COLORADO OFFICE
10758 W. CENTENNIAL RD., STE. 200
LITTLETON, CO 80127
TEL: (866) 981-4588
FAX: (720)-981-5643

WYOMING OFFICE
5880 ENTERPRISE DR., STE. 200
CASPER, WY 82609
TEL: (307) 265-2373
FAX: (307) 265-2801

LOST CREEK ISR, LLC

July 28, 2015

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Re: 2014 ALARA Audit and Public Dose Calculation
Lost Creek ISR Project License SUA-1598, Docket 040-09068, TAC J00717

Dear Mr. Saxton,

Please find, enclosed with this letter, the signed 2014 Annual ALARA Audit, and the public dose calculations for 2014.

Sincerely,

Chris Pedersen
Radiation Safety Officer

Cc: NRC Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate
Theresa Horne, Ur-Energy, Littleton
Mr. John Saxton, NRC (via email)

NMSS01

Lost Creek ISR

2014 Annual ALARA Audit

1.0 Executive Summary

As required by NRC Regulatory Guide 8.31, dated May 2002 entitled "Information Relevant to Ensuring That Occupational Radiation Exposure At Uranium Facilities Will Be As Low As Is Reasonably Achievable (ALARA)", Section 2.3.3 "Radiation Protection and ALARA Program Audit" the annual ALARA audit was performed at the Lost Creek ISR Project (LC-ISR) during the period October 1 to November 10, 2014 by Bill Kearney, Radiation Protection Specialist. Because the Lost Creek ISR Project is a new operation (production activities started on August 2, 2013) this is the first ALARA Audit completed. Therefore, this audit was very detailed and relatively all encompassing in order that monitoring programs used for radiation protection, employee exposure procedures, and standard operating procedures (SOPs) related to radiation protection could be reviewed to ensure they are suitable for current operations and conditions at the facility.

The on-site audit took place on November 4 and 5, 2014. The on-site audit team included Bill Kearney, John Cash (VP Regulatory Affairs), Kurt Brown (Mine Manager), Jay Pry (Plant Foreman) and Mike Gaither (Manager EHS and Regulatory Affairs). Chuck Kelsey (RSO) and Chris Pedersen (HPT/ARSO) assisted with the audit but were not official members of the audit team. The summary of the on-site audit, and recommendations from it, are included in Section 6.

In accordance with Section 2.3.3 of NRC Regulatory Guide 8.31 the following areas of the radiation protection program were reviewed and the results are summarized in this report:

- Employee exposure records
- Bioassay results
- Inspection log entries, daily and weekly inspections , and monthly summary reports
- Documented training program activities
- Radiation safety meeting reports
- Radiological survey and sampling data
- Reports on overexposure of workers submitted to the NRC, OSHA or States
- Operating procedures that were reviewed during the past year

In accordance with NRC guidance, the report on the annual radiation protection and ALARA audit should specifically discuss the following:

- Trends in personnel exposures for identifiable categories of workers and types of operational activities.
- Whether equipment used for exposure control is being properly used, maintained, and inspected.
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters.

2.0 Lost Creek ISR Project ALARA Activities

This ALARA Audit covers the period August 1, 2013 thru September 30, 2014 although additional activities associated with the audit carried on into early November 2014. This period was selected because uranium production and Plant operations started on August 2, 2013. Bill Kearney, Radiation Protection Specialist, conducted the full audit. The on-site ALARA Audit Team was comprised of John Cash- VP Regulatory Affairs EHS, Kurt Brown (Mine Manager), Jay Pry (Plant Foreman). Chuck Kelsey (RSO) and Chris Petersen (HPT/RSO) assisted with the audit but were not official members of the audit team.

At the time of the On-Site Audit (November 4 and 5) the workforce at the LC-ISR totaled 56 personnel with 15 workers assigned to the Plant, 20 workers assigned to the wellfield (operations and construction) and 21 office workers (geologists, management, environmental, safety and radiation protection staff). Because this was the first Annual ALARA Audit to be completed by LC-ISR, prior to the actual site audit by the Audit Team, Bill Kearney expended considerable time reviewing NRC license documents, site radiological monitoring data and Standard Operating Procedures. In summary, the following relevant documents were reviewed:

- NRC License No. SUA-1598
- NRC License Application Technical Report (emphasis on Section 5- "Operational Organization, Management, Programs and Training")
- Applicable NRC Regulatory Guides including, but not limited to nos. 4.14, 8.15,8.22, 8.25, 8.29 8.30, 8.31
- 10 CFR Part 20
- NUREG-1400 "Air Sampling in the Workplace"
- NUREG-1569 "Standard Review Plan for ISL Uranium Extraction License Applications"
- Monthly Radiation Safety Summary Reports
- Miscellaneous site records and reports generated by the Radiation Safety staff
- Standard Operating Procedures (SOPs)

In addition to the review of the above documents, the site RSO and RST were consulted and they provided details concerning their working knowledge of the Radiation Protection Program and

the various files and databases containing the data and records supporting the program. Additionally, several Plant Operators and Dryer Operators were also interviewed, in part, to assess their knowledge of the operations and familiarity with the Radiation Protection Program.

3.0 Review of Radiation Program Data

3.1 Employee Exposure Records

A detailed review of the employee exposure records was completed. The review of the records concentrated on the period January 1thru September 2014. In accordance with NRC requirements, employee exposure records are summarized by tracking the Total Effective Dose Equivalent (TEDE) for select employees. Accordingly, the TEDE records for employees at the LC-ISR are comprised of the internal Committed Effective Dose Equivalent (CEDE) from exposure to particulate uranium and radon daughters (radon) and the Effective Dose Equivalent (EDE) to external gamma radiation.

The Deep Dose Equivalent (DDE) is determined for gamma radiation exposure from Optically Stimulated Luminescence (OSL) personnel dosimeter badges that are exchanged every three months. The badges are supplied by Landauer Corporation.

The CEDE for uranium and radon is determined from air sampling data obtained from area sampling and breathing zone (BZ) monitoring. The BZ monitoring is used to estimate exposures to uranium and radon from Radiation Work Permit (RWP) activities. BZ monitoring is also routinely used to estimate exposures to uranium for personnel that work in the Dryer Room (Dryer Operators and maintenance workers). Actual occupancy times and credit for respiratory protection are used to estimate these doses. Additionally, on an infrequent basis, the internal dose to uranium is estimated from the uranium bioassay results.

Records for the Q1 and Q2 2014 were reviewed as the Q3 records were not complete at the time of the audit due to the processing of the Q3 2014 OSL badges by the supplier. A review of the records for Q1 and Q2 show that the TEDE was estimated for approximately 60 personnel. Most of these personnel work at the LC-ISR project on a regular full time basis but some of these personnel work out of the Casper Office and are only at the project site on an intermittent basis.

A review for the TEDE records show that personnel that do not routinely work at the Plant Restricted Area (office and EHS staff, wellfield and construction

personnel, geology and Casper office staff) received an estimated TEDE between 0.5 mrem and approximately 30 mrem for Q1 and Q2. These estimated doses are less than 1% of the Allowable Limit of Intake (ALI). If these estimated exposures are doubled to account for a full year period, they are still approximately 1% or less of the ALI. Consideration should be given to discontinue exposure monitoring and determining the TEDE for those work groups that have no significant potential radiation exposure.

The work groups that are expected to, and do, show some level of estimated exposure (TEDE) to radiation at the LC-ISR Project (i.e. yellowcake/uranium workers) include maintenance workers that work in the Plant, Plant Operators and Dryer Operators. On an infrequent basis Plant Operators may assist with drying operations and some of the Plant Operators were Dryer Operators for part of the period, prior to being reassigned as Plant Operators. A summary of the Q1 and Q2 2014 TEDE for these work groups follow:

Maintenance Workers TEDE:

Range- 39 to 69 mrem

Mean- 52 mrem (1.0% ALI)

Plant Operators TEDE:

Range- 28 to148 mrem

Mean- 80 mrem (1.6% ALI)

Dryer Operators TEDE:

Range- 179 to 220 mrem

Mean- 200 mrem (4.0% ALI)

The review of the TEDE records and the data presented above for these work groups show very low exposures to radiation. If these estimated exposures are doubled to account for a full year period, they are still approximately 2% or less of the ALI for the maintenance workers and Plant Operators. If these estimated exposures for Dryer Operators are doubled to account for a full year period, they are still approximately only 8% or less of the ALI. It should be noted that the TEDE exposures for the Dryer Operators are conservatively estimated since they are receiving doses from both the area uranium air monitoring data and the BZ monitoring data while working in the Dryer Room. Additionally, when detectable uranium bioassay results have occurred, the resulting internal doses are

conservatively estimated and added to the doses determined from the air monitoring data. More discussion concerning bioassays is included in the following section.

The estimated TEDE of the maintenance workers that work in the Plant, Plant Operators and Dryer Operators (yellowcake/uranium workers) is low and is expected to be maintained at less than 10% of the ALI on an annual basis. Therefore, the following recommendations are included concerning dose monitoring and the TEDE determinations to ensure that the radiation protection program focuses on the proper personnel at the LC-ISR Project:

- The radiation protection program should be modified such that routine doses and the TEDE only be determined for maintenance workers that work in the Plant, Plant Operators and Dryer Operators (yellowcake/uranium workers). This would be consistent with radiation protection programs at other ISR operations that have been in operation for many years.
- SOP-016 Radiation Dose Determinations should be revised accordingly to reflect this change.

3.2 Uranium Bioassay Results

A detailed review of the uranium bioassay program and records was completed. The bioassay program is contained in SOP- LC-HP 009 "Bioassay Monitoring." The review of the records concentrated on the period January 1 through September 2014. Uranium bioassay samples are obtained from workers representing all the work groups at the LC-ISR Project. Urinalysis for U-nat comprises the bioassay method. Bioassay samples are obtained on a routine basis from most workers at the LC-ISR Project. Bioassay samples are obtained more frequently from Plant and Dryer Operators who by the nature of the work directly handle yellowcake and/or uranium contaminated materials. In general, Dryer Operators and Plant Operators provide bioassay samples on a weekly basis when they return to work for their next shift. Maintenance personnel assigned to the Plant typically provide samples on a bi-weekly basis (every two weeks). Bioassay samples are also required for non-routine work activities (typically associated with Radiation Work Permits) where significant exposure to uranium may occur and respiratory protection may be required.

The main purpose for the bioassay program is to ensure that workers are not realizing an intake of uranium (typically by inhalation or ingestion) from activities not known to the LC-ISR management and the Radiation Protection staff. The bioassay program is also an integral part of the Respiratory Protection Program and is used to ensure that workers are properly utilizing respirators. This includes ensuring that the respirators utilized are of the

correct style, contain the correct types of filters, and afford the appropriate protection factor.

The review of the bioassay records showed that the laboratory results were not always available within 20 days of specimen collection. In part, this results from the remote location of the LCR ISR Project and the difficultly in shipping samples to the contract laboratory in a timely manner. The RSO was aware of this situation and has been working to mitigate it by shipping bioassay samples at least twice per month instead of once per month. It was verified with the RSO that the current contract laboratory (IML Sheridan, WY) provides very quick turnaround of the required uranium analyses and notifies the RSO or RST immediately (within the same day the analyses are completed) via phone and email of the detection of any positive results (including spikes). Notification is typically received at the LC-ISR Project within 3-4 business days of receipt of the samples by the lab.

The results for bioassay samples collected between approximately January 1 and September 2014 were reviewed in detail. Approximately 440 bioassay results were analyzed, not including quality control samples. It was determined that there were 37 detectable bioassay results during the period and they were correlated to 28 separate apparent uptakes of uranium by workers. It was determined that there were 29 results between 5 and 15 ug/L that did not require any investigation by the RSO. It was observed that there were 7 results greater than 15 ug/L. Bioassay results greater than 15 ug/L require a documented investigation by the RSO to try determine their cause. This group included the two highest bioassays (62 and 49.9 ug/L U nat) that were both for the same Dryer Operator in January 2014.

A review of the available records and discussion with the RSO determined that although varying levels of investigation of the elevated bioassays was conducted by the RSO, the investigations were not documented. SOP- LC-HP 009 and NRC Regulatory Guide 8.22 require the RSO to immediately investigate the apparent cause for all bioassay results that exceed 15 ug/L and it is inherent that the RSO document the investigations in writing. From discussions with the RSO it was determined that due to concerns with the number of elevated bioassays additional training with Dryer Operators and Plant maintenance personnel was conducted in early 2014 to assist in ensuring that workers were properly utilizing respiratory protection, following the proper personal hygiene procedures, properly taking urine samples and waiting the minimum 36 hours after work with yellowcake (uranium) to obtain the urine sample. A review of the bioassay data does show that the incidence of elevated bioassays has decreased since early 2014 and is trending in the desirable direction. To further assist in minimizing the frequency of elevated bioassays the following recommendations are included:

- The RSO should immediately investigate the apparent cause for all bioassay results that exceed 15 ug/L and document the investigations in a written memo.
- Efforts need to continue to ensure that laboratory results are available within 20 days of specimen collection.
- Additional observation of work habits and respiratory protection, as well as additional training, should be completed for individuals that are still incurring elevated bioassays. This is particularly important for Dryer Operators, especially those that have not been employed in that capacity for a significant period of time.
- Consideration should be given to obtaining powered air purifying respirators (PAPR) for non-routine maintenance activities typically associated with the dryers when airborne uranium concentrations are substantially elevated over normal drying and packaging operations. These types of respirators have a greater protection factor (1000) than a fullface air purifying respirator and are also more comfortable under hot and/or humid conditions. Their use would also be consistent with the ALARA principle.

Given the large quantity of bioassay samples currently being required by the RSO and the lack of detection of uranium in most of them, the following is recommended:

- To make the bioassay program more manageable and maintain the intent of the program, the RSO should reduce the number of bioassay samples required from personnel (work groups) that do not directly handle yellowcake and/or conduct maintenance on the contaimnated equipment in the Plant.

The in house QA/QC blank and spike bioassay samples for the period January 1through September 2014 were also reviewed in detail (approximately 50 samples). It was determined that blank and spike samples were included as required by SOP HP-009 "Bioassay Monitoring". The contract lab results were in close agreement with the spiked concentrations and no concerns were noted with the contract lab results. The following changes to the in house QA/QC procedures are recommended:

- The same "made up" names used for the blank and spike samples should not be submitted with each batch of bioassays in order that the contract lab is less aware of the check samples.
- Different concentrations for the bioassay spike samples should be considered so that the contract lab cannot always anticipate the spiked concentrations of 20 and 50 ug/L.

3.3 Daily and Weekly Inspections

A detailed review of the Daily and Weekly Radiation Safety Inspections reports (SOP HP-003 and Form HP-003A) completed in 2014 was conducted as part of the on-site

audit (see Section 6) by John Cash and Kurt Brown. It was observed that Form HP-003A "Radiation Safety/ALARA Inspections" which is used to document both the daily and weekly inspections covers an entire week (columns for each day, Sunday thru Saturday) and the form requires a notation each day whether the particular inspection is considered a daily or weekly inspection. In accordance with SOP HP-003, the weekly inspection requires that it be conducted by both the radiation protection staff and the Plant Foreman. It was observed that for five inspections reports (five weeks) the identification for the "weekly" inspection was not completed. It was assumed that these five inspections were completed as required but the lack of identification of the "weekly" inspections was an oversight.

The review of the records showed that the required inspections had been completed as required (except for the apparent oversight discussed above) and they identified conditions that needed to be addressed (such as the cleanup of yellowcake spills and/or splatter) to assist in promoting the ALARA concept. The review also showed that there were some omissions and inconsistencies with the records and having seven days of inspections on the same form is too cumbersome, as among other things, there is not enough room to adequately describe conditions, comments, or corrective actions. More specific recommendations follow which may require the revision of SOP HP-003:

- The radiation protection staff needs to ensure that the inspection form is completely filled out including specifying if the inspection is a "weekly" inspection.
- The form includes a line for the Plant Operator to "sign off". It was observed that this acknowledgment was not signed off on any form. SOP HP-003 does not specify if this needs to be done. Therefore, if this requirement remains on the form it should be discussed in the SOP and the required sign off must be documented for each inspection. If it is determined that it is not needed, the "sign off" should be removed from the form.
- SOP HP-003 should be revised so that qualified designees can complete the inspections for the RSO and/or Plant Foreman during vacations and other similar absences.
- The form includes a "sign off" by the Plant Foreman and the RSO acknowledging their review of the inspection findings. Some of these sign offs were not completed for over one month. These extended time frames are excessive and should not exceed a few days after completion of the weekly inspection. It should be noted that SOP HP-003 does not specify this requirement. If this requirement remains in the form it should be discussed (including the acceptable time frame for review and sign off) in the SOP.
- The inspection form should be revised so that there is only one form per day and there is more room for comments. The form should only be for the Plant (the Wellfield inspection items should be removed).

- A more appropriate form should be used for the Weekly Wellfield Inspections as the current form includes operations information such as pressure data and rotometer readings. SOP HP-003 should be revised accordingly.

3.4 Documented Training Program Activities

Records were reviewed for Radiation Protection Training. It was observed that the records were not very well organized and the topics covered (agenda) were not very detailed. The Radiation Protection Training includes the use of a detailed Power Point slideshow presented by the RSO and a quiz to demonstrate that trainees understand the key concepts. In summary, it was determined that Radiation Protection Training was presented to approximately 20 new employees in 2014. Numerous contractors were give Radiation Protection Training with the detail necessary for the work they were doing at the site. Records showed that Annual Radiation Protection Refresher training was given on May 22, June 5 and June 12, 2014.

Records show that initial Respiratory Protection Training was given to 12 workers (Plant Operators, Dryer Operators, Maintenance personnel and EHS staff) by the RSO in June 2013 prior to the start of uranium production. It was noted that additional training by the RSO and HPT occurred at least seven additional times in 2014.

A review of the training records for the RSO (Chuck Kelsey) and the ARSO/HPT (Chris Pedersen) showed that they both last attended "Radiation Refresher" training in October 2012. They both attended training for radioactive materials transportation at that time. NRC Regulatory Guide 8.31 "Information Relevant to Ensuring that Occupation Exposure to Radioactive Materials at Uranium Recovery Facilities Will Be ALARA" recommends that the RSO attend radiation protection refresher training every two years. Therefore, the RSO and ARSO/HPT need to attend refresher training in the near future. Relative to radiation training, the following recommendations are included:

- Radiation protection training records should be better organized.
- Documentation for the radiation protection training records should include more details of the material covered (attach agendas and/or supporting information).
- The RSO and ARSO/HPT should attend refresher training in the near future.

3.5 Radiation Safety Meeting Reports

The RSO completes a Monthly Radiation Safety/ ALARA report that is forwarded to LC-ISR and corporate management. The report summarizes the results of the daily and weekly inspections, radiation surveys and monitoring, radiation safety training, Radiation Work Permits (RWPs) completed, estimated exposures for the month. The report also

summarizes any compliance concerns and the need for corrective actions and it includes the quarterly TEDE estimates for employee exposures. A review of the 2014 reports shows that continual progress was made in enhancing the content of the reports and their timeliness of completion. The RSO should continue to use the current report format and keep management informed of the important aspects of the Radiation Protection Program.

3.6 Radiological Survey and Sampling Data

This audit focused on the radiological survey and sampling data used to support the ALARA program at the Plant (Restricted Area) as it relates to the protection of personnel from exposure to uranium and its daughters, including the determination of the TEDE. The radiological survey and sampling data used to support the environmental monitoring program was not reviewed in detail. The following radiological survey and monitoring data were reviewed; uranium and radon daughter monitoring (sampling) data, gamma (TLD) personnel monitoring, "clean" area contamination surveys, personnel contamination survey data and surveying (screening) of materials for unrestricted release.

Uranium Monitoring Data

In accordance with SOP HP-008 Indoor Airborne Rad Sampling it was verified that airborne uranium is routinely sampled at four locations in the Plant using high volume pumps (30 LPM) and particulate filters. The period January 1 through September 30, 2014 was reviewed. The required monthly "area" monitoring for airborne uranium was completed at the Yellowcake Slurry Area, Filter Presses, and Yellowcake Drum Storage Area. As expected, the results for these areas showed that airborne uranium concentrations are very low (0 to 3% DAC). Therefore, the potential exposure of workers in the Plant to airborne uranium is very minimal under normal operating conditions. This also shows that work practices and ventilation systems are effective in minimizing airborne uranium concerns.

The Dryer Room was monitored on the required weekly basis for "area" airborne uranium. This room is maintained as an "Airborne Radioactivity Area" under normal operating conditions. Therefore, workers are not permitted to enter the Dryer Room without the required respiratory protection (fullface negative pressure respirator). The weekly monitoring is conducted when drying and packaging operations may be in progress or when these work activities are not occurring. When work activities are not occurring the levels of uranium particulates in the room are expected to be less. It should be noted that workers utilize BZ samplers in order that the exposure to uranium can be more accurately determined during packaging activities and certain maintenance type work. Accordingly, worker exposure to uranium in the Dryer Room is not determined from the from the weekly "area" monitoring.

A review of this monitoring data shows that during normal operating conditions airborne uranium levels in the Dryer Room are typically from 0 to approximately 20% of the DAC even when some drying and packaging operations are occurring. The BZ monitoring data obtained from the workers in the Dryer Room does show considerably greater concentrations of uranium in the breathing zone, especially when packaging. Although the air monitoring data shows it may not always be required, LC-ISR maintains the Dryer Room as an "Airborne Radioactivity Area" as a conservative administrative control to keep the potential exposure of workers to uranium ALARA. Given these conditions the following is recommended:

- Because the Dryer Room is maintained as an "Airborne Radioactivity Area", workers utilize BZ monitoring to determine airborne uranium particulate concentrations to determine exposure to uranium, consideration should be given to discontinuing the weekly "area" uranium monitoring in the Dryer Room. It is recommended that this monitoring be lessened to a monthly frequency and it should be done when packaging operations are <u>not</u> in progress. SOP HP-008 Indoor Airborne Rad Sampling should be revised accordingly.

Radon Monitoring Data

In accordance with SOP HP-005 " Indoor Radon Monitoring, Sampling and Mitigation" it was verified that radon daughter concentrations (radon) are routinely monitored at locations in the Plant, Office area and Headerhouses. Radon daughter concentrations are determined using the Modified Kusnetz method. It was observed that the frequency of radon monitoring completed during the last year varied but it was done at least monthly at required locations. A review of the radon monitoring data shows that levels are very low and less than those typically observed at other operating ISR facilities. The very low levels of radon are attributed to the fresh air ventilation system used at the Plant, the tank ventilation systems, and the relatively closed nature of resin transfer and processing activities. Currently, IX resin is transferred within the Plant between vessels and there is no transfer of resin from trucks.

In summary, a review of the monitoring data shows that radon concentrations in the Office, Plant (except the Dryer Room) and headerhouses are typically only 1-2% DAC. The Dryer Room typically contains radon concentrations near 10% DAC. This higher concentration at the Dryer Room is attributed to the fact that the Dryer Room has negative ventilation which may be causing the buildup of radon daughters due to a lack of significant fresh air exchanges. Additionally, the radon daughter monitoring results may on occasion be impacted by uranium particulates captured on the filter. This would result in calculated radon daughters concentrations being elevated compared to actual concentrations. It should be noted that the Dryer Room is posted as an "Airborne

Radioactivity Area" due to the potential for elevated particulate uranium concentrations. Therefore, workers are also protected from any radon daughters present in Dryer Room.

On occasion, radon monitoring is augmented with radon continuous air monitors (CAM's) that assist in immediately identifying (via alarms) the presence of radon daughters. These monitors can also digitally log radon concentrations to permit further data analysis. These are used at the LC-ISR to investigate activities that could cause the release of radon as well as a warning device in case an unanticipated source of radon develops. Because these monitors have stringent calibration requirements and they are not approved by the NRC they are not used for dose determinations or compliance activities. The use of the CAMs is not covered in any SOP. Because the CAMs are an important component of the radon monitoring and detection program at the Plant, SOP HP-005 should be updated to include a description of how the CAMs are utilized and maintained. Alternatively, a new SOP dedicated to the CAMs could be developed.

Given the very low concentrations of radon at the LC-ISR Project, as evidenced by monitoring data, the following recommendations are included:

- Routine radon monitoring should be maintained at a monthly frequency.
- The monitoring locations should be adjusted to account for the relative lack of radon (i.e. randomly monitor only 1 or 2 headerhouses and 1 or 2 offices each month).
- Because the Dryer Room is maintained as an "Airborne Radioactivity Area" which requires the use of respiratory protection, consideration should be given to discontinuing routine radon monitoring at that location.
- SOP HP-005 should be revised to reflect the revised radon monitoring program.
- The use and operation of the radon CAMs should be included in SOP HP-005, or a new SOP that just addresses the use of the radon CAMs should be devloped.

Gamma Dosimetry Data

The gamma dosimetry data was reviewed. In accordance with SOP HP-002 "Personnel External Radiation Dosimetry," OSL personnel dosimeter badges are currently used to monitor gamma radiation exposure. The badges are supplied by Landauer Corporation and they are exchanged every three months.

Since the start of operations in Q3 2013 all personnel that work at the Lost Creek ISR project (approximately 60 personnel) have been required to wear badges. This includes personnel from the Casper office (management staff, EHS personnel, geologists) that are at the facility on a limited basis (typically only once or twice per week). Records for the Q1 and Q2 2014 were reviewed as the Q3 records were not complete at the time of the audit due to the processing of the Q3 2014 OSL badges by the supplier.

The Deep Dose Equivalent (DDE) data for this period was reviewed in respect to the various work groups that the personnel are assigned to. The only work groups that showed any DDE are as follows:

Maintenance Workers DDE:

Range- 0 to 24 mrem

Mean- 6 mrem (<1% ALI)

Plant Operators DDE:

Range- 15 to 55 mrem

Mean- 28 mrem (<1% ALI)

Dryer Operators DDE:

Range- 46 to 77 mrem

Mean- 62 mrem (<2% ALI)

Wellfield Operators DDE:

Range- 17 to 59 mrem

Mean- 35 mrem (<1% ALI)

Radiation Protection Staff DDE:

Range- 9 to 10 mrem

Mean- 10 mrem (<0.1% ALI)

Doubling the highest DDE (77 mrem for a Dryer Operator) to account for an estimated full year DDE (144 mrem) is less than 3% of the ALI. A review of the data for the period shows that the personnel that primarily work in the office at the LC-ISR Project (administrative/management personnel, Casper Office personnel, geologists, engineers and lab personnel) did not have any measurable DDE above background. In summary, the DDE at the LC-ISR Project is very low and many personnel working at the site have no measurable DDE above background. Therefore the following is recommended:

- OSL badge monitoring for gamma radiation exposure should be discontinued for administrative/management personnel, Casper Office personnel, geologists, wellfield construction workers, engineers and lab personnel. Monitoring should be maintained for maintenance workers, Plant and Dryer Operators, Wellfield Operators and the Radiation Protection staff.

Gamma Survey Data

Gamma radiation surveys are currently completed on a monthly basis to measure gamma radiation levels at various locations in the Plant, Office area and wellfield headerhouses. This is primarily done to ensure that tanks, IX vessels or other equipment in the Plant do not become a significant gamma radiation source that could require posting as a "Radiation Area" (greater than 5 mR/hr) and ensure that ALARA principles are adhered to in order that workers do not receive unacceptable levels of gamma radiation. Although SOP HP-006 Gamma Surveys specifies a minimum frequency of semi-annual monitoring, the radiation protection staff at the LC-ISR has been completing this monitoring on a monthly basis since the start of production operations. It is recommended that the monthly gamma survey frequency be continued, in part, to help ensure that any unknown sources of significant gamma radiation do not develop.

The monthly gamma survey data for the Plant and Office area for January through September 2014 was reviewed. The review showed that gamma levels in the Plant are low and in the range expected for a newer ISR IX Plant facility. In summary, tanks, IX columns and other equipment had relatively low gamma radiation levels of approximately 100 to 1,000 uR/hr. No survey data exceeded or approached the level requiring posting as a "Radiation Area." Areas that are routinely occupied by workers (Control Room, main floor areas (not between tanks)) exhibit lower gamma levels. This assists in maintaining actual employee exposures, as evidenced by the OSL personnel dosimetry data, low.

A review of the monthly gamma survey data for the Office area showed that gamma levels are at background except for a slight elevation at several of the offices located adjacent to the Plant. This was confirmed with a gamma survey on October 21, 2014. The gamma levels at these offices ranged from approximately 1 to 15 uR/hr above background. Personnel who utilize these offices do not routinely use these offices 8 hours a day. If they did use these offices a full 8 hours each day (2,000 hours annually) they would receive a maximum exposure of approximately 30 mrem annually. This is well below the NRC limit that requires monitoring if the expected annual dose exceeds 500 mrem.

Since production operations began, area OSL badges have also been used to measure gamma radiation exposure rates at the Plant Control Room, the Office Lunchroom and three offices located in the Office area. The gamma exposure rates for these OSL badges were compared to the monthly gamma monitoring data, as well as the actual gamma survey conducted in the Office area on October 21, 2014. The OSL gamma dose rates agreed closely with the estimated exposure rates calculated from the monthly gamma monitoring and the monitoring completed on October 21, 2014. Therefore, the following recommendations are included:

- Gamma radiation surveys of the Plant, wellfield headerhouses and Office areas should be maintained at a monthly frequency.

- The use of area OSL badges at the Plant Control Room, Office Lunchroom and three offices should be discontinued as it is redundant with the monthly gamma radiation surveys.

Personnel Contamination Surveys

Personnel contamination surveys (scanning) are conducted at three locations at the Plant (Main Survey Station in the foyer, the East Door and the North Door). The surveys are conducted for alpha/beta activity with a Ludlum Model 2360 meter equipped with a 43-93 probe. The RST periodically sets the acceptable limit for the alpha/beta activity based on the meter efficiency for alpha and for beta and background beta activity. Records of the surveys were observed at the survey stations. The records although not reviewed in detail, appeared complete.

It was determined that the method used to set the acceptable limit is not detailed in SOP HP-007 Personnel Surveys. Additionally, it is not understood how alpha/beta activity can be accurately used for the surveying and release limits when gamma radiation from the Plant is impacting the beta component of the measurements. Therefore, the following recommendations are included:

- SOP HP-007 Personnel Surveys should be revised to reflect all the procedures used to complete the surveys including how the limits are set for the meters and how the limits are posted.
- Consideration should be given to revising the personnel survey procedure to be consistent with Section 5.7.6.1 "Personnel Surveys" of the NRC approved Technical Report such that the procedure only use alpha activity to detect uranium and its daughters. This would eliminate issues with gamma interference of beta readings and would be more consistent with over 30 years of uranium industry procedures and written NRC guidance.

3.7 Reports on Over Exposure of Workers

There were no instances of over- exposure of any worker to radioactive materials. Therefore, no reports of this nature were reviewed.

3.8 Operating Procedures Reviewed During the Period

Because this is the first ALARA Audit completed for the LC-ISR, and many of the standard operating procedures (SOPs) related to radiation protection were developed prior to actual operations, Bill Kearney reviewed the radiation protection SOPs to ensure that they are suitable for the current operations and conditions at the facility. The following SOPs were reviewed:

- HP-001Radiation Work Permit
- HP-002 Personnel External Radiation Dosimetry

- HP-003 Radiation Safety / ALARA Inspections
- HP-004 Radiation Detection Instrumentation
- HP-005- Indoor Radon Monitoring, Sampling and Mitigation
- HP-006- Gamma Surveys
- HP-007 Personnel Surveys
- HP-008 Indoor Airborne Radionuclide Sampling
- HP-009- Bioassay
- HP-010 Surface Contamination (Swipe) Surveys
- HP-013 11e2 Byproduct Waste Management
- HP-014 Screening and Decontamination of Materials for Unrestricted Use
- HP-015 Licensed Material Security
- HP-016 Radiation Dose Determinations
- HP-018 Alpha-Beta Counting Systems
- HP-019 Determining Dose to Unmonitored Employees
- TR-007 Radioactive Material Shipping
- OHS-007 Respiratory Protection
- OPS-026 Yellowcake Packaging
- OPS-053 General Maintenance
- OPS-054 Yellowcake Drum Handling

4.0 Trends in Personnel Exposures

Section 3.1 "Employee Exposure Records" reviews and discusses the exposure of personnel at the LC-ISR Project to radioactive materials (uranium, radon daughters and gamma radiation) and makes a recommendation that only the maintenance workers that work in the Plant, Plant Operators and Dryer Operators (yellowcake/uranium workers) should be included in a routine exposure monitoring program even though their exposures are expected to be maintained at less than 10% of the ALI on an annual basis. Accordingly, the potential exposure of other personnel at the facility to radiation is insignificant and does not require monitoring according to NRC regulations. This is consistent with conditions at other NRC licensed ISR operations that have operated for many years.

It is desirable to assess any trends in the exposure of the yellowcake/uranium workers at the LC-ISR Project to radioactive materials. Because the facility has only been in operation for little more than one year it is not possible to discern any long term trends in the exposure of personnel to radiation or radioactive materials. Although the personnel exposures determined to date are low and Section 6 contains recommendations to further reduce exposures to the yellowcake/uranium workers, the following recommendation is included:

- Future Annual ALARA Audits should assess any trends in the exposure of yellowcake/uranium workers to radioactive materials, especially the doses attributed to positive bioassay results.

5.0 Equipment Used for Exposure Control

The equipment used at the LC-ISR Plant to control the exposure of workers to radioactive materials (radon daughters and particulate uranium) includes the following:

- Passive ventilation (open doors and overhead doors) is used in combination with wall vents and fans to assist in ensuring sufficient air exchanges in the Plant building to prevent the buildup of radon daughters.
- A ducted forced air ventilation system that filters incoming air of dust is used in combination with wall vents and fans, and passive ventilation, to assist in ensuring sufficient air exchanges in the building to prevent the buildup of radon daughters. .
- Point source ventilation that directly vents tanks, IX columns and the resin shaker deck via exhaust pipes and fans to the outside. This ventilation is primarily intended to vent radon daughters and chemical fumes outside the Plant.
- The Dryer Room contains a HEPA filter system that discharges filtered air from the Dryer Room to the Precipitation area of the Plant. This system maintains negative pressure in the Dryer Room to assist in ensuring that uranium particulates remain in the Dryer Room. This is especially important during yellowcake packaging activities when airborne uranium concentration in the Dryer Room can increase.
- In addition to passive ventilation via doors, headerhouses are equipped with fans that are continuously operated to minimize the buildup of radon daughters.
- Floor sumps and pumps are located in the Plant to assist with the cleanup of any spilled fluids and/or yellowcake.

During numerous visits to the Plant it was observed that varying combinations of the above ventilation systems were operating to prevent the accumulation of radon daughters. Based on the review of the radon daughter monitoring data and the estimated exposure of workers in the Plant to radon daughters (both of which are very low) it appears that the ventilation systems are operating as intended and meeting ALARA requirements.

It was observed that the HEPA filter system is continuously operated at the Dryer Room to assist in keeping uranium particulates in the Dryer Room, especially during packaging operations. A recommendation is included below in Section 6.1 to further assess the operation of this system.

During several visits to the wellfield area (including during the November 5 On-Site Audit) it was observed that the wall fans at all headerhouses were operating as intended to prevent the buildup of radon daughters within these buildings.

It was observed that the floor sumps and pumps located in the Plant to assist with the cleanup of any spilled fluids and/or yellowcake were operating and were being used on a routine basis.

6.0 On-Site Audit

The on-site audit took place on November 4 and 5, 2014. The on-site audit team included Bill Kearney, John Cash (VP Regulatory Affairs), Kurt Brown (Mine Manager), Jay Pry (Plant Foreman) and Mike Gaither (Manager EHS and Regulatory Affairs). Chuck Kelsey (RSO) and Chris Petersen (HPT/ARSO) assisted with the audit but were not official members of the audit team. The team conducted"walk-thru" audits of the Plant and of the wellfield. The team also reviewed various records. A summary of the walk-thru audit and review of the records follow.

6.1 Plant Walk-Thru Audit

On November 4 the audit team conducted a walk-thru audit of the Plant. At the time of the audit routine operations activities were occurring at the Plant including the transfer of resin from IX columns for elution and the precipitation of yellowcake. The Dryer was not operating during the walk-thru audit. In general, the Plant was orderly and clean, and the levels of visible yellowcake at the various process areas were acceptable. It was observed that the Dryer Room, which is routinely posted as an "Airborne Radioactivity Area," had recently been washed down to assist in minimizing the potential for airborne uranium. It was also observed that respirators were properly stored in plastic bags and the plastic containers. As a result of the walk thru audit the following recommendations are included:

- A sliding type door should be designed and installed on the Dryer Room side of the wall hatch where the drums pass thru on the roller deck in order that the ventilation system in the Dryer Room can be more effective and yellowcake dust can be better contained in the room during an upset condition. The door on the wall hatch should remain in the closed position expect when passing drums through the wall to the yellowcake storage room.
- The need to continuously operate the HEPA filter system for the Dryer Room should be investigated as it may be desirable to only run it when yellowcake packaging operations are being conducted. There is a concern that during an upset condition when the dryer(s) are operating (and workers may not be present in the room to observe the conditions for some time), a significant amount of uranium could be released to the air in the Dryer Room. If the amount of airborne uranium caused the HEPA filters to be overwhelmed, the filters could be by- passed leading to particulate uranium being ventilated into an area of the Plant where workers are not required to wear respiratory protection. Alternatively, it could be evaluated if

the HEPA filter system for the Dryer Room should be vented to the outside, or another area of the Plant.

- A review of the respirator log sheet which is used to record the Dryer Operator BZ monitoring did not appear to be complete. The Dryer Operators need to fully complete these records when conducting packaging operations.
- An additional washer and dryer should be considered to "double launder" contaminated clothing to ensure that most yellowcake is removed.
- A large sign should be obtained and placed on the non-contaminated waste dumpster alerting workers that all waste placed in the dumpster must not be contaminated with radioactive materials.
- It was observed that there was a small mesh trash can in the Control Room used to dispose of contaminated latex gloves. Other small trash cans for used contaminated waste disposal were located just outside the Control Room and in the adjacent lab room. A larger trash can (approximately 30 gallons) labeled "Contaminated Waste" should be placed just outside the Control Room and be used for disposal of gloves and other contaminated trash. Contaminated gloves should not be disposed in the Control Room.
- Signs reading "Entering Restricted Area" should be installed adjacent to the overhead door at the Yellowcake Warehouse and the IC/PC vault door on the west side of the Plant and between the two overhead doors on the north side of the Plant.
- The sheet metal wall behind the east filter press should be caulked at its base to prevent wash down fluids from seeping into maintenance portion of the Plant.
- Operations management should consider a designated outside storage area for the storage of contaminated equipment that needs to be kept for spare parts and the like. This area will need to be included in the "Restricted Area".
- A "smoke test" should be considered for the Dryer Room to assess the need for and/or effectiveness of the current room ventilation system.

6.2 Wellfield Walk-Thru Audit

On November 5 the audit team conducted a walk-thru audit of the operating Wellfield 1. At the time of the audit routine operations activities were occurring at Headerhouses 1-6. Mike Bauer, Wellfield Operator, accompanied the team. The current wellfield remains relatively limited in size. No concerns were identified.

The headerhouses were in good order and no leaks were observed. Each Headerhouse contained trash cans that were mostly labeled for contaminated or non-contaminated trash. Accordingly, the following recommendation is included:

- All trash cans located in the headerhouses should be labeled with large print that conspicuously identifies their use for non-contaminated or contaminated trash/waste.

6.3 Review of Radiation Work Permits (RWP's)

The Radiation Work Permits (RWP's) for 2014 were audited for completeness and agreement with SOP HP-001 "Safe Work Permit." It was observed that several RWPs completed earlier in 2014 did not have a radiation dose assessment determined for the activity. It appeared that the RWP program was mostly used to approve a work activity and specify the appropriate personal protective equipment (PPE). A review of SOP HP-001 showed that the procedure needs to be revised to include the requirement that a dose assessment be routinely included for most RWPs. The procedure also needs to be revised to describe how the calculated non-routine dose is captured and recorded in the employee exposure program.

It was also observed that the RWPs did not have a numbering system which is desirable for, among other things, tracking applicable air monitoring data and bioassay samples/results. The RWPs completed in 2013 and 2104 were just loosely kept in a folder. Due to the importance of these records and all attachments, they should be retained in a more organized manner such as a 3-ring binder or a 2-hole punched file that keep the RWPs in order. There were also a few instances where the RWP form was not signed by the issuer (RSO) or the personnel that would do the work. It is important that these signatures are recorded to support that personnel understand the requirements of the permit. Therefore, the following recommendations are included:

- SOP HP-001 and accompanying form HP-001A needs to be revised to include the requirement that a dose assessment be routinely included for most RWPs. The procedure also needs to be revised to describe how the calculated non-routine dose is captured and recorded in the employee exposure program.
- RWPs should have a numbering system and they should be retained in a more organized manner such as a 3-ring binder or a 2-hole punched file that keep the RWPs in order.
- All required signatures should be obtained prior to the final approval of RWPs.

6.4 Review of Yellowcake Shipment Records

A detailed review of the records for the shipment of yellowcake was completed. Records for all 18 shipments to date were reviewed. The records were determined to be well

organized and complete. One minor concern was identified with the "Driver Routing Instructions/Checklist" form. This form is sent from the transporter (RSB Logistics). The form contains a checklist which typically has the various items checked off. However, for eight shipments the checklist was found not to be checked. This discrepancy should be resolved. Therefore, the following recommendation is included:

- RSB Logistics should be contacted to resolve why the checklist contained on "Driver Routing Instructions/Checklist" form is not fully filled out (checked) for all shipments.

6.5 Review of 11E.2 Byproduct Shipment Records

To date, only two 11E.2 Byproduct shipments have been made from the LC-ISR. Both shipments went to the NRC licensed Shirley Basin 11E.2 Byproduct Disposal Facility located approximately 130 miles from the LC-ISR. The records for both shipments were reviewed in accordance with SOP TR-007 "Radioactive Materials Shipping". It was observed that a weight (estimated) was included on the manifest records (Exhibit B). This information is not required by the receiving facility and should not be included for future shipments to this facility. It was also observed that the radiation surveys done for both shipments were not consistent with each other and the checklist for Shipment LC11E.2 - 002 (Form TR-007D) was not fully checked off. Therefore, the following recommendations are included:

- The estimated weight should not be included for future shipments to the Shirley Basin facility.
- All procedures in SOP TR-007 need to be followed and all forms need to be completely filled out.

6.6 Review of Calibration Records for Radiation Detection and Survey Instruments

The calibration records for all radiation detection and survey instruments were reviewed. In general, these instruments require an annual calibration completed offsite by the manufacturer or lab facility specializing in this type of service. The records were observed to be complete and in good order. Due to the number of instruments and the varying required calibration dates, the following recommendation is included:

- An electronic calendar or other suitable method should be used to assist in tracking required instrument calibration dates in order that the instruments are sent offsite for calibration in a timely manner and equipment calibrations do not unexpectedly expire.

6.7 Review of Respirator User Medical Evaluations, Fit Test Results and Training Records

The records required for workers that are required to utilize respiratory protection were reviewed in detail. It appeared that documentation for respirator training was up to date. It was observed that six personnel were nearing the expiration of the current medical approval. During this review it was learned that the RST/ARSO had recently forwarded the required form to these personnel for completion and submittal to the Physician or Licensed Health Care Professional (PLHCP) for medical review and approval.

Although the respirator fit test documentation was available for each user, the completion of the forms showed a lack of attention to details as some of the OHS-007 forms did not include the make, model and size of the respirator and many of the "Fit Test Reports" were not signed on the signature line by the respirator user or the tester. The RST/ARSO, who is responsible for the Respiratory Protection Program, conveyed that he is currently in the process of changing some of the forms required to document respirator fit tests. Therefore, the following recommendations are included:

- SOP OHS-007 "Respiratory Protection" needs to be reviewed in detail and revised with the current procedures and all forms used for respirator fit testing and approval of respirator use.
- All forms need to be completely filled out including signatures by the respirator user and tester, where applicable.

7.0 Recommendations to Further Reduce Personnel Exposure to Uranium and Daughters

As discussed in previous sections, because the LC-ISR Project has only been in uranium production for approximately 14 months, it is not possible to determine any meaningful trends in most of the radiological survey and exposure data collected as part of the Radiation Protection Program. In general, the recommendations in previous sections of this report are intended to reduce personnel exposures However, as discussed in Section 3.2, the relatively high incidence of positive bioassays is of more significant concern. Therefore, the recommendations included in the Section 3.2 should be considered for implementation to lessen the frequency of positive bioassays and the accompanying estimated doses to uranium. It is important that the bioassay results and the actions taken to lessen the frequency of positive bioassays, be continuously evaluated during the next period and Annual ALARA Audit to reduce the frequency of positive bioassays.

8.0 Recommendations for Next Annual ALARA Audit

The following recommendations are included for the next ALARA Audit (expected for completion near the fourth quarter 2015):

- Assess any trends in the radiological monitoring and survey data used to determine employee exposures.
- Assess any trends in personnel exposure of yellowcake/uranium workers to radioactive materials especially as exposures relate to elevated bioassays.
- Assess the radiologic environmental monitoring program and determine if there are any trends in the data.
- Potentially review wellfield operations data as it relates to NRC License No. SUA-1598.

Signatures:

Bill Kearney _____ Date 11/21/14
Radiation Protection Specialist

John Cash _____ Date 11/21/14
VP Regulatory Affairs

Kurt Brown _____ Date 11/21/14
Mine Manager

Jay Pry _____ Date 11/21/14
Plant Foreman

Mike Gaither _____ Date 11/21/2014
Manager EHS and Regulatory Affairs

COLORADO OFFICE
10758 W. CENTENNIAL RD., STE. 200
LITTLETON, CO 80127
TEL: (866) 981-4588
FAX: (720) 981-5643

WYOMING OFFICE
5880 ENTERPRISE DR., STE. 200
CASPER, WY 82609
TEL: (307) 265-2373
FAX: (307) 265-2801

LOST CREEK ISR, LLC

MEMO

Date: May 8, 2015

To: Attachment to ALARA Audit Report

From: Chris Pedersen

Subject: Public Dose Calculation

The highest dose to a member of the public is either to a UPS driver or to a contractor working in the plant. There have not been any ranchers, campers, hunters, or other member of the public spending any significant amount of time near the plant during 2014. The only members of the public that would have received a significant dose are those that were on site for business purposes, and all visitors to the facility are required to sign in and sign out.

Of the several UPS drivers that deliver to Lost Creek they have collectively spent less than 173 hours on site throughout the year. The UPS driver dose calculation is based on the environmental results, without background subtracted, at the monitoring station immediately downwind of the plant (Passive Radiation monitor 5 and High Volume air sampling station 2); this sampling location was calculated using the MILDOS program before operations and is the most likely spot for the highest concentration. This sampling location will provide the radon concentration and the airborne particulate uranium concentration for the UPS driver. The gamma exposure rate at the warehouse and front office, where the UPS driver will deliver packages, measures between 20 and 30 uR/hr and is considered background. The calculation results can be seen in Table 1 below.

Table 1: UPS Driver Dose Calculation

	Concentration (uCi/mL)	DAC	%DAC	175 hr Dose (mrem)
Unat	4.65E-15	3.00E-10	1.55E-03	6.78E-03
Rn with daughters	1.10E-09	3.00E-08	3.67E-02	1.60E-01
			Total Dose	**1.67E-01**

The other member of the public likely to receive the highest dose is a contractor working in the plant. If a contractor is likely to work in the plant for more than a week, is working with radioactive material, or is likely to receive a significant dose then they will be trained as a radiation worker. Examples of workers not trained as radiation workers would be contractors hired to work on the air compressors or heat exchangers in the plant shop area; the contamination levels and external exposure rates in this area is very low, and significant doses are unlikely. Typically these projects occur in less than 3 days, but worst case scenario would be if they had to come back and perform work again. A conservative estimate of 40 hours will be used for these workers in the plant. Monthly sampling results will be used for radon daughter and airborne uranium dose calculations. A conservative approximation of 0.3 mR/hr will be used for the external dose calculation. Most areas in the plant a meter away from a tank are less than 0.3 mR/hr. See Table 2 for dose calculation results of contractors inside the plant considered members of the public. The Table 2 results show the results based on the average concentrations in the plant for 2014 and the results for the highest measurements collected during routine sampling.

Table 2: Inside Plant Member of the Public Contractor

	Concentration	DAC	%DAC	40 hr Dose (mrem)
Average Unat (uCi/mL)	2.29E-12	3.00E-10	1	1
Average Rn Daughters (mWL)	15	330	5	5
Gamma Dose Rate 0.3mrem/hr				12
			Total Dose	**18**
Max Unat (uCi/mL)	1.52E-11	3.00E-10	5	5
Max Rn Daughters (mWL)	110	330	33	33
Gamma Dose Rate 0.3mrem/hr				12
			Total Dose	**50**