From:	Mike Gaither
To:	Saxton, John
Cc:	John Cash
Subject:	[External_Sender] Lost Creek QAPP SUA-1598
Date:	Thursday, June 14, 2018 12:47:23 PM
Attachments:	LC QAPP 2013 vs 2016 comparison .docx Lost Creek QAPP_Jun2018 tracked.docx Lost Creek QAPP_Jun2018.pdf

---

John,

Attached is a revised/updated version of the Lost Creek ISR Project (SUA-1598) Quality Assurance Project Plan (QAPP). This version has restored some of the language that was inadvertently omitted in the 2016 revision. For clarity, the 2013 vs 2016 comparison version is attached, a track change version of the 2018 version has been provided, and the final PDF of the June 2018 version is attached.

It appears that the original April 2013 submittal version was used for the 2016 update instead of the July 2013 version. The revisions were compared to NRC's June 19, 2013 RAIs to ensure that certain changes were restored in the 2018 version which were consistent with your recent request for changes. Some administrative changes/corrections were incorporated in the 2018 version including:

- Some format changes
- Job title corrections
- Update for current radon track-etch detectors and associated LLDs
- Restoration/correction of language to be consistent with referenced Technical Report language.
- References of specific SOPs names were removed as well as the SOP list (original Appendix A). This was done so that if SOPs were changed or added, the QAPP would not need revision each time.
- Sample Chain-of-Custody forms were restored (as Appendix A).

Let me know if these changes are acceptable and satisfy your recent inquiries.

Regards,

Michael Gaither
Manager EHS and Regulatory Affairs
Ur-Energy USA Inc.
5880 Enterprise Dr. Suite 200
Casper, WY 82609 USA
(307) 265-2373 ext. 321

Your Uranium Powerhouse

Quality Assurance Project Plan (QAPP) Radiological Effluent and Environmental Monitoring Program for the Lost Creek ISR, LLC Facility

Prepared By

Lost Creek ISR, LLC.

July 2013

Revision 1 May 2016

Revision 2 June 2018

TABLE OF CONTENTS

Page No.

Executive Summary ES-1

ES.1 Overview of the Radiological Effluent and Environmental Monitoring Program ES-2

ES.2 Conditions to be Monitored ES-2

ES.3 Quality Assurance Project Plan Purpose ES-2

ES.4 Project Organization ES-2

1.0 Introduction, Organizational Structure and Responsibilities of Managerial and Operational Personnel and Applicable Standards 1-1

1.1 Introduction 1-1

1.2 Corporate Management Commitment 1-3

1.3 Organizational Structure and Responsibilities 1-3

1.3.1 President 1-4
1.3.2 Vice President 1-5
1.3.3 Mine Manager 1-5
1.3.4 Radiation Safety Officer (RSO) 1-5
1.3.5 Department Heads 1-6
1.3.6 Safety and Environmental Review Panel (SERP) 1-6

1.4 Summary of Major Elements of the QAPP 1-6

2.0 Personnel Qualifications and Training 2-1

2.1 Introduction on Qualifications and Training 2-1

2.2 Radiation Safety Training 2-1

3.0 Operating Procedures and Instructions 3-2

4.0 Record Keeping and Reporting Requirements 4-2

4.1 Types of Documents, Records and Reports 4-2

4.1.1 Field Documentation 4-3
4.1.2 Field Variance and Non-conformance Documentation 4-3

4.2 Validations and Verification (V&V) of Accuracy and Completeness 4-4

4.2.1 Field Measurement Data 4-5
4.2.2 Laboratory Data 4-5
4.2.3 Quality Control Samples 4-6
4.2.4 Qualification of Data and Corrective Actions 4-6
4.2.5 Determination of Anomalous Data 4-6
4.2.6 Data Screening 4-6
4.2.7 Technical Review 4-6
4.2.8 Follow-up Actions 4-7
4.2.9 Data Qualification 4-7

4.3 Preservation of Records and Record Retention 4-7
4.3.1 Corrections to Documents 4-9
4.4 Electronic Media 4-10
4.5 Reporting Requirements 4-10
5.0 Quality Assurance and Quality Control of Radiological Effluent and Environmental Monitoring Data and Samples 5-1
5.1 Regulatory Requirements and Limits 5-1
5.1.1 Regulatory Limits 5-1
5.2 Radiological Monitoring QA/QC 5-3
5.2.1 Overall Objectives 5-3
5.2.2 Survey Methods for Radiological Exposure Monitoring 5-4
5.2.3 Quality Control of Radiological Exposure Monitoring Measurements 5-4
5.3 Radiological Effluent and Environmental Monitoring QA/QC 5-5
5.3.1 Overall objectives 5-5
5.3.2 Airborne Radiological Effluent and Environmental Monitoring 5-5
5.3.3 Effluent Control and Waste Management 5-6
5.3.4 Quality Control of Radiological Effluent and Environmental Monitoring Measurements 5-8
5.4 Quality Control Samples 5-8
5.4.1 Types and Use of Field Duplicates and Blanks 5-9
5.5 Sample Handling, Custody, and Shipment 5-9
5.5.1 Sample Handling and Chain of Custody Requirements 5-9
5.5.2 Sample Handling and Chain of Custody Requirements for Radiological Effluent and Environmental Monitoring Samples 5-10
5.6 Application of Industry Standards 5-10
5.6.1 Application of Collection Efficiencies to Determine Actual Sample Volume 5-10
5.6.2 Uncertainty Limits for Volume and Mass Measurements 5-11
6.0 Laboratory Management and Quality Control 6-1
6.1 Verification and Validation of Contract Laboratory QA/QC Programs 6-1
6.1.1 Regulatory Requirements 6-1
6.1.2 Preparation and Analytical Methodology 6-1
6.1.3 Data Presentation and Reporting Results 6-1
7.0 Quality Control for Maintenance and Calibration of Radiological Effluent and Environmental Monitoring Instrumentation and Equipment 7-1
7.1 Instruments and System Calibration and Maintenance Requirements 7-1
7.1.1 Flow Monitoring Instrumentation 7-1

7.1.2 Calibration Protocols and Frequency for Radiological Survey Instruments 7-1
7.2 Calibration Requirements of Sampling Equipment and Containers 7-1
7.3 Frequencies and Procedures 7-1
8.0 Assessments, Audits, and Surveillances 8-1
8.1 Organizational Assignments 8-1
8.1.1 Responsibilities 8-1
8.1.2 Authorities and Qualifications of Inspectors and Auditors 8-1
8.2 Annual Audits 8-2
8.2.1 Verification and Validation of License Compliance and ALARA 8-2
8.3 Daily and Weekly Operational Inspections 8-3
8.3.1 Daily Inspections 8-3
8.3.2 Weekly Inspections 8-3
8.3.3 Monthly RSO Reports 8-4
8.3.4 Quarterly Storage Pond Inspections 8-4
8.3.5 Annual Technical Evaluation of Storage Ponds 8-4
8.4 Safety and Environmental Review Panel (SERP) 8-4
8.5 Assessment, Audit, and Surveillance Reports 8-4
8.6 Documentation and Record Retention Requirements 8-4
9.0 Preventive and Corrective Actions 9-1
10.0 References* and Pertinent Bibliography 10-1
11.0 Glossary and Acronyms 11-1

APPENDIX A - Sample Chain-of-Custody Form

EXECUTIVE SUMMARY

This Quality Assurance Project Plan (QAPP) has been prepared to ensure the quality of the results of measurements, required by United States Nuclear Regulatory Commission (USNRC) Regulatory Guide (RG) 4.14, of radioactive materials in the effluents and the environment at the Lost Creek Uranium Recovery Facility located near Bairoil, Wyoming in accordance with USNRC RG 4.15, Rev 2 (June 2007).

This QAPP is a component of Lost Creek ISR, LLC's (LCI) Lost Creek (LC) Project Environment, Health and Safety Management System (EHSMS). It defines objectives, goals and requirements for radiological effluent and environmental monitoring Quality Assurance (QA). These elements of the QAPP are in-line with applicable federal, state, and local regulatory requirements as well as institutional goals. While the QAPP provides a framework, Standard Operating Procedures (SOPs) developed for the Project shall provide the means for implementation of QAPP elements.

This QAPP documents (by reference where appropriate) key positions and responsibilities for QA during the Project, how data will be collected, assessed, and analyzed, as well as providing a blueprint of where, when, why, and how the Project will achieve data of the type and quality needed and expected to produce valid results. Following the objectives set out within this QAPP is an important method for ensuring compliance with USNRC requirements for radiological effluent and environmental monitoring at the Project. As discussed within this QAPP, continuous improvement processes will be used to ensure that quality of measurements and evolution of the QAPP are maintained as necessary. This process includes involving and empowering staff, supporting ideas for improvements, and evaluation of QA processes to identify areas of potential improvement. The QAPP provides the framework that continually improves the effectiveness of the management system through the use of quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions and management review.

Measurement of radionuclides generated at the LC Project is essential for the assessment of the potential for worker and public exposure. This QAPP ensures the quality of these measurements which are performed to facilitate minimization of adverse impacts to employee and public health and the environment, as well as to comply with the USNRC and other regulatory requirements for monitoring at uranium recovery facilities during pre-operational baseline monitoring through the operational and reclamation periods until license termination.

The QAPP is written consistent with recommendations outlined in the USNRC RG 4.15, *Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment* (USNRC 2007), USNRC RG 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills* (USNRC 1980), and

USNRC RG 8.31, *Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities will be As Low As is Reasonably Achievable* (USNRC 2002).

ES.1 Overview of the Radiological Effluent and Environmental Monitoring Program

The monitoring of surface waters, groundwater, soils, air, foodstuffs and biota is conducted to determine the impact of uranium recovery operations at the LC site on human health and the environment. The activities conducted under this program include the collection of surface waters, groundwater, waste waters, air, soils, foodstuff biota, and non-foodstuffs biota from the LC site including operational and non-operational areas. Other operations conducted under this program include sample shipment, sample preparation, sample analysis, data analysis, verification and validation (V&V), data on records management, and report writing.

ES.2 Conditions to be Monitored

Samples of surface and subsurface soil, groundwater, surface water, storage pond liquids, solution spills, biota (vegetation and biologic tissue), and air will be collected at various locations on and around the LC uranium recovery site. These samples are analyzed for radionuclide content in accordance with RG 4.14 requirements. These data are used to determine source terms from the facility and radionuclide content in the materials and to assess potential uptake in plants, animals, and humans and for dose assessment. The data are also used to monitor potential changes and/or trends in environmental levels of radionuclides over time.

ES.3 Quality Assurance Project Plan Purpose

This Radiological Effluent and Environmental Monitoring QAPP describes the policies and requirements to ensure that all radiological effluent and environmental samples are collected, analyzed, reported, and verified and validated in the manner specified herein in accordance with RG 4.14 and 4.15 requirements.

ES.4 Project Organization

The LC Radiological Effluent and Environmental Monitoring Program is under the direction of the Manager EHS and Regulatory Affairs and Radiation Safety Officer utilizing various trained technicians to conduct the sampling and analysis activities.

Various other organizations and subcontractors may be utilized, as necessary, to facilitate the execution of monitoring activities specified in this plan.

1.0 INTRODUCTION, ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES OF MANAGERIAL AND OPERATIONAL PERSONNEL AND APPLICABLE STANDARDS

1.1 INTRODUCTION

LC Project is committed to the design, implementation, and management of a Radiological Effluent and Environmental Monitoring QAPP for the LC Project. LC Project management will ensure that the QAPP is consistent with recommendations outlined in USNRC Regulatory Guide (RG) 4.15, *Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment* (USNRC 2007), USNRC RG 4.14*, *Radiological Effluent and Environmental Monitoring at Uranium Mills* (USNRC 1980), and USNRC RG 8.31, *Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities will be As Low As is Reasonably Achievable* (USNRC 2002), which provide acceptable methods for the design and implementation of a QAPP.

* The guidance provided by NRC Regulatory Guide 4.14 is summarized for each program component in the LC ISR Project Technical Report (TR) Sections 2.9 and 5.7.7. However, it must be recognized that this regulatory guide was written some years ago relative to the design and layout of conventional uranium mills. Accordingly, some modifications were made in the design and execution of the radiological effluent and environmental monitoring programs to accommodate the uranium ISR design, site layout and technology. Deviations as a result of the ISR technology are explained in the text of the Technical Report and justification is provided to assure that the intent of Regulatory Guide 4.14 has been preserved. Many of these deviations are supported by guidance presented in NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications". Modifications and deviations from Regulatory Guide 4.14 that are presented in NUREG-1569 have been considered valid and compliant with current NRC standards for modern ISR facilities such as the LC Project.

QA comprises those planned and systematic actions necessary to provide adequate confidence in measurements, and the assessment of those measurements. QA includes quality control (QC) which consists of those QA actions that provide a means to measure and control the characteristics of measurement equipment and processes to meet established standards and requirements. QA/QC processes are needed to eliminate, minimize, identify, and mitigate deficiencies in the sampling and measurement processes and report them to those responsible for these operations so that LC may take corrective action. These processes also provide a mechanism to establish and maintain a level of confidence in the results of the monitoring program to assure the regulatory agencies, workers and the public that the results are valid.

The purpose of a QAPP is to ensure that all measurements that support the radiological effluent and environmental monitoring programs are reasonably valid and of a defined quality, that personnel are adequately trained to safely perform their job functions, and that a regular schedule of audits and inspections is conducted to verify safe and compliant performance in all aspects of operations. This QAPP will comply with the requirements and regulations of licensing as well as

institutional goals. It will be documented by written policies, procedures or instructions, and will be carried out throughout the life of the project in accordance with those policies, procedures or instructions.

The Project's Environment, Health and Safety (EHS) administrators have developed a robust EHSMS which addresses quality in all aspects of operations and during all operational time periods, including design, construction, start-up and operation, as well as during decommissioning, reclamation, and long-term stabilization. Quantitative and qualitative QA criteria and responsibilities were established for the design and construction of the Project, as found within the NRC License Application TR, Sections 1.6 and 5.1. To avoid redundancy with the TR, reference will be made to applicable section(s) within the TR to quantitative and qualitative QA criteria established therein.

The Project's Radiological Effluent and Environmental Monitoring QAPP and LC Project SOPs identify the radiological effluent and environmental monitoring systems covered by the QAPP, and the major organizational elements participating in the program along with the designated functions of these elements. The QAPP will provide control over activities affecting the quality of the identified in-plant, radiological effluent and environmental monitoring systems, to an extent consistent with their importance to safety. Activities affecting quality will be accomplished under suitably controlled conditions. Controlled conditions include the use of appropriate equipment; suitable environmental conditions for accomplishing the activity, such as adequate cleanliness; and assurance that all prerequisites for the given activity have been satisfied. The QAPP will take into account the need for special controls, processes, test equipment, tools, and skills to attain the required quality, and the need for verification of quality by inspection and test.

Finally, QA during decommissioning, reclamation, and long-term stabilization of the LC Project will be performed in accordance with state and federal regulatory requirements. Federal regulatory requirements from NUREG 1757, 10 CFR 40 Appendix A criterion, and RG 4.14 (USNRC 1980) will be followed (See TR Section 5.7.9 and the Environmental Report Section 8.1). These QA requirements will include the outline for the type, quantity, and accuracy of measurements needed to determine that the site has been radiologically restored to conditions in accordance with regulatory requirements.

Corrective action measures are mandated by the QAPP, and implemented by LC Project SOPs, which will ensure that conditions adverse to quality are minimized, if not eliminated, and identified and corrected as necessary.

The regulatory drivers for the Radiological Effluent and Environmental Monitoring QAPP include, but are not limited to:

- 10 CFR Part 20, Standards for Protection Against Radiation
- 10 CFR Part 40, Domestic Licensing of Source Material
- USNRC Regulatory Guide 4.14, Section 3 and Section 6, Revision 1 April 1980, *Radiological Effluent and Environmental Monitoring at Uranium Mills*
- USNRC Regulatory Guide 4.15, Revision 2 July 2007, Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) - Effluent Streams and the Environment
- Lost Creek ISR, LLC Project USNRC License Application Casper, Wyoming, April 2010
- Applicable Wyoming Department of Environmental Quality Regulations

1.2 CORPORATE MANAGEMENT COMMITMENT

LC Project is committed to the design, implementation, and management of a Radiological Effluent and Environmental Monitoring QAPP for the LC Project to ensure quality in all aspects of radiological effluent and environmental monitoring.

The QAPP will address the following topics:

- management and operation of the radiological effluent and environmental monitoring programs;
- QAPP functions, and documentation; and
- authorities, duties and QAPP responsibilities of the organizational positions.

LC Project personnel or contracted organizations conducting QAPP functions will be given sufficient authority and organizational freedom: to identify quality problems, to initiate recommend or provide solutions; and to verify implementation of solutions. Reporting will be at the managerial level, independent of activity performance, costs, and schedule.

1.3 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES

This section designates the authority and duties of persons and organizations performing management and operation activities which affect the QA functions of in-house radiological effluent and environmental monitoring systems and components. The authorities, duties, and responsibilities of the positions within the organization responsible for developing, reviewing, approving, implementing, and enforcing the QAPP are designated. This includes radiological safety, radiological effluent and environmental monitoring and compliance. It also includes responsibilities for review and approval of written procedures as well as the preparation, review, and evaluation of monitoring data and reports related to the QAPP. These activities include both

the performance functions responsible for achieving quality objectives and the QA functions. The QA functions are those that (1) assure appropriate QA processes are established and effectively executed; and (2) verify, such as by checking, auditing, and inspecting, that activities affecting the radiological effluent and environmental monitoring functions have been correctly performed.

Persons and organizations performing QA functions will have sufficient authority and organizational freedom to identify quality problems; to initiate, recommend, or provide solutions, and to verify implementation of solutions. The persons and organizations performing QA functions report to a management level so that the required authority and organizational freedom, including sufficient independence from cost and schedule responsibilities when potentially in conflict with safety considerations, will be provided. Irrespective of the organizational structure, the individuals assigned the responsibility for assuring effective execution of any portion of the QAPP will have direct access to the levels of management necessary to perform this function. The implementation and effectiveness of a successful QAPP is the responsibility of everyone involved with the LC Project.

Management and operation of monitoring programs at the Project are the responsibility of several key positions. Those positions are:

1) LCI President;
2) LCI Vice President;
3) Mine Manager;
4) Radiation Safety Officer (RSO); and
5) Manager EHS and Regulatory Affairs
6) Department Heads.

The responsibilities of these positions are described below. The qualifications and training of these positions are described in QAPP **Section 2.0** (these positions and responsibilities are discussed within the TR Section 5.1, *Corporate Organization and Administration).*

1.3.1 President

The LC President maintains ultimate responsibility for all operations and activities for the LC Project, including providing direction to Project management and employees regarding the QAPP. The President will ensure that persons and organizations performing QA functions will have sufficient authority and organizational freedom to identify quality problems; to initiate, recommend, or provide solutions; and to verify implementation of solutions.

1.3.2 Vice President

The Vice President will have the responsibility and authority for LC ISR, LLC's EHS, radiation safety, environmental compliance, and QA at the Project and LC ISR, LLC's other development activities. This person will provide input to the RSO to ensure that all EHS, radiation safety, environmental compliance, QA and permitting/licensing programs are conducted in a responsible manner, and in compliance with all applicable regulations and permit/license conditions. The Vice President shall assist the Mine Manager in the annual review and resulting documentation of the EHS Management System.

1.3.3 Mine Manager

The Mine Manager reports to the LC President and is responsible for day-to-day operations such as implementing managerial and financial actions that affect mining operations, as well as the EHSMS, including the QAPP. The Mine Manager will assist in the development, administration, and enforcement of the QAPP as well as technical review, evaluation, and participation in routine audits of the QAPP. The Mine Manager also provides technical guidance and assistance concerning mining operations and activities. The Mine Manager has the responsibility and authority to immediately suspend, postpone, or modify an action or any work which may be deemed threatening to human health or the environment or deemed in violation of state and federal permitted and licensed regulations.

1.3.4 Radiation Safety Officer (RSO)

The RSO reports to the LCI Vice President and is responsible for day-to-day operations of the EHSMS and radiation safety programs of the Project, and will not have direct production responsibilities allowing sound decisions regarding EHS and radiation safety without undue production concerns. This individual's responsibilities will include implementing the QAPP.

1.3.4.1 Health Physics Technician

The Health Physics Technician (HPT) shall assist the RSO with the implementation of the QAPP. The HPT reports directly to the RSO.

1.3.5 Manager EHS and Regulatory Affairs

The Manager of EHS and Regulatory Affairs will have the responsibility and authority for LCI's radiation safety, environmental compliance, and quality assurance programs at the Project. This person works in

conjunction with the RSO in implementing the QAPP. The Manager of EHS and Regulatory Affairs reports directly to the Vice President.

1.3.6 Department Heads

The Department Heads report to the Mine Manager. They are responsible for the site's operational and maintenance activities and procedures. Department Heads shall enforce compliance with all facets of the EHSMS, including the QAPP. Development and review of procedures involving QAPP will be coordinated with the RSO.

1.3.7 Safety and Environmental Review Panel (SERP)

Per recommendations and/or requirements of the USNRC (e.g., RG 8.31, license conditions, etc.), a SERP is established to integrate the various roles that support the operation and maintenance of the LC Project as described in TR Section 5.2.2. Accordingly, changes to the QAPP may be referred to the SERP, as applicable, per LC Project's SOP AD-003 "Safety and Environmental Review Panel".

1.4 SUMMARY OF MAJOR ELEMENTS OF THE QAPP

This QAPP is a prescribed radiological effluent and environmental monitoring plan that will generate reasonably valid data of a defined quality. The QAPP is designed to:

- Ensure necessary Data Quality Objectives (DQO) are integral to specific monitoring programs, as noted in EPA (2006), which provides development examples to define acceptance and performance criteria;
- Plan for radiological effluent and environmental monitoring that documents data collection, analysis, assessment, and how to achieve expected data quality (TR 5.7.9);
- Provide for formal delineation of organization structure and management responsibilities; responsibility for both review/approval of written procedures and monitoring data/reports is provided;
- Define minimum qualifications and training programs for individuals performing radiological effluent and environmental monitoring and those individuals associated with the QAPP;
- Identify needs for written procedures for QA activities; these procedures include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting;
- Ensure procedures for QC in the laboratory, cover statistical data evaluation, instrument calibration, duplicate and spike samples; outside laboratory QA/QC programs are included;

- Define requirements for periodic management audits to verify that the QAPP is effectively implemented, to verify compliance with applicable rules, regulations, and license requirements, and to protect employees by maintaining radiological effluent releases and exposures ALARA;
- Define QA procedures, as described in RG 4.14, Sections 5 through 7, to ensure the quality of samples, to ensure that lower limits of detection consistent with the RG 4.14 requirements have been established for sample and measurement precision and accuracy, and to ensure recording and reporting of results;
- Establish that the QA records include: operating logs, results of reviews, inspections, tests, audits, and materials analyses. The records may also include data such as qualifications of personnel, procedures, and equipment. Testing and inspection records will identify the inspector or data recorder, the type of observation, the results, the acceptability, and any actions taken regarding deficiencies noted. Operational records will be identifiable and retrievable, and be retained by the RSO until license termination at the mine site (See QAPP **Section 4.0**); and
- Establish the QA auditing plan, providing that QA procedures will be audited annually by qualified individuals, but also providing that more frequent follow-up audits will be conducted, as necessary, to ensure effectiveness of program corrections. The audits will be conducted by qualified individuals.

2.0 PERSONNEL QUALIFICATIONS AND TRAINING

2.1 INTRODUCTION ON QUALIFICATIONS AND TRAINING

LC Project employees and staff will have proper qualifications for the positions they hold. The qualifications for personnel conducting the Radiation Safety Program (RSP) are provided in TR Section 5.4. These individuals are thereby also responsible for the QAPP as a component of the RSP. The personnel qualification standards were developed to be in compliance with USNRC RG 8.31, Sections 2.4, *Technical Qualifications of Health Physics Staff*, and 2.5, *Radiation Safety Training*. Per TR 5.7.9.2, applicable guidance and criteria in Section 2.3.1 of ANSI/ASQC (1994) and Section 2 of USNRC RG 4.15 is also considered regarding personnel development, training and qualification specifications.

Individuals with responsibility for performing quality-related activities will be trained and qualified in the principles and techniques of the activities to be performed. These individuals will maintain proficiency by retraining, re-examining, and recertifying or by periodic performance reviews, as appropriate. Continual training, through on-the-job and refresher training, will be conducted as needed to ensure that personnel maintain awareness of events and issues that could affect the quality of performance (USNRC 2007). This will include communication of events, lessons learned, and other issues to maintain awareness of activities that could affect the quality of performance.

2.2 RADIATION SAFETY TRAINING

Radiation safety training will be conducted per TR 5.5 as part of the EHSMS training program in accordance with applicable SOPs. After completion of training, employees and contractors will be required to sign a statement that they have received radiation safety training. The statement will outline the extent of the training and the dates when the training was received. The statement will also be signed by the instructor. These statements, as well as records of training program syllabus, dates of administration, attendance lists, and records of exam results will be maintained until license termination.

3.0 OPERATING PROCEDURES AND INSTRUCTIONS

LC Project EHSMS (TR 5.2) defines the Project's process for establishing and maintaining SOPs and Radiation Work Permits (RWP). The procedures are detailed in applicable SOPs. TR 5.7.9.3 further specifies written procedure requirements for all activities which generate data.

The Radiological Effluent and Environmental Monitoring Program will have written procedures for all activities that generate data, such as: sample collection, sample management and chain of custody documentation, sample preparation and analysis, data reduction and recording, data assessment and reporting, and final sample disposal. Qualified individuals will participate in preparation, review, and revision of these procedures.

The project SOPs are maintained in the EHSMS manuals in the EHS office at the project site.

4.0 RECORD KEEPING AND REPORTING REQUIREMENTS

In accordance with LC Project policy (TR 5.2.1), LC Project records, including QAPP records, will be maintained as hard copy originals or stored electronically in accordance with the requirements of 10 CFR 20 Subpart L and 10 CFR 40.61. Records will be readily available for regulatory inspection and may be transferred to the NRC after license termination. Records will also be provided to a new owner or new licensee in the event that the property or license is transferred (TR 5.7.9.4).

The RSO will be responsible for ensuring that LC Project EHSMS records are maintained and controlled with adequate safeguards against tampering and loss.

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 LC Project 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.

Any contractor or subcontractor performing support program activities shall retain records sufficient for LC Project to verify QA.

4.1 TYPES OF DOCUMENTS, RECORDS AND REPORTS

The LC Project will generate and maintain sufficient records and reports of Project conduct and performance to demonstrate Project regulatory compliance including adherence to the guidance of RG 4.15. These records and reports include but are not limited to:

- Records as described in **Section 4.3** of this QAPP;
- Records required by 10CFR Part 20 Subpart L;
- Reports required by 10CFR Part 20 Subpart M;
- Records of the training syllabus, dates of administration, attendance lists and records of exam results will be maintained in employee records;
- Records of equipment calibration, field calibration, repair or replacement of controlled instruments;
- Chain-of-Custody records;

- Equipment release records and associated instrument calibrations;
- Instrument daily function check records;
- Personnel contamination surveys at frisking stations;
- Field survey and analytical laboratory reports; and
- Standard Operating Procedures.

Reports are prepared as listed in TR Table 5.2-1. Additional reports may need to be prepared as required by corporate or regulatory specifications and/or license conditions.

LC Project will maintain a system that produces unequivocal, accurate records that document all monitoring activities including records of implementation of ongoing activities in accordance with the recommendations of RG 4.15 Section C.4. Specific content, format and record keeping details are included in the SOPs pertaining to the various monitoring elements of the Radiological Effluent and Environmental Monitoring Program.

4.1.1 Field Documentation

Field documentation requirements are specified in the sampling procedures. Any data entered on field, paper forms 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 for data entry will be available at the work site. The RSO or HPT 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.

4.1.2 Field Variance and Non-conformance Documentation

Changes from specified field protocols established in planning documents or standard operating procedures must be authorized by the Manager EHS and/or 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.

4.2 VALIDATIONS AND VERIFICATION (V&V) OF ACCURACY AND COMPLETENESS

Validation and verification methods used by LC Project for verification of field, sample analysis and calibration records are consistent with the guidance provided by RG 4.15 (USNRC 2007, Section C.8). MARLAP, Chapter 8, will be used as a guide for V&V of analytical data resulting from application of Project SOPs. Specific V&V requirements will be defined in each SOP resulting in a data set.

The RSO and Manager EHS are responsible for initiating the V&V process for critical aspects and activities, whose failure could have an impact on EHS. The RSO and EHS Manager are responsible to review and initial logbooks, QC reports, and forms on a recommended monthly basis for accuracy and completeness. The RSO and Manager EHS will review and approve the V&V results.

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.

Analytical and survey data and instrument calibrations will be reviewed and V&Ved by a qualified person(s) not involved in the production of the data.

Calculation steps are described in the technical and analytical procedures and software documentation. The calculations will be verified by knowledgeable individuals prior to initial use. Computer programs and spreadsheets used in the implementation of the radiological monitoring and radiological effluent and environmental monitoring program will be documented, verified, and validated before initial routine use and after each modification of the computer program. V&V performed by the vendor of commercially available software is acceptable as long as an onsite check of software output is performed and documented before the first use of the software. Additionally, routine data-transfer and data-entry verification checks will be performed.

4.2.1 Field Measurement Data

The objective of field data verification is to ensure that data are collected in a consistent manner and in accordance with approved procedures and per required schedules. 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 Manager EHS 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 (USNRC 2007, ISO 17025 2005). The erroneous material must not be obscured. The person validating the document, with the consent of the RSO or EHS Manager may also determine that incorrect data should not be entered into a database or that the data should have an additional qualifier.

4.2.2 Laboratory Data

External laboratories performing analyses will document the analytical data in accordance with standard procedures inherent in the analytical methods and as approved by the RSO and/or Manager EHS. 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 determine 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.

4.2.3 Quality Control Samples

Any applicable QC samples that may consist of field duplicate samples (replicated or co-located samples including thermoluminescent dosimeters and radon track-etch detectors), laboratory spikes, laboratory blanks, laboratory duplicates, and laboratory control samples are evaluated in the data validation process. The number and frequency of laboratory QC samples will be individually determined by an individual qualified to perform the test in question. The QC sampling procedures will be discussed in each respective SOP.

4.2.4 Qualification of Data and Corrective Actions

Qualification criteria are defined in the LC Project procedures. In addition to the process of qualifying the data, other corrective actions may be used. These may include re-analysis 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.

4.2.5 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.

4.2.6 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.

4.2.7 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.

4.2.8 Follow-up Actions

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

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

Based on the results of the follow-up action, the RSO and/or Manager EHS 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.

4.2.9 Data Qualification

After it has been determined that a data point is anomalous, the data point will be qualified as unusable or rejected in the database. Qualification of data will be noted with a brief justification for the rejection.

4.3 PRESERVATION OF RECORDS AND RECORD RETENTION

LC Project records will be legible and identifiable, retained in predetermined locations, and protected against damage, deterioration, or loss. Hard copy records, as applicable, of the Radiological Effluent and Environmental Monitoring Program will be maintained in the EHSMS files at the project site EHS office(s). Electronic records will be retrievable from the on-site LC Project servers. The LC Project electronic data is backed up nightly to Ur-Energy servers. Records will be maintained in a format that is easily retrievable. If the media for storage is electronic (as opposed to paper or microfilm/fiche), LC Project will maintain the equipment necessary to read and present the data in an uncorrupted form. The document retention system will allow reconstruction of all activities associated with the generation of analytical results including record corrections. LC Project retention time for records is consistent with licensing conditions and regulations as follows:

- Records of radiation safety technician logs and inspections shall be retained for three years.

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

    - Instrument calibrations not utilized to determine employee dose;
    - Equipment release records and associated instrument calibrations;
    - Records showing the results of surveys and calibrations required by 10 CFR §§ 20.1501 and 20.1906(b) and will reflect updated 10 CFR 20 requirements;
    - Records required by 10 CFR Part 40, Appendix A, Criteria 8A (daily inspections of waste retention systems);
    - Instrument daily function check records; and
    - Personnel contamination surveys from frisking stations.

- The following significant information will be permanently maintained and retained until license termination:

    - Records of the receipt, transfer, and disposal of any source or byproduct material processed or produced at the facility;
    - Records of on-site radioactive waste disposal such as by deep well injection, discharge, or burial under 10 CFR 20.2002 and 20.2007;
    - Records of the training syllabus, dates of administration, attendance lists and records of exam results will be maintained in employee records (TR 5.5.1);
    - Records of surveys, calibrations, personnel monitoring and bioassays as required by 10 CFR §20.2103 (b);
    - Records of the results of surveys to determine the dose from external sources and used in the absence of or in combination with individual monitoring data, in the assessment of individual dose equivalents;
    - Records of the results of measurements and calculations used to determine individual intakes of radioactive material and used in the assessment of internal dose;
    - Records showing the results of air sampling, surveys, and bioassays required pursuant to 10 CFR § 20.1703(c)(1) and (2);
    - Records of the results of measurements and calculations used to evaluate the release of radiological effluents to the environment,
    - Records of evaluations made by the SERP including proceedings and audits (TR 5.2.2.3). The records will include, but are not limited to:

- a description of the proposed change, test or experiment;
- the names and titles of each SERP member;
- the findings of each point outlined in TR 5.2.1.2; and
- conclusions and recommendations of the SERP including required actions, deadlines, and assignment of responsibility.

These records shall be maintained by the RSO and/or Manager EHS with copies distributed to the Mine/Operations Manager and the Vice President. An annual report summarizing all SERP actions will be submitted to the NRC.

- Records containing information important 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;
- Reports of Inspections of Storage Ponds;
- As-built drawings and photographs of structures, equipment, restricted areas, wellfields, areas where radioactive materials are stored, and any modifications showing the locations of these structures and systems;
- Records of the Health Physics Program, including program revisions, standard operating procedures, radiation work permits, training and qualification records;
- Records to demonstrate compliance and to help in evaluating dose, intake, and releases to the environment;
- Records of disposal of 11.e(2) byproduct material at an appropriately licensed radioactive disposal facility or other licensee authorized to receive same, in accordance with Title 10 of the CFR, Part 61 or NRC Agreement State equivalent regulations; and
- Records of management and disposal actions for the UIC Class I and V wells, based on WDEQ requirements.

4.3.1 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 (USNRC 2007).

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.

4.4 ELECTRONIC MEDIA

Electronic records and data will be processed on password protected operating systems. Computer software or databases containing the information will also be password protected. Systems with connections to the internet or receiving data from external sources, e.g., flash drives, CDs, etc., will have anti-virus and firewall protection to the extent practical.

Backup of critical data will be performed for onsite and off-site storage media daily.

LC Project will ensure that electronically archived material continues to be retrievable when operating systems, application software or storage media technologies change.

4.5 REPORTING REQUIREMENTS

The results of the Radiological Effluent and Environmental Monitoring Program shall be reported to the NRC semi-annually as required by 10 CFR 40.65.

Additionally, in accordance with the requirements of 10 CFR 20 Subpart M, LC Project will report all spills, lined storage pond leaks, excursions of recovery solutions, or process chemicals to the NRC Headquarters Project Manager by telephone or electronic mail within 48 hours of the event if the event may result in an exceedance of the limits described in 10 CFR 20 Subpart M. This notification will be followed by submittal of a written report to the NRC Headquarters Project Manager detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved within 30 days of the notification.

LC Project will document findings, communication of corrective actions and finding closeout processes for all assessments, audits, and surveillances as defined in **Section 8.5**, Assessment, Audit and Surveillance Reports.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL OF RADIOLOGICAL EFFLUENT AND ENVIRONMENTAL MONITORING DATA AND SAMPLES

5.1 REGULATORY REQUIREMENTS AND LIMITS

The regulatory drivers for the Radiological Effluent and Environmental Monitoring QAPP include, but are not limited to:

- 10 CFR Part 20, Standards for Protection Against Radiation
- 10 CFR Part 40, Domestic Licensing of Source Material
- USNRC Regulatory Guide 8.30, Health Physics Surveys In Uranium Recovery Facilities
- USNRC Regulatory Guide 8.31, Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable
- USNRC Regulatory Guide 8.22, Bioassay at Uranium Mills
- 10 CFR Part 61, Licensing Requirements for Land Disposal of Radioactive Waste
- USNRC Regulatory Guide 4.14, Section 3 and Section 6, Revision 1 April 1980, Radiological Effluent and Environmental Monitoring at Uranium Mills
- USNRC Regulatory Guide 4.15, Revision 2 July 2007, Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) — Effluent Streams and the Environment
- NUREG-1569 - Standard Review Plan for In Situ Leach Uranium Extraction License Applications
- NUREG-1576, Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP), July 2004
- Applicable conditions of the NRC source material license
- Applicable Wyoming Department of Environmental Quality Regulations
- Wyoming Department of Environmental Quality, 2001; source: WDEQ, Wyoming Surface Water Classification List, 2001
- Wyoming Department of Environmental Quality 1997; source: Wyoming Water Quality Rules and Regulations, Chapter 21, Standards for Reuse of Treated Wastewater, October 1997

5.1.1 Regulatory Limits

The LC Project will operate in compliance with all radiological and environmental regulatory limits as described in the LC Project TR, NRC regulations, and license conditions throughout all

pre-operational, operational, aquifer restoration and decommissioning/reclamation phases of the project including, but not limited to, the following:

Occupational Exposure Limits

- Regular plant workers will be provided personal monitoring devices, such as optically stimulated luminescence (OSL) badges, thermoluminescent dosimeters (TLD) or other device approved by the RSO. LC Project will determine routine monitoring requirements in accordance with the NRC guidance R.G. 8.30 (NRC 2002b), R.G. 8.34 (NRC 1992a) and R.G. 8.36 (NRC 1992b). Nonetheless, LC Project believes that it is unlikely that any employee working at the LC Project will accrue a dose approaching 10 percent of the regulatory limit and therefore require monitoring per 10 CFR 20.1502(a)(1) (i.e., 10 percent of 5 rem or 500 mrem/yr). Dosimeters will be provided and/or analyzed by a vendor that is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology. (TR 5.7.2);
- Demonstrate compliance with the occupational dose limits for workers, specified in 10 CFR 20.1201, and DAC/ALI values specified in 10 CFR 20, Appendix B, Table 1;
- Determine if an area needs to be posted in accordance with NRC regulations found in 10 CFR 20.1902(d);
- Determine whether additional precautionary measures of engineering controls or respiratory protection are required to comply with 10 CFR 20.1701 and 20.1702;
- Determine whether occupational exposures to radioactive materials are being maintained ALARA.

Radiological Effluent and Environmental Exposure Limits

The effluent control systems proposed at the LC Project include existing technologies that have demonstrated success at controlling effluents using specific procedures, training, and engineering controls to reduce effluent production and minimize the potential for accidental releases. The proposed monitoring and control systems will be located to optimize their intended function and are appropriate for the types of effluents generated during ISR construction, operation, aquifer restoration and decommissioning. Control procedures include recycling/reusing materials through segregation of waste, careful control of all materials delivered to or transported from the project area in accordance with US DOT requirements, extensive employee training in hazard recognition and prevention of accidental releases, use of signage, detailed SOPs and Spill Prevention/Response Plans, and use of engineering controls for all types of effluent. The SOPs and spill prevention plans (see OPS-021 “Spill Management”) address contingencies for all reasonably expected system failures and include appropriate personnel to be notified, measures to efficiently detect and

mitigate a release to the environment and confirmation that the SOPs comply with notification requirements (TR 4.0).

5.2 RADIOLOGICAL MONITORING QA/QC

5.2.1 Overall Objectives

LC Project will comply with all applicable laws, regulations, and requirements of the NRC and other regulatory agencies. The responsibilities and objectives described below have been designed to ensure compliance and further implement a policy for providing a safe working environment that is protective of the environment with cost effective incorporation of the philosophy of maintaining radiation exposures As Low As Reasonably Achievable (ALARA) for all employees, contractors, visitors and the public.

In order for an ALARA program to correctly function, all individuals including management, supervisors, health physics staff and workers, must take part in and share responsibility for keeping all exposures ALARA. This QAPP addresses this need and also, with the LC Project TR, describes the responsibilities of each level in the organization.

QA as part of worker radiation protection and radiological effluent and environmental monitoring program is a component of:

- External Radiation Exposure Monitoring for onsite and perimeter locations;
- Airborne Radiation Monitoring for onsite and off-site locations;
- Bioassay for workers; and
- Contamination Control.

Activities affecting quality will be accomplished under suitably controlled conditions. Controlled conditions include the use of appropriate equipment; suitable environmental conditions for accomplishing the activity, such as adequate cleanliness; and assurance that all prerequisites for the given activity have been satisfied. QA will take into account the need for special controls, processes, test equipment, tools, and skills to attain the required quality, and the need for verification of quality by inspection and test. QA will provide for indoctrination and training of personnel performing activities affecting quality, as necessary, to assure that suitable proficiency is achieved and maintained.

The RSO and/or Manager EHS shall regularly review the status and adequacy of LC Project QA. Section 5.3.1.3 of the TR specifies monthly reports which include a review of all monitoring and exposure data for the month. The RSO's monthly review will address any trends or deviations in

monitoring data and recordkeeping which includes QA/QC deviations, if any. Section 5.2.1 of the TR states that SOPs related to handling, processing, storing, or transporting radioactive materials and all health physics related SOPs will be annually reviewed by the RSO which includes QA/QC aspects of the procedures. Thus, Environmental and Effluent Monitoring SOPs address QA/QC issues relevant to monitoring to ensure quality results, and the RSO's annual review will address the associated QA/QC procedures as necessary. Data sets for environmental and effluent monitoring, which include QA/QC as applicable, are evaluated on a quarterly or semi-annual basis as they are compiled into the routine reports submitted to agencies.

5.2.2 Survey Methods for Radiological Exposure Monitoring

Passive gamma, air particulate and radon measurements are conducted in the vicinity of the project site to determine the potential dose to the general public from off-site emissions. Due to the remoteness of the facility, the administrative and engineering controls to be implemented and the nature of ISRs, the potential for a member of the public to be exposed to radon levels exceeding the limits outlined in 10 CFR §20.1301 is minimal. Radon is the only effluent which will be allowed to routinely leave the controlled site in a manner which may allow a dose to a member of the public (TR 4.1.2.2). Radiological effluent and environmental monitoring will be conducted according to established procedures prepared under the guidance of RG 4.14 and 4.15 and in accordance with the applicable requirements of 10 CFR 20, 10 CFR 40 and license conditions.

Health physics surveys are performed to protect workers at uranium recovery (UR) facilities (e.g., ISR facilities) from radiation exposures in excess of background and the chemical toxicity of uranium while on the job. The LC Project will perform occupational exposure surveys according to established procedures prepared under the guidance of RG 8.30 and 8.31 and in accordance with the requirements of 10 CFR 20 and license conditions.

Specific requirements and methods to be used for conducting radiological surveys, for measurements and calculations to assess exposure of workers, and for radiological effluent and environmental monitoring are defined in Radiation Safety and Environmental Monitoring Procedures as summarized in TR Section 5.7.

5.2.3 Quality Control of Radiological Exposure Monitoring Measurements

The QAPP requires a rigorous system of checks to ensure samples are being collected and analyzed properly. Specific details of the QC related to each sample type or monitoring procedure are listed in the applicable SOPs and in the LC TR Section 5.7. QC procedures are developed according to the guidance of RGs 4.14 and 4.15 for radiological effluent and environmental monitoring and in RGs 8.30 and 8.31 for occupational monitoring.

The radiological effluent and environmental monitoring program will generate valid data of a defined level of quality. The monitoring procedures must be designed to identify sampling and measurement processes, including any deficiencies and report them, and provide confidence that the monitoring results can be validated. The monitoring process will involve QA for analytical sampling, sample shipments, chain-of-custody documentation and laboratory QA and for radiological measurement data reduction, data evaluation, and reporting.

5.3 RADIOLOGICAL EFFLUENT AND ENVIRONMENTAL MONITORING QA/QC

5.3.1 Overall objectives

The primary objective of the Radiological Effluent and Environmental Monitoring QA/QC is to ensure that all radiation safety and radiological effluent and environmental monitoring measurements are conducted in a responsible manner, and in compliance with all applicable regulations and the conditions of the NRC license.

5.3.2 Airborne Radiological Effluent and Environmental Monitoring

Airborne radiological effluent and environmental monitoring will be carried out as recommended in NRC RG 4.14 and as described in Section 2.9, Section 5.7.7, and Section 5.7.8 of the TR. Air particulate samples will be collected continuously at the five Air Particulate Sampling Locations and used to determine U-nat, Th-230, Ra-226, and Pb-210. Air filters will be collected weekly (at least bi-weekly if weather conditions preclude weekly collection) and composited quarterly for each sampler unit and analyzed quarterly.

Radon gas will be monitored continuously (TR Figure 2.9-27) with quarterly analysis using Rapidos® alpha track etch detectors or equivalent. At least one location shall have two monitoring devices as part of QA/QC. In accordance with RG 4.14, the device shall be able to provide a lower limit of detection (LLD) of 0.2 pCi/L. Landauer's published minimum detection level (MDL) for their Rapidos® alpha track detectors is 0.108 pCi/L over 90 days. Other manuafacturers' track etch detector MDL or LLD will be evaluated and compered to the RG 4.14 detection limit requirement prior to use, as applicable.

For differing applications the LC Project RSO may vary placement durations to provide desired information; however, it will be important to be cognizant of the varying detection limits with respect to requirements and commitments. For example, during the years of LC Project baseline radon monitoring the ambient radon levels are consistently near 2 pCi/L (i.e. 2E-9µCi/), which is an order of magnitude above the RG 4.14 guidance for LLD. Since the ambient levels are so much

higher than either the 90 day Landauer published LLD or the RG 4.14 LLD specification, the LC Project RSO concludes that quarterly analysis of the passive radon detectors in this ambient environment is informative and enables better seasonal trend analysis.

Passive gamma will be measured continuously (TR Figure 2.9-27) with quarterly analysis using passive integrating devices or an equivalent. The device shall have a range of at least one mrem to 500 rem with an accuracy of at least plus or minus 15 percent. At least one location shall have two monitoring devices as part of QA/QC.

Operational sampling will be periodically assessed to determine if additional sampling locations will improve LC's ability to comply with regulatory requirements and guidance, and/or to enhance ability to demonstrate that public radiation exposure above background and potential environmental impact from project activities is being maintained ALARA.

Operational radiological effluent and environmental monitoring (TR Sections 5.7.7 and 5.7.8), including soil, vegetation and animal tissue is a continuation of the pre-operational monitoring described in the LC TR Section 2.9

5.3.3 Effluent Control and Waste Management

Airborne, liquid, and solid effluents will be produced by the Project. All of these effluents are typical of ISR projects currently operating in Wyoming. Existing Best Practicable Technology (BPT) will be used in all aspects of effluent and waste management at the Permit Area. Detailed discussions on effluent control and waste management are presented in Section 4.0 of the TR.

Solutions in the production zones will be controlled and adequately monitored to ensure that migration does not occur. For purposes of off-site exposures, no off-site releases of water are planned or expected. Therefore, there are no quantifiable water-related pathways. (TR 7.2.1.1)

Non-radioactive gaseous emissions will readily disperse in the atmosphere and will not create an adverse impact to air quality. Airborne particulates will be minimal. Fugitive dust emissions will be minimized due to the inherent nature of ISR operations, and the limited road use.

Airborne particulate radiological effluent is foreseen as negligible since ISR operations are conducted in a closed system consisting of wet materials and yellowcake vacuum drying and packaging. The only significant radiological emission from modern ISRs is radon 222 gas (and associated particulate progeny), which will be routinely monitored as described above and in **Sections 2.9** and **5.7.7** of the TR, and in detail in the applicable Environmental Procedures SOPs.

5.3.3.1 Radiological Effluent Monitoring

Radon will be the only significant radiological emission from the mining and ore processing, as it is present in the ore body and concentrated in the lixiviant solution. Radon will be released occasionally from the mine unit wells as gas is vented from the injection wells. Production wells will be continually vented to the surface; however, water levels will typically be low and radon venting will be minimal. All of the well releases will be outside of buildings and are directly vented to the atmosphere. Radon will also be released during ion exchange resin transfers and subsequent ore processing steps, as described in the TR Section 4.1.

The Radiation Safety Officer (RSO) will monitor air quality within the plant to determine if the designed ventilation capacity is sufficient to minimize radon and progeny exposure to workers ALARA during operations. Methods for measurement and associated QA/QC requirements are described in the applicable SOPs of the Health Physics Program.

5.3.3.2 QA Considerations for Air Particulate Monitoring

Regulatory Guide 4.15 requires that errors in estimates of the volume of air that has passed through filters should be avoided by accurate calibration of the flow rate, and by preventing or correcting for the loss of flow caused by accumulation of material on the filter. As material accumulates on filter material the air flow rate will drop. Thus less air volume will be sampled. Air flow rates through filters should be determined by calibrating pumps with the filter in place once every 12 months to ±20% accuracy. These calibrations should be done in accordance with the manufacturer's recommendations. Further information on these calibrations is contained in Regulatory Guide 8.25, “Air Sampling in the Workplace”, Section 5.2 "Calibration Frequency and Methods”. Refer to the applicable Radiation Safety and Environmental Monitoring SOPs for additional detail.

5.3.3.3 Grab Sampling of Liquid Effluent Process Streams

The LC Project will generate several different types of liquid wastes, including three classified as 11.e(2) byproduct materials by NRC. These are: 1) liquid process wastes, including laboratory chemicals, 2) “affected” groundwater generated during well development and operations, and 3) groundwater generated during aquifer restoration.

The liquid 11.e(2) byproduct materials generated during the LC Project will be managed by deep well injection in conjunction with use of interim storage in the Storage Ponds. Grab samples of the effluent stream must be collected and analyzed according to ENV-010 “Storage Pond Monitoring” and ENV-011 “Deep Disposal Well Monitoring. The SOPs for sampling of effluent

streams comply with the procedures in Operations Plan Attachment OP-8 *Groundwater Monitoring Plan* of LC Project's WDEQ Application for In Situ Permit to Mine (Ur-Energy, 2009).

5.3.4 Quality Control of Radiological Effluent and Environmental Monitoring Measurements

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 and field blanks, as appropriate, for the matrix and analytes involved. An additional volume of groundwater for selected analyses will be collected for matrix spike/matrix spike duplicate (MS/MSD) use, if 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.

5.4 QUALITY CONTROL SAMPLES

Environmental data must 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. To assist in the achievement of these objectives, quality control samples are necessary. Accordingly, monitoring strategy to achieve sampling and analytical QA data objectives 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.
- Data will be complete, representative, and comparable.

5.4.1 Types and Use of Field Duplicates and Blanks

Field duplicates are taken to assess the representativeness of the sampling. Samples can be co-located or split. Blanks are used, where appropriate, to assess adequacy of contamination controls.

The field duplicate will be collected by the same method as the field sample.

At least 5% of the samples to be analyzed should be QC samples.

5.5 SAMPLE HANDLING, CUSTODY, AND SHIPMENT

The custody of individual samples for the Radiological Effluent and Environmental Monitoring Program will be documented by recording each sample's identification, number of containers, and matrix on a vendor supplied Chain of Custody (CoC) form. This form will be used to list all transfers of sample possession. A sample CoC form is provided with this document as **Appendix A**.

Samples will be prepared for shipment according to USDOT regulations depending on radioactive material content.

5.5.1 Sample Handling and Chain of Custody Requirements

Sample integrity should be maintained through chain of custody procedures. Regulatory Guide 4.15 defines Chain of Custody as procedures that provide the means to trace the possession and handling of a sample from collection to data reporting. The records include records of tracking and control (CoC) throughout all processes from sample collection through analysis and reporting of results, including unique identifiers, descriptions, sources, dates/times, packaging/preparation/shipping, and required analyses. This form will also track preservation methods for samples requiring preservation.

Each sample to be used for compliance data will have a CoC form that accompanies the sample from collection through analysis and disposal.

5.5.2 Sample Handling and Chain of Custody Requirements for Radiological Effluent and Environmental Monitoring Samples

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

5.6 APPLICATION OF INDUSTRY STANDARDS

Industry Standards are available for use in developing field sample collection and/or measurement techniques using guidance (as recommended in 2.9.2 of NUREG-1569) from NUREG/CR–5849, "Manual for Conducting Radiological Surveys in Support of License Termination" (USNRC 1992) or NUREG–1575, Revision 1, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)" as applicable. For sampling and analysis of water, guidance from the EPA "Manual for Chemical Analysis of Water and Wastes" EPA-625-/6-74-003a, 1974 may also be used.

These field methods will be incorporated into the SOPs as applicable.

Laboratory methods used for analysis of the radionuclide content of air particulate filters, sediment, soil, surface and groundwater, vegetation, and animal tissue should be referenceable to EPA and National Environmental Laboratory Accreditation Program (NELAP) methods when available. Selected analytes may be analyzed using validated methods other than EPA or NELAP with justification of the technical basis.

5.6.1 Application of Collection Efficiencies to Determine Actual Sample Volume

Required sample volumes will be derived for each type of sample based on the measurement requirements. For liquid or solid samples, consideration will be given for the density/composition of the matrix, the counting efficiency of the laboratory or instrumentation, applicable analytical chemical recovery, preservation techniques and homogeneity of the sample.

Sample volumes for airborne particulates are impacted by filter collection efficiency, filter dust loading and flow rates of the sampling equipment.

Methods used to determine actual sample volumes are specified in the environmental sampling and analysis SOPs.

5.6.2 Uncertainty Limits for Volume and Mass Measurements

The LC Project procedures for reporting sample analysis results will comply with the guidance of RG 4.15 and 4.14.

6.0 LABORATORY MANAGEMENT AND QUALITY CONTROL

6.1 VERIFICATION AND VALIDATION OF CONTRACT LABORATORY QA/QC PROGRAMS

LC is responsible for the validity of any analytical results provided to demonstrate compliance. Therefore, any laboratory providing analytical results shall meet identical requirements as those specified for an onsite laboratory.

6.1.1 Regulatory Requirements

The LC Effluent and Environmental Monitoring Program may depend upon the services of a radioanalytical laboratory, therefore, prior onsite audits of the laboratory may be conducted to ensure that the laboratory is capable of fulfilling the project criteria.

6.1.2 Preparation and Analytical Methodology

Procedures will be provided for sample preparation, including preservation methods for samples not analyzed within two days from the time of collection, that have holding time sensitivities.

6.1.3 Data Presentation and Reporting Results

6.1.3.1 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 in addition to the individual sample results and uncertainty:

- 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, confidence level on the analytical uncertainty, and dilution factors; and
- Summary of results (e.g., case narrative).

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

7.0 QUALITY CONTROL FOR MAINTENANCE AND CALIBRATION OF RADIOLOGICAL EFFLUENT AND ENVIRONMENTAL MONITORING INSTRUMENTATION AND EQUIPMENT

Instrumentation calibration and equipment quality control is discussed in this section with identification of referenced procedures, materials, and documents. Control of monitoring equipment includes discussions on calibration and maintenance requirements, frequency, verification of compliance or non-compliance, documentation, tracking, and record keeping.

7.1 INSTRUMENTS AND SYSTEM CALIBRATION AND MAINTENANCE REQUIREMENTS

7.1.1 Flow Monitoring Instrumentation

Any flow-rate measuring devices associated with a system will be calibrated to determine actual flow rates at the conditions of temperature and pressure under which the system will operate. These flow rate devices will be recalibrated annually, but the frequency may be extended to that established for the radiation detector system, provided sufficient operating experience exists and an accelerated measurement check frequency gives sufficient data to ensure reliable performance. SOPs will establish monitoring frequencies of flow rates considering the variability of the instrument, and will establish control limits that when exceeded will require recalibration.

7.1.2 Calibration Protocols and Frequency for Radiological Survey Instruments

Radiation survey instruments will be calibrated meeting at least the minimum practices specified in LC Project TR Section 5.7.2.

7.2 CALIBRATION REQUIREMENTS OF SAMPLING EQUIPMENT AND CONTAINERS

Sampling equipment to make precise measurements, such as thermometers, balances, conductivity meters, and sample collection containers will be calibrated according to manufacturer recommendations or using best practices, as appropriate, to meet precision requirements.

7.3 FREQUENCIES AND PROCEDURES

The frequency of calibrations is specified in the SOPs pertaining to the use of the instrumentation.

8.0 ASSESSMENTS, AUDITS, AND SURVEILLANCES

Assessments, audits, and surveillances are elements used to evaluate the initial and ongoing effectiveness of QA, and to monitor and control the quality of the radiological effluent and environmental monitoring programs. This section defines the policies and processes for performance assurance (the internal reviews, inspections, and audits that are routinely conducted) to verify and validate company performance in accordance with the requirements of the LC Project EHSMS procedures, other corporate policies and procedures that can affect safety and environmental protection, compliance to license and permit conditions, etc.

Authorities of personnel responsible for QA and how the QA function is integrated with Radiation Safety are presented in TR Section 5.3. Minimum qualifications of personnel are defined in TR 5.3.

8.1 ORGANIZATIONAL ASSIGNMENTS

8.1.1 Responsibilities

Both management and employees shall participate in assessments, audits, surveillances, and inspections.

8.1.2 Authorities and Qualifications of Inspectors and Auditors

The minimum qualifications and experience levels required of personnel assigned the responsibility of conducting inspections, assessments, surveillances and audits are described in TR 5.4. Assessments, audits, and surveillances are elements used to evaluate the initial and ongoing QA effectiveness to monitor and control the quality of a radiological effluent and environmental monitoring program.

Management having responsibility in the area being reviewed will document and review the results of these activities.

Assessments that are independent of the day-to-day operations will be performed routinely, including management surveillance, peer reviews, and SERP, and readiness reviews for new or revised systems and methods. Additional types of assessments include: spill assessments, exposure incident assessments, and follow-up on bioassay anomalies.

It will be the responsibility of the RSO and radiation protection staff to conduct radiation safety surveillance and investigations to ensure that occupational exposures are as far below the specified

limits as is reasonably achievable. Additionally, the RSO and radiation protection staff should be vigilant in searching out new and better ways to perform all jobs with lower radiation doses. The RSO is assigned sufficient authority to enforce safe ALARA operations, and employees are trained to understand and apply the ALARA philosophy.

8.2 ANNUAL AUDITS

8.2.1 Verification and Validation of License Compliance and ALARA

As described in TR Section 5.3.3, an annual audit of the Health Physics and ALARA programs will be performed by the Manager EHS and Regulatory Affairs and the Mine Manager. The Manager EHS may also call on outside technical expertise to complete the audit. A technical expert for the purposes of this section shall be an individual who meets the qualifications of an RSO, and who has at least five years of experience in applied radiation safety including at uranium recovery facilities. The RSO or HPT may be called upon to provide data but shall not be involved in audit findings or the writing of the Annual ALARA Audit Report.

The purpose of the audit shall be to: 1) determine the effectiveness of the Health Physics and ALARA programs and ensure the veracity of radiation measurements and calculations, 2) ensure compliance with applicable regulations, procedures, and policies, 3) ascertain trends in employee and public exposure and potential reasons for trends, and 4) look for methods to further mitigate employee and public exposure to radionuclides. The Annual ALARA Audit shall be conducted in accordance with NRC Regulatory Guide 8.31. A written report of the audit findings will be submitted to the President, Vice President, Mine Manager, and all Department Heads. Additionally, the report findings and their implications shall be discussed with all employees during annual radiation safety training.

The Annual ALARA Audit Report shall summarize:

- employee exposure records (external and time-weighted calculations);
- bioassay results;
- inspection log entries and summary reports of daily, weekly, and monthly inspections;
- documented training activities;
- radiation safety meeting reports;
- radiological survey and sampling data;
- unusual occurrences with implications for significant radiation exposure above background;
- reports on overexposure of workers submitted to the NRC and other applicable regulatory agencies; and

- operating procedures that were reviewed during this time period.

The report shall specifically address the following:

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

8.2.2 Annual Quality Assurance Program Audit

Per TR Section 5.1.5, the RSO, being responsible for LC Project Quality Assurance Program, will conduct or direct an Annual Quality Assurance Program Audit with assistance from the Manager EHS as needed. The audit may be conducted in conjunction with the Annual ALARA Audit described in Section 8.2.1. The annual audit will focus on reviewing the QAPP, verifying inclusion of QA/QC in monitoring programs, verification of proper data management, and review of QA/QC issues, if any, in the monthly RSO report (Section 8.3.3). This audit plan is implemented through LC Project SOPs.

8.3 DAILY AND WEEKLY OPERATIONAL INSPECTIONS

8.3.1 Daily Inspections

Daily inspections will be performed as specified in TR Section 5.3.1.1.

8.3.1.1 Daily Storage Pond Inspections

The daily storage pond inspections will be performed as specified in TR Section 5.3.2.1.

8.3.2 Weekly Inspections

The weekly inspections will be performed as specified in TR Section 5.3.1.2.

8.3.2.1 Weekly Storage Pond Inspections

The weekly storage pond inspections will be performed as specified in TR Section 5.3.2.2.

8.3.3 Monthly RSO Reports

The RSO will provide monthly reports as specified in TR Section 5.3.1.3

8.3.4 Quarterly Storage Pond Inspections

The quarterly storage pond inspections will be performed as specified in TR Section 5.3.2.3.

8.3.5 Annual Technical Evaluation of Storage Ponds

The annual technical inspection of the storage ponds will be performed by the Vice President, as specified in TR Section 5.3.2.4.

8.4 SAFETY AND ENVIRONMENTAL REVIEW PANEL (SERP)

A Safety and Environmental Review Panel (SERP) reviews proposed changes, tests, or experiments to determine whether they require a license amendment. The composition and functions of the SERP are described in TR 5.2.2. Changes, tests, or experiments may be conducted without prior NRC approval if:

- they do not conflict with any requirements specifically stated in the license or impair the licensee's ability to meet all applicable NRC regulations;
- there is no degradation in the essential safety or environmental commitments in the license application or those provided in an approved reclamation plan; and
- they are consistent with NRC conclusions regarding actions analyzed and selected in the facility environmental assessment.

8.5 ASSESSMENT, AUDIT, AND SURVEILLANCE REPORTS

The SOPs for conducting assessments, audits, and surveillances also include requirements for documenting findings, communicating corrective actions and closeouts.

8.6 DOCUMENTATION AND RECORD RETENTION REQUIREMENTS

All assessments, audits, and surveillances will be documented and a record of the assessment, audit, or surveillance findings, corrective actions and finding closeouts will be retained as described in **Section 4.0** of the QAPP.

9.0 PREVENTIVE AND CORRECTIVE ACTIONS

LC's SOPs address implementing corrective actions when conditions that can impact worker or public safety or are adverse to quality have been identified.

Deficiencies and non-conformances, as well as areas of improvement, are identified through assessments, audits, inspections and surveillances. The input to management from these sources allows actions to be taken to correct the deficiencies and to identify more efficient processes and methods of accomplishing tasks.

Continuous improvement processes will be used to ensure that quality of measurements and evolution of the QAPP are maintained as necessary. The preventative actions assist in the mitigation of accidents and non-conformances.

LC Project assessments, audits and surveillances will identify degrading conditions, and corrective actions will be taken when conditions fall outside quality or regulatory acceptance criteria. For conditions that are adverse to quality, the corrective action process includes the following basic elements:

- identification and documentation
- classification
- cause analysis
- corrections
- follow-up
- closure

Findings and corrective actions will be documented, tracked, and reported to management. Follow-up reviews will be performed to verify the effectiveness and adequacy of the corrective actions (USNRC 2007).

Violations or noted findings, which require corrective action, should be reviewed by personnel who have authority to correct the problem. When conducting an audit or surveillance of laboratory services, a prime area of review should be the effectiveness of the laboratory's corrective action processes.

10.0 REFERENCES* AND PERTINENT BIBLIOGRAPHY

ANSI (American National Standards Institute, Inc.), 1996, HPS N13.30-1996, *An American National Standard – Performance Criteria for Radiobioassay,* Health Physics Society, McLean, Virginia.

ANSI (American National Standards Institute), 2003a N42.23-2003, *Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories*, American National Standards Institute, New York, NY.

ANSI (American National Standards Institute), 2003b, ANSI-N323B *American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instrumentation for Near Background Operation,* Health Physics Society, McLean, Virginia.

ANSI (American National Standards Institute), 2004 N42.18-2004, *Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents,* Health Physics Society, McLean, Virginia.

ANSI/ASQC (American National Standards Institute/American Society for Quality Control, 1994, ANSI/ASQC E4-1994, *Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs*, New York, NY.

ASME, 1994, NQA-1-1994, *Quality Assurance Program Requirements for Nuclear Facilities* (with Addenda), American Society of Mechanical Engineers, New York, NY, 1994.

ASTM MNL 7A-2002, *ASTM Manual for Presentation of Data and Control Charts.*

ASTM, 2006, D7282-2006 - *Standard Practice for Set-up, Calibration, and Quality Control of Instruments Used for Radioactivity Measurements.*

Brown, S. 2007, *Radiological Aspects of In Situ Uranium Recovery*, American Society of Mechanical Engineers, Proceedings of 11th International Conference on Environmental Management, Bruges, Belgium; ASME Press, New York, NY, ISBN 0-7918-3818-8.

Brown, S. 2008, *The New Generation of Uranium In Situ Recovery Facilities: Design Improvements Should Reduce Radiological Impacts Relative to First Generation Uranium Solution Mining Plants.* Proceedings of the 2008 Waste Management Symposium, Phoenix, ASME Press, New York, NY, ISBN # 978160560422.

EPA, 2002, *Guidance for Developing Quality Systems for Environmental Programs* **(**QA/G-1***)***, November 2002.

EPA, 2006, *Guidance on Systematic Planning using the Data Quality Objectives Process* (**QA/G-4**), February 2006.

HPS/ANSI N13.1-1999, *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities* (including the guidance presented in Appendix A of ANSI N13.1).

ISO/IEC-17025-2005, *General Requirements for the Competence of Testing and Calibration Laboratories* (as referenced in RG 4.15).

NRC ML103210590, *Requested Page Changes and Revised Table of Contents*, November, 2010.

NRC ML12153A287, *Lost Creek ISR, LLC Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming, Summary of April 30, 2012, Teleconference* - (TAC Nos. J00652 & J00660).

NRC ML12053A326, *Acknowledgment of Receipt of Responses to the Request for Additional Information, NRC License SUA-1598, Docket No. 40-9068,* (TAC J00652).

Ur-Energy 2009, Lost Creek ISR, LLC Project Wyoming Department of Environmental Quality Application for In Situ Permit to Mine, Casper, Wyoming, October 2009.

Ur-Energy 2010, Lost Creek ISR, LLC Project USNRC Technical Report, Casper, Wyoming, April 2010.

USDOT 49 CFR 173.433(a) and (b) *Requirements for Determining Basic Radionuclide Values, and for the Listing Of Radionuclides on Shipping Papers and Labels.*

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

USNRC, 1986a, Regulatory Guide 3.56, *General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills* (May 1986)

USNRC, 1986b, NUREG 0874, Internal Dosimetry Model for Applications to Bioassay at Uranium Mills. (July 1986).

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

USNRC, 1992a, Regulatory Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses* (July 1992).

USNRC, 1992 b, Regulatory Guide 8.25, *Air Sampling In the Workplace* (Revision 1, June 1992).

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

USNRC, 1996, Regulatory Guide 8.29, *Instructions Concerning Risks from Occupational Radiation Exposure* (Revision 1, February 1996.

USNRC, 1999a, Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* June 1999.

USNRC, 1999b, Regulatory Guide 8.15, *Acceptable Programs for Respiratory Protection* (Revision 1, October 1999).

USNRC, 2001, NUREG/CR-6733, *A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees*, September 2001.

USNRC, 2002a, Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities will be As Low As Reasonably Achievable*, Revision 1, May 2002.

USNRC, 2002b, NUREG 1623, *Design of Erosion Protection for Long-Term Stabilization - Final Report*, September 2002.

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

USNRC, 2003b, NUREG 1620 (USNRC 2003b), *Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites under Title II of the Uranium Mill Tailings Radiation Control Act of 1978*, June 2003.

USNRC, 2004, NUREG-1576, *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP), July 2004.

USNRC, 2006, USNRC NUREG 1757, Volume 1, *Consolidated Decommissioning Guidance, Decommissioning Process for Materials Licensees* (Revision 2), September 2006.

USNRC, 2007, Regulatory Guide 4.15, Revision 2, *Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment*, July 2007.

USNRC, 2008, Regulatory Guide 3.11, *Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities*, November 2008.

USNRC 10 CFR 20, *Standards for Protection Against Radiation*.

USNRC 10 CFR Part 40—*Domestic Licensing of Source Material*.

USNRC 10 CFR 40, Appendix A to Part 40—*Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content.*

USNRC 10 CFR50, Appendix B, *Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.*

USNRC 10 CFR Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste.*

Wyoming Department of Environmental Quality, 1997; source: Wyoming Water Quality Rules and Regulations, Chapter 21, Standards for Reuse of Treated Wastewater, October 1997.

Wyoming Department of Environmental Quality, 2001; source: WDEQ, Wyoming Surface Water Classification List, 2001.

*This QA Plan provides references to many documents. Unless otherwise specified (e.g., version number, date), the documents referenced in the QA Plan and subsequent procedures are assumed to be the latest revision available (normative reference).

11.0 GLOSSARY AND ACRONYMS

11e.(2) byproduct Material	The "tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for it source material content" (42 United States Code 2014[e][2]; Atomic Energy Act [*as amended*], Chapter 2, Section 11)
$[UO_2(CO_3)_3]^{-4}$	uranyl tricarbonate ion
$[UO_2(CO_3)_2]^{-2}$	uranyl dicarbonate ion
°F	degrees Fahrenheit
µCi	microcuries
µCi/mL	microcuries per milliliter
µg	microgram
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
µmhos/cm	micromhos per centimeter
µR/hr	microroentgens per hour
ACEC	Area of Critical Environmental Concern
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit on Intake
ANSI	American National Standards Institute
ARSO	Alternate Radiation Safety Officer
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ASQC	American Society for Quality Control
AUM	animal unit months
Basin	Great Divide Basin
BLM	Bureau of Land Management
BMP	Best Management Practice
BPT	Best Practicable Technology
BR	breathing rate
$CaCO_3$	calcium carbonate
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
c/m	counts per minute
cm^2	square centimeter
CO	carbon monoxide
Conoco	Conoco, Inc.
C_r	concentration of radionuclide r in air
CR	County Road

Cs-137	cesium-137
CSU	Colorado State University
CV	curriculum vitas
CWL	Continuous Working Level
DAC	derived air concentration
dBA	A-weighted decibels
DC	dose coefficient
DCF	dose conversion factor
DC_r	dose conversion factor for radionuclide r
DDE	Deep Dose Equivalent
DOE	Department of Energy
DOT	Department of Transportation
dpm	disintegrations per minute
DQO	Data Quality Objectives
EA	environmental assessment
Eh	oxidation-reduction potential
EHS	Environment, Health, and Safety
EHSMS	Environment, Health, and Safety Management System
ELI	Energy Laboratories Incorporated
EMT	Emergency Medical Technician
EPA	Environmental Protection Agency
ER	Environmental Report
ft amsl	feet above mean sea level
ft bgs	feet below ground surface
ft/d	feet per day
ft/ft	feet per foot
ft/mi	feet per mile
ft/s	feet per second
ft^2/d	square feet per day
FTE	full-time equivalent
FSER	final safety evaluation report
FWS	Fish and Wildlife Service
g	gram
g/cm^3	grams per cubic centimeter
g/L	grams per liter
GEIS	Generic Environmental Impact Statement
GIS	Geographic Information System
gpd/ft	gallons per day per foot
gpm	gallons per minute
GPS	Global Positioning System

GSP	Gross State Product
H	number of hours of exposure
HDPE	high-density polyethylene
HMA	Herd Management Area
HPGe	High-Purity Germaniun
HPIC	High-Pressure Ionization Chamber
HPRCC	High Plains Regional Climate Center
HPS	Health Physics Society
HPT	Health Physics Technician
IBC	International Building Code
ICRP	International Commission on Radiological Protection
IEC	International Electrotechnical Institute
I_r	annual intake of radionuclide r by inhalation
IR	Isolated Resource
ISO	International Organization for Standardization
ISR	In Situ Recovery
JCR	Job Completion Report
km	kilometers
kPa	kiloPascal
lb/mi^3	pounds per cubic mile
LC	Lost Creek
LC ISR, LLC	Lost Creek ISR, LLC
LLD	lower level detection
LLRWDF	low-level radioactive waste disposal facility
LQD	Land Quality Division
LS	Lost Soldier
LSA	Low Specific Activity
m^2	square meters
m^3/h	cubic meters per hour
m/s	meters per second
man-Sv	man-Sievert
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MBHFI	Migratory Birds of High Federal Interest
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MeV	million electron volts
mg/cm^2	milligrams per square centimeter
mg/L	milligrams per liter
MiniVol	Mini Volumetric
MIT	mechanical integrity test

mph	miles per hour
MQO	Measurement Quality Objective
mR/hr	milliRoentgens per hour
mrem	millirem
mrem/yr	millirem per year
MSHA	Mine Safety and Health Administration
mSv	milliSievert
n	number of exposure periods in the year
NA	not applicable
Na_2S	sodium sulfide
NAAQS	National Ambient Air Quality Standards
NaI	sodium iodide
NARM	Naturally occurring and/or Accelerator-produced Radioactive Material
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Protection Act
NFU, LLC	New Frontiers Uranium, LLC
NIRMA	Nuclear Information and Records Management Association
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NO_2	nitrogen dioxide
NQA	National Quality Assurance
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSS	Native Species Status
NVLAP	National Voluntary Laboratory Accreditation Program
NWIS	National Water Information System
NWS	National Weather Service
O_3	ozone
OHV	off-highway vehicle
OSHA	Occupational Safety and Health Administration
OSL	optically stimulated luminescence badges
Pb-210	lead-210
PBL	Performance-Based License
PC	personal computer
pCi/L	picocuries per liter
Permit Area	Lost Creek Permit Area
person-rem/yr	person-rem per year
PE	Performance Evaluation

PF	respirator protection factor
PFN	Prompt Fission Neutron
PILT	Payments in Lieu of Taxes
PM_{10}	particulate matter less than ten micrometers
PPE	personal protective equipment
ppm	parts per million
Program	Contamination Control Program
Project	Lost Creek Project
PSD	Prevention of Significant Deterioration
psi	pounds per square inch
psig	pound-force per square inch gauge
PT	Performance Testing
PVC	polyvinyl chloride
PWMTF	Permanent Wyoming Mineral Trust Fund
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
Ra-226	radium-226
Ra-228	radium-228
rad/d	rad per day
rem	roentgen equivalent in man
RG	Regulatory Guide
RL	Reporting Level
RMP	Resource Management Plan
Rn-222	radon-222
RnD	radon decay products
RO	reverse osmosis
RPP	Radiation Protection Program
RSD	Radiation Safety Department
RSO	Radiation Safety Officer
RV	recreational vehicle
RWP	Radiation Work Permit
SAR	sodium adsorption ratio
SCS	Soil Conservation Service
SDR	standard dimension ratio
SDWS	Secondary Drinking Water Standard
SEM	scanning electron microprobe
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SHPO	State Historic Preservation Office

SMU	soil mapping unit
SO_2	sulfur dioxide
SOP	standard operating procedure
SSC	structure, system, or component
Sv/Bq	Sievert per Becquerel
SWEDA	Sweetwater Economic Development Association
TAC	Technical Assignment Control
T&E	threatened and endangered
TDS	total dissolved solids
TEDE	Total Effective Dose Equivalent
TER	Technical Evaluation Report
Texasgulf, Inc.	Texasgulf
TF	Technical Guide
Th-230	thorium-230
TLD	Thermoluminescent Dosimeter
TR	Technical Report
U_3O_8	uranium oxide
UCL	Upper Control Limit
UIC	Underground Injection Control
U-nat	natural uranium
Ur-E	Ur-Energy USA Inc.
URPA	Ur-E Project Air
US	United States
USGS	United States Geological Survey
V&V	Verification and Validation
VP	Vice President
VRM	Visual Resource Management
WAAQS	Wyoming Ambient Air Quality Standard
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WHDP	Wyoming Housing Database Partnership
WL	Working Level; measured concentration of radon decay products
WOS	Wildlife Observation System
WQD	Water Quality Division
WRDS	Water Resources Data System
WS	Wyoming Statute
WSA	Wilderness Study Area
WSEO	Wyoming State Engineer's Office
WYDOT	Wyoming Department of Transportation
WYPDES	Wyoming Pollution Discharge Permit

APPENDIX A
SAMPLE CHAIN-OF–CUSTODY FORM

Inter-Mountain Labs

Sheridan, WY and Gillette, WY

- CHAIN OF CUSTODY RECORD -

Page of

All shaded fields must be completed.

This is a legal document; any misrepresentation may be construed as fraud.

#WEB

Client Name	Project Identification	Sampler (Signature/Attestation of Authenticity)	Telephone #

Report Address	Contact Name	
		Email
Invoice Address		Phone
	Purchase Order #	Quote #

ANALYSES / PARAMETERS

ITEM	LAB ID (Lab Use Only)	DATE SAMPLED	TIME SAMPLED	SAMPLE IDENTIFICATION	Matrix	# of Containers									REMARKS
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															

LAB COMMENTS	Relinquished By (Signature/Printed)	DATE	TIME	Received By (Signature/Printed)	DATE	TIME

SHIPPING INFO	MATRIX CODES		TURN AROUND TIMES	COMPLIANCE INFORMATION		ADDITIONAL REMARKS
❑ UPS	Water	WT	**Check desired service**	Compliance Monitoring ?	Y / N	
❑ Fed Express	Soil	SL	❑ Standard turnaround	Program (SDWA, NPDES,…)		
❑ US Mail	Solid	SD	❑ **RUSH - 5 Working Days**	PWSID / Permit #		
❑ Hand Carried	Filter	FT	❑ **URGENT - < 2 Working Days**	Chlorinated?	Y / N	
❑ Other_____	Other	OT	***Rush & Urgent Surcharges will be applied***	Sample Disposal: Lab	Client	

ENERGY LABORATORIES
Trust our People. Trust our Data.

Chain of Custody & Analytical Request Record

www.energylab.com

Page _____ of _____

Account Information *(Billing information)*

Company/Name		
Contact		
Phone		
Mailing Address		
City, State, Zip		
Email		
Receive Invoice ☐Hard Copy ☐Email	Receive Report ☐Hard Copy ☐Email	
Purchase Order	Quote	Bottle Order

Report Information *(if different than Account Information)*

Company/Name
Contact
Phone
Mailing Address
City, State, Zip
Email
Receive Report ☐Hard Copy ☐Email
Special Report/Formats: ☐ LEVEL IV ☐ NELAC ☐ EDD/EDT *(contact laboratory)* ☐ Other_____

Comments

Project Information

Project Name, PWSID, Permit, etc.	
Sampler Name	Sampler Phone
Sample Origin State	EPA/State Compliance ☐ Yes ☐ No

URANIUM MINING CLIENTS MUST indicate sample type.
☐ Unprocessed Ore
☐ Processed Ore (Ground or Refined) **CALL BEFORE SENDING
☐ 11(e)2 Byproduct Material (Can ONLY be Submitted to ELI Casper Location)

Matrix Codes

A - Air
W- Water
S - Soils/ Solids
V - Vegetation
B - Bioassay
O - Other
DW - Drinking Water

Analysis Requested

All turnaround times are standard unless marked as RUSH.

Energy Laboratories MUST be contacted prior to RUSH sample submittal for charges and scheduling – See Instructions Page

Sample Identification *(Name, Location, Interval, etc.)*	Collection Date	Collection Time	Number of Containers	Matrix *(See Codes Above)*										See Attached	RUSH TAT	ELI LAB ID *Laboratory Use Only*
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

Custody Record MUST be signed	Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
	Relinquished by (print)	Date/Time	Signature	**Received by Laboratory (print)**	**Date/Time**	**Signature**

LABORATORY USE ONLY

Shipped By	Cooler ID(s)	Custody Seals	Intact	Receipt Temp	Temp Blank	On Ice	Payment Type	Amount	Receipt Number *(cash/check only)*
		Y N C B	Y N	°C	Y N	Y N	CC Cash Check_____	$	

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.