of potential impacts and thus establishing who or what will be affected by the proposed project (Zerbe and Bellas 2006). As a practical matter the proposed project will be limited to the potential impacts it may have on Converse and Natrona County.

7.2.2.4 Potential 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 proposed 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 proposed 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.

7.3 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 proposed project. For this analysis, economic impacts are measured by number of jobs and state and local tax revenues generated from the project.

The economic analyses were derived using IMPLAN (IMpact Analysis for PLANning) software and databases. IMPLAN was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the USDI Bureau of Land Management to assist the Forest Service in land and resource management planning. The IMPLAN system has been in use since 1979. In 1993, Minnesota IMPLAN Group, Inc was formed to privatize the data and software.

IMPLAN allows the user to build an input-output model tailored to predict the potential impact of a proposed project on a specific community or region. The IMPLAN system is flexible and contains a database of over 500 economic sectors linked to the North American Industrial Classification System (NAICS). The NAICS is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. Using inputs such as labor, costs, or value of product for a particular IMPLAN sector, a user can project outputs of direct, indirect, and induced employment, generated tax revenues, and value.

The outputs are general estimates, based on a variety of parameters and multipliers built into the IMPLAN software and data. Actual economic effects may vary for a variety of reasons. The following analysis is intended to provide only a general estimate for purposes of comparing the No Action Alternative with the Proposed Action Alternative.

7.3.1 IMPLAN Input Data

Wyoming was selected as the study area for IMPLAN impact analysis for a number of reasons. Although the project is located in Converse County, using only the county as the economic study area would result in an understatement of the overall economic impact of the project. This is because Converse County, with an estimated population of slightly less than 13,000 is too small for economic impact analysis purposes. The proposed project operator will necessarily look outside of the county for some of the goods and services needed to construct and operate the facility. Using the state of Wyoming (with an estimated population of 523,000 and with several larger retail/business communities such as Casper, Gillette, and Cheyenne) provides a greater likelihood that more of the goods and services needed for the project will come from the economic study area.

For economic analysis purposes, the proposed project is considered as two distinct components: 1) operations, and 2) construction and decommissioning. Operations include operation of the Satellite facilities and wellfields and wellfield restoration. It was assumed that decommissioning would involve similar parameters to construction.

IMPLAN calculations were based on costs and numbers of employees directly employed by the proposed project. The schedule, cost estimates, and direct employment and payroll information prepared by Uranium One were used as the economic analysis inputs. (Refer to Figures 7-1 through 7-4.)

Economic effects of operations were calculated using IMPLAN sector 24 (gold, silver or other metal ore mining). There is no separate IMPLAN sector for uranium facilities. The NAICS code for uranium-related industries (2212291) is included in IMPLAN Sector 24. The IMPLAN data for Wyoming for Sector 24 was modified for the proposed project analysis to better correspond to the project parameters as follows. The Wyoming state data included proprietary income as part of "Per Worker Earnings" for Sector 24. Since proprietor income inflated per worker earnings in Sector 24 compared to payroll cost projections prepared by Uranium One, it was zeroed from the equation. This adjustment then brought the per worker earnings into better alignment with the proposed project payroll cost estimates. Once this adjustment was made, the number of direct employees (for operations only) was used as the input to the IMPLAN model to predict the economic outputs of operating wellfields and Satellite facilities and restoring wellfields.

Economic effects of construction and decommissioning were calculated using two IMPLAN sectors: Sector 36 (construct other non-residential structures) and Sector 205 (construction machinery manufacturing). These sectors were arrived at by examining

U.S. Bureau of Economic Analysis Capital Flow data. The Capital Flow data indicate that approximately 44 percent of metal mining commodity expenditures are spent on construction activities, 30 percent on equipment and machinery, and 15 percent on transportation equipment (e.g., vehicles). The remaining 11 percent is spread among a number of categories in small amounts. IMPLAN's Regional Purchase Coefficient (RPC) for sector 36 in Wyoming is 100 percent. RPC represents the proportion of goods and services purchased from local producers. IMPLAN's RPC for sector 205 (construction machinery manufacturing) was 2.6 percent, meaning that although a high percentage of machinery and equipment may be purchased in Wyoming, only 2.6 percent of the total amount would be spent on construction machinery and equipment produced in Wyoming and the other 97.3 percent of expenditures would go to equipment and machinery manufacturing firms outside of Wyoming. There was no comparable category for transportation equipment in the IMPLAN sectors for Wyoming—vehicle manufacturing occurs in other states.

To arrive at estimated impacts, 44 percent of the total costs of construction (payroll and non-payroll costs) was applied to sector 36 (construction) and 30 percent of the total was applied to sector 205 (construction machinery) using the RPC of 2.6 percent. Much of the balance of 26 percent is assumed to be "leakage" from the state of Wyoming—costs going to goods produced elsewhere, such as vehicles. Still, the overall economic impacts of construction for this project are likely to be a conservative estimate, since some of the other goods and services that will be needed may be produced in Wyoming.

7.3.2 Employment Benefits

Using the above inputs and assumption, Table 7-1 summarizes the potential employment-related effects that could be generated by the proposed project. Table 7-1 shows the potential direct, indirect, and induced effects on state-wide employment. Employment is expressed as numbers of jobs. IMPLAN, like the Regional Economic Information System (REIS) of the US Bureau of Economic Analysis (BEA), measures an industry's employment as the average annual full and part-time number of employees. These numbers are estimates only. Actual numbers may vary based on a number of factors.

The direct employment effects refer to the employment directly generated by the project. These jobs would primarily be on the project site in Converse County. Estimated direct jobs per year peak in the fifth year of the project (in Year 2017) with approximately 96 jobs. Direct jobs include payroll positions with proposed project as well as persons employed through contract on construction and decommissioning.

Indirect employment includes jobs resulting from increased demand for products or goods related to the direct effects of construction, operations, and decommissioning. Indirect employment would include jobs such as those needed to support the direct activities on site such as vehicle repair. Estimated indirect jobs peak at approximately 37 in the seventh year of the project (in 2019).

Induced employment is the result of expenditures caused by new household income generated by the direct and indirect effects. Food and beverage establishments, medical facilities, and retail businesses might likely require more employees to serve new residents or households with expanded incomes resulting from the increases in direct and indirect employment. Estimated induced jobs peak at approximately 36 in the seventh year of the project (in 2019).

Total potential direct, indirect, and induced employment figures fluctuates from year to year because each year there is a different combination of construction, operations, and decommission activities. At peak total employment in 2017, the project will provide approximately 164 total direct, indirect, and induced jobs..

Table 7-1 Employment Effects of the Proposed Project

	Direct	Indirect	Induced	Total
Year 2013 - Construction	65.4	16.2	17.3	98.9
Year 2013 - Operations	0.0	0.0	0.0	0
Subtotal	**65.4**	**16.2**	**17.3**	**98.9**
Year 2014 - Construction	37.9	9.4	10.0	57.3
Year 2014 - Operations	14.0	7.8	7.4	29.2
Subtotal	**51.9**	**17.2**	**17.4**	**86.5**
Year 2015 - Construction	65.4	16.2	17.3	98.9
Year 2015 - Operations	17.0	9.5	9.0	35.5
Subtotal	**82.4**	**25.7**	**26.3**	**134.4**
Year 2016 - Construction	37.9	9.4	10.0	57.3
Year 2016 - Operations	27.0	15.0	14.3	56.3
Subtotal	**64.9**	**24.4**	**24.3**	**113.6**
Year 2017 - Construction	65.4	16.2	17.3	98.9
Year 2017 - Operations	31.0	17.3	16.5	64.8
Subtotal	**96.4**	**33.5**	**33.8**	**163.7**
Year 2018 - Construction	37.9	9.4	10.0	57.3
Year 2018 - Operations	44.0	24.5	23.4	91.9
Subtotal	**81.9**	**33.9**	**33.4**	**149.2**
Year 2019 – Construction	40.4	10.0	10.7	61.1
Year 2019 - Operations	48.0	26.7	25.5	100.2
Subtotal	**88.4**	**36.7**	**36.2**	**161.3**
Year 2020 - Construction	0.0	0.0	0.0	0.0
Year 2020 - Operations	48.0	26.7	25.5	100.2
Subtotal	**48.0**	**26.7**	**25.5**	**100.2**
Year 2021 - Construction	0.0	0.0	0.0	0.0
Year 2021 - Operations	35.0	19.5	18.6	73.1
Subtotal	**35.0**	**19.5**	**18.6**	**73.1**
Year 2022 - Construction/Decommission	24.7	6.1	6.5	37.3
Year 2022 - Operations	34.0	18.9	18.0	70.9
Subtotal	**58.7**	**25.0**	**24.5**	**108.2**
Year 2023 - Construction/Decommission	0.0	0.0	0.0	0.0
Year 2023 - Operations	18.0	10.0	9.6	37.6
Subtotal	**18.0**	**10.0**	**9.6**	**37.6**
Year 2024 - Construction/Decommission	24.7	6.1	6.5	37.3
Year 2024 - Operations	17.0	9.5	9.0	35.5
Subtotal	**41.7**	**15.6**	**15.5**	**72.8**
Year 2025 - Construction/Decommission	0	0	0	0.0
Year 2025 - Operations	1	0.6	0.5	2.1
Subtotal	**1.0**	**0.6**	**0.5**	**2.1**
Year 2026 - Construction/Decommission	24.7	6.1	6.5	37.3
Year 2026- Operations	0	0	0	0.0
Subtotal	**24.7**	**6.1**	**6.5**	**37.3**

7.3.3 State and Local Tax Revenue Benefits

In addition to employment effects, IMPLAN models can provide general estimates of expected tax revenues. In order to remain consistent with the scope of impact, federal taxes are not included in this analysis. Tax revenue projections are estimates only. Actual numbers may vary based on a number of factors.

Potential state and local tax revenues associated with the proposed project are presented in Table 7-2. While IMPLAN models produce information on expected tax revenues from employee compensation (e.g., social insurance tax) and induced household expenditures (e.g., personal income tax, personal property tax and personal motor vehicle license tax), these tax revenues are not reported here because they represent a transfer of wealth rather than a net economic gain. Conversely, corporate dividend taxes and taxes included in the indirect business tax category are paid by businesses. Indirect business taxes consist of excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses, but do not include taxes on profit or income. The indirect business taxes in Table 7-2 include all the direct, indirect, and induced effects.

Because all monetary inputs into the IMPLAN model were in constant 2009 dollars (regardless of the year in the overall project schedule) adjusted by the IMPLAN software program to constant 2007 dollars, no discount rate was applied to the results, which are also expressed in 2007 dollars.

Table 7-2 State and Local Tax Revenue (IMPLAN Projections expressed in 2007 dollar equivalents

	Enterprise Tax		Indirect Business Tax		
Year	Construction-Decommissioning	Operations	Construction-Decommissioning	Operations	TOTAL
2013	16,384	0	234,978	0	251,362
2014	9,486	102,706	136,023	638,543	886,758
2015	16,384	124,715	234,948	775,373	1,151,420
2016	9,486	198,076	136,023	1,231,475	1,575,060
2017	16,384	227,421	234,948	1,413,916	1,892,669
2018	9,486	322,791	136,023	2,006,848	2,475,148
2019	10,126	352,135	145,209	2,189,289	2,696,759
2020	0	352,135	0	2,189,289	2,541,424
2021	0	352,135	0	2,189,289	2,541,424
2022	6,193	249,429	88,814	1,550,746	1,895,182
2023	0	132,051	0	820,983	953,034
2024	6,193	124,715	88,814	775,373	995,095
2025	0	7,336	0	45,610	52,946
2026	6,193	0	88,814	0	95,007
Totals	106,315	2,545,645	1,524,594	15,826,734	20,003,288

During the estimated 13 years of the proposed project, annual state and local tax revenues are estimated to range from $53,000 to $2.7 million. Over the estimated 13-year project, total taxes are estimated at $20 million.

7.4 EXTERNAL COSTS OF PROJECT CONSTRUCTION AND OPERATION

In this section of the analysis, external costs of the proposed 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 project are also identified and described.

7.4.1 Short Term External Costs

7.4.1.1 Housing Shortages

At its peak levels of employment, the proposed project is estimated to produce approximately 164 total jobs in Wyoming. This includes jobs created directly or indirectly by the project or induced by related household expenditures. Many of the jobs will be ongoing over the life of the project (such as the number of persons directly employed by the operator or its contractors for ongoing operations and wellfield and Satellite construction). Others will be tied to specific phases, such as construction or decommissioning, and will be shorter-term rather than on-going. As a result, the total number of jobs is estimated to fluctuate from year to year.

Compared to the rest of the nation, unemployment rates are low in Converse and Natrona Counties, the area most likely to be affected by the increased number of jobs and associated housing demand. These counties are however beginning to feel the effects of the national recession. In June 2009, the unemployment rate in Converse County was 5.2 percent (compared to 2.8 percent in June 2008) and 6.1 percent in Natrona County (compared to 3.0 percent in June 2008). In June 2009, the national unemployment rate was 9.5 percent. The average unemployment rate between July 2008 and June 2009 was 7.6 percent in the nation, but it remained below 4 percent in Converse and Natrona Counties. It is anticipated that Converse and Natrona Counties will continue to have lower unemployment rates than the state and the nation. In part, due to the relatively lower unemployment in the local area and the small population base, it is assumed that the supply of available workers is limited locally and that many (and possibly most) of the employees needed to fill the projected new local jobs will come from outside Converse and Natrona Counties.

At the peak of direct employment numbers (in 2017), the proposed project would account for approximately 96 new jobs. Assuming each new job resulted in a separate demand for housing, 96 housing units would be needed. Homeowner vacancy rates were 2.3 percent in Converse County and 1.5 percent in Natrona County; according to the 2000 Census (the most recent for which such census data are available at the county level). In a multiple listing service (MLS) internet web search on March 26, 2009, there were 420 listings for houses priced at $300,000 or less in Glenrock (27), Douglas (36), and Casper (357). In July 2007, Converse County had an estimated two vacant units out of 424 total rental units (.47 percent rental vacancy rate) and Natrona County had 44 vacant rental units (1.07 percent rental vacancy rate). The lack of available rental units in Converse County was reported in the Douglas Budget on November 26, 2008. Many people who desire rental units have been staying in hotels/motels for weeks and months at a time.

Based on these data, there would be adequate supply of houses available for sale for needs associated with direct employment from the proposed project and a very limited supply of rental units. It is assumed that the supply of houses for sale that are in good "move-in" condition and in desirable areas may be less than the total number of houses for sale, but with more than 400 available (as of March 2009), there would be sufficient numbers for the estimated 96 new homes needed for direct employment numbers. Some of the employees will likely be hired from the existing local labor pool and therefore 96 homes may overestimate housing demand from direct employment. Based on current trends, it is anticipated that at least some workers will continue to have a residence outside of Converse and Natrona Counties and will be commuting long distance for shift work. While on site, many of these workers would likely be staying in rentals or hotels/motels, based on historical trends. Unless additional rental units are created, this will exacerbate the existing tight rental market.

The total of all new direct, indirect, and induced jobs estimated by the IMPLAN analysis are for the state of Wyoming, not just Converse and Natrona Counties. If all 164 new direct, indirect, and induced jobs (at the peak of total employment in 2017) were in Converse and Natrona Counties, there would be adequate housing stock to purchase (based on the March 2009 homes for sale), but rental housing would be inadequate and put additional strains on hotels and motels.

7.4.1.2 Impacts on Schools and Other Public Services

The estimated total of 164 new direct, indirect, and induced jobs of the peak employment year for the proposed project would result in a total population increase of 397 persons, based on average household size in Wyoming of 2.42 in 2006 (per U.S. census estimates) and assuming that all of the jobs are filled with persons not already living in Wyoming.

Although the IMPLAN analysis study area was for the entire state of Wyoming, for purposes of analyzing the impacts to schools and other public services, all 164 jobs were projected to result in population increases to Converse and Natrona Counties. This overestimates the likely potential for impacts to these two counties because some of the indirect and induced jobs will be located outside of these two counties and some of the jobs in Converse and Natrona Counties will be filled with local residents. The addition of 397 persons would be an increase of less than half of one percent to the total combined 2007 estimated population of 84,618 for Converse and Natrona Counties.

Children between the ages of five and 19 constituted approximately 20 percent of total estimated population in Converse and Natrona Counties in 2007. Using 20 percent as the ratio for school age children, there would be approximately 79 school age children anticipated from the projected increase in total direct, indirect, and induced employment.

Converse School District No.1 in Douglas was adding new facilities in 2008 and 2009 and was anticipating it could handle 350 additional students in grades K-5 and 250 additional students in Middle and High School. Converse School District No. 2 in Glenrock was under capacity in 2008 and would be able to increase enrollment by another 200 students without additional expansion (other than what has already been planned or recently completed). The Natrona County School District (primarily in the Casper area) has approximately 11,500 students.

A total increase of less than half of one percent to the total population of Converse and Natrona County is not likely to create a significant impact on other public services such as fire, police, water, and utilities.

7.4.1.3 Impacts on Noise and Congestion

The existing ambient noise in the vicinity of the proposed project area is dominated by the traffic noise from State Highways 95 and 93.There are a total of 67 residential sites within the 2.0- mile buffer area. There a small cluster of occupied housing units and one operating ranch in the vicinity of the proposed project. The nearest resident is approximately 0.5 miles to the north. The Leuenberger Ranch lies within the proposed project area. The proposed Leuenberger Satellite facility is approximately 2,000 feet from the property boundary of a small rural residential subdivision. Assuming that the noise level produced by unshielded machinery at the plant site is 85dB at 50 feet, the sound pressure level attained at the property boundary will be well below the level identified by the USEPA as suitable for outdoor areas where human activity takes place (approximately 55 dB). After appropriate engineered controls (i.e. the protective enclosure for the equipment) are installed, noise levels will not impact the residences, and are unlikely to approach the levels attained by State Highway 95.

As a result of the remote location of the proposed project area and the low population density of the surrounding area, impact to noise or congestion above ambient background noise 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 Glenrock, Douglas, Casper, or other neighboring counties.

There will be an increase in traffic from workers to/from the site and also equipment and machinery, and truck traffic in transporting resin to and from the offsite Central Processing Plant. Traffic congestion is not anticipated to be a significant issue, because existing traffic is low (Average Daily Traffic on Highway 95 near Rolling Hills was 1810 in 2006, and Average Daily Traffic on Highway 93 near Orpha was 340 in 2006) and site activities will not increase that traffic volume significantly.

There may also be an insignificant increase in noise levels from associated traffic.

7.4.2 Long Term External Costs

7.4.2.1 Impairment of Recreational and Aesthetic Values

While opportunities for developed and dispersed recreation exist in the 50-mile area surrounding the proposed project, the closest public recreation site is the Bixby Access site (Wyoming Fish and Game) on the North Platte River. The next closest is the Fort Fetterman Historical site, approximately four miles from the proposed project.

7.4.2.2 Land Disturbance

The proposed project area has been used for grazing and some oil and gas development. As the proposed project would use ISR methods, there would be limited land surface disturbance compared to conventional surface mining techniques. 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 wellfields. No tailings or waste rock would be generated. Satellite facilities and private access roads would be confined to delineated areas.

7.4.2.3 Habitat Disturbance

Currently, there is no federally or state designated wildlife habitat identified within the proposed project area. As the proposed project area has been historically used extensively for livestock grazing, 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 project.

7.4.3 Groundwater Impacts

It is unlikely that any future irrigation development would occur within the proposed Project area due to limited water supplies, topography, soils, and climate. Irrigation within the two-mile review area is anticipated to be consistent with the past. Based on population projections, future water use within the two-mile review area would likely be a continuation of present use. Since ISR production is a theoretically closed hydraulic system, except for the one percent bleed, and considering that local water sources are derived from aquifers located above the Production Zone (see Section 7.2.5.2) the surrounding groundwater should not be affected. Therefore, it is anticipated that there would be no significant changes from the existing conditions for public water supply in the project area and within the two mile buffer zone surrounding the proposed project area.

Minimal effects to the existing aquifer as a result of drawdown are anticipated. Following standard mining practice, any contaminated water drawn from the aquifer on site would either be treated before re-injection or disposed through deep well injection. Upon decommissioning, the affected groundwater would be restored and all wells would be plugged and abandoned. The primary goal of the groundwater restoration program would be to return groundwater affected by mining operations to baseline values on a mine unit average. The secondary goal 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 mine unit 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 limited domestic groundwater use, and the groundwater restoration program associated with the proposed 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.

7.4.4 Radiological Impacts

As the proposed project would be using ISR techniques, most of the identified radioactivity in the ore body would remain permanently underground. Following standard ISR procedures, routine operational monitoring of air, surface water and groundwater, and soil would be undertaken by Uranium One as discussed in Section 5. Prior to process 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 start only after NRC approval of a Decommissioning Plan in accordance with the most current applicable NRC 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 facility including; tanks, filters, pumps, piping, etc., would be designated for one of the following removal alternatives:

- Removal to a new location within the proposed project area for further use or storage;
- Removal to another NRC licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release.

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 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.

Under the proposed operating and decommissioning conditions, the potential long-term radiological impacts at the project are anticipated to be negligible compared to the existing background no action conditions.

7.5 BENEFIT-COST SUMMARY

A primary economic benefit of the project is the creation of 164 new permanent and part time jobs at peak employment within the county and surrounding areas, including the direct, indirect and induced employment effects over the construction and operating life of the project (Table 7-3). Additionally, the project may generate up to $20 million in total state and local business tax revenues over the life of the project, which is a significant economic gain compared to the no action alternative.

Table 7-3 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 project.

The proposed project is likely to place negligible short-term or long-term cost burdens on the Converse and Natrona Counties, while providing increased revenue and employment opportunities; therefore, the development and operation of the proposed project would provide a net economic benefit to Converse and Natrona Counties when compared to the no action alternative.

Table 7-3 Summary of Benefits and Costs for the Proposed Project

Benefits	Costs
• **Tax revenue** 1 $20. million • **Temporary and permanent jobs** 2 164 jobs at peak employment 3	• **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

Figure 7-1: Proposed Project Schedule for Construction, Operations, and Decommissioning.

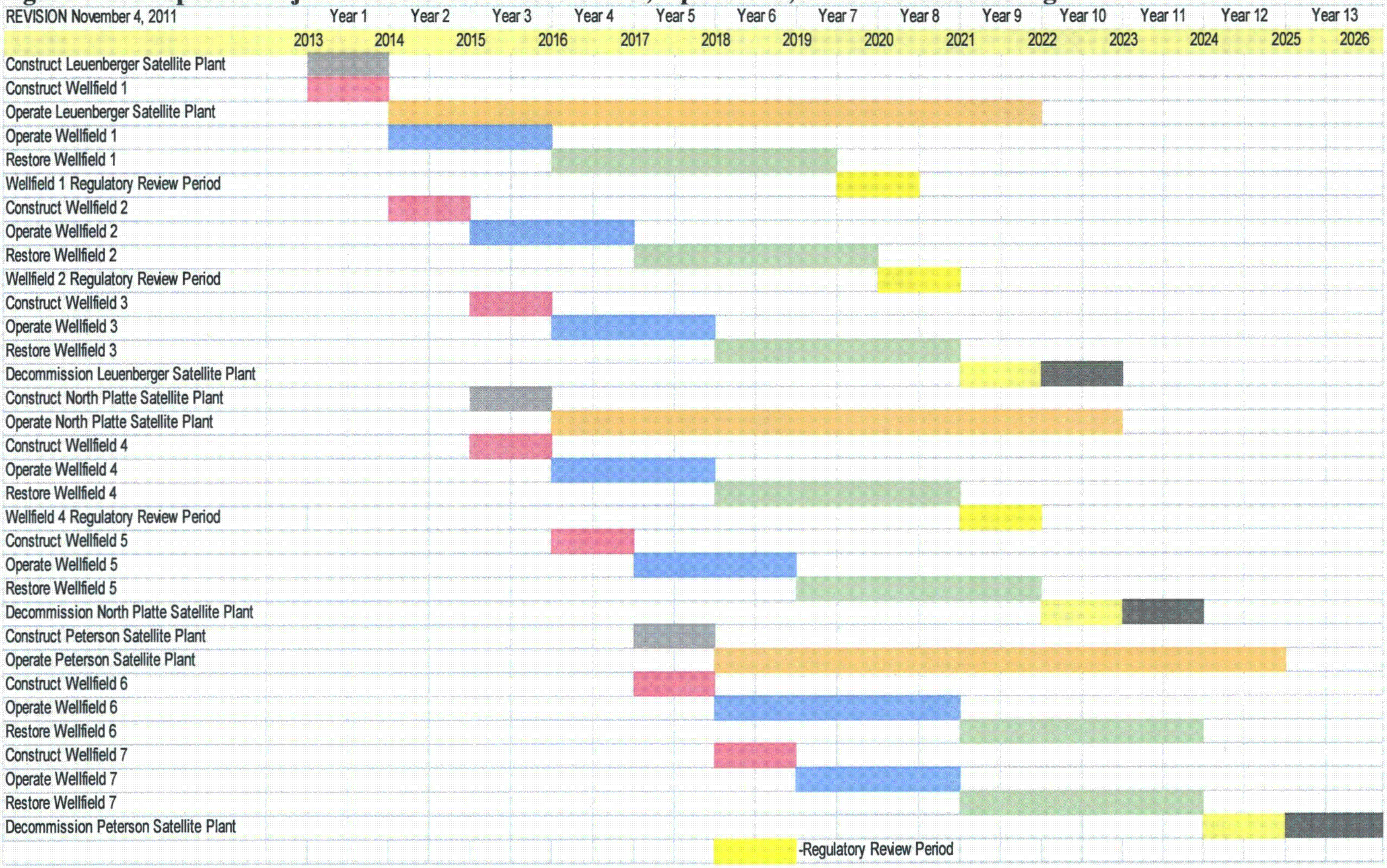

Figure 7-2: Estimated Non-Payroll Costs of Construction, Operations, and Decommissioning by Year (in constant 2009 $)

REVISION November 4, 2011	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Construct Leuenberger Satellite Plant	6,983,871													
Construct Wellfield 1	10,498,233													
Operate Leuenberger Satellite Plant		1,240,039	1,240,039	1,240,039	1,240,039	1,240,039	1,240,039	1,240,039	1,240,039					
Operate Wellfield 1		417,232	417,232											
Restore Wellfield 1														
Wellfield 1 Regulatory Review Period														
Construct Wellfield 2		9,783,336												
Operate Wellfield 2			417,232	417,232										
Restore Wellfield 2														
Wellfield 2 Regulatory Review Period														
Construct Wellfield 3			10,498,233											
Operate Wellfield 3				417,232	417,232									
Restore Wellfield 3														
Decommission Leuenberger Satellite Plant										6,308,491				
Construct North Platte Satellite Plant			6,983,871											
Operate North Platte Satellite Plant				1,240,039	1,240,039	1,240,039	1,240,039	1,240,039	1,240,039	1,240,039				
Construct Wellfield 4			9,783,336											
Operate Wellfield 4				417,232	417,232									
Restore Wellfield 4														
Wellfield 4 Regulatory Review Period														
Construct Wellfield 5				10,498,233										
Operate Wellfield 5					417,232	417,232								
Restore Wellfield 5														
Decommission North Platte Satellite Plant											6,308,491			
Construct Peterson Satellite Plant					6,983,871									
Operate Peterson Satellite Plant						1,240,039	1,240,039	1,240,039	1,240,039	1,240,039	1,240,039	1,240,039		
Construct Wellfield 6					9,783,336									
Operate Wellfield 6						417,232	417,232	417,232						
Restore Wellfield 6														
Construct Wellfield 7						10,498,233								
Operate Wellfield 7							417,232	417,232						
Restore Wellfield 7														
Decommission Peterson Satellite Plant													6,308,491	
Subtotal - Construction-Non Payroll	17,482,104	9,783,336	27,265,440	11,749,929	16,767,207	10,498,233	0	0	0	6,308,491	6,308,491	0	6,308,491	
Subtotal - Operations-Non Payroll		1,657,271	2,074,503	3,731,774	3,731,774	4,554,581	4,554,581	4,554,581	3,720,117	2,480,078	1,240,039	1,240,039	0	
Total - Non Payroll	17,482,104	11,440,607	29,339,943	15,481,703	20,498,981	15,052,814	4,554,581	4,554,581	3,720,117	8,788,569	7,548,530	1,240,039	6,308,491	

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Figure 7-3: Estimated Payroll Costs of Construction and Decommissioning by Year (Direct Payroll of Proposed Project in Constant 2009 $)

REVISION November 4, 2011	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025 2026
Construct Leuenberger Satellite Plant													
Construct Wellfield 1	802,575												
Operate Leuenberger Satellite Plant													
Operate Wellfield 1													
Restore Wellfield 1													
Wellfield 1 Regulatory Review Period													
Construct Wellfield 2		802,575											
Operate Wellfield 2													
Restore Wellfield 2													
Wellfield 2 Regulatory Review Period													
Construct Wellfield 3			802,575										
Operate Wellfield 3													
Restore Wellfield 3													
Decommission Leuenberger Satellite Plant										603,450			
Construct North Platte Satellite Plant													
Operate North Platte Satellite Plant													
Construct Wellfield 4			802,575										
Operate Wellfield 4													
Restore Wellfield 4													
Wellfield 4 Regulatory Review Period													
Construct Wellfield 5				802,575									
Operate Wellfield 5													
Restore Wellfield 5													
Decommission North Platte Satellite Plant											603,450		
Construct Peterson Satellite Plant													
Operate Peterson Satellite Plant													
Construct Wellfield 6					802,575								
Operate Wellfield 6													
Restore Wellfield 6													
Construct Wellfield 7						802,575							
Operate Wellfield 7													
Restore Wellfield 7													
Decommission Peterson Satellite Plant													603,450
Subtotal - Construction-Non Payroll	802,575	802,575	1,605,150	802,575	802,575	802,575	0	0	0	603,450	603,450	0	603,450
Subtotal - Operations-Non Payroll		0	0	0	0	0	0	0	0	0	0	0	0
Total - Non Payroll	802,575	802,575	1,605,150	802,575	802,575	802,575	0	0	0	603,450	603,450	0	603,450

Figure 7-4 Estimated Number of Payroll Positions for Construction, Operations, and Decommission (Direct payroll of the Proposed Project)

REVISION November 4, 2011	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025 2026
Construct Leuenberger Satellite Plant	0												
Construct Wellfield 1	7												
Operate Leuenberger Satellite Plant		10	10	10	10	10	10	10	1				
Operate Wellfield 1		3.5	3.5										
Restore Wellfield 1				0	0	0							
Wellfield 1 Regulatory Review Period													
Construct Wellfield 2		7											
Operate Wellfield 2			3.5	3.5									
Restore Wellfield 2					3.5	3.5	3.5						
Wellfield 2 Regulatory Review Period													
Construct Wellfield 3			7										
Operate Wellfield 3				3.5	3.5								
Restore Wellfield 3						3.5	3.5	3.5					
Decommission Leuenberger Satellite Plant										10			
Construct North Platte Satellite Plant			0										
Operate North Platte Satellite Plant				10	10	10	10	10	10	1			
Construct Wellfield 4			7										
Operate Wellfield 4				3.5	3.5								
Restore Wellfield 4						3.5	3.5	3.5					
Wellfield 4 Regulatory Review Period													
Construct Wellfield 5				7									
Operate Wellfield 5					3.5	3.5							
Restore Wellfield 5							3.5	3.5	3.5				
Decommission North Platte Satellite Plant											10		
Construct Peterson Satellite Plant					0								
Operate Peterson Satellite Plant						10	10	10	10	10	10	1	
Construct Wellfield 6					7								
Operate Wellfield 6						3.5	3.5	3.5					
Restore Wellfield 6									3.5	3.5	3.5		
Construct Wellfield 7						7							
Operate Wellfield 7							3.5	3.5					
Restore Wellfield 7									3.5	3.5	3.5		
Decommission Peterson Satellite Plant													10
Subtotal - Construction-Non Payroll	7.0	7.0	14.0	17.5	7.0	7.0	0.0	0.0	0.0	10.0	10.0	0.0	10.0
Subtotal - Operations-Non Payroll	0.0	13.5	17.0	30.5	34.0	47.5	51.0	47.5	31.5	7.0	17.0	1.0	0.0
Total - Non Payroll	7.0	20.5	31.0	48.0	41.0	54.5	51.0	47.5	31.5	17.0	27.0	1.0	10.0

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8 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

This Environmental Report began with Section 1 outlining the purpose and need for the proposed Ludeman Project (proposed project). The alternatives considered by Uranium One are described in Section 2 including the alternative considered in the formulation of the Proposed Action and Reasonable Alternatives Considered but Rejected. Uranium One has characterized the existing baseline environment of the proposed project and the surrounding area in Section 3. The potential environmental impacts (adverse and positive) of the proposed action are discussed in detail in Section 4. In this impact analysis, Uranium One identifies potential unavoidable impacts of the proposed action. Alternatives for mitigation for these impacts are discussed in Section 5. Environmental measurements and monitoring are detailed in Section 6 of this ER. An analysis of the Benefits-Costs of the proposed project is included in Section 7 of this ER.

Table 8-1 summarizes the few potential environmental impacts which likely cannot be avoided. Where available, means of mitigation are also summarized. The potential unavoidable environmental impacts of the proposed construction, operation, and decommissioning of the proposed project all are included. Each impact is quantified (where possible). Due to the benign nature of ISR uranium recovery the potential environmental impacts are minor. Because of the relatively short duration of the proposed project (approximately 13 years from construction to decommissioning) all environmental impacts are short-term. The predicted impacts will exist during the construction, operation, and decommissioning of the proposed project. No significant long-term impacts extending beyond the duration of the project have been identified. For each potential impact, mitigative measures are summarized.

Only a few resources are deemed irretrievable during project construction and operation, aquifer restoration and decommissioning. Those include chemicals used during the ISR process, power consumed during the ISR process, fuel consumed during employee transport to and from the project area, plus the fuel consumed for equipment operation. At the conclusion of the proposed project, the project area will be fully restored to its pre-construction conditions and released for unrestricted use.

Table 8-1: Unavoidable Environmental Impacts

Impact	Estimated Impact	Mitigation Measures
Production		
Production of U3O8 (lbs.)	6,300,000 pounds	None
Use of Natural Resources		
Temporary Land Surface Impacts (acres)	Minimal temporary impacts in wellfield areas: 763 Acres; Significant surface and subsurface disturbance confined to plant sites = approximately 15 acres.	Sediment and topsoil management during construction and operation; Surface reclamation following operational activities to return surface to pre-operational condition.
Temporary Land Use Impacts	Restriction of agricultural production (livestock grazing) in the impacted area (estimated 815 acres) for duration of project.	Surface reclamation following operational activities to return surface to pre-operational use.
Groundwater consumption (net gpm)	Estimated net consumptive use of 100-300 gpm for 12 year mining and restoration life.	None
Groundwater quality impacts	Temporary impacts to groundwater quality in the mining zone.	Proven groundwater restoration following mining to return groundwater quality to baseline or pre-operational water uses.
Visual and scenic impacts	Moderate impact; noticeable minor industrial component	Use of harmonizing colors; use of existing vegetation and topography; avoidance of straight line site roads to follow topography; removal of construction debris.

Table 8-1: Unavoidable Environmental Impacts

Impact	Estimated Impact	Mitigation Measures
Emissions		
Dust emissions (tons/yr.)	15.5	Dust control measures implemented where appropriate.
Radon emissions (Curies/yr.)	1,655	None
Radiological Impacts		
Additional maximum predicted dose (mrem/yr.)	1.56	None
Fractional increase to background continental dose (percent)	Very low and not measurable	None
Socioeconomic Impacts		
Direct Employment		
• Full time employment	44 to 48	None
• Contractor employment	10 to 20	None
• Part time and contractor employment during construction	50	None
Construction Capital Expenditures	$92,000,000	None
Non-payroll workers (Construction, 2008-2009)	164	None
Non-payroll workers (Full operations, 2010-2019)	147	None
Non-payroll workers (Restoration, Satellite operations, 2020-34)	53	None

Table 8-1: Unavoidable Environmental Impacts

Impact	Estimated Impact	Mitigation Measures
Total Enterprise and Business Tax revenues	$20,000,000	None
Waste Management Impacts		
Wastewater (gpm)	81 gpm during normal operations and approximately 315 gpm during restoration	Permanent disposal in Class I UIC disposal well(s)
Solid waste produced (yd^3/yr.)	2,000	Permanent disposal at license landfill
11e.(2) byproduct waste produced (yd^3/yr.)	250	Waste minimization; decontamination; permanent disposal at a licensed disposal facility.

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Figure 3.1-1 Notes and Sources:

Figure 3.1-1 (Land Use Within Two-Mile Ludeman Survey Area) was prepared using a variety of sources. The primary data source was the agricultural land use map from the Wyoming Geographic Information Science Center at the University of Wyoming. This source has five land use categories: 'ir' for irrigated cropland, 'ni' for non-irrigated cropland, 'ur' for urban or built up, 'na' for non-agricultural land, and 'gc' for golf courses. There were no 'ur' or 'gc' polygons in the area analyzed for the Two-Mile Ludeman Survey Area Land Use map. Non-agricultural land includes all lands that are not cropland, urban or build up, or golf courses. Site visits confirmed that in the survey area the use of non-cropland is predominately for rangeland forage.

Recreational sites were identified by using Wyoming Game and Fish Department maps. The North Platte River-Bixby Fishing Access site was the only site found to be inside the two-mile survey area boundary. The U.S. Department of the Interior, Bureau of Land Management, Wyoming Historic Trails was the source for location of the Bozeman Trail.

Surface water was identified by overlaying the "Hydrography for Wyoming" dataset with the agricultural land use dataset and assigning a land use category of 'sw' for surface water to Hydrography polygons with a Minor1 code of '412' for wide river and '421' for lake or pond within the two-mile survey area boundary.

Residence sites within the two-mile survey area boundary were located using ©2008 Google Earth imagery, cross-checked against surface ownership polygons, and compared to general site reconnaissance. Due to limitations with resolution, it was not possible to always distinguish differences between houses and outbuildings. Where buildings were grouped together and isolated from other residence sites, it was assumed that these building groups were farm/ranch residence(s) and outbuildings (and identified as a single residential site for mapping purposes).

Figure 3.1-1 Sources: ©2008 Google

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Scott Schierman	Senior Safety Health& Environmental Specialist
Dayton Lewis	Manager, Wyoming Project Development
Greg Kruse	District Geologist
Kristin Reed	Project Geologist
Penny Hague	Land Assistant
Rick Kukura	Supervisor, Field Operations

10.2 TREC, INC.

TREC, Inc.
900 Werner Court, Suite 150
Casper, WY 82601

Matt Yovich, P.E.	Project Manager/Principal
Linda (Wendy) Stansbury, P.E.	Project Engineer/Wetland Specialist
Jim Shriver	Project Manager
Renaldo De Luna	Senior Project Scientist
Karen LaClair	Scientist/Wetland Specialist
Kellen Waldo	Project Scientist
Pat Lau	Associate Engineer
Donna Hawley	GIS Specialist

10.3 BKS ENVIRONMENTAL ASSOCIATES, INC.

BKS Environmental Associates, Inc
P.O. Box 3467
Gillette, Wyoming 82718

Vegetation	
Brenda Schladweiler	Senior Soil Scientist/Senior Vegetation Ecologist
Cindy Robinson	Vegetation Ecologist/Wetland Technician Specialist
Jamie Eberly	Vegetation Ecologist
Rachel Jones	Vegetation Ecologist
Land Surveying, Inc.	(drafting/GIS)

Soil	
Brenda Schladweiler	Senior Soil Scientist/Senior Vegetation Ecologist
Bonnie Laws	Soil Scientist
Land Surveying, Inc.	(drafting/GIS)

10.4 ETHNOSCIENCE, INC.

Ethnoscience, Inc.
4140 King Avenue East
Billings, Montana 59101

Lynelle Peters	Senior Archaeologist

10.5 INTERMOUNTAIN LABORATORIES

Inter-Mountain Laboratories
555 Absaraka
Sheridan, Wyoming 82801

Ronn Smith	Project Engineer
Shane Hansen	Air Quality Meteorologist

10.6 ENVIRONMENTAL RESTORATION GROUP, INC.

Environmental Restoration Group, Inc.
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Albuquerque, NM 87113

Mike Schierman	Senior Health Physicist

10.7 TETRA TECH

Tetra Tech
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Randy Whicker, M.S.	Environmental Health Physicist, Tetra Tech
Jan Johnson, Ph.D., CHP	Senior Health Physicist, Tetra Tech
Robert Meyer, Ph.D.	Senior Health Physicist, Tetra Tech
Paul Cartier, M.S.	GIS Analyst, Terrasat Inc.
Bryan Boyd, M.S.	GIS Analyst, Tetra Tech
Michelle Whicker, M.B.A.	Technician, Tetra Tech

10.8 ICF JONES AND STOKES

ICF Jones & Stokes
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Gwyn McKee	Project Director
Brian Grasman	Senior Wildlife Biologist
Jennifer Ottinger	Wildlife Biologists
Kristen Chodachek	Wildlife Biologists

10.9 COSSITT CONSULTING

Cossitt Consulting
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Anne Cossitt	Principal