Safety Evaluation Report
for the Lost Creek Project,
Sweetwater County, Wyoming,
Materials License No. SUA- 1598

Docket No. 40-9068
Lost Creek ISR, LLC

U.S. Nuclear Regulatory Commission

Office of Federal and State Materials and Environmental Management Programs

August 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

11e.(2) byproduct material	Tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within this definition.
^{o}C	degree Celsius
^{o}F	degree Fahrenheit
%g	percent gravity
a	acre
ACL	alternative concentration limit
ALARA	as low as is reasonably achievable
ALI	annual limit on intake
ANSI	American National Standards Institute
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
BAT	best available technology
bgs	below ground surface
BLM	Bureau of Land Management
BPT	best practicable technology
Bq	becquerel
CAP	corrective action program
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
CO_2	carbon dioxide
cpm	counts per minute
C_r	concentration of radionuclide, *r*, in air
DAC	derived air concentration
DC	dose coefficient
DCF	dose conversion factor
DC_r	dose conversion
DDE	deep dose equivalent
DOT	Department of Transportation
dpm	disintegrations per minute
DQO	data quality objectives
EA	environmental assessment
Eh	oxidation-reduction potential
EHS	Environment, Health, and Safety
EHSM	Environment, Health, and Safety Manager
EIS	environmental impact statement
ELI	Energy Laboratories, Incorporated

EPA	U.S. Environmental Protection Agency
ER	environmental report
FONSI	finding of no significant impact
Federal Register	FR
ft	feet
ft/d	feet per day
ft/s	feet per second
g	acceleration of gravity
(g)	gaseous form
g/cm^3	grams per cubic centimeter
GEIS	Generic Environmental Impact Statement
gpd/ft	gallons per day per foot
gpm	gallons per minute
GPS	Global Positioning System
h	hour
H	number of hours of exposure
ha	hectare
HPIC	high-pressure ionization chamber
HPT	health physics technician
HV	high velocity
HVAC	heating, ventilation, and air conditioning systems
i	exposure period, *i*
IBC	International Building Code
ICRP	International Commission on Radiological Protection
in	inch
I_r	annual intake of radionuclide *r* by inhalation
ISR	in situ recovery
IX	ion exchange
JFD	joint frequency distribution
kg	kilogram
km	kilometer
km^2	square kilometers
L	liter
LC	Lost Creek
lb	pound
lb/ft^3	pound per cubic foot
LCI	Lost Creek ISR, LLC
LLD	lower limit of detection
Lpm	liters per minute
LS	Lost Soldier
m	meter
m^2	square meter
m^2/d	square meter per day

m^3	cubic meter
m^3/h	cubic meter per hour
m^3/s	cubic meter per second
m/s	meter per second
ma	million years ago
man-Sv	man-sievert
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MDC	minimum detectable contamination
mg	milligram
mg/L	milligram per liter
mi	mile
mi^2	square miles
MIT	mechanical integrity test
mm	millimeter
MOU	memorandum of understanding
mR/hr	milliroengtens per hour
mrem	millirem
mrem/yr	millirem per year
mSv	millisievert
t	metric ton
n	number of exposure periods n, in the year
NA	not applicable
$NaHCO_3$	sodium bicarbonate
Na_2CO_3	sodium carbonate
NaI	sodium iodide
NCDC	National Climatic Data Center
NELAC	National Environmental Laboratory Accreditation Conference
NEPA	National Environmental Protection Act
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
NVLAP	National Voluntary Laboratory Accreditation
NWS	National Weather Service
OSHA	U.S. Occupational Safety and Health Administration
Pb-210	lead-210
pCi/L	picocuries per liter
person-rem/yr	person-rem per year
Po-210	polonium-210
PM_{10}	particulate matter less than ten micrometers
PPE	personal protective equipment
ppm	parts per million
psi	pounds per square inch
PV	pore volumes
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control

R&D	research and development
Ra-226	radium-226
Ra-228	radium-228
RAI	request for additional information
rem	roentgen equivalent man
RG	regulatory guide
Rn-222	radon-222
RO	reverse osmosis
RWP	radiation work permit
SEIS	Supplemental Environmental Impact Statement
SER	safety evaluation report
SERP	Safety and Environmental Review Panel
SPT	standard penetration tests
SHPO	State Historic Preservation Office
SM	source material
SOP	standard operating procedure
Sv	sievert
Sv/Bq	sievert per becquerel
TAC	technical assignment control
TEDE	total effective dose equivalent
TER	technical evaluation report
Th-230	thorium-230
TLD	thermoluminescent dosimeter
TG	Technical Guide
TR	technical report
TWA	time-weighted average
UBC	Uniform Building Code
UCL	upper control limit
UIC	Underground Injection Control
µg	microgram
U-nat	natural uranium
U_3O_8	uranium oxide
UO_2	uranium dioxide
UO_3	uranium trioxide
$UO_2(CO_3)_2^{2-}$	uranyl dicarbonate
$UO_2(CO_3)_3^{4-}$	uranyl tricarbonate
UPS	uninterruptible power supply
Ur-E	Ur-Energy USA, Inc.
URPA	Ur-Energy Passive Air
U.S.	United States
USGS	United States Geological Survey
WDEQ	Wyoming Department of Environmental Quality
WQD	Water Quality Division
wt.	weight
WY	Wyoming
x	number of radionuclides of interest

INTRODUCTION

On October 30, 2007, Lost Creek ISR, LLC (LCI or the applicant) submitted a license application to the U.S. Nuclear Regulatory Commission (NRC) to construct and operate the Lost Creek Project in Sweetwater County, WY. The proposed project is a uranium in situ recovery (ISR) project. The application consisted of a technical report and an environmental report (LCI, 2007a, 2007b, 2007c). The applicant withdrew the application (LCI, 2008a) and resubmitted it with supporting documentation on March 31, 2008 (LCI, 2008b, 2008c, 2008d). Source material licenses are subject to safety requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, "Domestic Licensing of Source Material."

The NRC staff notified the applicant of the staff's decision to accept the application (LCI, 2008c, 2008d) for detailed technical and environmental review on June 10, 2008 (NRC, 2008a). In response to the staff's requests for additional information and open issues (NRC, 2008b, 2009a, 2009f, 2009g), the applicant provided revisions to the technical report in correspondence dated December 12, 2008, January 16, 2009, February 27, 2009, August 5, 2009, and April 22, 2010 (LCI, 2008e, 2009a, 2009b, 2009c, and 2010a). This safety evaluation report (SER) documents the NRC staff's technical review of the revised technical report and supplements. All references to the application in this SER refer to the LCI technical report (LCI, 2008c, 2010a) and exclude the environmental report unless stated otherwise.

The Atomic Energy Act of 1954, as amended, authorizes the NRC to issue licenses for the possession and use of source material and byproduct material. The NRC must license facilities, including ISR operations, in accordance with NRC regulatory requirements to protect public health and safety from radiological hazards. In accordance with 10 CFR 40.32, "General Requirements for Issuance of Specific Licenses," the NRC is required to make the following safety findings when issuing an ISR license:

- The application is for a purpose authorized by the Atomic Energy Act;
- The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life or property;
- The applicant's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property; and
- The issuance of the license amendment will not be inimical to the common defense and security or to the health and safety of the public.

Exemption to 10 CFR 40.32(e)

Commencement of construction before the NRC staff has completed its environmental review of the proposed facility and concluded that a license authorizing uranium milling should be granted is grounds for denial of a license to possess and use source and byproduct material under 10 CFR 40.32(e). The term ''commencement of construction'' is defined by 10 CFR 40.32(e) as "any clearing of land, excavation, or other substantial action that would adversely affect the environment of a site;" and excludes "site exploration, roads necessary for site exploration, borings to determine foundation conditions, or other preconstruction monitoring or testing to establish background information related to the suitability of the site or the protection of environmental values." In May 2009, LCI notified the NRC that LCI had inadvertently exceeded the limits on construction as defined in 10 CFR 40.32(e) (LCI, 2009d). Between July and

October 2008, LCI installed 67 wells including the monitoring well ring, overlying and underlying aquifer monitoring wells, and production zone baseline wells in order to provide the Wyoming Department of Environmental Quality (WDEQ) information to characterize the groundwater conditions and obtain mine permits for the Lost Creek Project (LCI, 2009d). These activities occurred before the NRC staff issued its letter to the WDEQ noting acceptable drilling activities (NRC, 2009c).

The WDEQ informed the NRC in a letter dated February 17, 2009 (WDEQ, 2009a), of its proposed policy to require more detailed hydrologic testing data in applications for new ISR operations. This detailed hydrologic testing would require ISR facility applicants to install the monitoring wells associated with the first wellfield that the applicant would operate after license issuance (WDEQ, 2009a). Monitoring wells associated with a typical wellfield include those wells in the perimeter ring, overlying aquifer and underlying aquifer (NRC, 2003a). In a telephone call on February 25, 2009 (NRC, 2009d; WDEQ, 2009b), the NRC staff informed the WDEQ that the NRC staff interprets 10 CFR 40.32(e) as allowing installation of a limited number of wells for pumping tests and baseline data collection for the site (NRC, 2009d). The NRC staff explained the basis for the NRC staff not allowing the installation of the entire monitoring well network without review is because the monitoring ring is a key component of the safety infrastructure of an ISR (NRC, 2009c). The WDEQ followed-up with a letter dated March 10, 2009 (WDEQ, 2009b), that stated it requires the installation of background monitoring and test wells to provide site-specific geologic and hydrologic characterization data to satisfy the technical portion of the WDEQ permit application. However, the WDEQ would not require full installation of the monitoring well network or production/injection wells. The NRC staff confirmed that the activities described by the WDEQ fall within the scope of authorized preconstruction monitoring under 10 CFR 40.32(e) (NRC, 2009c).

In response to LCI's notification of this violation (LCI, 2009d), the NRC staff stated that the clause in 10 CFR 40.32(e) concerning preconstruction monitoring was not explicit as to permissible pre-licensing construction and that the activities occurred before the staff issued a letter noting acceptable drilling activities (NRC, 2009d). The staff concluded the NRC warranted no further action at that time. However, the staff informed the applicant that if the staff approves the license and determines that the well spacing, or the monitoring well ring's distance from the wellfield, would not provide operational data adequate to ensure the protection of underground sources of drinking water, LCI would be required to reinstall a monitoring network. In addition, the staff informed the applicant that if the NRC issues a license, the staff will require, by license condition, review of the well construction details during the first inspection prior to operations (NRC, 2009d).

LCI subsequently requested an exemption from the "commencement of construction" provisions of 10 CFR 40.32(e) (LCI, 2009e). The staff completed a review of this exemption request (LCI, 2009e) and prepared a technical evaluation report (TER) (NRC, 2010a) and an environmental assessment (EA) with a finding of no significant impact (FONSI) (75 FR 17167; April 5, 2010). The staff did not authorize construction of the processing plant nor the drilling of the borings and casing of wells that the applicant would use to dispose of liquid byproduct material. The staff found that these activities have a nexus to radiological health and safety and require NRC staff review and approval because:

- The processing plant serves to concentrate and package yellowcake slurry,
- 10 CFR 20.2002(a) requires the NRC to perform a risk evaluation, and
- 10 CFR 20.2002(d) requires that doses be kept ALARA.

The NRC authorized the applicant to undertake the following activities, with the understanding that the exemption to 10 CFR 40.32(e) did not indicate that a license would later be issued (NRC, 2010b):

- Leveling and surfacing of the area around the plant and maintenance building;
- Constructing the plant and maintenance buildings (excluding construction of areas where radioactive materials are processed);
- Installing household septic systems for the plant and maintenance buildings;
- Installing fence around the plant and maintenance building area;
- Upgrading existing road access from the west to the plant;
- Upgrading existing road access from the east to the plant;
- Installing fence for early wellfield area;
- Installing power line to the plant and maintenance buildings and drillers shed; and
- Constructing a drillers shed and staging area.

Safety Evaluation Report

This SER documents the safety portion of the staff's review of the March 31, 2008, application (LCI, 2008c), as amended (LCI, 2010a). This SER includes an analysis to determine LCI's compliance with the requirements listed above, and with the applicable requirements and objectives set forth in 10 CFR Parts 20 (Standards for Protection Against Radiation) and 40 (Domestic Licensing of Source Material), and 10 CFR Part 40, Appendix A (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). A Supplemental Environmental Impact Statement (SEIS) (NRC, 2011d) has been prepared in parallel with this SER to address the environmental impacts of the proposed action.

The staff's safety review of the proposed Lost Creek Project was performed using NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications," (NRC, 2003a) and is a comprehensive assessment of LCI's proposed ISR facility. The regulations in 10 CFR Parts 20 and 40, and those in Appendix A to 10 CFR Part 40, contain the technical requirements for licensing an ISR facility. The staff organized this SER following the organization of NUREG-1569, except that sections addressing environmental aspects are not included in the SER as they are addressed in the SEIS (NRC, 2011d).

The staff's analysis throughout this SER refers to actions that the applicant will take after license issuance only upon a determination that the applicant has met the relevant regulatory requirements for license issuance. The staff's review of this application for the proposed Lost Creek Project identified a number of facility-specific issues that require license conditions, to ensure that the operation of the facility will be adequately protective of public health and safety. Table 1 includes the license condition language, as well as the section of this SER, where the staff identified the need for the license condition. Appendix A of this SER contains standard license conditions that the NRC staff applies to all ISR facilities. The staff concludes that the findings described in succeeding sections of this SER, including the necessary license conditions, support the issuance of a license authorizing the construction and operation of the

facility. The staff supports the issuance of a license authorizing the construction and operation of the facility if the conditions identified below are included in the license. The staff issued draft licenses to Lost Creek, LLC on January 11, May 5, July 11, 2011, and August 11, 2011 (NRC, 2011a, 2011b, 2011c, 2011f). By email dated August 12, 2011, Lost Creek, LLC agreed to these license conditions (LCI, 2011).

Table 1: License Conditions

SER Section	LC	License Condition (LC)
2.2.4	12.8	The licensee will continue to collect additional meteorological data on a continuous basis at a data recovery rate of 90 percent until the data collected is determined by the NRC to be representative of long-term conditions. Justification of the similarity or validity of the data will include analysis of the statistical data presented to illustrate confidence in the representativeness of the data. The data collected shall include, at a minimum, temperature, precipitation, wind speed, wind direction, and an annual wind rose. The submittal shall include a summary of the stability classification.
2.4.4	10.10	Prior to the injection of lixiviant into a production unit, the licensee will attempt to locate and abandon all historic drillholes located within the perimeter well ring such that the drillhole will not provide a conduit for the migration of production fluids. The licensee will document its efforts to identify and properly abandon all abandoned drillholes within the area of influence of a wellfield in a report submitted to the NRC prior to the start of operations at the production unit. If the licensee detects a vertical excursion during operations, the licensee will cease injection of lixiviant into the area surrounding the monitoring well until the licensee demonstrates to the satisfaction of NRC staff that the vertical excursion has been mitigated.
2.4.4	10.11	For mine units that abut (located within 100 feet of) the Lost Creek Fault, the licensee shall submit a plan to the NRC, for review, documenting the location and screened horizon of monitoring wells to monitor potential excursions across the fault into the upper and/or lower aquifers on the opposite side of the fault. The additional wells will be included in the routine excursion-monitoring program. The monitoring parameters will include the depth to water measurements and corresponding groundwater elevations.
2.4.4 5.7.9.4	10.12	Wellfield Packages. Prior to principal activities in a new wellfield, the licensee shall submit a hydrologic test data package to the NRC for review. The licensee shall submit a hydrologic test package at least 60 days prior to the planned start date of lixiviant injection. In each wellfield data package, the licensee will document that all perimeter monitoring wells are screened in the appropriate horizon in order to provide timely detection of an excursion. The licensee shall not proceed with any lixiviant injection in the new wellfield before it receives written NRC verification of the submitted hydrologic test data package.

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SER Section	LC	License Condition (LC)
2.6.4	12.9	The licensee shall submit to the NRC, prior to major site construction, a radiological environmental monitoring program report that will include soil samples co-located with air particulate samples, as described in Regulatory Guide 4.14 to comply with 10 CFR Part 40, Appendix A, Criterion 7.
3.1.4	10.13	Wellfield Inspections. Injection manifold pressures and flow rates shall be measured and recorded daily by the on-line computer system and/or Wellfield Operator. During wellfield operations, injection pressures shall not exceed the specified maximum operating pressure as specified in Section 3.2.6 of the approved license application. To the extent possible, the daily inspections should visually inspect and document leaks or other abnormalities in the wellfield piping, wellheads, or header houses in accordance with Section 3.2.7.5 of the approved license application. The licensee shall conduct the weekly in-plant inspection and audit programs described in Section 5.3 of the approved license application. In addition, as described in Sections 5.7.1 and 5.7.6 of the approved license application and supplements, the RSO, HPT(s), or designee shall document that radiation control practices are being implemented appropriately.
4.2.4	12.7	The licensee shall install two monitoring wells (MW-2 and MW-3) in the southwestern and southeastern corner of the storage pond area in accordance with Section 4.2.5.4 of the approved license application. These two wells, along with existing wells MW-1 and MW-4, will be included in the quarterly monitoring program as described in Section 5.3.2.3 of the approved license application.
5.5.4	10.17	The licensee shall ensure radiation safety training is consistent with Regulatory Guides 8.13, "Instruction Concerning Prenatal Radiation Exposure," (as revised); Regulatory Guide 8.29, “Instruction Concerning Risks from Occupational Radiation Exposure,“ (as revised); and Section 2.5 of Regulatory Guide 8.31 (as revised), or NRC-approved equivalent.
5.7.3.4	10.16	Any area with exposure rates that exceed 2 millirem in any 1 hour must be immediately treated as either a controlled area or restricted area in accordance with 10 CFR 20.1301(a)(2).
5.7.3.4	10.14	The licensee will use calibrated radiation instrumentation that can measure the full range of radiation exposure rates, or dose rates, that can be reasonably expected at an ISR facility, to ensure the magnitude and extent of radiation levels are measured in accordance with 10 CFR 20.1501(a)(2)(i). The instrumentation used to measure airborne concentrations of radioactive materials will allow for a lower limit of detection (LLD), as described in Regulatory Guide 8.30 (as revised), to provide a 95% confidence that measurements are in conformance with 10 CFR 20.1201, 20.1204, 20.1301, 20.1501, and 20.1502.

SER Section	LC	License Condition (LC)
5.7.4.4	10.15	The licensee shall conduct radiological characterization of airborne samples for natural U, Th-230, Ra-226, Po-210, and Pb-210 for each restricted area air particulate sampling location at a frequency of once every 6 months for the first 2 years following issuance of the license, and annually thereafter to ensure compliance with 10 CFR 20.1204(g). The licensee shall also evaluate changes to plant operations to determine if more frequent radionuclide analyses are required for compliance with 10 CFR 20.1204(g).
5.7.5.4	12.12	The licensee shall submit to the NRC for review and approval the procedures by which it will ensure that unmonitored employees will not exceed 10 percent of the dose limit.
5.7.7.4	12.11	Prior to the preoperational inspection, the licensee shall develop a survey program for beta-gamma contamination for personnel contamination from restricted areas, and beta-gamma contamination in unrestricted and restricted areas, that will meet the requirements of 10 CFR Part 20, Subpart F. The licensee shall provide, for NRC review and written verification, the surface contamination detection capability (scan MDC) for radiation survey meters used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the scanning mode for the alpha and beta-gamma radiation expected shall be provided in terms of dpm per 100 cm^2.
5.7.8.4	12.10	Prior to the preoperational inspection, the licensee shall provide the following information for the airborne effluent and environmental monitoring program in which it shall develop written procedures to: A) Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted-for in, and verified by, surveys and/or monitoring. B) Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302. C) Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2. D) Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire license area from licensed operations will be accounted-for in, and verified by, surveys and/or monitoring.

SER Section	LC	License Condition (LC)
5.7.8.4	12.15	Prior to the start of operations, the licensee shall submit a report to the NRC for review and verification that all water supply wells within one kilometer of the license area have been sampled for baseline quality and included in the routine environmental sampling program provided the owner consents to the sampling.
5.7.10	12.14	At least 60 days prior to the preoperational inspection, the licensee will submit a completed Quality Assurance Project Plan (QAPP) to the NRC for review to verify the license application statement that the QAPP will be consistent with Regulatory Guide 4.15 (as revised).
6.4.4	12.13	The applicant will submit to the NRC for review and approval a revised decommissioning, decontamination, and reclamation plan within 90 days of receipt of license. The revised plan will include soil cleanup criteria for radionuclides other than radium based on the radium benchmark dose method, as well as procedures to monitor for beta-gamma contamination on equipment, structures, and material released for unrestricted use. The soil cleanup criteria, based on the radium benchmark dose methodology for U and other radionuclides, will demonstrate that residual radioactivity in soil meets the criteria in 10 CFR Part 40, Appendix A, Criterion 6(6).

The NRC staff finds that the application for the Lost Creek Project materials license complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations. Based on its review, as documented in this SER, the staff concludes that the application meets the applicable requirements in 10 CFR Parts 20 and 40. More specifically, in accordance with 10 CFR 40.32(b)-(c), the staff finds that LCI is qualified by reason of training and experience to use source material for its requested purpose; and that LCI's proposed equipment and procedures for use at its Lost Creek Project facility are adequate to protect public health and minimize danger to life or property. Therefore, in accordance with 10 CFR 40.32(d), the staff finds that issuance of a license to LCI will not be inimical to the common defense and security or to the health and safety of the public.

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NRC, 2009b. "Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities," NUREG-1910, NRC, Washington, DC, May 2009.

NRC, 2009c. "Letter to Donald R. McKenzie, WDEQ, Regarding Detailed Hydrologic Studies for Proposed In Situ Recovery Facilities in Wyoming (TAC J50076)," April 9, 2009, ADAMS Accession No. ML090771156.

NRC, 2009d. "Letter to John W. Cash, LCI, Regarding Pre-Licensing Well Construction Lost Creek ISR Uranium Recovery Project, Lost Creek ISR, LLC, Sweetwater County, Wyoming," July 24, 2009, ADAMS Accession No. ML091520101.

NRC, 2009e. "Letter to John W. Cash, LCI, Regarding Request for Exemption from 10 CFR 40.32(e), Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming (TAC J00559)," July 28, 2009, ADAMS Accession No. ML092090186.

NRC, 2009f. "Letter to Wayne Heili, LCI, Regarding Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming Summary of September 25, 2009 Teleconference—Lost Creek ISR, LLC (TAC J00559)," November 9, 2009, ADAMS Accession No. ML093130083.

NRC, 2009g. "Letter to Wayne Heili, LCI, Regarding Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming Summary of September 25, 2009 Teleconference—Lost Creek ISR, LLC (TAC J00559)," December 18, 2009, ADAMS Accession No. ML093500010.

NRC, 2010a. "Technical Evaluation Report: Lost Creek ISR, LLC Lost Creek Uranium Recovery Facility 10 CFR 40.14 Exemption Request," Docket No. 40-9068, March 25, 2010, ADAMS Accession No. ML093350365.

NRC, 2010b. "Letter to John W. Cash, LCI, Regarding Request for Exemption from 10 CFR 40.32(e), Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming (TAC J00559)," April 6, 2010, ADAMS Accession No. ML093350365.

NRC, 2011a. U.S. Nuclear Regulatory Commission, "Letter to Wayne Heili, LCI, Regarding Draft Materials License, Lost Creek ISR, LLC, Lost Creek In Situ Recovery (ISR) Facility, Sweetwater County, Wyoming (TAC No. J00559)," January 11, 2011, ADAMS Accession No. ML111120307.

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NRC, 2011c. U.S. Nuclear Regulatory Commission, "Letter to Wayne Heili, LCI, Regarding Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming, Summary of May 31, 2011, Teleconference - (TAC NO. J00559)," July 11, 2011, ADAMS Accession No. ML111890482.

NRC, 2011d. "Environmental Impact Statement for the Lost Creek Project in Sweetwater County, Wyoming, Supplement to the Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities," NUREG-1910, Supplement 3, June 2011, ADAMS Accession No. ML111580539.

NRC, 2011f. U.S. Nuclear Regulatory Commission, "Email to Wayne Heili, LCI, Regarding Materials License, Lost Creek ISR, LLC, Lost Creek In Situ Recovery (ISR) Facility, Sweetwater County, Wyoming (TAC No. J00559)," August 11, 2011, ADAMS Accession No. ML112280010.

WDEQ, 2009a. "Letter to NRC Regarding Installation of Monitor Wells at Proposed ISL Sites," February 17, 2009, ADAMS Accession No. ML090750685.

WDEQ, 2009b. "Letter to NRC Regarding Installation of Monitor Wells at Proposed ISL Sites," March 10, 2009, ADAMS Accession No. ML090900379.

1.0 PROPOSED ACTIVITIES

1.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the summary of the proposed activities at the Lost Creek Project complies with 10 CFR Part 40.31, which describes the general requirements for issuance of a specific license.

1.2 ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40.31 using the acceptance criteria in Section 1.3 of NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications (NRC, 2003a) (Standard Review Plan, (SRP).

1.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 1.3, unless otherwise stated, is from Section 1 of the technical report (LCI, 2008c). LCI proposes to construct and operate an ISR facility at the Lost Creek Project in Sweetwater County, south-central Wyoming (LCI, 2008a, 2008c). The Lost Creek Project is comprised of approximately 1,707 hectares (ha) (4,220 acres [a])), including 199 unpatented Federal lode claims and one state mineral lease. The Lost Creek Project is located on public land administered by the Bureau of Land Management (BLM) and the State of Wyoming as illustrated in SER Figure 1.3-1.

According to the applicant, the main ore body at the Lost Creek Project is approximately 4.8 kilometers (km) (3 miles [mi]) in length and 0.61 km (0.379 mi) wide. Uranium mineralization occurs between 107 and 213 meters (m) (350 and 700 feet [ft]) below ground surface (bgs). Section 2.6 of the technical report (LCI, 2008c, 2010a) and SER Section 2.3 present detailed descriptions of the Lost Creek Project's geology and mineralogy and the NRC's detailed evaluation. The applicant estimates the uranium content in the ore body at the Lost Creek Project to total 4.9 million kilograms (kg) (10.9 million pounds [lbs]) from 8.3 million metric tons (t) (9.3 million tons) of uranium ore at grades 0.058 percent (92%) and 0.076 (8%), respectively (LCI, 2008c, 2010a).

In situ recovery (ISR) involves extracting uranium from underground ore bodies without bringing the ore itself to the surface (NRC, 2010c). The ISR process involves injecting a leaching solution through wells into underground, saturated ore bodies to dissolve the uranium. The leaching solution consists of native groundwater mixed with an oxidant, such as oxygen (e.g. O_2 gas) or hydrogen peroxide (H_2O_2), and a complexing agent, such as sodium carbonate (Na_2CO_3). The oxidant transforms uranium in minerals from the insoluble tetravalent state (+4) (e.g. uranium dioxide [UO_2]) to the soluble hexavalent state (+6) (e.g. uranium trioxide [UO_3]); the complexing agent enhances uranium's solubility and mobility (IAEA, 1993). The solution, called lixiviant, is collected in a series of recovery wells, through which it is pumped to a processing plant where the uranium is separated from the pregnant lixiviant by chemical adsorption of the anionic (i.e. negative charged ions) uranium carbonate complexes onto an ion exchange (IX) resin. Elution, a chemical process, extracts the uranium from the "loaded" resin by exchanging the uranium carbonate complex ions (e.g. $UO_2(CO_3)_2^{2-}$, $UO_2(CO_3)_3^{4-}$) with anionic ions in the eluant, such as chloride (Cl^-) from a sodium chloride solution. The eluted resin is

recycled, and the uranium in the eluant is purified, concentrated, and dried to produce "yellowcake," a uranium oxide and end-product of a uranium mill. The barren lixiviant is refortified with the oxidant and complexing agents and recirculated into the injection wells. The process is repeated until uranium recovery from the ore body is no longer economical (NRC, 2010c).

LCI will design and construct mine units using patterns of wells that consist of four corner injection wells and one central production well (5-spot pattern). The applicant provides detailed descriptions of the ISR process, including operations and design of the mine units, central distribution centers (called header houses), and the processing plant, in Section 3 of the technical report (LCI, 2008c, 2010a), which the NRC staff reviews and evaluates in SER Section 3. According to LCI in application Section 3.1, buried pipelines will transfer lixiviant between the mine units and the processing plant. Pipes will connect small groups of injection and production wells to header houses, where LCI will add oxygen or hydrogen peroxide as oxidants to the injection fluid. The applicant will add carbon dioxide to the injection solution at the processing plant or the header houses. LCI proposes to use a carbonate/bicarbonate lixiviant to maximize efficiency of uranium recovery and reduce reactions with other minerals. The carbonate/bicarbonate lixiviant will be prepared by varying the amounts and combinations of the following to the natural groundwater: sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), carbon dioxide ($CO_{2(g)}$), oxygen ($O_{2(g)}$), and/or hydrogen peroxide (H_2O_2) added to the native groundwater. The applicant describes the mine unit process in detail in Section 3.2 of the technical report (LCI, 2008c, 2010a). Storage and potential accidents involving these and other chemicals are described and evaluated in SER Sections 3.2.3.3 and 7.3.1.

The applicant designed the plant to process 22,712 liters per minute (Lpm) (6,000 gallons per minute [gpm]) of lixiviant through an IX circuit and process 909,000 kg (2 million lbs) per year of yellowcake slurry from the elution and precipitation circuits. The proposed processing plant in the license application does not contain a dryer, thus the product of the ISR will be yellowcake slurry that will be shipped off-site to a licensed facility for further processing. The applicant expects to produce approximately 455,000 kg (1 million lbs) of yellowcake (U_3O_8) per year for a period of at least eight years. The applicant submitted a letter of intent dated January 6, 2010, that states LCI plans to submit an amendment application after receiving the license to add a dryer in the processing plant (LCI, 2010c).

LCI's operations will generate byproduct material as defined in Section 11e.(2) of the Atomic Energy Act (AEA). Liquid byproduct material generated from the production and restoration operations at the Lost Creek Project will be disposed through deep well injection regulated by the State of Wyoming Department of Environmental Quality (WDEQ). Solid byproduct material, such as production equipment and piping, will be disposed of at a licensed mill tailings facility or other licensed facility not yet identified.

Once extraction is completed in a wellfield, restoration will begin. Restoration will consist of groundwater sweep, groundwater treatment, and stability monitoring, which the staff described and evaluated in SER Section 6.0. After restoration is completed and approved by the NRC staff, the Lost Creek wellfields will undergo decommissioning and reclamation.

SER Figure 1.3-2 illustrates the estimated schedule of construction, operation, restoration, decommissioning, and reclamation at the Lost Creek Project. The applicant based the schedule on an initial production rate of 20,500 kg (45,000 lbs) of yellowcake in the first year to allow for pre-production construction and a sustained production rate of 455,000 kg (1 million lbs) per

year in subsequent years. The applicant will adjust the actual development schedule and production rates to actual site conditions and the market demand for uranium.

A series of Federal, State, and local permits, license, and approvals are required prior to the possible start of operations including:

- Permit to Mine and the Mine Unit Number1 issued by the Wyoming Department of Environmental Quality (WDEQ)
- Source Materials License issued by the NRC
- Plan of Operations approved by the U.S. Bureau of Land Management (BLM)
- UIC permit for the Class I & Class III wells from the WDEQ
- Aquifer exemptions from the U.S. Environmental Protection Agency (EPA)

Should the Commission issue a source material license, the applicant proposed that construction begin immediately, with ISR and restoration operations expected to continue for 10 years after the start of production. According to SER Figure 1.3-2, production should begin six months after construction begins. Presently, the WDEQ has issued only the UIC permit for five Class I wells (Wyoming Permit 09-586, 2010).

The applicant committed to having an approved financial assurance arrangement in place prior to startup of operations (LCI, 2008c, 2010a). The financial assurance arrangement will be consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 9 and will include estimated costs for ground water restoration, radiological decontamination, facility decommissioning, and surface reclamation of sites, structures, and equipment used during operation of the Lost Creek Project.

1.4 EVALUATION FINDINGS

The staff reviewed the summary of the proposed activities at the Lost Creek Project in accordance with the review procedures and acceptance criteria in Sections 1.2 and 1.3 of the Standard Review Plan, respectively. Information contained in the application described the proposed activities at Lost Creek, including: (1) the corporate entities involved, (2) the location of the facility, (3) land ownership, (4) ore-body locations, (5) the proposed recovery process, (6) operating plans and design throughput, (7) schedules for construction, startup, and duration of operations, (8) waste management and disposal plans, (9) groundwater quality restoration, decommissioning, and reclamation plans, and (10) financial assurance.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of SRP Section 1.3 and the requirements of 10 CFR 40.31, which describes the general requirements for the issuance of a specific license.

1.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

Atomic Energy Act of 1954, as amended, 42 U.S.C. § 2011 et seq.

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LCI, 2008b. "Letter to NRC, Regarding Submittal of License Application for the Lost Creek ISR Project Docket No. 40-9068 TAC No. LU0142," March 20, 2008, ADAMS Accession No. ML081060502.

LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

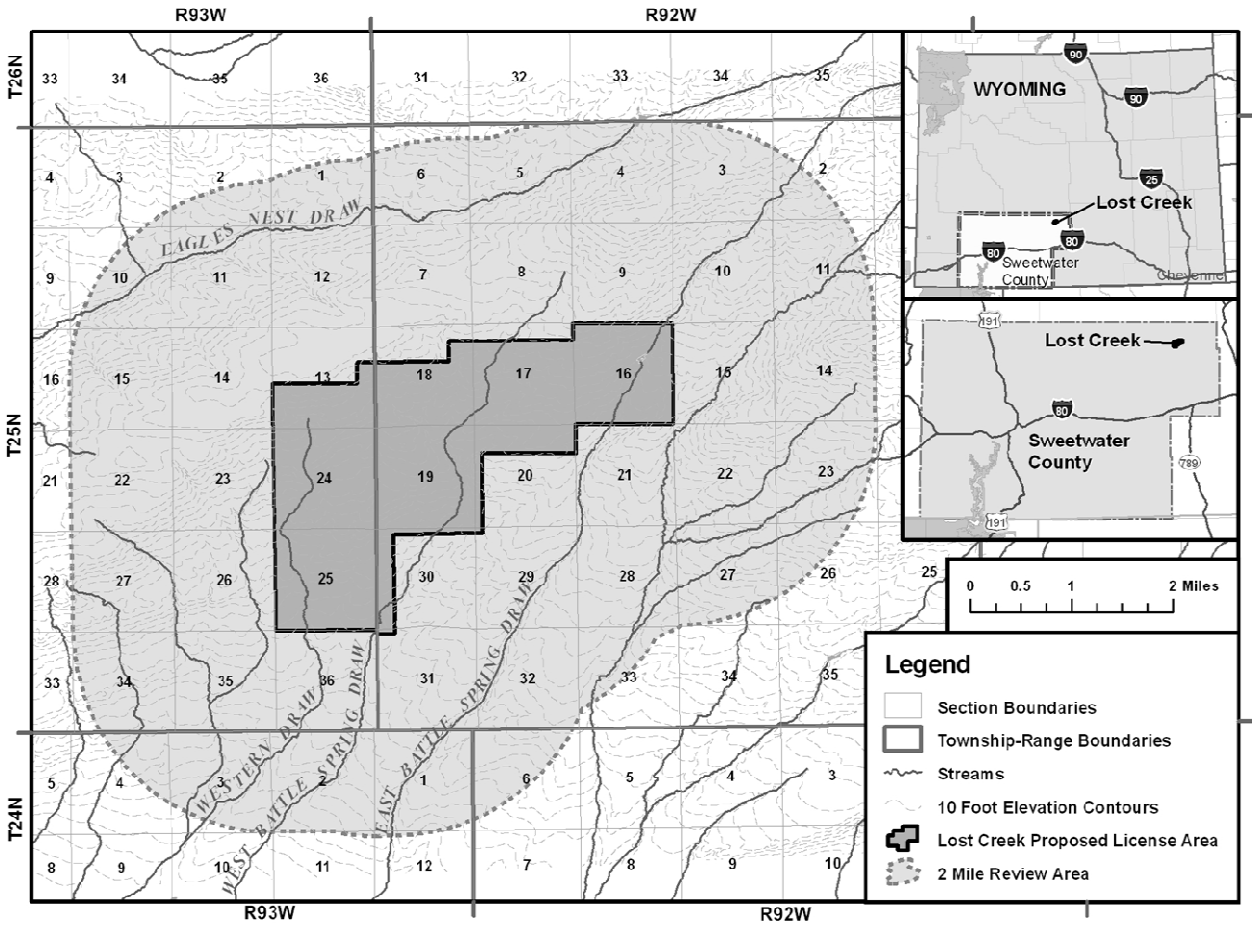
LCI, 2010c. "Letter to NRC, Lost Creek Project, Clarifications to TR Docket No. 40-9068 TAC No. LU0142," January 6, 2010, ADAMS Accession No. ML100130206.

NRC, 2003a."Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

NRC, 2010c. "In Situ Recovery Facilities," Nuclear Regulatory Commission, http://www.nrc.gov/materials/uranium-recovery/extraction-methods/isl-recovery-facilities.html.

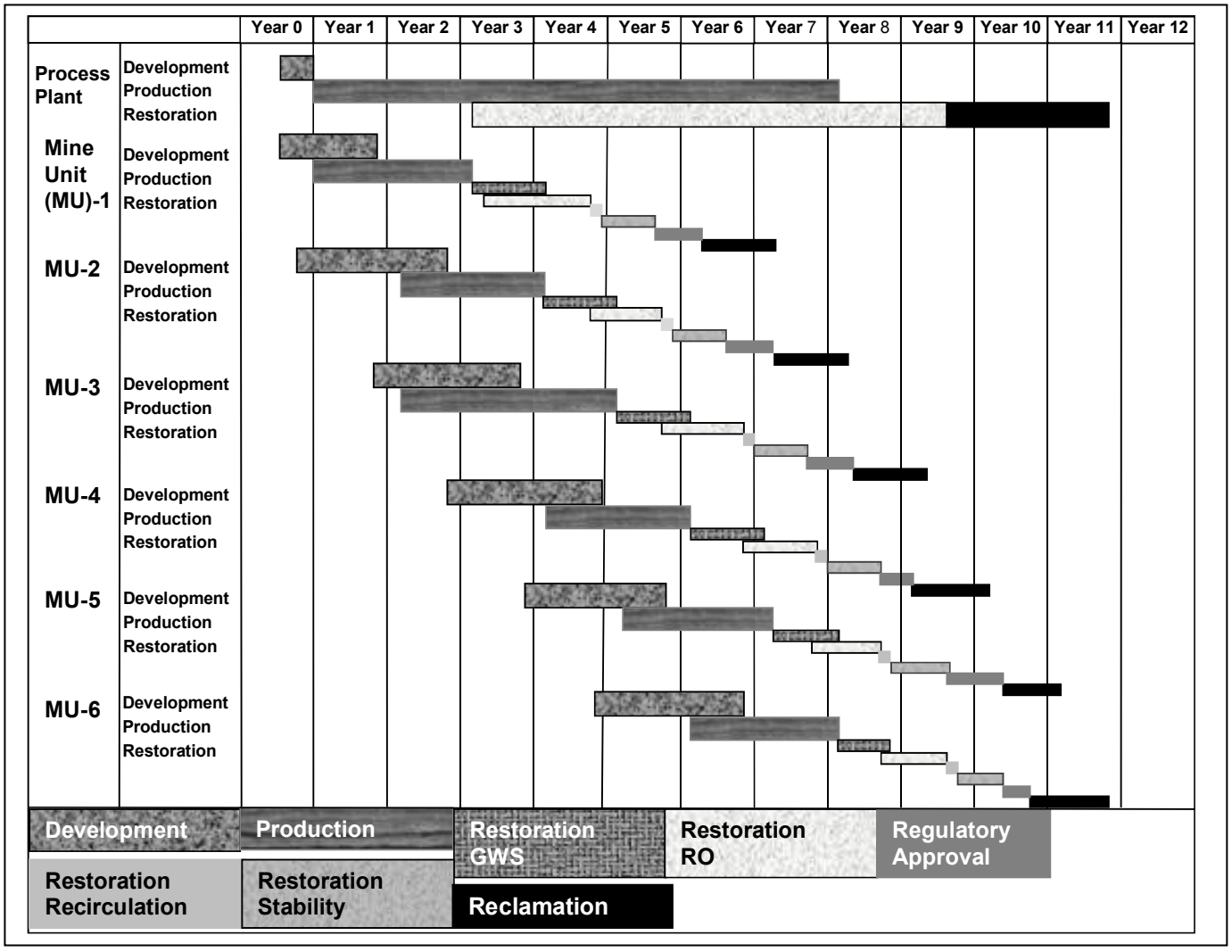
Ur-Energy, 2010. Ur-Energy, USA, letter to Charles L. Miller, U.S. Nuclear Regulatory Commission, November 1, 2010, ADAMS Accession No. ML103130276.

Wyoming Permit 09-586, UIC Class I, Lost Creek Disposal Wellfield, May 28, 2010.



(LCI, 2008c) (Adapted from Figure 1.3-1 of technical report)

Figure 1.3-1: Location of Lost Creek Project Site in Sweetwater County, WY



(LCI, 2010a) (Adapted from Figure 1.7-2 of technical report)

Figure 1.3-2: Lost Creek Project Schedule

2.0 SITE CHARACTERIZATION

2.1 SITE LOCATION AND LAYOUT

2.1.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the site location and layout are consistent with the requirements of 10 CFR 40.31(g)(2).

2.1.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in Section 2.1.3 of the Standard Review Plan (SRP) (NRC, 2003a).

2.1.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 2.1.3, unless otherwise stated, is from Section 2.1 of the technical report (LCI, 2008c, 2010a). The applicant stated that the proposed Lost Creek Project is located in the Great Divide Basin on 1,707 hectares (ha) (4,220 acres [a]) of public land in Sweetwater County, Wyoming, within Township 25 North and Ranges 92 and 93 West of the Sixth Principal Meridian (SER Figure 1.3-1). The BLM and the State of Wyoming administer 1,448 and 259 ha (3580 and 640 a), respectively, of the proposed project area. The Lost Creek Project is approximately 40 km (25 mi) south of Jeffrey City, 145 km (90 mi) southwest of Casper, 24 km (15 mi) southwest of Bairoil, 129 km (80 mi) northeast of Rock Springs, and 61 km (38 mi) northwest of Rawlins. The Lost Creek Project is centered at approximately 42 degrees, 8 minutes north latitude and 107 degrees, 51 minutes west longitude. According to the applicant, in Section 1.3 of the application (LCI, 2008c), less than 100 people inhabit Bairoil, which is the nearest town.

LCI provided a topographic map (Figure 2.1-1 of the technical report (LCI, 2008c) delineating the proposed locations of the plant, roads, transmission lines, pipelines, six mine units' surface water drainage system, and the local public land survey system in the vicinity of proposed license area. The staff observed that the topography in the proposed licensed area consists of sub-horizontal surface with a uniform, extremely shallow southerly grade transected by moderately incised channels associated with a network of ephemeral streams (WSGS, 2009). The applicant stated (LCI, 2010a) that no perennial streams are present within the proposed license area. No publicly maintained roads exist within the proposed licensed area. Although grazing allotments for livestock are within the proposed licensed area, no farms or residences exist within or adjacent to the proposed licensed area. The applicant proposed to fence all mine units for security. The applicant has no plans to divert the existing stream network (LCI, 2008c, 2010a).

No residential structures are located within the proposed Lost Creek Project boundary. The applicant reported the nearest resident is located in Bairoil. One NRC licensed facility, the Kennecott Sweetwater Uranium Mill (NRC license SUA-1350), is located with 8 km (5 mi) of the Lost Creek Project.

Staff reviewed the information describing the proposed licensed area in the application (LCI, 2008c, 2010a) and found the information acceptable because the applicant used recognized data sources. These data sources included the U.S. Geological Survey (USGS), the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), the U.S. Census Bureau, BLM, and the Wyoming Game and Fish Department (WGFD) (LCI, 2008c, 2010a). Additionally, the staff observed the site as described during site visits in the summers of 2007 and 2009 (NRC, 2007a).

2.1.4 EVALUATION FINDINGS

The staff has reviewed the site location and layout of the Lost Creek Project in accordance with the review procedures in SRP Section 2.1.2 and the acceptance criteria in SRP Section 2.1.3. The applicant has described the site location and layout with appropriately scaled and labeled maps showing the site layout, principal facilities and structures, boundaries, and topography. Based upon the review conducted by staff as indicated above, the information provided in the application meets the applicable acceptance criteria of SRP Section 2.1.3 and the requirements of 10 CFR 40.31(g)(2).

2.1.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2003a."Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

NRC, 2007a. "Lost Creek Project Site Visit," Memoranda to Docket File 040-09068, July 12, 2007, ADAMS Accession No. ML072060085.

WSGS, 2009. Wyoming State Geological Survey, "Land Areas of Wyoming Designated Unique and Irreplaceable or Rare and Uncommon," [map], 1:500,000. Unique and Irreplaceable or Rare and Uncommon Areas in Wyoming Series: 92: generated by Timothy M. Sprague, September 2009.

2.2 METEOROLOGY

This section discusses meteorological conditions of the region surrounding and including the applicant's facility. Meteorological data are used for the selection of environmental monitoring locations, assessing the impact of operations on the environment, and determining radiological dose assessments as required in 10 CFR Part 20. The information presented in SER Section 2.2, unless stated otherwise, is obtained from Section 2.5 of the application (LCI, 2008c, 2010a).

2.2.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the meteorology program – which is part of the site monitoring programs required by 10 CFR Part 40, Appendix A, Criterion 7 – is sufficiently complete to allow for estimating doses to workers and members of the public.

2.2.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7, using the acceptance criteria in Section 2.5.3 of the Standard Review Plan (SRP) (NRC, 2003a).

2.2.3 STAFF REVIEW AND ANALYSIS

The following sections present the staff's review and analysis of various aspects of the meteorological conditions and monitoring at the Lost Creek Project. The aspects reviewed in the following sections include meteorological data acquisition, general site conditions, atmospheric dispersion, and meteorological data quality.

2.2.3.1 Meteorological Data Acquisition

According to Regulatory Guide 3.63, "Onsite Meteorological Measurement Program for Uranium Recovery Facilities—Data Acquisition and Reporting," (NRC, 1988b), an onsite meteorological measurement program employs instrument systems physically located on or near the site that are capable of measuring meteorological information representative of the site vicinity. Meteorological measurements should be made in locations that can provide data representative of the atmospheric conditions into which material will be released and transported. The information is used to estimate the maximum potential annual radiation dose to the public and the environmental impact resulting from the routine release of radioactive materials in gaseous and particulate effluents.

Information in SER Section 2.2.3.1, unless otherwise stated, is from Section 2.5 of the technical report (LCI, 2008c, 2010a). The applicant installed meteorological stations near Bairoil, Wyoming, 19 km (12 mi) northeast from the proposed licensed area in April 2006 and within the Lost Creek Project in May 2007. The stations are known as the Lost Soldier (LS) and Lost Creek (LC) Stations, respectively (see SER Figure 2.2-1). LCI initially submitted data collected from the Lost Soldier Station to describe the onsite meteorological conditions at Lost Creek (LCI, 2008c). LCI collected additional data at the Lost Creek Project and included it in the applicant's revised technical report (LCI, 2010a; Brown, 2010; Kelsey, 2010). The applicant observed microclimatological differences between the LC and LS sites and the regional meteorological stations. The applicant has therefore committed to continued operation of both stations until it has collected sufficient data to support site operations without the need for additional measurements at one or both of the stations (Brown, 2010). The staff has included the applicant's commitment in a license condition to ensure the applicant collects enough data to represent long-term conditions. The staff discusses this commitment further in SER Section 2.2.4.

The applicant stated in Section 2.5.1 of the technical report that temperature was measured using a temperature and relative humidity probe at 2 m (6.6 ft) above ground (LCI, 2010a). LCI used a dual system to measure the differential temperature for dispersion and inversion

modeling at 2 and 10 m (6.6 and 33 ft) from the ground. LCI measured precipitation with a rain gauge located 1 m (3.3 ft) above ground and 5 m from the meteorology station. The applicant used an anemometer and wind vane to measure wind speed and direction, and a pyranometer to measure solar radiation with wavelengths between 400 and 1100 nm, at 10 m (33 ft). The staff concludes that the applicant collected on-site data consistent with the recommendations in Regulatory Guide 3.63 (NRC, 1988b), as discussed below.

Regulatory Guide 3.63 defines the minimum amount of meteorological data needed to be that amount of data collected on a continuous basis for a consecutive 12-month period that is representative of long-term (e.g., 30 years) meteorological conditions in the site vicinity. To verify if the period of record is characteristic of long-term meteorological conditions, the regulatory guide suggests comparing a concurrent period of meteorological data from a National Weather Service (NWS) station with the long-term meteorological data from that NWS station.

The NWS station selected for this comparison should be in a similar geographical and topographical location and be within 80 km (50 mi) of the site. For this comparison, the applicant (LCI, 2008c) initially chose the NWS station in Muddy Gap, Wyoming (see SER Figure 2.2-1), to compare with Lost Soldier meteorological data. The NRC staff observed that

Table 2.2-1: Comparison of Temperature (^{o}F) Collected at Various Locations

Period of Record	Station									
	Lost Creek		Lost Soldier		Muddy Gap		Jeffery City		Rawlins	
	7/07 - 11/07; 3/08 - 11/09		5/06 - 11/08; 1/09 - 8/09		10/19/1949 - 12/31/2007		4/10/1964 - 6/30/2009		3/6/1951 - 5/31/2008	
Month	Temperature (^{o}F)									
	Avg. High	Avg. Low	Avg. High	Avg. Low	Avg. High	Avg. Low	Avg. High	Avg. Low	Avg. High	Avg. Low
January	31.8	5.6	22.4	7.0	31.3	13.8	30.6	8.5	30.8	12.6
February	34.1	9.8	29.5	14.1	34.9	15.9	34.1	10.6	33.8	14.7
March	35.9	11.9	38.0	20.1	43.4	21.4	43.5	18.5	41.3	20.4
April	47.3	22.7	47.0	26.0	55.2	29.2	54.5	26.3	52.6	27.6
May	61.1	34.4	61.0	37.9	66.0	37.9	64.6	34.8	63.9	36.3
June	70.4	41.1	72.4	46.7	76.2	46.4	75.2	42.6	75.4	44.6
July	84.3	50.6	81.6	55.5	85.1	53.5	85.2	49.6	83.8	51.5
August	80.7	48.3	78.4	52.6	83.1	52.2	82.9	48.3	81.1	50.0
September	69.7	38.7	64.7	41.7	72.8	42.5	71.7	38.2	70.5	40.8
October	52.4	26.4	52.6	31.7	59.9	32.9	59.2	28.8	57.0	31.2
November	44.8	18.1	42.5	23.6	42.1	22.1	41.0	17.2	40.7	20.4
December	27.9	4.0	26.0	10.2	32.7	15.2	30.9	9.3	32.0	14.0

(LCI, 2008c)
(Source: Table 2.5-1b in the technical report)

the Muddy Gap NWS station is located 45 km (28 mi) northwest of the proposed licensed area and recorded data between 1949 and 2008. Thus, the staff concluded that the applicant could not use the Muddy Gap NWS station data to determine if the LC station data was representative of long-term conditions because the data were not collected concurrently.

The applicant (LCI, 2010a) compared the average monthly precipitation and temperature data measured during various record periods at several sites to the precipitation and temperatures measured at the LS and LC stations as shown in SER Figure 2.2-2 and SER Table 2.2-1. Staff observed that these data presented do not verify that the data collected at Lost Creek or Lost Soldier are representative of long-term conditions because the periods of collection were not the same at the various sites. In addition, the staff found that it is difficult to compare average rainfall data because the data could have included years with exceptional rainfall or droughts.

The applicant modified Table 2.5-1b in the technical report (LCI, 2010a) to compare concurrent average temperature data collected at the Lost Creek, Lost Soldier, Jeffrey City, and Rawlins stations between July and November 2007 and March 2008 and November 2009 (Brown, 2010). As shown in SER Table 2.2-2, the staff observed that the average high and low temperatures measured in December 2008 were lower than temperatures measured in January 2009 at each of the stations. The staff observed that comparing the average temperatures measured concurrently at Lost Soldier, Jeffrey City, and Rawlins stations to the long-term average temperatures measured at these stations indicates a slight variation in pattern from the

Table 2.2-2: Average Temperature Data (^{o}F) at Locations During the Same Period

	Station									
	Lost Creek		**Lost Soldier**		**Muddy Gap**		**Jeffery City**		**Rawlins**	
Period of Record	**7/07 - 11/07; 3/08 - 11/09**									
Month	**Temperature (^{o}F)**									
	Avg. High	Avg. Low	Avg. High	Avg. Low	-	-	Avg. High	Avg. Low	Avg. High	Avg. Low
January	31.8	5.6	30.1	12.3	-	-	35.2	10.2	33.7	13.0
February	34.1	9.8	32.7	15.6	-	-	40.0	15.3	35.4	17.9
March	35.9	11.9	34.6	17.4	-	-	40.3	15.0	40.5	19.0
April	47.3	22.7	45.1	25.1	-	-	49.8	24.3	49.7	25.3
May	61.1	34.4	58.8	36.9	-	-	62.9	35.6	62.9	36.4
June	70.4	41.1	68.0	44.1	-	-	71.8	42.5	72.9	42.5
July	84.3	50.6	81.5	54.9	-	-	85.8	51.0	86.0	51.4
August	80.7	48.3	78.3	52.7	-	-	82.5	48.2	82.5	49.0
September	69.7	38.7	67.7	43.4	-	-	72.8	38.9	72.1	40.4
October	52.4	26.4	50.3	29.9	-	-	54.8	27.8	54.6	28.8
November	44.8	18.1	43.1	23.2	-	-	48.9	19.4	46.7	22.8
December	27.9	4	26.7	8.4	-	-	30.6	7.5	31.2	12.5

*- Indicates data are unavailable at Muddy Gap station because it was discontinued in 2008.
(LCI, 2008c, 2010a)
(Source: Table 2.5-1b in the technical report)

long-term data. The applicant did not perform the proper statistical analysis to determine whether the data collected at the proposed facility is representative of long-term climate trends, per Regulatory Guide 3.63 (NRC, 1988b). Thus, the NRC staff cannot determine if the applicant collected the minimum amount of data or if the data collected is sufficient to represent long-term conditions. Because the applicant did not meet SRP Section 2.5.3 acceptance criterion (3), continued collection of data will be required by the license condition presented in SER Section 2.2.4 until the applicant has demonstrated that sufficient data has been collected to represent

long-term conditions, which is needed to demonstrate compliance with 10 CFR Part 40, Appendix A, Criterion 7.

2.2.3.2 General Site Conditions

This project is located in the Great Divide Basin, in south-central Wyoming. According to the information provided by the applicant (LCI, 2008c, 2010a), the average annual temperatures range from a low of -3.3 degrees Celsius (°C) (26 degrees Fahrenheit [°F]) to a high of 12 degrees C (53 degrees F) (see SER Table 2.2-1 for average monthly temperatures). The staff observed that July was the warmest month recorded at the Lost Creek station and the average maximum and minimum warmest daily temperatures measured were 29 degrees C (84 degrees F) and 11 degrees C (51 degrees F), respectively. The staff observed that December was the coldest month recorded at the Lost Creek station; average maximum and minimum coldest daily temperatures measured were -2.2 degrees C and -16 degrees C (28 degrees F and 4 degrees F), respectively. The staff finds that measurements in July were similar to the average measurements at the other weather stations in SER Tables 2.2-1 and 2.2-2.

SER Table 2.2-3 presents the monthly maximum and minimum humidity recorded at the Lost Creek and Lost Soldier stations, which show that the average relative humidity at Lost Creek is lowest in the summer and highest in the winter. The applicant reported that the lowest and highest measurements at Lost Creek station occurred in June (30%) and February (76%), respectively. The staff finds that SER Table 2.2-3 shows a similar pattern at the Lost Creek and Lost Soldier stations with the average minimum and maximum humidity measured in July and January, respectively.

2.2.3.3 Atmospheric Dispersion

Dispersion is the transport and diffusion of effluents that can result in dilution and deposition of a contaminant on the ground and in the breathing zone. Dispersion and deposition are dependent on wind speed, wind direction, atmospheric stability, and mixing height, as well as the type of terrain and height and density of structures near the release site. Mixing height is the vertical distance of a homogenous layer in the atmosphere between the Earth's surface and a temperature inversion. Temperatures usually decrease with altitude. An inversion is created when the temperature increases with altitude. Turbulence generated within the mixing layer from interaction between the atmosphere and the Earth's surface or heating and cooling of the Earth's surface, further mixes air, and thus effluent. Mixing heights typically undergo large diurnal and seasonal variations that increase and decrease in depth proportionally with solar heat. Static stability occurs within the inversion layer, which impedes vertical and/or horizontal mixing and immobilizes the contaminant beneath the inversion. The stability class can vary from extremely unstable to extremely stable, and can be determined by temperature differences between two heights or the fluctuation of horizontal wind direction at a given height.

Table 2.2-3: Average Monthly Humidity Measured, Lost Creek and Lost Soldier

Month	Year of Record	Lost Creek		Lost Soldier	
		Maximum Humidity %	Minimum Humidity %	Maximum Humidity %	Minimum Humidity %
January	2009	99.7	17.5	99.8	12.5
February	2009	99.0	20.6	97.3	28.0
March	2008, 2009	97.8	20.7	97.0	22.5
April	2008, 2009	99.1	10.3	98.9	11.6
May	2008, 2009	97.8	20.7	99.3	10.3
June	2008, 2009	97.5	6.5	99.8	7.1
July	2007, 2008, 2009	97.3	5.9	96.3	5.8
August	2007, 2008, 2009	96.8	7.3	95.7	7.2
September	2007, 2008	99.4	8.8	98.7	8.9
October	2007, 2008	97.8	20.7	98.4	11.1
November	2007, 2008	97.9	20.7	99.2	14.8
December	2008	98.4	30.8	96.3	30.5

(LCI, 2008c, 2010a)
(Source: Table 2.5-2b of the technical report)

Joint frequency distribution (JFD) illustrates the frequency in which a joint frequency category occurs in a specified period. Each joint frequency category represents a range of wind speeds, directions, and stability conditions. The average morning and afternoon mixing heights and JFD are meteorological characteristics used as input parameters in atmospheric dispersion and transport computer codes, such as MILDOS-AREA, to calculate the concentration of a contaminant and the radiation dose commitments at a receptor point from the release site.

The applicant collected wind speed, wind direction, solar radiation, precipitation, temperature, relative humidity, and stability data between September 1 and November 1, 2007 and March 1, 2008 and August 31, 2009, except for brief interruptions as described in Section 2.5 of the technical report (LCI, 2010a; Brown, 2010). The applicant reported (LCI, 2008c) that the annual average wind speed at the Lost Soldier station between May 2006 and April 2007, was 7 meters per second (m/s)(23 feet per second [ft/s]), and that the prevailing monthly wind direction is from the west-northwest and west for most of the year. The predominant wind from the Lost Creek station is from the west and west-southwest (see SER Figure 2.2-3). LCI observed (LCI, 2010a) microclimates between the two stations and the regional NWS station, and suggested that the JFD differences observed at Lost Creek and Lost Soldier may result from the short sampling periods or topographical differences. SER Figure 2.2-3 illustrates the JFD of wind speed and direction for Lost Creek and Lost Soldier, respectively, collected during the same periods at both locations.

LCI stated in Section 2.5.1.4 of the application that it used the Pasquill methodology (Pasquill, 1961) to classify atmospheric and measured wind speed and solar radiation measured on site to calculate the stability (LCI, 2010a). Stability class distribution at the Lost Creek and Soldier stations are presented in SER Figure 2.2-4, and show that conditions are predominantly neutral (stability class D) and range from moderately and slightly unstable (stability classes B and C, respectively) to slightly stable (stability class E). The applicant (LCI, 2010a) stated that it used mixing height data collected at a National Climatic Data Center (NCDC) station at Lander/Riverton, Wyoming, and reported that the average annual mixing height is 348 m (1142 ft) in the morning and 2300 m (7546 ft) in the afternoon.

The applicant provided (LCI, 2010a) two journal articles (Fearon and Brown, 2000; Martner and Marwitz, 1982) that support the use of an average mixing height, such as that measured at Lander/Riverton, Wyoming, for the Lost Creek Project. The first article (Fearon and Brown, 2000) described the use of 12-hr forecasts of mixing height and mean transport wind flow obtained from NWS stations to model smoke output from forests fires in regional areas for periods from 48 hrs to 10 days. The second article (Martner and Marwitz, 1982) describes the studies conducted by University of Wyoming (UW) of wind speeds, direction, frequency distributions to determine the diurnal and seasonal variability, as well as the meteorological and topographical factors governing airflow in southern Wyoming. According to these articles, the Great Divide Basin in southern Wyoming serves as a natural vessel for stable air from the Great Divide Basin in Utah and Nevada. The mountain ranges create a "wind corridor," according to Kolm (1977) that funnels wind from the west in a tapered, faster configuration toward the east.

The UW studies (Martner and Marwitz, 1982) indicate that wind speed-frequency distributions are wider in the winter and directions are more from the west in winter than in the summer, which the NRC staff finds is consistent with the data observed at LC and LS stations (SER Figure 2.2-3). The vertical profile of wind speed in southern Wyoming has been observed to be uniform in the day, rather than at night (Martner and Marwitz, 1982). However, the diurnal trend has been determined to be a function of atmospheric stability.

The NRC staff finds the journal articles provided by the applicant support LCI's use of the mixing height data collected at the Lander/Riverton station because the articles demonstrate that the data collected at the Lander/Riverton station are representative of conditions in the Great Divide Basin. Thus, the staff finds that LCI can use the mixing height data collected at the Lander/Riverton station to provide the mixing height at Lost Creek and Lost Soldier facilities because these facilities are located in the Great Divide Basin. The staff further concludes the meteorology data collected by the applicant on site and the mixing height data collected at the Lander/Riverton station are acceptable because the methodology used follows the guidance provided in Regulatory Guide 3.63 (NRC, 1988b) and peer-reviewed studies supported the methodology. The peer-reviewed studies demonstrate that models to predict wind transport in Wyoming have used mixing heights measured in regional stations successfully (Fearon and Brown, 2000) and that wind speed and direction measured at LCI are characteristic of wind speed and direction in the Great Divide Basin (Martner and Marwitz, 1982).

2.2.3.4 Meteorological Data Quality

The applicant provided a description of the types and specifications for the meteorological instrumentation in Section 2.5.1 of the technical report (LCI, 2010a). The staff finds that the instruments, placement, and accuracies of the systems were consistent with guidance in Regulatory Guide 3.63 (NRC, 1988b). The applicant reported that it linked sensors to Campbell Scientific CR1000 and CR10X data loggers at the Lost Creek and Lost Soldier stations, respectively, and that data recovery rates at these stations exceeded 90 percent. The staff finds that LCI provided instrument calibration sheets (LCI, 2010a) in accordance with recommendations in Regulatory Guide 3.63. The applicant used satellite links to download the data and verify accuracy. The applicant stated that the only lapse in data recovery resulted from battery failure during extreme cold weather conditions during one winter. As a result, the applicant buried the batteries at increased depths that prevented a reoccurrence of battery failure (LCI, 2010a).

The NRC staff has concluded that the data was collected in accordance with Regulatory Guide 3.63. The applicant collected precipitation and joint-frequency distribution data following the

guidance in the regulatory guide in the placement of instruments measuring and recording wind direction, wind speed, stability class, period of record, and height of data measurement. The average inversion height was provided as well and thus, the staff concludes the data are acceptable because the information meets SRP Section 2.5.3 acceptance criterion (1) (NRC, 2003a). Staff further concludes that the applicant has described meteorological data sufficiently that the staff finds that the meteorological data quality is acceptable to use in calculations to determine effluent concentrations and radiation doses as required in 10 CFR 20.1301 and § 20.1302.

2.2.4 Evaluation Findings

Staff reviewed the monitoring of meteorological conditions at the Lost Creek Project in accordance with SRP Section 2.5.3 (NRC, 2003a). The applicant used data from an on-site and various NWS meteorological stations to represent conditions at the Lost Creek Project; however, the information was insufficient to determine if the data are representative of long-term conditions. Because the applicant has not statistically analyzed the data to demonstrate that the data provided are representative of long-term meteorological conditions consistent with SRP Section 2.5.3 acceptance criterion (3), the applicant will need to continue to collect on-site meteorological data as recommended by Regulatory Guide 3.63 in order to meet the requirements in 10 CFR Part 40, Appendix A, Criterion 7. The staff is adding the following license condition to ensure that the applicant collects representative data before the applicant discontinues on-site data collection:

> The licensee will continue to collect additional meteorological data on a continuous basis at a data recovery rate of 90 percent until the data collected is determined by the NRC to be representative of long-term conditions. Justification of the similarity or validity of the data will include analysis of the statistical data presented to illustrate confidence in the representativeness of the data. The data collected shall include, at a minimum, temperature, precipitation, wind speed, wind direction, and an annual wind rose. The submittal shall include a summary of the stability classification.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information to be collected and confirmed in accordance with the noted license condition, meets the applicable acceptance criteria of SRP Section 2.5.3 (NRC, 2003a) and the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.2.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, “Standards for Protection Against Radiation,” U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, “Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or

Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content,” U.S. Government Printing Office, Washington, DC.

Brown, E., 2010. AATA International, Inc., email to Tanya Oxenberg, NRC, June 24, 2010, ADAMS Accession No. ML101820139.

Fearon, M. G., and T. J. Brown, 2000. "Experimental Daily NCEP Eta Model Smoke Management Forecasts," *Proceedings Third Symposium on Fire and Forest Meteorology*, Long Beach, American Meteorological Society.

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Kolm, K.E., 1977: "Predicting surface wind characteristics of Wyoming from remote sensing of eolian geomorphology," Ph.D. Dissertation, University of Wyoming, Laramie.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

LCI, 2010d. "Letter to NRC, Regarding Lost Creek Project, Requested Clarifications Docket No. 40-9068 TAC No. LU0142," November 11, 2010, ADAMS Accession No. ML103210590.

LCI, 2010e. "Letter to NRC, Regarding Lost Creek Project, Meteorology Page Change Docket No. 40-9068 TAC No. LU0142," November 16, 2010, ADAMS Accession No. ML103280186.

LCI, 2010f. "Letter to NRC, Regarding Lost Creek Technical Report Page Changes Docket No. 40-9068 TAC No. LU0142," December 3, 2010, ADAMS Accession No. ML103490862.

Martner, B. E., and J. D. Marwitz, 2001. "Wind Characteristics in Southern Wyoming," *Journal of Applied Meteorology*, 21, 1815-1827.

NRC, 1988b. "Onsite Meteorological Measurement Program for Uranium Recovery Facilities—Data Acquisition and Reporting," Regulatory Guide 3.63, Washington, DC, March 1988.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

Pasquill, F., 1961. "The Estimation of Windborne Material," *Meteorological Magazine*, Vol. 90, pp. 33-49.

2.3 GEOLOGY AND SEISMOLOGY

2.3.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has characterized the geology and seismology at the Lost Creek Project sufficiently such that the applicant's ability to maintain control over production fluids containing source and byproduct materials is adequately documented as required in 10 CFR 40.41(c).

2.3.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR 40.41(c), using the review procedures in Section 2.6.2 and acceptance criteria in Section 2.6.3 of the Standard Review Plan (SRP) (NRC, 2003a).

2.3.3 STAFF REVIEW AND ANALYSIS

Information reported in SER Section 2.3, unless otherwise stated, is from Section 2.6 of the technical report (LCI, 2008c, 2010a). The following sections present the staff's review and analysis of various aspects of the geology and seismology at the Lost Creek Project. The information reviewed in the following sections includes geographic setting, regional geology, site geology, soils, and seismology.

2.3.3.1 Geographic Setting

The applicant described the regional and local geology in and around the Lost Creek License area (LCI, 2008c). Regionally, the license area is located northeast portion of the Great Divide Basin. The Great Divide Basin is an oval-shaped basin located along the Great Divide in south-central Wyoming (LCI, 2008c; WSGS, 2011). The aerial extent of the basin is approximately 9,064 square kilometers (km^2) (3500 square miles [mi^2]) (LCI, 2008c; WSGS, 2011). The basin developed following the Laramide Orogeny (80 to 25 million years ago [ma]) (LCI, 2008c; Bates and Jackson, 1984), which formed the Wind River and Granite Mountain Range to the north, Rawlins Uplift to the east, Wamsutter Arch to the south, and the Rock Spring uplift to the west of the basin (LCI, 2008c; WSGS, 2011).

Topography in the proposed licensed area consists of sub-horizontal surface with a uniform, extremely shallow southerly grade transected by moderately incised channels associated with a network of ephemeral streams. Ground surface elevations within the licensed area range from 2073 to 2149 m (6800 to 7050 ft) above mean sea level (LCI, 2008c; WSGS, 2011; Welder, 1966).

Staff reviewed the geographic setting information provided by the applicant and found that that the description, presented by the applicant, was consistent with published data and that the characterization of the regional geographic setting supported its conceptual model. Based on this review, the staff concludes that the applicant has provided an adequate description of the regional geographic setting because it meets the requirements of 10 CFR Part 40, Appendix A, Criterion 5G(2).

2.3.3.2 Regional Geology

A generalized license area stratigraphic column is presented in SER Figure 2.3-1. The information presented in SER Section 2.3.3.2, unless stated otherwise, is obtained from Section 2.6.1 of the application (LCI, 2008c, 2010a). The applicant states that the subsurface strata consist of a thick sequence (approximately 7,409 m [24,300 ft]) of consolidated sedimentary rock units overlying a Precambrian-age (greater than 540 ma) crystalline bedrock (LCI, 2008c). SER Figure 2.3-2 shows a generalized regional stratigraphic column. Strata consists of an upper, approximately 3,308-m (10,850-ft) sequence of Tertiary age (65 to 2 ma) rocks that include, from youngest to oldest, the Early Eocene (53 to 34 ma) Battle Spring Formation and the Paleocene (65 to 53 ma) Fort Union Formation. The Battle Spring Formation is 1,890 m (6,200 ft) thick and unconformably overlies the Fort Union Formation. The Fort Union Formation

is 1,418 m (4,650 ft) thick and unconformably overlies the Late Cretaceous age (135 to 65 ma) Lance Formation. Both Tertiary Formations are considered aquifers. Uranium mineralization occurs in the upper sections of the Battle Spring Formation. The Battle Spring Formation has been mapped as being exposed at ground surface throughout the license area as well as throughout the eastern portions of the Great Divide Basin. Underlying the Fort Union Formation is approximately a 4,101-m (13,450-ft) sequence of Cambrian to Cretaceous age (540 to 65 ma) rock units (LCI, 2008c, 2010a). As reported by the applicant, several of these rock units are designated as potential aquifers and the respective depths below grade are as follows:

Formation	Depth Below Grade (m [ft])
Lance	3,305 (10,850)
Frontier	5,747 (18,850)
Dakota	6,052 (19,850)
Nugget Sandstone	6,174 (20,250)

Although not mapped within the license area, the Tertiary rocks may be overlain by a thin veneer of unconsolidated Quaternary alluvium (less than 2 ma) generally limited to the present-day stream channels within the basin (LCI, 2008c, 2010a). A thin veneer of soils overlies all consolidated rock units throughout the basin because of their long exposure at ground surface. The applicant reports that the regional structure of the subsurface strata is generally monoclinal, with a relatively shallow (3-degree) dip to the southwest (LCI, 2008c, 2010a). Dip increases to approximately 25 degrees along the margins of the Great Divide Basin. Due to the steeper dips, essentially all of the rock units, including the Precambrian basement, have been mapped with surficial exposures in the highlands along the northern perimeter of the Great Divide Basin. Surficial exposures in the northern highlands provide direct recharge to the various aquifers Clarey et al., 2010).

The applicant includes geologic mapping that exhibits anticlinal and synclinal fold axes throughout the basin (LCI, 2008c, 2010a). In addition, the applicant reported that several regional faults are east and north of the license area.

Staff reviewed the regional geologic information supplied by the applicant and finds that the description presented by the applicant is consistent with published data for the regional geologic setting (Welder and McGreevy, 1966; Sheridan et al., 1961; Pipiringos, 1961; and Masursky, 1962) and supports its conceptual model of the subsurface. Based on this review, the staff concludes that the applicant has provided adequate description of the regional geologic setting in accordance with requirements of 10 CFR 40.41(c).

2.3.3.3 Site-Specific Geology

The applicant reports that the uranium mineralization is found in the Battle Spring Formation to depths of approximately 610 m (2,000 ft); however, the economically viable mineralization is found at depths of less than 213 m (700 ft) (LCI, 2008c, 2010a). The Battle Spring Formation mapped within the license area consists of interbedded thick sequences of very fine to coarse-grained arkosic sandstones (sandstones containing 25 percent feldspar) with layers of siltstones and mudstones. Conglomeritic lenses can locally exist within the layering.

The applicant has identified five mineralized horizons in the upper 213 m (700 feet) of the Battle Spring Formation in the license area. Mineralized horizons are reportedly fine-grained arkosic sandstone and siltstone layers that can contain minor carbonaceous material (LCI, 2008c, 2010a). The applicant referred to these horizons from shallowest to deepest, as the BC, DE,

FG, HJ, and KM Horizons (LCI, 2008c, 2010a). LCI reported that it considered the horizons aquifers in that they have the ability to transmit water; however, each horizon contains lenses of fine-grained shales, siltstones, and mudstones (LCI, 2008c, 2010a). Thicker (up to 23 m [75 ft]) more- contiguous layers of shales, siltstones, and mudstones (LCI, 2008c, 2010a) separate designated horizons from one another. The applicant considered these contiguous layers as aquitards in the sense that the ability to transmit water is significantly low. Important aquitards that bracket the HJ Horizon (mineralized zone) are the overlying Lost Creek Shale (LCS) and the underlying Sage Brush Shale (SBS), names designated by the applicant (LCI, 2008c, 2010a). Based on isopach mapping supplied by the applicant, thickness of the overlying LCS within the proposed area varies from 1.5 to 14 m (5 to 45 ft); the typical thickness is between 3 and 7.6 m (10 and 25 ft). Thickness of the underlying SBS within the license area varies between 1.5 and 7.6 m (5 and 75 ft); the typical thickness is between 3 and 7.6 m (10 and 25 ft) (LCI, 2008c, 2010a).

The applicant reported the majority of mineralization in the area occurs within the two deeper horizons, the HJ and KM horizons, and the applicant subdivides each of those horizons into an upper, middle, and lower subzone (LCI, 2008c, 2010a). Fifty percent of the mineral resource is found in the middle HJ (MHJ) zone (LCI, 2008c, 2010a). Total thickness of the HJ Horizon is 33.5 to 40 m (110 to 130 ft); the thickness of individual ore bodies varies from 1.8 to 8.5 m (6 to 28 ft) with an average thickness of 44.9 m (16 ft). The mineralization zone in the HJ horizon is at depths between 122 and 137 m (400 and 450 ft) below grade.

The applicant discussed the geochemistry of the mineralized zone. The mineralized zone consists of unaltered, reduced grayish sandstone that contains carbon trash (amorphous carbon) and trace levels of pyrite. Uranium-bearing minerals are uraninite and coffinite (LCI, 2008c, 2010a), which occur as coating around sand grains, voids between grains, within larger interstitial clay particles or intergrown with the pyrite. The mineralization ranges from 0.03 to 0.20 percent equivalent uranium oxide (LCI, 2008c, 2010a).

The applicant reported a general east-west trend to the ore body throughout the license area and provided one longitudinal and two transverse cross-sections through the proposed licensed area/ore body. The cross sections depict the stratigraphic relation of the near-surface mineralized zones, layers separating those mineralized zones, and traces of the potentiometric surfaces for the various horizons.

In addition to the regional monoclinal structure to the subsurface geology, the applicant reported that one major fault with several subsidiary faults bisects the ore body within the license area (LCI, 2008c, 2010a). The maximum displacement of the fault is 24 m (80 feet). The applicant interprets the structural feature as a sequence of sub-parallel faults with opposite displacement occurring in an en echelon configuration.

Based on drawdown observed during the pumping tests and differences in static potentiometric head across the fault, the applicant's conceptual model of the Lost Creek Fault is a zone of low permeable materials such that the fault is a hydrogeologic barrier (see SER Section 2.4). In Figure 2.7-11e of the technical report, the applicant depicts an approximately 30-m (100-ft) wide zone of lower permeability associated with the Lost Creek Fault through Mine Unit 1 (LCI, 2008c).

The applicant provided isopach mapping of the immediately underlying aquifer (upper KM horizon), underlying confining unit (Sage Brush Shale), the production aquifer (HJ Horizon) and the overlying confining unit (Lost Creek Shale), and structural contour mapping for the top of

those respective units. Based on the isopach mapping, structural contour mapping, and cross-sections, the applicant concluded that the overlying and underlying confining layers, in general, appear to be sufficiently thick and continuous to isolate the production zone in the HJ Horizon Mine Unit, though thickness of the overlying and underlying layers may decrease to 5 feet (LCI, 2008c). As discussed in SER Section 2.4, the applicant concluded that the pumping test data supported the conceptual model of the applicant that the geology provides sufficient capacity to contain production fluids to the production zone.

Staff reviewed the site-specific geologic information provided by the applicant and found that the applicant provided sufficient information to assess the site-specific geology. The information in the application presented a comprehensive view of the subsurface strata consistent with the applicant's conceptual model and met the acceptance criteria in SRP Section 2.6.3. The staff further evaluated and verified the consequences of the thinner areas of the overlying and underlying aquitards and the potential impact of the fault on the confinement of production fluids, which are discussed in SER Section 2.4.4.

2.3.3.4 Historic Borings

The applicant reported information on nearby historic boreholes and wells in a variety of sections of the technical report (e.g., Attachment 2.6-2, Tables 2.2-2, 2.2-3, 2.2-4, and 2.6-4 (LCI, 2008c)). In Attachment 2.6-2 in the application, the applicant listed 809 historic borings completed within 3.2 km (2 mi) of the license area of which 220 borings were drilled since 2000. In Table 2.2-2 in the application, the applicant listed 306 groundwater use permits within 3.2 km (2 mi) of the license area. Groundwater uses consisted of livestock water supply, industrial (including dewatering), monitoring, and miscellaneous uses. Applicants for the majority of groundwater use permits were Kennecott Uranium Company, Ur-Energy USA, Inc., NFU Wyoming, LLC, or LCI. Applicants for groundwater use permits associated with livestock watering were Kennecott Uranium Company and the BLM. In Table 2.2-3 of the application, the applicant listed 161 abandoned and cancelled (i.e., permitted but not installed) wells within 3.2 km (2 mi) of the license area. The applicant for most of those wells was Texasgulf, Inc, a former owner of the property. In Table 2.2-4 of the application, the applicant listed 15 potentially active and three abandoned/cancelled domestic and stock wells within 8 km (5 miles) of the license area. The applicants for those wells were either BLM or Kennecott Uranium Company (LCI, 2008c).

The applicant reported no other subsurface mineral exploration or production within the license area at the same horizon as the proposed project. The nearest mineral production is a gas field located approximately 16 km (10 mi) southwest of the license area (LCI, 2008c, 2010a).

The staff reviewed the information provided by the applicant and found the information consistent with guidance in NUREG-1569. Section 2.2.3 of NUREG-1569 states:

> "*locations of abandoned wells and drill holes, including …plugging procedure used…for each well or drill hole within the site area and within 0.4 km [.25 mi] of the wellfield boundary.*"

Section 2.6.3 of NUREG-1569 states that the staff can find the characterization of the geology acceptable if:

> *"plugging and abandonment records are provided from State, Federal, and local sources, as appropriate, and that the applicant should provide evidence that*

action has been undertaken to properly plug and abandon all wells that cannot be documented in this manner."

The staff acknowledges that the applicant has undertaken efforts to provide information on historic abandoned boreholes/wells (drillholes) and taken steps to properly reseal "questionable" abandoned drillhole. The applicant did not provide information as to why those 19 abandoned drillholes were questionable whereas the other documented abandoned boreholes were not questionable. Staff notes that the applicant committed to the plugging of abandoned drillholes based on results of pumping tests. In the application (LCI, 2008c), the pumping tests performed by the applicant exhibited slight communication between the overlying and production aquifer. In Attachment 2.7.3 of the application, the applicant stated:

"*While LC ISR, LLC has undertaken an extensive abandonment program of historic boreholes, it is unknown whether additional boreholes are responsible for the responses observed. Additional data will be collected during subsequent testing to better understand the integrity of the overlying and underlying confining shale units. Based on testing results to date, it is anticipated that the minor communication between the HJ Horizon and the overlying and underlying sands can be managed through operational practices, detailed monitoring, and engineering operations."*

The applicant further stated in the application that:

"If previously unknown drill holes or wells are detected during the mine unit installation and testing, e.g., if communication is detected during a pump test, the drill hole or well will be abandoned in accordance with the procedures currently in use"

Based on the mapping in the technical report (Attachment 2.6-2 Plates A26-2a through A26-2c) (LCI, 2008c), the abandoned drillholes are generally on 200-foot centers with approximately 40 abandoned drillholes within each of the proposed mine units. The applicant committed to attempt to locate and properly abandon all historic drillholes within each mine unit (LCI, 2010b). Based on the applicant's commitment and the staff's review of the applicant's data submitted, staff finds that the applicant will be able to operate safely within the existing setting. The staff is memorializing this commitment in a license condition (see SER Section 2.4.4).

2.3.3.5 Soils

The applicant described the soils in the proposed license area based on a soil survey conducted in 2006 in Section 2.6.4.1 of the technical report (LCI, 2008c, 2010a). References to historical regional soil surveys were included (e.g., surveys by the National Resources Conservation Service (NRCS) or the Soil Conservation Service (SCS)), but the figures provided by the applicant included no discernable information due to the regional scale. LCI provided a map of soils within the license area in technical report Plate 2.6-3 (LCI, 2008c, 2010a). The applicant described the soils in the license area as typical for semi-arid grasslands and shrub lands in the Western United States. The soil developed from degradation from the sedimentary bedrock. Due to the limited precipitation, calcium and other divalent cations have not substantially leached and the soil pH is slightly alkaline with low organic matter.

The applicant classified soils into one of three taxonomically units using established field soil survey protocols (LCI, 2008c): Typic Torriorthent, loamy, mixed mesic (34 percent of the area);

Typic Torriorthent, fine-loamy, mixed mesic (46 percent of the area); and Typic Torriorthent, fine-loamy over sand, mixed mesic (20 percent of the area). Suitable to marginally suitable top soil was present throughout the most of the license area: one soil sample of the B horizon was considered unsuitable due to slightly high percentage of coarse fragments. The applicant reported limiting factors to be low saturation percentages. Prior disturbance of the soils included 42 km (26 mi) of unimproved roads for mineral exploration activities, possibly hunting and stock tank usage (LCI, 2008c, 2010a).

The staff finds that the soil identification by the applicant consisted of proper documentation for the analysis of on-site sample samples, on-site test pits, and the classifications based on established protocols and widely accepted soil taxonomy. NRC staff finds that the applicant adequately described the soils in the proposed license area as the field survey conducted by the applicant was in accordance with established field survey protocols and the descriptions are consistent with regional surveys by established federally recognized NRCS or CSC.

2.3.3.6 Seismology

Information in SER Section 2.3.3.6, unless otherwise stated, is from Section 2.6.3 of the technical report (LCI, 2008c, 2010a). The applicant reported the historical earthquakes for the area, performed a Uniform Building Code (UBC) analysis, included a deterministic analysis of active faulting, provided a tectonic province floating earthquake source analysis, and summarized a short-term seismic hazard analysis. Based on the historic earthquake data, the applicant concluded that the intensities of historic earthquakes have been generally low to moderate with intensities between III and V; however, the applicant reported that two moderate earthquakes of intensity VI to VII were to have occurred over 100 years ago in the Casper area (approximately 145 km (90 mi) from the license area). From the UBC analysis, the applicant suggested that an average peak horizontal acceleration of 7.5 percent gravity (%g) “could be applied” in the design of a non-critical facility.

From the deterministic analysis of active faults, the applicant indicated a maximum peak horizontal acceleration of approximately 20 to 23 %g at Bairoil (24 km (15 mi) east of the license area) from a possible earthquake along the two nearby fault systems (South Granite Mountain and Chicken Springs fault systems). The applicant concluded the maximum tectonic province for a floating earthquake source was a magnitude 6.0 to 6.5 for this area. From the short-term probabilistic seismic hazard analysis, the applicant suggests that based on the 500-year probability map (a 10 percent probability of exceedance in 50 years), the estimated peak horizontal acceleration in the licensed area is approximately 6.5 %g. The applicant finishes this section with the statement that the estimated acceleration in the licensed area is 20 %g on the 2,500-year probability map.

The staff has determined that the applicant has provided the requisite information for the application and verified that the information is from reputable published sources. Based on the narrative and the analysis for the pond embankment, the applicant used the 6.5 to 7.5 %g for its design criterion assuming the UBC meets the existing State codes; however, the Wyoming Fire Marshal code adopted the International Building Code (IBC) as of February 11, 2008. The IBC based the criterion on the 2,500-year probability. The applicant committed to using the design criteria appropriate for the prevailing applicable codes (LCI, 2009b). Use of the IBC criterion is more conservative and provides the best assurance that the potential for failure of any constructed pond embankment due to seismic activity is minimized during the proposed life of the facility. Therefore, based on the staff’s review of the applicant's and published data, NRC

staff finds the assessment of the seismology acceptable because the risk of a failure of a pond embankment during the life of the proposed facility is ALARA.

2.3.4 EVALUATION FINDINGS

The staff has completed its review of the site characterization information addressing geology and seismology at the Lost Creek Project in accordance with review procedures in Section 2.6.2 and acceptance criteria in SRP Section 2.6.3 (NRC, 2003a). The applicant has adequately described the geology and seismology by providing (a) a description of the local and regional stratigraphy, (b) geologic, topographic, and isopach maps at acceptable scales showing surface and subsurface features and locations of all wells and site explorations used in defining stratigraphy, (c) a geologic and geochemical description of the mineralized zone and the geologic units adjacent to the mineralized zone, (d) a description of the local and regional geologic structure, (e) a discussion of the seismicity and seismic history of the region, (f) a generalized stratigraphic column that includes the thickness of rock units, a representation of rock units and a definition of mineralized horizon, and (g) a description and map of the soils. Therefore, the information provided in this section meets the requirements of 10 CFR 40.41(c) with the following exception. Although the applicant has provided documentation that all known historic exploratory drillholes have been properly abandoned and has provided information that the applicant has re-abandoned several drillholes, the applicant notes that observed responses to the pumping tests may be attributed to unknown drillholes.

The applicant committed to abandon any historic drillhole that could be a pathway for lixiviant migration to the overlying aquifer, the staff observed that improperly abandoned historic drillholes unknown to the applicant, could not contain production fluids. Furthermore, the fault could not provide adequate containment of the production fluids during operations in areas in which the mineralized zone is juxtaposed to another horizon. Staff reviewed and verified the applicant's hydrogeologic data (presented in SER Section 2.4.4) and finds that the site conditions provide adequate containment based on the data presented with the addition of verification monitoring. Verification monitoring can adequately address the slight uncertainties of improperly abandoned historic drillholes and leakage through the fault. The verification monitoring will be included as license conditions as discussed in SER Section 2.4.4.

2.3.5 REFERENCES

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2.4 HYDROLOGY

2.4.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has characterized the surface and groundwater hydrology at the Lost Creek Project sufficiently to document the applicant's ability to maintain control over production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

2.4.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for consistency with applicable requirements of 10 CFR 40.41(c), using the review procedures in Section 2.7.2 and acceptance criteria in Section 2.7.3 of the Standard Review Plan (SRP) (NRC, 2003a).

2.4.3 STAFF REVIEW AND ANALYSIS

The following sections present staff's review and analysis of various aspects of the surface water and groundwater hydrology at the Lost Creek Project. In SER Section 2.4.3, unless otherwise stated, the reported information is from Section 2.7 of the application (LCI, 2008c, 2010a).

2.4.3.1 Surface Water

Information in SER Section 2.4.3.1, unless otherwise stated, is from Section 2.7.1 of the technical report (LCI, 2008c, 2010a). The applicant stated that at the regional scale, the Lost Creek Project is located in the Great Divide Basin, a topographically closed system that drains internally to a system of playa lakes. Near the site, the applicant stated the license area is located in two drainage basins: the Battle Spring Draw drainage basin and an unnamed basin, as shown in SER Figure 2.4-1.

SER Figure 2.4-2 illustrates a detailed site watershed map. The applicant stated that the Battle Spring Draw is the principal drainage in the license area and divides into two tributaries: the West Battle Spring Draw and East Battle Spring Draw watersheds (LCI, 2008c, 2010a). As shown on SER Figure 2.4-2, both watersheds make up the eastern two-thirds of the license area. The applicant refers to the watershed in the western unnamed basin as the West Draw watershed. The applicant provided calculated peak flows for the three watersheds, which SER Table 2.4-1 summarizes (LCI, 2008c, 2010a).

The application states that the Battle Spring Draw drains to the southwest with an average slope of 1.2 percent while the western unnamed drainage trends to the southwest with an average slope of 1.5 percent (LCI, 2008c, 2010a). All existing drainages are incised with wide u-shaped or trapezoidal cross sections to the channels. The channels are typically vegetated with sagebrush. No perennial or intermittent streams exist within the license area drainages or on adjacent lands; the applicant reports that the channels are dry for the majority of the year (LCI, 2008c, 2010a).

The applicant reported that most surface water in the license area is derived from precipitation or snowmelt and, in the arid environment, is quickly absorbed by plants, evaporates, or infiltrates into ground to the shallow groundwater located 24 to 46 m (80 to 150 ft) below ground surface (LCI, 2008c, 2010a). Therefore, runoff through the drainages is very low due to high infiltration and low annual precipitation. Peak runoff from high intensity rain events can be significant but surface flow is generally short lived. No significant ponds or springs exist within the license area (LCI, 2008c, 2010a).

The applicant reported that two USGS gauging stations are located on perennial streams within 64 km (40 mi) of the license area, but the flows are not representative of those within the license area (LCI, 2008c, 2010a). Within the license area, the applicant estimated peak flows at various recurrence intervals for the Battle Spring Draw and West Draw watersheds using regression equations developed by Miller (2003). SER Table 2.4-1 summarize results and show that expected peak flows range from 0.7 cubic meters per second (m^3/s) [23.6 cubic feet per second (cfs)] for the 2-year flood event to 9.7 m^3/s (343.6 cfs) for a 100-year flood event (LCI, 2008c, 2010a).

The applicant did not provide a flood analysis for the license area, but stated that the drainage areas are less than 2.59 km^2 (10 mi^2), and the corresponding peak flows would not be sufficient

to inundate significant areas within the license area (LCI, 2008c, 2010a). The applicant committed to installing a 15.2-centimeter (6-inch) concrete berm around the plant as a precaution to inundation and/or erosion and to providing secondary containment. The applicant also indicated that it is unlikely that any wells would be located in drainages. Further, the applicant stated that if wells need to be located within or close to a drainage where flooding may

Table 2.4-1: Calculated Peak Flows

Watershed	Area (km^2/mi^2)	2-year ($m^3/s/cfs$)	5-year ($m^3/s/cfs$)	10-year ($m^3/s/cfs$)	25-year ($m^3/s/cfs$)	50-year ($m^3/s/cfs$)	100-year ($m^3/s/cfs$)
West Battle Spring Draw (at Point B4)	18.1/7.0	0.8/28.7	2/73.7	3.3/118.6	5.47/193.2	7.4/262.3	9.7/343.6
East Battle Spring Draw (at Point C2)	13.2/5.1	0.7/23.6	1.7/61.3	2.9/99.5	4.6163.3	6.2/222.8	8.3/293.3
West Draw (at Point A2)	7.51/2.9	0.5/16.9	1.3/45.0	2.1/73.9	3.4/123.0	4.7/169.3	6.3/224.9

(Source: LCI, 2010b)
(Table 2.7-1b in the technical report)

be of concern, it will install additional wellhead protection and committed to design any necessary erosion protection around drainages (LCI, 2008c, 2010a).

Based on a site tour in the summer of 2009 and review of the topographic mapping, staff finds the applicant adequately described the surface water drainages. Staff verified that the published data used to estimate peak flows are applicable to the site and that the applicant calculated the flows correctly. Based on existing licensees, staff agrees with the applicant that it can place wells in a wellfield to minimize disturbance to a drainage channel, and if one cannot be avoided, added measures can be used to protect a specific wellhead. Consequently, staff finds that the applicant provided sufficient information to meet the acceptance criteria in SRP Section 2.7.3.

2.4.3.2 Regional Hydrogeology

Unless otherwise stated, information in SER Section 2.4.3.2 derives from Section 2.7.2.1 of the application (LCI, 2008c, 2010a). The project area is located in the north-central portion of the Great Divide Basin, which is an internal drainage basin. Surface water flows to the central area of the basin located southwest of the license area and contains a series of lakes, springs, and playa lakebeds (LCI, 2008c, 2010a).

Primary aquifers for the basin are found within the consolidated sedimentary rock units younger than the Upper Cretaceous (65 to 70 ma) Lewis Shale. The Lewis Shale effectively isolates the aquifers above it from the aquifers below because of its thickness (in excess of 305 m (1000 ft) throughout the basin) and low permeability. Rock units older than (below) the Lewis Shale are not widely used as aquifers due to their depths within the basin and, in some cases, poor groundwater quality. Older rock units can be used as water sources near the basin perimeter where they are found at shallow depths (LCI, 2008c, 2010a).

Of the consolidated rock units found above the Lewis Shale, the Lance, Fort Union, and Battle Spring Formations have been used as aquifers within the basin. Unconsolidated Quaternary sediments are found in localized stream channels and can yield good quality groundwater; however, due to their limited extent, those discrete localized sediments have limited storage capabilities, which preclude their usage as a significant water resource

Groundwater flow in aquifers above the Lewis Shale mirrors the topography of the basin. Recharge occurs along the perimeter of the basin where many of the subsurface rock units have surficial exposures. The upgradient regional recharge area for the Battle Spring Formation aquifer is located along the northern perimeter of the basin. The primary discharge points for the regional ground water flow are surface water bodies located in the center of the basin (Clarey et al., 2010). SER Figure 2.4-3 shows a generalized potentiometric surface contour map for the regional Battle Spring aquifer.

The staff finds that the applicant adequately described the regional hydrogeology in accordance with the acceptance criteria in SRP Section 2.7.3 by describing the setting using established mapping from published sources (e.g. USGS). Staff based this determination on the quality and quantity of the hydrogeologic information provided by the applicant, as independently confirmed and verified by the staff.

2.4.3.3 License Area Hydrogeologic Units

Unless otherwise stated, the information reported in this section is from Sections 2.7.3.2 and 2.7.4.2 of the application (LCI, 2008c, 2010a). The applicant evaluated the near-surface Battle Spring aquifer within the license area. The applicant's conceptual model of the near surface aquifer within the license area is as follows:

- Battle Spring Formation extends from the surface to a depth of 1,890 m (6200 ft) and consists of a heterogeneous mixture of mudstone, siltstone, and fine to coarse sandstone layers;
- uranium mineralization viable for ISR extraction is found within the upper 213 m (700 ft) of the Battle Spring Formation;
- thicker, coarser grained sandstone layers within the upper 213 m (700 ft) of the Battle Spring Formation can be divided into mapable hydrostratigraphic horizons in the application as follows (from shallowest to deepest):
    - DE Horizon (shallowest occurrence of groundwater):

      sands and discontinuous clay/shale units, top of unit is 30 to 61 m (100 to 200 ft) bgs;

      coalesces with underlying FG Horizon to the south; and

      water levels in the DE Sand are typically 43 to 61 m (140 to 200 ft) bgs;
    - Upper No Name Shale (upper confining unit to the FG Horizon):

      0 to 15 m (0 to 50 ft) thick;
    - FG Horizon (includes overlying aquifer to HJ Horizon):

subdivided into UFG, MFG and LFG Sands (upper, middle and lower subhorizon;

total thickness of horizon is 30 m (100 ft);

top of unit is 61 to 107 m (200 to 350 ft) bgs;

LFG Sand is the overlying aquifer to the HJ horizon;

LFG Sand is 6.1 to 15 m (20 to 50 ft) thick; andwater levels in the LFG Sand are typically 49 to 61 m (160 to 200 ft) bgs;

- Lost Creek Shale (LCS) (upper confining unit to the HJ horizon):

  laterally continuous across licensed area;

  1.5 to 14 m (5 to 45 ft) thick; and

  confining properties demonstrated from water levels and pump test;

- HJ Horizon (contains the primary production zone):

  subdivided into UHJ, MHJ, and LHJ Sands, although sands are hydraulically connected;

  coarse-grained arkosic sands with thin lenticular intervals of fine sand, mudstone and siltstone;

  averages 37 m (120 ft) thick;

  top of unit is 91 to 137 m (300 to 450 ft) bgs and

  water levels in the HJ Horizon range from 46 to 61 m (150 to 200 ft) bgs;

- Sage Brush Shale (SBS) (lower confining unit to the HJ Horizon:

  laterally continuous across licensed area;

  1.5 to 23 m (5 to 75 ft) thick;

  top of unit 137 to 183 m (450 to 550 ft) bgs; and

  confining properties demonstrated from water levels and pump test;

- KM Horizon (includes underlying aquifers):

  subdivided into UKM, MKM and LKM Sands;
  massive coarse sandstones with thin lenticular fine sandstone intervals;
  contains mineralized zones not subject for mining through this application;
  top of unit is 137 to 183 m (450 to 600 ft) bgs;
  UKM Sand is the first underlying aquifer;
  UKM Sand is 9.1 to 18.3 m (30 to 60 ft) thick;
  water levels in the UKM Sand are generally 56 to 67 m (185 to 220 ft) bgs;

- No Name Shale is the lower confining unit to the UKM Sand;

  No Name Shale is 3 to 9.1 m (10 to 30 ft) thick and laterally extensive but will require additional characterization; and

- K Shale is an additional shale unit that separates the UKM from the MKM horizons.

  The applicant acknowledges that additional characterization is need for this horizon in the future.

- Horizons designated as “aquifers” (i.e., DE, FG, HJ, and KM horizons) may contain one or more discontinuous lenses of finer grained mudstones;
- The majority of mineralization is found in the “HJ” horizon; the application is specifically for production of that horizon although the applicant suggests that production from other horizons may be sought in the future;
- the Lost Creek Fault bisects the mineralized ore body. According to the applicant, due to the low hydraulic conductivity of that fault zone, it acts as an effective hydraulic barrier.

Data submitted by the applicant in support of its hydrogeologic conceptual model were derived from the following:

- 85 existing wells
- 13 single-well pumping tests conducted in 2006
- four short-term (less than 2 days) low-yielding [less than 72 Lpm (19 gpm) constant-rate pumping tests conducted in 2006 with multiple observation wells, and
- two long-term (5 days), high-yielding (142 to 162.4 Lpm [37.4 to 42.9 gpm]) constant-rate pumping tests conducted in 2007 with multiple observation wells.

Seventy-five of the wells were installed between 2006 and 2008; ten wells were installed after the initial submittal of this application (LCI, 2008c, 2010a).

The applicant also reported results of four pumping tests conducted in 1982 by others at several pre-existing wells. Data from the 1982 pumping tests were used to design the more recent tests, and, in general, the recently installed wells and pumping tests were conducted at or near locations of the former 1982 wells/pumping tests. Locations of most existing wells are within the extent of the proposed Mine Unit 1, which is north of the Lost Creek Fault, or Mine Unit 2, which is south of the Lost Creek Fault as well as Mine Unit 1. The applicant proposes that more detailed, definitive data will be determined in the future by testing to be conducted prior to the operation of any mine unit.

NRC staff reviewed the applicant’s information on the site geology and finds it acceptable because (a) it is consistent with the regional data from published sources, (b) the applicant used acceptable methods to investigate the subsurface, (c) the applicant used a sufficient number of and adequately spaced locations for data collection, and (d) the applicants conceptual model for the geology can be verified by the hydrogeologic testing as discussed in SER section 2.4.3.5.

2.4.3.4 Water Level Data

Unless otherwise stated, the information presented in this section is from the Section 2.7.2.2 of the application (LCI, 2008c, 2010a). The applicant provided the following groundwater elevation (depth to water) data for selected wells over a limited period:

- Groundwater elevation data for one day in 1982 at 12 formerly existing wells. The wells represent well-clusters of three wells at four different locations. The wells were screened within the lower FG (LFG), HJ or upper KM (UKM) horizons and within Mine Unit 1 or Mine Unit 2; and
- Groundwater elevation and depth to water data for 24 wells for one or more of three days in 2006 or 2007. The wells included five locations of paired wells. The wells are screened in the DE, LFG, HJ, or UKM horizon. The wells include several areas outside of Mine Unit 1 and Mine Unit 2 but within the license area.
- Detailed groundwater data collected during the short- and long-term pumping tests October 2006, November 2006, June 2007 and October 2007;
- Boring logs (included in a subsequent submittal to WDEQ); and
- Potentiometric surface contour maps.

Based on the applicant's map for the potentiometric surface in the DE horizon (application Figure 2.7-11a), the depth to water table varies from approximately 12 to 61 m (40 to 200 ft) below grade. The water table is found within the DE horizon throughout the license area. Water table contours indicate groundwater flow is from the northeast to southwest through the license area (SER Figure 2.4-4). Horizontal hydraulic gradient is approximately 0.008 m/m, though immediately west of the Mine Unit 1 location, the gradient is less (0.0045 m/m) for a distance of approximately 1,220 m (4,000 ft).

The applicant reported vertical gradients between the LFG, HJ, and UKM horizons at six locations, five of which are located within Mine Unit 1. The vertical gradient between the DE and LFG horizons is reported for two locations. Data indicate a downward gradient between horizons at all locations, between 0.05 and 0.37 m/m.

In addition to the water table contour map, the applicant provided potentiometric contour maps for the LFG, HJ, and UKM horizons throughout the license area (SER Figures 2.4-5, 2.4-6 & 2.4-7). Groundwater flow direction in each horizon is similar to that for the water table aquifer, though the horizontal hydraulic gradients are slightly different. The applicant reported horizontal gradients between 0.0034 to 0.0056 m/m for the HJ horizon, 0.0048 to 0.0058 m/m for the LFG horizon, and 0.0053 to 0.0063 m/m for the UKM horizon.

According to potentiometric surface contour maps, the applicant depicted the Lost Creek Fault as having an impact on the potentiometric surface for the HJ and LFG horizons, with a lesser impact to the DE and UKM horizons. Site-specific potentiometric surface maps for the HJ Horizon depict a steep gradient to the HJ Horizon potentiometric surface across the Lost Creek Fault under static conditions (SER Figure 2.4-5). The applicant also depicted the fault zone with a width of approximately 30 m (100 ft) (see Figure 2.7-11e in the application (LCI, 2008c)).

The staff performed a detailed review of the water level data. Staff verified that the potentiometric surface elevations and gradients are consistent with published regional data for the Battle Spring Formation. The applicant provided mapping at suitable mapping and cross-sections to interpret the hydrostratigraphy. The differences in potentiometric head for the various horizons are consistent with the applicant's proposed conceptual model that the horizons are confined/semi-confined aquifers separated by confining units throughout the license area. The faulting affects water levels data consistent with a barrier to flow. Therefore, staff finds that the applicant's analysis of the water level data acceptable and consistent with the

review procedures in SRP Section 2.7.2 and acceptance criteria in SRP Section 2.7.3 (NRC, 2003a).

2.4.3.5 Pumping Test Data

Unless otherwise stated, the information presented in this section is from the Attachments 2.7-1, 2.7-2, and 2.7-3 in the application (LCI, 2008c). The applicant conducted 13 single-well short-duration constant-rate pumping tests in 2006, four short-term low-yield pumping tests with multiple observation wells in 2006, and two long-term high-yield pumping tests with multiple observation wells in 2007. Because of the extensive data supplied by the applicant, the data as reported and/or interpreted by the applicant will be presented for all pumping tests. Staff's evaluation of the entire data set will follow that presentation in this section.

Staff finds that the data collection methods used, and analyses performed by the applicant are consistent with conventional data collection methods and analyses used as standard practices by the hydrogeologic community. The results of those analyses are consistent with published values for similar geologic materials.

1982 Pumping Tests

The applicant reported that firms retained by former owners of the property performed two tests in 1982 (LCI, 2008c). Each test lasted approximately 25 hours, performed at a pumping rate of 114 Lpm (30 gpm), and used pumping wells completed in the HJ horizon south of the Lost Creek Fault. The applicant reported that the data: (1) included observation wells in the HJ, LFG and UKM horizons; (2) exhibited no response in the HJ aquifer north of the Fault; and (3), indicated no effects from the pumping tests on water levels at monitoring wells in the LFG and UKM horizons. Based on the 1982 pumping test results, the applicant calculated a transmissivity between 7.2 and 24.8 square meters per day (m^2/d) (580 to 2000 gallons per day per foot [gpd/ft]) for the HJ horizon and a storativity for that horizon between 0.00033 and 0.00084.

The applicant also provided the following interpretation of the 1982 data:

- pumping wells were completed across the entire HJ horizon;
- calculated transmissivities were generally similar to those from the 2006 testing with consideration of the completion interval; and
- although the original consultant concluded that the fault did not act as a barrier, the applicant disagreed citing the lack of drawdown at an observation well on the opposite side of the fault and water level behavior at the pumping well that the applicant interpreted as an indicator of a barrier effect.

The original 1982 data were not included in the technical report.

2006 Single-Well Pumping Tests

The applicant performed single-well, short-duration pumping tests at 13 different wells in 2006. The wells include two wells in the HJ horizon, four wells in the LFG horizon, four wells in the KM horizon, and three wells in the DE horizon. Test durations varied between 30 minutes to 5 hours at pumping rates between 2.5 and 53 Lpm (0.67 and 14 gpm).

The applicant concluded that the transmissivity:

- for the HJ horizon as determined by the single well tests was between 3.7 and 37.2 m^2/d (302 and 3007 gpd/ft);
- for the LFG horizon was between 0.4 and 3.7 m^2/d (33 and 303 gpd/ft), which is dramatically lower than the transmissivity determined for the HJ wells;
- for the UKM wells was between 2.4 and 10.6 m^2/d (195 and 858 gpd/ft), which is only slightly less than the transmissivity for the HJ wells; and
- for the DE wells was a function of the saturated thickness. Saturated thickness of the easternmost well is very low and its pumping test yielded a low transmissivity of 0.1 m^2/d (10 gpd/ft). To the south and west, the saturated thickness increases at the DE wells and yielded a transmissivity of up to 13.6 m^2/d (1098 gpd/ft).

The applicant used the straight-line method for evaluation of transmissivity based on observed drawdown versus time data for each pumping well. Generally, the applicant noted two trends for the behavior in drawdown at most wells; one trend was noted for the early-time data and the other for the late-time data (the trends are discussed below). The applicant attributed the observed trends at several wells to (a) a barrier effect (fault: wells LC27M and LC20M); (b) a higher transmissive zone (well LC26M); (c) borehole storage effects (wells LC18M and LC21M); (d) aquifer properties near the well; or (e) regional aquifer properties.

The applicant also noted a pattern in the response to location of the wells. Data from wells located north of the Lost Creek Fault (LC19M and LC27M) exhibited an increasing trend to the late-time drawdown data. Data from wells located south of the Lost Creek Fault (LC16M and LC26M) exhibited a decreasing trend to the late-time data (relative to the early time data). The applicant attributed the increasing trend to a barrier effect of the Lost Creek Fault. The applicant attributed the decreasing trend to intercepting a higher permeable zone south of and paralleling the Lost Creek Fault.

2006 Short-term Low-yield Pumping Tests

The applicant presented results of four short-term low-yield pumping tests conducted at three wells: LC19M (two tests), LC16M and LC22M (note that the applicant characterized these tests as long-term tests). All pumping wells were completed in the HJ horizon. Test durations varied between 20 and 45 hours (one of two tests at well LC19M was only 11 hours) and the pumping rates were between 57 and 71 Lpm (15 and 19 gpm). The applicant calculated barometric pressure efficiencies of 0.35 to 0.5 for the wells based on the correlation of water levels with barometric pressure changes during the tests. A summary of the applicant's conclusions is discussed below for each test.

LC19M Tests

Well LC19M is located approximately 146 m (480 ft) north of Lost Creek Fault within the west-center portion of Mine Unit 1. Maximum drawdown at the pumping well was 8.0 m (26.4 ft). The applicant interpreted the late-time data from the pumping well as indicating hydraulic barrier effects (Lost Creek Fault). Early-time data from the pumping well were fitted to a model curve yielding a transmissivity of 12.9 m^2/d (1039 gpd/ft), which the applicant determined was representative of the properties for the aquifer. Late-time data yielded a transmissivity of 6.8 m^2/d (553 gpd/ft), which the applicant attributed to affects from the Fault (hydraulic barrier).

The applicant concluded that water levels in the HJ observation wells south of the fault were not affected by the pumping and thus the fault was an effective barrier. However, staff notes that the observation wells were located far from the pumping well and the drawdown might have been minimal considering the pumping rate and limited duration of the test. Fluctuations in water levels at the nearest wells in the overlying (LFG horizon) and underlying (UKM horizon) were relatively minor, consistent with background trends, and warranted no drawdown analysis. The applicant concluded that there was no significant communication with the LFG horizon during the test.

LC16M Test

Well LC16M is located approximately 277 m (550 ft) south of Lost Creek Fault within Mine Unit 2. Maximum drawdown at the pumping well was 6.6 m (21.8 ft). The applicant interpreted the data from the pumping well as encountering a higher transmissive zone at the end of the test as the drawdown leveled off at the end of the test. Early-time data from the pumping well were matched to a model curve yielding a transmissivity of 7.4 m^2/d (594 gpd/ft), which the applicant attributed to being representative of the properties for the aquifer. Late-time data yielded a transmissivity of 10.1 m^2/d (818 gal/d/ft), which the applicant attributed to being representative of the aquifer properties at a distance from the pumping well.

The applicant concluded that water levels in the HJ observation wells north of the fault were not affected by the pumping and thus the fault was a hydrogeologic barrier. However, staff notes that the wells were located far from the pumping well that the drawdown might have been minimal at the pumping rate and limited duration of the test. The applicant concluded that the fluctuations in water levels at the nearest wells in the overlying (LFG horizon) and underlying (UKM horizon) were relatively minor, consistent with background trends and warranted no analysis.

Monitoring at one observation well within the LFG horizon was discontinued at the start of the pumping phase because it was located across the fault from the pumping well. The magnitude of water level changes in the LFG horizon at the wells monitored during the test was 0.06 m (0.2 ft). The applicant suggested that the variation is similar to trends observed during the background phase and indicates very little hydraulic communication between the LFG and HJ horizons. Magnitude of water level changes in the wells in the UKM horizon was 0.06 m (0.2 ft). The applicant interpreted the data as no measurable response to the pumping.

LC22M Test

Well LC22M is located approximately 1,400 m (4,600 ft) southwest of the proposed Mine Unit 1. The maximum drawdown observed at the pumping well was 11.1 m (36.3 ft). The applicant reported that the late-time data from pumping well leveled off - a behavior that is typically associated with a leaky confined aquifer. However, the applicant indicated that the degree of leakage indicated by the behavior exceeded that expected, based on responses in water levels at wells completed the overlying or underlying horizons. The applicant attributed the behavior to recharge or contact with a dramatically higher transmissive zone and postulated that the internal confining layers within the HJ horizon are discontinuous, more permeable or absent near this well. Early time data for the pumping test yielded a transmissivity of 4.1 m^2/d (329 gpd/ft), which the applicant considered representative of the aquifer. Late time data for the pumping well yielded a transmissivity of 37.2 m^2/d (3007 gpd/ft), which the applicant attributed to regional properties for the aquifer.

The applicant concluded that water levels in the HJ observation wells were not affected by the pumping; however, these wells were located far from the pumping well. For the LFG wells, the maximum magnitude of water level changes was 0.06 m (0.2 ft). No significant water level change was observed at the well located closest to the pumping well, which could be attributed to the pumping. A significant change was noted at the other well in the LFG horizon and was attributed to moving the test equipment rather than the pumping or natural fluctuations.

For the UKM wells, the maximum magnitude of water level changes was 0.06 m (0.2 ft). The observation well located closest to the pumping well exhibited a small decline at the start of the test, but the applicant concluded that the magnitude was so small that it was indistinguishable from natural fluctuations.

2007 Pumping Tests

LCI reported results of two long-term high-yield pumping tests conducted at two wells, LC19M and LC16M. Both pumping wells are completed in the HJ horizon and were the same wells subjected to a short-term test in 2006. The duration of both tests was approximately five days and the pumping rate was between 140 and 163 Lpm (37 and 43 gpm). A summary of the data presented and the applicant's conclusions is discussed below for each test.

LC19M Test

Well LC19M is located approximately 146 m (480 ft) north of Lost Creek Fault within the west-center portion of Mine Unit 1. The pumping test was conducted between June 27, 2007 and July 3, 2007 at an average pumping rate of 162 Lpm (42.9 gpm). During the test, water levels were monitored at 15 observation wells, nine wells in the HJ horizon, two wells in the LFG horizon, and three wells in the UKM horizon. Observation well identifications and distances to the pumping well are summarized in SER Table 2.4-2.

Table 2.4-2: Wells Monitored during the 2007 Pumping Test at Well LC19M

Location	Well ID	Distance From Pumping Well (feet)	Side of Fault	Drawdown at end of Pumping Test (feet)	Response attributed to Pumping
Pumping Well	LC19M	0	North	93.32	Yes
Production Zone	HJMP-104	638	North	36.44	Yes
	HJMP-110	338	North	40.48	Yes
	HJMP-111	470	North	35.56	Yes
	HJT-104	501	North	40.44	Yes
	UKMO-102	783	North	21.51	Yes
	HJMP-107	606	South	1.34	Yes
	LC16M	1284	South	1.47	Yes
	UKMO-101	810	South	5.71	Yes
	HJT-105	242	South	493	Yes
Overlying Aquifer	LC18M	15	North	1.1	Yes
	LC25M	697	South	1.55	Yes
Underlying Aquifer	LC20M	14	North	0.87	No
	UKMP-102	785	North	1.15	Yes
	UKMP-101	815	South	0.53	No

NOTES: Test conducted between June 27, 2007 and July 3, 2007. Pumping rate for test was 42.9 gallons per minute

(Source: LCI, 2008c)
(Table 4.2 of Attachment 2.7-2 to the technical report)

The applicant concluded the following from the pumping test:

- results provide sufficient aquifer characterization of the HJ horizon;
- HJ horizon has sufficient transmissivity such that extraction operations can be conducted consistent with the Operations Plan;
- HJ horizon is sufficiently isolated from the overlying and underlying sands by the Lost Creek and Sage Brush Shales;
- hydraulic continuity of the HJ horizon has been demonstrated over a large scale (e.g., more than 305 m (1,000 ft)) such that mine planning (e.g., mine unit and monitor well layout) can proceed;
- hydraulic properties of the Fault have been defined over the test area to an extent such that mine planning can be achieved; and
- testing data to date indicate that the Fault significantly restricts flow in the HJ horizon.

The applicant noted that additional specific detailed information (e.g., ability of the site to contain production fluids, proper screening of the perimeter monitoring wells and baseline water quality data) will be needed for the Mine Unit 1 hydrologic package.

LC16M Test

Well LC16M is located approximately 167 m (550 ft) south of Lost Creek Fault within Mine Unit 2. This pumping test was conducted between October 22, 2007 and October 28, 2007 at an average pumping rate of 142 Lpm (37.4 gpm). Water levels were monitored at 35 observation wells, 22 wells in the HJ horizon, four wells in the LFG horizon, and nine wells in the KM horizon (seven wells in the UKM and 2 wells in the MKM horizon). Observation well identifications and distances to the pumping well are summarized in SER Table 2.4-3.

In the HJ Horizon, nine wells south of fault exhibit a drawdown between 4.1 and 20.7 m (13.4 and 67.9 ft) after four days of pumping, whereas 13 wells located within the fault zone or north of the fault exhibit significantly less drawdown with a maximum drawdown of 0.67 m (2.2 ft). The applicant concluded that all wells completed in the HJ Horizon responded to the pumping at well LC16M. Based on the drawdown versus time data for selected observation wells south of fault, the applicant estimated a range in transmissivity of 5.5 to 8.4 m^2/d (440 to 680 gpd/ft) [average 7.1 m^2/d (570 gal/d/ft)] and storativity of 3.5 x 10^{-5} to 9.1 x 10^{-4} (average of 2.9 x 10^{-4}) for the HJ Horizon south of the fault Based on limited drawdown north of the fault, the radius of influence for the pumping test was estimated to be at least 610 m (2,000 ft).

The applicant presented a drawdown contour map for drawdown after four days of pumping (SER Figure 2.4-8). The applicant included a discussion on the impacts of the fault on the drawdown and a limited discussion on the asymmetry to the drawdown within the HJ horizon south of the fault. This discussion on asymmetry (or directional transmissivity) is limited to the estimation of spatial variations in transmissivity that the applicant correlated with thicker or cleaner sands within the HJ horizon near or parallel to the fault. The applicant stated, "The observed variation in T [transmissivity] is not expected to significantly impact ISR mining and has no apparent regulatory implications." Furthermore, the applicant states that due to "the overriding impact of the fault, no attempt was made to determine directional transmissivity using analytical methods for this pump test."

Table 2.4-3: Wells Monitored During the 2007 Pumping Test at Well LC 16M

Location	Well ID	Distance To Pumping Well (feet)	Side of Fault	Drawdown on 10/26/07 (feet)	Drawdown at end of Pumping Test (feet)	Response attributed to Pumping
Pumping Well	LC16M	0	South	67.9	69.3	Yes
Production Zone	HJMP-101	1276	North	0.9	*	Yes
	HJMP-102	1996	North	0.6	*	Yes
	HJMP-103	1920	North	0.7	*	Yes
	HJMP-104	1666	North	0.7	*	Yes
	HJMP-105	1603	North	0.7	*	Yes
	HJMP-106	1452	North	0.8	*	Yes
	HJMP-107	866	South	24.9	27.4	Yes
	HJMP-108	1186	North	0.9	*	Yes
	HJMP-109	650	South	23.1	*	Yes
	HJMP-110	936	North	1.2	1.9	Yes
	HJMP-111	896	North	1	*	Yes
	HJMP-112	221	South	23.2	*	Yes
	HJMP-113	273	South	34.1	37.7	Yes

Location	Well ID	Distance To Pumping Well (feet)	Side of Fault	Drawdown on 10/26/07 (feet)	Drawdown at end of Pumping Test (feet)	Response attributed to Pumping
	HJMP-114	448	South	27.8	30.0	Yes
	HJT-101	2002	North	0.9	*	Yes
	HJT-102	1665	North	0.7	*	Yes
	HJT-103	1375	South	13.4	*	Yes
	HJT-104	898	North	2.2	3	Yes
	HJT-105	236	South	15.6	17.5	Yes
	UKMO-101	479	South	19.1	21.0	Yes
	UKMO-102	466	North	1.1	1.6	Yes
	UKMO-103	741	North	1	1.3	Yes
Overlying Aquifer	HJMO-112	225	South	0.3	*	Yes
	HJMO-113	284	South	0.6	*	Yes
	HJMO-114	454	South	0.8	*	Yes
	LC15M	17	South	0.2	1.0	Yes
Underlying Aquifer	HJMU-112	245	South	1.5	*	Yes
	HJMU-113	273	South	1.5	*	Yes
	HJMU-114	440	South	1.1	*	Yes
	LC17M	22	South	1.4	2.1	Yes
	LC24M	383	North	0.4	*	Yes
	UKMP-101	473	South	0.3	*	Yes
	UKMP-102	475	North	1.1	*	Yes
	UKMU-101	479	South	0.2	*	Yes
	UKMU-102	466	North	0.3	*	No

NOTES Test conducted between October 22, 2007 and October 28, 2007. Pumping rate for test was 37.4 gallons per minute.

* = Test prematurely ended due to generator failure; no final water levels at the end of the pumping phase

(Source: LCI, 2008c)

(Table 4.2 of Attachment 2.7-3 to the technical report)

The applicant stated that small responses were observed in water levels at wells completed in the LFG and UKM horizons. In fact, staff notes all wells exhibited a response, and the maximum reported response was 0.64 m (2.1 ft). The applicant concluded that "the communication observed at Lost Creek is much lower (e.g., five to ten times less) than that observed in other ISR operations where engineering practices were successfully implemented to isolate lixiviant from the overlying and underlying aquifers" (LCI, 2008c, 2010a).

Staff has determined that applicant's dataset is acceptable because the methods used and distribution of observations were sufficient to provide information on the potential for control on fluid migration for this setting. The methods used to collect the data and the analytical methods used to evaluate the data are consistent with the acceptable methods listed in the review procedures in SRP Section 2.7.2 and acceptance criteria in SRP Section 2.7.3. However, the observed drawdown deviated somewhat from the expected model curves. In some cases, the deviation was attributed by the applicant to the Lost Creek fault being a hydraulic barrier. As discussed above, the applicant attributed unexpected responses in the overlying aquifer to minor leakage that could be controlled and possibly attributed to leaky abandoned drillholes. The applicant attributed the deviations from a homogeneous aquifer as evident by the

anisotropic drawdown to thicker or cleaner sands but did not elaborate on the effect on fluid migration.

Although the applicant met the requirements for submittal of pumping test data and provided a reasonable evaluation of the data, staff performed an independent evaluation of data to verify the applicant's conceptual model for the hydrogeology. Staff's evaluation of the data focused on the following areas:

(1) influence of the fault on groundwater flow during operations;
(2) ability of the confining units to inhibit flow to the surrounding aquifers;
(3) potential for historic wells to be a preferential flow path; and
(4) anisotropy in hydraulic properties of the aquifer that result in preferred flow paths.

To address these areas, the staff developed simple numerical groundwater flow models to analyze the data presented (NRC, 2010d). Results of the numerical model evaluation are summarized in SER Sections 2.4.3.5.1 through 2.4.3.5.4.

2.4.3.5.1 Influence of the Fault on Operational Groundwater

Based on the numerical model results, the estimated hydraulic properties for the fault are consistent with low permeable materials as proposed in the applicant's conceptual model. The staff simulated the fault using a horizontal flow barrier (HFB) with a hydraulic characteristic of 0.0002 to 0.005 day^{-1}. Although the model cannot define a thickness of the HFB, the corresponding permeabilities for thicknesses of up to several feet are consistent with the hydraulic conductivities used for the mudstone layers.

Two predictive simulations were performed to evaluate the effectiveness of the fault as a hydrogeologic barrier. The first simulation consisted of a generalized pattern for the production units under a balance scenario (uniform distribution of pumping/injection rates with a 1-percent bleed). Under this scenario, several production wells in close proximity to the HFB (fault) went dry, resulting in a localized imbalance to the operational flow regime. This was particularly true for a production unit that straddled the fault. It is unlikely that production units will be installed in the field straddling the Lost Creek Fault; however, the applicant depicted a wide zone of low permeable materials associated with the fault and similar imbalance may result if a portion of production unit is within this zone. Based on staff's experience at an existing ISR facility, long-term excursions can result in areas in which a production unit thins dramatically.

A particle pathline analysis demonstrated that an imbalance condition led to the migration of several particles across the HFB. This situation (i.e., migration of several particles across the HFB (fault)) was more widespread in the second predictive simulation in which selected production units close to the fault were selectively placed in imbalanced conditions simulating excursions.

Staff's conclusion based on the independent verification results is that the fault will act as an adequate hydrogeologic barrier under typical operating conditions; however, for units near the fault, the likelihood of an imbalance operation increases the potential for production fluids to be able to migrate through the fault. Given this increased potential, the staff concludes that enhanced monitoring of the fault performance during operations is necessary. Therefore, in accordance with 10 CFR 40.31(b), the staff includes a license condition to address this issue as discussed in SER Section 2.4.4.

2.4.3.5.2 Ability of the Confining Units to inhibit Flow

Based on the model results, the vertical hydraulic conductivity of the overlying and underlying aquitards is estimated at 3.5×10^{-7} centimeter per second (cm/s) (0.001 feet per day (ft/day)). For predictive flows under a typical balanced operation (i.e., the wellfield is maintaining an inward flow using a 1 percent bleed), flow through all aquifers was adequately controlled (i.e., flow was from the surrounding aquifers to the production aquifer). For the predictive simulation modeling imbalanced conditions (excursions), the confinement of the surrounding aquitards was adequate throughout most of the production units. For enhanced scenarios near the fault, the additional overpressure resulted in a slight breakthrough to the overlying or underlying aquifers. However, the vertical breakthrough was significantly less than the distribution of particles in the production aquifer that would have been detected in the perimeter monitoring wells (horizontal excursion). The extent of the horizontal excursion was a function of the location of the imbalanced unit within the production pattern; however, in all cases, a horizontal excursion would have been detected prior to breakthrough of the overlying or underlying aquitards.

Based on the modeling results, the staff concludes that the confinement of the overlying/underlying aquitards is sufficient provided monitoring for horizontal excursions is maintained. As discussed below, the vertical anisotropy of the aquifers aids in confinement of the fluids, but also requires that the monitoring wells be screened in the horizon(s) subject to uranium recovery processes.

2.4.3.5.3 Affect of Historic Wells on Flow

A predictive simulation was performed to demonstrate a signature of leakage through improperly abandoned wells during a typical pumping test. The simulation included a hypothetical pumping well and associated observation wells that were placed at various distances from known locations of abandoned wells. Results of the predictive simulation indicates that a signature can be identified provided sufficient observation wells are located at various distances from a pumping well and the production well is located close to the abandoned well. However, the number of observation wells needed to identify leaky abandoned wells is not logistically viable for a typical pumping test. Based on the modeling results, the staff concludes that a license condition is needed to ensure that the abandoned drillholes are adequately abandoned. In accordance with 10 CFR 40.31(b), the staff proposes a license condition for this issue as discussed in SER Section 2.4.4.

2.4.3.5.4 Anisotropy of Hydraulic Properties

The model was revised to include an additional zone with higher hydraulic conductivities in an attempt to simulate the observed anisotropy to the drawdown observed during the 2007 pumping test at LC19M (see SER Figure 2.4-8). Staff performed a variety of scenarios using the numeric groundwater flow model to simulate anisotropic conditions; however, the solutions did not adequately fit the observed data. After additional evaluation of the screened intervals to observation wells used during the pumping test by the applicant (NRC, 2010d), the anisotropy was determined to be in the vertical, rather than horizontal, direction. Based on the modeling results, the staff concludes that the fine-grained lenses in the production zone, in particular, lenses separating the upper from the middle HJ horizon, and the middle from the lower HJ horizons, could not provide complete separation and will prevent the timely detection of an horizontal excursion should the screened interval for the perimeter monitoring well be a different subhorizon than the production well.

To confirm regulatory compliance, the staff recommends that the licensee demonstrate that the perimeter wells are located in the same horizon as the production wells in the wellfield data package. Therefore, in accordance with 10 CFR 40.31(b), the staff proposes a license condition for this issue as discussed in SER Section 2.4.4.

2.4.4 EVALUATION FINDINGS

The staff completed its review of the hydrologic site characterization information for the proposed Lost Creek Project. The review included an evaluation using the review procedures in SRP Section 2.7.2 and the acceptance criteria outlined in SRP Section 2.7.3.

The applicant has acceptably described the surface water hydrology by providing the following:

- the location of the drainages in and around the license area;
- peak flood estimates for appropriate recurrence intervals for all drainages;
- a flood potential analysis for the facilities; and
- acceptable erosion protection against the effects of flooding from nearby streams.

The applicant has acceptably described the groundwater hydrology by providing the following:

- a description of the regional hydrogeology; and
- a description of the overlying aquifer, extraction zone, and underlying aquifer hydrogeology using potentiometric surfaces maps with acceptable contour intervals based on an appropriate number of monitoring wells.

Based on a detailed review conducted of the characterization of the surface and groundwater hydrology at the Lost Creek Project, the staff concludes that the information provided by the applicant is acceptable, except for the following items, which can be addressed through the following license conditions:

- Potential for historic abandoned wells to act as a conduit for fluid flow from the production aquifer during operations. Staff's license condition is, as follows:

  > Prior to the injection of lixiviant into a production unit, the licensee will attempt to locate and abandon all historic drillholes located within the perimeter well ring such that the drillhole will not provide a conduit for the migration of production fluids. The licensee will document its efforts to identify and properly abandon all abandoned drillholes within the area of influence of a wellfield in a report submitted to the NRC prior to the start of operations at the production unit. If the licensee detects a vertical excursion during operations, the licensee will cease injection of lixiviant into the area surrounding the monitoring well until the licensee demonstrates to the satisfaction of NRC staff that the vertical excursion has been mitigated.

- Lost Creek Fault acting as an impermeable barrier should an imbalance operation condition arise during operations. Staff's license condition is, as follows:

  > For mine units that abut (located within 100 feet of) the Lost Creek Fault, the licensee shall submit a plan to the NRC, for review, documenting the location and screened horizon of monitoring wells to monitor potential

excursions across the fault into the upper and/or lower aquifers on the opposite side of the fault. The additional wells will be included in the routine excursion-monitoring program. The monitoring parameters will include the depth to water measurements and corresponding groundwater elevations.

- Screened horizons for perimeter monitoring wells need to be placed in the same horizon (i.e., upper, middle, or lower HJ Horizon) as the production wells. Staff's license condition is, as follows:

  Wellfield Packages. Prior to principal activities in a new wellfield, the licensee shall submit a hydrologic test data package to the NRC for review. The licensee shall submit a hydrologic test package at least 60 days prior to the planned start date of lixiviant injection. In each wellfield data package, the licensee will document that all perimeter monitoring wells are screened in the appropriate horizon in order to provide timely detection of an excursion. The licensee shall not proceed with any lixiviant injection in the new wellfield before it receives written NRC verification of the submitted hydrologic test data package.

In summary, the applicant provided a description of the site-specific hydrogeologic units, included pumping test data that were acquired using acceptable methodologies, and performed data analyses using appropriate analytical models to estimate site-specific hydraulic properties of the subsurface strata. Although the data submitted and analyses performed by the applicant in the application (LCI, 2008c, 2010a) are consistent with guidance in the SRP, the analyses included a degree of uncertainty due to the use of analytical models for the complexities of the subsurface setting (e.g., the Lost Creek Fault) that required further review and verification by staff. Consequently, staff performed an independent analysis of the pumping test data using numeric groundwater flow data. Results of the independent evaluation confirm that the applicant can operate safely an in a controlled manner. Based upon the review conducted by the staff as indicated above and information provided by the applicant as supplemented by information to be collected in accordance with the above license conditions, staff finds that the applicant will be able to control the migration of production fluids in the subsurface and thus meets the applicable acceptance criteria for this section and requirements of 10 CFR 40.31(b).

2.4.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

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

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LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

LCI, 2010b. Lost Creek ISR, LLC, "Letter to NRC, Lost Creek Project, Clarifications to TR Docket No. 40-9068 TAC No. LU0142," May 14, 2010, ADAMS Accession No. ML101600528.

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NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

NRC, 2010d. "Technical Evaluation Report: Numeric Ground Water Flow Model Development to Evaluate the Lost Creek Source Material License Application," Docket No. 40-9068, August 30, 2010, ADAMS Accession No. ML112232261.

Wyoming, 2005. Wyoming Department of Water Quality, "Water Quality Rules and Regulations, Chapter 8, Standards for Wyoming Groundwaters," March 16, 2005.

2.5 BACKGROUND SURFACE WATER AND GROUNDWATER QUALITY

2.5.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the characterization of surface and groundwater quality at the Lost Creek Project has been performed to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7 using the review procedures in Section 2.7.2 and acceptance criteria in Section 2.7.3 of the Standard Review Plan (SRP) (NRC, 2003a).

2.5.3 STAFF REVIEW AND ANALYSIS

The following sections present staff's review and analysis of various aspects of the surface water and groundwater quality at the Lost Creek Project. The information presented in this section, unless stated otherwise, is obtained from Section 2.7 of the application.

2.5.3.1 Surface Water

In Section 2.7.1 of the application (LCI, 2008c, 2010a), the applicant stated that the surface water drainages within the Lost Creek license area were ephemeral in nature so that surface water sampling could not be done on a routine basis. The applicant was able, however, to provide some surface water quality data for the license area by placing storm water samplers in

drainages at the locations in SER Figure 2.5-1. Samples were collected in April 2007 and were considered representative of the spring runoff from precipitation events. Each sample was analyzed for all of the analytes listed in Table 2.7.3-1 of NUREG 1569.

The applicant provided surface water quality results (LCI, 2008c, 2010a) for the sampling locations in the license area where a sufficient sample was obtained in April 2007. These locations included LC1, LC2, LC4, LC5, LC10, LC11, and LC12. SER Table 2.5-1 shows the measured surface water quality parameters for four of these locations: LC1, LC2, LC5, and LC10. LC5 was located on the Battle Spring Draw in the eastern portion of the license area. LC1 was located in the far western portion of the license area. LC2 and LC10 were located in separate drainages south (downstream) of the proposed mine units. Staff included the results of these two locations in SER Table 2.5-1 because they are representative of the water quality reported by the applicant for all sampling locations are located immediately downstream of the proposed mine units. The surface water quality measured at these locations generally met standards for potable water, but exceeded Wyoming Class I and EPA primary and secondary drinking water standards for iron, manganese, aluminum, and ammonia nitrogen.

2.5.3.2 Groundwater

The applicant established the site pre-operational groundwater quality in the license area from well data collected by recent samples collected in 2006 and 2007 and historical samples collected by Conoco in the late 1970s and early 1980s (LCI, 2008c). Recent data consisted of four quarters of water sampling during the fall and winter of 2006 and the spring and summer of 2007. Groundwater quality was measured in three wells in the DE (uppermost) aquifer, four wells in LFG overlying aquifer, six wells in HJ ore zone aquifer, and four wells UKM underlying aquifer. The well locations are shown in SER Figure 2.5-2. The applicant presented the groundwater quality data for all four quarters for all wells. Groundwater quality parameters measured included all suggested parameters in Table 2.7.3-1 of NUREG 1569, except silver.

NRC staff reviewed the average groundwater quality in the Lost Creek license area from wells in the uppermost DE aquifer, overlying LFG aquifer, HJ ore zone aquifer and UKM underlying aquifer from the data (SER Table 2.5-2). The average water quality in the uppermost DE aquifer exceeded the WDEQ Class I, II and III for gross alpha, uranium, and combined radium-226 and radium-228. The average water quality in the LFG overlying aquifer exceeded the WDEQ Class I, II, III, and EPA primary drinking water standards for gross alpha, uranium, and combined radium-226 and radium-228 in all of the wells over all four quarters. Uranium concentrations in these four wells ranged from 0.251-0.546 mg/L.

Table 2.5-1: Surface Water Quality at Lost Creek - April 2007

Water Quality Parameter (mg/L) *unless otherwise stated	Lost Creek License Area			
	LC1	LC2	LC5	LC10
	4/17/2007	4/17/2007	4/17/2007	4/17/2007
Bicarbonates as HCO_3	12	27	30	29
Carbonates as CO_3	<1	<1	<1	<1
Alkalinity	10	22	25	4
Chloride	2	1	2	1
Conductivity (umhos/cm)	36.4	57.3	64.5	100
Fluoride	<0.1	<0.1	<0.1	<0.1
pH (s.u.)	7.1	6.86	6.83	7.12
Total Dissolved Solids	29	43	52	46
Total Suspended Solids	36	422	5280	4
Silica	6.9	9.9	14.5	0.9
Sulfate	3	3	5	13
Radium 226 (pCi/l)	<0.2	0.5	<0.2	<0.2
Gross Alpha (pCi/l)	1.3	3.6	2.6	1.2
Gross Beta (pCi/l)	<2.0	<2.0	<2.0	<2.0
Nitrogen, Ammonia as N	0.46	0.6	1.11	8.7
Nitrogen, Nitrate+Nitrite as N	0.3	0.3	<0.1	0.3
Aluminum	0.3	0.7	0.6	<0.1
Arsenic	0.002	0.003	0.006	0.002
Barium	<0.1	<0.1	<0.1	<0.1
Boron	<0.1	<0.1	<0.1	<0.1
Cadmium	<0.01	<0.01	<0.01	<0.01
Calcium	2.8	5.6	5.5	3.3
Chromium	<0.05	<0.05	<0.05	<0.05
Copper	<0.01	<0.01	<0.01	<0.01
Iron (mg/L)	0.66	0.76	1.26	0.04
Lead	<0.05	<0.05	<0.05	<0.05
Magnesium	0.9	1.5	1.6	0.6
Manganese	0.03	0.01	0.4	0.07
Mercury	<0.001	<0.001	<0.001	<0.001
Molybdenum	<0.1	<0.1	<0.1	<0.1
Nickel	<0.05	<0.05	<0.05	<0.05
Potassium	4.1	6.2	7.8	8.4
Selenium	<0.001	<0.001	<0.001	<0.001

(Source: LCI, 2008c)
(Adapted from Table 2.7-4 of the technical report)

Table 2.5-2: Average Pre-operational Baseline Groundwater Quality for Lost Creek

Water Quality Parameter	Lost Creek License Area			
	DE Surficial Aquifer	**LFG Overlying Aquifer**	**HJ Ore zone Aquifer**	**UKM Underlying Aquifer**
Bicarbonates as HCO_3 (mg/L)	150	114	111	82
Carbonates as CO_3(mg/L)	ND	2.5	3.5	27.8
Alkalinity (mg/L)	104.5	102.2	105.5	84.5
Chloride (mg/L)	6.3	5.3	5.5	5.5
Conductivity (umhos/cm)	566.8	463	485.9	558
Fluoride (mg/L)	0.3	0.21	0.21	0.20
pH (s.u.)	7.68-8.07	**7.32-8.57**	**7.85-9.51**	**7.66-11.6**
Total Dissolved Solids (mg/L)	347	296	311	297
Sulfate (mg/L)	135.7	121.5	131.9	117.6
Radium 226 (pCi/l)	**2.8**	**26.6**	**143.3**	**9.1**
Radium 228 (pCi/l)	**2.4**	**3.8**	**6.6**	**3.49**
Uranium (mg/L)	**0.74**	**0.41**	**0.17**	**0.031**
Gross Alpha (pCi/l)	**495.9**	**356**	**395.4**	**41.3**
Gross Beta (pCi/l)	157.7	107.9	117.5	23.1
Nitrogen, Ammonia as N (mg/L)	0.027	0.08	0.015	0.39
Nitrogen, Nitrate+Nitrite as N (mg/L)	0.7	0.6	ND	ND
Aluminum (mg/L)	ND	ND	ND	ND
Arsenic (mg/L)	0.003	0.003	0.006	0.006
Barium (mg/L)	ND	ND	ND	ND
Boron (mg/L)	ND	ND	ND	ND
Cadmium (mg/L)	ND	ND	ND	ND
Calcium (mg/L)	68.1	58.8	67.7	51.5
Chromium (mg/L)	ND	ND	ND	ND
Copper (mg/L)	ND	ND	ND	ND
Iron (mg/L)	0.21	**0.37**	0.09	0.12
Lead (mg/L)	ND	ND	ND	ND
Magnesium (mg/L)	4.3	3.31	3.65	2.45
Manganese (mg/L)	ND	ND	ND	ND
Mercury (mg/L)	ND	ND	ND	ND
Molybdenum (mg/L)	ND	ND	ND	ND
Nickel (mg/L)	ND	ND	ND	ND
Potassium (mg/L)	2.3	3.1	4.4	10.9
Selenium (mg/L)	0.079	0.024	0.002	0.002
Silica (mg/L)	15.6	14.1	14.9	14.4
Sodium (mg/L)	40.3	32.3	31.5	36.2
Vanadium (mg/L)	ND	ND	ND	ND
Zinc (mg/L)	ND	ND	ND	ND

*Numbers in bold exceeded Wyoming Class I or EPA drinking water standards.
(Source: LCI, 2008c) (Adapted from Table 2.7-13 of the technical report)

Average water quality in the HJ ore zone aquifer exceeded the WDEQ Class I, II, III, and EPA primary drinking water standards for gross alpha and combined radium-226 and radium-228 in all of the wells over all four quarters. One well, LC 26M, in the eastern part of the license area, exceeded the WDEQ Class I and EPA secondary drinking water standards for sulfate and TDS.

Average water quality in the UKM underlying ore zone aquifer exceeded the WDEQ Class I, II, III, and EPA primary drinking water standards for gross alpha and combined radium-226 and radium-228 in all of the wells over all four quarters. Two wells, LC20M and LC24M, which are located in the ore zone area, also exceeded the standard for uranium.

2.5.4 EVALUATION FINDINGS

Staff reviewed the pre-operational surface and groundwater quality characterization at the Lost Creek ISR facility. The review included an evaluation using review procedures in Section 2.7.2 and the acceptance criteria outlined in SRP Section 2.7.3.

The staff finds that the applicant acceptably described the pre-operational surface water quality by providing appropriate chemical and radiochemical analyses of water samples from drainages in and near the mineralized zones. The surface water sampling represented the annual storm water runoff from the snowmelt. The surface water quality is representative of un-impacted melt water with limited interaction with the sediments/soils during runoff. The streams on the Lost Creek Project are ephemeral and the depth to water is significantly below the base of the stream channels. Discharge of groundwater to surface water is not expected and the reported differences in water quality between surface water and groundwater are consistent with that expectation.

It is difficult to obtain a representative background surface water quality due to the ephemeral nature of the streams at the Lost Creek. Based on the information provided in the application and a review of published literature of the surface water drainage in the watersheds, the staff finds that the pre-operational surface water quality within the license area is represented by the data submitted by the applicant because the procedures used by the applicant are consistent with guidance in the SRP. Staff expects that the background surface water quality in the future will be similar to that reported by the applicant).

The applicant described the pre-operational groundwater quality for the horizons within the Battle Spring Formation including the DE, FG, HJ and KM horizons by collecting four quarters of data from several locations. The staff concludes that the sample results are representative of area-wide pre-operational groundwater quality of the license area because the sampling meets the acceptance criteria in SRP Section 2.7.3.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria for this section and requirements of 10 CFR Part 40 Appendix A, Criterion 7.

2.5.5 REFERENCES:

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, “Domestic Licensing of Source Material.”

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, “Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content.”

LCI, 2008c. Lost Creek ISR, LLC, “Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report,” Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2003a.NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

2.6 BACKGROUND RADIOLOGICAL CHARACTERISTICS

This section discusses the background radiological characteristics of the surrounding environment. Background radiological characteristics are used to evaluate the potential radiological impact of operations on the environment and human health and safety. Such impacts could result from spills, routine discharges from operations, and other potential releases to the environment. In addition, the data collected is used to identify a radiological baseline for decontamination, decommissioning, restoration, and reclamation.

2.6.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the background radiological characteristics or the preoperational environmental monitoring program is in compliance with 10 CFR Part 40, Appendix A, Criterion 7.

A preoperational monitoring program must be conducted at least one-full year prior to any major site construction, and establishing background concentrations in environmental media is needed to determine operational and post operational compliance with the following regulations:

- Criteria 6(6) of Appendix A to 10 CFR Part 40 requires that soil concentrations not exceed background concentrations by more than 5 pCi/g of radium-226, averaged over the first 15 cm below the surface.
- Criterion 8 of Appendix A to 10 CFR Part 40 requires control of emissions to reduce population exposures to the maximum extent and avoid site contamination.

2.6.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the one-year sampling requirement of 10 CFR Part 40, Appendix A, Criterion 7 using the acceptance criteria in Standard Review Plan (SRP) Section 2.9.3 (NRC, 2003a). The baseline radiological characterization is acceptable if:

- The sampling frequency, sampling methods, and sampling location and density are in accordance with pre-operational monitoring guidance provided in Section 1.1 of Regulatory Guide 4.14 (NRC, 1980).
- The monitoring program includes air (particulate and radon), water (ground and surface), vegetation, food, fish, soil, sediment, direct radiation, and radon flux.
- Air monitoring stations are located in a manner consistent with the principal wind directions reviewed in Section 2.5 of NUREG-1569 (NRC, 2003a).
- Soil sampling is conducted at both a 5 cm (2 in) depth, as described in Regulatory Guide 4.14, Section 1.1.4 (NRC, 1980), and 15 cm [6 in] for background decommissioning data.

The staff recognizes that some samples might not be collected due to weather conditions, availability, applicability, or access to an area. These situations are discussed in the next section.

2.6.3 STAFF REVIEW AND ANALYSIS

The following sections present the staff's review and analysis of various aspects of the background radiological characteristics of the Lost Creek Project. Review areas addressed in this section include air particulate and radon sampling, radon flux monitoring, vegetation, food, and fish sampling, direct radiation measurements, soil sampling, sediment sampling, groundwater sampling, and surface water sampling.

2.6.3.1 Air (Particulate and Radon) Sampling

Regulatory Guide 4.14 (NRC, 1980) recommends pre-operational air particulate and radon sampling at three locations at or near the site boundaries, one location at or near the nearest residence, and one control location remote from the site. Factors to consider in determining sampling locations include: (a) average meteorological conditions (wind speed, wind direction, atmospheric stability), (b) prevailing wind direction, (c) site boundaries nearest to mill, (d) direction of nearest occupiable structure, and (e) location of estimated maximum concentrations of radioactive materials.

In Sections 2.9.2, 2.9.3.1, 2.9.3.7, and 2.9.4 of the technical report (LCI, 2008c, 2010a), the applicant describes the methodology and locations of the radon and air particulate samplers used to collect quarterly samples. The applicant collected initial radon samples between November 2006 and March 2008 (LCI, 2009a, 2010a) using Landauer Radtrak® alpha-track detectors with a filter to prevent access of thoron (radon-220) and measure only radon-222. Samples were collected 3 feet above the ground in suspended inverted cups to allow continuous airflow and to shield the detectors from the weather. Sample locations identified by URPA (Ur-Energy Passive Air) and number, are shown in SER Figure 2.6-1. According to the applicant (LCI, 2010a), locations represent conditions both upwind (west) and downwind (east) of the proposed licensed area boundaries, as determined by the meteorological data discussed in SER Section 2.2. Sampling location URPA 1 (Ur-Energy Passive Air 1) was established at the closest full-time residence, in Bairoil, WY, and sampling locations URPA 7, URPA 8, URPA 13, and URPA 10 were placed at the western, southeastern, eastern, and northeastern site boundaries, respectively (LCI, 2008c). LCI placed sampling location URPA 9 at the center of the site to coincide with the ore body. LCI presents the radon sampling results in application Table 2.9-26 (LCI, 2010a).

The applicant began collecting air particulate samples in November 2007 (LCI, 2009a, 2010a) (SER Figure 2.6.1) and analyzed composite air particulate samples quarterly for natural uranium, Ra-226, Pb-210, and Th-230. SER Table 2.6-1 presents the results of these air samples. The applicant selected air particulate sampling locations using criteria from Regulatory Guide 4.14, meteorological data, and results from MILDOS-AREA calculations conducted in 2007 and 2008 (LCI, 2009a, 2010a). High velocity (HV) air particulate samplers were placed at four on-site locations and one off-site near the closest resident (HV-1) at the same location as a radon sampler in Bairoil (LCI, 2009a, 2010a).

On-site locations consisted of a background (HV-3), two boundary sites (HV-4, HV-5), and one near the highest radioactivity (HV-2). The applicant stated (LCI, 2010a) that the background

position was selected because it was located the farthest distance from the plant, more than 3.2 km (2 mi), and upwind of the radioactivity of the plant and ore body. The two boundary sites were placed to the east (HV-4, downwind) and northwest (HV-5, upwind) of the plant. MILDOS-AREA simulations identified two receptor points with elevated radiation on the boundary: one located east-southeast of the plant and adjacent to the ore body and a second directly north of the plant (see SER Figure 2.6-2). Air particulate sampler HV-2 was placed slightly east of the plant and southeast of one of the receptor sites and an additional radon sampler (annotated as SEB1 in SER Figure 2.6-2) was placed on the other receptor point adjacent to the ore body. In contrast to recommendations in Regulatory Guide 4.14, the staff finds that only two of the five particulate air samplers were co-located with radon sampling stations.

The applicant conducted additional MILDOS-AREA simulations in 2009 (LCI, 2010a) to determine the maximum exposure to a potential receptor within and along the boundary based on the highest predicted ground concentrations of radon progeny resulting from the radon emissions from the plant and wellfields. Forty receptors were positioned in 100 m intervals to a

Table 2.6-1: High Velocity Air Particulate Sampling Results (2007-2009)

Period	Location	Start Date	End Date	Volume (mL)	U-nat (µCi/ml)	Th-230 (µCi/ml)	Ra-226 (µCi/ml)	Pb-210 (µCi/ml)
Q1	HV1	11/30/2007	3/1/2008	3.85E+09	<1.00E-16	<1.00E-16	2.86E-16	1.78E-14
	HV2	11/30/2007	3/1/2008	3.84E+09	<1.00E-16	<1.00E-16	2.34E-16	1.53E-14
	HV3	11/30/2007	3/8/2008	4.08E+09	<1.00E-16	<1.00E-16	2.23E-15	1.31E-14
	HV4	11/30/2007	3/1/2008	3.70E+09	<1.00E-16	1.62E-16	3.51E-16	2.38E-14
	HV5	11/30/2007	3/1/2008	3.78E+09	<1.00E-16	2.38E-16	2.91E-16	1.81E-14
Q2	HV1	3/1/2008	6/5/2008	4.08E+09	<1.00E-16	<1.00E-16	<1.00E-16	6.81E-15
	HV2	3/1/2008	6/5/2008	3.70E+09	<1.00E-16	<1.00E-16	<1.00E-16	3.02E-15
	HV3	3/8/2008	6/5/2008	4.11E+09	<1.00E-16	<1.00E-16	<1.00E-16	5.01E-15
	HV4	3/1/2008	6/5/2008	4.11E+09	<1.00E-16	<1.00E-16	<1.00E-16	9.24E-15
	HV5	3/1/2008	6/5/2008	4.11E+09	<1.00E-16	<1.00E-16	<1.00E-16	5.28E-15
Q3	HV1	6/5/2008	8/29/2008	3.39E+09	5.61E-15*	1.95E-16	<1.00E-16	2.22E-14
	HV2	6/5/2008	8/29/2008	3.39E+09	1.48E-15*	<1.00E-16	<1.00E-16	1.62E-14
	HV3	6/5/2008	8/29/2008	3.39E+09	1.18E-15*	2.59E-16	<1.00E-16	1.41E-14
	HV4	6/5/2008	8/29/2008	3.39E+09	<1.00E-16*	<1.00E-16	<1.00E-16	1.95E-14
	HV5	6/5/2008	8/29/2008	3.17E+09	2.21E-15*	<1.00E-16	<1.00E-16	1.51E-14
Q4	HV1	8/29/2008	12/2/2008	4.07E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.69E-14
	HV2	8/29/2008	12/2/2008	4.08E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.62E-14
	HV3	8/29/2008	12/2/2008	4.04E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.91E-14
	HV4	8/29/2008	12/2/2008	4.08E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.72E-14
	HV5	8/29/2008	12/2/2008	3.85E+09	<1.00E-16	<1.00E-16	<1.00E-16	2.31E-14
Q5	HV1	12/2/2008	3/19/2009	4.58E+09	<1.00E-16	2.28E-16	<1.00E-16	1.11E-14
	HV2	12/2/2008	3/19/2009	4.58E+09	1.55E-16	<1.00E-16	<1.00E-16	1.15E-14
	HV3	12/2/2008	3/19/2009	4.51E+09	1.48E-16	<1.00E-16	<1.00E-16	1.67E-14
	HV4	12/2/2008	3/19/2009	4.56E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.57E-14
	HV5	12/2/2008	3/19/2009	3.77E+09	1.36E-16	2.01E-16	<1.00E-16	1.05E-14
Q6	HV1	3/19/2009	6/15/2009	3.70E+09	<1.00E-16	1.15E-16	<1.00E-16	1.05E-14
	HV2	3/19/2009	6/15/2009	3.76E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.15E-14
	HV3	3/19/2009	6/15/2009	3.39E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.12E-14
	HV4	3/19/2009	6/15/2009	3.74E+09	<1.00E-16	<1.00E-16	<1.00E-16	1.11E-14
	HV5	3/19/2009	6/15/2009	3.80E+09	<1.00E-16	<1.00E-16	<1.00E-16	9.53E-15
Q7	HV1	6/15/2009	9/18/2009	4.01E+09	1.98E-16*	<1.00E-16	<1.00E-16	8.20E-15
	HV2	6/15/2009	9/18/2009	4.08E+09	1.21E-16*	<1.00E-16	<1.00E-16	9.43E-15
	HV3	6/15/2009	9/18/2009	4.07E+09	1.44E-16*	<1.00E-16	<1.00E-16	1.38E-14
	HV4	6/15/2009	9/18/2009	4.11E+09	1.29E-16*	<1.00E-16	<1.00E-16	1.30E-14
	HV5	6/15/2009	9/18/2009	4.10E+09	1.56E-16*	<1.00E-16	<1.00E-16	7.16E-15

(LCI, 2010a) (Source: Adapted from Table 2.9-4 of the technical report)
*Method blank or entire sample batch apparently exposed to uranium contamination during the digestion process discussed in detail in Attachment 2.9-2 of the technical report

distance of 500 m in eight compass directions from the center of the proposed plant location, as illustrated in SER Figure 2.6-3.

The applicant stated that four of the six highest predicted ground concentrations of radon progeny were within the boundary of the processing plant (square in SER Figure 2.6-3) (LCI, 2010a). The remaining two were outside of the plant-fenced area, but within the permit boundary north and east of the plant. These locations are annotated as N200 and E200, respectively, in SER Figure 2.6-2.

The applicant stated that the 2009 MILDOS-AREA simulations also verified that the four on-site particulate air samplers were located within the range of airborne radioactivity concentrations and exposure doses predicted within the proposed licensed area (LCI, 2010a). According to the applicant, HV-2 was located near the E200 receptor point that had the second highest predicted ground concentrations outside of the processing plant boundary (see SER Figure 2.6-2). HV-3 was located at a position that had the lowest total effective dose equivalent (TEDE) of any modeled receptor and indicated background conditions during operations. HV-4 and HV-5 were located at receptor sites predicted to be at intermediate concentrations and therefore, were downwind of the plant and wellfields (LCI. 2008c; LCI, 2010a).

The staff concludes that the instrumentation and number of samplers used to collect radon and air particulate samples in the second set of data followed the guidance in Regulatory Guide 4.14 (NRC, 1980) for establishing baseline conditions. The applicant's information provided a complete summary of the rationale for sampler placement and indicates that it will have collected samples on a continuous basis for at least 12 months to establish background radon and radioactive air particulate conditions. The applicant, thereby, demonstrates compliance with regulatory requirements in 10 CFR Part 40, Appendix A, Criterion 7.

2.6.3.2 Radon Flux Monitoring

The applicant did not collect any radon flux monitoring data because the applicant stated in Section 2.9.3.6 of the technical report (LCI, 2010a) that there would be no tailings impoundments and that any residues that may accumulate in the site's liquid waste storage ponds will be disposed of offsite in compliance with all regulatory requirements. In addition, the applicant stated that upon site decommissioning, soils near the former storage pond locations will be remediated, if necessary, as part of site closure plans, and will subsequently be surveyed according to applicable regulatory guidance to demonstrate compliance with all applicable soil cleanup standards. Based on the applicant's proposed operations and cleanup activities, NRC staff agrees that radon flux monitoring is not necessary for preoperational monitoring because radon flux measurements are only needed if the applicant needs to demonstrate compliance with 40 CFR 192.02. Radon flux measurements evaluate radon emitted per unit area per time, such as radon emitted from a tailings impoundment. According to 40 CFR 192.02, radon flux from the tailings impoundment cannot exceed 20 $pCi/m^2/s$. Therefore, the staff concludes that the applicant is not required to collect radon flux measurements to comply with 10 CFR Part 40, Appendix A, Criterion 7.

2.6.3.3 Vegetation, Food, and Fish Sampling

Regulatory Guide 4.14 recommends the following: (a) vegetation samples from three locations near the site in three different sectors having the highest predicted airborne radionuclide concentration due to milling operations; (b) three food sample locations that include crops, livestock, etc., within 3 km (2 mi) of the site; and (c) samples of fish in each body of water. In

Section 2.2.1 of the technical report (LCI, 2010a), the applicant stated that the only agricultural production within the licensed area or within 3.2 km (2 mi) of the licensed area is related to grazing. The applicant identified three grazing allotments, which provide forage for cattle, horses, and sheep.

The applicant collected vegetation samples in 2008 and analyzed the samples for U-natural, Th-230, Ra-226, Pb-210, and Po-210. Sampling locations and results are shown in SER Figure 2.6-4 and SER Table 2.6-2, respectively. For purposes of evaluating preoperational conditions for the anticipated dryer installation (LCI, 2010c), NRC staff finds the vegetation sampling program consistent with recommendations in Regulatory Guide 4.14 because the applicant collected vegetation samples from three locations near the proposed plant site in three different sectors having the highest predicted airborne radionuclide concentration due to operations. Therefore, the staff finds the vegetation baseline vegetation sampling acceptable for addressing this aspect of the operations. However, the sampling program did not address the effects of radon progeny deposition, as discussed below.

Table 2.6-2: Analytical Results for 2008 Vegetation Sampling

Sample Location	Analyte	Units	Sampling Date		
			July 17	August 4	August 20
A	U mass	mg/kg-dry	0.76	0.08	0.11
	U Activity	uCi/kg	0.00052	0.00006	0.000076
	Pb-210		0.0015	<0.00065	0.00069
	Po-210		0.000072	0.000035	0.000100
	Ra-226		0.000083	0.000075	0.00015
	Th-230		0.000016	0.000014	0.000028
B	U mass	mg/kg-dry	0.17	0.06	0.06
	U Activity	uCi/kg	0.00012	0.00004	0.000042
	Pb-210		0.0019	0.0009	0.001
	Po-210		0.00035	0.000068	0.00008
	Ra-226		0.00071	0.00015	0.00016
	Th-230		0.00022	0.000024	0.000034
C	U mass	mg/kg-dry	0.2	0.09	0.08
	U Activity	uCi/kg	0.00013	0.00006	0.000052
	Pb-210		0.00089	<0.00062	0.00079
	Po-210		0.000032	0.000035	0.000097
	Ra-226		0.00015	0.00015	0.00013
	Th-230		0.000032	0.000039	0.000019
Average Concentrations	U mass	mg/kg-dry	0.18		
	U Activity	uCi/kg	0.00012		
	Pb-210		0.00092		
	Po-210		0.000062		
	Ra-226		0.00012		
	Th-230		0.000025		

(LCI, 2010a)
(Source: Section 2.0 of Attachment 2.9-7 of the technical report)

As described in SER Section 2.6.3.1, the applicant conducted MILDOS-AREA simulations in 2009 (LCI, 2010a) to determine areas where radon progeny may deposit and collected additional samples from seven locations based on the MILDOS-AREA analysis (see SER Figure 2.6-5). Samples were collected on June 24-25, 2009, and twice again at 2-week intervals following the initial sampling, and analyzed for U-natural, Th-230, Ra-226, Pb-210, and Po-210. SER Table 2.6-3 presents these results. The applicant stated (LCI, 2010a) that it avoided sampling sagebrush, rabbitbrush, succulents, and other non-grazing vegetation

because cattle generally do not consume them, and therefore, any radioactivity present would be unlikely to enter the human food chain.

According to the applicant (LCI, 2010a), sampling locations D and E within the plant boundary in SER Figure 2.6-5 were predicted by MILDOS-AREA modeling to have the most ground concentrations of radon progeny during operations. Locations F, G, H, and I (see SER Figure 2.6-5) were areas that the direct gamma scan survey (described in SER Section 2.6.3.4) indicated elevated gamma activity. The applicant stated that location J (see SER Figure 2.6-5) measured background exposure readings in the baseline direct gamma scan survey and was upwind during operations where MILDOS-AREA modeling predicts radon deposition to be low or non-existent (LCI, 2010a). The NRC staff finds that the applicant collected and analyzed the revised baseline vegetation sampling consistent with Regulatory Guide 4.14 because the applicant sampled forage vegetation at least three times during the grazing season in grazing areas in three different sectors having the highest predicted airborne radionuclide concentration due to milling operations, as recommended in the regulatory guide.

Table 2.6-3: 2009 Baseline Vegetation Sampling Results

Location‡	Date	Pb-210 (µCi/kg)	Po-210 (µCi/kg)	Ra-226 (µCi/kg)	Th-230 (µCi/kg)	U(mg/kg)
D	6/24/2009	3.1E-04	1.4E-05	5.4E-05	1.5E-05	0.029
	7/10/2009	3.7E-04	7.0E-06	8.8E-05	7.0E-06	0.029
	7/29/2009	5.2E-04	2.3E-05	1.4E-04	2.7E-05	0.053
E	6/24/2009	2.8E-04	1.4E-05	5.4E-05	6.4E-06	0.019
	7/10/2009	3.3E-04	1.5E-05	7.1E-05	8.8E-06	0.023
	7/29/2009	2.8E-04	1.6E-05	9.9E-05	1.7E-05	0.033
F	6/25/2009	2.0E-04	1.1E-05	9.3E-05	2.1E-05	0.051
	7/9/2009	2.2E-04	6.0E-06	8.9E-05	1.1E-05	0.029
	7/28/2009	3.1E-04	7.3E-06	2.4E-04	2.3E-05	0.078
G	6/25/2009	6.3E-04	5.3E-06	1.1E-04	1.7E-05	0.028
	7/9/2009	7.8E-04	1.2E-05	2.1E-04	2.6E-05	0.066
	7/28/2009	1.5E-03	2.7E-05	5.5E-04	7.1E-05	0.150
H	6/25/2009	1.2E-04	2.8E-06	7.1E-05	9.2E-06	0.025
	7/9/2009	2.9E-04	5.2E-06	1.6E-04	1.6E-05	0.059
	7/28/2009	2.4E-04	1.1E-05	1.1E-04	2.0E-05	0.040
I	6/25/2009	3.6E-04	1.1E-05	9.0E-05	2.5E-05	0.029
	7/9/2009	4.8E-04	1.1E-05	1.6E-04	2.2E-05	0.027
	7/28/2009	7.2E-04	3.3E-05	1.5E-04	2.0E-05	0.029
J	6/24/2009	3.7E-04	2.9E-05	6.9E-05	1.6E-05	0.038
	7/10/2009	7.6E-04	9.1E-06	1.6E-04	3.5E-05	0.140
	7/29/2009	6.5E-04	2.0E-05	6.7E-05	1.6E-05	0.033

(LCI, 2010a) ‡ See Figure 2.6-4 for sampling locations
(Source: Table VSS-1 in Attachment 2.9-7of the technical report)

The applicant did not collect preoperational crop or fish samples. In Section 2.2.1 of the technical report (LCI, 2010a), the applicant stated that there is no crop production within the licensed area or within 3.2 km (2 mi) of the licensed area. The applicant indicated that no fish species are found on the site, as all water bodies are ephemeral in nature and do not contain

sufficient water to support aquatic fish species. NRC staff concludes that the applicant's justification for not collecting fish and crop samples is adequate.

The applicant collected samples of meat (muscle tissue), kidney, and bone from cattle with access to grazing fodder within three kilometers of the processing plant site in fall 2008 and 2009 (LCI, 2010a). LCI collected samples at the time of slaughter and analyzed them for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. The applicant also analyzed a liver sample in 2009. Analytical results were in Attachment 2.9-8 of the technical report (LCI, 2010a). The NRC staff finds that the applicant collected and analyzed preoperational beef samples consistent with the food sampling recommended in Regulatory Guide 4.14 because LCI collected more than three livestock food samples and provided sufficient justification for not collecting crops. The staff concludes that the applicant collected vegetation that could also be foraged by livestock or game that may be consumed by humans, and therefore, potentially in the pathway-to-man. Though the applicant only collected samples from two cattle, it collected three different tissue samples, the liver, kidney, and muscle, that could be consumed by humans; and a tissue sample (i.e. bone) that could be a site of deposition (i.e. target organ) if uranium uptake occurs. Therefore, staff finds that the applicant's baseline livestock sampling is acceptable and is consistent with acceptance criterion (1) in SRP Section 2.9.

The applicant did not address preoperational sampling for game animals. In Section 2.2.1 of the technical report (LCI, 2010a), the applicant stated that the Wyoming Game and Fish Department hunting areas for antelope, deer, elk, and mountain lion include the licensed area. The applicant also stated that the hunt areas are not primarily within 3.2 km (2 mi) of the licensed area. Furthermore, the applicant stated that neither large nor small game is hunted to any extent in the licensed area, and that the livestock samples were better food samples and more likely to be in the pathway-to-man (NRC, 2011c). Based on the information concerning hunting at the proposed Lost Creek Project license area, the staff agrees with the applicant's assessment and, thus, finds that the applicant's baseline food sampling is acceptable and meets acceptance criterion (1) in SRP Section 2.9.

2.6.3.4 Direct Radiation

Regulatory Guide 4.14 recommends 80 direct radiation measurements at 150-meter (m) intervals up to a distance of 1500 m in eight directions from the center of the milling area. In addition, direct radiation measurements should also be made at the same locations used for the collection of particulate air samples once prior to site construction. The applicant proposed (LCI, 2008c, 2010a) an alternate methodology to characterize background gamma radiation at Lost Creek because the sampling design recommended in Regulatory Guide 4.14 was designed for a conventional mill rather than an ISR facility. Conventional mill operations are centralized between the mill complex and tailings disposal impoundments, whereas ISR operations are dispersed in the licensed area with multiple wellfields and header houses at each wellfield.

This alternate methodology presented by the applicant consisted of two components. The first component consisted of placing thermoluminescent dosimetry (TLD) in the same locations as the radon samplers. SER Figure 2.6-1 and Table 2.6-1 present the sampling locations and results, respectively. The initial placement of the TLD's and radon samplers (LCI, 2008c) were not at the same locations as the particulate air samplers as recommended in Regulatory Guide 4.14. However, based on additional MILDOS-AREA analyses, the applicant began an additional year of sampling in 2010 (LCI, 2010a). As shown in SER Figure 2.6-3 , the applicant placed radon samplers and TLDs at 12 locations in and around the proposed licensed area in

order to obtain baseline radon and gamma measurements in areas with maximum predicted radioactivity produced from LC ISR activities (LCI, 2010a). Five TLDs and radon samplers will be co-located with the five air particulate samplers. The staff finds the use of TLDs is consistent with Regulatory Guide 4.14 because the applicant measured the exposure dose with passive integrating devices as recommended in the regulatory guide. The staff finds the placement of the TLDs in the current baseline-monitoring program (LCI, 2010a)

The second component characterized the licensed area by measuring gamma exposure rates with sodium iodide (NaI) detectors mounted to off-highway vehicles (OHVs). The applicant paired the NaI detectors with global positioning system (GPS) receivers. Simultaneous GPS and exposure rate data for hundreds of thousands of gamma measurement throughout the licensed area were recorded using an onboard personal computer. NaI detectors are energy dependent, thus these detectors respond differently to radionuclides with higher or lower gamma energies compared to its calibration radionuclide. True gamma exposure rates are best measured with an energy independent system such as a high-pressure ionization chamber (HPIC). NaI detectors are more durable so they are a better choice under the field conditions experienced by the applicant. To address this issue, the applicant cross-calibrated the NaI detectors with HPICs (LCI, 2008c). The applicant stated that cross-calibration will allow a comparison of preoperational data with data obtained later without relying on identical detectors. The staff finds the applicant's rationale for cross-calibration reasonable and prudent because it is unlikely the applicant will use the same instruments when the site is decommissioned. The applicant presented the results of the NaI surveys and the HPIC measurements in Figure 2.9-4 in the technical report (LCI, 2008c).

Although the applicant did not collect direct radiation measurements in accordance with Regulatory Guide 4.14, the staff finds that the methodology used followed site characterization methodology recommended in NUREG-1575, Revision 1, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC, 2000b). The staff determined that the applicant collected a sufficient number of gamma survey measurements to characterize the licensed area and thereby demonstrates compliance with establishing baseline direct radiation readings of the proposed licensed area as required by 10 CFR Part 40, Appendix A, Criterion 7.

2.6.3.5 Soil Sampling

Regulatory Guide 4.14 recommends collecting up to 40 surface soil samples at 300 m intervals to a distance of 1500 m in eight meteorological sectors, five or more surface soil samples at air particulate stations, and at least five subsurface soil samples in four meteorological sectors.

The applicant proposed, in Section 2.9.1 of the technical report (LCI, 2010a) an alternate preoperational surface soil sampling methodology that consisted of two components. The first component consisted of collecting composite soil samples from 10-x-10 m (33- x-33 ft) grids. The applicant stated that these grids were the basis for developing a statistical correlation between measured soil Ra-226 concentrations and gamma exposure rates at the collection site, and thus the applicant called them "correlation" grids. LCI collected soil samples in a roughly radial pattern with the origin located near a potential site of the processing plant. The applicant stated that LCI selected sample locations to cover the range of gamma measurements made in the licensed area, rather than to employ a rigidly fixed spatial pattern, as recommended by Regulatory Guide 4.14 (LCI, 2010a). The applicant collected a composite sample of 10 sub-samples to a depth of 15 cm (6 in) within each grid and analyzed for Ra-226, natural uranium, Th-230, and Pb-210. The applicant stated (LCI 2010c) that LCI measured the average exposure rate for each grid, and recorded the GPS coordinates at the center of each sampling

grid. SER Figure 2.6-6 illustrates a sample grid. Application Figures 2.9-7 and 2.9-14 and application Table 2.9-1 present the analytical results and the statistical correlation between soil Ra-226 concentrations and gamma exposure rates (LCI 2008c, 2010a).

The second component of the surface soil sampling methodology described by the applicant (LCI, 2008c) consisted of applying the data obtained from the correlation grids to the entire licensed area. NaI/HPIC cross calibration data was combined with the soil Ra-226 concentration and gamma exposure rate correlation data (LCI 2008c). Radium-226 concentrations in soil across the licensed area were estimated by kriging, as illustrated in SER Figure 2.6-7. Kriging is a geostatistical interpolation procedure that fits a mathematical function, such as the statistical correlation, to a specified number of nearest points within a defined radius to determine an output value for each location.

NRC staff finds that the number of samples collected and the surface soil sampling methodology are consistent with Regulatory Guide 4.14, with the exception that the applicant did not collect surface soil samples at air particulate stations as recommended by Regulatory Guide 4.14. In contrast, the applicant (LCI, 2010a) collected additional vegetation and surface soil samples at seven locations determined by the gamma survey and 2009 MILDOS-AREA simulations to range from background conditions to sites predicted to have the maximum radon progeny deposition (see Figure 2.6-5). The applicant stated that it selected the sampling locations were to better define a baseline against which to assess environmental impacts. SER Table 2.6-4 presents these sampling results. As discussed in SER Section 2.6.3.3, the applicant stated that locations F, G, H, and I had higher gamma exposure readings from the direct radiation survey and MILDOS-AREA 2009 simulations predicted the highest deposition of radon progeny at locations D and E. However, in SER Table 2.6-4, the staff observed that Location D had higher gamma exposure readings than Location H. The staff observed that higher exposure rates correlated with the highest concentrations of Ra-226, Th-230, and U in soil. The staff found that Location J results are the lowest concentrations measured for all isotopes and consistent with background conditions as the applicant suggested (LCI, 2010a).

Table 2.6-4: June 2009 Baseline Surface Soil Sampling Results

Location‡	Pb-210 (µCi/kg)	Ra-226 (µCi/kg)	Th-230 (µCi/kg)	U(mg/kg)	Mean Gamma (µR/hr)
D	<2.1	3.8	2.0	7.2	34.6
E	<2.0	1.6	1.1	2.5	28.9
F	<2.0	6.3	4.0	17.5	45.2
G	<2.0	6.5	5.2	23.6	48.2
H	<2.0	1.7	0.9	2.6	27.6
I	2.9	3.8	2.1	4.1	38.9
J	<2.0	1.3	0.8	2.1	26.3

(LCI, 2008c, 2010a)(Source: Table VSS-1 in Attachment 2.9-7 of the technical report)
‡ See Figure 2.6-5 for sampling locations

The NRC staff finds that the applicant's rationale for selecting soil sampling locations, rather than a radial pattern from the center of the plant, was an acceptable alternative because it sampled baseline conditions at locations that the direct gamma survey and MILDOS-AREA modeling predicted would be affected by operations. However, the applicant has not provided a justification for not co-locating surface soil samples with each of the air particulate sampling

locations (see SER Figure 2.6-2), as recommended in Section 1.1.4 b. of Regulatory Guide 4.14.

The staff finds that collecting soil, direct radiation, radon, and air particulate samples at the same locations could allow the applicant to observe possible trends in radioisotope concentrations in the various media. Thus, the staff cannot conclude that the applicant has provided complete baseline data for the site and its environs, as required by 10 CFR Part 40, Appendix A, Criterion 7. Therefore, this requirement will be included in a license condition, as discussed in Section 2.6.4.

The applicant collected six subsurface soil samples to a depth of 1 m (3.3.ft) in three soil types and analyzed for concentrations of natural uranium, Ra-226, Th-230, and Pb-210. The soil types were Pepal Sandy Loam, Poposhia Loam, and Teagulf Sandy Loam. Results are presented in SER Table 2.6-5. The highest concentrations of Ra-226 and Th-230 were in the deepest layer (84 to 152 cm [33-60 in]) at location LCDS-C (see SER Figure 2.6-8). The highest concentrations of U were observed in the deepest layers ($\geq$77 cm [$\geq$31 in]) at locations LCDS-CE, LCDS-N, and LCDS-W. Based on the information presented in the application, the NRC staff finds that the baseline subsurface soils sampling was collected and analyzed consistent with Regulatory Guide 4.14.

Table 2.6-5: Baseline Soil Profile Sampling Results

Location	Soil Type	Depth (in)	Date	Pb-210 (µCi/kg)	Ra-226 (µCi/kg)	Th-230 (µCi/kg)	U (mg/kg)
LCDS-C	Pepal Sandy Loam	0-12	Sep 2008	<3.0	1.7	0.5	1.08
		12-33		<3.0	2.3	1.3	2.14
		33-60		4.2	2.8	2.7	0.52
LCDS-CE	Poposhia Loam	0-8		<3.0	2.1	1.3	3.37
		8-18		<3.0	2.1	1.3	2.17
		18-34		<3.0	1.7	1.6	1.49
		34-48		<3.0	1.2	1.9	3.72
LCDS-N	Pepal Sandy Loam	0-24	Dec 2008	<3.0	1.5	1.0	2.19
		24-33		<3.1	1.0	0.8	1.77
		33-40		<3.0	1.1	1.4	4.84
LCDS-E	Pepal Sandy Loam	0-8		<3.5	1.2	0.1	2.9
		8-40		<3.0	0.8	0.9	2.71
LCDS-S	Teagulf Sandy Loam	0-10	Sep 2008	<4.0	1.9	0.8	0.57
		10-60		<3.0	1.2	0.6	1.55
LCDS-W	Pepal Sandy Loam	0-21	Dec 2008	<3.0	1.5	1.1	2.53
		21-31		<3.0	1.2	1.1	1.79
		31-40		<3.0	1.4	0.6	3.01

(LCI, 2010a)
(Source: Table VSS-3 in Attachment 2.9-7 of the technical report)

2.6.3.6 Sediment Sampling

Regulatory Guide 4.14 recommends sediment sampling at two locations in each surface water location (e.g., streams, rivers, drainages) and one in each water impoundment. The applicant collected sediment samples in December 2008 at the upstream and downstream permit boundaries and at the Crooked Well Reservoir, as illustrated in SER Figure 2.6-9, which coincided with seven of the surface water sampling locations (LCI, 2010a). The applicant stated

that Crooked Well Reservoir is a small on-site impoundment of East Battle Draw, which traps sediment when there is flow in the drainage. Crooked Well Reservoir is dry for the majority of the year, but fills with snow melt during the months of March and April (LCI, 2010a). The applicant collected composites of 10 to 20 subsamples along the transect to a depth of 8 cm (3 in). Samples were analyzed for Pb-210, Ra-226, Th-230, and U. Analytical results are presented in SER Table 2.6-8. The staff observed the largest concentrations of U and Th-230 in samples from the Crooked Well Reservoir, which is expected because it collects sediments during run-off events.

Based on the information presented in the application, the staff concludes the collection and analysis of sediments in the license area are consistent with Regulatory Guide 4.14 because the applicant collected sediment samples from the same surface-water locations as described in Section 1.1.2 of the regulatory guide. As recommended by the regulatory guide, LCI collected samples in a traverse across the streambed and composited for analysis.

2.6.3.7 Groundwater Sampling

Regulatory Guide 4.14 recommends that samples should be collected quarterly from at least three sampling wells located down gradient from the proposed tailings area, at least three locations near other sides of the tailings area, and one well located up gradient from the tailings area to serve as a background sample. Samples should be analyzed for dissolved U-natural, Th-230, Ra-226, Po-210, and Pb-210. Additional groundwater samples should be collected quarterly from each well within 2 km (1.2 mi) of the proposed tailings area that is or could be used for drinking water, watering of livestock, or crop irrigation and analyzed for dissolved and suspended U-natural, Th-230, Ra-226, Po-210, and Pb-210. The applicant does not plan to have tailings impoundments on site and thus, did not include analysis of radionuclides other than those constituents suggested in Table 2.7.3-1 in NUREG-1569.

Staff agrees that the applicant is not required to follow Regulatory Guide 4.14 groundwater monitoring guidance for tailings impoundments because LCI will not use tailings impoundments; however, the applicant plans two storage ponds for use prior to deep well injection and thus, must establish baseline groundwater conditions at the storage ponds site, as discussed in SER Sections 4.2.3.1.1.1 and 4.2.4. As described in detail in SER Section 4.2.3.1.1.1, Storage Pond Site Characterization, the applicant installed three monitoring wells and sampled them quarterly, as recommended in Regulatory Guide 4.14, but the applicant demonstrated that only two were screened at an appropriate depth. In addition, LCI did not install the fourth well as proposed in Section 5.3.2.3 of the application (LCI, 2008d, 2010a). Therefore, the staff will include a license in SER Section 4.2.4 that will require the licensee to install two additional wells in the southwestern and southeastern portions of the storage pond area and to collect baseline samples prior to operations.

SER Section 2.5.3.2 and SER Table 2.5-2 describe the groundwater analyses. The applicant collected quarterly samples in the fall of 2006 through the summer of 2007 at 17 wells; three in the uppermost, four in the overlying, six in the ore zone, and four in the underlying aquifers. LCI installed 10 additional wells in October 2008 and quarterly sampling began in August 2009, but two wells, MB-7 and MB-10 in the DE Horizon, have insufficient water to sample. SER Figure 2.5-2 illustrates the location of the wells. The applicant analyzed samples for Ra-226, Ra-228, U, gross alpha, and gross beta. SER Table 2.5-2 presents the average baseline results. The applicant stated in Section 2.7.3.2 of the technical report (LCI, 2008c) that in more than two-thirds of the samples collected, the Ra-226 and Ra-228 concentrations exceed the

EPA's MCL and the average U concentrations are an order of magnitude greater than the EPA MCL. The staff finds that these higher concentrations are expected in aquifers near ore zones.

The staff finds that the groundwater samples were collected at locations and analyzed for constituents consistent with recommendations in the SRP, which the NRC staff concludes meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7, with the exception of the two storage pond wells as discussed above. The staff finds that the applicant provided sufficient information that showed the applicant followed the sample methodology recommendations in the SRP (NRC, 2003a), which the staff finds are acceptable methods and approaches to determine baseline conditions as required by 10 CFR Part 40, Appendix A, Criterion 7.

2.6.3.8 Surface Water Sampling

Regulatory Guide 4.14 recommends surface water sampling for several types of areas. The locations can include large permanent onsite water impoundments, such as a pond or lake, offsite impoundments that could be subject to direct surface drainage from potentially contaminated areas, surface waters, or drainage systems crossing the site boundary, and surface waters that could be subject to drainage from potentially contaminated areas. These surface water samples are to be collected as a grab sample on a monthly and quarterly basis for water impoundments and drainage systems, respectively. Regulatory Guide 4.14 recommends analyzing surface water samples separately for suspended and dissolved natural uranium, Ra-226, Th-230, Pb-210, and Po-210 at specific intervals.

In Section 2.7.1 of the technical report, the applicant states that there are no perennial or intermittent streams with the licensed area or on adjacent lands and describes the drainage system of the licensed area. The proposed license area is located in two drainage basins, the Battle Spring Draw drainage basin and an unnamed basin, as shown in Figure 2.4-1. The Battle Spring Draw is divided into its two tributaries, the West Battle Spring Draw and East Battle Spring Draw watersheds, and the western unnamed basin is referred to as the West Draw watershed. According to the applicant, the principal drainage within the licensed area is Battle Spring Draw, which drains to the southwest and is dry for the majority of the year. Most of the surface water is runoff from precipitation or snowmelt, and it quickly infiltrates, recharging shallow groundwater, evaporates, or is consumed by plants through evapotranspiration. See SER Figure 2.4-2 for the surface drainage map for the Lost Creek Project.

In Sections 2.2.1 and 2.9.3.4 of the technical report, the applicant identifies four Bureau of Land Management (BLM) stock ponds near the license area, each associated with a groundwater right. According to the applicant, none of the BLM ponds is subject to drainage from potentially contaminated areas. The stock ponds associated with BLM East Eagle Nest Draw Well, BLM Battle Spring Well No. 4777, and BLM Boundary Well No. 4775 are in a separate drainage system, outside the drainage network, or upgradient of the proposed license area, respectively. BLM Battle Springs Draw Well No. 4451 feeds a pond of a small tributary to East Battle Springs Draw, but no operational activities are planned within the contributing area of this pond. The staff finds that the applicant's rationale for not sampling the BLM ponds is reasonable because the ponds are should not be affected by the proposed Lost Creek Project.

Seven samplers collected full, one-liter samples from snowmelt runoff in March and April 2007. LCI collected samples on April 17, 2007 and analyzed for dissolved natural uranium, Pb-210, Po-210, and Th-230. The applicant also analyzed the samples for suspended natural uranium, Pb-210, Po-210, Th-230, and Ra-226. The radiological monitoring results for these seven samples are summarized in Table 2.7-4 (page 3 of 3) of the technical report. SER Table 2.5-1

presents the results for four of the sampling locations: LC1, LC2, LC5, and LC10. LC1 was located in the far western portion of the license area. LC5 was located on the Battle Spring Draw in the eastern portion of the license area. LC2 and LC10 were located in separate drainages south and immediately downstream of the proposed mine units.

Most radionuclides were below detection limits, except for four samples (LC-1, LC-2, LC-4, and LC-5 in SER Figure 2.5-1) that contained total U concentrations between 3 to 9 µg/ml. Two of these samples, LC-2 and LC-4, had dissolved and suspended U concentrations of 3-4 µg/ml and 5-6 µg/ml, respectively. Radium-226 was only measured in one sample, LC-2, located in a large channel near the center of the license area and ore body. The highest gross alpha activity was also measured at this location. The results met EPA drinking water standards for radionuclides for those measured. However, the applicant did not report results for dissolved Ra-226, as recommended by Regulatory Guide 4.14, nor did it provide a justification for not doing so. The applicant stated that it attempted to collect such samples but could not, because of insufficient snowmelt to collect surface water samples (NRC, 2011c). Based on the information provided by the applicant regarding infrequent rainfall and absence of significant snowmelt, the staff finds the applicant has sufficiently established baseline surface water monitoring and, thus, finds that the applicant's baseline surface water monitoring program is acceptable.

2.6.4 EVALUATION FINDINGS

Staff reviewed the background radiological characteristics of the Lost Creek Project in accordance with SRP Section 2.9.3. The applicant has provided adequate justification for not conducting radon flux monitoring, analysis for dissolved Ra-226 in surface water samples, and game, crop, and fish sampling during preoperational monitoring. The applicant has established background radiological characteristics by providing monitoring programs that include sampling frequency and methods, sampling locations, and types of analyses. Although, the applicant collected baseline soil samples, these samples were not co-located with air samples, as recommended by Regulatory Guide 4.14. Therefore, to completely comply with 10 CFR 40, Appendix A, Criterion 7, the staff is adding the following license condition to ensure that all representative data are collected prior to major site construction:

> The licensee shall submit to the NRC, prior to major site construction, a radiological environmental monitoring program report that will include soil samples co-located with air particulate samples, as described in Regulatory Guide 4.14 to comply with 10 CFR Part 40, Appendix A, Criterion 7.

Based upon the review conducted by the staff as indicated in SER Section 2.6.3, the information provided in the application, as supplemented information collected in accordance with the noted license condition, is consistent with the applicable acceptance criteria of SRP Section 2.9.3 and the requirements of 10 CFR 40, Appendix A, Criterion 7.

2.6.5 REFERENCES

10 CFR Part 20. *Code of Federal Regulations,* Title 10, *Energy,* Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. *Code of Federal Regulations,* Title 10, *Energy,* Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content," U.S. Government Printing Office, Washington, DC.

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LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2009a. "Letter to NRC, Regarding 2nd Round Response to NRC Request for Additional Information (RAI), Dated November 6, 2008 Technical Report for the Lost Creek Project, Great Basin, Wyoming Docket No. 40-9068 TAC No. LU0142," January 16, 2009, ADAMS Accession Nos. ML090360160 and ML090360161.

LCI, 2009b. Lost Creek ISR, LLC, letter to Ronald Burrows, U.S. Nuclear Regulatory Commission, February 27, 2009, ADAMS Accession Nos. ML090840397 and ML090840398.

LCI, 2009c. "Letter to NRC, Regarding Lost Creek Project Responses to Health Physics Comments," August 5, 2009, ADAMS Accession No. ML092310728.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

LCI, 2010c. "Letter to NRC, Lost Creek Project, Clarifications to TR Docket No. 40-9068 TAC No. LU0142," January 6, 2010, ADAMS Accession No. ML100130206.

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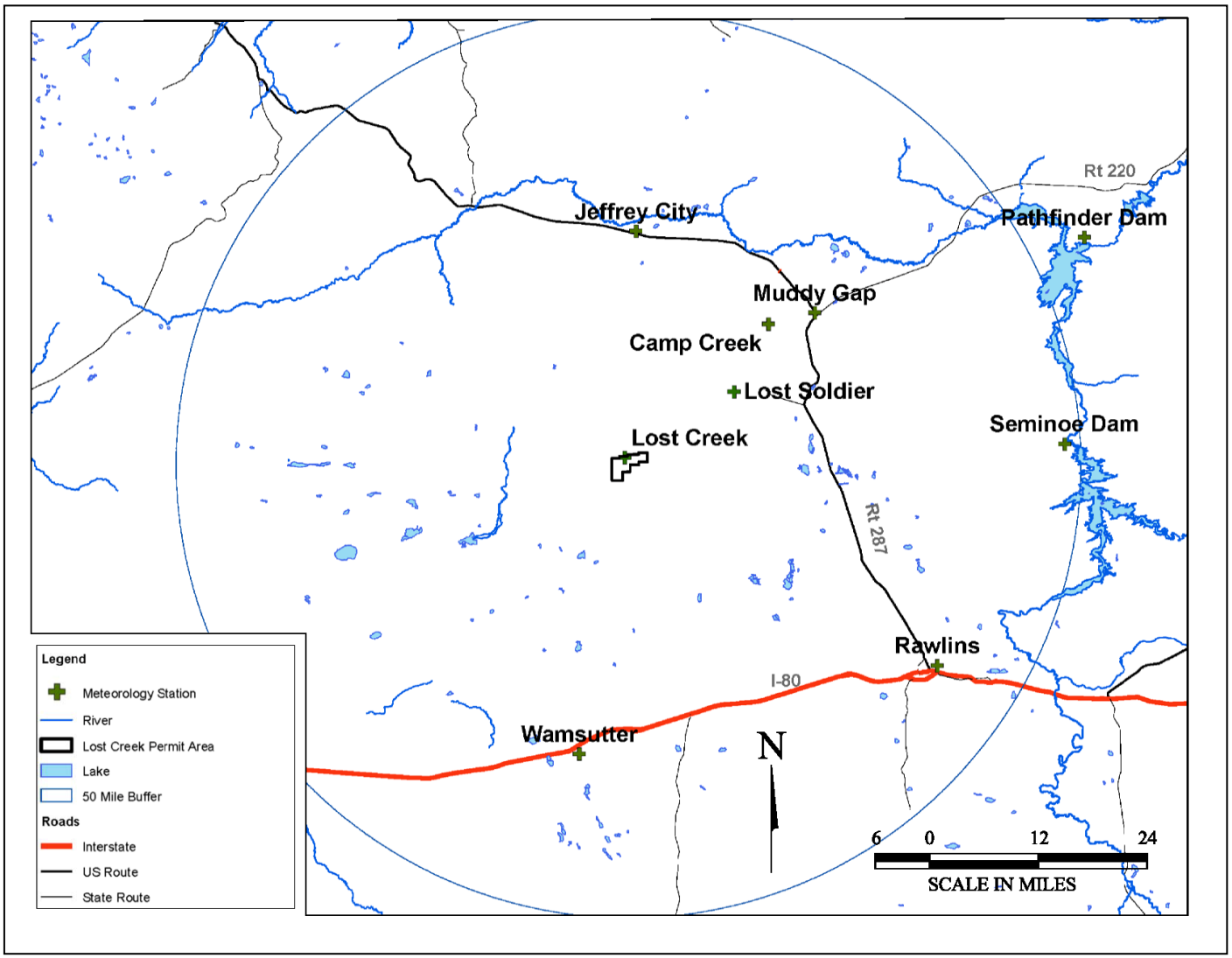
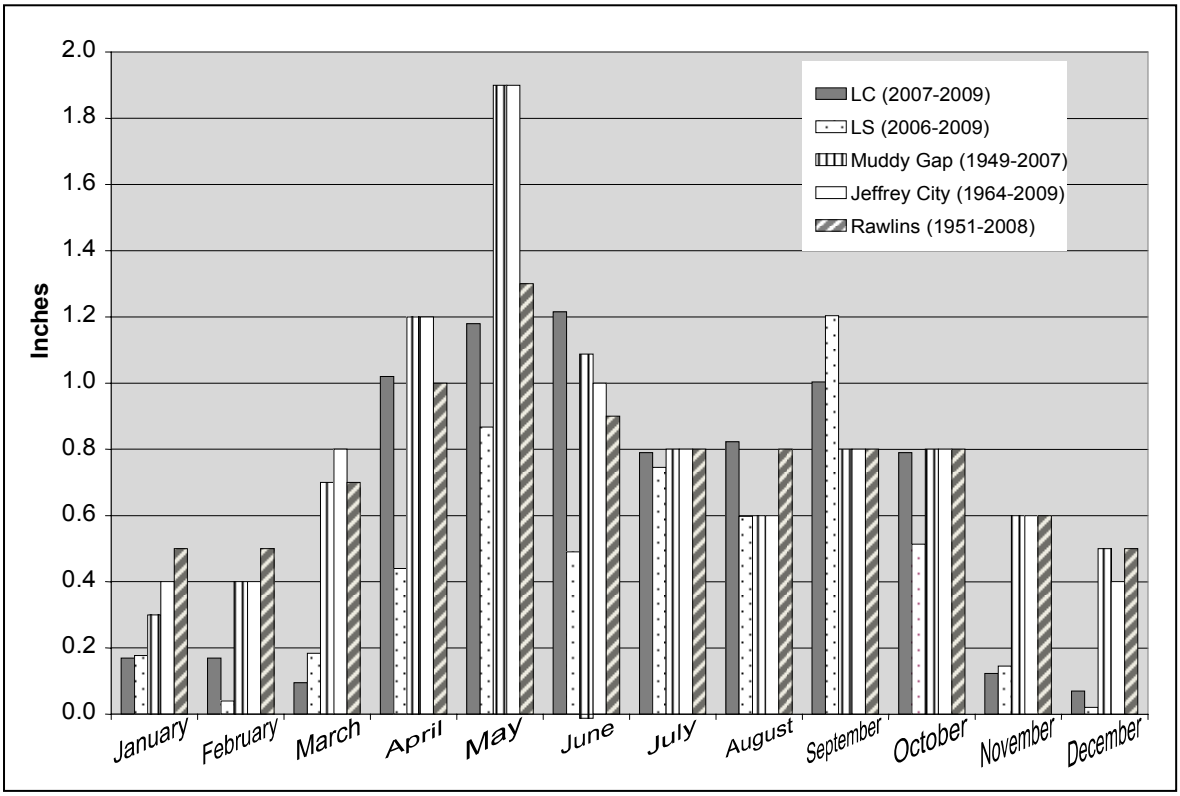
NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

NRC, 2011c. U.S. Nuclear Regulatory Commission, "Letter to Wayne Heili, Lost Creek ISR, LLC, Regarding Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming, Summary of May 31, 2011, Teleconference - (TAC NO. J00559)," July 11, 2011, ADAMS Accession No. ML111890482.



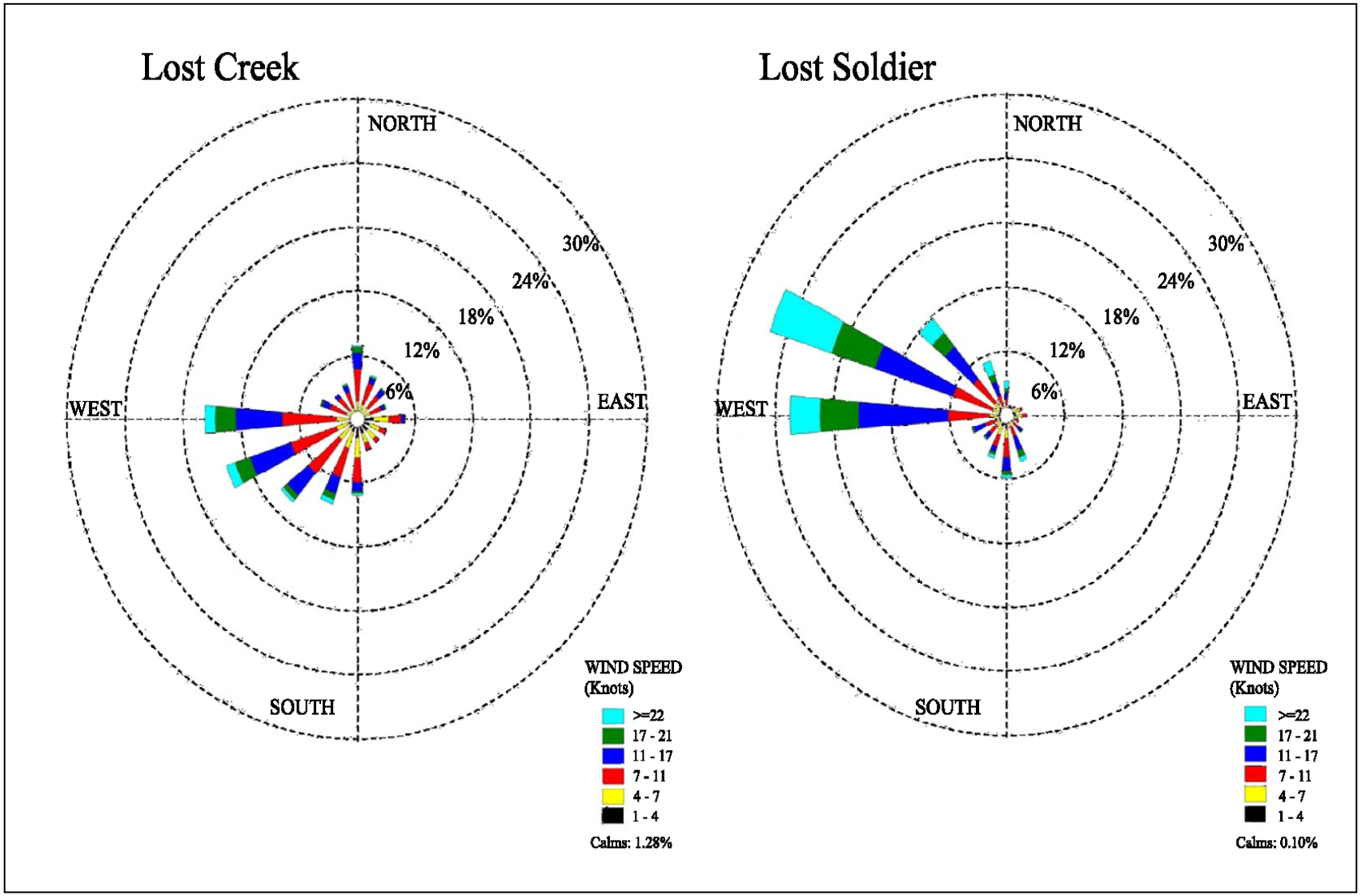
(LCI, 2010a)
(Source: Adapted from Figure 2.5-1 of the technical report)

Figure 2.2-1: Meteorological Stations within 50 Miles of the Lost Creek



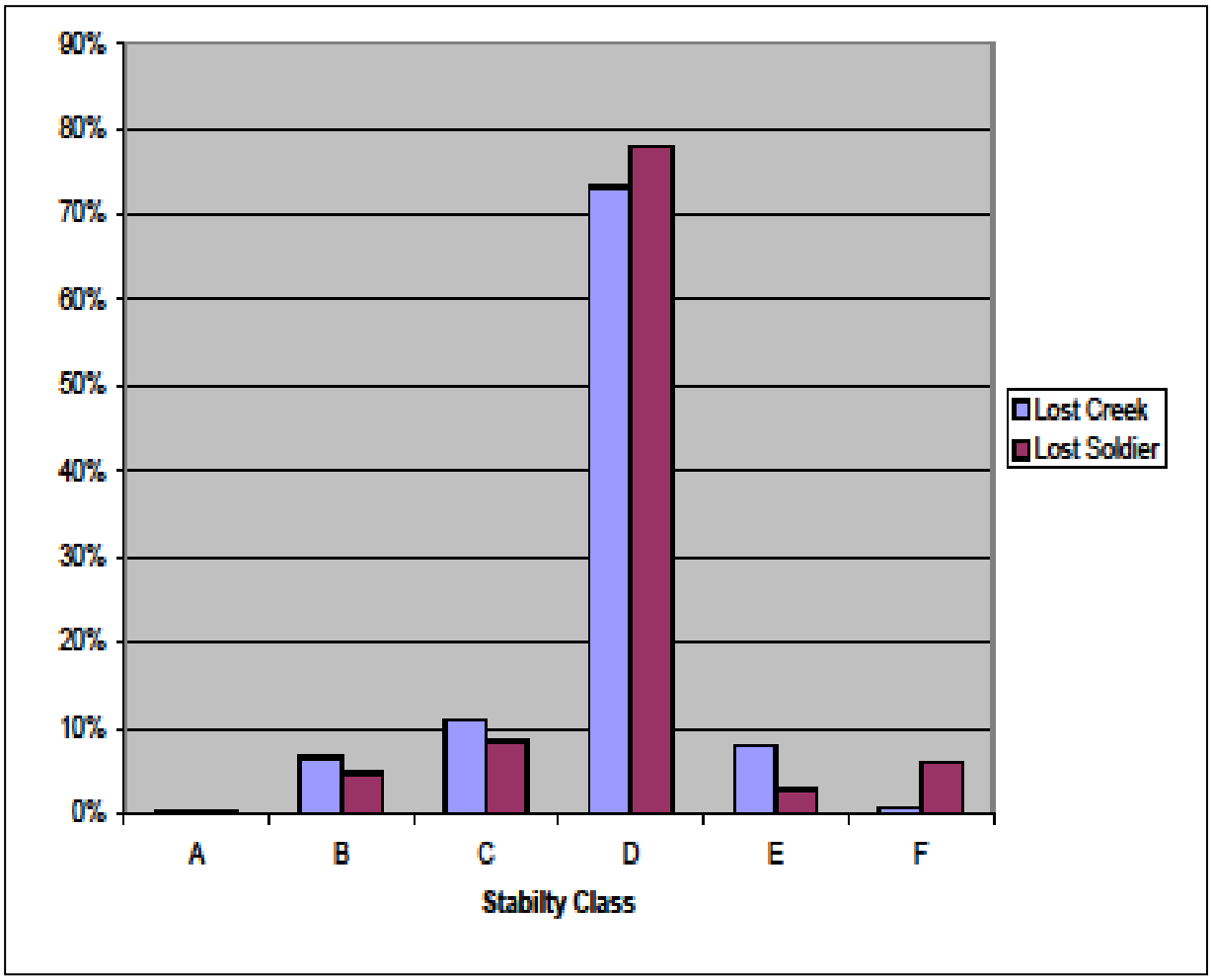
(Kelsey, 2010; Brown, 2010 (Adapted from Figure 2.5-2b in the technical report)

Figure 2.2-2: Average Monthly Precipitation Collected at Varoius Stations



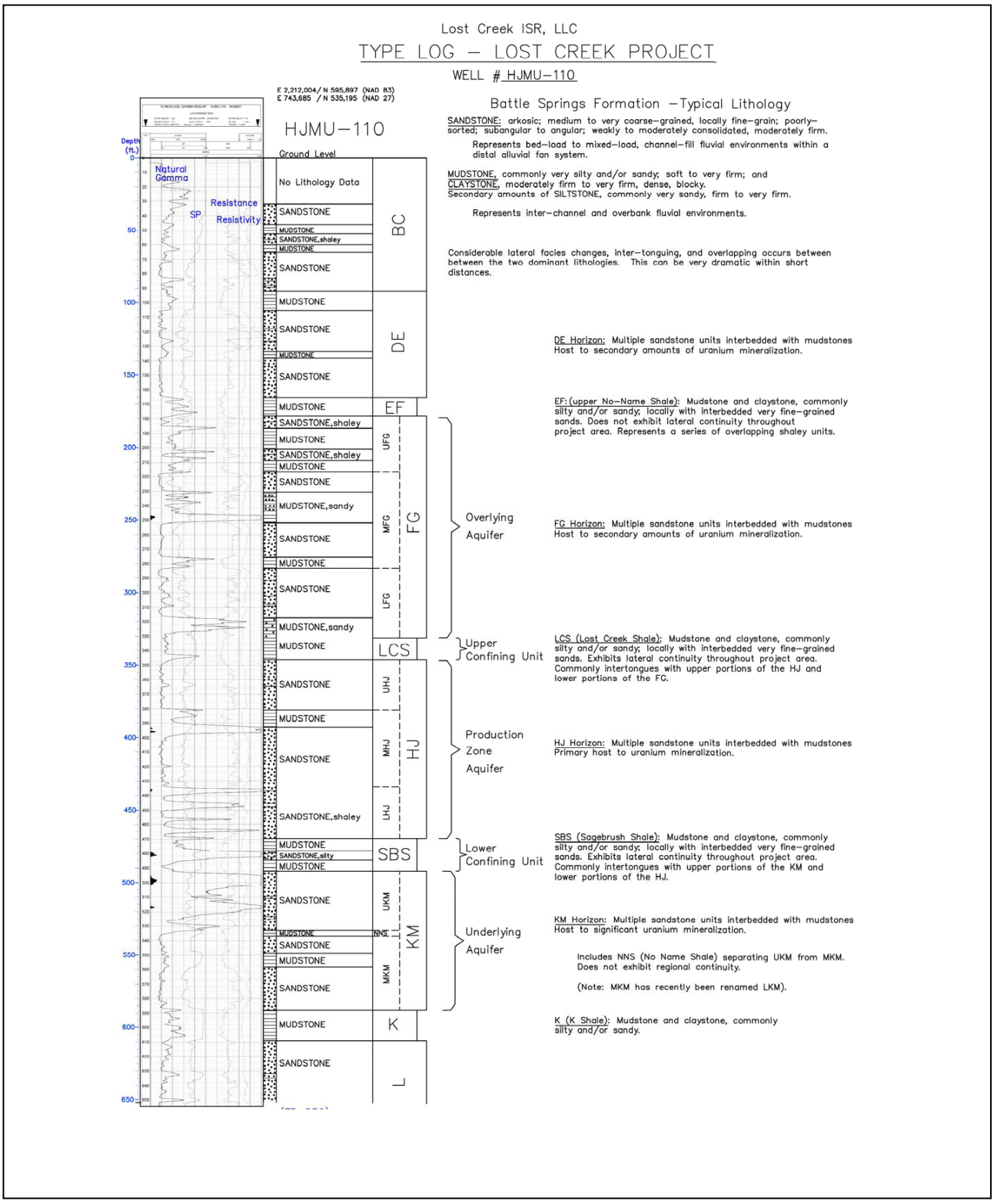
(LCI, 2010a; Brown, 2010) (data collected between (1) September 1 and November 30, 2007, and (2) March 1, 2008, and August 31, 2009) (Adapted from Figure 2.5-3b of the technical report)

Figure 2.2-3: Wind Rose Plot of Lost Creek and Lost Soldier



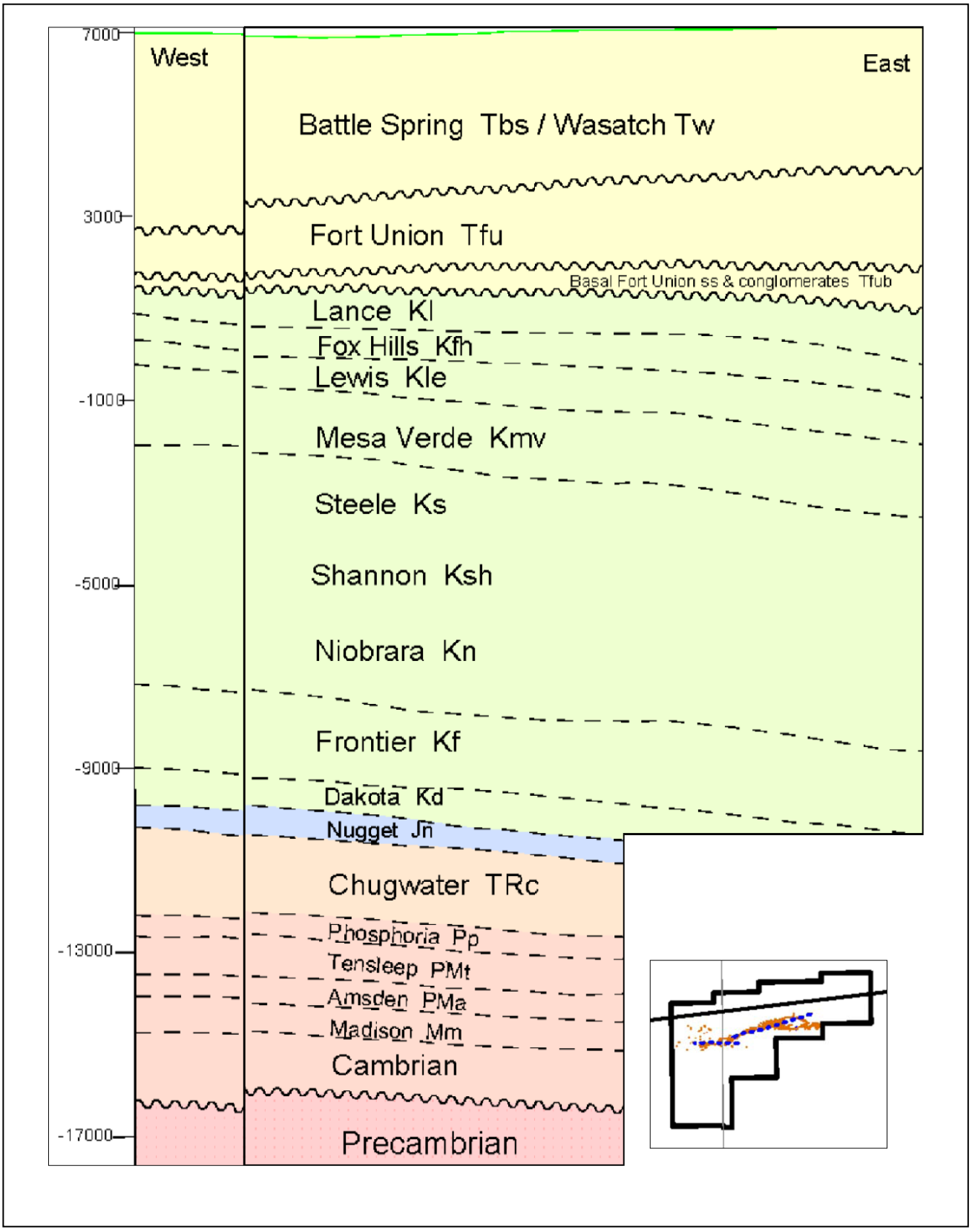
(LCI, 2010a)
(Source: Figure 2.5-4 of the technical report)

Figure 2.2-4: Comparison of Lost Creek and Lost Soldier Stability Data



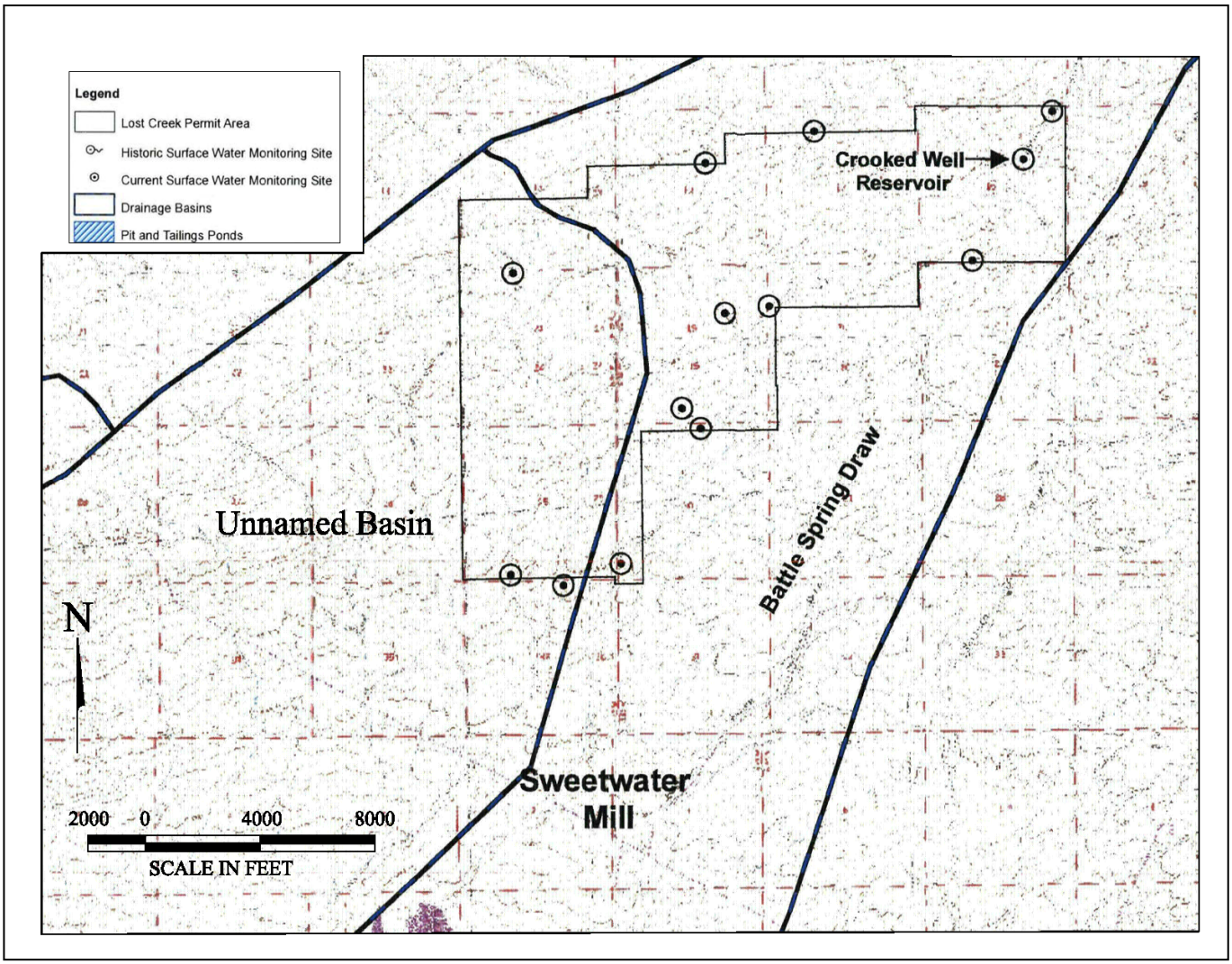
(Source: LCI, 2008c; LCI, 2010a) (Figure 2.6-2b in the technical report)

Figure 2.3-1: Generalized Stratigraphic Column for the License Area



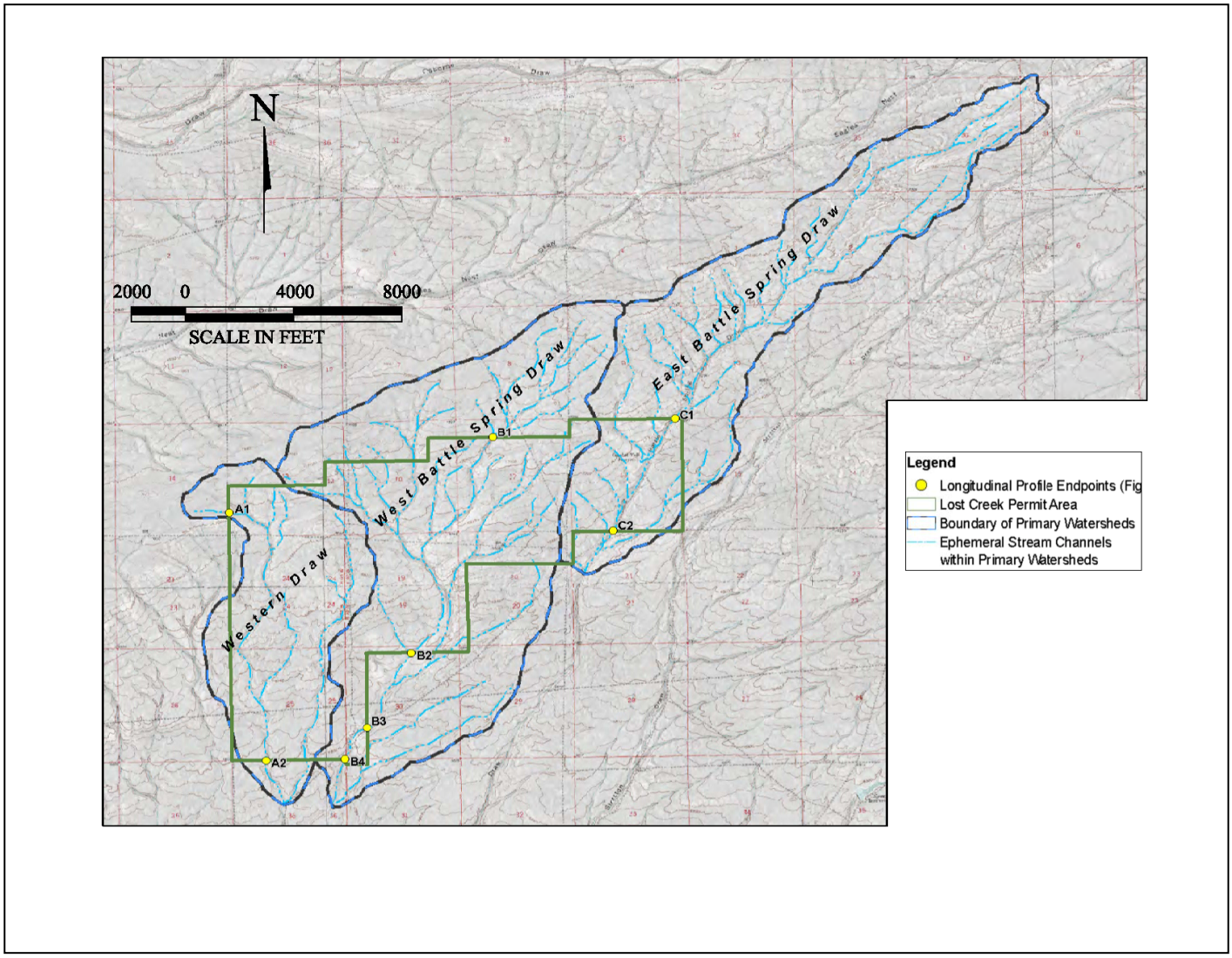
Source: LCI, 2008c) (Figure 2.6-2a in the technical report)

Figure 2.3-2: Schematic Stratigraphic Column



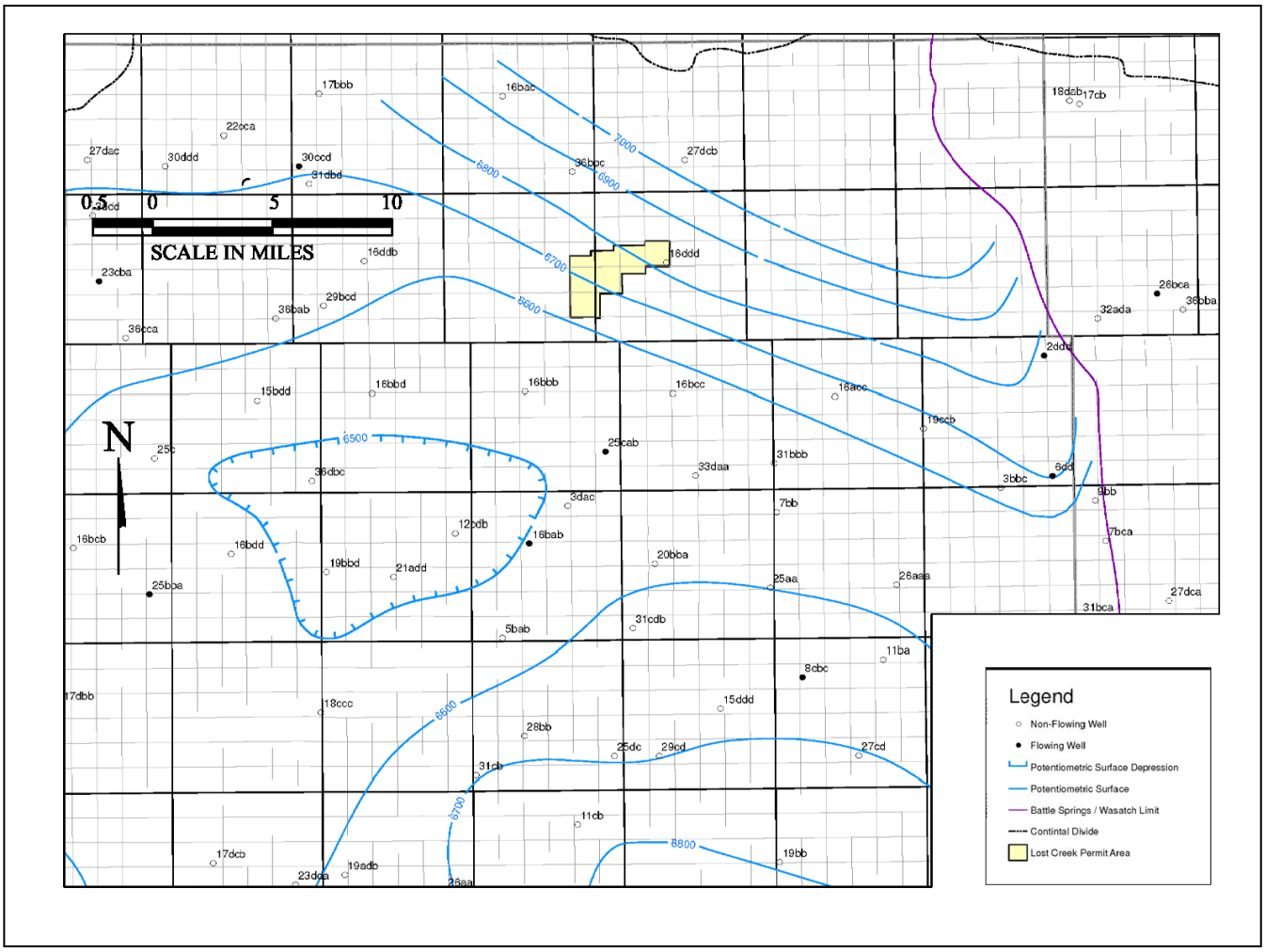
(Source: LCI, 2008c) (Adapted from the Initial Figure 2.7-1 in the technical report)

Figure 2.4-1: Lost Creek Drainages and Surface Water Sampling Points



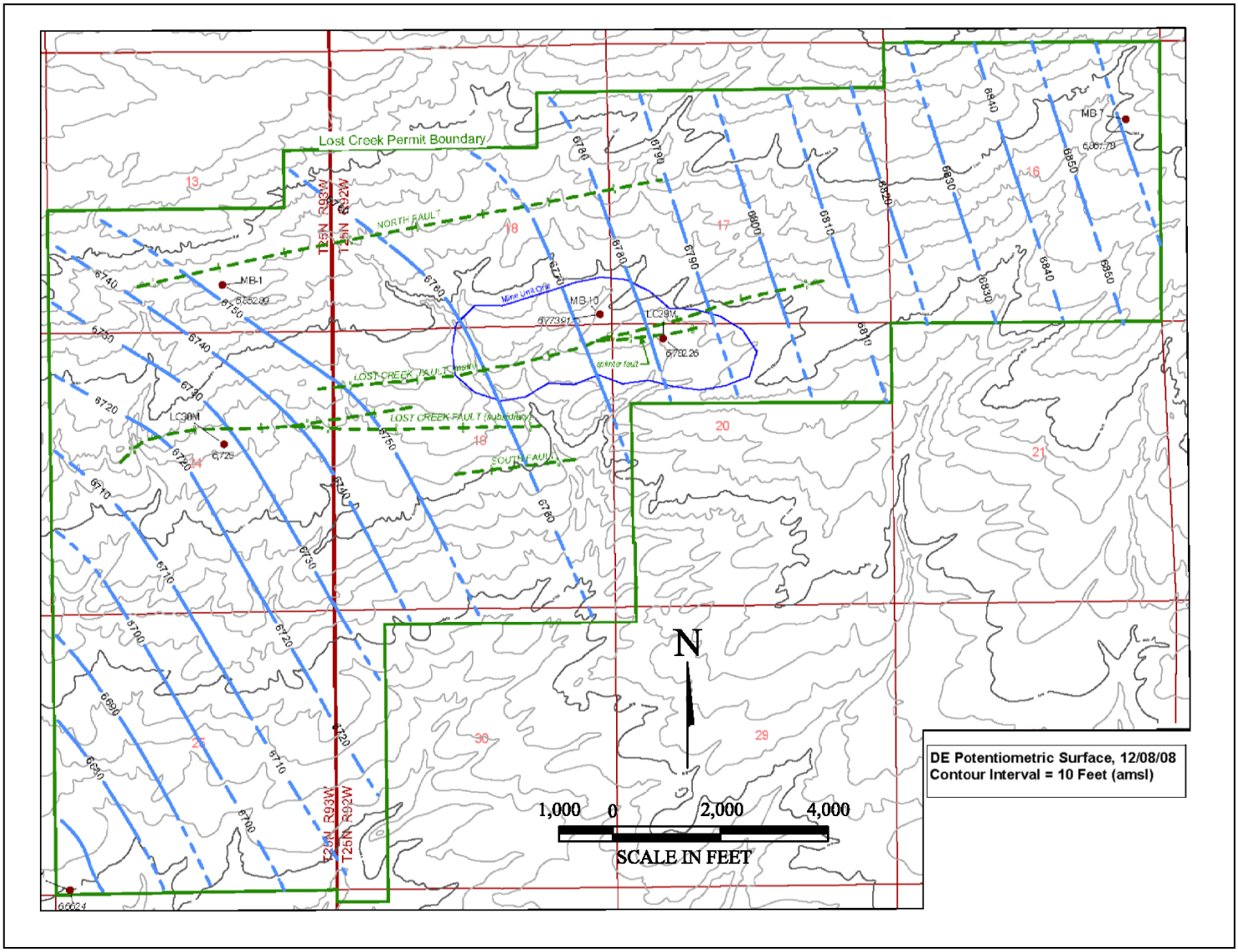
(Source: LCI, 2010a) (Adapted from Figure 2.7-1 in the technical report)

Figure 2.4-2: Watersheds within the Proposed Licensed Area



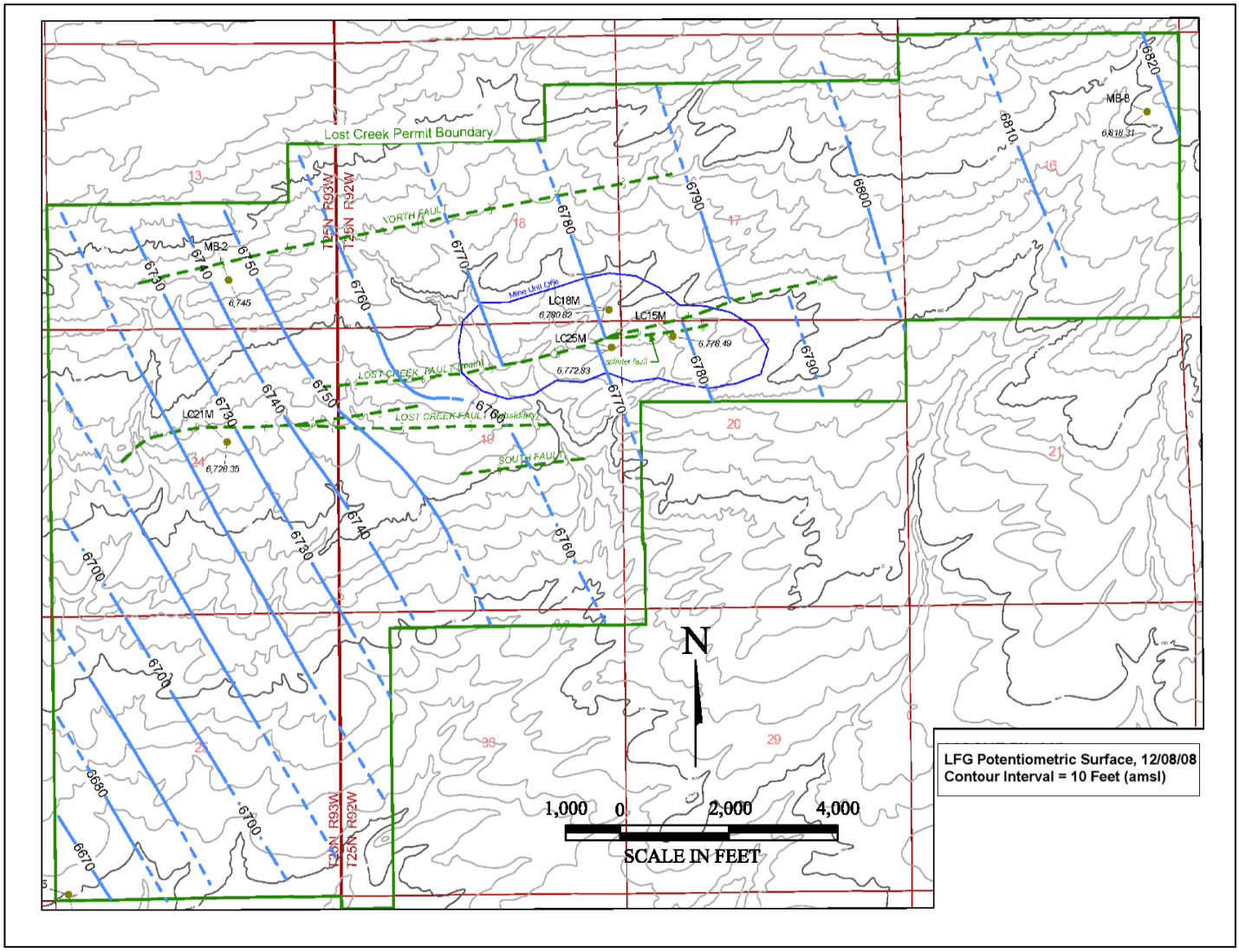
(Source: LCI, 2008c) (Adapted from Figure 2.7-6 in the technical report)

Figure 2.4-3: Regional Potentiometric Surface Map for the Battle Spring Aquifer



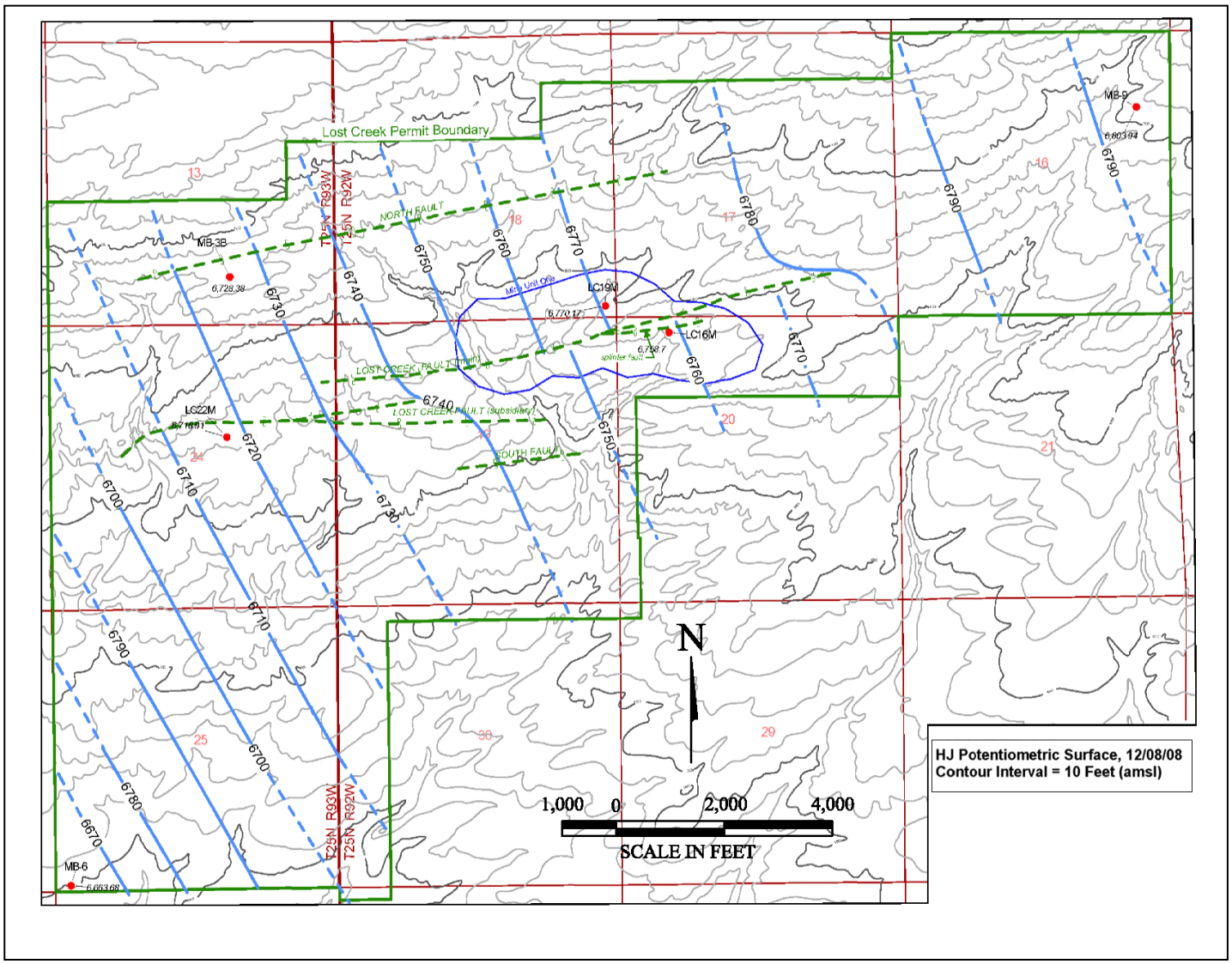
(Source: LCI, 2010a) (Figure 2.7-11a in the technical report)

Figure 2.4-4: Potentiometric Surface Contour Map for the DE Horizon



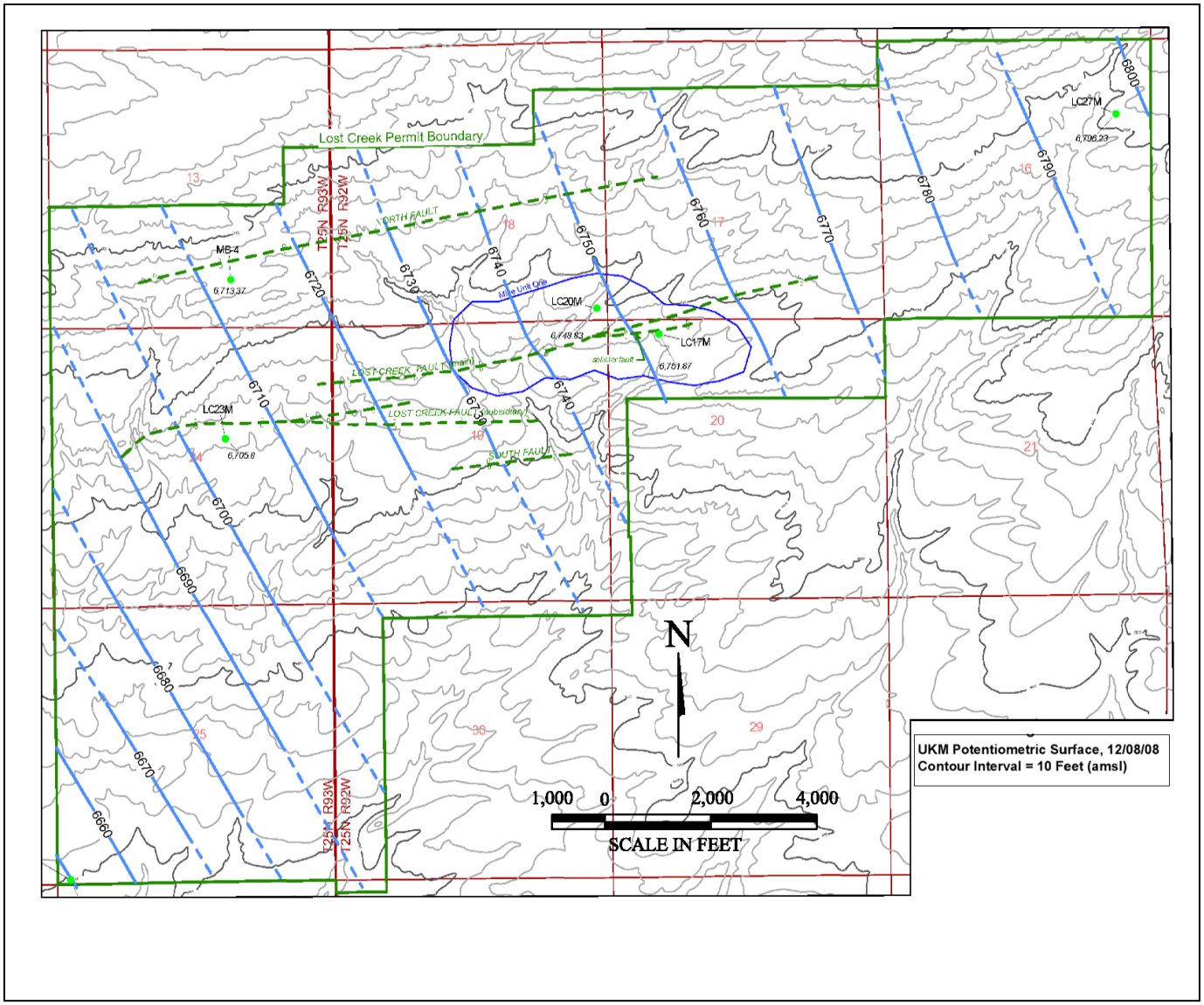
(Source: LCI, 2010a) (Figure 2.7-11b in the technical report)

Figure 2.4-5: Potentiometric Surface Contour Map for the LFG Horizon



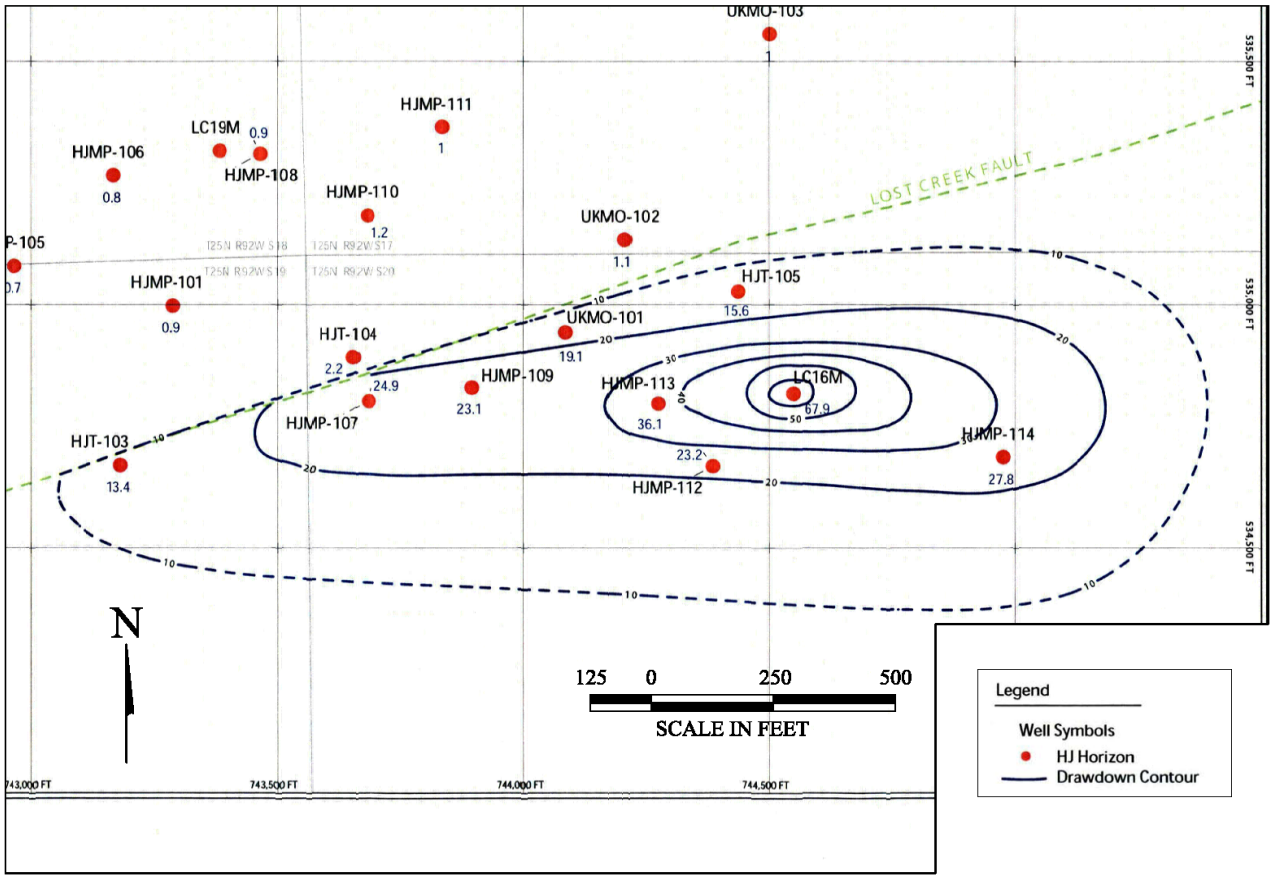
(Source: LCI, 2010a) (Figure 2.7-11d in the technical report)

Figure 2.4-6: Potentiometric Surface Contour Map for the HJ Horizon



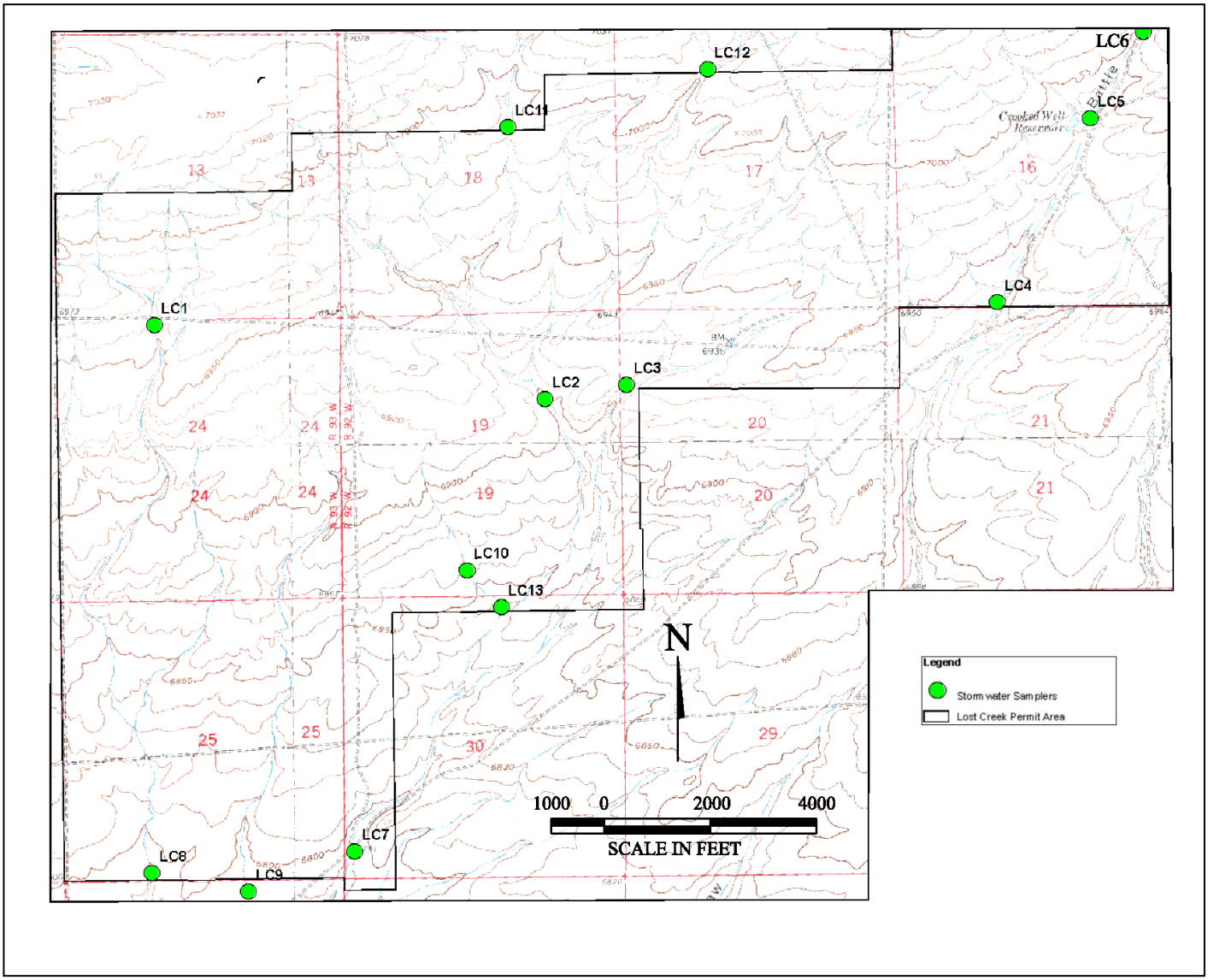
(Source: LCI, 2010a) (Figure 2.7-11g in the technical report)

Figure 2.4-7: Potentiometric Surface Contour Map for the UKM Horizon



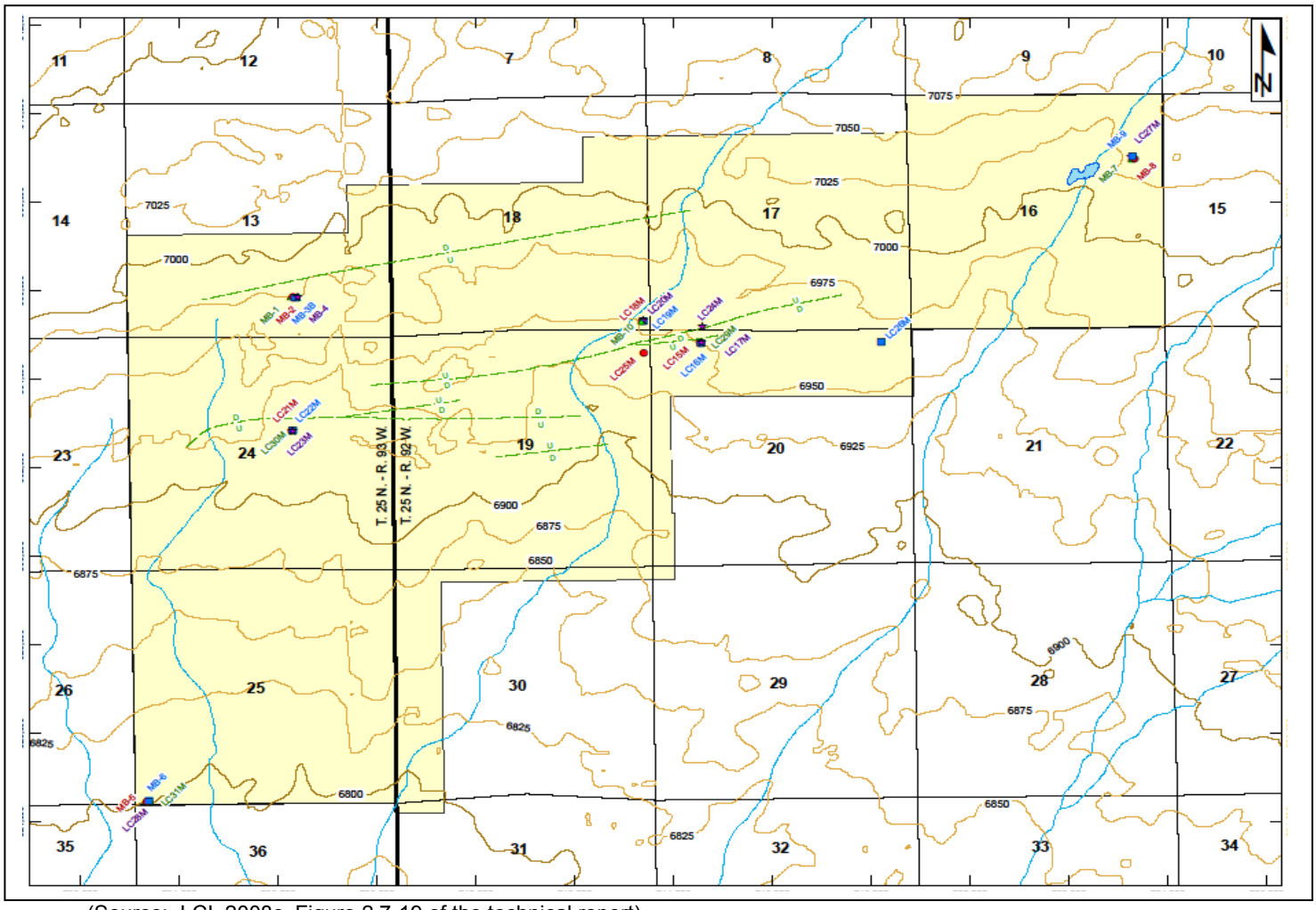
(Source: LCI, 2010a) (Figure 6 13 of Attachment 2.7-3 to the technical report)

Figure 2.4-8: 2007 Drawdown Contour Map in Well LC19M (HJ Horizon)



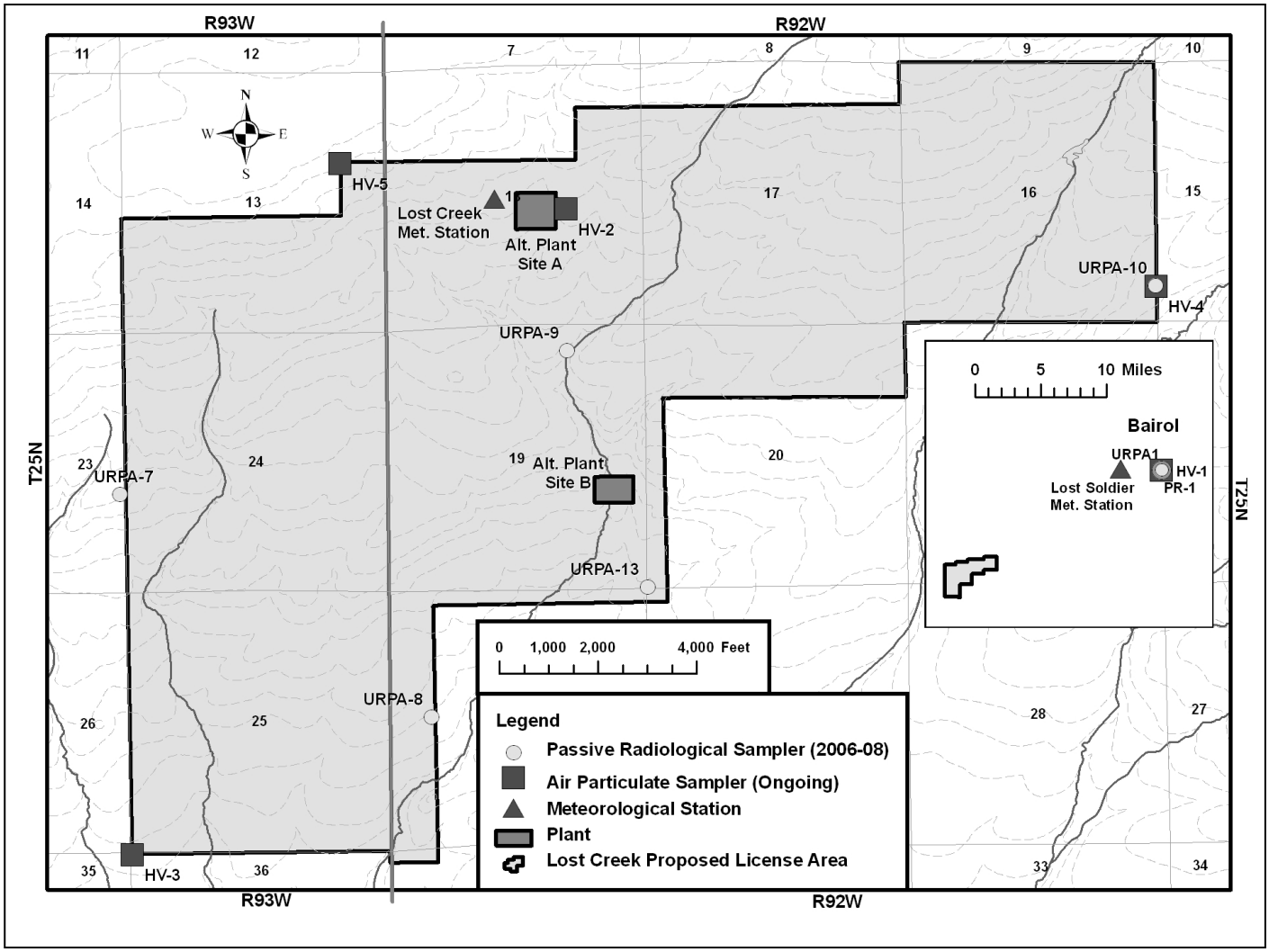
(Source: LCI, 2008c) (Figure 2.7-5 of the technical report)

Figure 2.5-1: Surface Water Sampling Locations at Lost Creek



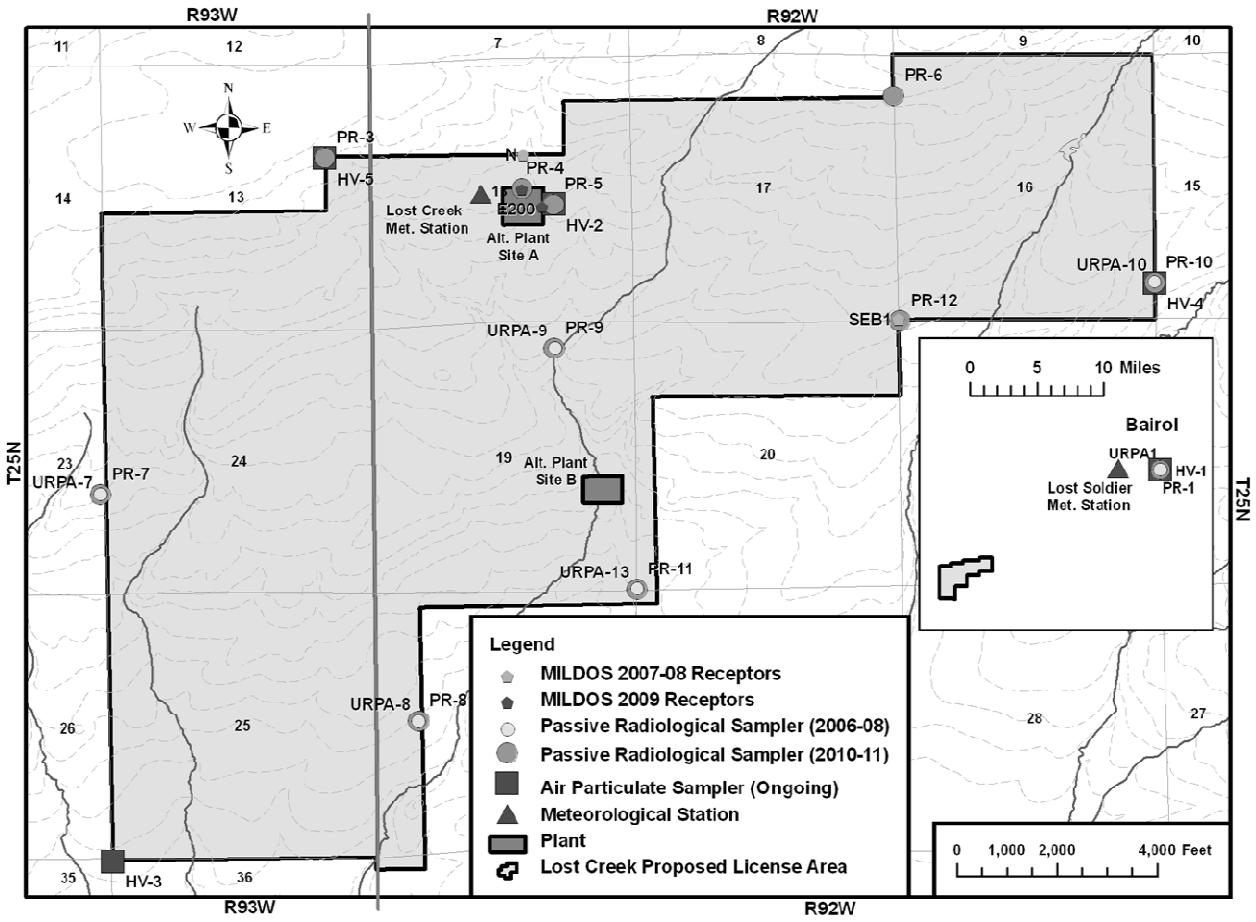
(Source: LCI, 2008c, Figure 2.7-19 of the technical report)

Figure 2.5-2: Pre-operational Well Locations in Lost Creek



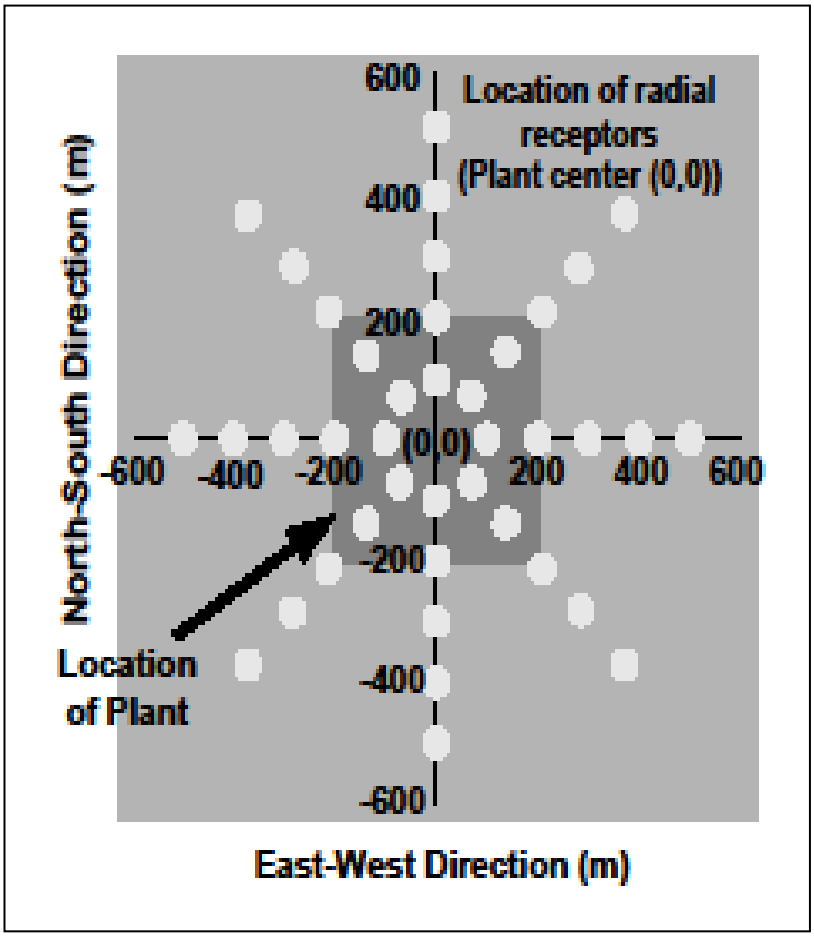
(LCI, 2010a) (Source: Adapted from Figure 2.9-26 of the technical report)

Figure 2.6-1: Radon, Passive Gamma (URPA #), and Air Particulate (HV-#) Locations



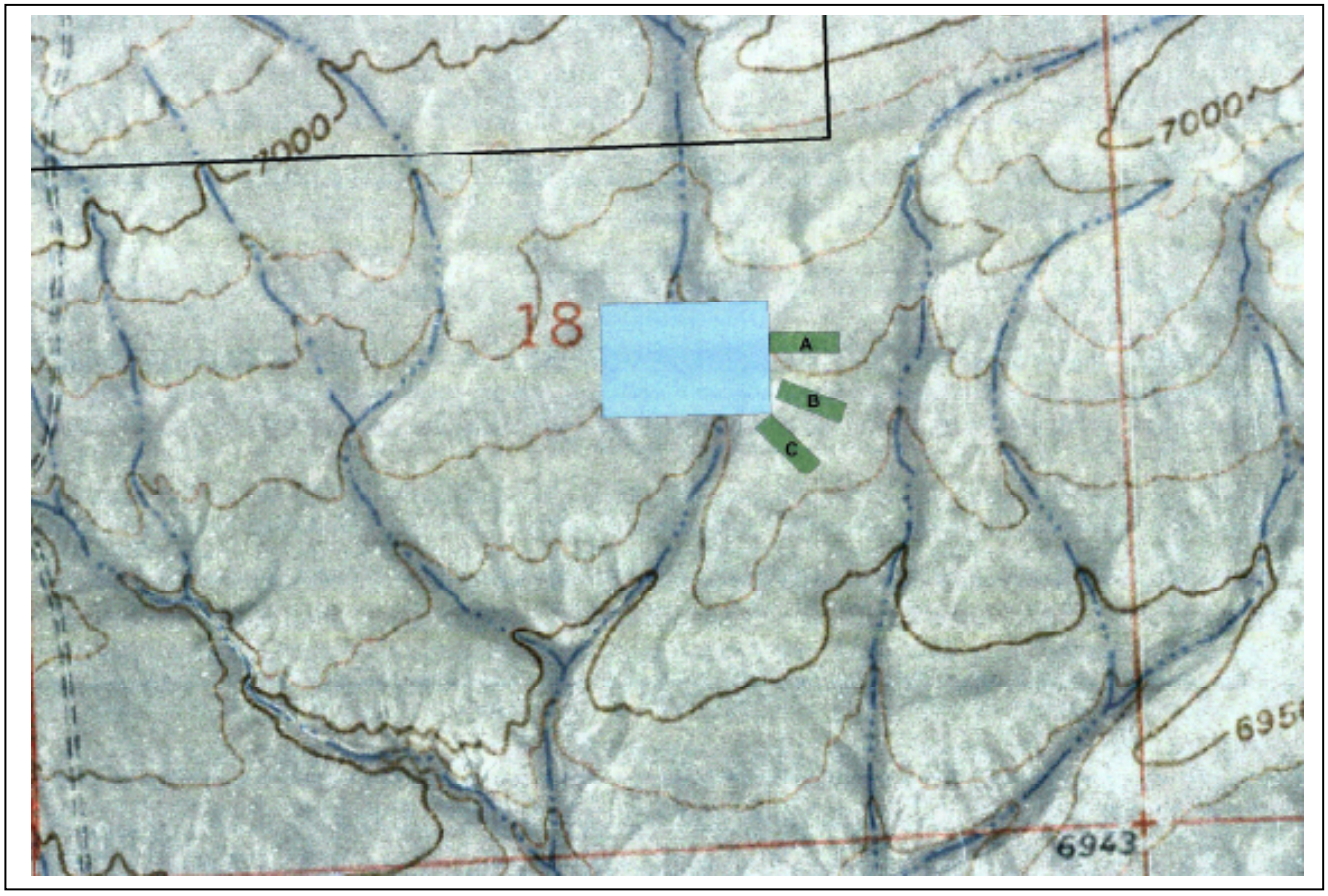
(LCI, 2010a) Source: Figure 2.9-27 of the technical report

Figure 2.6-2: Radon, Direct Radiation, and Air Particulate Sampling Locations



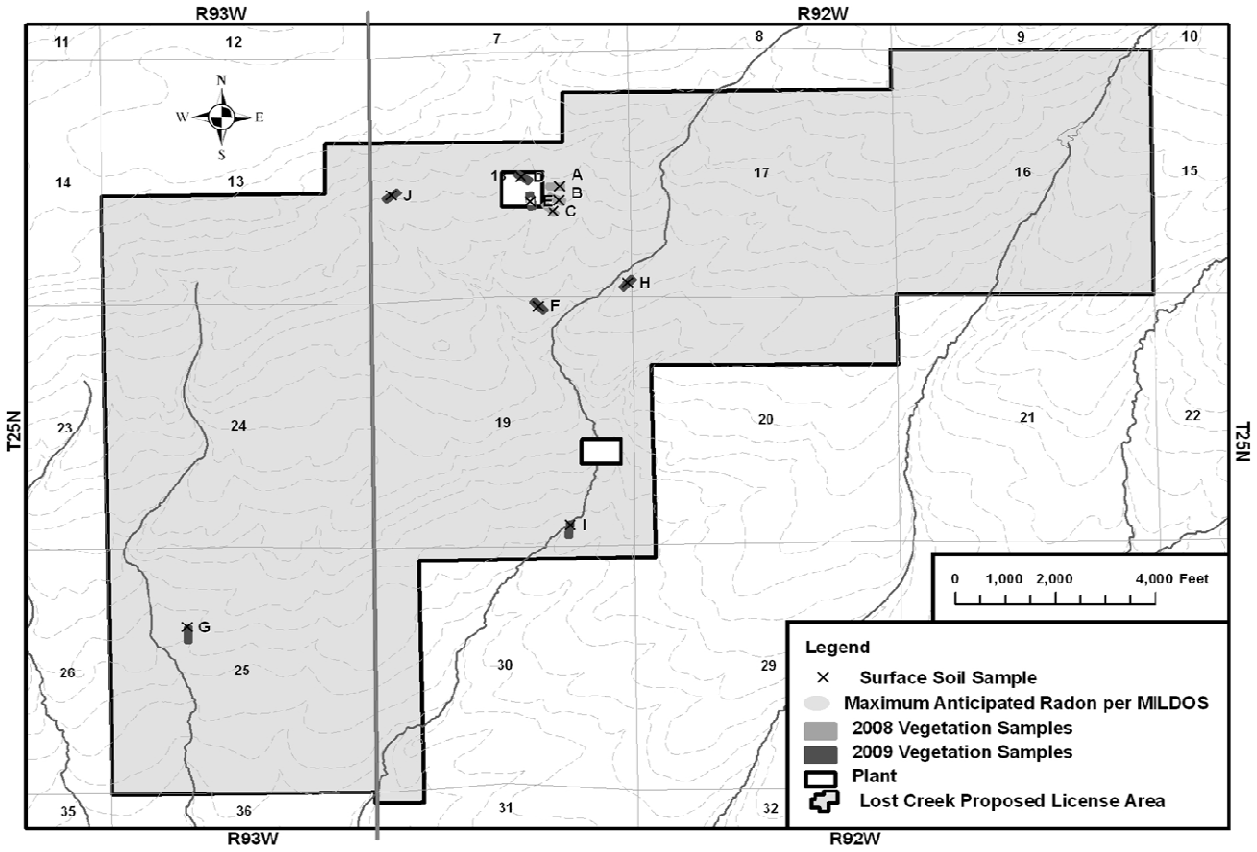
(LCI, 2010a) (Source: Adapted from Figure 2.9-17 of the technical report)

Figure 2.6-3: Location of Radial Receptors from Plant Center



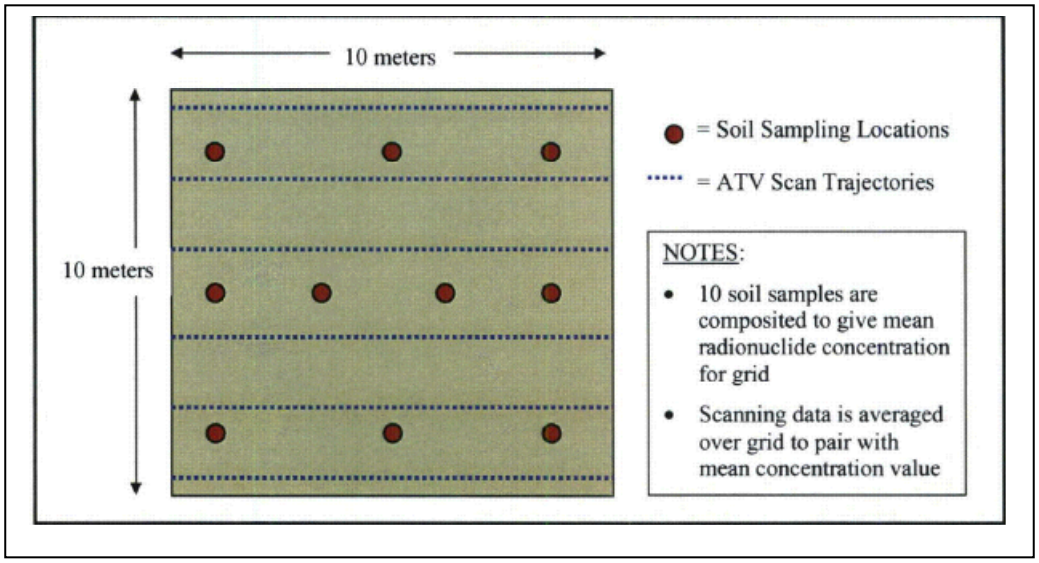
(LCI, 2010a) (Source: Figure Veg-1 in Attachment 2.9-6 of the technical report)

Figure 2.6-4: 2008 Vegetation Sampling Locations



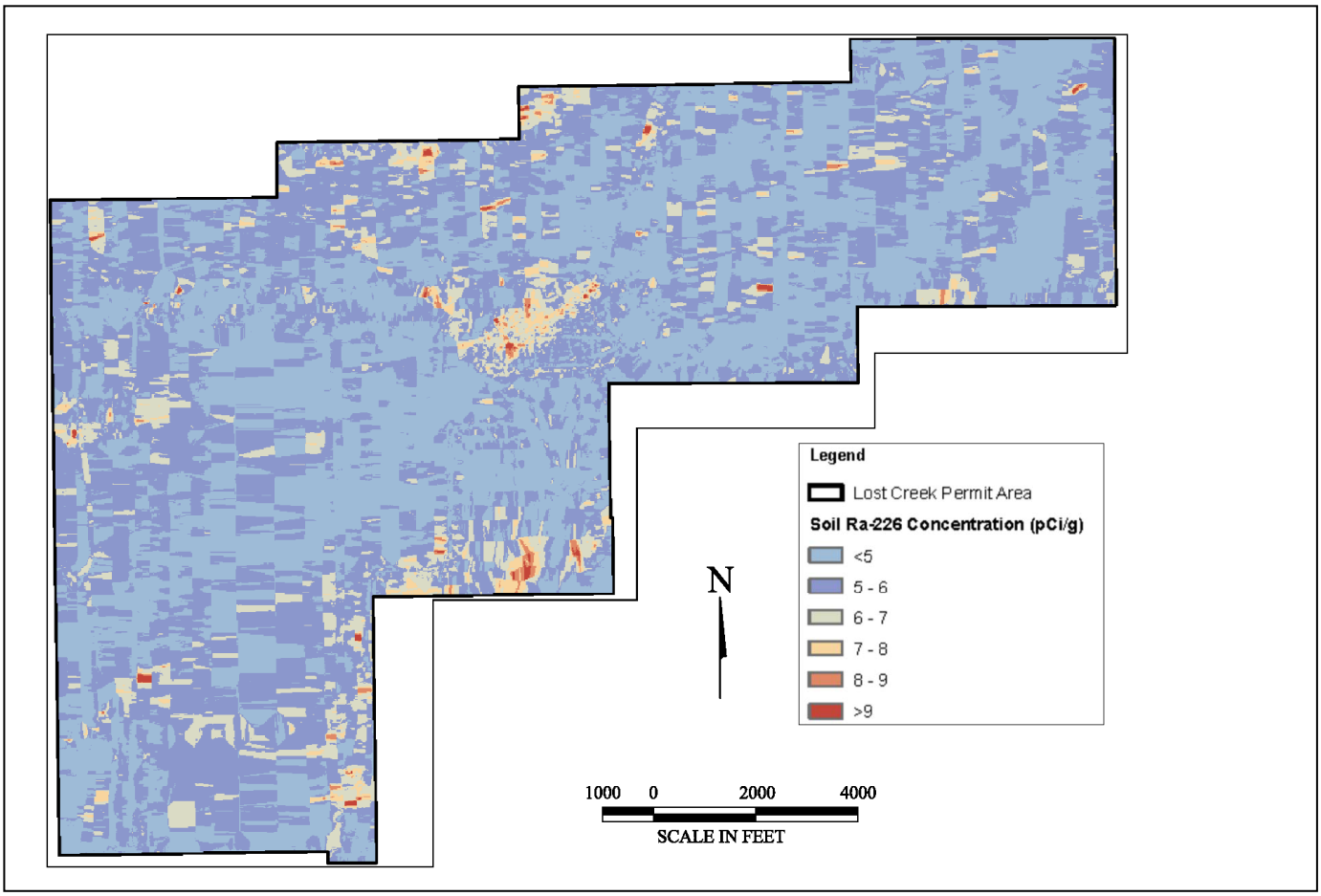
(LCI, 2010a) Source: Adapted from Figure 2.9-22 in the technical report

Figure 2.6-5: 2009 Vegetation and Soil Sampling Locations



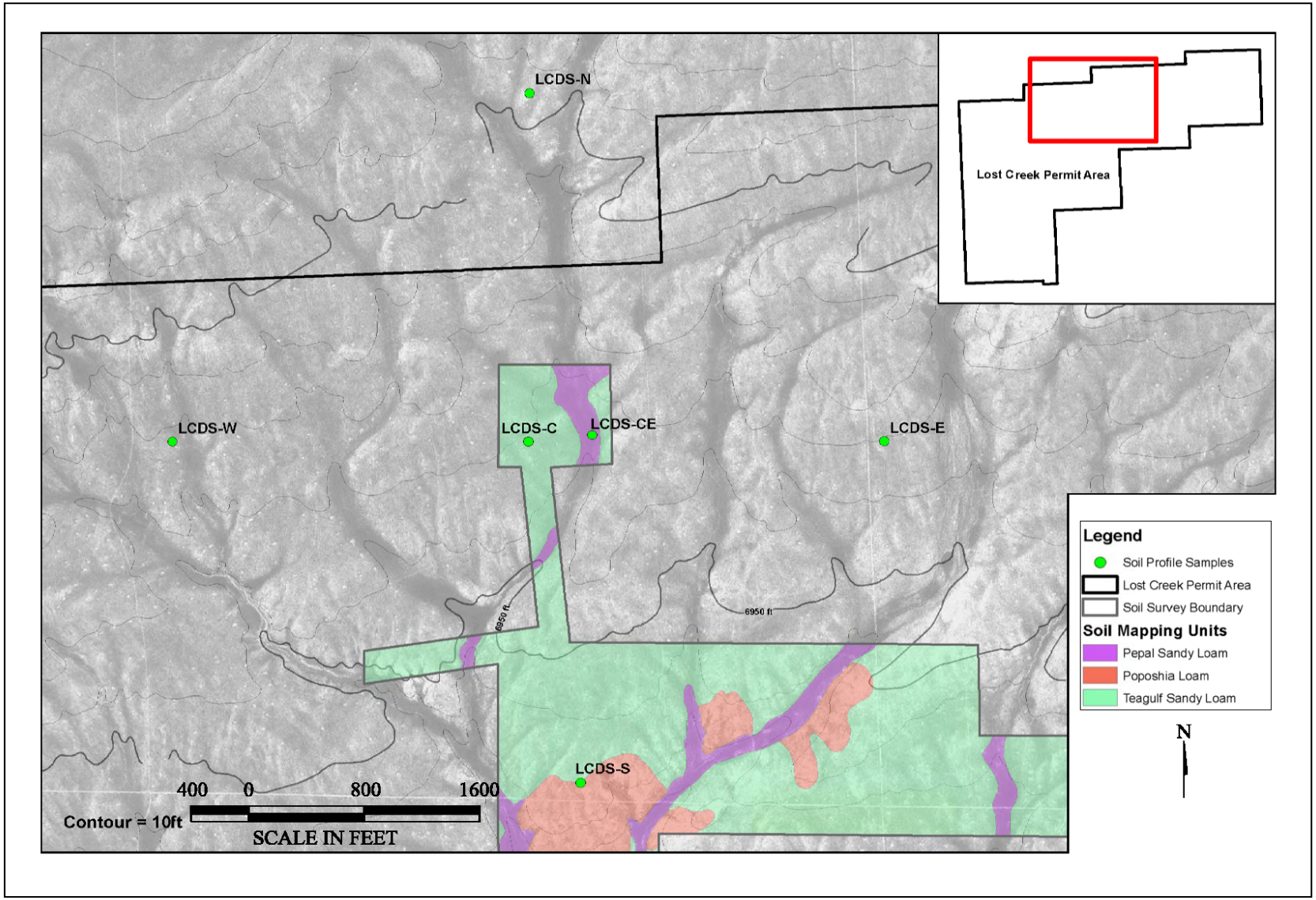
(LCI, 2008c, 2010a) (Source: Figure 2.9-2 of the technical report)

Figure 2.6-6: Correlation Grid Sampling Design



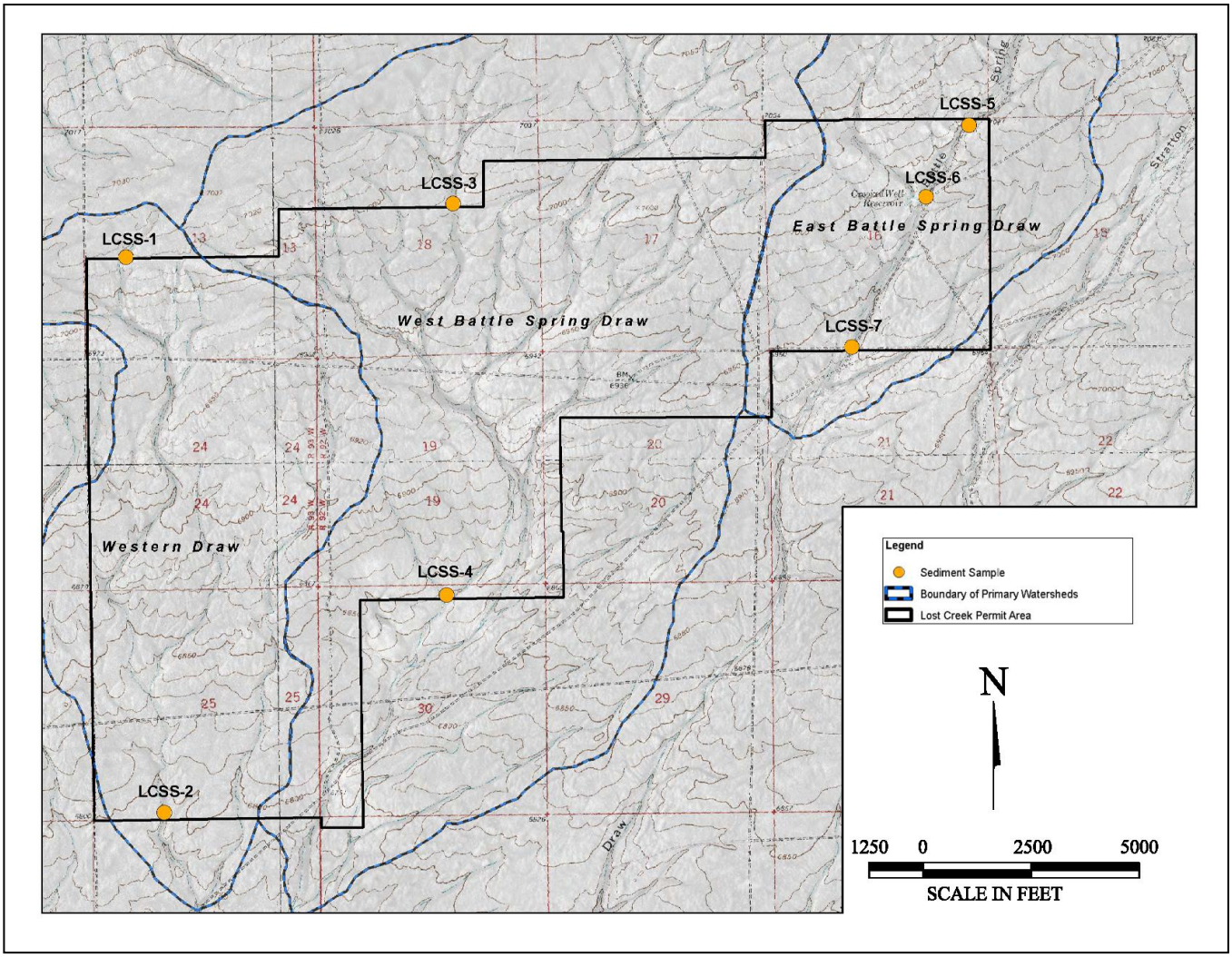
(LCI, 2008c, 2010a)(Source: Adapted from Figure 2.9-15 of the technical report)

Figure 2.6-7: Estimated Soil Ra-226 Concentrations



(LCI, 2008c, 2010a) **(Source: Figure 2.9-23 of the technical report)**

Figure 2.6-8: Soil Profile Sampling Locations



(LCI, 2008c, 2010a) **(Source: Adapted from Figure VSS-7 in Attachment 2.9-7 of the technical report)**

Figure 2.6-9: Sediment Sampling Locations

3.0 DESCRIPTION OF PROPOSED FACILITY

3.1 IN SITU RECOVERY (ISR) PROCESS AND EQUIPMENT

3.1.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) demonstrated that the equipment and processes used in the wellfields during operations at the Lost Creek Project meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.1.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using review procedures in Section 3.1.2 and acceptance criteria outlined in Section 3.1.3 of the Standard Review Plan (SRP) (NRC, 2003a).

3.1.3 STAFF REVIEW AND ANALYSIS

The following sections present the staff's review and analysis of various aspects of the ISR processes and equipment proposed for the Lost Creek Project. Review areas addressed in this section include wellfield infrastructure, operations in the HJ Horizon, and the proposed schedule for operations. In SER Section 3.1.3, unless otherwise stated, the information presented was from Section 3.1 of the application (LCI, 2008c, 2010a).

To evaluate the application of the ISR process at the Lost Creek license area, NRC staff first reviewed the ore body characteristics and mine unit infrastructure, examining such features as well installation and completion, mechanical integrity testing, mine unit piping, header house design, water balances, and wastewater disposal capacity. The staff then reviewed the ISR mine unit operations to ensure that the applicant will be able to conduct its in-situ recovery operations in a safe manner.

3.1.3.1 Ore Body

The applicant described the ISR process and equipment to be used at the proposed Lost Creek Project (LCI, 2008c, 2020a). SER Figure 3.1-1 illustrates the Lost Creek Project license area, which will contain six mine units and a processing plant. The license area covers 1,705 ha (4,220 acres [a]) and the surface area to be affected is about 115 ha (285 a). Ore deposits in the license area are found in long narrow trends, which are a few hundred to several thousand meters (feet) long and 15.2 to 76.2 m (50 to 250 ft) wide. Uranium will be extracted from three mineralized sands in the "HJ Horizon" at depths of 106.7 to 152.4 m (350 to 500 ft) below ground surface (bgs). Depending on the location, only one or all three sands may be present in the "HJ Horizon" (LCI, 2008c, 2010a). In Section 1.4 of the application, the applicant stated that the project contains 8.5 million tons of uranium ore at a grade of 0.058 percent (LCI, 2008c, 2010a).

NRC staff reviewed this information in the application and finds it consistent with the acceptance criterion (1) of SRP Section 3.1.3 because the provided information is sufficiently detailed. Moreover, the ore body characteristics (including grade (see SER Section 3.1.3), mineralogy and roll-front deposit type (see SER Section 2.3.3.3), and hydrogeologic setting (see SER

Section 2.4.3) are consistent with those properties at existing NRC-licensed ISR facilities where operations have
been conducted in a manner that is protective of public and worker health and safety and the environment.

3.1.3.2 Lost Creek License Area Mine Unit Infrastructure

The applicant stated that the license area is to be divided into six mine units where the injection and extraction wells would be installed. Each mine unit will consist of approximately 20.2 ha (50 a) and will be developed, produced, and restored as a unit. Each mine unit will be subdivided into operational areas defined by header house locations, with up to 10 header houses per unit. Each header house will have approximately 20 production wells and 40 injection wells (LCI, 2008c, 2010a).

The applicant stated that, after installation, all wells will undergo a mechanical integrity test (MIT). The applicant will also test wells every five years after they become in-service and after any workovers or suspected surface or subsurface damage. MIT will procedures begin with isolating the casing above the top of the production zone to ground surface using a down hole packer and wellhead cap. The applicant will then increase the pressure inside the casing to a specified pressure. The applicant specified that the pressures for the initial MIT might be up to 95 percent of the casing rating pressure but would never exceed 90 percent of the hydraulic fracture pressure. The applicant committed to using a pressure of 150 psi for the initial MIT. During subsequent tests, the pressures for a MIT are typically 125 percent of the maximum operational pressures for a specific header house. Integrity of a well will pass an MIT if 95 percent of the initial pressure is maintained for ten minutes. If the well fails this requirement, the applicant will repair and retest the well. If the applicant cannot repair the well, the applicant will plug and abandon the well. The applicant will document all MITs and maintain the records on site for NRC review (LCI, 2008c, 2010a).

NRC staff reviewed the applicant's data and finds the mechanical integrity testing procedures are consistent with acceptance criterion (2) of SRP Section 3.1.3 because these procedures reflect standard industry practices for in-situ recovery operations and have been accepted by NRC staff as protective safety measures for such operations. The staff will include the standard license condition for conducting MITs in the license (see LC 10.5 in Appendix A).

The applicant stated that mine unit piping will be constructed of high density polyethylene, PVC and/or stainless steel. Piping will have an operating pressure of 150 psig. The applicant will operate all equipment in the mine units at pressures less than or equal to the designed piping ratings. The applicant will bury individual well lines and trunk lines to prevent freezing (LCI, 2008c, 2010a). NRC staff reviewed the applicant's mine unit piping specifications and finds the information to be consistent with industry standard practices that the NRC has accepted as protective safety measures at existing facilities and, thus, are consistent with acceptance criterion (2) in SRP Section 3.1.3.

The applicant described the instrumentation, alarms, and control features of the mine units. Within each mine unit, injection and production will be automatically monitored and transmitted to the plant for review. The applicant stated that the header houses will have automated monitoring for oxygen pressures to identify abnormal operating conditions. Automated monitoring of pressure and flow rate also will be done on the main injection and recovery header lines at each header house. Pipelines will have automated pressure monitoring at pump discharges, header house entrances and the inlet and outlet of booster stations. Individual

injection wells will have the flow rate automatically monitored. Header house sumps will have automated monitoring of sump levels and the operating status of sump pumps (LCI, 2008c, 2010a).

NRC staff reviewed information regarding the mine unit instrumentation, alarms, and control features. The staff finds this information acceptable because it is consistent with the features used safely at existing NRC-licensed facilities for several years and because it is clearly described and, thus, is consistent with acceptance criterion (4) in SRP Section 3.1.3 .

The applicant stated the control system will have several alarms that will notify the Wellfield Operator of an upset condition in the wellfield or header houses. Pipelines will have high and low set points and, if pressures are exceeded, an alarm will be activated. In the header house, high and low set points will be in place for pressure and flow rate of the main production header and main injection header. If either set point is exceeded, the operators will be notified by alarm. Injection and production wellheads will have fluid detection systems that will alarm in the presence of a leak. If water is detected in header house sumps, the sumps will be activated and the fluid pumped to the production header. Anytime this occurs, the operator will receive an alarm (LCI, 2008c, 2010a). NRC staff reviewed the applicant's descriptions of wellfield equipment practices and monitoring systems and finds that the described systems are acceptable for the safe operation of an ISR facility because they are similar to those used by existing NRC-licensed facilities that have operated safely.

The applicant described control features such as valves, pressure switches, and interlocks that LCI will use on the oxygen system, production systems, injection systems, and header house sumps. These control systems will either shutdown the system automatically or allow operators to shutdown operations manually in portions of the mine unit as necessary (LCI, 2010a). NRC staff reviewed the schematic drawings of the pipe layout for a typical header house and found the descriptions of the instrumentation, alarms, and control systems in the mine units adequate because these features are consistent with those that have operated safely at existing NRC-licensed facilities. Therefore, the applicant met acceptance criterion (9) in SRP Section 3.1.3 .

The applicant described the mine unit and header house physical inspection program to ensure timely detection of leaks. It stated that operators will be responsible for taking measurements and looking for leaks in header house. They will also check wellheads for fluids or salts from evaporation. They will also be required to drive the pipeline locations and check valve stations for fluids or salts. The applicant indicated that the first line of defense for timely detection of a leak is the daily presence of operators in the field. Part of the operator's responsibility is to check for leaks (LCI, 2008c, 2010a). The applicant did not commit to a regular program for documenting field surveys or commit to a regular schedule for conducting field surveys. Documenting daily inspections is the current practice at ISR facilities and is a best practice for identifying potential problems. Therefore, the staff included a license condition to ensure that a routine program is performed. SER Section 3.1.4 discusses this license condition.

The applicant provided a water balance in Figure 3.2-6 of the application (LCI, 2008c). In that figure, the applicant separated water balances for mine units in production from those for mine units in restoration. For production, the liquid effluent from the plant will be mainly the production bleed, and is shown to be 1.0 percent of 22712 Lpm (6000 gpm) or 227 Lpm (60 gpm). In the narrative, the applicant stated that the maximum bleed will be 1.5 percent of the total production flow of 22712 Lpm (6000 gpm) or 341 Lpm (90 gpm). For restoration, the water balance showed the liquid waste would be 492 Lpm (130 gpm) of concentrated brine and 363 Lpm (96 gpm) permeate from the reverse osmosis. The applicant indicated that the

concentrated brine liquid waste (492 Lpm [130 gpm]) would be sent to the lined storage ponds and then to the deep disposal wells. The applicant showed the permeate liquid waste (363 Lpm [96 gpm]) would be sent to the one pond only (LCI, 2008c, 2010a). NRC staff reviewed the water balance provided by the applicant and finds it to be acceptable because the information provided is consistent with the operation plans and design of the plant described in the application, and similar to water balances reported for existing ISR facilities. Therefore, the applicant's aforementioned discussions are consistent with acceptance criterion (5)(c) in SRP Section 3.1.3 because the proposed plant material balances and flow rates are acceptably described, as the mass balance inputs and calculations have been independently verified by staff.

The applicant stated that two to five deep injection wells would be installed for liquid waste disposal (LCI, 2008c, 2010a); each well will have a capacity for injecting 378 Lpm (100 gpm). The applicant received Wyoming Permit 09-586 on May 28, 2010, to construct and operate five Class I disposal wells (WDEQ, 2010). NRC staff notes that if only two wells are installed and a failure occurs in one disposal well, one well might not be sufficient to handle the concentrated brine during restoration (492 Lpm [130 gpm]). If the disposal capacity is lost, the applicant will utilize on-site storage facilities for a short-term solution. However, the applicant committed to ceasing unnecessary operations if the disposal and/or storage capacity is exceeded (LCI, 2008e). The applicant stated that it has not planned any alternatives to the deep well injection for liquid waste disposal at this time (LCI, 2008c, 2010a). Staff reviewed the applicant's plan and commitment to maintain adequate liquid waste disposal capacity and finds that the applicant's information on liquid waste disposal is adequate because the proposed and WYDEQ-permitted waste disposal capacity is sufficient for safe ISR operations, including liquid byproduct waste generated during wellfield restorations. Therefore, the applicant's proposed facilities are consistent with acceptance criteria (5) and (6) in SRP Section 3.1.3 and the applicant has shown that these facilities' operations will be conducted safely with an adequate capacity to properly dispose of liquid byproduct waste for the following reasons:

- An adequate liquid byproduct waste disposal capacity assures that the downhole injection pressures avoid exceeding failure and formation fracture pressures as well as avoiding hydrofracturing the aquifer which would promote leakage to the overlying aquifer;
- An adequate liquid byproduct waste disposal capacity assures that the overall production rates are higher than injection rates;
- An adequate liquid byproduct waste disposal capacity assures that the applicant can maintain control of lixiviant migration from the production area during operations and restoration; and
- An adequate liquid byproduct waste disposal capacity assures that the proposed operation plan and schedules can be met.

3.1.3.3 Schedule

The applicant presented a general production, restoration and decommissioning schedule for its proposed ISR operations in Figure 3.1-3 of the application (LCI, 2010a). This schedule indicates that production at the first mine unit will begin immediately after construction of the processing plant, production in the other mine units will start sequentially thereafter, and production for a specific mine unit will last almost two years. Restoration will begin immediately after production, and will consist of one year of groundwater sweep, followed by approximately

one year of reverse osmosis and finally a short period of recirculation. Restoration stability monitoring will begin immediately following completion of the active restoration activities (e.g., groundwater treatment, groundwater recirculation), and will last for less than a year; the applicant committed to four quarterly sampling for stability monitoring (LCI, 2008c, 2010a). Decommissioning will commence in a mine unit at the end of restoration (LCI, 2008c, 2010a). The applicant noted that these are proposed timelines that will be updated as necessary. NRC staff reviewed the proposed restoration schedule and stability monitoring program and finds the proposed schedule is consistent with acceptance criterion (6) of SRP Section 3.1.3 provided that the applicant updates the schedule as needed in order to comply with the requirements of 10 CFR 40.42.

3.1.4 EVALUATION FINDINGS

The staff reviewed the ISR process and equipment proposed for use at the Lost Creek Project in accordance with review procedures in Section 3.1.2 and acceptance criteria in SRP Section 3.1.3. The applicant described the mine unit infrastructure, equipment and ISR operations for the Lost Creek Project. Based on these descriptions, the staff finds the applicant has satisfactorily documented the ore body characteristics that are consistent with ore bodies that are undergoing safe operations at existing NRC-licensed ISR facilities. The staff finds that applicant provided commitments to protect against unwanted vertical and horizontal migration of fluids, including materials used in construction of the infrastructure and routine monitoring in the surface and subsurface. The staff finds that the applicant's proposed ISR processes will meet the following safety criteria:

- overall production rates are higher than injection rates to create and maintain a cone of depression;
- plant material balances and flow rates are appropriate;
- reasonable estimates of gaseous, liquid, and solid wastes and effluents are provided (used in evaluation of effluent monitoring and control measures in SRP Section 4.0).

Based on the staff's review of the applicant's components with respect to safety risk and current industry practice at existing NRC-licensed ISR facilities, the staff concludes that the applicant provided an acceptable description of the instrumentation and monitoring that will prevent and correct spills and/or excursion, as well as provided acceptable operating plans, schedules, and timetables for mine unit operation, surface reclamation, and groundwater restoration. Requirements for several aspects of the operations (in particular, lixiviant makeup, limitations on throughput capacity, ground water monitoring and spill reporting), will be enumerated in standard license conditions to be included in the license (see LC 10.1 in Appendix A for lixiviant makeup, LC10.2 for facility throughput and LC's 11.1 through 11.6 for monitoring and reporting requirements).

The applicant has committed not to excessively drawdown the aquifer within the wellfield in order to maintain an adequate water column in the event that additional drawdown is needed for excursion corrective actions. This commitment will be required under a standard license condition for safe operation of the facility, which is described in Appendix A of this SER (see LC 10.7 in Appendix A).

The applicant has not committed to documenting results of daily inspections for leaks during routine field surveys/activities. Therefore, the staff will include the following license condition to ensure daily inspections are conducted:

Wellfield Inspections. Injection manifold pressures and flow rates shall be measured and recorded daily by the on-line computer system and/or Wellfield Operator. During wellfield operations, injection pressures shall not exceed the specified maximum operating pressure as specified in Section 3.2.6 of the approved license application. To the extent possible, the daily inspections should visually inspect and document leaks or other abnormalities in the wellfield piping, wellheads, or header houses in accordance with Section 3.2.7.5 of the approved license application. The licensee shall conduct the weekly in-plant inspection and audit programs described in Section 5.3 of the approved license application. In addition, as described in Sections 5.7.1 and 5.7.6 of the approved license application and supplements, the RSO, HPT(s), or designee shall document that radiation control practices are being implemented appropriately.

In addition, staff will include a standard license condition stating the applicant's commitment to MIT procedures as proposed in the application (see LC 10.5 in Appendix A).

Based upon the review conducted by the staff as indicated in this section, the information provided in the application as supplemented by the information to be collected and activities to be conducted in accordance with the noted license conditions, meet the applicable acceptance criteria of SRP Section 3.1.3 and the requirements of 10 CFR 40.32(c) and10 CFR 40.41(c). Staff finds that the proposed ISR operations are consistent with those currently being used at existing NRC-licensed facilities and are NRC-accepted practices. Based on commitments in the application and the license conditions identified above, NRC staff concludes that the applicant will be able to operate the ISR process in a manner that is safe for workers' and the public health and safety and the environment.

3.1.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2008e. "Letter to NRC, Regarding Response to NRC Request for Additional Information (RAI), Dated November 6, 2008 Technical Report for the Lost Creek Project, Great Basin, Wyoming Docket No. 40-9068 TAC No. LU0142," December 12, 2008, ADAMS Accession No. ML090080451.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

LCI, 2010b. "Letter to NRC, Lost Creek Project, Clarifications to TR Docket No. 40-9068 TAC No. LU0142," May 14, 2010, ADAMS Accession No. ML101600528.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

WDEQ, 2010. "Underground Injection Control Class I Injection Well Permit Number 09-586, issued by the State of Wyoming Department of Environmental Quality Water Quality Division to Lost Creek ISR, LLC, UIC Facility Number WYS-037-00122," Water Quality Division, May 28, 2010, ADAMS Accession No. ML100190468.

3.2 PROCESSING PLANT, WELLFIELDS, AND CHEMICAL STORAGE FACILITIES

3.2.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the equipment and processes used during operation in the processing plant and other facilities at the Lost Creek Project meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.2.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in Section 3.2.3 of the Standard Review Plan (SRP) (NRC, 2003a).

3.2.3 STAFF REVIEW AND ANALYSIS

This section discusses the physical descriptions and operating characteristics of the major equipment that the applicant will use during processing. These descriptions pertain to the processing plant, wellfields, chemicals that the applicant will use on-site, and the potential hazards associated with these chemicals. Information in SER Section 3.2.3, unless otherwise stated, is from Section 3.2 of the technical report (LCI, 2008c, 2010a).

3.2.3.1 Processing Plant

The applicant (LCI, 2008c, 2010a) stated that the processing plant will be housed in a building approximately 79.2 m long by 48.8 m wide (260 ft long by 160 ft wide). The plant will include the following major processing circuits: ion exchange (IX), elution, and precipitation/filtration. Equipment located in the plant will include IX and elution vessels, precipitation tanks, filter presses, storage tanks, and the associated piping, pumps, and valves required to be able to move the solutions throughout the plant. The applicant has provided a drawing showing the layout of the major components within the plant in Figure 5.7-1 in the application (LCI, 2008c, 2010a) (see SER Figure 5.7-1). The final product at the plant will be yellowcake slurry, which the applicant will transport to an NRC licensed facility for processing into yellowcake. The staff notes that the applicant (LCI, 2010c) plans to install a yellowcake dryer at the facility in the future; the NRC staff will review the safety aspects of adding a yellowcake dryer as part of a separate licensing action upon receipt of an amendment request from the applicant.

The staff's review of aspects of the facility affecting radon exposure can be found in SER Sections 4.1.3.1.1 and 4.1.3.1.2. The applicant (LCI, 2008c, 2010a) will use building ventilation in the process equipment area that will consist of an exhaust system that draws in fresh air and sweeps the plant air output to the atmosphere. The applicant plans to install general building ventilation capable of providing approximately six air changes per hour. The applicant plans to use tank ventilation systems for the IX tanks, wastewater tanks, elution tank, and permeate

tank. The applicant plans to use specific ventilation systems for the resin shaker screens, elution columns, restoration columns, and the transfer bay. Additionally, the deep disposal well houses will have a ventilation system. The applicant has identified the planned location, sizing and normal operating condition (i.e., always on, on/off as needed, etc.) for the ventilation systems.

By describing the major components of the plant in sufficient detail and providing drawings showing the location and layout of the proposed ISR facilities, the applicant (LCI, 2008c, 2010a) has addressed SRP Section 3.2.3 acceptance criterion (1) (NRC, 2003a). Additionally, the staff observes that the processing plant design and proposed equipment are similar to those used in the ISR industry. For these reasons, these aspects of the proposed facility are acceptable to the NRC.

3.2.3.2 Controls

The applicant described monitoring and alarm systems in Section 3.2.7.5 of the technical report (LCI, 2008c, 2010a). LCI will install instrumentation in the plant and in the wellfields to monitor and control various aspects of the ISR operation. Monitoring in the processing building will include parameters such as flow, pressure, temperature, pH, as well as other indicators to verify proper operation of the facility. In the event that LCI finds a parameter to be outside of the expected operating range, the applicant will use an alarm will to notify the operator to correct the condition. Monitoring in wellfields will include the following: flow rate, liquid pressure, and oxygen pressure in the header houses; injection pressure and flow rate; and liquid levels in the header house sumps. The applicant will use audio or visible alarms to notify an operator of an unplanned condition.

The staff observes that the controls and monitoring features planned for the processing plant and wellfields are similar to those in use in the ISR industry. The staff concludes that the applicant has proposed monitoring parameters that are important to operation of the facility. Because the information in the application describes the controls and monitoring features that will be used at the facility to protect radiological health and safety, the application is consistent with SRP Section 3.2.3 (NRC, 2003a). LCI described plans for eliminating or mitigating the hazards in accordance with SRP Section 3.2.3 acceptance criteria (5) and (7). For these reasons, these aspects of the proposed facility are acceptable to the NRC.

3.2.3.3 Chemical Storage Facilities

The applicant stated in Section 3.3.1 of the application that sodium carbonate, sodium bicarbonate, carbon dioxide, hydrochloric acid, sulfuric acid, and hydrogen peroxide will be used at the facility (LCI, 2008c, 2010a). The applicant performed a risk assessment to evaluate the impacts that the presence of process chemicals could have on radiological safety, which was discussed in Sections 3.3, 7.4, and 7.6 of the application (LCI, 2008c, 2010a). This risk assessment examined chemical compatibility issues between process chemicals and possible tank or pipe materials. Results of the risk assessment will be used to guide the applicant in the selection of proper materials for piping and storage tanks of the process chemicals. Results will also be used to develop operational procedures to minimize the potential for chemical interactions that could impact radiological safety. The staff observes that the risk assessment considers chemicals that are likely to be used at the facility and compatibility issues between the chemicals and the materials used for constructing tanks or pipes at the facility. The staff finds the applicant followed guidance in NUREG/CR-6733, “A Baseline Risk-Informed Performance-

Based Approach for *In-Situ* Leach Uranium Extraction Licensees," (Mackin, et al., 2001) and therefore agrees with this risk assessment.

The applicant has identified the type and maximum quantity of the chemicals that it plans to store and use on-site. Chemicals identified include: hydrogen peroxide, hydrochloric acid, sodium chloride, sodium peroxide, soda ash, and bicarbonate. The applicant plans to store all of the chemicals identified in the previous sentence, with the exception of hydrochloric acid, in the plant area. Hydrochloric acid will be stored outside of the plant in a secure area. The applicant has also identified the operating temperature, pressure, and flow rates planned for these chemicals. The applicant will follow applicable Occupational Safety and Health Administration (OSHA) and Wyoming regulations when handling the chemicals (LCI, 2008c, 2010a). The applicant's identification of applicable Federal and State regulations to ensure proper handling of hazardous chemicals is consistent with SRP Section 3.2.3 acceptance criterion (6) (NRC, 2003a). Additionally, the applicant has described the chemicals that will be used on site; the storage methods, and the potential impacts on radiological health and safety. The staff reviewed the chemicals, storage methods, and potential impacts on radiological health and safety and finds the applicant's proposal is consistent with the SRP Section 3.2.3 acceptance criterion (5) (NRC, 2003a). Therefore, the staff finds this information acceptable.

In its application, the applicant indicated that it plans to accept uranium rich IX resins from other ISR satellite facilities operated by the applicant or other producers. In Section 5.8.1.1 of the application, the applicant stated that the likely frequency of resin shipments would be 1 per day and that the shipments would be from facilities located within 161 km (100 mi) of the Lost Creek Project (LCI, 2008c, 2010a). The staff notes that resin shipments processed at the Lost Creek Project would count towards the overall production limit for the facility. Additionally, the staff observes that liquid effluents generated during the processing of resins would be handled in the same manner as other liquid byproduct materials generated at the facility; this is further discussed in SER Section 4.2. The Lost Creek plant was designed to receive resins from other ISR facilities. The applicant has committed to complying with the applicable Department of Transportation and NRC shipping regulations in Section 5.6.3 of the technical report. The staff notes that the ability to accept and process uranium rich IX resins is a common industry practice. As processing of externally generated resins would be performed within the overall production limit, the staff observes that there would be no increase in dose at the Lost Creek Project from this activity beyond what has been analyzed in this SER. For these reasons, the applicant's approach is acceptable to the staff.

3.2.4 EVALUATION FINDINGS

The staff reviewed the proposed equipment to be used and materials to be processed in the recovery plant and chemical storage facilities at the Lost Creek Project in accordance with the review procedures and the acceptance criteria in SRP Section 3.2.2 and Section 3.2.3, respectively. The applicant described the equipment, facilities, and procedures that will be used to protect health and minimize danger to life or property.

Based upon the review conducted by the staff as indicated in SER Section 3.2, the information provided in the application meets the acceptance criteria of SRP Section 3.2.3 as well as the requirements of 10 CFR 40.32(c) and 10 CFR 40.41(c).

3.2.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

LCI, 2010c. "Letter to NRC, Lost Creek Project, Clarifications to TR Docket No. 40-9068 TAC No. LU0142," January 6, 2010, ADAMS Accession No. ML100130206.

Mackin, P.C., D. Daruwalla, J. Winterle, M. Smith, and D.A. Pickett, 2001. "A Baseline Risk-Informed Performance-Based Approach for In-Situ Leach Uranium Extraction Licensees," NUREG/CR–6733, September 2001.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

3.3 INSTRUMENTATION AND CONTROL

3.3.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the instrumentation and control proposed for the Lost Creek Project meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.3.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in Section 3.3.3 of the Standard Review Plan (SRP) (NRC, 2003a).

3.3.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 3.3.3, unless otherwise stated, is from Section 3.3 of the technical report (LCI, 2008c, 2010a). LCI describes the instrumentation that will be used in the trunk lines, header houses, wellfields, and processing plant at the facility. Trunk line instrumentation will allow for measurement of pressures and flow rates. Within the plant, instrumentation will be provided to measure flow rates, pressures, and liquid levels. Main production lines will typically have automated valves to provide the ability to bypass the plant and recirculate the liquids to the wellfield if a problem, such as a power failure, arises. Liquid levels within the tanks will be continuously monitored. The monitoring network will include a series of high and low set points to identify the presence of a problem; if a condition outside of the set points is detected, an alarm will activate (LCI, 2008c, 2010a). Staff reviewed the proposed monitoring network and notes that the applicant proposes to monitor parameters that can provide information on how the plant is operating. The staff concludes that monitoring of these parameters, combined with alarm set points will provide the operators with the ability to recognize and address problems that might arise. The NRC staff concludes that the applicant has identified instrumentation, monitoring parameters, and backup systems that are consistent with staff observations of practices at operating ISR facilities. By providing this information, the applicant has addressed

the SRP Section 3.3.3 acceptance criteria (NRC, 2003a). Therefore, this approach is acceptable to the staff.

Instrumentation within the header houses will be installed in a manner that allows for balancing of flow rates, injection pressures, shutdown in case of a piping failure, automatic oxygen shutoff, and leak detection. In addition to the plant's capability to detect problems and shut down processes, the plant will have three emergency stops. One will be located in the chemical storage area, one will be located near the main entrance to the facility, and one will be located near the rear entrance to the facility. Plant personnel in the event of an emergency will use the emergency stops to shut down pumps and valves until the problem is resolved. In the event of a total power failure, the applicant designed the header houses to include solenoid valves, which automatically shut the necessary valves (LCI, 2008c, 2010a). The staff finds that this approach is consistent with generally accepted industry practices. By providing information on instrumentation, backup systems, and injection pressures, the applicant has demonstrated consistency with the SRP Section 3.3.3 acceptance criteria (1), (3), and (4) (NRC, 2003a). Therefore, this approach is acceptable to the staff.

In the wellfields and header houses, LCI will conduct checks of operating pressures and for the presence of leaks. This will include monitoring pressure for the injection wells on a daily basis. The staff notes that injection pressures need to be maintained within an allowable range to prevent vertical excursions. Monitoring injection pressures to verify that the reading is within the allowable range will minimize the potential for vertical excursions. The wellfield operators will also perform visual inspections of trunk line rights of way to check for leaks (LCI, 2008c, 2010a). The staff concludes that this approach is consistent with the general industry practices. By describing the method in which the applicant will check operating pressures of injection wells, the applicant has demonstrated consistency with SRP Section 3.3.3 acceptance criterion (4) (NRC, 2003a). Therefore, this approach is acceptable to the staff.

The applicant plans to construct a system of transfer and injection pumps to convey liquid byproduct material from the processing plant to the deep disposal wells. Monitored parameters for the deep disposal wells include operating pressure and flow rate. The deep disposal pump system will have interlocks to prevent the transfer pump from operating independently of the injection pump.

The staff observes that the applicant has described the instrumentation and control aspects of the facility that will be used to monitor the in situ recovery process. The staff notes that the applicant proposed features of the design and operation that are consistent with general industry practices. By providing information on instrumentation and backup systems, the applicant's information is consistent with SRP Section 3.3.3 acceptance criterion (3). Therefore, these aspects of the facility are acceptable to NRC staff.

3.3.4 Evaluation Findings

The NRC staff has completed its review of the instrumentation and control techniques proposed for use at the Lost Creek Project. This review included an evaluation using the review procedures in SRP Section 3.3.2 and the acceptance criteria in SRP Section 3.3.3. The instrumentation and control systems have been acceptably described for components, including the wellfields, wellfield houses, trunk lines, plant, and deep disposal wells. As discussed in SER Section 3.3.3, the instrumentation will allow for continuous monitoring and control of systems, including flow rates for total inflow to the plant, total waste flow exiting the plant, and liquid levels. Appropriate alarms and interlocks are part of the instrumentation systems. Each control

system is equipped with an acceptable alternative that allows for shut down of the system in the event of an emergency or power failure.

Based on the information provided in the application and the staff's detailed review of the instrumentation and control for the Lost Creek Project, the staff concludes that the proposed instrumentation is acceptable and is in compliance with 10 CFR 40.32(c) and 10 CFR 40.41(c).

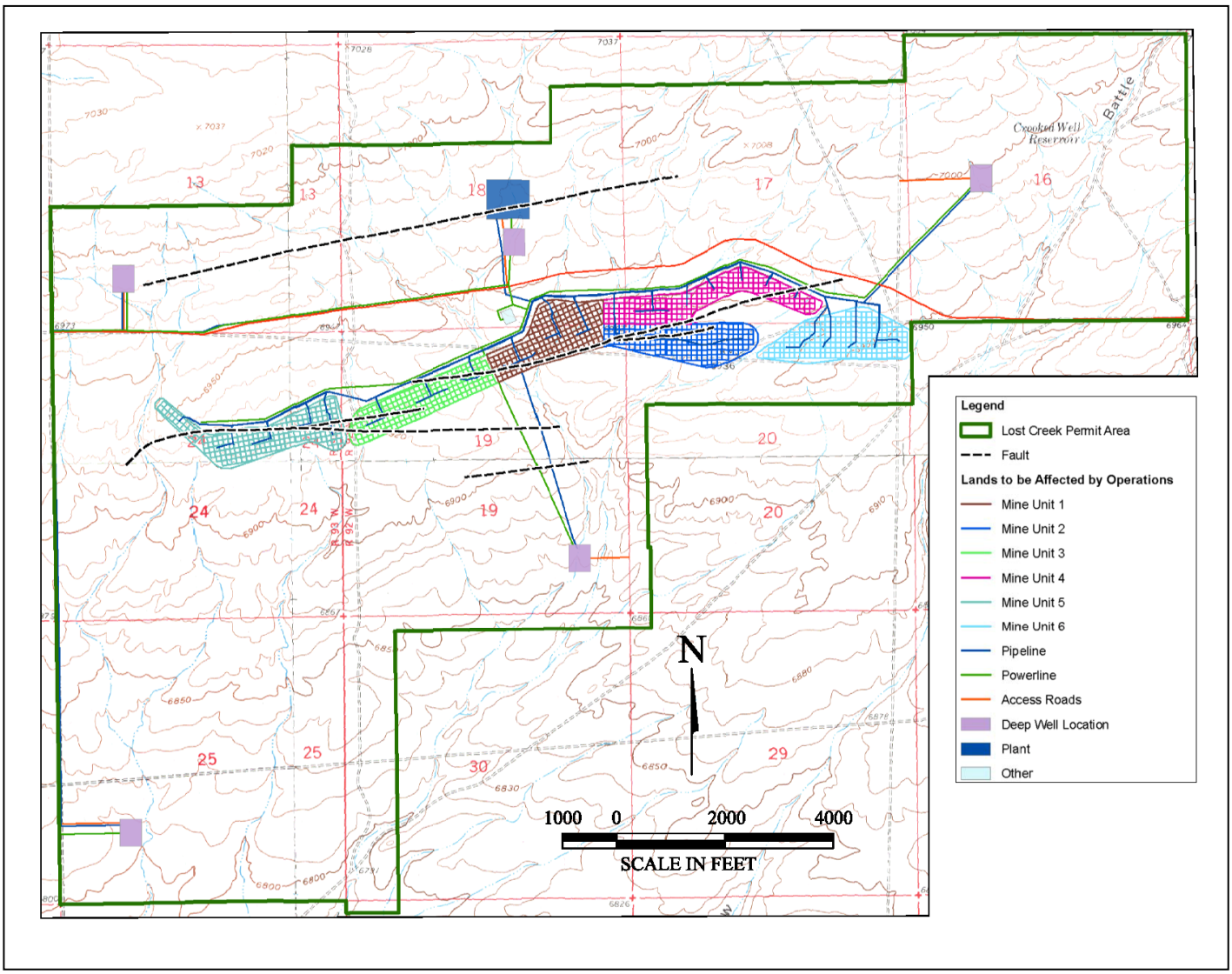
3.3.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.



(LCI, 2010a) Source: Adapted from application Figure 3.1-2)

Figure 3.1-1: Lost Creek license area mine units and central processing plant

4.0 EFFLUENT CONTROL SYSTEMS

4.1 GASEOUS AND AIRBORNE PARTICULATES

This section discusses the basic design and operation of the gaseous and airborne particulates effluent control systems for ISR facilities. Effluent control systems serve to (a) prevent and minimize the spread of gaseous and airborne particulate contamination to the atmosphere using emission controls, and (b) ensure compliance for radiation dose limits to the public.

4.1.1 REGULATORY REQUIREMENTS

For gaseous and airborne particulates generated at the Lost Creek Project, the staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated compliance with 10 CFR Part 40, Appendix A, Criterion 8, which requires milling operations to be conducted so that all airborne effluent releases are reduced to levels as low as reasonably achievable (ALARA). The applicant must also demonstrate that gaseous and airborne particulates comply with other relevant sections of 10 CFR Part 20 and 10 CFR Part 40.

4.1.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements in 10 CFR Parts 20 and 40 using the acceptance criteria in Standard Review Plan (SRP) Sections 4.1.3 and 5.7.1.3 (NRC, 2003a) that apply to effluent controls. Effluent monitoring is addressed in SER Section 5.7.8, Effluent and Environmental Monitoring.

4.1.3 STAFF REVIEW AND ANALYSIS

The following sections present the staff's review and analysis of various aspects of the gaseous and airborne particulates that the applicant will generate at the Lost Creek Project, as well as the equipment and systems that the applicant proposed to use to control the release of these radioactive materials to the atmosphere. Review areas addressed in this section include identification of (a) major discharge release points; (b) ventilation, filtration, and confinement systems to be used to control the release of radioactive materials to the atmosphere; and (c) airborne radioactive effluents.

4.1.3.1 General

The applicant stated in Section 4.1.2 of the technical report (LCI, 2008c, 2010a) that the expected radioactive materials released during normal operations will be principally radon-222, and that it expects only minor, incidental releases of uranium during normal operations. In addition, the applicant stated that uranium released during accident situations would be low due to the lack of a yellowcake dryer and a yellowcake thickener. The staff agrees with the applicant's assessment because (a) the proposed uranium recovery operations described in the technical report (LCI, 2008c, 2010a) do not identify on-site capability for drying the yellowcake slurry produced at the proposed facility; and because (b) NUREG/CR-6733 (Mackin et al., 2001) states that radioactive particulate releases are expected to be associated with yellowcake drying and packaging operations. NRC staff notes that a dryer is not the only source of radioactive airborne particulates. Radon-222, a radioactive gas with a 3.8-day half-life, decays to several solid particles that tend to be electrically charged and can deposit on surfaces or attach to dust particles (Mohamed et al., 2008). Radon progeny can build-up in buildings, such as the header houses, if the ventilation is not adequate to ensure complete air exchange. NUREG/CR-6733

also states that spills of radioactive liquids can be a source of air particulates and pose an inhalation hazard if the spills dry before they are cleaned.

According to the applicant (LCI, 2010c), yellowcake slurry from the applicant's facilities will be dried and packaged at an NRC- or Agreement-State-licensed facility until the applicant installs its own dryer. To install and use a dryer at the Lost Creek Project, the applicant would need to submit a license amendment application to the NRC (LCI, 2010c). Only upon a determination by the NRC staff that the applicant has met the relevant regulatory requirements for license amendment issuance, would the NRC staff issue an amendment authorizing installation and use of a dryer (see § 40.44).

4.1.3.1.1 Ventilation Systems

The applicant provided information in Section 5.7.1, Effluent Control Techniques, of the technical report (LCI, 2010a) that described the modes of ventilation to control radon effluents in the plant, header houses, and wellfields. The staff concludes that the applicant's description of the ventilation system is consistent with acceptance criterion (3) in SRP Section 4.1.3 and acceptance criterion (1) in SRP Section 5.7.1.3 (NRC, 2003a) by providing sufficient detail describing the ventilation systems intended to control radon effluents and by following Section 3.3 of Regulatory Guide 8.31, as described below. The applicant provided the following details in its technical report (LCI, 2008c, 2010a):

- Plant
    - Passive ventilation or natural ventilation includes doors and overhead doors to reduce radon levels;
    - General area ventilation or wall and area fans to provide an adequate exchange of air in the plant where radon is likely to gather; and
    - Point source ventilation from tanks and process equipments or direct ventilation to the roof or outside of the plant using a stack and, in some cases fans, to increase ventilation flow rate.
- Header Houses
    - Area ventilation consists of a wall fan drawing from the basement of the header house and exhausting out of the rear wall of the header house. This fan is designed to operate 24 hours a day, year round; and
    - Passive ventilation includes opening doors that allows cross-ventilation with fans (active mode) to reduce radon levels.

The applicant stated that wellfields would rely on passive or natural ventilation to control radon effluents at the wellheads (LCI, 2008c, 2010a). The staff finds that the description of the natural and engineered ventilation systems provided by the applicant, and discussed in more detail in SER Sections 4.1.3.2 and 4.1.3.3, is consistent with the guidance for ventilation and exhaust fans in Section 3.3 of Regulatory Guide 8.31 (NRC, 2002b) because the description follows the Regulatory Guide's recommendations for limiting airborne concentrations in buildings. The staff also finds that the applicant located discharge stacks away from building ventilation intakes, as recommended in Regulatory Guide 8.31 (NRC, 2002b), to minimize exposures in accordance with 10 CFR 20.1101(b).

4.1.3.1.2 Control Systems for Airborne Effluents

The applicant described the operating capacity, air exchange rates, and specifications of the ventilation systems in Section 4.1.2.2 of the application (LCI, 2008c, 2010a). Designs of the planned heating, ventilation, and air conditioning systems (HVAC) and their locations were in Attachment 4.1-1 to the application. The applicant stated that all of the utility fans will typically vent through a tank filled with fresh water to remove particulates and moisture so that only air (i.e. gas) is vented from the building. The Radiation Safety Officer (RSO) will monitor air quality within the plant to determine if the emission controls are operating sufficiently to maintain ALARA (LCI, 2010a). The staff finds the applicant's proposed effluent control systems is consistent with acceptance criteria (2) of SRP Section 4.1.3 and (4) of SRP Section 5.7.1.3 by describing (a) the airborne effluent control systems that are appropriate for the types of effluents generated and (b) performance specifications for the operation of the effluent controls that are consistent with those in Regulatory Guide 3.56, Section 1 (NRC, 1986a).

4.1.3.2 Airborne Uranium

The applicant stated in Section 4.1.2.1 of the technical report (LCI, 2008c, 2010a) that minimal uranium releases are expected during normal operations because the applicant's facility, as currently proposed, will not have a yellowcake dryer and its storage ponds will be kept wet. In Section 4.2.5.6 of the application, the applicant committed to cleaning up spills as soon as practicable and to restricting access to the impacted area to minimize production of airborne particulates and exposure to an inhalation hazard (LCI, 2010a). The staff agrees with the applicant's assessment that there will be minimal uranium releases during operations because as stated in SER Section 4.1.3.1, the yellowcake slurry produced will be wet and transferred into trucks for transport to an NRC- or Agreement-State-licensed drying and packaging facility, and because the applicant proposes to use procedures, as recommended in NUREG/CR-6733 (Mackin, et al., 2001), to prevent airborne uranium generated from spills (LCI, 2010a).

The applicant considered several accident scenarios, but stated that the failure of a yellowcake thickener tank, as described in NUREG/CR-6733, is an accident that would be the most representative of a potentially large source of particulates produced from a failure of yellowcake slurry tanks (LCI, 2010a). A thickener removes much of the water from yellowcake slurry before the yellowcake goes into the dryer to remove the remaining water. The applicant stated that the NUREG/CR-6733 analyses of the yellowcake thickener bound the accidental releases caused by failure of its slurry storage tanks and the consequential radiation doses to a member of the public closer than 100 m (328 ft) from the accidental release (Mackin, et al., 2001). The applicant stated that the nearest plant boundary is 333 m (1092.5 ft). Furthermore, the applicant stated that the containment volume in the bermed area of the processing plant is adequate to capture or contain any yellowcake slurry released from its two slurry storage tanks and to prevent its release outside the production facility (LCI, 2010a).

The staff finds the applicant's assessment to be reasonable. The staff finds that the applicant's design of the ventilation system and controls should be sufficient to maintain airborne concentrations of natural uranium and its daughters in the workplace to less than 25% of the Derived Air Concentration (DAC) given in Table 1 of Appendix B to 10 CFR Part 20, as recommended in Regulatory Guide 8.31 (NRC, 2002b). Further, staff agrees with the applicant's estimation that the exposure of a member of the public to uranium in concentrations above the dose limits established in 10 CFR 20.1301 is not likely because (a) the distance of the facility from the public and (b) the engineering and administrative controls proposed will limit

the public's exposure. The staff finds that the applicant describes (a) emergency procedures in the event of equipment failures or spills, (b) the health and safety impacts of system failures, and (c) contingencies for such occurrences, thereby meeting acceptance criteria (6) in SRP Section 5.7.1.3 and (4) in SPR Section 4.1.3 (NRC, 2003a).

4.1.3.3 Radon

According to the applicant in Sections 4.1.2.2 and 5.7.1.1 of the technical report (LCI, 2008c, 2010a), radon will be released directly to the atmosphere at injection and production wells, and radon-222 in the closed production systems will be directed outside the facility by ventilation systems during subsequent yellowcake processing steps. The applicant expects there to be occupational exposures to radon released during ion exchange (IX) resins transfers and processing and from production bleed fluids. The applicant maintains that the general area ventilation systems will exhaust radon-222 released inside to outside the building to minimize occupational exposures (LCI, 2010a).

The applicant stated in Section 4.1.2.2 of the technical report (LCI, 2008c, 2010a) that potential radon exposures to workers will be reduced and eliminated using (a) general area ventilation that directs radon outside the buildings using high-volume exhaust fans and (b) personal protective equipment (PPE). Additionally, the applicant stated that exposures will be reduced by limiting exposure durations with standard operating procedures and an Radiation Work Permit (RWP) in the case of unanticipated release. According to the applicant, general area ventilation exhaust fans are expected to provide six air changes per hour. The applicant stated that redundant general ventilation exhaust fans are provided and that the exhaust fans will continue to operate on emergency power from a backup generator in the event of a power loss (LCI, 2008c, 2010a).

The applicant stated in Section 4.1.2 of the technical report (LCI, 2008c, 2010a) that it will use an Alpha Nuclear PRISM radon progeny continuous working level (CWL) monitor as a warning device to alert workers to increasing radon progeny levels in the plant. According to the applicant in Section 5.7.3.2 of the technical report, it will not replace routine operational radon progeny monitoring with CWL monitors. Radiation monitoring or surveys, described in Section 5.7.3.2 of the technical report, will be used to determine workers' radiation doses from radon-222 progeny. The applicant stated that it plans to perform checks according to the CWL monitor manufacturer's instructions and that the manufacturer will conduct annual calibrations of the CWL monitor (LCI, 2008c, 2010a).

The staff finds that the applicant's design of the ventilation system and controls should be sufficient to maintain airborne concentrations of radon and its progeny in the workplace to less than 25% of the Derived Air Concentration (DAC) given in Table 1 of Appendix B to 10 CFR Part 20, as recommended in Regulatory Guide 8.31 (NRC, 2002b). According to the regulatory guide, the 25% figure is used (a) to encourage the use of ventilation systems and controls in an effort to prevent the existence of airborne radioactivity areas, as defined in 10 CFR 20.1003, and (b) to comply with § 20.1701, which requires "the use, to the extent practical, process or other engineering controls (e.g., containment or ventilation) to control the concentration of radioactive material in air." The staff finds that the applicant described operational monitoring and control systems for radon in the buildings consistent with acceptance criteria (1) and (2) of SRP Section 4.1.3 and (1) of SRP Section 5.7.1.3. The proposed systems are, thus, acceptable to the staff.

4.1.4 EVALUATION FINDINGS

The staff reviewed the proposed effluent control systems for gaseous and airborne releases of radioactive materials for the Lost Creek Project in accordance with Sections 4.1.3 and 5.7.1.3 of the SRP (NRC, 2003a). The applicant described the release points and sources of both uranium and radon at the Lost Creek Project. The applicant provided, in Sections 4.1.1 and 7.2 of the technical report (LCI, 2008c, 2010a), information on the radiological impact from normal and accidental releases, and stated that it will provide worker training and spill control procedures to deal with these accidental situations. The applicant has committed to meeting 10 CFR Part 20 occupational dose limits and public dose limits and to maintaining these doses ALARA.

Based upon the review conducted by the staff as indicated above, the information provided in the application and supplements is consistent with the acceptance criteria in SRP Sections 4.1.3 and 5.7.1.3, and meets the requirements of 10 CFR Parts 20 and 40.

4.1.5 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "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 ," U.S. Government Printing Office, Washington, DC.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

LCI, 2010c. "Letter to NRC, Lost Creek Project, Clarifications to TR Docket No. 40-9068 TAC No. LU0142," January 6, 2010, ADAMS Accession No. ML100130206.

Mackin, P.C., D. Daruwalla, J. Winterle, M. Smith, and D.A. Pickett, 2001. "A Baseline Risk-Informed Performance-Based Approach for In-Situ Leach Uranium Extraction Licensees," NUREG/CR–6733, September 2001.

Mohamed, A., A. A. Ahmed, A. E. Ali, and M. Yuness, 2008. "Attached and Unattached Activity Size Distribution of Short-Lived Radon Progeny (^{214}Pb) and Evaluation of Deposition Fraction," *Journal of Nuclear and Radiation Physics.* 3, no. 2: 101-08.

NRC, 1986a. "General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills," Regulatory Guide 3.56, Washington, DC, May 1986.

NRC, 2002b. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1, Washington, DC, May 2002.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

4.2 LIQUIDS AND SOLIDS

4.2.1 REGULATORY REQUIREMENTS

For liquid effluents generated at the Lost Creek Project, the staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated compliance with 10 CFR 20.1301, 20.2002, and 20.2007. For solid effluents generated at the Lost Creek Project, the staff determines if the applicant demonstrated compliance with 10 CFR Part 40 Appendix A, Criterion 2.

4.2.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in Section 4.2.3 of the Standard Review Plan (SRP) (NRC, 2003a). Additionally, the staff reviewed the application for compliance with the requirements of 10 CFR Part 20 using acceptance criteria 13 in Section 6.1.3 of the SRP.

4.2.3 STAFF REVIEW AND ANALYSIS

The following sections present the staff's review and analysis of various aspects of the liquid and solid effluents that will be generated at the Lost Creek Project. Information in SER Section 4.2.3, unless otherwise stated, is from Sections 4.2 and 4.3 of the technical report (LCI, 2008c, 2010a).

4.2.3.1 Liquids

LCI has described the types and quantities of liquid wastes that will be generated at the facility (LCI, 2008c, 2010a). Types of liquid wastes that will be generated include storm water runoff; native groundwater encountered during well development, sampling, and pump testing; waste petroleum products and chemicals; domestic sewage; production bleed; and brine generated from the reverse osmosis process. Production bleed, brine generated from the reverse osmosis process, and any other waste liquids generated during the uranium recovery process are considered liquid byproduct material. Storm water runoff, development water, waste petroleum products and chemicals, and domestic sewage are considered liquid non-byproduct material. The staff reviewed the type and quantities of liquid waste that will be generated by the applicant and notes that the list is consistent with the staff's experience at operating ISR facilities and is consistent with the acceptance criterion (13) of Section 6.1.3 of the SRP.

4.2.3.1.1 Liquid byproduct material

LCI identifies several types of liquid byproduct material that will be generated at the facility (LCI, 2008c, 2010a). These wastes include affected groundwater during aquifer restoration and liquid process wastes, such as production bleed, eluant bleed, and yellowcake wash water. The applicant will manage these wastes using a system of storage ponds and underground injection control (UIC) Class I wells, also referred to as deep disposal wells. The applicant has WDEQ-WQD approved permit (Number 09-586) for the construction and operation of five (5) UIC Class I deep disposal wells (WDEQ, 2010). LCI will use these wells to dispose of liquid byproduct material disposal. The applicant has indicated that LCI will monitor the deep disposal wells in accordance with the UIC permit and that an evaluation of well performance will be included in the annual report submitted to the NRC. The WDEQ issued the permit on May 28, 2010 for a 10-year period.

To issue the UIC permit, WDEQ verifies that the injected fluids are isolated from the accessible environment, including potential sources of drinking water. Use of deep disposal wells also requires an NRC finding that the applicant meet the requirements in 10 CFR 20.1301 and § 20.2002. As identified in 10 CFR 20.2002, an application seeking approval for a waste disposal method under this regulation shall include:

- A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk evaluation, and the proposed manner and conditions of waste disposal.
- An analysis and evaluation of pertinent information on the nature of the environment.
- The nature and location of other potentially affected licensed and unlicensed facilities.
- Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits of 10 CFR Part 20, including those in 10 CFR 20.1301.

The applicant provided the anticipated liquid byproduct material characteristics in Table 4.2-1 of the technical report (LCI, 2008c, 2010a). By providing details on the characteristics of liquid byproduct material, LCI has met acceptance criterion (13) in Section 6.1.3 (NRC, 2003a). Therefore, the staff finds this table to be acceptable.

Deep disposal wells will serve as the only disposal method for the liquid byproduct wastes generated at the facility (LCI, 2008c, 2010a). The target formation depth for the deep disposal wells is the Fort Union formation, which is located between 1,920.2 and 2914.5 m (6,300 and 9,562 ft) below the ground surface. The applicant (LCI, 2008c, 2010a) has prepared a water balance that reflects the planned operating conditions for the processing plant. Based on a plant flow of 22,712 Lpm (6,000 gpm) and a two stage reverse osmosis process, the applicant anticipates that liquid byproduct material will be generated at a rate of approximately 492 Lpm (130 gpm). The staff observes that with an estimated deep disposal well injection rate of 378 Lpm (100 gpm), a minimum of two deep disposal wells will be required at the facility. If the actual injection capacity of an installed deep disposal well is less than 378 Lpm (100 gpm), the staff finds that LCI might need to install additional wells to achieve the desired injection capacity. The applicant has received a permit from WDEQ for up to 5 deep disposal wells at the facility, and this permit would allow for an estimated injection rate of 1890 Lpm (500 gpm). Because the applicant has a permitted disposal capacity of 1890 Lpm (500 gpm), which is greater than the anticipated liquid byproduct material generation rate of 492 Lpm (130 gpm), the staff determined that there will be ample permitted capacity in the event that a well becomes inoperable.

The staff notes that Class I wells are used to inject wastes into deep, isolated aquifers (40 CFR Parts 147 and 268). Typically, deep disposal wells are constructed with several layers of materials that provide redundant layers of protection to minimize the possibility of liquids contaminating protected aquifers. Operators are required by WDEQ regulation to demonstrate that no significant leaks exist prior to operation through an MIT and every five years thereafter for the life of operation of the well (WDEQ, 1993). Additionally, WDEQ regulations require operators to monitor several parameters, such as injection pressure and flow rate, which would indicate potential failure of a deep injection well. This pressure and flow rate data, which are required by the State's regulations, will be summarized in reports that are available for NRC review during inspections of the facility.

The staff performed a dose analysis for the direct radiation pathway for the applicant's deep well disposal method using MicroShield® version 5.05 (Grove Engineering Company) (see SER Appendix B). The staff estimated that ten curies of radium-226 would be disposed of based on the expected operating period, disposal rate, and characteristics of the liquid byproduct material. NRC staff calculated the dose rate based on a conservative value of 100 Curies of radium-226 and 100 Curies of bismuth-214 (ingrowth from radium-226) injected to a subsurface level of 1,829 m (6,000 ft) with a soil density of 1.76 grams per cubic centimeter (g/cm^3) (110 pounds per cubic foot [lb/ft^3]) (Lindeburg, 2003). The calculated dose rate at a receptor point 0.9 meters (3 feet) directly above the deep well injection point to be 7.2×10^{-25} mR/Hr. The staff notes that this calculated dose rate is extremely small and cannot be measured by conventional radiation measuring devices used today. It is likely that this calculated dose rate could not be differentiated from natural background exposure levels. Integrating this dose rate over a one year period would result in an annual dose that would be below the dose limits in 10 CFR Part 20. The staff notes that the uranium inventory was not included in this dose analyses because natural uranium by itself is not a significant gamma dose contributor and the uranium inventory value would not significantly alter the final calculated dose rate for the direct radiation pathway.

For its deep well disposal plans, the applicant has shown that it would be in compliance with the NRC regulations for the alternate disposal of byproduct material in 10 CFR 20.2002, as well as the dose limits in 10 CFR 20.1301. By providing information on the methods that will be used to control liquid effluents and obtaining a permit from WDEQ for Class I deep disposal wells, the staff finds that the applicant has described liquid waste effluents and disposal methods in accordance with acceptance criteria (1), (2), (7), and (8) in SRP Section 4.2.3 (NRC, 2003a). Therefore, LCI's plans are acceptable to the NRC staff.

The applicant plans to construct two storage ponds to serve as buffer storage capacity in the event that the deep disposal wells need to be shut down for maintenance. Each pond would have the following characteristics:

- dimensions of 155 ft by 260 ft (approximately 3884 m^2 (0.95 acres [a]));
- double geosynthetic liner with a leak detection layer;
- perimeter sumps connected to the leak detection layer to allow personnel to check for the presence of liquids in the leak detection layer;
- a maximum liquid depth of 6-ft; with 3-ft of freeboard between the top of the water surface and the inside crest of the embankment slope; and
- a series of monitoring wells.

The staff's review included an assessment of: (a) information related to the site of the storage ponds, including the soil conditions; (b) design and construction details of the storage ponds; and (c) closure and decommissioning of the storage ponds.

4.2.3.1.1.1 Storage Pond Site Characterization

The applicant (LCI, 2008c, 2010a) completed a subsurface investigation to support the construction of the storage ponds, which included a series of four borings drilled to between 10.7 and 13.7 m (35 and 45 ft) below the existing ground surface. These borings were located near the four corners of the proposed location of the storage ponds and the applicant installed monitoring wells at three of these four borings. The applicant obtained soil samples from a variety of depths and had laboratory tests performed to identify the engineering properties of the soil. Geotechnical engineering properties determined from laboratory testing include gradation characteristics, liquid limit, plastic limit, plasticity index, moisture content, and water-soluble sulfate (LCI, 2008c, 2010a). Staff's review of the boring logs indicates that the subsurface soil properties are relatively consistent near the storage ponds.

The subsurface investigation for the storage ponds included installation of groundwater monitoring wells (MW-1, MW-3, and MW-4) in three borings; the applicant noted that a monitoring well (MW-2) was not installed because a shallow aquitard was not encountered (LCI, 2008c, 2010a). The wells were completed to a depth of approximately 7.6 m (25 ft) below the ground surface (MW-1 and MW-4) and 6.1 m (20 ft) below grade (MW-3). The applicant stated (LCI, 2008c, 2010a) that no water was encountered during drilling to a depth of 10.7 m (35 feet). The uppermost aquifer is typically encountered at approximately 61 m (200 ft) below the ground surface near the storage ponds.

Section 5.3.2.3 of the application (LCI, 2008c, 2010a) stated that the uppermost aquifer is isolated from the storage ponds by shallow aquitards, which would impede the infiltration of fluids should a leak develop in the liner system. Based on its review of the available data, specifically the boring logs, the staff observed the presence of a low permeability layer between the uppermost aquifer and the surface. Therefore, the staff agrees with the applicant that the uppermost aquifer is isolated from the storage ponds and is unlikely to be affected should the liner system leak. The applicant proposed (LCI, 2008c, 2010a) installing four monitoring wells that will be completed immediately above the "shallowest aquitard down-gradient of the storage ponds," and proposed having quarterly monitoring of water levels in those wells during the life of the facility. If the water levels increase, which suggest that a leak might have occurred, the applicant proposes to attempt to collect a water sample from the wells. If that water chemistry is similar to that in the ponds, then the applicant proposes an investigation to determine if the ponds were leaking. The applicant did not obtain a sample of the uppermost aquifer in the immediate vicinity of the ponds (LCI, 2008c, 2010a).

Staff agrees with the applicant's approach to monitor "perched" water table conditions for a timely detection of a leak. However, based on the reported sieve analyses, the applicant has demonstrated only that two of the three monitoring wells (MW-1 and MW-4) are screened at an appropriate depth. The applicant did not provide adequate evidence that MW-3 was completed to an appropriate depth, and the applicant failed to install the fourth well (MW-2) that was proposed in the application. Without having four monitoring wells surrounding the storage ponds, LCI does not have a proper detection monitoring program as required by 10 CFR 40, Appendix A, Criterion 7A. Therefore, the staff will include a condition in the license issued to LCI. This condition will require the applicant to install wells MW-2 and MW-3 in the southwestern and southeastern portion of the storage pond area prior to operations. The

presence of four monitoring wells around the ponds will provide sufficient coverage and will ensure timely detection of a release above the shallowest aquitard given the potentially complex unsaturated flow direction. SER Section 4.2.4 contains the text of this license condition.

The staff reviewed the proposed monitoring frequency of the monitoring wells near the storage ponds, which serves as a backup to the leak detection system. If a release were to occur without being observed in the leak detection system, the staff notes that the accumulation and migration of the release to the environment would not be instantaneous, but would take some time to reach the monitoring wells. The staff observes that a quarterly monitoring frequency for the monitoring wells is sufficient for a timely detection of a release. The staff notes that timely detection of a release can aid remediation efforts. Therefore, the staff will include a condition in the license issued to the applicant. This condition will require the applicant to monitor all four wells on a quarterly basis. Based on the environmental conditions near the storage ponds, the staff finds that quarterly monitoring is an appropriate frequency to detect leaks from the ponds. SER Section 4.2.4 presents this license condition.

The staff finds that soil properties were determined at various depths from borings near the storage ponds. Additionally, the staff notes that laboratory testing techniques were performed in accordance with appropriate American Society for Testing and Materials (ASTM) standards. Because LCI collected samples from various locations near the storage ponds and determined engineering properties using ASTM standards, the staff finds that the applicant has adequately characterized the subsurface conditions at the planned site of the storage ponds, with the exception of groundwater conditions discussed above. Therefore, the staff has determined that the applicant's characterization of the storage pond site is sufficient to support engineering assessments related to performance of the storage pond embankment.

4.2.3.1.1.2 Storage Pond Design

The applicant has presented the engineering and construction aspects of the storage pond design (LCI, 2008c, 2010a). The proposed storage pond capacity is approximately 2.8 million liters (750,000 gallons each), for a total of approximately 5.7 million liters (1.5 million gallons). Ponds will be approximately 79.2 by 47.2 meters (260 by 155 feet) and will have a maximum embankment height of approximately 2.1 meters (7 feet). A double geosynthetic liner with a leak detection system will be installed under each pond. The remainder of this section addresses specific storage pond design components (LCI, 2008c, 2010a).

Slope Stability

LCI presented both a static and pseudo static stability analysis for the critical pond cross section (LCI, 2008c, 2010a). At the critical cross-section, the embankment reaches its maximum height of 2.1 m (7 ft). The staff reviewed the material properties, critical cross-section geometry, and loading cases for the slope stability analysis, and finds that they are representative of the site conditions. This analysis was performed using a widely available computer program STABR v. 2.84 (MS-DOS) (Duncan & Wong, 1984) and the Modified Bishop Method, which is a generally accepted analysis method. Results of the analyses indicated that the minimum factor of safety for the analyses exceeds the 1.5 and 1.0 minimum values for static and pseudo-static analyses used in standard practice. The staff concludes that LCI has demonstrated that the storage ponds will be stable under anticipated loading conditions. By demonstrating the stability of the storage ponds, the staff finds the applicant has shown that this approach is consistent with acceptance criterion (4) in SRP Section 4.2.3, which states that the design of surface impoundments used in the management of byproduct material meets or exceeds the

requirements in 10 CFR Part 40, Appendix A, Criterion 5A; and with Regulatory Guide 3.11, Section 2 (NRC, 2008), which outlines acceptable methods for slope stability and settlement analyses. In particular, the staff finds the applicant has not presumed that the liner system will function without leakage in its demonstration of the structural integrity, as required by Criterion 5A(5) of Appendix A to 10 CFR Part 40; and the static stability analysis follows the recommendations in Section 2.1.1.2 of Regulatory Guide 3.11. Therefore, the staff finds the approach acceptable.

Settlement

The applicant's grading plan for the storage ponds calls for a maximum cut of up to approximately 2.4 m (8 ft) below the existing ground surface (LCI, 2008c, 2010a). The applicant identified that soil excavated from the bottom of the storage pond will be used to form the perimeter embankment. The staff observes that when holding liquids, the storage ponds will increase the stresses within the foundation soils, which could result in settlement. The applicant identified that the foundation soils of the storage pond have a bearing capacity that is significantly higher than the anticipated ground pressures from the storage ponds when full of liquid. Therefore, LCI does not anticipate settlement of the storage ponds (LCI, 2008c, 2010a). Soil properties and loading conditions are representative of the site conditions, and the applicant evaluated potential settlement of the storage ponds. The staff reviewed LCI's evaluation of settlement of the storage ponds. The staff observes that applicant's evaluation considered the loading conditions near the storage ponds and was based on the soil conditions identified during the site characterization. For these reasons, LCI's approach meets acceptance criterion (4) in SRP Section 4.2.3 (NRC, 2003a) and is consistent with the settlement analyses guidance in Section 2 of Regulatory Guide 3.11. Therefore, the applicant's methods are acceptable to the NRC staff.

Liquefaction Potential

The applicant addressed liquefaction potential in the storage pond design (LCI, 2008c, 2010a). LCI's subsurface investigation showed that the soils in the area of the storage ponds have a fines content ranging from 25 to 30 percent. Standard penetration tests (SPT) performed during drilling yielded high blow counts within 1.5 m (5 ft) of the existing ground surface. Additionally, soils encountered during drilling were found to be dry with water contents typically below 10 percent. These water contents indicate a degree of saturation that is less than the 80 to 85 percent generally considered necessary for liquefaction to occur (LCI, 2008c, 2010a). The staff reviewed this data on SPT blow counts and water content based on the guidance available in Regulatory Guide 3.11. The staff determined that soils with these characteristics are typically not susceptible to liquefaction; therefore, no further analysis is warranted. Because the applicant submitted information documenting that liquefaction is not a concern, the staff finds this aspect of the storage pond design meets the acceptance criterion (3) in SRP Section 4.2.3 (NRC, 2003a). Therefore, this approach is acceptable to NRC staff.

Freeboard

The applicant presented an evaluation for the potential overtopping of the storage ponds to determine the required freeboard (LCI, 2008c, 2010a). LCI identified that the storage ponds at the site will have a perimeter embankment and no spillway. LCI's grading plan for the storage ponds showed that surface water runoff will be diverted around the ponds (LCI, 2008c, 2010a). Based on LCI's design, the staff finds that the only water that will enter the storage ponds will be either process water, or precipitation that falls directly into the ponds. The staff reviewed the

grading plan and agrees that because the storage ponds have a perimeter embankment that is higher than the surrounding ground surface, runoff will not enter the storage ponds. Based on expected wind speeds at the facility, LCI expects the freeboard to prevent overtopping. For an 128 kph (80 mph) wind, the required freeboard to prevent overtopping was found to be 0.83 m (2.71 ft) (LCI, 2008c, 2010a). LCI has designed the ponds to have a freeboard of 0.91 m (3 ft), which is greater than the freeboard necessary to prevent overtopping. In Section 4.2.5.5 of the application, the applicant committed to developing standard operating procedures (SOPs) designed to minimize the possibility that the ponds could overflow. Development of SOPs will be required by a standard license condition (LC 10.4 in Appendix A) and are subject to review during inspections. The staff notes that SOPs provide detailed information on how to operate the facility and that as-built information might be needed to develop and complete SOPs. As discussed above, the storage ponds will have a freeboard of 0.91 m (3 ft), which is greater than the anticipated freeboard resulting from a 128 kph (80 mph) wind. Therefore, the staff finds that the applicant meets acceptance criterion (2) of SRP Section 4.2.3, and this aspect of the pond design is acceptable to the staff.

Liner and Leak Detection

The applicant has proposed using a double geomembrane liner system for the storage ponds. A leak detection system will be installed between the two liners. From top to bottom, the liner system components are as follows:

- 40 mm thick polypropylene geomembrane (primary liner);
- 10.2 cm (4-inch) diameter perforated pipe with sand cover in herringbone pattern (leak detection);
- 40-mm thick polypropylene geomembrane (secondary liner); and
- native soil

The staff finds that the proposed liner system components meet the regulations in 10 CFR Part 40, Appendix A, which requires that a synthetic liner have a leak detection system (LCI, 2008c, 2010a). The staff notes that the storage ponds have been designed to prevent migration of wastes to the subsurface, which is consistent with acceptance criteria (2) of Section 4.2.3 of the SRP. Typically, a leak detection system consists of a highly permeable layer beneath a low permeability liner system. The highly permeable layer is designed to convey liquids that escape the primary liner to a low point where liquids can easily be detected and collected. Perforated pipe and sand cover will likely be several orders of magnitude more permeable than the geomembrane liner. Therefore, in the applicant's design, the perforated pipe and sand cover serve as the leak detection system (LCI, 2008c, 2010a). The applicant has described the materials that will be used to construct the liner and leak detection systems. The applicant has also identified that welded seams will be used to connect the pieces of the polypropylene geomembrane (LCI, 2008c, 2010a).

The applicant has addressed chemical compatibility between the polypropylene liner and the liquids that will be stored in the ponds (LCI, 2008c, 2010a). The applicant provided information demonstrating that the nature of the liquid byproduct material is not expected to cause the storage pond polypropylene liner to decay. By providing this information, the staff finds that the applicant has adequately addressed acceptance criterion (4) in Section 4.2.3 of the SRP. Therefore, the applicant's choice of liner is acceptable to the staff.

The applicant has proposed an inspection plan for the storage ponds consisting of daily, weekly, quarterly, and annual inspections (LCI, 2008c, 2010a). The applicant also plans to install an automated monitoring device to check for the presence of liquids in the leak detection system. If liquids are encountered in the leak detection system, the liquid will be tested for specific conductance. If the specific conductance is more than half of the specific conductance of the water in the pond, additional testing will be performed to characterize the liquid. The inspection program also identifies aspects of the ponds that will need to be observed for maintenance purposes. These aspects include integrity of the liner system (i.e., rips, tears, and anchorage), erosion rills, and the condition of the embankment slopes (LCI, 2008c, 2010a). The staff notes that LCI will evaluate the same water quality parameters when sampling the leak detection system and the perimeter storage pond monitoring wells. The applicant will notify the NRC within 48 hours by telephone or email if a leak is detected in the storage ponds (LCI, 2008c, 2010a). The staff reviewed LCI's storage pond inspection plan and observes that LCI proposed daily, weekly, quarterly, and annual inspections as well as notification requirements in the event of a leak. LCI proposed inspection activities that are consistent with acceptance criterion (2) of SRP Section 4.2.3. Therefore, LCI's plan is acceptable to the staff.

Construction Considerations

The applicant provided a set of construction specifications and drawings that provide details of the construction aspects of the storage ponds (LCI, 2008c, 2010a). NRC staff reviewed the following items: (a) engineering drawings 0802.101 through 0802.104; (b) three unnumbered engineering drawings; (c) specification TS-1 (General Requirements); (d) specification TS-3 (Earthwork); and (e) specification TS-4 (Double Liner with Leak Detection). The staff finds the drawings provide a conceptual-level location of the storage ponds, a cross-section of the liner system, and details related to the liner and leak detection system.

The staff notes that the applicant's construction specifications provide details regarding the manner in which the storage ponds will be constructed. LCI identified that the topsoil within the storage pond footprint will be stripped and stockpiled for surface reclamation (LCI, 2008c, 2010a). Additionally, LCI will use excavated material to form the embankment, which will be placed in 20 cm (8 in) thick layers and will be compacted to at least 90-percent of the maximum dry density measured by ASTM D1557. LCI's specifications call for moisture conditioning the soil as necessary to aid in achieving the desired density. For the geomembrane and leak detection system, the applicant has described the techniques that will be used to install these features (LCI, 2008c, 2010a). The staff reviewed the construction specifications and drawings, and notes that the applicant has provided information regarding storage pond construction. The staff notes that the applicant has construction specifications that clearly identify performance requirements during construction. The staff finds that these specifications follow the construction guidance in Section 3 of NRC Regulatory Guide 3.11 (NRC, 2008c), are consistent with standard engineering practices in the geosynthetics industry, and are protective of public health. Therefore, the staff finds these specifications acceptable.

4.2.3.1.1.3 Closure

The applicant anticipates that the storage ponds will be in use over the life of the facility (LCI, 2008c, 2010a). After completion of uranium recovery operations and groundwater remediation activities, the storage ponds will be closed and decommissioned. The closure activities will include moving remaining sediments, pond liners, and other contaminated materials to a licensed byproduct material facility for final disposal. After the pond liner has been removed, the

soils beneath the storage pond will be surveyed to ensure that the area is suitable for release. Finally, the applicant will recontour the footprint of the storage ponds, cover the area with topsoil, and revegetate the area (LCI, 2008c, 2010a). The staff reviewed the components of the design for the storage ponds related to closure and decommissioning. By providing information on decommissioning aspects of the storage ponds, the staff concludes that the applicant meets acceptance criterion (1) of SRP Section 4.2.3. Therefore, LCI's approach is acceptable to the staff.

4.2.3.1.2 Liquid Non-byproduct material

Storm water runoff and development water that will not be affected by ISR processes will be generated at the facility. LCI stated that they will obtain a Wyoming Pollutant Discharge Elimination System (WYPDES) permit to allow for surface discharge of native groundwater and to control storm water runoff from the facility. The anticipated quantities of other liquid non byproduct material that are anticipated to be at the facility are summarized below.

Table 4.2-1: Types of Non-Byproduct Material Liquid Waste

Type of Waste	Quantity
Waste petroleum products	151-302 Lpy (40-80 gpy)
Waste chemicals	19-38 Lpy (5-10 gpy)
Domestic liquid waste/sewage	1,893-2,650 Lpd (500-700 gpd)

Waste petroleum products and waste chemicals that are not involved in the processing of uranium will be stored and collected by a commercial business for recycling or disposal at an appropriately licensed facility (LCI, 2008c, 2010a). LCI stated that it plans to install a septic system that meets the requirements of Water Quality Division (WQD) of the WDEQ to handle domestic liquid wastes or sewage generated at the facility. The approaches to liquid non-byproduct material management described above are considered acceptable by the NRC staff, as the applicant has identified plans for surface discharge, septic system, recycling, or disposal of these materials that are consistent with acceptance criterion (1) in SRP Section 4.2.3 (NRC, 2003a). Additionally, the applicant has identified State permits that are required for disposal of liquid non-byproduct material. By identifying the State permits required, the staff finds that the applicant has addressed acceptance criterion (7) in SRP Section 4.2.3.

4.2.3.1.3 System Failure

The applicant has identified (LCI, 2008c, 2010a) possible sources of accidental releases in the storage ponds, wellfields, and buildings. The applicant has described the techniques that will be used to monitor the facility for accidental releases, including inspections of the wellfields, inspection of the header houses, inspections of the plant, automated control, and monitoring of pressure and flow rates. For example, LCI plans to install sumps with fluid detection sensors with alarms and automatic shutoffs in the header houses. These sumps will provide an alarm in the event of a leak. Furthermore, the applicant identified the potential consequences of any failures in process or wellfield equipment. If an accidental release occurs, LCI has outlined the planned spill response procedures. If necessary, a RWP will be developed to provide guidance to the facility staff performing the work. The applicant also identified recordkeeping efforts related to spills (LCI, 2008c, 2010a). By identifying possible sources of accidental spills or releases, and the techniques that will be used to monitor for accidental releases, the staff finds the applicant has addressed acceptance criteria (4), (5), and (6) in SRP Section 4.2.3. The staff observes that LCI's monitoring techniques are consistent with generally accepted practices in

the ISR industry, which the staff has found to be protective of public health and safety. Therefore, these approaches are acceptable to the staff.

The main central processing plant will be constructed with concrete curbing to help contain liquid releases within the plant (LCI, 2008c, 2010a). The applicant has provided details about the size and location of the curbing and the volume of liquids contained in the tanks in the plant. LCI plans to construct a concrete curb around the entire process building. This curb will be designed to contain the contents of the largest tank within the building in the event of a rupture. Any spill of plant fluids will be contained within the concrete curbing allowing all fluids to drain to a low point and pumped to the waste disposal system (LCI, 2008c, 2010a). The staff reviewed the tank volume and volume provided by the concrete curb and has determined that the applicant has proposed acceptable design features to provide containment in the event of a spill within the plant.

4.2.3.2 Solids

LCI anticipates (LCI, 2008c, 2010a) generating solid wastes, such as piping, valves, instrumentation, miscellaneous equipment, plastic, steel, wood products, paper, biodegradable items, sewage sludge, batteries, waste petroleum products, spent IX resin, filter media, tank sludge, tanks, used personal protective equipment (PPE), and possibly soils contaminated from spills. These wastes can be categorized into either solid byproduct material or solid non-byproduct material. Items that are considered solid byproduct material include spent IX resin, spent filter media, tank sludge, contaminated soil from spills, and pipes or pumps that cannot be decontaminated. LCI anticipates generating between 80 and 100 cubic yards of solid byproduct material on an annual basis. LCI has described how these materials will be stored prior to disposal and has committed to disposing this waste at a facility licensed by either the NRC or an Agreement State. LCI will develop an agreement with a facility that has been appropriately licensed by either the NRC or an Agreement State for solid byproduct material disposal. The applicant has committed to notifying the NRC if the disposal agreement expires or is terminated, and to submitting a new agreement to the NRC within 90 days of the expiration or termination (LCI, 2008c, 2010a). The staff finds that the solid disposal agreement has not been finalized at this time; however, finalizing such an agreement will be required prior to commencement of operations at the facility by the standard license condition presented in SER Section 4.2.4.

Any hazardous waste generated at the facility will be stored in sealed containers meeting OSHA and EPA requirements (LCI, 2008c, 2010a). The total amount of hazardous wastes generated at the Lost Creek Project is expected to be small and the facility will be classified as a Conditionally Exempt Small Quantity Generator.

4.2.4 Evaluation Findings

The staff reviewed the aspects of the solid and liquid effluents to be generated at the proposed Lost Creek Project in accordance with the procedures in Section 4.2.2 and acceptance criteria in SRP Section 4.2.3. The applicant has acceptably described the common liquid effluents generated at the facility. Appropriate control methods, i.e., deep well injection and surface storage ponds, have been identified. The applicant has proposed an approach to monitor "perched" water table conditions for a timely detection of a leak near the storage ponds. However, the applicant has not demonstrated that all monitoring wells are screened at an appropriate depth or have been placed in the most probable down gradient direction from the ponds. Because this information was not provided in the application, the staff is adding the following license condition:

> The licensee shall install two monitoring wells (MW-2 and MW-3) in the southwestern and southeastern corner of the storage pond area in accordance with Section 4.2.5.4 of the approved license application. These two wells, along with existing wells MW-1 and MW-4, will be included in the quarterly monitoring program as described in Section 5.3.2.3 of the approved license application.

The above license condition will be included as part of the pre-operational conditions.

On the basis of the information presented in the application, and the license conditions discussed above, the NRC staff concludes that the characterization information provides an acceptable basis to enable the staff to make a finding on compliance with the applicable criteria in 10 CFR Part 40, Appendix A. The applicant has described how any dikes used to form a surface impoundment are designed, constructed, and maintained with sufficient structural integrity to prevent a massive failure. The design of the embankments that will be used to construct the storage ponds is consistent with Regulatory Guide 3.11, Sections 2 and 3 (NRC 2008), and therefore meets the requirements of 10 CFR Part 40, Appendix A, Criterion 5A(5).

The applicant provided acceptable plans and procedures that address contingencies for all reasonably expected system failures. The applicant has demonstrated that sump capacity is sufficient to contain the volume of the largest hazardous material source.

The applicant has committed to securing an agreement for disposal of solid byproduct materials; however, the applicant does not yet have an acceptable plan for the disposal of solid byproduct materials generated by the facility. Therefore, the staff is adding the following license condition to ensure that an agreement is in place prior to operations (see standard LC 12.6 in Appendix A).

The applicant does have plans in place to obtain the appropriate water quality certification and discharge permits. By providing information on the health and safety impacts of system failures and identifying preventive measures and mitigation for such occurrences, the applicant has shown that effluent control systems will limit radiation exposures under both normal and accident conditions.

Based upon the review conducted by the staff as indicated above, the staff has concluded that the proposed control systems for liquid and solid effluents meet the applicable acceptance criteria in SRP Section 4.2.3 and the applicable requirements in 10 CFR Parts 20 and 40.

4.2.5 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, “Standards for Protection against Radiation,” U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, “Domestic Licensing of Source Material,” U.S. Government Printing Office, Washington, DC.

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, “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 ,” U.S. Government Printing Office, Washington, DC.

40 CFR Part 147. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 147, "State, Tribal, and EPA-Administered Underground Injection Control Programs," Subpart ZZ—Wyoming, § 147.2550, "State-administered program—Class I, III, IV and V wells," U.S. Government Printing Office, Washington, DC.

40 CFR Part 268. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 268, "Land Disposal Restrictions," U.S. Government Printing Office, Washington, DC.

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NRC, 2008c. "Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities," Regulatory Guide 3.11, Washington, DC, November 2008.

WDEQ, 1993. "Class I Hazardous Waste and Non-Hazardous Waste Wells Underground Injection Control Program," Chapter 13 in *Water Quality Rules and Regulations*, March 11, 1993.

WDEQ, 2005. "Standards for Wyoming Groundwaters," Chapter 8 in *Water Quality Rules and Regulations*, March 16, 2005.

WDEQ, 2010. "Underground Injection Control Class I Injection Well Permit Number 09-586, issued by the State of Wyoming Department of Environmental Quality Water Quality Division to Lost Creek ISR, LLC, UIC Facility Number WYS-037-00122," Water Quality Division, May 28, 2010, ADAMS Accession No. ML100190468.

5.0 OPERATIONS

5.1 CORPORATE ORGANIZATION AND ADMINISTRATIVE PROCEDURES

5.1.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed corporate organization and administrative procedures for the Lost Creek Project are consistent with 10 CFR 40.32(b), which requires that the applicant be qualified through training and experience to use source materials.

5.1.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria outlined in Section 5.1.3 of the Standard Review Plan (SRP), NUREG-1569 (NRC, 2003a).

5.1.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 5.1.3, unless otherwise stated, is from Section 5.1 of the technical report (LCI, 2008c, 2010a). The management portion of the corporate organization included its President, General Manager, Mine Manager, Manager of Environmental Health and Safety and Regulatory Affairs, and Radiation Safety Officer, as shown in the organizational chart in SER Figure 5.1-1 (Hoy, 2010a). The President has the ultimate responsibility for all operations as well as protection of human health and protection of the environment. The President has the authority to immediately suspend, postpone, or modify any action that threatens human health or the environment or is in violation of State or Federal regulations (LCI, 2010a).

The General Manager reports to the President and is responsible for maintaining safe operations at the Lost Creek Project (LCI, 2010a). One of the roles of the General Manager is to perform and document the annual review of the Environmental Health and Safety Management System. The Mine Manager oversees the financial and managerial aspects of the operation. This person is also responsible for the implementation of the systems designed to protect worker health and safety, including radiation safety, as well as environmental compliance. The Mine Manager has the authority to immediately suspend, postpone, or modify any action that threatens human health or the environment or is in violation of State or Federal regulations. The Manager of Environmental Health and Safety and Regulatory Affairs has the responsibility and authority for environmental compliance, radiation safety, and quality assurance at the Lost Creek Project. This includes direct supervision of the Site Supervisor for Environment, Health, and Safety/Radiation Safety Officer (Site Supervisor EHS/RSO) (LCI, 2010a).

The applicant identified the Site Supervisor EHS/RSO in the Lost Creek Project organizational chart (LCI, 2008c; Hoy, 2010a). This person has several responsibilities including: serving as a member of the ALARA committee, conducting radiation protection training for employees, implementation and administration of radiation safety program, maintaining radiation safety samples and records are complete, development of radiation work permits (RWPs), verifying that workers are wearing approved dosimetry, and maintaining compliance for transportation of radioactive materials. The Site Supervisor EHS/RSO has the authority to immediately terminate any activities that may be a threat to worker safety, public health, or the environment. The Site Supervisor EHS/RSO will work with supervisory personnel (i.e., Department Heads) to review

and approve Standard Operating Procedures and to ensure that workers follow established procedures. This person reports directly to the Manager of Environmental Health and Safety and Regulatory Affairs (LCI, 2010a).

The staff finds the Site Supervisor EHS/RSO responsibilities are consistent with the responsibilities and authority described in Regulatory Guide 8.31, Section 1.2. Both of these positions do not have any direct production responsibilities. According to the applicant, the Mine Manager, Department Heads, and Site Supervisor EHS/RSO will all be located at the project site. This will allow workers to easily raise safety and environmental issues to senior managers (LCI, 2010a). Figure 5.1-1 of the technical report (SER Figure 5.1-1) is a Lost Creek Project organization chart (Hoy, 2010a) and identifies the Manager EHS & Regulatory Affairs as the Quality Assurance Program Manager as recommended in Regulatory Guide 4.15 (NRC, 2007). The staff finds the applicant has met description of its organization and organizational responsibilities is consistent with acceptance criteria (1) and (4) of SRP Section 5.1.3 (NRC, 2003a) and has demonstrated a strong commitment to support the development and implementation of the radiation safety and ALARA program as recommended in Regulatory Guide 8.31 (NRC, 2002b) to meet the regulatory requirements in 10 CFR Part 20, Subparts B, C, D, and F.

The staff finds the organizational structure provides for integration between plant management and the group responsible for plant construction in accordance with acceptance criterion (2) of SRP Section 5.1.3 (NRC, 2003a). According to the applicant (LCI, 2008c, 2010a), construction activities will be overseen by the engineering staff, which is managed by the Project Engineer. Engineering staff will be responsible for performing inspections during construction to verify that the applicant is constructing the facility in accordance with the approved design. Environmental, Health, and Safety staff also have a role during the design and start up of the facility in verifying that ALARA principles are followed (LCI, 2010a). The staff finds the applicant has incorporated radiation safety and ALARA program into the design of the facility to ensure compliance with regulatory requirements in 10 CFR 20, Subparts B, C, D, and F, which demonstrates a capability to meet qualifications required in 10 CFR 40.32(b) to use source materials.

Section 5.2.1 of the application (LCI, 2008c, 2010a) described the organization, procedures, and responsibilities of the Safety and Environmental Review Panel (SERP). The SERP will review proposed changes, tests, or experiments at the facility to verify that they do not conflict with any license requirements or NRC regulations; and that LCI maintains its commitments to safety and the environment. The SERP will consist of at least three individuals with appropriate managerial, financial, operations, environmental, and radiation safety responsibilities (i.e., RSO or equivalent) at the facility. The SERP will base its decisions on a thorough review of the proposal. Note that the applicant may add additional members to the SERP depending on the magnitude or technical issues (LCI, 2010a). By establishing the SERP and describing the procedures, members, and their responsibilities in sufficient detail the staff finds that the applicant has met acceptance criterion (3) of SRP Section 5.1.3 (NRC, 2003a). The staff finds the applicant's organization of the panel follows recommendations in the SRP by requiring at least one member having expertise in operations and another in radiation safety, and thus, is acceptable.

5.1.4 EVALUATION FINDINGS

The staff reviewed the corporate organization of the proposed Lost Creek Project in accordance with SRP Section 5.1.3. The applicant described its corporate organization and defined management responsibilities and authority at each level. The staff finds the organizational

management structure diagram portrays the proposed integration among groups that support operation and maintenance of the facility. The proposed management structure maintains sufficient independence for radiation safety personnel to raise safety issues to management. Therefore, the proposed management structure is acceptable to the staff. Based upon the review conducted by the staff as indicated above, the staff concludes that the proposed corporate organization and administrative procedures provided in the application are consistent with the acceptance criteria of SRP Section 5.1.3 and meet the requirements of 10 CFR 40.32(b).

5.1.5 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. Code of Federal Regulations, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

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NRC, 2007b. "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)—Effluent Streams and the Environment," Regulatory Guide 4.15, Washington, DC, July 2007.

5.2 MANAGEMENT CONTROL PROGRAM

5.2.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed management control program for the Lost Creek Project are consistent with requirements of Subparts L, "Records," and M, "Reports" of 10 CFR Part 20, 10 CFR 40.61, and Criteria 8 and 8a of Appendix A to 10 CFR Part 40.

5.2.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria outlined in Section 5.2.3 of the Standard Review Plan (SRP) (NRC, 2003a).

5.2.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 5.2.3, unless otherwise stated, is from Section 5.2 of the technical report (LCI, 2008c, 2010a). The applicant has committed to developing written standard operating procedures (SOPs) for all routine tasks that may be a hazard to employee safety, public safety, operations, or the environment. LCI will develop SOPs for process activities involving radioactive materials, and for non-process activities including environmental monitoring, radiological protection, emergency actions, and industrial safety. The RSO will review and approve all procedures involving radiation safety, and will perform an annual documented review of the operating procedures. RWPs will be issued for activities of a non-routine nature with potential for significant exposure to radioactive materials and for which no operating procedure exists (LCI, 2008c, 2010a). The staff finds this approach acceptable because it is consistent with the recommended practices in Regulatory Guide 8.31 for maintaining worker, members of the public, and environmental exposures ALARA and complies with 10 CFR Part 20, Subparts B, C, and D.

The applicant has developed a recordkeeping program that will document the control of source and byproduct material, including records related to transfer and disposal of these materials (LCI, 2008c, 2010a). The applicant will also maintain the types of records identified in Section 5.2 of NUREG-1569 (NRC, 2003a). LCI will develop adequate safeguards against tampering and loss and will make the records available to a new owner or will transfer the records to the NRC staff. The applicant will maintain records for the period specified in license conditions or until license termination, and it will maintain these records as hard copy originals, on microfiche, or on electronic media. Records will be available for NRC inspection until license termination. Table 5.2-1 of the technical report summarizes the internal and external reports that the applicant will prepare and which reports it will submit to the NRC. Additionally, LCI would notify the NRC project manager by telephone or e-mail within 24 hours of discovery of a spill or excursion that is reportable to the WDEQ (LCI, 2008c, 2010a). The staff finds the applicant's proposed recordkeeping complies with regulatory requirements for records and reports in 10 CFR Part 20, Subparts L and M, respectively. Standard license condition discussed in SER Section 5.2.4 will memorialize the records retention requirements.

The applicant has committed to submitting semi-annual effluent monitoring reports, SERP reviews, ALARA report, land use survey report, and corrective action program report to the NRC (LCI, 2008c, 2010a). The applicant has requested a performance based license and has provided for the establishment of a SERP. The staff finds that LCI has appropriately described

in detail in the application the SERP makeup, responsibilities, and review procedures, and the applicant has identified the SERP records that it will maintain until license termination (LCI, 2008c, 2010a). The staff finds the applicant's proposed recordkeeping and reporting comply with 10 CFR 40.61 and 10 CFR Part 20, Subparts L and M. Furthermore, the staff notes that all current NRC ISR licenses are performance-based licenses (NRC, 1998) that operate with a SERP with similar duties as outlined in this paragraph. Decisions of the SERP are subject to NRC inspection and review, and the NRC staff has found them to be protective of public health and safety, and the environment. Therefore, the staff finds applicant's description of the SERP process is consistent with acceptance criteria (2), (4), and (13) of SRP Section 5.2.3 and meets regulatory requirements in 10 CFR Part 20, Subparts B, C, and F, as well as those described above.

The applicant has performed Class I and Class III archeological surveys in the license area and included the results of the surveys in the application (LCI, 2008c, 2010a). LCI performed surveys over the entire license area. The applicant has committed to complying with the National Historic Preservation Act, the Archeological Resources Protection Act, and each law's implementing regulations. In addition, LCI has committed to cease any work resulting in the discovery of previously unknown cultural artifacts to ensure that no unapproved disturbance occurs (LCI, 2008c, 2010a). The staff notes that this commitment will be included as a standard license condition listed in SER Appendix A (license condition 9.8), which is further discussed in SER Section 5.2.4. This standard license condition will require that in the event of discovery of previously unknown artifacts the applicant shall conduct an inventory and evaluation of the artifacts in accordance with 36 CFR Part 800. NRC authorization will be required before the applicant would be allowed to proceed with activities. LCI shall comply with the stipulations for cultural resource protection in the Memorandum of Agreement dated October 4, 2010 (NRC, 2010e) provided in the NRC letter to the Advisory Council on Historic Preservation dated January 13, 2011 (NRC, 2011e).

5.2.4 EVALUATION FINDINGS

The staff reviewed the management control program of the proposed Lost Creek Project in accordance with SRP Section 5.2.3. The applicant has proposed acceptable record keeping and retention and reporting programs that will be adequate to ensure that the applicant is able to track, control, and demonstrate control over the source and byproduct materials that are processed, produced, or stored at the facility during its operating life, through decommissioning, and until license termination. Record keeping and retention plans will assist the applicant in ensuring that it keeps both on-site and off-site exposures within regulatory limits and in documenting compliance with NRC regulations. The applicant has demonstrated an acceptable program to maintain records on spills, likely contamination events, and unusual occurrences for use in calculating annual surety amounts and to ensure acceptable decommissioning. The applicant will maintain records for decommissioning, on-site and off-site disposal, personnel exposure, and off-site releases of radioactivity, as permanent records for the facility that will be transferred to any new owner or applicant, and ultimately to NRC, before license termination. LCI will make reports to the NRC, as required by regulations. The staff notes that spills, excursions, and other contamination events at ISR facilities may not be captured by Part 20 and Part 40 reporting requirements, but such events nonetheless need to be tracked to adequately ensure that the health and safety requirements of 10 CFR 40.32(c) will be met. Therefore, the staff is adding the following standard license condition to ensure that the applicant reports and documents these activities during operation of the facility (see LC 11.6 in SER Appendix A):

Until license termination, the licensee shall maintain documentation on unplanned releases of source or byproduct materials (including process solutions) and process chemicals. Documented information shall include, but not be limited to: the date, spill volume, total activity of each radionuclide released, radiological survey results, soil sample results (if taken), corrective actions, results of postremediation surveys (if taken), a map showing the spill location and the impacted area, and an evaluation of NRC reporting criteria.

The licensee shall have written procedures for evaluating the consequences of the spill or incident/event against 10 CFR Part 20, Subpart M, "Reports," and 10 CFR 40.60 reporting criteria. If the criteria are met, then the licensee shall report to the NRC Operations Center as required.

If the licensee is required to report any production area excursions and spills of source material, byproduct material, or process chemicals that may have an impact on the environment, or any other incidents/events, to any State or other Federal agencies, a report shall be made to the NRC Headquarters Project Manager (PM) by telephone or electronic mail (e-mail) within 24 hours. In accordance with LC 9.3, this notification shall be followed, within 30 days of the notification, by submittal of a written report to NRC Headquarters detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved.

Based on the information provided in the application, the information required by the license condition above, and the detailed review conducted of the management control program for the Lost Creek Project, the staff concludes that the proposed management control program is acceptable and is in compliance with 10 CFR Part 20 Subpart L and 10 CFR 40.62.

5.2.5 REFERENCES

10 CFR Part 40. Code of Federal Regulations, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

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

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

NRC, 2010e. "Memorandum of Agreement Among U.S. Nuclear Regulatory Commission, Wyoming State Historic Preservation Officer, Bureau of Land Management Rawlins Field Office, Northern Arapaho Tribe, Eastern Shoshone Tribe, and Lost Creek ISR, LLC Regarding Archeological Data Recovery at 48SW16604, Sweetwater County, Wyoming," October 4, 2010, ADAMS Accession No. ML110590864.

NRC, 2011e. "Letter to Mr. Reid Nelson, Advisory Council on Historic Preservation, "Memorandum of Agreement Regarding the Adverse Effect Determination for Archaeological Data Recovery at 48sw16604, Lost Creek In-Situ Uranium Recovery Project, Sweetwater County, Wyoming," January 13, 2011, ADAMS Accession No. ML103470098.

5.3 MANAGEMENT AUDIT AND INSPECTION PROGRAM

5.3.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed management audit and inspection program for the Lost Creek Project meet the requirements of 10 CFR 40.32(b) and (c).

5.3.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria outlined in Section 5.3.3 of the Standard Review Plan (SRP) (NRC, 2003a).

5.3.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 5.3.3, unless otherwise stated, is from Section 5.3 of the technical report (LCI, 2008c, 2010a). The applicant plans to perform inspections related to radiation safety and the storage ponds and will perform an annual audit of the radiation safety and ALARA programs. The applicant stated that the RSO, a health physics technician, or a qualified person designated by the RSO would perform daily walkthrough inspections of the facility. The applicant has identified the criteria for a qualified person designated by the RSO to perform the daily walk through inspections; it described these qualifications in Section 5.4.3.2 of the technical report. The purpose of the daily inspection is to observe radiation safety practices, SOPs, and to identify the need for corrective actions (LCI, 2008c, 2010a). The staff notes that proper qualifications of designated personnel are critical to being able to identify poor radiation safety practices and propose corrective actions during the daily inspections. The staff finds that the designee's qualifications as described by the applicant in Section 5.4.3.2 of the technical report do not meet the training and experience requirements of an RSO or HPT as suggested by Regulatory Guide 8.31 (NRC, 2002b).

However, the staff notes that LCI has proposed (LCI, 2010a) to limit designees to performing daily inspections on weekends, holidays, or other times when the RSO and HPT are not available on site. Additionally, the applicant proposed the constraint that the designee will not be allowed to perform daily inspections for more than two consecutive days, except in the event of a Federal or company holiday. Daily inspections prepared by the designee will be reviewed by the RSO or HPT as soon as practical upon his/her return, but no later than 3 hours from the beginning of the next workday following an absence, weekend, or holiday. The RSO will conduct a weekly inspection (with the Operations Manager) of all facility areas where radioactive materials or radiation levels above background may exist. The RSO will prepare a

monthly written summary of the daily and weekly inspections, with a focus on the personnel exposure data at Lost Creek. The monthly summary will include an evaluation of trends related to the ALARA program along with recommendations for corrective actions and improvements (LCI, 2008c, 2010a).

The staff finds that the inspections and RSO's responsibilities described by the applicant are acceptable because they follow the recommendations of Regulatory Guide 8.31 and meet the regulatory requirements of 10 CFR Part 20 Subpart B, C, F and L. However, the staff will include a license condition, discussed in SER Section 5.3.4, requiring the applicant to submit a health physics training program for the designee(s) to the NRC for review and written verification prior to commencement of operations at the Lost Creek ISR Project to ensure the designee is qualified through training and experience to use source materials in accordance with 10 CFR 40.32(b).

The applicant will perform inspections of storage pond on a daily, weekly, quarterly, and annual basis (LCI, 2008c, 2010a). Daily inspections will include verification of the required freeboard; visual checks for cracks, seepage, and erosion; and conditions of piping and valves. The applicant has proposed using an automated leak detection system to monitor for the presence of liquids in the leak detection layer. Weekly inspections will include checks of the leak detection system, diversion channels, perimeter fencing. LCI will obtain groundwater samples from the monitoring wells on a quarterly basis. Additionally, the crest and toe portions of the embankment will be examined for cracks, differential settlement, and erosion. Annual inspections will include a review of the daily, weekly, and quarterly reports as well as surveys of the embankments to check for movement. Annual inspections will also include a visual review of the different components of the pond. The Manager of EHS and Regulatory Affairs will conduct annual inspections with potential help from outside technical experts (LCI, 2008c, 2010a). The staff finds that the inspections and monitoring described by the applicant are acceptable because they follow the recommendations of Regulatory Guide 8.31 and meet the regulatory requirements of 10 CFR Part 20 Subpart B, F and L.

The applicant will conduct annual audits of the radiation safety and ALARA programs to provide assurance that all radiation protection procedures and license condition requirements are being conducted properly (LCI, 2008c, 2010a). LCI will conduct audits in accordance with recommendations in NRC Regulatory Guide 8.31. The applicant will submit ALARA audit reports to the President, General Manager, Mine Manager, and Department Heads. The staff finds that the applicant's audit program is acceptable because it complies with 10 CFR 20.1101.

5.3.4 EVALUATION FINDINGS

The staff reviewed the management audit and inspection program of the proposed Lost Creek Project in accordance with SRP Section 5.3.3. The applicant described the various aspects of daily and weekly inspections that its staff will perform within the facilities and at the storage ponds. The applicant described the personnel that will perform these inspections and has requested an alternative to the guidance that is recommended in Regulatory Guide 8.31. The staff reviewed the applicant's proposed management audit and inspection program and notes that it is generally consistent with the applicable guidance available in Regulatory Guide 8.31. Additionally, the staff reviewed the applicant's proposed alternative to allow a designee to perform daily inspections at the facility and considers the proposal acceptable. The staff approval of the alternative to Regulatory Guide 8.31 is reflected in license condition 9.7:

The licensee shall follow the guidance set forth in NRC, Regulatory Guides 8.22, "Bioassay at Uranium Mills," (as revised) and 8.30, "Health Physics Surveys in Uranium Recovery Facilities," (as revised) or NRC-approved equivalent.

The licensee shall follow the guidance set forth in Regulatory Guide 8.31, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable (ALARA)," (as revised) or NRC approved equivalent, with the following exception:

The licensee may identify a qualified designee(s) to perform daily inspections in the occasional absence of the RSO and health physics technician(s) (HPT). The qualified designee(s) will have health physics training, and the licensee will specify the training program and submit it to the NRC for review and verification prior to commencement of operations at the Lost Creek Project. The qualified designee(s) may perform daily inspections on weekends, holidays, and times when both the RSO and HPT(s) must both be absent (e.g., illness or offsite training). A designee(s) shall not perform daily inspections for more than two consecutive days except in the event of a Federal or company holiday, whereby no more than three consecutive days will be exceeded. Reports will be reviewed by the RSO or HPT as soon as practical, but no later than 3 hours from the beginning of the next work day following an absence, week-end, or holiday. The licensee will also have the RSO or HPT available by telephone while the qualified designee(s) is performing the daily inspections.

Notwithstanding the License Condition (LC) 9.4 change process, no additional exceptions to the guidance will be implemented without written NRC verification that the criteria in LC 9.4 do not require a license amendment.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented with the noted license condition, meet the applicable acceptance criteria of this section and the requirements of 10 CFR 40.32(b) and 10 CFR 40.32(c).

5.3.5 REFERENCES

10 CFR Part 40. Code of Federal Regulations, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

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

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2002b. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1, May 2002.

NRC, 2003a.NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

5.4 QUALIFICATIONS RADIATION SAFETY PERSONNEL

5.4.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the personnel conducting the radiation safety program complies with 10 CFR 20.1101, which defines the radiation protection program requirements, and 10 CFR 40.32(b), which provides requirements for applicant qualification.

5.4.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria outlined in Section 5.4.3 of the Standard Review Plan (SRP) (NRC, 2003a). Regulatory Guide 8.31 provides recommendations for technical qualifications of radiation safety staff.

5.4.3 STAFF REVIEW AND ANALYSIS

5.4.3.1 Radiation Safety Officer (RSO)

Information in SER Section 5.4.3, unless otherwise stated, is from Section 5.4 of the technical report (LCI, 2008c, 2010a). The applicant identified the requirements for an RSO. Regarding education, this included a bachelor's degree in physical science, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in radiation protection related to uranium recovery (LCI, 2008c, 2010a). The staff notes that Regulatory Guide 8.31, Section 2.4.1, states that two years of relevant experience are generally considered equivalent to one year of academic study (NRC, 2002b).

Other minimum qualifications for the RSO identified by the applicant include health physics experience (LCI, 2008c, 2010a). Specifically, at least one year of work experience relevant to uranium recovery operations in applied health physics, radiation protection, industrial hygiene, or similar work. The applicant also identified specialized training for the RSO, which would include at least four weeks of specialized classroom training in health physics specifically applicable to uranium recovery. Lastly, the applicant identified specialized knowledge requirements that include a thorough knowledge of the proper application and use of all health physics equipment used during uranium recovery activities (LCI, 2008c, 2010a). NRC staff has determined that the RSO qualifications identified by the applicant are consistent with Regulatory Guide 8.31 and finds them acceptable because they meet the acceptance criterion in SRP Section 5.4.3 and comply with 10 CFR 40.32(b).

5.4.3.2 Health Physics Technician (HPT)

The applicant identified the minimum qualifications for the HPT as one of the following two combinations of education, training, and experience in Section 5.4.3.1 of the technical report (LCI, 2008c, 2010a). One set of qualifications would include an associate degree or two or more years of study in the physical sciences, engineering, or a health related field; at least a total of four weeks of generalized training in radiation protection applicable to uranium recovery facilities; and one year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene or industrial safety measures to be applied in a uranium recovery facility (LCI, 2008c, 2010a).

The alternative set of qualifications proposed by the applicant (LCI, 2008c, 2010a) includes a high school diploma, a total of at least three months of specialized training in radiation protection relevant to uranium recovery facilities of which up to one month may be on-the-job training, and two years of relevant work experience in applied radiation protection (LCI, 2010a). NRC staff has determined that the HPT qualifications identified by the applicant are consistent with the training and experience recommended in Regulatory Guide 8.31, Section 2.4, and acceptance criterion in SRP Section 5.4.3 and, meet the requirements of 10 CFR 40.32(b).

5.4.3.3 Designee

The staff notes that regulatory Guide 8.31 suggests that a daily inspection be conducted by the RSO or designated HPT. The applicant identified the minimum qualifications for the designee to perform daily inspections in the absence of the RSO and HPT (LCI, 2008c, 2010a). The staff finds the designee's qualifications as described by the applicant in Section 5.4.3.2 of the technical report (LCI, 2010a) do not meet the training and experience requirements of an RSO or HPT as suggested by Regulatory Guide 8.31. Therefore the applicant in Section 5.3.1.1 of the technical report (LCI, 2010a) has limited the designee to performing inspections only on week-ends or holidays or when both the RSO and HPT are absent because of illness or training, to no more than 3 consecutive days. Additionally, the RSO or HPT must be available by telephone for assistance (LCI, 2010a). Although the applicant's minimum qualifications for the designee do not meet the requirements for an RSO or HPT as suggested in Regulatory Guide 8.31, the staff recognizes that the regulatory guides provide an example of merely one method of satisfying the NRC's regulatory requirements. In this particular instance, the staff approves the use of a designee proposed by the applicant contingent upon the NRC's review and verification of the designee's training requirements, as discussed in SER Section 5.3.4.

5.4.4 EVALUATION FINDINGS

The staff reviewed the qualification requirements of the personnel conducting the radiation safety program at the proposed Lost Creek Project in accordance with SRP Section 5.4.3. The applicant described qualifications of the RSO and HPT that are consistent with Regulatory Guide 8.31 (NRC, 2002b). The applicant proposed an alternate designee in the absence of the RSO and HPT during limited periods and provided qualifications of the designee that do not meet the qualifications recommended in Regulatory Guide 8.31. The license condition described in Section 5.3.4 of the application will require daily inspections be conducted in accordance with Regulatory Guide 8.31 unless the applicant has submitted a modified training program for the designee to the NRC and has received written NRC verification that the criteria in LC 9.4 do not require a license amendment. Based upon the review conducted by the staff as indicated above, the information provided in the application and the license condition

discussed in SER Section 5.3.4 meet the applicable acceptance criteria of this section and the requirements of 10 CFR 20.1101 and 10 CFR 40.32(b).

5.4.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

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

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2002b. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1, May 2002.

NRC, 2003a.NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

5.5 RADIATION SAFETY TRAINING

5.5.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed radiation safety training program for the Lost Creek Project complies with 10 CFR 19.12, which provides requirements for instructions to workers, 10 CFR 20.1101, which defines radiation protection program requirements, and 10 CFR 40.32(b), as it relates to applicant qualifications through training.

5.5.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 19, 20, and 40 using the acceptance criteria outlined in Section 5.5.3 of the Standard Review Plan (SRP) (NRC, 2003a). Regulatory Guides 8.13 (NRC, 1999a), 8.29 (NRC, 1996a), and 8.31 (NRC, 2002b) provide guidance on (1) protecting the fetus, (2) a basis for training employees on the risks from radiation exposure in the work place, and (3) the fundamentals of protection against exposure to uranium and its progeny, respectively.

5.5.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 5.5.3, unless otherwise stated, is from Section 5.5 of the technical report (LCI, 2008c, 2010a). The applicant stated that annual worker training will include, among other topics, the following: basic radiation science and radiation safety principles, the Radiation Safety Program for ISR operations at the licensed area, dose monitoring requirements, contamination and spill control, and security and emergency procedures. In addition, radiation safety training for female employees will address risks associated with prenatal exposure and the applicant's policy for declared pregnant workers. Managers will receive additional specialized occupational radiation protection training on their supervisory responsibilities (LCI, 2008c, 2010a).

The applicant stated that specific, detailed worker radiation training materials will be presented in the Radiation Safety Manual, which will include materials for initial employee training (eight hours) (LCI, 2008c, 2010a). Training will also include refresher training (four hours) that will occur on an annual basis for each employee (LCI, 2010a). The staff notes that Regulatory Guides 8.13 (NRC, 1999a), 8,29 (NRC, 1996a), and 8.31 (NRC, 2002b) provide methods acceptable to the NRC staff for implementing the regulatory requirements in 10 CFR 19.12, 10 CFR 19.13, 10 CFR 19.15, 10 CFR 19.16, and 10 CFR Part 20, Subpart C. The staff finds that the radiation safety training program proposed by the applicant is primarily complete except for the following items:

- how the applicant's policy on declared pregnant women may affect a woman's work situation after she has filed a written declaration of pregnancy consistent with 10 CFR 20.1208 as recommended in Regulatory Guide 8.13 (NRC; 1999a);
- acknowledgement in writing by each trainee that the instruction has been received and understood as recommended in Regulatory Guides 8.29 (NRC, 1996a) and 8.31 (NRC, 2002b); and
- risk of biological effects resulting from exposure to radiation commensurate with the radiological risks present in the workplace as recommended in Regulatory Guide 8.29.

The staff is reasonably assured that the applicant's proposed radiation safety training program will be sufficient to ensure compliance with 10 CFR Parts 19 and 20, contingent upon the fulfillment of the license condition in SER Section 5.5.4, which will require the applicant to administer a training program consistent with Regulatory Guides 8.13, 8.29, and Section 2.5 of Regulatory Guide 8.31, or an NRC-approved equivalent.

The applicant stated that each permanent employee that has completed the new employee radiation safety training will annually attend an abbreviated retraining course (LCI, 2008c, 2010a). This course will discuss, among other topics, the following: results from the ALARA report, changes in regulations and license conditions and exposure trends. The applicant also stated that a written or oral test will be conducted following radiation safety training for new employees and annual refreshers. Incorrect answers to test questions will be discussed to ensure a correct understanding of the material. If an employee fails to pass the test (less than 70 percent of the answers being correct), additional training will be provided prior to re-testing. Tests and results will be maintained on file until license termination (LCI, 2008c, 2010a). NRC staff finds the applicant's plan for retraining and testing consistent with the recommendations in Section 2.5 of Regulatory Guide 8.31 and therefore, is consistent with acceptance criterion (1) of SRP Section 5.5.3 (NRC, 2003a).

Regarding radiation safety for visitors, the applicant stated that visitors will be instructed on radiological and non-radiological hazard prevention specific to the areas of visitation (LCI, 2008c, 2010a). In addition, contractors who handle contaminated equipment will receive the same training and radiation safety instruction required of permanent employees. Contractors, who have previously completed the full training for the Lost Creek Project or who have evidence of recent and relevant training elsewhere will receive job-specific radiation safety instruction. An employee with proper training and knowledge of potential hazards must escort all visitors and contractors that have not received proper training (LCI, 2008c, 2010a). The staff finds the applicant's plan for training visitors and contractors consistent with the recommendations in Section 2.5 of Regulatory Guide 8.31.

5.5.4 EVALUATION FINDINGS

The staff reviewed the radiation safety training aspects of the proposed Lost Creek Project. As discussed above, the applicant's radiation safety training program is primarily complete, and the staff is reasonably assured that the applicant's program will ensure the applicant's compliance with 10 CFR 19.12, Part 20-Subpart C, and 10 CFR 40.32(b). However, because certain items, discussed above, were omitted from the training program, this staff's reasonable assurance determination is contingent upon the fulfillment of the following license condition:

> The licensee shall ensure radiation safety training is consistent with Regulatory Guides 8.13, "Instruction Concerning Prenatal Radiation Exposure" (as revised); Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure"(as revised); and Section 2.5 of Regulatory Guide 8.31 (as revised), or NRC approved equivalent.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by the noted license condition, is consistent with the applicable acceptance criteria of SRP Section 5.5.3 and meets the requirements of 10 CFR 19.12, 10 CFR Part 20, Subpart C, and 10 CFR 40.40.32(b).

5.5.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

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

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations."

LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 1996b. "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.

NRC, 1999a. "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Revision 3, June 1999.

NRC, 2002b. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1, May 2002.

NRC, 2003a.NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

5.6 SECURITY

5.6.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed security measures for the Lost Creek Project meet the requirements of 10 CFR 20, Subpart I.

5.6.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria outlined in Section 5.6.3 of the Standard Review Plan (SRP) (NRC, 2003a).

5.6.3 STAFF REVIEW AND ANALYSIS

Information in SER Section 5.6.3, unless otherwise stated, is from Section 5.6 of the technical report (LCI, 2008c, 2010a). The applicant has committed to controlling active wellfields and storage ponds with fences and signs to prevent members of the public from entering. LCI also indicated that active mine units will be inspected by site personnel on a regular basis. Access to the processing plant, including areas where byproduct materials are stored, will be controlled with a fence and locked gate. LCI indicated that security cameras will be placed throughout the processing plant; these cameras will be continuously monitored. The processing plant will have security staff on duty 24 hours a day, seven days per week. Plant operators will perform an inspection at the beginning of each shift to verify source material quantities and ensure proper storage and security of licensed material. In its transportation of licensed materials, the applicant will meet all U.S. Department of Transportation (DOT) requirements for packaging, labeling, shipping, handling, and security (LCI, 2010a). The staff finds that the applicant's transportation and security procedures are acceptable because the transportation procedures comply with the requirements in 49 CFR Parts 172 and 173 and 10 CFR 71.5(a)(1); and security procedures comply with 10 CFR Part 20, Subpart I, "Storage and Control of Licensed Material." The staff concludes that LCI has described the security measures that will be used at the Lost Creek Project in sufficient detail to meet the acceptance criterion in SRP Section 5.6.3 because

it has acceptable passive controls, such as fencing for well fields, and active controls, such as daily inspections and locks for plant buildings (NRC, 2003a).

5.6.4 EVALUATION FINDINGS

The applicant has described the security measures that will be used for stored material and control measures for material not in storage. The security measures at the Lost Creek Project, as discussed above, demonstrate that the applicant has acceptable active and passive constraints on entry to the licensed and restricted areas. The applicant has identified acceptable passive controls, for example, fencing, locked gates, and warning signage for site control and active security systems for buildings.

Based on the information provided in the application and the detailed review conducted of the security measures for the Lost Creek Project, the staff concludes that the security measures are acceptable and are in compliance with 10 CFR Part 20, Subpart I, which provides requirements for the security of stored material and control of material not in storage.

5.6.5 REFERENCES

LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

5.7 RADIATION SAFETY CONTROLS AND MONITORING

This section discusses radiation safety controls and monitoring techniques used to ensure the applicant maintains radiation exposures and releases of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable (ALARA).

5.7.1 STANDARDS

5.7.1.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed radiation safety controls and monitoring for the Lost Creek Project meet the requirements of 10 CFR Part 20 and Criteria 7 and 8 of Appendix A to 10 CFR Part 40. 10 CFR 20.1101 requires the applicant to employ procedures and engineering controls based upon sound radiation protection principles to achieve ALARA doses to workers and the public.

Further, 10 CFR 20.1101 compels the applicant to develop, document, and implement a radiation safety program to ensure compliance with the requirements in the following:

10 CFR Part 20, Subparts –

- C-Occupational Dose Limits, 10 CFR 20.1201-20.1208;
- D-Radiation Dose Limits for Individual Members of the Public, 10 CFR 20.1301 and 20.1302;
- F-Surveys and Monitoring, 10 CFR 20.1501 and 20.1502;
- H-Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas, 10 CFR 20.1701-20.1705;
- I-Storage and Control of Licensed Material, 10 CFR 20.1801 and 20.1802;
- J-Precautionary Procedures, 10 CFR 20.1901-20.1906
- L-Records, 10 CFR 20.2101-20.2110; and
- M-Reports, 10 CFR 20.2201-20.2206

10 CFR Part 20, Appendices

- A - Assigned Protection Factors for Respirators; and
- B - Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupations Exposure; Effluent Concentrations; Concentrations for Release to Sewerage.

10 CFR 20.1101(c) requires an annual review of the program content and implementation to ensure compliance. 10 CFR 20.1301(e) requires a licensee subject to the provisions of EPA's environmental radiation standards in 40 CFR Part 190, such as uranium mills or an ISR, to comply with those standards. 40 CFR Part 190 mandates that the maximum annual dose equivalent cannot exceed 25 millirems to the whole body and 25 millirems to any organ of any member of the public as the result of exposures to radiation and to planned discharges of radioactive materials, excluding radon and its progeny, to the general environment from uranium milling operations.

In addition to 10 CFR Part 20, Appendix A to 10 CFR Part 40 requires the following:

- Criterion 7 requires an operational monitoring program must be conducted throughout the construction and operating phases of the mill (1) to measure or evaluate compliance with applicable standards and regulations; (2) to evaluate performance of control systems and procedures; (3) to evaluate environmental impacts of operation; and (4) to detect potential long-term effects.
- Criterion 8 requires that all airborne effluent releases are reduced to ALARA.

5.7.1.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20, 10 CFR Part 40 and 40 CFR Part 190 using the acceptance criteria in the subsections of Section 5.7 of the Standard Review Plan (SRP) (NRC, 2003a) and the guidance provided in the following:

- Regulatory Guide 3.46, "Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining," June 1982.
- Regulatory Guide 3.51, "Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations," March 1982.

- Regulatory Guide 3.56, “General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills,” May 1986.
- Regulatory Guide 3.59, “Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations,” March 1987.
- Regulatory Guide 3.63, “Onsite Meteorological Measurement Program for Uranium Recovery Facilities—Data Acquisition and Reporting,” March 1988.
- Regulatory Guide 4.14, “Radiological Effluent and Environmental Monitoring at Uranium Mills,” April 1980.
- Regulatory Guide 4.15, “Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)—Effluent Streams and the Environment,” July 2007.
- Regulatory Guide 8.7, “Instructions for Recording and Reporting Occupational Radiation Exposure Data,” Revision 2, November 2005.
- Regulatory Guide 8.9, “Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program,” Revision 1, July 1993.
- Regulatory Guide 8.10, “Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable,” Revision 1-R, May 1977.
- Regulatory Guide 8.13, “Instruction Concerning Prenatal Radiation Exposure,” Revision 3, June 1999.
- Regulatory Guide 8.15, “Acceptable Programs for Respiratory Protection,” Revision 1, October 1999.
- Regulatory Guide 8.22, “Bioassay at Uranium Mills,” Revision 1, August 1988.
- Regulatory Guide 8.25, “Air Sampling in the Workplace,” Revision 1, June 1992.
- Regulatory Guide 8.29, “Instruction Concerning Risks from Occupational Radiation Exposure,” Revision 1, February 1996.
- Regulatory Guide 8.30, “Health Physics Surveys in Uranium Recovery Facilities,” Revision 1, May 2002.
- Regulatory Guide 8.31, “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” Revision 1, May 2002.
- Regulatory Guide 8.34, “Monitoring Criteria and Methods To Calculate Occupational Radiation Doses,” July 1992.
- Regulatory Guide 8.36, “Radiation Dose to the Embryo/Fetus,” July 1992.
- Regulatory Guide 8.37, “ALARA Levels for Effluents from Materials Facilities,” July 1993.
- NUREG-1575, “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),” Revision 1, 2000.
- Branch Technical Position, “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material,” Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety, Washington, DC April 1993.

5.7.2 EFFLUENT CONTROL TECHNIQUES

During the course of the review, the staff determined that areas of review and acceptance criteria in SRP Section 5.7.1 (NRC, 2003a), which addresses effluent control techniques, are in other sections of this SER. The staff's review of the applicant's proposed effluent control techniques and monitoring are in SER Sections 4.1 and 5.7.8, respectively.

5.7.3 EXTERNAL RADIATION EXPOSURE MONITORING PROGRAM

5.7.3.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed external radiation exposure monitoring program for the Lost Creek Project meets the requirements of 10 CFR Part 20, Subparts B, C, F, J, L, and M, and 10 CFR 40.61.

5.7.3.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in Section 5.7.2.3 of the Standard Review Plan (SRP). Regulatory Guides 4.14 (NRC, 1980), 8.7 (NRC, 1992b), 8.10 (NRC, 1977), 8.30 (NRC, 2002a), 8.31 (NRC, 2002b), and 8.34 (NRC, 1992a) provide guidance on how compliance with the regulations can be demonstrated.

5.7.3.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the external radiation exposure monitoring program for the Lost Creek Project. Review areas addressed in this section include radiation surveys, personnel monitoring, records, and reporting.

5.7.3.3.1 Surveys

The applicant stated in section 5.7.2 of the technical report (LCI, 2008c, 2010a) that direct gamma exposure rate surveys will be conducted at least semi-annually at all employee work stations and near processing equipment that could be a source of gamma radiation (e.g., tanks and filters). SER Figure 5.7-1 illustrates approximately 46 gamma survey locations. The applicant stated (LCI, 2010a) that gamma survey frequency will increase to quarterly if an exposure rate exceeds 5 mrem/hr and the area will be designated and posted as a radiation area in accordance with 10 CFR 20.1902(a). The RSO will investigate and document the cause for any radiation areas. In accordance with the ALARA principle, the applicant stated that engineering and/or administrative controls will be implemented to reduce gamma exposure rates in all radiation areas if exposure rates cannot otherwise be reduced during operations(LCI, 2008c, 2010a).

The staff finds that the applicant's commitment to conduct gamma surveys and maintain exposures ALARA is consistent with those recommendations in Regulatory Guides 8.10 (NRC, 1977) and 8.31 (NRC, 2002b), and with acceptance criterion (7) in SRP Section 5.7.2.3, which recommends keeping radiation doses ALARA by following these two regulatory guides. The applicant included a drawing that depicted the facility layout and location of monitors for external radiation, as recommended in Regulatory Guide 4.14, Sections 1.1.5 and 2.1.6 (NRC, 1980), and therefore is consistent with acceptance criterion (1) in SRP Section 5.7.2.3. However, 10 CFR 20.1301(a)(2) does not allow dose rates from external radiation sources to exceed

2 mrem in any one hour in unrestricted areas. The applicant did not address what actions will be taken if employee work areas in an unrestricted area exceed 2 mrem/hr. The staff has reasonable assurance that the applicant will ensure that exposures in unrestricted areas are limited because in Section 5.7.2 of the technical report (LCI, 2010a) the applicant committed to preventing visitors or other unmonitored individuals from entering into areas where the exposure rate exceeds 2 mrem/hr per the requirements of 10 CFR 20.1301(a)(2). Because the applicant has not addressed those actions it will take if exposure dose rates exceed 2 mrem/hr in unrestricted areas, the staff finds a license condition is warranted to ensure exposure dose rates do not exceed 2 mrem/hr in unrestricted areas and comply with 10 CFR 20.1301(a)(2). This license condition is discussed in SER Section 5.7.3.4.

The staff notes that the types of survey instruments required depend on the exposures and doses expected. The applicant stated (LCI, 2008c, 2010a) that occupational exposures are expected to be less than 4 percent (200 mrem) of the allowable annual dose (5 rem). The applicant acknowledged that elevated dose rates may be as high as 8 mrem/hr in areas associated with radium precipitation in pipes and accumulation of radium and progeny in ion exchange (IX) resins and filters. According to the applicant, typical dose rates in the wellfields are not expected to exceed background (LCI, 2008c, 2010a).

LCI described the survey instrumentation that it plans to use in Section 5.7.2.2 and Table 5.7-2 of the application (LCI, 2008c, 2010a) (see SER Table 5.7-1). The applicant committed to calibrating instruments at least annually by the manufacturer. The manufacturer's calibration procedures were included in Attachment 5.7-3 to the technical report. LCI stated that it will calibrate instruments with sources traceable to the National Institute of Standards and Technology (NIST) and in compliance with American National Standards Institute (ANSI) standard N323 (ANSI, 1978). The applicant will use check sources in fixed geometry to perform instrument response validation and will perform background checks each day that the instrument is used. Control charts will be maintained for each instrument and will include the mean and standard deviation of the response based on at least 20 measurements, as well as the acceptance range, which is three standard deviations above and below the mean (LCI, 2008c, 2010a). The staff finds the applicant's description of instrument use and calibration is consistent with the recommendations in Section 8, Calibration of Survey Instruments, in Regulatory Guide 8.30, and in compliance with 10 CFR 20.1501(b) and 20.2103(a). The applicant's commitments are also consistent with acceptance criterion (3) of SRP Section 5.7.2.3 by (a) identifying the monitoring equipment by type, (b) describing the use of the monitoring equipment to protect health and safety, and (c) describing the calibration methods, frequency, and sensitivity.

The applicant stated that a Ludlum Model 3 survey meter equipped with a Model 44-9 pancake probe will be used to measure beta exposure rates if needed (LCI, 2008c, 2010a). Gamma exposure rate surveys will be made with a Ludlum Model 2350-1 rate meter equipped with a Model 44-10 detector (2-inch NaI detector) or with a Ludlum Model 19 or equivalent instrument (LCI, 2010a). The staff finds that the Ludlum technical specifications indicate that the range of the Model 19 instrument is 0 to 5000 micro R/hr (µR/hr) over five ranges: 0 – 25 µR/hr, 0–50 µR/hr, 0–250 µR/hr, 0–500 µR/hr, 0–5000 µR/hr (Ludlum, 2010a). The staff notes that a gamma survey meter must have the capability beyond the intended range needed to ensure radiation areas comply with 10 CFR 20.1902 and exposures do not exceed 10 CFR Part 20, Subparts B and C. The applicant stated (LCI, 2008c, 2010a) that exposure rates may be as high as 8 mrem/hr, but the staff observes that the Model 19 instrument cannot measure exposure rates beyond 5000 µR/hr or 5 mR/hr (Ludlum, 2009). However, the staff notes that the technical specifications indicate that the range of the Model 3 instrument is 0 to 200 mR/hr

(Ludlum, 2010b). The staff concludes that the applicant's external radiation exposure monitoring program is acceptable to the staff, with the exception that the applicant must select an appropriate instrument for radiation fields that exceed 5mR/hr. To ensure that the correct radiation exposure readings are measured and posted in accordance with 10 CFR 20.1501(a)(2)(i) and 20.1902(a), the staff is imposing a license condition (presented in SER Section 5.7.3.4).

Figure 1 of Regulatory Guide 8.30 (NRC, 2002a) shows that the surface beta dose rate changes as a function of time after separation from the ore as the short-lived uranium progeny increase. The applicant stated in Section 5.7.2.2 of the technical report that it does not expect beta radiation to be a problem given that dried yellowcake will not be stored at the facility and storage periods for yellowcake slurry will be brief (LCI, 2008c, 2010a). The applicant calculated that it would expect only the beta radiation emitted from Pa-234m to penetrate the thickness of the fiberglass tank walls during the periods that yellowcake slurry is stored for extended periods. However, LCI stated that it will evaluate the beta dose rates when operations begin to ensure exposures remain below limits as delineated in NRC Regulatory Guide 8.30, Section 2.4. If the RSO determines that beta surveys are required, LCI will develop a survey program specifying the frequency, instrumentation, calibration, methodology, and location in accordance with Regulatory Guide 8.30, Appendix C, to ensure LCI maintains worker doses ALARA (LCI, 2008c, 2010a). The staff finds that the applicant's plans to conduct beta exposure surveys are consistent with acceptance criterion (8) of SRP Section 5.7.2.3 and are consistent with recommendations to conduct surveys and re-evaluate the radiation safety program to minimize exposures in Regulatory Guides 8.10, 8.30, and 8.31, and thus in compliance with 10 CFR 20.1101(b) and 20.1501(a)(2)(i). Therefore, the staff finds the applicant's commitment to evaluate beta dose rates acceptable to comply with 10 CFR 20.1501(a).

5.7.3.3.2 Personnel Monitoring

The applicant identifies LCI's criteria to provide employees personnel dosimetry in Section 5.7.2.1 of the technical report (LCI, 2008c, 2010a). These proposed criteria are essentially that LCI will monitor all adult employees excluding declared pregnant women, likely to receive 10 percent of the 10 CFR 20.1201(a) limits. The following persons will be issued personnel dosimetry: declared pregnant women likely to receive 100 mrem during the entire pregnancy minors likely to receive 100 mrem/yr deep dose equivalent (DDE) or 150 mrem/yr to the lens of the eyes or 500 mrem/yr shallow dose equivalent and all employees that enter a high radiation area (LCI, 2008c, 2010a).

The applicant stated (LCI, 2008c, 2010a) that the RSO will administer the external dosimetry program in accordance with Regulatory Guide 8.34 (NRC, 1992a). The applicant proposed to use a commercial personnel dosimetry service accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) to monitor beta and gamma exposure with a minimum range of 10 mrem to 500 rem. Workers will wear personnel dosimeters on the torso between the neck and waist and will exchange them quarterly. The applicant specified the use, storage, and process for reporting and handling lost personnel dosimeters. LCI will maintain a permanent dose record for each employee according to Regulatory Guide 8.7 (NRC, 2005). LCI will provide employees with radiation dose information annually and at termination in accordance with 10 CFR Part 20, Subpart C. LCI will provide contractors with a potential to exceed 100 mrem/yr. radiation worker training and will monitor their radiation exposures. The applicant also stated that visitors and unmonitored individuals will not be allowed in areas that exceed 2 mrem/yr from the external exposure pathway (LCI, 2008c, 2010a). The staff finds that the applicant's personnel monitoring program is consistent with Regulatory Guides 8.7 and 8.34

and, thus, consistent with acceptance criteria (2), (5), and (10) in SRP Section 5.7.2.3. Therefore, the staff finds the applicant's personnel monitoring program for employees, contractors, and visitors to comply with 10 CFR 19.13 and 10 CFR Part 20, Subparts C, D, F, and L.

5.7.3.3.3 Records and Reporting

The applicant addressed records and reporting in Sections 5.7.2.1 and 5.7.2.2 of the technical report (LCI, 2008c, 2010a). The applicant stated that it would maintain permanent dose records for each employee according to Regulatory Guide 8.7. As stated earlier, in accordance with 10 CFR Part 20, Subpart C, LCI will provide employees radiation dose information annually and at termination of employment (LCI, 2008c, 2010a). The staff finds that the applicant's records and reporting for the personnel-monitoring program are consistent with Regulatory Guide 8.7 and, thus, consistent with acceptance criterion (5) of SRP Section 5.7.2.3 and in compliance with 10 CFR Part 20, Subparts C, L, and M.

5.7.3.4 Evaluation Findings

The staff reviewed the radiation safety controls and monitoring aspects of the proposed Lost Creek Project in accordance with SRP Section 5.7.2.3. The applicant has provided a drawing that depicts the facility layout and the location of external radiation monitors. The applicant has identified radiation instrumentation that it will use to conduct gamma radiation surveys and the frequency of these surveys. The applicant has committed to conduct beta dose rate surveys in accordance with Regulatory Guide 8.30 when needed. The applicant will provide dosimetry to all process plant employees and measure the DDE and shallow-dose equivalent, if applicable. Although the staff has reasonable assurance that LCI will comply with radiation exposure limits in 10 CFR Part 20 by ensuring that unrestricted areas do not exceed 2 mrem/hr and that surveys will be conducted with the appropriate survey instruments, the staff is including two license conditions to ensure that these requirements are met. The first addresses the treatment of controlled areas or restricted areas:

> Any area with exposure rates that exceed 2 millirem in any 1 hour must be immediately treated as either a controlled area or restricted area in accordance with 10 CFR 20.1301(a)(2).

The second license condition addresses the requirement in 10 CFR 20.1501(a)(2)(i) to conduct surveys to evaluate the magnitude and extent of radiation levels. The range of one of the gamma radiation survey meters proposed by the applicant will not meet requirements for radiation exposure readings above 5 mR/hr, which the applicant stated may occur within the facility. Therefore, the following condition will be included in the Lost Creek Project license:

> The licensee will use calibrated radiation instrumentation that can measure the full range of radiation exposure rates, or dose rates, that can be reasonably expected at an ISR facility to ensure the magnitude and extent of radiation levels are measured in accordance with 10 CFR 20.1501(a)(2)(i). The instrumentation used to measure airborne concentrations of radioactive materials will allow for a lower limit of detection (LLD), as described in Regulatory Guide 8.30 (as revised), to provide a 95% confidence that measurements are in conformance with 10 CFR 20.1201, 20.1204, 20.1301, 20.1501, and 20.1502.

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by the license conditions above, is consistent with the applicable acceptance criteria of SRP Section 5.7.2.3 and meets the applicable requirements of 10 CFR 20.1101, 20.1201(a), 20.1501 and 20.1502, and 10 CFR Part 20, Subparts L and M.

5.7.3.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

ANSI, 1978. "Radiation Protection Instrumentation Test and Calibration," N323-1978, American National Standard, Approved September 13, 1977, Reaffirmed March 11, 1991.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

Ludlum, 2010a. Ludlum Measurements, Inc., *MicroR/Ratemeter - Model 19* (2009). November 3, 2010, http://ludlums.com.

Ludlum 2010b. Ludlum Measurements, Inc.,*Alpha Beta Gamma Counter - Model 3 with 44-9* (2009). November 3, 2010, http://ludlums.com

NRC, 1977. Regulatory Guide 8.10, Revision 1-R, "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable," May 1977.

NRC, 1980. Regulatory Guide 4.14, Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills," Washington, DC, April 1980.

NRC, 1992b. Regulatory Guide 8.34, "Monitoring Criteria and Methods To Calculate Occupational Radiation Doses," July 1992.

NRC, 2002a. Regulatory Guide 8.30, Revision 1, "Health Physics Surveys in Uranium Recovery Facilities," May 2002.

NRC, 2002b. Regulatory Guide 8.31, Revision 1, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," May 2002.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

NRC, 2005. Regulatory Guide 8.7, Revision 2, "Instructions for Recording and Reporting Occupational Radiation Exposure Data," November 2005.

5.7.4 IN-PLANT AIRBORNE RADIATION MONITORING PROGRAM

5.7.4.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed in-plant radiation monitoring program for the Lost Creek Project meets requirements of 10 CFR Part 20, Subparts B and C, 10 CFR 20.1501, and 10 CFR 20.1702.

5.7.4.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in Section 5.7.3.3 of the Standard Review Plan (SRP) (NRC, 2003a). Regulatory Guide 8.30 provides guidance on how the applicant can demonstrate compliance with the regulations.

5.7.4.3 Staff Review and Analysis

This section describes the in-plant airborne radiation-monitoring program. In-plant airborne radiation monitoring includes the airborne uranium particulate monitoring, radon progeny concentration monitoring, and respiratory protection program. In-plant airborne radiation monitoring measures airborne concentrations at various locations in the processing plant to determine necessary posting requirements, respiratory protection needs, and dose assessments. In demonstrating compliance with these requirements, the applicant must provide acceptable methods for determining internal radiation dose including accounting for the presence of mixtures of contaminants as described in 10 CFR Part 20, Subpart C. Table 1 in Appendix B to 10 CFR Part 20 specifies the Derived Air Concentrations (DACs) for each contaminant. Each DAC identifies the concentration for that radionuclide that, if breathed over a course of 2000 hours by a worker, would result in an Annual Limit of Intake (ALI), which equates to the annual occupational dose limit.

5.7.4.3.1 General Program Description

The staff notes that while the primary operations at Lost Creek Project will be wet operations and the lixiviant will be contained within its primary boundary, airborne radioactivity could result from spills, leaks, and maintenance activities. The applicant should design the in-plant airborne radiation monitoring program to detect these contaminants if they escape the primary boundary.

The applicant stated in Section 5.7.3 of the application (LCI, 2008c, 2010a) that the proposed locations of routine airborne particulate and radon progeny sampling are depicted in Figure 5.7-1 of the technical report, which is reproduced in this SER as Figure 5.7-1. SER Table 5.7-1 presents the types of surveys, frequencies, and analyses that LCI will conduct in support of the in-plant radiation-monitoring program. The applicant stated (LCI, 2008c, 2010a) that area air sampling frequency will be determined in accordance with Regulatory Guide 8.30, and that the air sampling program will be conducted in accordance with Regulatory Guide 8.25, "Air Sampling in the Workplace" (1992a). The remaining subsections in SER Section 5.7.4 describe the staff's detailed analysis of the specific air monitoring programs.

5.7.4.3.2 Airborne Particulate Uranium Monitoring

The applicant stated in Section 5.7.3.1 of the application (LCI, 2008c, 2010a) that measurement of airborne uranium will be performed by gross alpha counting of the glass fiber

Table 5.7-1: Summary of Routine In-Plant Radiation Surveys and Monitoring

Type of Survey	Areas to be Surveyed	Frequency	Equipment	Type of Analysis	Estimated LLD
Particulate Air Monitoring: Breathing Zone	As determined by the RSO or required by a RWP	As determined by the RSO or required by a RWP	1. Lapel sampler 2. Alpha counting equipment	Gross alpha	2×10^{-12} µCi/ml
On-site Particulate Air Monitoring	In areas shown in Figure 5.7-1 and as determined by the RSO	Monthly	Low volume sampler Alpha counting equipment	Gross alpha	2×10^{-12} µCi/ml
Radon decay products (Working Level)	All buildings normally occupied by workers and as required by an RWP	Monthly for concentrations < 0.08 WL. Weekly for concentrations >0.08 WL	Sampling pump and filter cassettes Alpha counting equipment	Working Level by Kusnetz Method	0.03 WL
Fixed Surface Contamination	All occupied buildings at locations designated by the RSO (lunchrooms, etc.)	Weekly	Alpha survey meter	Total alpha	500 dpm-100 cm^2
Removable Surface Contamination	Same as above	Weekly	Smears Alpha counting equipment	Removable alpha	100 dpm-100 cm^2
Personal contamination self survey	Survey hands, feet, clothing	On leaving the restricted area or entering lunchrooms or break areas	Alpha survey meter	Gross alpha, meter set to alarm at 20 cpm	100 dpm-100 cm^2
Vehicle survey	Tires, wheel wells, cab, truck bed, and other areas as appropriate	On leaving the restricted area	GM pancake probe	50 cpm above background	500 dpm-100 cm^2
Equipment Contamination	All surfaces, scan and smears	Prior to release for unrestricted use or use off site	Alpha survey meter GM pancake probe Smears Alpha counting equipment	Gross alpha and gross beta Removable gross alpha	Fixed 500 dpm-100 cm^2 Removable 100 dpm-100 cm^2
Gamma exposure rate	In plant (see Figure 5.7-1)	Semi-annual except quarterly in designated "Radiation Areas"	MicroR meter or equivalent	Gamma exposure rate	5 µR/hr above background

(LCI, 2008c, 2010a)
(Source: Adapted from Table 5.7-1 in the technical report)

filters for uranium air particulates. Samples will be collected monthly at the slurry storage tanks and filter press using an F&J Specialty Products, Inc., Model LV-1 low volume or equivalent sampler (F&J, 2010). The applicant selected these locations for sampling because it expects workers at these locations to have the highest potential for exposure to airborne uranium. Additionally, the applicant committed to using breathing zone samplers, worn on the upper torso, anytime a worker may be exposed to 12 DAC-hours in any single week (LCI, 2008c, 2010a).

The staff notes that radium-226 and lead-210 (from the decay of radon-222 and its short-lived progeny) might also be present in the air, and, thus, a mixture of radionuclides might be present on the air filters. Although the applicant (LCI, 2010a) stated that analysis of samples will be delayed 24 hours to allow short-lived radon progeny to decay, the staff notes that gross alpha counting of the air filters will not be able to differentiate specific radionuclides. Consequently, the applicant might not be able to determine accurately if the action level for uranium or other alpha emitting radionuclides, such as radium-226, has been reached by relying on gross alpha counting of the air filters.

To confirm that natural uranium is the primary radionuclide of concern in airborne particulate samples, the applicant stated in Section 5.7.3.2 of the technical report (LCI, 2010a) that LCI will conduct isotopic airborne sampling from each of the air particulate monitoring locations, as indicated in Figure 5.7-1 of the technical report. Analytical results will be compared to mixture requirements in 10 CFR 20.1204(g) to ensure that the appropriate DAC is used. If a mixture of radionuclides exists that does not meet the exclusion rule of 10 CFR 20.1204(g), LCI will use a sum of fractions method to determine the appropriate DAC in accordance with 10 CFR 20.1202(b)(1), 20.1204(e) and (g), and Appendix B to 10 CFR Part 20 (LCI, 2008c, 2010a).

The applicant stated that it will use a DAC value for inhalation Class W natural uranium for occupational airborne concentrations, and stated the LLD for natural uranium, Class W, will be less than 3.0×10^{-11} µCi/mL (LCI, 2008c, 2010a). The staff notes that 3.0×10^{-11} µCi/mL of air represents 10 percent of the DAC for natural uranium, Class W, for inhalation in Table 1 of Appendix B to 10 CFR Part 20. Therefore, the staff has determined that the applicant has established the LLD for uranium in air within the processing plant consistent with Regulatory Guide 8.30 and acceptance criterion (3) of SRP Section 5.7.3.3. However, to ensure that the appropriate DAC is used to limit and determine personnel exposures, as described in Section 5.7.4 of the technical report (LCI, 2008c, 2010a) and discussed in SER Section 5.7.5, a license condition (presented in SER Section 5.7.4.4) will be imposed to ensure that the applicant conducts the isotopic analyses as stated in the technical report. The analyses to identify the isotopes and concentrations of each isotope present are required to ensure the appropriate DAC is selected from Table 1 in Appendix B of 10 CFR Part 20 and exposures are in compliance with 10 CFR 20.1201 and 20.1204. Additionally, the analyses are required to ensure that the sum of all nuclides are considered in accordance with 10 CFR 20.1204(e)(1) or meet the requirements to be disregarded as described in 10 CFR 20.1204(g) and measured in accordance with 10 CFR 20.1502(b).

5.7.4.3.3 Radon Progeny Concentration Monitoring

The applicant stated in Section 5.7.3.3 of the technical report (LCI, 2010a) that the predominant radionuclide expected to be present in the processing plant in air would be radon-222, and that radon samples will be analyzed monthly on an alpha scaler using the modified Kusnetz method. Furthermore, the LLD for radon-222 with progeny will be no greater than 0.03 working level

(WL) (LCI, 2008c, 2010a). The staff notes that 0.03 WL represents 10 percent of the DAC for radon-222 with progeny for inhalation in Table 1 of Appendix B to 10 CFR Part 20. Regulatory Guide 8.30 recommends that the quantity of the air sampled and the method of analysis should be 10 percent of the Appendix B to 10 CFR Part 20 limit for radon; therefore, the staff determined that the LLD for radon in air is consistent with Regulatory Guide 8.30 and Appendix B to 10 CFR Part 20, and is, therefore, acceptable. Also, because the applicant will not be operating a dryer, the staff agrees that radon is expected to be the predominant airborne radionuclide at the Lost Creek Project.

The purpose of the modified Kusnetz method is to reduce the magnitude of the counting error by use of a time factor to back-calculate the true concentration during sampling if nonequilibrium conditions exist (NRC, 2002a). Considering the nature of the operational process and activities that could occur in the plant and that radon will be the predominant radionuclide in the plant, the staff notes that a potential exists for nonequilibrium conditions to occur during operations. Results of radon progeny sampling will be expressed in WLs, according to the applicant (LCI, 2010a) and in accordance with 10 CFR Part 20, where 1 WL is defined as any combination of short-lived radon-222 progeny in 1 liter of air, without regard to equilibrium, that emits 1.3×10^5 million electron volts of alpha energy. The staff has reviewed the proposed modified Kusnetz method for the radon progeny monitoring program and determined that the method is consistent with recommendations in Regulatory Guide 8.30 and is in compliance with exposure calculations in 10 CFR 20.1201 and 20.1204. However, as discussed in SER Section 5.7.4.3.2, the applicant must verify that alpha radiation measured is actually radon progeny. By conducting isotopic analyses of air samples and including longer lived radon progeny Po-210 and Pb-210 in the analyses, the staff finds that the applicant can obtain data to support the applicant's assumptions (a) that radon will be the primary airborne radioactive material present and (b) that natural uranium will be the primary air particulate present to be used in dose calculations.

5.7.4.3.4 Action Levels

Regulatory Position 3.3, "Ventilation Systems," of Regulatory Guide 8.31 states that the facility should establish a facility-specific operational ALARA goal for concentrations of natural uranium and its progeny at less than 25 percent of the DAC values (NRC, 2002b). The applicant set an action level of 25 percent of the DAC for natural uranium in the plant, and the DAC for (inhalation Class W) natural uranium is 3×10^{-10} µCi/mL (LCI, 2010a). Due to the lack of actual operational data, the applicant will assume the natural solubility is Class W for purposes of establishing the initial DAC upon plant startup (LCI, 2010a). The staff notes that if after operations commence the applicant would like to change the inhalation class, it will be required to submit samples demonstrating that such a change is warranted.

The DAC in Table 1 of Appendix B to 10 CFR Part 20 for radon-222 with its progeny present is 0.33 WL. The applicant proposed an action level of 25 percent of the DAC or 0.08 WL (LCI, 2010a). The applicant indicated that air sample results that exceed the action level would result in an investigation of the cause of the elevated concentrations (LCI, 2010a). The staff has determined that the proposed action of 25 percent of the DAC for radon-222 with progeny is consistent with Regulatory Guide 8.31 and that the action levels for natural uranium and radon will adequately protect the Lost Creek Project workers and comply with 10 CFR Part 20.

5.7.4.3.5 Respiratory Protection

The applicant stated in Section 5.7.10 of the technical report (LCI, 2010a) that respiratory protection will be used where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials and that this respiratory protection program will be implemented in accordance with Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection, (NRC, 1999b). The staff finds that this approach also meets the requirements of 10 CFR 20.1702, "Use of Other Controls," which requires monitoring and limiting intake by one or more methods to maintain the TEDE ALARA if engineering controls are not practical. These methods include controlling access, limiting exposure times, use of respirators, and additional safety factors other than radiological to determine if respirators should be used.

The applicant stated that its respirator program will only be used as a last line of defense against airborne particulate (LCI, 2010a). The RSO will evaluate the effectiveness of existing engineering and administrative controls in order to determine when a respirator is required, and will ensure that the respiratory protection program includes the following as recommended in Regulatory Guide 8.15:

- Respirators will be National Institute for Occupational Safety and Health (NIOSH) approved;
- Monitoring, including air sampling and bioassays to evaluate actual intakes;
- Performing and documenting the required medical evaluation;
- An operational test to include fit testing;
- Written procedures describing proper respirator use and maintenance; and
- An air-sampling program sufficient to identify potential hazards, permits proper equipment selection, and assign doses.

Accordingly, the staff finds the applicant's respiratory protection program to be consistent with the recommendations in Regulatory Guides 8.15 and 8.25 and in compliance with the regulatory requirements in 10 CFR Part 20, Subpart H, Respiratory Protection. The staff finds the applicant also plans to monitor workers' intake by air sampling or bioassay to determine exposure as required by § 20.1204 and § 20.1502(b). The staff notes that § 20.1703(c)(4)(vii) requires written procedures that address the quality assurance (QA) of respiratory protection equipment in addition to the use and maintenance described by the applicant. The applicant's proposed Quality Assurance Project Plan (QAPP), which is described briefly in Attachment 5.2-1 to the technical report (LCI, 2010a), is planned for environmental and effluent monitoring following guidance in Regulatory Guide 4.15 (NRC, 2007b). Although the applicant did not specifically address a QA program, the applicant committed to developing and administering a respirator program consistent with requirements in 10 CFR 20.1703 (LCI, 2010a). The staff finds the applicant's proposed respiratory protection program to be in compliance with 10 CFR Part 20, Subparts B, C, F, and H, and thus, acceptable.

5.7.4.4 Evaluation Findings

The staff reviewed the in-plant airborne radiation monitoring program of the proposed Lost Creek Project in accordance with SRP Section 5.7.3.3. The applicant plans to conduct in-plant airborne monitoring consistent with Subpart B, "Radiation Protection Programs," of 10 CFR Part 20 (10 CFR 20.1101), which defines the radiation protection

program. This program includes monitoring for the two primary contaminants and the instruments that it will use to collect and analyze the results of the air samples. The applicant has demonstrated that adequate methods will be used to fully evaluate the airborne particulate monitoring as required by 10 CFR 20.1501 and 20.1502(b). The applicant has identified methods that will meet the occupational dose limit requirements of Subpart C of 10 CFR Part 20 and will control the concentration of radioactive material in air as required in § 20.1701. Additionally, the applicant has committed to using the sum of fractions method to determine the appropriate DAC if LCI identifies that a mixture exists that does not meet the exclusion rule of 10 CFR 20.1204(g). To ensure the applicant meets this commitment and complies with the exposure limits in 10 CFR 20.1201, § 20.1204 and Table 1 of Appendix B to 10 CFR Part 20, the following license condition is included in the Lost Creek Project license:

> The licensee shall conduct radiological characterization of airborne samples for natural U, Th-230, Ra-226, Po-210, and Pb-210 for each restricted area air particulate sampling location at a frequency of once every 6 months for the first 2 years following issuance of the license, and annually thereafter to ensure compliance with 10 CFR 20.1204(g). The licensee shall also evaluate changes to plant operations to determine if more frequent radionuclide analyses are required for compliance with 10 CFR 20.1204(g).

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by information submitted in accordance with the noted license condition, meets the applicable acceptance criteria of SRP Section 5.7.3.3 and the requirements of 10 CFR Part 20, Subparts B, C, and H, 10 CFR 20.1501, and 10 CFR 20.1502(b).

5.7.4.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

ANSI, 1978. "Radiation Protection Instrumentation Test and Calibration," N323-1978, American National Standard, Approved September 13, 1977, Reaffirmed March 11, 1991.

F&J, 2010. F&J Specialty Products, Inc., Model LV-1 (2005), December 6, 2010 from http://www.fjspecialty.com/lv-1.htm

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 1992a. Regulatory Guide 8.25, Revision 1, "Air Sampling in the Workplace," June 1992.

NRC, 1999b. Regulatory Guide 8.15, Revision 1, "Acceptable Programs for Respiratory Protection," October 1999.

NRC, 2002a. Regulatory Guide 8.30, Revision 1, "Health Physics Surveys in Uranium Recovery Facilities," May 2002.

NRC, 2002b. Regulatory Guide 8.31, Revision 1, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," May 2002.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

5.7.5 EXPOSURE CALCULATIONS

5.7.5.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed exposure calculation for the Lost Creek Project meets requirements of Subparts C, F, L, and M of 10 CFR Part 20. Specific regulations that must be followed include 10 CFR 20.1201(e), 10 CFR 20.1204(f), 10 CFR 20.1204(g), and 10 CFR 20.1502.

5.7.5.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in Section 5.7.4.3 of the Standard Review Plan (SRP) (NRC, 2003a). Regulatory Guides 8.13 and 8.36 (NRC, 1992a) provide guidance on how compliance with the regulations can be demonstrated.

5.7.5.3 Staff Review and Analysis

The following sections discuss the exposure calculations, which include internal and external occupational radiation dose as well as radiation doses to the embryo/fetus. Occupational workers can be exposed externally and internally to radioactive material in a number of ways. This could include radioactive material in the air, loose surface contamination, or radioactive material that might be stored or processed inside equipment or components.

5.7.5.3.1 Worker Dose Calculations

The applicant stated in Section 5.7.4 of the technical report (LCI, 2010a) that it will monitor worker exposures by using the following or a combination of the following methods:

- personal dosimeters,
- area radon progeny concentration measurements as described in Section 5.7.3.2 of the technical report,
- area measurements of gross alpha concentrations in airborne particulate matter as described in Section 5.7.3.1 of the technical report, and
- measurement of radionuclide concentrations in worker breathing zones.

The applicant will use dosimetry to measure the deep dose equivalent (DDE), which can be used as the effective dose equivalent (EDE) or the external component of occupational exposure (LCI, 2008c, 2010a). The applicant stated that the committed effective dose equivalent (CEDE) or internal dose component of the occupational exposure will be calculated from air sampling results and/or bioassays (LCI, 2010a). The staff notes that both of these components are needed to determine the total effective dose equivalent (TEDE) (i.e., TEDE = DDE + CEDE) to assess compliance with 10 CFR Part 20 annual occupational dose limits. Direct calculations of the annual dose of inhaled radionuclides may be determined from the DAC concentration of a radionuclide in air as discussed in SER Section 5.7.4. The applicant committed in Section 5.7.3.2 of the technical report to assess the DAC for site-specific conditions (LCI, 2010a). Additionally, the applicant proposed to implement corrective actions for workers that exceed 25 percent of the 10 CFR Part 20 annual occupational dose limits (LCI, 2008c, 2010a).

The applicant stated that intakes will be totaled and entered onto each employee's occupational exposure record (LCI, 2008c, 2010a). Reporting and recordkeeping will be consistent with Regulatory Guide 8.7 (NRC, 2005) and 10 CFR 20.2103. The applicant stated that employees will be informed of their annual dose, and their dose records will be maintained by the licensee (LCI, 2010a). The staff finds that the applicant's worker dose calculations and record keeping procedures are consistent with acceptance criteria (1) and (8) of SRP Section 5.7.4.3 (NRC, 2003a), are consistent with recommendations in Regulatory Guides 8.7 and 8.34, and are in compliance with requirements in 10 CFR 19.13(b) and 10 CFR Part 20, Subparts C, F, L and M. The staff finds that the applicant described this information in sufficient detail to demonstrate compliance with the NRC's regulations and that it is, therefore, acceptable.

5.7.5.3.2 External Dose Calculation

The applicant described worker dose calculations in Section 5.7.4 of the technical report (LCI, 2010a) and stated that worker doses will be calculated annually based on personal dosimetry data and the airborne radionuclide concentration measurements if the TEDE potentially exceeds 10 percent of the annual dose limit specified in 10 CFR Part 20. The applicant committed (LCI, 2010a) to following Regulatory Guides 8.30, 8.34, and 8.36, "Radiation Dose to the Embryo/Fetus" (NRC, 1992c).

The applicant stated (LCI, 2008c, 2010a) that exposure calculations will be based on exposure to natural uranium and radon-222 progeny and will be measured with individual dosimeters, such as TLDs, or optically stimulated luminescence dosimeters that will be exchanged quarterly. Dosimetry will be provided by a vendor with NVLAP accreditation as required by 10 CFR Part 20, Subpart F, and will be issued in accordance with 10 CFR 20.1502(a), to employees that may be exposed to 10 percent of the annual limits in 10 CFR 20.1201, 20.1207, and 20.1208 (LCI, 2010a).

Staff finds that this approach is acceptable for determining external exposures by measurement with an external personal monitoring device and that the applicant will use the DDE to define the TEDE from external exposures. The applicant committed (LCI, 2010a), in Section 5.7.4 of the technical report, to recording the results in accordance with 10 CFR Part 20, Subpart L; therefore, this approach is acceptable to the staff to meet the applicable regulatory requirements, as detailed above.

The applicant stated that the RSO would use monitoring and survey data to ensure that external radiation exposures are less than 10 percent of the occupational dose limit for all unmonitored

workers (LCI, 2008c, 2010a). The applicant did not describe the frequency that it will monitor the survey data. Consequently, the staff has determined that unmonitored employees could possibly receive a dose in excess of 10 percent of the dose limits prior to the RSO's review. The applicant has not adequately described how it will ensure that unmonitored employees who do not have dosimetry have not exceeded 10 percent of the dose limit. Therefore, the staff will include a license condition requiring the applicant to submit to the NRC for review and approval, procedures by which LCI will ensure that unmonitored employees will not exceed 10 percent of the dose limits in 10 CFR Part 20, Subpart C. SER Section 5.7.5.4 describes this license condition.

5.7.5.3.3 Internal Dose Calculation

The applicant has provided equations and input parameters for computing the intake from natural uranium and radon progeny in Section 5.7.4.1 of the technical report (LCI, 2008c, 2010a). The staff finds that the equations and input parameters follow the recommendations in Regulatory Guide 8.30 and 8.25, and, as such, are in compliance with 10 CFR 20.1202. The applicant stated (LCI, 2010a) that it will analyze the in-plant air particulate samples for gross alpha, assumed to be primarily natural uranium, and will use the specific activity of 0.68 µCi/g for natural uranium to convert the gross alpha counts from the filter paper to airborne concentration of natural uranium (LCI, 2010a). According to the applicant, inhalation is the most probable route of intake of airborne particulate matter under routine operating conditions. The applicant will assume the airborne uranium particulates to be inhalation Class W with DAC of 3 x 10^{-10} µCi/mL (LCI, 2008c, 2010a). The staff finds that the equations used by the applicant and discussed in the subsequent paragraphs are consistent with the recommendations in Regulatory Guides 8.25 and 8.30 and thus in compliance with 10 CFR 20.1204. However, as discussed in SER Section 5.7.4 , the applicant will need to have the isotopic analyses of the air samples to verify that uranium or radon progeny or a mixture of radionuclides are present and to calculate workers doses in accordance with 10 CFR Part 20.

Equation 1: Calculation of Intake from Long-Lived Radionuclide Using Monitoring Data

$$I_r = \sum_{i=1}^{i=n} \frac{\left(BR * C_r * H * \left(\frac{10^6 ml}{m^3}\right)\right)}{PF}$$

Where I_r = annual intake of radionuclide *r* by inhalation (µCi)
r = radionuclide of interest
i = exposure period
n = number of exposures in the year
BR = breathing rate, 1.2 m^3/hr
C_r = concentration of radionuclide r (µCi/ml)
H = period of exposure (hr)
PF = the respirator protection factor (unitless)

The applicant stated in Section 5.7.4.1 of the technical report (LCI, 2010a) that it will use breathing zone samplers when workers may be exposed to airborne radioactivity in excess of 10 percent of the DAC, and will record the time of exposure as the actual time the sampler was worn. The applicant stated that when it uses a single breathing zone sampler to monitor the exposure of a group of employees, it will use the data collected from the sampler to determine and record the exposure for the entire group. Additionally, LCI will use employee time sheets to

estimate the period of exposure for employees working in areas with the potential for airborne radioactivity concentrations exceeding 10 percent of the DAC and will monitor using air samplers rather than breathing zone samplers. The applicant stated that it would use time sheets to determine the period of exposure when the airborne concentrations are expected to be greater than 10 percent of the DAC averaged over an 8-hour day (LCI, 2008c, 2010a). The staff finds that the applicant's proposed use of (a) breathing zone samplers, (b) the DAC to determine the CEDE, and (c) the equation used to calculate the CEDE is consistent with acceptance criteria (5) and (6) of SRP Section 5.7.4.3 because (a) the applicant described exposure calculations for routine, non-routine, maintenance, and cleanup operations, and (b) exposure calculations are representative of conditions at the site and include time-weighted exposures that incorporate occupancy time and average airborne concentrations. Furthermore, the staff finds that the applicant's proposal is consistent with the guidance in Regulatory Guides 8.25 and 8.30 and in compliance with 10 CFR 20.1204. .

Equation 2: Calculation of CEDE from Inhalation Intake of Long-Lived Radionuclide by Using DAC-hr

$$CEDE = \sum_{i=1}^{i=n} \frac{\left(C_r * H * \left(\frac{0.0025rem}{DAC-hr}\right)\right)}{DAC * PF}$$

Where $CEDE$ = committed effective dose equivalent (rem)
r = radionuclide of interest
i = exposure period
n = number of exposures in the year
C_r = concentration of radionuclide r (µCi/ml)
H = period of exposure (hr)
DAC = derived air concentration (µCi/ml)
PF = the respirator protection factor (unitless)

Equation 3: Calculation of CEDE from Inhalation Intake of Radon Progeny

$$CEDE = \sum_{i=1}^{i=n} \frac{\left(WL * H * 5rem\right)}{\left(\frac{170hr}{month}\right) * 4WLM * PF}$$

Where WL = Working Level, measured concentration of radon progeny.
WLM = Working Level Month, exposure of 1 WL for 1 working month (170 hours) equals 1 WLM cumulative exposure.

The applicant also included calculations using dose conversion factors (DCFs) from Federal Guidance No. 11 (EPA, 1988) and dose coefficients (DCs) from International Commission on Radiological Protection (ICRP) Report No. 68 (ICRP, 1995) (LCI, 2008c, 2010a). However, the applicant acknowledged that 10 CFR Part 20 is based on ICRP 26 and 30, and that it must obtain approval prior to use of ICRP 68. Therefore, the applicant will seek NRC approval if it wants to use these methods in the future (LCI, 2008c, 2010a). The staff finds that the applicant's calculations using the working level for the measured concentration of radon

progeny, as determined by the modified Kusnetz method, to determine the CEDE and the equation used to calculate the CEDE are:

(1) consistent with acceptance criterion (2) and (3) of SRP Section 5.7.4.3 because the exposure calculations for natural uranium are consistent with Regulatory Guide 8.30, Section 3, and

(2) airborne radon progeny exposure is consistent with Regulatory Guides 8.30 and 8.34, Section C. Additionally, the staff finds that the applicant's method of calculation is consistent with the recommendations in Regulatory Guides 8.25 and 8.30 and complies with 10 CFR 20.1201(d) and 20.1204.

The applicant stated that initial DAC used at the startup of the operations will be based on inhalation Class W value for moderately soluble natural uranium, which is 3.0×10^{-10} µCi/mL (LCI, 2008c, 2010a). Should the applicant choose to alter the inhalation class, simulated lung fluids studies would be required, and such information would be submitted to the NRC as part of a license amendment request (LCI, 2010a). However, the staff notes that the applicant is under no obligation to change the inhalation class, and may use the Class W during operations.

In accordance with 10 CFR 20.1204(f), if the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture must be the most restrictive DAC of any radionuclide in the mixture. The applicant stated that to confirm that natural uranium is the primary radionuclide of concern in airborne particulate samples, isotopic airborne samples will be analyzed from air particulate monitoring locations in Figure 5.7-1 of the technical report (LCI, 2008c, 2010a). Results of these samples will be compared with the mixture requirements in 10 CFR 20.1204(g) to ensure that the appropriate DAC value is used. If a "mixture" exists that does not meet the exclusion rule of 10 CFR 20.1204(g), a sum of fractions method will be used to determine the appropriate DAC (LCI, 2010a). The staff has determined that the applicant will need to conduct periodic isotopic airborne sampling and compare the results to 10 CFR 20.1204(g) to ensure that the appropriate DAC from Table 1 of Appendix B to 10 CFR Part 20 is used, and will include a license condition to achieve this purpose. The language for this license condition is discussed in SER Section 5.7.4.4.

In addition to the annual dose limits, the applicant will limit soluble uranium intake by an individual to 10 mg in a week in consideration of the chemical toxicity in accordance with 10 CFR 20.1201(e) (LCI, 2008c, 2010a). The average concentration at the soluble weekly intake limit is approximately equal to 50 percent of the DAC, as calculated using inhalation Class W, as discussed above. The applicant will demonstrate compliance with this requirement by recording worker airborne exposure in DAC hours whenever long-lived particulate concentrations in air are determined to be greater than or equal to 10 percent of the DAC. Assignments of positive airborne exposures will be reviewed weekly and any exposures of soluble uranium greater than 20 percent of the 10 mg per week limit will be recorded (in DAC hours) and controlling exposures to be 25 percent of the DAC. The applicant stated that this procedure will ensure both that the weekly intake limit is not exceeded, and will be ALARA (LCI, 2008c, 2010a). The staff finds that the applicant's procedures are consistent with acceptance criterion (1) in SRP Section 5.7.4.3 by describing proposed methodologies in accordance with 10 CFR 20.1201 and 20.1204 and the applicant has demonstrated an acceptable method for ensuring the soluble intake of uranium is limited to comply with 10 CFR 20.1201(e).

5.7.5.3.4 Prenatal/Fetal Dose

The applicant stated in Section 5.7.4 of the SER (LCI, 2008c; LCI, 2010a) that the dose equivalent to the embryo/fetus will be determined by monitoring its declared pregnant female employees at the Lost Creek Project. The DDE will be used for this purpose during the gestation period and the applicant will apply this DDE to the embryo/fetus for external dose. For internal dose, exposure calculations will be performed in accordance with Regulatory Guide 8.36. Doses to the embryo/fetus will be determined if the intake is likely to exceed 1 percent of the ALI during the entire period of gestation. The applicant stated that female workers will receive training on the risks associated with prenatal radiation exposure and LCI policy for declared pregnant women, including dose limits and rates (LCI, 2008c; LCI, 2010a). The staff finds these procedures for calculating and limiting the dose of the pregnant employee and fetus to be acceptable, as they are consistent with the guidance in Regulatory Guide 8.36 and acceptance criterion (4) of SRP Section 5.7.4.3 (NRC, 2003a), , and thus comply with 10 CFR 20.1208.

5.7.5.3.5 Records

According to 10 CFR 19.13, "Notifications and Reports to Individuals," any employee may request a written report of his or her exposure history at any time. Pursuant to 10 CFR 19.13, these reports must be provided within 30 days of the request or within 30 days after the exposure of the individual has been determined by the licensee, and must provide the information indicated in the regulation. The applicant committed, in Section 5.7.2.1 of the technical report, to provide employees with copies of exposure reports annually and upon termination of employment (LCI, 2008c; LCI, 2010a). Although the applicant did not specifically state that it would provide an exposure report within 30 days upon request from an employee, the description of the annual worker training in Section 5.5 of the technical report (LCI, 2010a) provides the NRC staff reasonable assurance that the applicant is prepared to meet this regulatory requirement. Because the applicant stated in Section 5.5 of the application that annual training would include worker rights, responsibilities, and notifications "to insure that site personnel will, at all times, have sufficient awareness", the staff has reasonable assurance that the applicant is aware of, and will comply with, the regulatory requirements of 10 CFR Part 19. The staff finds that the applicant's discussion of monitoring, records, and reports is consistent with acceptance criterion (8) of SRP Section 5.7.4.3 and in compliance with the regulatory requirements in 10 CFR Part 20, Subparts F, L, and M. Therefore, the staff finds these procedures acceptable.

5.7.5.4 Evaluation Findings

The staff reviewed the exposure calculations for the proposed Lost Creek Project in accordance with SRP Section 5.7.4.3. The applicant has identified techniques for exposure calculations at the Lost Creek Project to determine intake of radioactive materials by personnel in work areas. The applicant provided exposure calculations for natural uranium and airborne radon progeny exposure. These calculations include prenatal and fetal radiation, as well as routine operations, nonroutine operations, maintenance, and cleanup activities. The applicant has classified the inhalation class and solubility for the DAC to determine the correct internal dose. The applicant will also identify each radionuclide in a mixture when the concentration of one or more is not known, so that the DAC for the mixture is the most restrictive DAC of any radionuclide in the

mixture, as required by 10 CFR 20.1204 and 20.1502(b). A license condition, described in SER Section 5.7.4.4, will be imposed to ensure that these requirements are met.

The applicant's program for calculating internal and external exposures to workers is acceptable, except that the applicant has not completely described the methods that it will use to ensure that unmonitored employees who do not have dosimetry have not exceeded 10 percent of the dose limit to ensure compliance with 10 CFR 20.1502(a)(1). Therefore, the staff has included the following license condition that must be fulfilled prior to commencement of operations:

> The licensee shall submit to the NRC for review and approval the procedures by which it will ensure that unmonitored employees will not exceed 10 percent of the dose limits in 10 CFR Part 20, Subpart C.

Based upon the review conducted by the staff as indicated above, the staff is reasonably assured that the applicant will properly calculate internal and external exposures to workers, contingent upon the applicant's fulfillment of the above license condition. Furthermore, the information provided in the application, as supplemented by information submitted in accordance with the noted license condition, is consistent with the acceptance criteria of SRP Section 5.7.4.3 and meets the requirements of 10 CFR Part 20, Subparts C, F, L, and M.

5.7.5.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

Presidential Memorandum:"Radiation Protection Guidance to Federal Agencies for Occupational Exposure," signed by Ronald Reagan, *Federal Register,* 52 FR 2822; January 27, 1987.

EPA, 1988. "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Federal Guidance Report No. 11, EPA 520/1-88-02, September 1988.

International Commission on Radiological Protection (ICRP), 1995. "Dose Coefficients for Intakes of Radionuclides by Workers," ICRP Publication 68," *Annals of the ICRP*, Vol. 24, No. 4, Pergamon Press, Oxford, England.

NRC, 1992a. Regulatory Guide 8.25, Revision 1, "Air Sampling in the Workplace," June 1992.

NRC, 1999b. Regulatory Guide 8.15, Revision 1, "Acceptable Programs for Respiratory Protection," October 1999.

NRC, 1992c. Regulatory Guide 8.36, "Radiation Dose to the Embryo/Fetus," July 1992.

NRC, 2001. NUREG-1736, "Consolidated Guidance: 10 CFR Part 20 Standards for Protection Against Radiation," November 2001.

NRC, 2002a. Regulatory Guide 8.30, Revision 1, "Health Physics Surveys in Uranium Recovery Facilities," May 2002.

NRC, 2002b. Regulatory Guide 8.31, Revision 1, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," May 2002.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

NRC, 2005. Regulatory Guide 8.7, Revision 2, "Instructions for Recording and Reporting Occupational Radiation Exposure Data," November 2005.

5.7.6 BIOASSAY PROGRAM

5.7.6.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed bioassay program for the Lost Creek Project meets the requirements of Subparts C, L, and M of 10 CFR Part 20.

5.7.6.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in Section 5.7.5.3 of the Standard Review Plan (SRP) (NRC, 2003a). Regulatory Guides 8.9 (NRC, 1993a), 8.22 (NRC, 1988c), 8.30 (NRC, 2002a), and 8.34 (NRC, 1992b) provide guidance on meeting the applicable regulations.

5.7.6.3 Staff Review and Analysis

The following sections discuss the applicant's proposed bioassay program, which is designed to monitor and document potential internal uptakes and radiation exposures and to confirm the results of the airborne uranium particulate monitoring program.

5.7.6.3.1 Frequency

The applicant stated in Section 5.7.5 of the technical report (LCI, 2008c, 2010a) that the bioassay program will follow guidelines set forth in Regulatory Guide 8.22 and NUREG-0874, Internal Dosimetry Model for Applications to Bioassay at Uranium Mills (NRC, 1986b); and that urinalysis will be the bioassay method used to detect exposures to low-fired, relatively soluble uranium compounds. LCI proposed in Section 5.7.4 of the technical report to initially assume that airborne uranium compounds are inhalation Class W and to evaluate the solubility issue

after operations begin. According to the applicant, it will collect bioassay samples at the following frequencies:

- baseline urinalysis sample for new employees prior to working at the facility
- monthly for employees who have the potential to be exposed to dried yellowcake or more frequently as determined by the RSO
- upon termination of employment for all employees

The applicant stated that it would establish action levels for employees that submit bioassay samples based on Tables 1 and 2 of Regulatory Guide 8.22 (LCI, 2008c, 2010a). Furthermore, employees will deposit and submit the monthly urine samples following 1–2 days off from work to allow for clearance and elimination of uranium that does not become systemic and absorbed by the kidneys. According to the applicant, standard practice for routine urinalysis programs is to assume that the exposure/intake occurred on the day or days immediately following the previous sample collection. Additionally, the applicant stated (LCI, 2010a) that samples may also need to be collected in response to the following:

- potentially elevated airborne concentrations;
- as may be required by RWPs;
- whenever respiratory protection devices are found to be internally contaminated following use; and
- whenever internal exposure has been suspected, such as in response to positive nasal and/or mouth swabs.

The staff finds that the proposed collection frequency and analysis of urine samples are consistent with recommendations in Regulatory Guide 8.22 to ensure occupational exposures are monitored and comply with the limits in 10 CFR Part 20, Subparts C and F.

Regulatory Guide 8.22 recommends that users consider in vivo lung counts or alternate sampling times and action levels for exposures to Class W or Class Y materials. The applicant stated that it would perform in vivo analyses as follow up to confirmed urinalysis results in excess of action levels, as specified in Table 1 of Regulatory Guide 8.22 (LCI, 2008c, 2010a). The staff finds that this procedure is acceptable, as it is consistent with the recommendations in Regulatory Guide 8.22 and complies with occupational exposure requirements in 10 CFR Part 20, Subparts C and F.

5.7.6.3.2 Dose Determination

The applicant stated in Section 5.7.5 (LCI, 2008c; LCI, 2010a) that it will assign occupational dose to workers using the stochastic inhalation ALI and DAC per methods 1 and 2 identified in Regulatory Guide 8.30. The bioassay program will assess the adequacy of the airborne sampling program. At air concentrations that exceed 10 percent of the DAC, the applicant will estimate and assign the DAC-hrs to workers. The applicant stated that confirmed bioassay results might need to be used in situations where (a) the estimated dose could approach or exceed ALIs or (b) the RSO determines that the confirmed bioassay results provide greater accuracy or would be more representative of actual intake. The applicant stated that the methods and assumptions described in Regulatory Guide 8.9 will be used to estimate and assign internal dose using bioassay results (LCI, 2008c; LCI, 2010a).

The applicant stated that if a positive urinalysis result is confirmed, the RSO will conduct an investigation into the circumstances and determine whether internal exposure for an individual should be determined based on bioassay results in accordance with recommendations in Regulatory Guide 8.22 (LCI, 2008c; LCI, 2010a). The staff finds that the applicant has defined an acceptable method for evaluating events when the applicant confirms positive bioassay urinalysis results and makes a decision to convert the confirmed results to a dose. The staff finds that the applicant's methodology described in the application complies with the requirements in 10 CFR Part 20, Subparts C and F.

The applicant will assume U-238 inhalation Class W for purposes of establishing the initial DAC upon plant startup in accordance with Table 1 of Appendix B to 10 CFR Part 20 (LCI, 2008c; LCI, 2010a). The applicant stated that it might continue using the Class W designation for the duration of operations; however, it may perform simulated lung fluid studies to change the classification, if desired (LCI, 2010a). The staff has determined that the initial DAC of Class W is appropriate for determining compliance with Subpart C of 10 CFR Part 20, and thus, the applicant's proposed procedures are acceptable.

5.7.6.3.3 Records and Reporting

10 CFR Part 20, Subparts L and M require recording and reporting monitoring results for employees who are monitored for internal and/or external exposure as required by 10 CFR Part 20, Subpart C. The applicant stated that a permanent radiation dose record for each worker will be maintained by the RSO in a format compliant with NRC Regulatory Guide 8.7 (LCI, 2008c; LCI, 2010a). LCI will provide copies annually to each worker and upon termination of employment. As discussed in SER Section 5.7.3, the applicant stated that the RSO will investigate the cause and possible methods to modify procedures to reduce exposures if a worker receives greater than ten percent of the occupational dose limits in 10 CFR Part 20, Subpart C. The RSO will document investigation findings and results of any corrective actions (LCI, 2008c; LCI, 2010a). The staff finds that LCI's recordkeeping and reporting activities are consistent with recommendations in Regulatory Guide 8.30, and meet acceptance criterion (5) of SRP Section 5.7.5.3, and the regulatory requirements in 10 CFR Part 20, Subparts L and M. The applicant's plan to provide copies of exposure records to employees complies with 10 CFR 19.13. Accordingly, the staff finds the applicant's exposure record and reporting program to be acceptable.

5.7.6.3.4 Quality Assurance/Quality Control (QA/QC)

The applicant committed to follow the QA/QC guidance in Regulatory Guide 8.22 (LCI, 2008c; LCI, 2010a). The applicant will send three blind samples to the laboratory with each batch of samples. The three blind samples will be spiked with uranium as follows: one blank sample with no added uranium, one sample with 10 - 20 µg/L, and one sample with 40-60 µg/L of uranium, respectively, as specified in Regulatory Guide 8.22. LCI stated that the contract laboratory's LLD for uranium in urine will be 5 µg/L or less. If the laboratory results are not within 30 percent of the actual uranium concentrations, the laboratory will re-analyze the samples. In addition, 10 percent of the samples, including blanks and standards, will undergo a duplicate analysis by the laboratory (LCI, 2008c; LCI, 2010a).

The applicant stated that the laboratory should provide results to the RSO within 20 days after the sample collection (LCI, 2010a). The contract laboratory shall report, by telephone, results exceeding 35µg/L within 20 days after sample collection. The applicant states that it will retain a

record of bioassay results and associated QA/QC until license termination and in a form compliant with Regulatory Guide 8.7 (LCI, 2008c; LCI, 2010a). The staff finds that the applicant provided sufficient details for the staff to determine that the QA/QC program is consistent with Regulatory Guide 8.7's recommendations regarding blind samples, duplicates, sample turn-around time, and analytical LLD. Therefore, the staff finds that the applicant's proposed QA/QC procedures for the bioassay program are acceptable because the bioassay data will meet the (a) monitoring requirements in 10 CFR 20.1502; (b) exposure limits in 10 CFR 20.1201, 20.1207, or 20.1208; and (c) recording requirements in 10 CFR 20.2106.

5.7.6.4 Evaluation Findings

The staff reviewed the bioassay program for the proposed Lost Creek Project in accordance with SRP Section 5.7.5.3. The applicant has provided a description of the program for baseline bioassay urinalysis prior to, during, and upon exiting employment. Individuals routinely exposed to yellowcake dust are a part of the bioassay program and, as indicated SER Section 5.7.6.3.1 action levels identified in Table 1 of Regulatory Guide 8.22 will be used at this site.

The applicant has assumed that the inhalation class for the uranium at the Lost Creek Project is Class W, and acknowledges that tests would be required to change that class. Furthermore, the applicant discussed the manner in which confirmed bioassay (urinalysis) results will be converted and assigned as an internal dose to the individual in accordance with 10 CFR 20.1204(b), 20.1703(c)(2), and 20. 2103(b)(3). Based upon the review conducted by the staff as indicated above, the information provided in the application is consistent with the applicable acceptance criteria of SRP Section 5.7.5.3 and meets the requirements of 10 CFR Part 20, Subparts C, L, and M.

5.7.6.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 1977. Regulatory Guide 8.10, Revision 1-R, "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable," May 1977.

NRC, 1986b. NUREG-0874, "Internal Dosimetry Model for Applications to Bioassay at Uranium Mills," July 1986.

NRC, 1988c. Regulatory Guide 8.22, Revision 1, "Bioassay at Uranium Mills," August 1988.

NRC, 1992a. Regulatory Guide 8.25, Revision 1, "Air Sampling in the Workplace," June 1992.

NRC, 1992b. Regulatory Guide 8.34, "Monitoring Criteria and Methods To Calculate Occupational Radiation Doses," July 1992.

NRC, 1993a. "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," Regulatory Guide 8.9, Revision 1, July 1993.

NRC, 1999b. Regulatory Guide 8.15, Revision 1, "Acceptable Programs for Respiratory Protection," October 1999.

NRC, 2002a. Regulatory Guide 8.30, Revision 1, "Health Physics Surveys in Uranium Recovery Facilities," May 2002.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

NRC, 2005. Regulatory Guide 8.7, Revision 2, "Instructions for Recording and Reporting Occupational Radiation Exposure Data," November 2005.

5.7.7 CONTAMINATION CONTROL PROGRAM

5.7.7.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed contamination control program for the Lost Creek Project meets requirements of Subparts B, C, and F of 10 CFR Part 20.

5.7.7.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria in Section 5.7.6.3 of the Standard Review Plan (SRP) (NRC, 2003a). Regulatory Guide 8.30 provides guidance on how compliance with the applicable regulations can be demonstrated.

5.7.7.3 Staff Review and Analysis

This section discusses the applicant's proposed contamination control program. The contamination control program is designed to detect radiological contaminants that have escaped the boundary of the uranium recovery process equipment. This contamination can take the form of loose surface contamination and reside on structures, equipment, materials, or personnel. The purpose of this program is to ensure that contamination will be confined and monitored in known areas and not spread to other areas outside of the confined area (e.g., lunchroom, bathrooms, office areas, etc.) or to unrestricted areas.

5.7.7.3.1 Contamination Surveys

The applicant proposed a contamination control program that addresses contamination surveys for personnel, plant area, and material and equipment release in Section 5.7.6 of the technical report (LCI, 2008c, 2010a).

5.7.7.3.1.1 Personnel Contamination Surveys

The applicant stated in Section 5.7.6.1 of the technical report (LCI, 2008c; LCI, 2010a) that it will designate and post the processing area of the plant as restricted and limit access to only those individuals who (a) have received appropriate training and/or (b) are escorted by an experienced employee. SER Figure 5.7-1 illustrates the proposed restricted area. Further, the applicant stated that all exit doors from restricted areas that do not have contamination survey equipment will be designated and labeled as emergency exits only. The applicant stated that the RSO may choose to approve a temporary contamination survey station at exits if needed (LCI, 2008c; LCI, 2010a).

According to the applicant, all individuals must perform and document an alpha contamination survey before leaving the restricted area (LCI, 2008c; LCI, 2010a). In addition, individuals who have been in the wellfields[1] or byproduct storage area or near the deep well or storage ponds will perform and document an alpha survey immediately upon returning to the office, before eating, or before leaving the mine site, whichever comes first. The applicant indicated that it will perform contamination surveys with a Ludlum Model 43 alpha detector and a Model 177 alarming ratemeter or equivalent. According to the applicant, a typical alarm setting is 20 counts per minute. The applicant stated that the goal is no personal contamination above background (LCI, 2008c; LCI, 2010a).

The applicant's description of personnel contamination surveys is acceptable to the staff, except with respect to beta-gamma contamination surveys. The applicant proposed equipment and instruments needed to comply with 10 CFR Part 20 (see Tables 5.7-1 and 5.7-2 and Figure 5.7-1); however, it stated in Section 5.7.6.1 of the technical report (LCI, 2008c; LCI, 2010a) that it will not perform beta-gamma contamination surveys if it does not detect alpha contamination. The applicant justifies this statement by concluding that in-growth of beta-gamma contamination from fresh yellowcake product will require approximately four months, and that fresh yellowcake will not remain at the facility long enough for such in-growth to occur. The staff notes that aged yellowcake can remain in certain portions of the facility from spills and maintenance activities. The staff also notes that according to Table 5.7-1 in the technical report (LCI, 2008c; LCI, 2010a), the applicant applied beta release limits to equipment contamination, but not personnel contamination. Therefore, to ensure compliance with the ALARA requirements in 10 CFR Part 20, the staff is including a license condition discussed in SER Section 5.7.7.4. This license condition will require the applicant to develop, prior to the pre-operational inspection, a survey program for beta-gamma contamination for personnel contamination from restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F..

Based on its review of the applicant's personnel contamination survey program, the staff is reasonably assured that this program is sufficient to protect occupational health and safety. This reasonable assurance determination is contingent upon the fulfillment of the license condition presented in SER Section 5.7.7.4 and discussed above.

5.7.7.3.1.2 Plant Area(s) Contamination Surveys

The applicant stated in Section 5.7.6.2 of the technical report (LCI, 2008c; LCI, 2010a) that it will regularly evaluate, by visual inspection and measurement, surface contamination in plant areas. Further, the applicant stated that it will control surface contamination in restricted areas to

[1] The applicant uses the term mine unit in the technical report to describe the injection and production wellfields. For the purposes of clarity and consistency, the NRC staff refers to mine units as wellfields.

minimize the potential for resuspension of uranium dust that can result in inhalation or ingestion intake. The applicant did not propose any specific limits for control of surface contamination in restricted areas (LCI, 2010a). .

For unrestricted areas (e.g., offices, laboratory, etc.) and restricted areas of the plant where work with uranium is not performed, the applicant stated that these areas will be surveyed (spot-checked) weekly for removable contamination (smear surveys) (LCI, 2008c; LCI, 2010a). The applicant also stated that the goal for these areas is background and that areas that exceed the contamination limit of 1000 dpm alpha per 100 cm^2 will be cleaned immediately and re-surveyed. Alternatively, LCI might perform total contamination surveys if the total contamination level exceeds the 1000 dpm alpha per 100 cm^2 removable contamination limit. The removable contamination level will be determined using smears (LCI, 2010a). The staff notes that plant area contamination surveys address alpha contamination, but not beta-gamma contamination

Similar to personnel contamination surveys, which were discussed in the previous section of this SER, LCI's plant contamination survey program is acceptable, except that it does not address the potential for beta-gamma contamination. Therefore, to ensure compliance with the ALARA requirements in 10 CFR Part 20, the staff is including a license condition discussed in SER Section 5.7.7.4. This license condition will require the applicant to develop, prior to the pre-operational inspection, a survey program for beta-gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F.

Based on its review of the plant area(s) contamination surveys program, the staff is reasonably assured that the applicant will perform the appropriate surveys and control radiological contamination. This reasonable assurance determination is contingent upon the fulfillment of the license condition in SER Section 5.7.7.4 and discussed above.

5.7.7.3.1.3 Equipment and Materials Contamination Surveys

For releasing potentially contaminated items, the applicant stated that the RSO or HPT will survey these items before they are released from the facility. The applicant committed to using Table 1 of NRC "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses, for Byproduct, Source, or Special Nuclear Material," to determine if equipment can be released for unrestricted use. NRC staff notes that Table 5.7-1 of the technical report (LCI, 2008c) indicated that surveys for these types of items will rely on gross alpha and beta surveys. Additionally, Table 5.7-1 in the technical report indicated that the LLD for removable surface and personal contamination self surveys will be 100 dpm/100 cm^2. Regulatory Guide 8.30 recommends that removable alpha contamination levels on respirator face pieces and hoods should be less than 100 dpm/100 cm^2. The LLD must be lower than the contamination limit to minimize potential survey errors. Therefore, a license condition, which is discussed in SER Section 5.7.7.4, is warranted to ensure that the applicant will comply with 10 CFR 20.1501(a)(2)(i), which requires surveys that evaluate the magnitude.

5.7.7.3.2 Survey Equipment

The applicant stated that it will use a Ludlum Model 2224 counter and Model 44-9 pancake GM probe or equivalent survey equipment or materials for unrestricted release, and that it will calibrate survey equipment according to the manufacturer's specifications and at least annually (LCI, 2010a). The applicant's personnel monitoring system will consist of a Ludlum Model 43-5 alpha detector coupled to a Model 177 alarming rate meter or equivalent. LCI will use Ludlum

Model 44-9 detectors for beta contamination surveys. The applicant has not provided the survey capability or scan MDC in terms of dpm per 100 cm^2 for these surveys meters (LCI, 2010a). As stated in SER Sections 5.7.7.3.1.1 and 5.7.7.3.1.2, NRC staff also notes that the applicant did not propose conducting both beta-gamma and alpha contamination surveys prior to release of materials and equipment or for personnel contamination.

The staff finds the applicant's proposed survey equipment is acceptable and will be suitable to perform the necessary surveys, except that the applicant did not provide information regarding the equipment used to measure beta-gamma contamination. Therefore, the staff is including a license condition in SER Section 5.7.7.4 that requires, as discussed in SER Section 5.7.7.3.1.1, the applicant to develop a survey program for beta-gamma contamination for personnel contamination.

5.7.7.3.3 Inspections

Information in SER Section 5.7.7.3, unless otherwise stated, is from Section 5.7.6 of the technical report (LCI, 2008c; LCI, 2010c). The applicant stated that unannounced quarterly spot surveys of personnel will be performed by the RSO, HPT, or Designee, in accordance with Regulatory Guide 8.30, Section 2.6. The spot surveys will take place in unrestricted areas and will include personnel that work in mine units (i.e., wellfields) and process areas. The applicant intends to use spot surveys to ensure that personnel perform contamination self surveys before leaving the restricted areas (LCI, 2008c; LCI, 2010c). The staff finds that spot surveys comply with the requirements in 10 CFR 20.1501(a)(1), (a)(2)(i), and (a)(2)(ii), which require surveys to evaluate the magnitude and extent of radiation levels and concentrations of radioactive material. The applicant's proposed survey schedule is consistent with the survey frequencies recommended in Regulatory Guide 8.30, and, therefore, the staff finds this acceptable.

The applicant has proposed daily inspections of the plant by the RSO, HPT, or Designee to check for proper containment of yellowcake and process solutions, proper storage of personal protective equipment (PPE), radiation protection signage, access control, and security measures (LCI, 2010a). SER Section 5.3.3 discusses the qualifications for the designee..

The applicant addressed precautions to be taken for spill prevention of process solutions (LCI, 2010a). Inspections of mine units and header houses will be periodically inspected to identify potential problems that could lead to lixiviant leaks and spills, and actions taken to prevent the spread of contamination (LCI, 2010a). The applicant also proposed an approach for assessment of a spill to determine the radiological risks and whether reporting to the NRC is required. The applicant designated responsibility for this assessment to the RSO or HPT, who may request the assistance of the expertise of the area supervisor (LCI, 2010a). The staff finds that the applicant's approach is reasonable and complies with 10 CFR Part 20, Subpart F, "Surveys and Monitoring;" Subpart J, "Precautionary Procedures;" and Subpart M, "Reports."

Based on the proposed radiation safety program, the staff has reasonable assurance that the applicant can safely operate its facility due to its plans to study airborne contaminants and to evaluate the need for beta surveys, as outlined in Regulatory Guide 8.30, Section 2.4, and discussed in Sections 5.7.3.2 and 5.7.2.2, respectively, of the technical report (LCI, 2010a). The applicant's willingness to continue to evaluate the site specific conditions and adjust the radiation safety program accordingly indicates to the staff that the applicant is committed to operating safely and minimizing effects to the public and environment in accordance with 10 CFR 40.32(c).

5.7.7.3.4 Records and Reporting

The applicant identified the records that will be maintained for the life of the license (LCI, 2010a). These include the following: daily RSO inspections of the plant, weekly RSO inspections of non-process areas, personnel surveys and spot checks, all material release surveys, including transport of yellowcake slurry, calibration and function checks of survey instruments used for material release, personnel surveys, and surface contamination surveys. Section 5.7.6.7 of the technical report describes additional aspects of the recordkeeping and reporting activities proposed by the applicant (LCI, 2010a). NRC staff has determined that the applicant's recordkeeping and reporting activities are consistent with the guidance in Regulatory Guide 8.30 and comply with the requirements for 10 CFR Part 20, Subparts L and M, and 10 CFR 40.32(b), which requires the applicant to be trained and experienced to protect health and minimize danger to life or property. Therefore, the staff finds the record keeping and reporting element of the applicant's program to be acceptable.

5.7.7.4 Evaluation Findings

The staff reviewed the contamination control program for the proposed Lost Creek Project in accordance with SRP Section 5.7.6.3. The staff finds that the applicant has identified controls for preventing contamination from leaving a restricted area using appropriate survey equipment and instrumentation for natural uranium. The applicant proposed to conduct contamination surveys in clean areas, appropriate survey equipment, and an appropriate survey and inspection schedule to detect and control radiological contamination.

The staff finds that the applicant described its radiation protection program in sufficient detail, followed survey guidance in Regulatory Guide 8.30, and committed to evaluating the isotopic composition of airborne radioactive material and the need for site specific beta-gamma surveys.. The staff also finds that the applicant has provided a description of contamination survey instruments capability in dpm per 100 cm^2 that demonstrates that the range and calibration of the monitoring equipment will protect the health and safety of employees during the full scope of facility operations.

The staff finds that the applicant's contamination control program is acceptable and that the applicant will appropriately survey, detect, and control radiological contamination, as required by 10 CFR Part 20, Subparts B, C, F and 10 CFR 40.32(c), except that applicant has not addressed beta-gamma contamination in personnel surveys, plant area contamination surveys, and survey equipment. Therefore, the staff is including the following condition in the Lost Creek Project license:

> Prior to the preoperational inspection, the licensee shall develop a survey program for beta-gamma contamination for personnel contamination from restricted areas, and beta-gamma contamination in unrestricted and restricted areas, that will meet the requirements of 10 CFR Part 20, Subpart F.
>
> The licensee shall provide, for NRC review and written verification, the surface contamination detection capability (scan MDC) for radiation survey meters used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the

scanning mode for the alpha and beta-gamma radiation expected shall be provided in terms of dpm per 100 cm^2.

Based on the contamination control program information provided by the applicant, as supplemented by the above license condition, the staff is reasonably assured that the applicant will appropriately survey, detect, and control radiological contamination.

5.7.7.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 1977. Regulatory Guide 8.10, Revision 1-R, "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable," May 1977.

NRC, 1993d. Policy and Program Guidance, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," April 1993 Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety Washington, DC, ADAMS Accession No. ML003745526.

NRC, 2002a. Regulatory Guide 8.30, Revision 1, "Health Physics Surveys in Uranium Recovery Facilities," May 2002.

NRC, 2002b. Regulatory Guide 8.31, Revision 1, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," May 2002.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

5.7.8 AIRBORNE EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAM

During the course of the evaluation, the staff found that there was overlap among the areas of review and acceptance criteria in Standard Review Plan (SRP) Sections 4.1, Gaseous and Airborne Particulates; 5.7.1, Effluent Control Techniques; and 5.7.7, Airborne Effluent and Environmental Monitoring Program (NRC, 2003a). As discussed in SER Section 5.7.2, the staff reduced the overlap in the SER by limiting the discussion of the staff's review of the effluent control techniques to SER Section 4.1 and effluent monitoring to SER Section 5.7.8.

5.7.8.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed airborne-effluent and environmental monitoring program for the Lost Creek Project meets the requirements of 10 CFR 20.1003, 20.1301, 20.1302, 20.1101(d), 20.1501, 40.65, and Criteria 7 and 8 of Appendix A to 10 CFR Part 40.

5.7.8.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria in Section 5.7.7.3 of the SRP and applicable acceptance criteria in SRP Section 4.1.3 (NRC, 2003a). Regulatory Guides 4.14 and 8.37 provide guidance on how the applicant can comply with the applicable regulations.

5.7.8.3 Staff Review and Analysis

The following sections discuss the applicant's proposed airborne effluent and environmental monitoring program. This includes radiation monitoring outside of the plant area during operations and monitoring environmental media within the plant area, at the boundary of the facility, and at a background location.

The applicant is required to demonstrate how it will comply with 10 CFR Part 40, Appendix A, Criterion 7, which states, "Throughout the construction and operating phases of the mill, an operational monitoring program must be conducted to measure or evaluate compliance with applicable standards and regulations; to evaluate performance of control systems and procedures; to evaluate environmental impacts of operation; and to detect potential long-term effects." The applicant is also required to demonstrate how it will comply with 10 CFR Part 40, Appendix A, Criterion 8, which states, "Milling operations must be conducted so that all airborne effluent releases are reduced to levels as low as is reasonably achievable. The primary means of accomplishing this must be by means of emission controls. Notwithstanding the existence of individual dose standards, strict control of emissions is necessary to assure that population exposures are reduced to the maximum extent reasonably achievable and to avoid site contamination." The applicant is also required to demonstrate compliance with 10 CFR 40.65. Specifically, it must report "…the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in gaseous effluents…"

5.7.8.3.1 Airborne Effluent Monitoring

Aside from the reporting requirements in 10 CFR 40.65, an applicant must provide details on how they will perform surveys sufficient to demonstrate compliance with 10 CFR 20.1302, which requires compliance with dose limits for individual members of the public. An applicant must also demonstrate compliance with 10 CFR 20.1501, which requires surveys that are reasonable under the circumstances to evaluate concentrations or quantities of radioactive materials and the potential radiological hazards.

In demonstrating compliance with 10 CFR 20.1302(a), applicants must demonstrate that they will make appropriate surveys of radioactive materials in effluents released to unrestricted and controlled areas as specified in the regulation. For point sources (e.g., a defined stack or pipe), the release point will generally be the effluent discharge point (i.e., where the uncontrolled effluent is released to the air). If the effluent is discharged to a restricted area, the applicant

may propose measuring or calculating the effluent quantities or concentrations (a) at the effluent discharge point or (b) at the unrestricted/controlled area boundary. If the effluent is measured or calculated at the discharge point, the applicant may use (a) this undiluted value or (b) an appropriate model, to estimate the concentrations to which people are exposed. For dose calculations, the applicant may also propose taking direct measurements at the unrestricted area boundary. Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities" (NRC, 1993b), provides additional guidance on airborne radioactive effluent monitoring.

Information in SER Section 5.7.8.3, unless otherwise stated, is from Section 5.7.7 of the technical report (LCI, 2008c, 2010a). The applicant identified several sources of airborne radiological effluents associated with the Lost Creek ISR facility in Sections 4.1.2 and 5.7.1 of the technical report (LCI, 2008c, 2010a). The sources described were both point sources and fugitive, or diffuse sources. Point sources include those operations that have their exhaust confined in a stack, duct, pipe, etc., prior to atmospheric release, such as process tank vents. Fugitive sources are not confined prior to being released to the atmosphere and include, among other things, pump seals, losses from container loading not captured in ventilation systems, airborne contamination from dried spills, and pressure relief devices. Fugitive sources include radon emanating from the wellfield (LCI, 2010a).

The applicant stated in Section 4.1.2 of the application that radioactive airborne effluents will be minimal because (a) yellowcake drying and packaging will not occur, (b) the storage ponds will be kept wet, and (c) ventilation systems will exhaust radon from buildings, which according to the applicant, will quickly dissipate in the atmosphere (LCI, 2010a). In Sections 4.1.2 and 5.7.1 of the technical report (LCI, 2010a), the applicant described the sources of radon effluent from two places: inside the plant and outside in the wellfield. In the plant, the applicant is proposing to use pressurized downflow vessels in the ion exchange (IX) circuit. According to the applicant, work areas with the potential for radon exposure include the vents from (a) the bleed storage tanks, (b) the resin transfer points, (c) the fluid collection sumps, (d) the yellowcake slurry loading area, (e) low-lying areas, and (f) confined spaces. The applicant stated it will vent nonpressurized tanks and sumps to the atmosphere outside the building via a stack. In addition to tank-specific ventilation, a general area ventilation system will displace air in the plant by blowing it outside (LCI, 2010a).

Outside the plant, the applicant stated that radon will be released occasionally from the mine unit wells as gas is vented from the injection wells (LCI, 2010a). The applicant stated that it will continually vent production wells, but venting will be minimal. Therefore, during normal operations, the applicant concluded that radon will be the main radioactive effluent from operations (LCI, 2010a). The staff agrees with the applicant's assessment described above, that radon will be the primary effluent from the sources within the processing plant, header houses, and wellfields, based on the staff's assessment of the information presented in the application and the staff's knowledge of ISR operations.

Although the applicant stated in Section 5.7.7.1 of the technical report (LCI, 2010a) that it will conduct effluent monitoring as recommended in Regulatory Guide 4.14 (NRC, 1980), the staff finds that LCI does not propose to conduct radon effluent monitoring, such as stack sampling, as recommended in Regulatory Guide 4.14. The applicant stated (LCI, 2010a) that in accordance with NRC guidance, such as Regulatory Guide 3.59 (NRC, 1987) and NUREG-1569 (NRC, 2003a), it will use calculations to estimate radionuclide source terms and calculate off-site dose to the public (LCI, 2010a). The applicant further stated that it will provide the quantity of each of the principal radionuclides released to unrestricted areas through the methods described in these NRC guidance documents in its semi-annual report to the NRC, as

required by 10 CFR 40.65. The applicant proposed to use calculations because 10 CFR 40.65 does not require "measurement" (LCI, 2010a). The applicant stated that "the disperse and diffuse nature of potential radon releases from multiple locations at ISRs makes empirical measurement impractical" (LCI, 2010a).

The staff finds that the applicant's proposed effluent monitoring program is acceptable aside from two slight deficiencies: assessing doses in unrestricted areas and the lack of stack sampling. Regarding doses in unrestricted areas, the staff notes that the applicant plans to continue collecting radon and air particulate samples as part of the operational environmental monitoring program at sampling locations used to collect preoperational samples (LCI, 2010a). As shown in SER Figure 2.6-3, two radon sampling locations, PR-4 and PR-5, and one air particulate sample, HV-2, are located near the proposed processing plant, and one radon sampling location, PR-9, is located in the ore body.

The applicant provided information in Section 7.2 of the application suggesting that the dose limits in 10 CFR 20.1301 would not be exceeded for members of the public in unrestricted areas or at the nearest residence location (LCI, 2010a). The applicant justified its proposed plan to use MILDOS-AREA dose calculations to determine airborne source terms by stating that there has not been any evidence of public exposure from radon releases in excess of 10 CFR Part 20 limits in 30 years of ISR operational experience in the United States (LCI, 2008c, 2010a). While the staff agrees that licensees are permitted to estimate doses through calculations, calculations must be confirmed through periodic sampling; otherwise, the staff cannot determine with sufficient certainty that doses to the public are below the 10 CFR 20.1301 limits. Sampling of effluents is a clear recommendation in the staff's guidance. For example, Regulatory Guide 3.59 states that the staff prefers "reliable monitoring data when available." Based on information provided by the applicant, the staff is reasonably assured that the applicant will monitor airborne effluents and control doses to the public in accordance with 10 CFR 20.1301. This reasonable assurance determination is based on calculations provided by the applicant showing that doses from its operations will not exceed public dose limits and its commitment to perform operational effluent monitoring. However, this reasonable assurance determination is contingent upon confirmatory sampling, which will be required by a license condition discussed in Section 5.7.8.4.

Regarding stack sampling, the applicant did not propose stack sampling consistent with acceptance criteria (1) and (2) in SRP 5.7.7.3, and as described in Regulatory Guide 4.14, Section 2.1.1 "Stack Sampling". The regulatory guide recommends that (a) stacks should be sampled at least semiannually; (b) the sampling should be adequate to determine the release concentrations of uranium, Th-230, Ra-226, and Pb-2 10; and (c) flow rates should be measured at the time of sampling. The staff discusses in-plant monitoring for occupational exposures and doses in SER Section 5.7.3, and as stated above, certain samplers and monitors will be located in specific areas outside the plant. While additional stack sampling is recommended, the staff notes that licensees have flexibility in meeting the requirements of 10 CFR 40.65 and 10 CFR 20.1301, and the currently proposed sampling program could be part of the applicant's compliance strategy. However, the applicant must inform the NRC of the precise manner in which effluents will be quantified. This requirement is reflected in a license condition presented in Section 5.7.8.4. The staff is reasonably assured that the applicant will measure and quantify effluents from the Lost Creek Project based, in part, on the current in-plant and exterior monitoring programs. This reasonable assurance determination is contingent upon the applicant's fulfillment of the license condition in SER Section 5.7.8.4.

5.7.8.3.2 Environmental Monitoring

5.7.8.3.2.1 Air Particulate Sampling

Regulatory Guide 4.14, Table 2, suggests that air particulate sampling locations should be at or near the site boundaries and in different sectors that have the highest predicted concentrations of airborne particulates, as well as one at the nearest residence or occupiable structure(s), and one control location that should be in the least prevalent wind direction from the site The air particulate sampling should be continuous with weekly filter changes and quarterly composite by location for natural uranium, Ra-226, Th-230, and Pb-210 analysis. The following factors should be considered in determining the sampling locations: (1) average meteorological conditions (wind speed, wind direction, atmospheric stability), (2) prevailing wind direction, (3) site boundaries nearest to mill, (4) direction of nearest occupiable structure, and (5) location of estimated maximum concentrations of radioactive materials. Additionally, Regulatory Guide 4.14, Table 2, suggests that radon sampling should be conducted at five or more locations using the same guidelines as stated for air particulate sampling with the exception that the frequency of the analysis should be monthly for Rn-222.

The applicant stated that air particulate samples will be collected continuously at the five locations identified in SER Figure 2.6-3 and analyzed for natural uranium, Th-230, Ra-226, and Pb-210 in accordance with Regulatory Guide 4.14. Sampler HV-2 is located approximately 200 m east of the plant at a location that the applicant's models predicted would have the highest soil deposition as described in section 2.9.4 of the technical report. Sampler HV-3 is located at a position that the applicant stated had the lowest total effective dose equivalent (TEDE) of any modeled receptor. Samplers HV-4 and HV-5 are located at receptor sites that the applicant stated the model predicted to be at intermediate concentrations and are downwind of the plant and wellfields.

During operations, the applicant will monitor radon gas and passive gamma radiation at the same locations as discussed in Section 2.9.4 of the technical report and shown in SER Figure 2.6-3. There are 12 sampling radon sampling locations, of which five of these sample sites are co-located with the air particulate samplers as recommended in Regulatory Guide 4.14. The staff finds that the air particulate and radon environmental monitoring locations are consistent with Regulatory Guide 4.14 and therefore, acceptable to meet the operational environmental monitoring requirements in Criterion 7 of Appendix A to 10 CFR Part 40.

5.7.8.3.2.2 Soil Sampling

Regulatory Guide 4.14, Table 2, suggests that soil sampling should be conducted in five or more locations that are the same as for air particulate sampling. It suggests collecting annual grab samples and analyzing for natural uranium, Ra-226, and Pb-210. The applicant stated that there will be no significant release of airborne particulate radionuclides during operations because Lost Creek Project will not have the types of operations, such as ore crushing and grinding that have the potential to produce particulate effluent. However, the applicant acknowledged that the decay of radon from the facility may result in deposition of radon decay products, which will decay to Pb-210. The applicant has committed to collecting soil samples annually during operations at the five air particulate sampling locations and analyze them for natural uranium, Th-230, Ra-226, and Pb-210 in accordance with Regulatory Guide 4.14. Further, the applicant stated that radionuclide particulates, including the long lived radon progeny Pb-210, which are detected will be compared to baseline values to assess impacts

and/or undesirable trends. The staff finds that the soil sampling frequency and locations proposed by applicant are consistent with Regulatory Guide 4.14 and therefore, acceptable

5.7.8.3.2.3 Sediment Sampling

Regulatory Guide 4.14, Table 2, suggests that sediment sampling be conducted as an annual grab sample from each water body identified for surface water sampling. The sediment samples should be analyzed for natural uranium, Th-230, Ra-226, and Pb-210.

In Section 5.7.8.2, the applicant stated that the Lost Creek licensed area has three shallow ephemeral drainages within the licensed area. These drainages contain water only immediately following a heavy rain storm or during snow melt in March and April (LCI, 2008c). The applicant described the Lost Creek Project as high desert terrain, which receives nominal precipitation. The applicant described four existing impoundments within the licensed area and immediate vicinity in Section 2.7.1.1 of the technical report. The impoundments rarely contain water; therefore, the applicant does not propose to collect routine sediment samples.

The applicant stated that three of the four impoundments are not subject to drainage from the licensed area. The fourth stock pond is on an ephemeral drainage that drains the easternmost portion of the licensed area, with limited operations upstream. However, if a spill impacts a drainage, the applicant stated that an automatic sampler will be installed in the downstream and upstream channel to quantify the radionuclide content of the surface water during the next precipitation event that results in flow in the channel following the spill. The applicant stated that the upstream sampler will serve as a background measurement. However, because surface water is present so infrequently, the staff does not find that sediment sampling as part of the operational monitoring program is warranted at this time.

5.7.8.3.2.4 Food and Fish Sampling

Where a significant pathway to man is identified, Regulatory Guide 4.14 suggests analyzing three of each type of crop, livestock, etc., raised within 3 km of the mill site. Samples should be collected at the time of harvest or slaughter and analyzed for Ra-226 and Pb-210. Note (o) in Regulatory Guide 4.14, Table 2 clarifies that an exposure pathway should be considered important if the predicted dose to an individual would exceed 5 percent of the applicable radiation protection standard. For purposes of analyzing doses to the public from food and fish, the dose limit is 100 mrem/yr total effective dose equivalent (TEDE), pursuant to 10 CFR 20.1301. Therefore, an exposure pathway should be considered important if the predicted dose to an individual would exceed 5 mrem/yr TEDE.

The applicant did not propose to perform any food or fish sampling during operations (LCI, 2010a). In Section 2.2.1 of the technical report, the applicant stated that there is no crop production within the licensed area or within 3.2 km (2 mi) of the licensed area. Therefore, NRC staff concludes that not collecting crop samples during operations is consistent with Regulatory Guide 4.14 (LCI, 2010a). Staff, thus, finds the applicant's reason for not sampling crops during operations to be acceptable.

In Section 2.9.3.5 of the technical report, the applicant stated that there is insufficient water in the area to support aquatic life, so fish sampling will not be performed (LCI, 2010a). NRC staff concludes that the applicant's reason for not collecting fish samples during operations is consistent with Regulatory Guide 4.14. Therefore, staff finds the applicant's reason for not collecting fish samples during operations to be acceptable.

In Section 2.2.1 of the technical report, the applicant stated that the only agricultural production within the licensed area, or within 3.2 km (2 mi) of the licensed area, is related to grazing (LCI, 2010a). The applicant identified three grazing allotments, which provide forage for cattle, horses, and sheep. In Section 2.9.3.5 of the technical report, the applicant stated that samples of meat (muscle tissue), kidney, and bone from cattle with access to grazing fodder within three kilometers of the processing plant site were collected in fall 2008 and 2009 as part of the baseline sampling program. Samples were collected at the time of slaughter and were analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Additionally, a liver sample was also analyzed in 2009 (LCI, 2010a).

The applicant has established a baseline for decommissioning, but no operational sampling has been proposed. NRC staff notes that deposition of radon progeny products onto forage and cattle drinking water sources can also provide a pathway for exposure to cattle. Although a potential pathway to man exists, the staff does not find that routine cattle sampling as part of the operational monitoring program is needed at this time. However, the staff will require that the applicant specify in its airborne effluent and environmental monitoring program, required by the license condition presented in SER Section 5.7.8.4, particular conditions that will trigger the need for the applicant to conduct operational livestock sampling.

In Section 2.2.1 of the technical report, the applicant stated that Wyoming Game and Fish Department hunting areas for antelope, deer, elk and mountain lion include the licensed area. The applicant also stated that the hunt areas are not primarily within 3.2 km (2 mi) of the licensed area (LCI, 2010a). However, during discussions with the applicant concerning the draft license, the applicant stated that neither large or small game is hunted to any extent in the licensed area, and that the livestock samples were better food samples and more likely to be in the pathway-to-man (NRC, 2011c). Based on the information concerning hunting at the proposed Lost Creek Project license area, the staff finds that including game as a food source is not warranted at this time as part of the operational monitoring program.

5.7.8.3.2.5 Vegetation Sampling

Where a significant pathway to man is identified, Regulatory Guide 4.14 suggests analyzing vegetation or forage from animal grazing areas near the mill site in the direction of the highest predicted airborne radionuclide concentrations. Samples should be collected three times during the grazing season and analyzed for Ra-226 and Pb-210. Note (o) in Regulatory Guide 4.14, Table 2 clarifies that an exposure pathway should be considered important if the predicted dose to an individual would exceed 5 percent of the applicable radiation protection standard. Individual members of the public are subject to the dose limits in 10 CFR 20.1301. Pursuant to 10 CFR 20.1301, the dose limit is 100 mrem/yr TEDE.

Therefore, an exposure pathway should be considered important if the predicted dose to an individual would exceed 5 mrem/yr TEDE. The applicant did not propose to perform any vegetation sampling during operations. The applicant stated that BLM guidance stipulates that 58 hectares (ha) (144 acres [a]) are required annually in the Lost Creek area to support one head of livestock and that such meagerness of forage cannot result in significant cattle exposure through this pathway (LCI, 2010a). The applicant stated that there are no cattle on the Lost Creek Project used for human consumable milk production; consequently, the milk consumption pathway is not a consideration. Further, the applicant stated that the well pattern area and the plant will be fenced off from cattle, so cattle exposure through spillage is also of negligible concern. However, as NRC staff noted above, deposition of radon progeny products

onto forage can also provide a pathway for exposure to cattle and game hunted in the area. Furthermore, the applicant identified three grazing allotments that provide forage for cattle, horses, and sheep within 3.2 km (2 mi) of the licensed area (LCI, 2010a). Consequently, the staff will require that the applicant specify in its airborne effluent and environmental monitoring program, required by the license condition presented in SER Section 5.7.8.4, particular conditions that will trigger the need for the applicant to conduct operational vegetation sampling.

5.7.8.3.2.6 Direct Radiation

Regulatory Guide 4.14, Table 2, suggests five or more passive integrating radiation devices at the same locations as air particulate sampling. The passive integrating radiation devices should be changed out on a quarterly basis and measured for gamma exposure rate.

As described in SER Section 5.7.8.3.2.1, the applicant will monitor passive gamma radiation during operations at the same locations as discussed in Section 2.9.4 of the technical report and shown in SER Figure 2.6-3. There are 12 sampling passive gamma radiation monitoring locations, of which five of these sample sites are co-located with the air particulate samplers as recommended in Regulatory Guide 4.14. The applicant stated in Section 5.7.7.1 of the technical report that direct radiation will be measured continuously with quarterly analysis using passive integrating devices or an equivalent, with a range of at least one mrem to 500 rem and an accuracy of at least plus or minus 15 percent. As part of the QA/QC program, the applicant stated that at least one sampling location shall have two monitoring devices. The staff finds that the direct radiation monitoring locations are consistent with Regulatory Guide 4.14 and therefore, acceptable.

5.7.8.3.2.7 Nearby Groundwater

The applicant reported that no drinking water or agricultural wells are located within two kilometers of the license area. The applicant also reported that no livestock watering wells are located within the license area; however, groundwater use permits exist for four (4) BLM livestock wells within two kilometers of the license area. Of those, two wells were reported active (in 2007); activity of one was questionable and one well was inactive. The applicant committed to quarterly sampling of groundwater at all operation wells within one kilometer of the license area, provided that BLM consents to the sampling during the active operation life of the project.

Based on the information supplied, staff is unable to determine the number of wells that will be included in this sampling program. Furthermore, baseline data for the wells to be sampled need to be collected prior to start of operations. A pre-operational license condition, presented in SER Section 5.7.8.4, will be included to ensure staff review and verification.

5.7.8.3.2.8 On-site Groundwater

The applicant proposed monitoring 25 on-site monitoring wells as part of its “Life-of-Mine” monitoring program (see SER Section 5.7.9.3.1.6). The proposed program consists of quarterly measurements of the groundwater elevations. In addition, the applicant indicated other water quality parameters may be analyzed at selected wells in this program based upon future activities near the wells. The staff reviewed the applicant’s approach regarding on-site groundwater sampling, and agrees with this approach as it provides an additional level of groundwater protection.

5.7.8.3.2.9 Surface Water

The applicant did not propose any operational surface water monitoring for the license area because it concluded that all of the drainages were ephemeral. In its application, the applicant stated that runoff to the drainages does occur during major precipitation events and some of it infiltrates to the surficial aquifer. NRC staff notes that it is possible that spills from wellheads or piping in the license area might be captured by runoff, carried to drainages, infiltrate into the subsurface, and potentially affect the water quality in the surficial aquifer. Lost Creek has established several surface water sampling points around the license area with storm water samplers, which were effective at measuring surface water quality during major precipitation events. NRC staff concludes these samplers may be used on an event basis to evaluate surface water runoff. Due to the lack of perennial streams, the NRC staff concludes that the routine surface water monitoring within the licensed area is not appropriate.

5.7.8.4 Evaluation Findings

NRC staff has completed its review of the airborne effluent and environmental monitoring program of the proposed Lost Creek ISR facility in accordance with SRP Section 5.7.7.3 and the applicable parts of SRP Section 4.1.3. The applicant will sample radon, air particulates, surface soils, and direct radiation. The applicant provided justification for not sampling crops, fish, routine surface water, routine sediments, and game, but did not provide sufficient justification for not sampling vegetation and cattle, as recommended in Regulatory Guide 4.14. Furthermore, the applicant did not completely describe its method for measuring and quantifying all radiological effluents or its methods for calculating doses to the public in unrestricted areas. Although the applicant did not completely describe its methods for quantifying airborne effluents, the staff is reasonably assured that the applicant will appropriately measure and quantify effluents pursuant to 10 CFR 40.65. As previously stated, the applicant described three radon and one air particulate sampling locations that appear to the staff to be intended by the applicant to be used as effluent monitors in its operational environmental monitoring program and should be used in its report submitted in compliance with 10 CFR 40.65. Notwithstanding the currently proposed program, the staff's reasonable assurance determination is contingent upon the applicant providing the information required in the following license conditions:

Standard License Condition 11.2:

> The licensee shall submit the results of the annual review of the radiation protection program content and implementation performed in accordance with 10 CFR 20.1101(c). These results shall include an analysis of dose to individual members of the public consistent with 10 CFR 20.1301 and 10 CFR 20.1302.

New license condition:

> Prior to the preoperational inspection, the licensee shall provide the following information for the airborne effluent and environmental monitoring program in which it shall develop written procedures to:
>
> A) Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted-for in, and verified by, surveys and/or monitoring.

B) Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302.

C) Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.

D) Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire license area from licensed operations will be accounted-for in, and verified by, surveys and/or monitoring.

To completely fulfill License Condition 12.10, as described in SER Sections 5.7.8.3.2.4 and 5.7.8.3.2.5, the applicant must specify the particular conditions that will trigger the need for the applicant to conduct operational vegetation and cattle sampling.

Regarding nearby groundwater, the applicant notes that four (4) BLM livestock wells exist within two kilometers of the license area and committed to quarterly sampling of all wells within one kilometer of the license area provided the owner consents to the sampling. Staff will require a pre-operational license condition to establish compliance with this commitment as follows:

> Prior to the start of operations, the licensee shall submit a report to the NRC for review and verification that all water supply wells within one kilometer of the license area have been sampled for baseline quality and included in the routine environmental sampling program provided the owner consents to the sampling.

Based on the staff's review of the applicant's airborne effluent and environmental monitoring program, the staff is reasonably assured that the applicant will appropriately measure airborne effluents and doses to the public, as required in 10 CFR 20.1101(b), 20.1302, 20.1501, and 20.1502, and Table 2 to Appendix B of 10 CFR Part 20, and consistent with SRP Section 5.7.7.3. This reasonable assurance determination is contingent upon the applicant's fulfillment of the aforementioned license conditions.

5.7.8.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, DC.

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

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

40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," U.S. Government Printing Office, Washington, DC.

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LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

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NRC, 1977. "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable," Regulatory Guide 8.10, Revision 1-R, May 1977.

NRC, 1980. "Radiological Effluent and Environmental Monitoring at Uranium Mills," Regulatory Guide 4.14, Revision 1, April 1980.

NRC, 1982c. "Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations," Regulatory Guide 3.51, March 1982.

NRC, 1982d. "Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining," Regulatory Guide 3.46, June 1982.

NRC, 1982e. "Compliance Determination Procedures for Environmental Radiation Protection Standards for Uranium Recovery Facilities 40 CFR Part 190," NUREG-0859, March 1982.

NRC, 1986a. "General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills," Regulatory Guide 3.56, May 1986.

NRC, 1987. "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations," Regulatory Guide 3.59, March 1987.

NRC, 1993b. "ALARA Levels for Effluents from Materials Facilities," Regulatory Guide 8.37, July 1993.

NRC, 1996b. "Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors," Regulatory Guide 4.20, December 1996

NRC, 2002b. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1, May 2002.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

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Yuan, Y.C., J.H.C. Wang, and A.J. Zielen, 1989. "MILDOS-AREA: an Enhanced Version of MILDOS for Large-Area Sources," ANL/ES-161, Argonne National Laboratory, Argonne, IL., June 1989.

5.7.9 GROUNDWATER AND SURFACE WATER MONITORING PROGRAMS

5.7.9.1 Regulatory Requirements

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed groundwater and surface water monitoring program for the Lost Creek Project meets the requirements of 10 CFR 40.32(c), 10 CFR 40.41(c), 10 CFR Part 40, Appendix A, Criterion 5B(5), and 10 CFR Part 40, Appendix A, Criterion 5D.

5.7.9.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the review procedures in Section 5.7.8.2 and acceptance criteria in Section 5.7.8.3 of the Standard Review Plan (SRP) (NRC, 2003a).

5.7.9.3 Staff Review and Analysis

In this section, NRC staff reviews the groundwater and surface water monitoring programs to be implemented at the Lost Creek Project to establish baseline water quality, detect excursions during operations and other monitoring during operations. Pre-operational monitoring is addressed in SER Section 2.6.3 and restoration monitoring is addressed in SER Section 6.1.3. In Section 5.7.9.3, unless specifically stated otherwise, the reported information is from Section 5.7.8 of the application (LCI, 2008c, 2010a).

5.7.9.3.1 Groundwater Monitoring

In Section 6.2 of the application (LCI, 2008c, 2010a), the applicant discussed three baseline monitoring programs for (1) the perimeter monitoring wells, (2) production zone monitoring wells, and (3) monitoring wells in the overlying or underlying aquifers. In Section 6.2.2 of the application, the applicant proposed establishing baseline water quality for all three programs at each mine unit by collecting a minimum of four samples from each well at least 14 days apart. LCI will analyze each sample for the suite of parameters in accordance with WDEQ-LQD Guidelines 4 and 8, except for silver (see SER Table 5.7-2). In Section 5.7.8.1 of the application (LCI, 2010a), the applicant stated that it will collect baseline groundwater samples in

accordance with instructions in the applicant's Environmental Manual (LCI, 2010a). However, the staff notes that in Section 5.7.8.2 of the application, the applicant committed to collecting one round of samples for the complete suite of parameters listed in Table 5.7-4 of the application, but it will only analyze for excursion indicator parameters (chloride, alkalinity, and conductivity) in the other three rounds (LCI, 2010a). The staff notes that the parameters listed in Table 5.7-4 of the application (LCI, 2010a) differ slightly from the list of parameters in SER Table 5.7-2 as follows: (a) radium-226 and radium-228 are listed as separate parameters; (b) pH is also measured in the laboratory; and (c) nitrate (NO_3) (total) versus nitrate (NO_3) plus nitrite (NO_2). To resolve the inconsistencies, the NRC staff will require the applicant to adhere to the parameters as discussed in Section 6.2.2 of the application (i.e., SER Table 5.7-2), and, as discussed below, commit to sampling a full suite of parameters for more than one of four rounds of sampling.

5.7.9.3.1.1 Baseline Monitoring – Perimeter Monitoring Wells

In Section 6.2.2 of the technical report (LCI, 2010a), the applicant stated that it will establish the baseline values for the perimeter wells on a parameter-by-parameter, well-by-well basis. The applicant discussed the number of wells it will install for a monitoring well ring in Section 3.2.2 of the technical report (LCI, 2010a). The applicant stated that the anticipated distance to the perimeter monitoring wells from the wellfield is approximately 500 feet with the anticipated distance between wells being approximately 500 feet; the actual distances will be based on the aquifer characteristics of that mine unit to ensure timely detection of any excursion. The applicant provided justification for the 500-foot distances based on results from the regional pumping tests and indicated that the spacing for a specific mine unit will be based on the mine unit pumping test. LCI will target the completion horizon for each well in the ring to the mineralized zones adjacent to a specific well (LCI, 2010a).

The staff finds that the applicant's proposed baseline monitoring program for the perimeter monitoring wells meets acceptance criterion (3) in SRP Section 5.7.8.3 because, based on the applicant's analysis, as verified by staff, the proposed spacing will ensure timely detection of a horizontal excursion along the perimeter of a wellfield. However, due to complexities of the geologic setting as discussed in SER Section 2.4.4, wellfields that abut the Lost Creek Fault will require enhanced monitoring along the fault for staff to be reasonably assured that a potential excursion through the fault can be detected. Based on staff's independent verification of the applicant's data, staff finds that the risk for such an excursion is low. Nevertheless, staff finds that the enhanced monitoring along the fault is a defense-in-depth measure designed to bring that risk to as low as reasonable achievable. Consequently, staff has included a license condition, discussed in SER Section 2.4.4, requiring an enhanced perimeter monitoring program along the Lost Creek Fault for wellfields that abut the fault.

As discussed in SER Section 2.4.4, staff will require that the screened horizon for the perimeter monitoring wells be documented in the wellfield data package. Acceptance criterion (3) in SRP Section 5.7.8.3 states "[perimeter monitoring wells] generally surround the entire wellfield and are screened over the entire production zone hydrogeologic unit." In general, screening over the entire unit will ensure that the excursion fluids are captured. However, if the production zone is a narrow horizon within the hydrogeologic unit, as is the case at most ISR facilities, screening over the entire unit may tend to dilute the sample collected from a well thus reducing the effectiveness for the detection of an excursion. A solution is to reduce to screened horizon of the perimeter wells to match the thickness of the production zone as close as possible. The reduced screened horizon, if properly placed, will better ensure a timely detection of an excursion, thus meeting the requirement in 10 CFR 40.41(c) for a licensee to confine his

possession and use of source and byproduct material to the locations and purposes authorized by a license.

The hydrogeologic settings at the Lost Creek facility exhibit a vertical anisotropy and the applicant proposes to produce from multiple horizons within the production zone hydrogeologic unit. Therefore, in accordance with requirements 10 CFR 40.41(c), staff has included the aforementioned license condition to require that the applicant demonstrate that all perimeter wells are screened in the appropriate horizon for a wellfield in the wellfield data package.

Table 5.7-2: List of Baseline Parameters.

Alkalinity	pH (field measured)	Specific Conductance (field measured)		Temperature (field measured)	Total Dissolved Solids
Aluminum (d)	Manganese (t & d)	Barium (d)	Boron	Cadmium (d)	Chromium (d)
Copper (d)	Iron (t & d)	Lead (d)	Mercury (d)	*Bicarbonate*	Sodium (d)
Nickel (d)	Selenium (d)	Vanadium	Zinc (d)	Molybdenum (d)	Radium-228
Ammonia	Nitrate + Nitrite	Calcium (d)	Potassium (d)	Magnesium (d)	
Gross Alpha	Carbonate	*Chloride*	Silica (d)	Sulfate	Radium-226
	Gross Beta	Fluoride	Uranium (d)	Arsenic (d)	

(LCI, 2008c, 2010a)Notes: A "d" signifies dissolved fraction; a "t" signifies total fraction. Parameters list in italics are the proposed excursion parameters.

5.7.9.3.1.2 Baseline Monitoring – Production Zone Monitoring Wells

In Section 3.2.2 of the technical report (LCI, 2010a), the applicant stated that the number of production zone monitoring wells in a given mine unit will be based on the size of the pattern area and density of production and injection wells. Staff reviewed the applicant's proposed plan for the production zone monitoring and finds that the commitment to a density of wells in the mine unit production zone is consistent with acceptance criterion (1) in SRP Section 5.7.8.3 because the proposed sampling density would provide a statistically valid dataset for the wellfields proposed by the applicant. However, staff finds that the applicant committed neither to a specific number or minimum density of production zone monitoring wells, which would meet criterion (1) of SRP Section 5.7.8.3, nor to using the same baseline wells for determining restoration performance, which would meet criterion (3) of SRP Section 6.1.3. By providing a specific number or minimum density of production zone monitoring wells and committing to use the same baseline wells during restoration, the applicant would be able to develop a statistically valid analysis for the restoration to ensure that the constituent levels after license termination is protective of human health and safety and the environment.

Consequently, staff will impose a standard license condition that requires a minimum of six wells to a baseline data set for any wellfield, and that wells used for baseline are those used to establish restoration performance (see standard license condition 11.3(a) in Appendix A of this SER).

5.7.9.3.1.3 Baseline Monitoring – Overlying and Underlying Aquifers

In Section 3.2.2 of the technical report (LCI, 2010a), the applicant stated that the number of monitoring wells in the overlying and underlying aquifers will be at a density of one well per 16,187 m^2 (4 ac) of mine unit area. The location and number of wells in the overlying or underlying aquifers may target site-specific conditions (e.g., areas at which the intervening aquitard is thinnest) (LCI, 2010a). The monitoring wells in the overlying and underlying aquifers will be screened in a zone nearest the production zone (LCI, 2010a).

The staff reviewed the applicant's proposed monitoring program for the overlying and underlying aquifers and finds that the proposed monitoring program will ensure timely detection of a vertical excursion by (1) selectively monitoring areas in which the intervening aquitard is the thinnest thus monitoring within an area the potential has the fastest "breakthrough" for any fluid from the production zone, and (2) screening the overlying or underlying aquifers closest to the production zone thus minimizing the migration distance to the wells. The proposed monitoring program for the overlying and underlying aquifers meets requirements in 10 CFR 40.41(c) for a licensee to confine its possession and use of source and byproduct material to the locations and purposes authorized by a license and is consistent with acceptance criterion (3) in SRP Section 5.7.8.3.

5.7.9.3.1.4 Excursion Monitoring

The applicant includes a discussion on the proposed excursion detection monitoring program (LCI, 2010a). The proposed indicator parameters for this program are chloride, conductivity and alkalinity. In Section 5.7.8.2 of the technical report (LCI, 2010a), the applicant includes justification for those indicator parameters based on the chemical makeup of the groundwater and lixiviant and the usage of similar lixiviants at existing ISR facilities in Wyoming. The applicant proposes to have the option for different indicator parameters based on water quality results for a specific wellfield (LCI, 2010a).

The applicant states that the upper control limit (UCL) for defining an excursion status will be set at five (5) standard deviations above the mean value for each indicator parameter (LCI, 2010a). The applicant states that the excursion detection monitoring program will consist of semi-monthly sampling with a minimum 10-day interval between sampling events at all monitoring wells along the perimeter ring and in the overlying and underlying aquifers (LCI, 2010a).

The applicant states that if sampling results for a well during the detection monitoring program indicate that at least two (2) of the three (3) indicator parameters exceed their respective UCLs or any single parameter exceeds its UCL by 20 percent, it will perform additional sampling first for verification of the excursion and then under excursion status, if warranted (LCI, 2010a). Verification monitoring consists of a second re-sampling (within 24 hours) and/or third re-sampling (within 48 hours) of the well(s) that exceed UCLs, if needed (LCI, 2010a). If the verification sampling confirms the initial results (i.e., two of the three sampling results exceed one of the triggering thresholds), then the well will be placed on excursion status. If the verification sampling does not confirm the initial results (i.e., the second and third sampling results are equal to or below the triggering thresholds), then the initial result is deemed a "false positive" and the well is returned to the excursion detection monitoring program (LCI, 2010a).

For a well on excursion status, the applicant proposes to notify the NRC Project Manager by e-mail or telephone within 48 hours of verifying the excursion status with a follow-up written report to the NRC Project Manager within 30 days (LCI, 2010a). While on excursion status, the applicant proposes weekly sampling of the affected well until the excursion status for the well is

terminated (LCI, 2010a). If an excursion is not corrected within 30 days, the applicant proposes sampling for a complete set of parameters per WDEQ requirements. The excursion status is deemed terminated after three consecutive weeks for which all excursion parameter levels are below the UCLs and NRC is notified of the termination in writing (LCI, 2010a). If an excursion status for a well exceeds 60 days, the applicant proposes a requirement to terminate lixiviant injection, or to provide additional reclamation surety that is agreeable to the NRC (LCI, 2010a).

NRC staff reviewed the applicant's proposed excursion monitoring program and finds it acceptable because the program will provide reasonable assurance the production fluids are confined to the wellfield thus meeting requirements in 10 CFR 40.41(c) for a licensee to confine his possession and use of source and byproduct material to the locations and purposes authorized by a license. The proposed program is consistent with criterion (5) of SRP Section 5.7.8.3. The excursion monitoring program as proposed by the applicant will be included in the narrative for standard license conditions 11.4 and 11.5 (see Appendix A of this SER).

5.7.9.3.1.5 Wellfield Pumping Tests

The applicant states that a pumping test will be conducted after development of a patterned area (wellfield) to document hydraulic communication within the wellfield, between the production zone and perimeter monitoring wells, and the lack of hydraulic communication between the production zone and overlying and underlying aquifers (LCI, 2010a). The data will be documented in a Wellfield Data Package (LCI, 2010a).

Staff finds that the proposed information to be included in the Wellfield Data Package will provide reasonable assurance that operations at a specific wellfield will be controlled and monitored by a means that is protective of human health and safety and the environment. Furthermore, based on the pre-operational pumping test (see SER Section 2.4), staff is reasonably assured that the applicant can operate the Lost Creek Project in a manner that will confine source and byproduct materials to the authorized locations. These reasonable assurance determinations, that the applicant's operations will be performed in accordance with 10 CFR 40.41(c), is contingent on the fulfillment of a license condition requiring the submittal of each mine unit wellfield data package to the NRC for review and verification prior to lixiviant injection in each new wellfield as discussed in SER Section 5.7.9.4.

5.7.9.3.1.6 Other Monitoring

In the application (LCI, 2010a), the applicant proposes quarterly monitoring at the operational BLM stock wells within one kilometer of the licensed area (Private Well Monitoring), quarterly monitoring of water levels at the 25 wells sampled during the pre-operational survey (Life-of-Mine Monitoring), and quarterly monitoring of shallow wells surrounding the storage ponds as discussed in SER Section 4.2.3.1.1.1.

The Private Well Monitoring program is a regional groundwater monitoring program that is to be conducted and reported as part of effluent/environmental monitoring (LCI, 2010a). The wells will be sampled based on consent of the property owner (i.e., BLM) and the data will be maintained on site (LCI, 2010a). If the consent of the property owner is not provided or the property owner declines to participate in the program, the affected property will not be sampled. The sampling will be conducted in accordance with the recommended monitoring in Regulatory Guide 4.14 and requirements in 10 CFR 40.65 (LCI, 2010a). Results of this monitoring program are to be reported to NRC in the semi-annual or annual effluent monitoring reports as discussed in SER Section 4.2.

The Life-of-Mine Monitoring program is in addition to the monitoring programs required by NRC (LCI, 2010a). The applicant's intent for this program is to monitor trends in groundwater elevations during operations. The applicant does not propose any action levels as a result of this monitoring program and indicates that the data from this program will be maintained on site (LCI, 2010a). NRC staff agrees that the monitoring is a best management practice as water level monitoring within an active wellfield is difficult to perform using only the production and injection wells. The additional data obtained through the program will be useful for the applicant and NRC staff in reviewing operation performance and corrective actions for an excursion should one occur. Staff agrees that the data should be retained on site and readily available to staff upon request though not specifically required by the regulations.

Quarterly monitoring of shallow wells surrounding the storage ponds is a requirement at existing licensed facilities and stems from requirements in 10 CFR Part 40, Appendix A, Criterion 7. The pond design includes a double liner system and a leak detection monitoring program to satisfy requirements of 10 CFR Part 40, Appendix A, Criterion 5E(1). Staff's finds that the applicant's proposed groundwater monitoring program surrounding the ponds is adequate because it is a defense in depth measure that will ensure protection of human health and safety and the environment, if fully implemented.

5.7.9.3.2 Surface Water Monitoring

The applicant did not propose routine monitoring of surface water because of the ephemeral nature of the streams through the license area (LCI, 2010a). In Section 5.7.8.2 of the technical report (LCI, 2010a), the applicant committed to installing automatic surface water samplers in a drainage following a spill that impacts surface water drainage. The automatic samplers will be placed in the drainage, one upstream and one downstream of the spill location, to collect water samples during the next precipitation event (LCI, 2010a).

5.7.9.4 Evaluation Findings

NRC staff has completed its review of the surface water and groundwater monitoring programs at the Lost Creek ISR facility. This review included an evaluation of the review procedures in SRP Section 5.7.8.2 and the acceptance criteria outlined in SRP Section 5.7.8.3.

Overall, the applicant has defined an acceptable sampling program. However, the staff notes that the applicant's proposed sampling program has:

- Discrepancies in the sampling parameters and frequency of monitoring to determine the baseline water quality data for the perimeter monitoring wells, production zone wells and monitoring wells in the overlying or underlying aquifers.
- A lack of a commitment to a minimum number of wells to be used for the baseline data for a mine unit, or to using the same wells for the evaluation of a restoration performance as were used to establish the baseline data.
- A lack of a commitment to submit a wellfield or mine unit specific hydrogeology package (i.e., Wellfield Data Package) establishing baseline quality and hydrogeologic characteristics of the wellfield to NRC for review and approval prior to injecting lixiviant

Contingent on the imposition of four license conditions, to which the applicant agreed in January 2011 and May 2011 (NRC, 2011b, 2011c), the staff is reasonably assured that the proposed surface and groundwater monitoring programs are sufficient for use in detecting contamination, developing restoration standards, and determining restoration progress and completeness. Therefore, the staff finds that the surface and groundwater monitoring programs are consistent with the acceptance criteria in SRP Section 5.7.8.3 and provide assurance that the facility can be operated in a manner that is protective of human health and safety and the environment.

The first standard license condition is License Condition 11.3 as follows:

> Establishment of Background Water Quality. Prior to injection of lixiviant in each production area, the licensee shall establish background groundwater quality data for the ore zone, and overlying and underlying aquifers. The background water quality will be used to define the background groundwater protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) for the ore zone aquifer and surrounding aquifers. Water quality sampling shall provide representative pre-operational groundwater quality data and restoration criteria as described in Section 5.7.8.1 of the approved license application.
>
> The data for each wellfield shall consist, at a minimum, of the following sampling and analyses:

A) Ore Zone. Samples shall be collected from production and injection wells at a minimum density of one production or injection well per 4 acres. A minimum of six wells will be required for the baseline data per mine unit. The data for subhorizons may be combined if the licensee demonstrates that the grouping of data is statistically valid. Wells selected for the baseline data will be those used to determine when restored groundwater meets the NRC's groundwater protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5).

B) Perimeter Monitoring Wells. Samples shall be collected from all perimeter monitoring wells that will be used for excursion monitoring in the HJ Horizon. Perimeter wells will be installed for a mine unit in accordance with information presented in Section 3.2.2.2 of the approved license application. In no case will the perimeter monitoring wells be installed outside of the UIC permit area approved by the Wyoming Department of Environmental Quality. If the production patterns include multiple subhorizons within the HJ Horizon, the above requirements will be applicable to all subhorizons.

C) Overlying and Underlying Aquifers. Samples shall be collected from all monitoring wells in the first overlying and first underlying aquifer at a minimum density of one well per 4 acres of production area.

D) Sampling and Analyses. Four samples shall be collected from each well to establish background levels. Consecutive sampling events shall be at least 14 days apart. The samples shall be analyzed for parameters listed in Table 6.2-1 of the approved license application. The licensee can reduce the list of parameters analyzed in the third and fourth sampling events. The parameters that can be deleted from analysis are those that measure below the minimum analytical detection limits (MDL) during the first and second sampling events, provided the MDLs meet the data quality objectives for the sampling.

E) Background Water Quality. For the perimeter monitoring wells (LC 11.3(B)) and monitoring wells in the overlying and underlying aquifers (LC 11.3(C)), the background levels shall be

the mean values on a parameter-by-parameter per well-by-well basis in accordance with Section 6.2.2 of the approved license application. For the ore zone monitoring wells, the background levels shall be established on a parameter-by-parameter basis using either the wellfield or well-specific mean value. The restoration target value (RTV) for each parameter shall be established using the mean value plus a statistically valid factor to account for spatial variability in the data.

The second standard license condition that the applicant agreed to (NRC, 2011b, 2011c) is License Condition 11.4 as follows:

Establishment of UCLs. Prior to injection of lixiviant into a production area, the licensee shall establish excursion control parameters and their respective upper control limits (UCLs) in designated overlying aquifer, underlying aquifer, and perimeter monitoring wells in accordance with Section 5.7.8.2 of the approved license application. Unless otherwise determined, the default excursion parameters are chloride, conductivity, and total alkalinity. The UCLs shall be established for each excursion control parameter and for each well based on the mean plus five standard deviations of the data collected for LC 11.3. The UCL for chloride can be set at the sum of the background mean concentration and either (a) five standard deviations or (b) 15 mg/L, whichever sum provides the higher limit.

The third standard license condition that the applicant agreed to (NRC, 2011b, 2011c) is License Condition 11.5 as follows:

Excursion Monitoring. Monitoring for excursions shall be conducted twice monthly (semi-monthly) and at least 10 days apart for wells installed under LC 11.3 (B) and (C) at all wellfields. If, for any well during a semi-monthly sampling event, the concentrations of any two-excursion indicator parameters exceed their respective UCL or any one excursion indicator parameter exceeds its UCL by 20 percent, then the excursion criterion is exceeded and a verification sample shall be taken from that well within 48 hours after results of the first analyses are received. If the verification sample confirms that the excursion criterion is exceeded, then the well is placed on excursion status. If the verification sample does not confirm that the excursion criterion, the licensee shall collect a third sample within 48 hours after the verification sampling. If the third sample shows that the excursion criterion is exceeded, the well on is placed on excursion status. If the third sample does not show that the excursion criterion is exceeded, the first sample shall be considered to be an error and routine excursion monitoring is resumed (the well is not placed on excursion status).

Upon confirmation of an excursion, the licensee shall notify NRC, as discussed below, implement corrective action, and increase the sampling frequency for the excursion indicator parameters at the well on excursion status to at least once every seven days. Corrective actions for confirmed excursions may be, but are not limited to, those described in Section 5.7.8.2 of the approved license application. An excursion is considered corrected when concentrations of all indicator parameters are below the concentration levels defining the excursion for three consecutive weekly samples.

If an excursion is not corrected within 60 days of confirmation, the licensee shall either (a) terminate injection of lixiviant within the wellfield until an excursion is corrected; or (b) increase the surety in an amount to cover the full third-party cost of correcting and cleaning up the excursion. The surety increase shall remain in force until the NRC has

verified that the excursion has been corrected and cleaned up. The written 60-day excursion report shall identify which course of action the licensee is taking. Under no circumstances does this condition eliminate the requirement that the licensee must remediate the excursion to meet groundwater protection standards as required by LC 10.7 for all constituents established per LC 11.3.

The licensee shall notify the NRC Project Manager (PM) by telephone or email within 24 hrs of confirming a lixiviant excursion, and by letter within 7 days from the time the excursion is confirmed, pursuant to LC 11.6 and 9.3. A written report describing the excursion event, corrective actions taken, and the corrective action results shall be submitted to the NRC within 60 days of the excursion confirmation. For all wells that remain on excursion after 60 days, the licensee shall submit a report as discussed in LC 11.1(A)

Finally, the fourth license condition, which is a site-specific condition that the applicant agreed to (NRC, 2011b, 2011c) is, as follows:

Wellfield Packages. Prior to principal activities in a new wellfield, the licensee shall submit a hydrologic test data package to the NRC for review. The licensee shall submit a hydrologic test package at least 60 days prior to the planned start date of lixiviant injection. In each wellfield data package, the licensee will document that all perimeter monitoring wells are screened in the appropriate horizon in order to provide timely detection of an excursion. The licensee shall not proceed with any lixiviant injection in the new wellfield before it receives written NRC verification of the submitted hydrologic test data package.

Appropriate wellfield test procedures are established, and, by license condition, the applicant will provide the wellfield hydrologic data packages to the NRC for review and verification under the license condition discussed above and in SER Section 2.4.2.2. Furthermore, the applicant has prepared an acceptable excursion corrective action plan, including notification of NRC and subsequent reporting in the event of an excursion. The staff notes that under 10 CFR 40.65, the applicant will be required to submit semiannual effluent monitoring reports that identify the quantity of principal radionuclides released to unrestricted areas in liquid (including groundwater) and gaseous effluents.

Based on the information provided in the application and on the detailed review conducted by staff of the groundwater and surface water monitoring programs at the Lost Creek Project, and contingent upon the license conditions above, the staff concludes that the groundwater and surface water monitoring programs are acceptable and comply with the following regulations:

- 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life and property
- 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license;
- 10 CFR Part 40, Appendix A, Criterion 5B(5), which provides concentration limits for contaminants;
- 10 CFR Part 40, Appendix A, Criterion 5D, which requires a groundwater corrective action program; and
- 10 CFR Part 40, Appendix A, Criterion 7, which requires a detection and compliance groundwater monitoring program.

5.7.9.5 References

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material," U.S. Government Printing Office, Washington, DC.

Deutsch, W. J.; W. J.; Martin, L. E.; Eary, R. J., Serne, 1985. "Method of Minimizing Ground-Water Contamination From In Situ Leach Uranium Mining," (Final Report), NRC (Ed.), NUREG/CR-3709, Washington DC, 1985, 88 p.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003. ML032250177

NRC, 2011b. U.S. Nuclear Regulatory Commission, "Letter to Wayne Heili, LCI, Regarding Second Draft Materials License, Lost Creek ISR, LLC, Lost Creek In Situ Recovery Project, Sweetwater County, Wyoming (TAC No. J00559)," May 5, 2011, ADAMS Accession No. ML111120307.

NRC, 2011c. U.S. Nuclear Regulatory Commission, "Letter to Wayne Heili, LCI, Regarding Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming, Summary of May 31, 2011, Teleconference - (TAC NO. J00559)," July 11, 2011, ADAMS Accession No. ML111890482.

Staub, W. P., N. E., Hickle, R. E., Williams, F., Anastasi, J., Osiensky, D., Rogness, 1986. "An Analysis of Excursions at Selected In Situ Uranium Mines in Wyoming and Texas," NUREG/CR-3967, ORNL/TM-9956, Washington, DC, 1986, 297 p.

5.7.10 QUALITY ASSURANCE (QA)

5.7.10.1 Regulatory Requirements

Staff's analysis will determine if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed quality assurance program for the Lost Creek Project meets requirements of 10 CFR 20.1101, 10 CFR Part 20 Subpart L, and Subpart M.

5.7.10.2 Regulatory Acceptance Criteria

The staff reviewed the application for compliance with applicable requirements of 10 CFR Part 40 using acceptance criteria outlined in Section 5.7.9.3 of the Standard Review Plan (SRP), NUREG-1569 (NRC, 2003a). Regulatory Guide 4.15 provides guidance on demonstrating compliance with the applicable regulations.

5.7.10.3 Staff Review and Analysis

Unless otherwise stated, the information in SER Section 5.7.10.3 was from Section 5.7.9 of the technical report (LCI, 2008c, 2010a). This section discusses the proposed QA programs for radiological and non-radiological monitoring activities. QA is a methodical program of procedures and controls required to provide sufficient confidence in the evaluation of monitoring results (NRC, 2007b). Quality control (QC) is the methodology, such as tests, audits, and analyses, used within the QA program to verify that established standards are met. The QA/QC program includes all radiological and non-radiological measurements that support the radiological, effluent, and environmental monitoring programs. The QA/QC program is essential to ensure that data collected and recorded to demonstrate compliance with 10 CFR Parts 20 and 40, and 40 CFR Part 190 are reasonably valid and of a defined quality.

5.7.10.3.1 Radiological and Non-radiological Monitoring Programs

Regulatory Guide 4.14, Radiological Effluent and Environmental Monitoring at Uranium Mills, (NRC, 1980), Sections 3 and 6, describe requirements to ensure that representative effluent and environmental monitoring data are collected by implementing sampling and analytical procedures, collecting samples at appropriate locations, using correct and calibrated equipment, and minimizing random and systemic errors. Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination) - Effluent Streams and the Environment (NRC, 2007b) and Regulatory Guide 4.14 state that analytical processes should be tested with periodic cross-check analyses with independent laboratories. Further, Regulatory Guide 4.15 suggests that any contractor performing monitoring activities should provide a QA program and program data summaries consistent with the guidance established in the guide.

The applicant states that QA and QC programs are to be documented in a Quality Assurance Project Plan (QAPP) (LCI, 2010a). The purpose for a QAPP is to ensure that the procedures and practices for any operational or decommissioning monitoring program are based on sound radiation protection principles to achieve doses to the workers and public are as low as reasonably achievable (ALARA) and that the data acquire to make the ALARA determinations are precise and accurate. The underlying regulatory requirement for the QAPP is 10 CFR 20.1101. That regulation requires licensees to develop, document, and implement the QAPP; however, the regulations do not require that the QAPP be developed prior obtaining a license.

In Attachment 5.2-1 of the technical report (LCI, 2010a), the applicant provided a description of the proposed QAPP, including a Table of Contents and Executive Summary, for the environmental and effluent monitoring programs to be conducted at the Lost Creek Project. The proposed QAPP will include the following items (LCI, 2010a):

- delineation of organizational structure and responsibilities of management;
- minimum personnel qualifications and training for individuals performing radiological monitoring, to include job descriptions, training program, and continuing training and education requirements;
- written operating procedures and instructions for general laboratory and internal QC that includes instrument calibration, external performance evaluation, and data verification and validation;

- procedures covering statistical data evaluation, instrument calibration, duplicate sample programs, and spike sample programs;

- audits and qualifications of personnel conducting the audits; and

- preventive and corrective actions to ensure continuous improvements in the program, which include evaluating performance levels and deficiencies, corrective actions, and efficacy evaluations.

In Section 5.2.1 of the Technical Report (LCI, 2010a), the applicant committed to completing and installing the QAPP for the operational monitoring programs before initiation of construction activity. For the decommissioning plans, the applicant stated that Chapter 6 of the technical report constituted the initial decontamination plan for the facility (LCI, 2010a), and committed to submitting additional decommissioning plans, which will address quality assurance issues, summarized as follows (LCI, 2010a):

> For mine units, which can be decommissioned as separate outdoor areas, an initial decommissioning plan will be submitted in the respective wellfield data package(s). The applicant will submit wellfield data package(s) to NRC for review and verification prior to operations in the respective wellfield. The applicant commits to submitting an updated decommissioning plan after operations are completed.
>
> For the processing and support facilities that will not be removed until the end of the Project, the applicant committed to submitting, at least 12 months prior to the planned decommissioning activities, an updated decommissioning plan to NRC for review and approval.

Staff reviewed the applicant's description of the QA program and finds that the submitted information is not consistent with the acceptance criteria for a completed QAPP in SRP Section 5.7.9.3 (NRC, 2003a) nor is it consistent with guidance in Regulatory Guide 4.14, Section 3 and 6 (NRC, 1980) and Regulatory Guide 4.15 (NRC, 2007b). The QA program is supposed to be designed to assure data collected in the monitoring programs are representative of site conditions and those values can be relied on for evaluation of risks to human health or the environment. Section 10 CFR 40.31(h) states that "[*an] application … shall contain proposed written specifications relating to milling operations and the disposition of the byproduct material to achieve the requirements and objectives set forth in appendix A*". Although the application contains a comprehensive overview of goals for a QA program, the staff will require that the applicant provide details on their proposed in-house monitoring programs for the NRC staff to review and verify prior to implementing those programs. Therefore, the NRC staff will require the applicant to submit a completed QAPP consistent with its Table of Contents (TOC) to NRC staff for review prior to startup of operations for the staff to verify that the QAPP will be consistent with Regulatory Guide 4.15 (as revised). Furthermore, the NRC staff will review the QAPP to ensure the environmental monitoring data collected meet regulatory requirements in Criterion 7 of Appendix A to 10 CFR Part 40. The license condition is discussed in SER Section 5.7.10.4.

5.7.10.3.2 Organizational Structure and Responsibilities

The applicant identified six key positions of the organization with Quality Assurance/Quality Control (QA/QC) responsibilities (LCI, 2010a). Three positions, the President of LCI, General

Manager, and Manager of Environmental Health and Safety (EHS) and Regulatory Affairs, represent the applicant's corporate positions and will operate from offices in Cody, Wyoming. The remaining three positions consist of the Mine Manager, Site Supervisor EHS/RSO, and affected department head, all of which are located on-site (LCI, 2010a).

The EHS Manager has responsibility for, and authority over, the QA/QC program for the Lost Creek ISR Project (LCI, 2010a). The EHS Manager is responsible for all radiation protection, health and safety, and environmental programs and for ensuring that the applicant complies with all applicable regulatory requirements. The EHS Manager also advises the radiation safety officer (RSO) to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements (LCI, 2010a).

The Site Supervisor EHS/RSO, who reports to the EHS Manager, is the designated site QA/QC Coordinator and manages the QAPP (see SER Figure 5.1-1) (Hoy, 2010b; LCI, 2010a). The RSO works with supervisory personnel to review and approve new equipment and changes in processes and procedures that may affect radiological safety, and to ensure that established programs are maintained. The RSO has no production-related responsibilities, and the mine manager cannot unilaterally override a decision of the RSO to suspend, postpone, or modify any activity. The Mine Manager conducts technical review and evaluation of audits of the QA/QC program (LCI, 2010a).

NRC staff has determined that the organizational structure and responsibilities outlined in Sections 5.1 and 5.7.9.1 and Figure 5.1-1 (Hoy, 2010b) of the technical report (LCI, 2010a) provides the QA/QC coordinator sufficient authority and organizational freedom to implement the QA program consistent with guidance provided in Regulatory Guide 4.15. The staff will verify that this information is contained within the QAPP submitted to NRC for review prior to startup of operations.

5.7.10.3.3 Specification of Qualifications of Personnel

In Section 2 of the QAPP TOC in Attachment 5.2.1 of the technical report, the applicant proposes to provide details on the personnel qualifications and training for the QA program (LCI, 2010a). NRC staff has reviewed the information to be provided and finds that it will be acceptable provided the information is in sufficient detail and consistent with Regulatory Guide 4.15. However, because the applicant failed to submit a completed QAPP detailing the qualifications of personnel in the QA programs, as described in the acceptance criteria in SRP Section 5.7.9.3, NRC staff will require the applicant to submit a completed QAPP consistent with its Table of Contents and Regulatory Guide 4.15 to NRC staff for review and verification.

5.7.10.3.4 Operating Procedures and Instructions

In Section 3 of the QAPP TOC in Attachment 5.2.1 of the technical report, the applicant proposes to provide operating procedures and instructions (LCI, 2010a). NRC finds that the information to be provided will be acceptable provided the information is addressed in the QAPP in sufficient detail and consistent with the guidance provided in Regulatory Guide 4.15. Accordingly, the NRC staff will require the applicant to submit a completed QAPP consistent with its Table of Contents to NRC staff for review to verify the applicant has met the commitments in its approved application prior to startup of operations. This license condition is discussed in SER Section 5.7.10.4 (see LC 12.14 in Table 1 of the Introduction).

5.7.10.3.5 Records

In Section 4 of the QAPP TOC in Attachment 5.2.1 of the technical report, the applicant proposes to provide record requirements and document controls for the QA program (LCI, 2010a). NRC staff has reviewed the information to be provided and finds that it will be acceptable provided the information is in sufficient detail and consistent with Regulatory Guide 4.15. However, because the applicant did not submit a completed QAPP detailing the records and documents controls for the QA programs as required by the acceptance criterion in SRP Section 5.7.9.3, NRC staff will require the applicant to submit a completed QAPP consistent with its TOC to NRC staff for review and verification prior to startup of operations.

In Section 4 of the QAPP TOC, the applicant proposes to provide record requirements and document controls for the QA program (LCI, 2010a). NRC staff has reviewed the information to be provided and finds that it will be acceptable provided the information is in sufficient detail and consistent with Regulatory Guide 4.15. NRC staff will require the applicant to submit a completed QAPP consistent with its Table of Contents to NRC staff for review to verify the applicant has met commitments in its approved application prior to startup of operations.

5.7.10.3.6 Quality Control

In Sections 5, 6, and 7 of the QAPP TOC in Attachment 5.2.1 of the technical report, the applicant proposes to provide quality control (QC) procedures for the environmental monitoring programs (LCI, 2010a). NRC staff has reviewed the information to be provided and finds that it will be acceptable provided the information is in sufficient detail and consistent with Regulatory Guide 4.15. NRC staff will require the applicant to submit a completed QAPP consistent with its Table of Contents to NRC staff for review to verify that the applicant met its commitments stated in its approved application prior to startup of operations.

5.7.10.3.7 Verification and Validation

The verification and validation (V&V) of certain aspects and support activities of the measurement process or monitoring program are essential to the QA program (NRC, 2007b). These aspects and activities include data and computer software V&V and project method validation. Project method validation is the demonstration that a performance-based method is capable of providing analytical results to meet criteria in the analytical protocol specification. Acceptable project method validation is necessary before the radiological analysis of samples or the taking of measurements in a monitoring program (NRC, 2007b).

In Section 8 of the QAPP TOC in Attachment 5.2.1 of the technical report, the applicant proposes to provide V&V of data used for the monitoring programs (LCI, 2010a). NRC staff has reviewed the information to be provided and finds that it will be acceptable provided the information is in sufficient detail and consistent with Regulatory Guide 4.15. NRC staff will require the applicant to submit a completed QAPP consistent with its TOC to NRC staff for review to verify the applicant met the commitments in its approved license application prior to startup of operations.

5.7.10.3.8 Assessments, Audits, and Preventive and Corrective Actions

Assessments, audits, and surveillances are elements used to evaluate the initial and ongoing effectiveness of the QA program to monitor and control the quality of a radiological monitoring program. Management having responsibility in the area being reviewed should document and

review the results of the assessments, audits and surveillances. Audits of the QA programs of contractors providing materials, supplies, or services affecting the quality of the laboratory's operations should be performed periodically (NRC, 2007b).

Integral components of a QA program include identifying areas for improvement, defining performance or programmatic deficiencies, and initiating appropriate corrective or preventive actions. The QA program for radiological effluent and environmental monitoring programs should contain both a continuous-improvement program and a program for implementing corrective actions when conditions adverse to quality have been identified (NRC, 2007b).

In Section 9 of the QAPP TOC in Attachment 5.2.1 of the technical report (LCI, 2010a), the applicant proposes to provide details on the assessments and audit programs. The applicant committed to assessments and audits of the training and surveillance programs. In Section 10 of the QAPP TOC (LCI, 2010a), the applicant proposes to provide details on the preventive and corrective action programs. In Section 5.2 of the technical report, the applicant discusses the role of SERP in assessing and auditing of the sampling program (LCI, 2010a). The applicant will be required to include the SERP's assessments concerning lessons learned and quality improvement, as well as other routine assessments and audits of the environmental monitoring programs in the QAPP (LCI, 2010a).

NRC staff has reviewed the information to be provided and finds that it will be acceptable provided the information is in sufficient detail and consistent with Regulatory Guide 4.15 and with the assessments noted above. The staff has reasonable assurance that the applicant intends to follow the TOC, which serves as a template for the applicant to develop its QA program, contingent upon a license condition that requires LCI to submit a completed QAPP that is consistent with Regulatory Guide 4.15 to the NRC staff for review and verification. The applicant agreed to the proposed license condition in public meetings with the NRC staff in January and May 2011, in which the staff discussed the draft license (NRC, 2011b, 2011c).

5.7.10.4 Evaluation Findings

The applicant has provided an acceptable corporate organization that defines management responsibilities with sufficient authority at each level and organizational freedom to implement a QA program. The proposed organizational management structure diagram portrays integration among groups that support the operation and maintenance of the facility that the staff finds adequate because it indicates management intends to comply with the guidance in Regulatory Guides 4.15 to ensure the environmental data collected and analyzed will meet regulatory requirements in 10 CFR Part 40, Appendix A.

The question is whether a TOC of a proposed QAPP forms a sufficient basis from which the staff may conclude regulatory compliance or whether the applicant must submit a completed QAPP Acceptance criterion (1) of SRP Section 5.7.9.3 presumes that an applicant will submit a complete QAPP with its applicant. NRC staff has determined that the QAPP TOC submitted by LCI with the application (LCI, 2010a) identifies that information to be included in the QAPP on a level of detail such that staff has reasonable assurance the applicant's proposed QAPP would be consistent with the guidance in Regulatory Guide 4.15, ensure the samples it collects and analyzes are defendable. However, to ensure that the final QAPP remains consistent with the applicant's commitments made in its application as outlined in the TOC and to ensure the environmental data collected will meet regulatory requirements, the staff will include a license condition, to which the applicant has agreed, requiring that the applicant submit the completed QAPP to the NRC staff for review and verification prior to preoperational inspection.

Additionally, the staff finds that the components of the QA/QC identified in the application demonstrates the applicant understands the need for precise and accurate data, and commitments made throughout the application demonstrates the applicant understands the ALARA principle. For example, the application included the operations manual for equipment to be used for radiation protection (Attachment 5.7-3 of the application (LCI, 2010a)), discussions on the calibration, correction factors and measurement procedures (Section 5.7.2 of the application (LCI, 2010a), and responsibilities of personnel performing the radiation protection program (Section 5.7.2 of the application (LCI, 2010a)). Staff finds that the understandings documented in the application for a proper radiation protection program and the TOC presented in the application for the QAPP are sufficient bases for staff's determination that the applicant will develop a program that meets the requirements in 10 CFR 20.1101. Staff's findings are contingent upon the imposition of the following license condition:

> At least 60 days prior to the preoperational inspection, the licensee will submit a completed Quality Assurance Project Plan (QAPP) to the NRC for review to verify that the QAPP will be consistent with Regulatory Guide 4.15 (as revised).

5.7.10.5 Reference

Hoy, R., 2010b. AATA International, Inc., email to Tanya Oxenberg, NRC, June 24, 2010, ADAMS Accession No. ML101820138.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

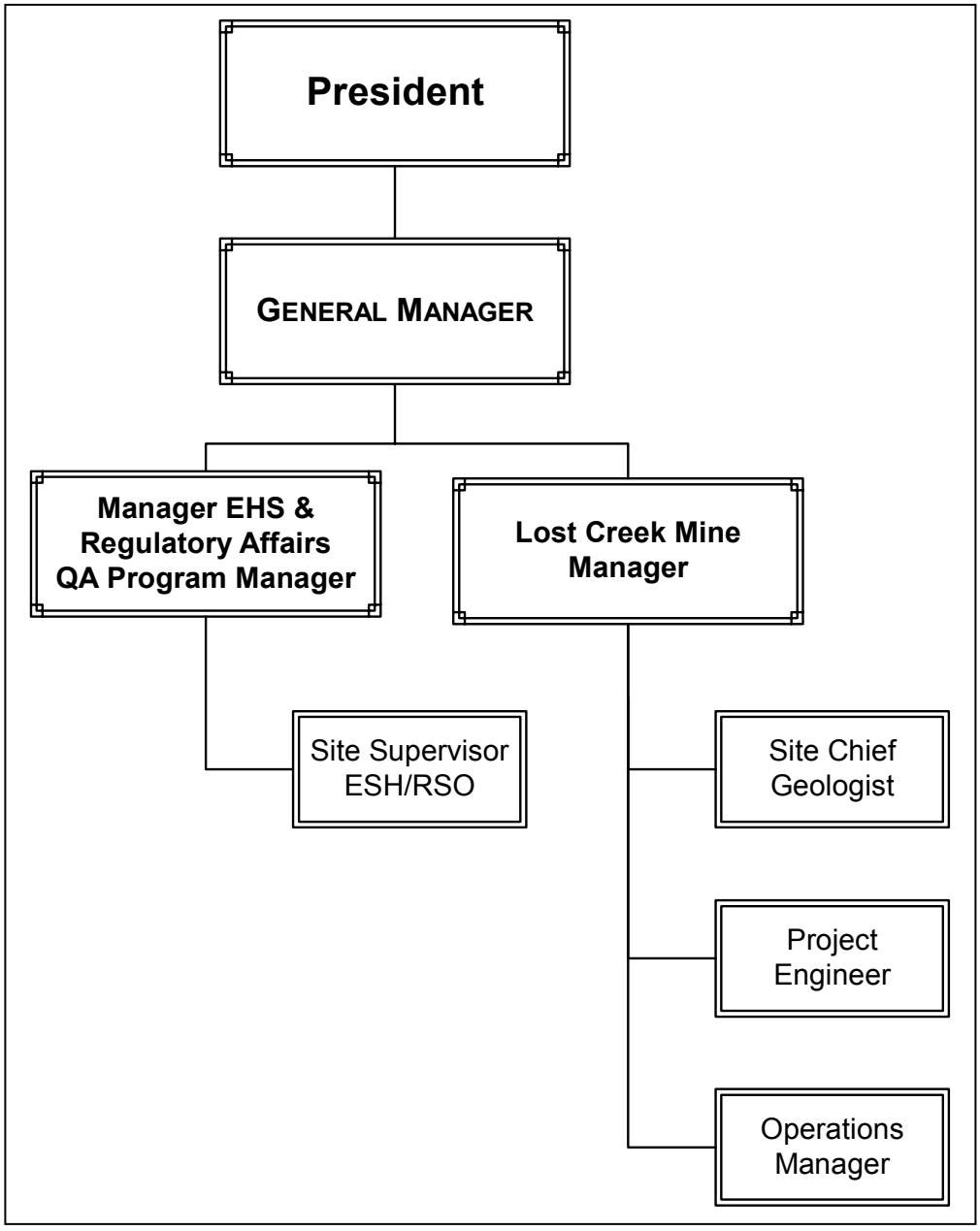
NRC, 1980. "Radiological Effluent and Environmental Monitoring at Uranium Mills," Regulatory Guide 4.14, Revision 1, Washington, DC, April 1980.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," NUREG-1569, Washington, DC, June 2003.

NRC, 2007b. "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) - Effluent Streams and the Environment," Regulatory Guide 4.15, Revision 2, Washington, DC, July 2007.

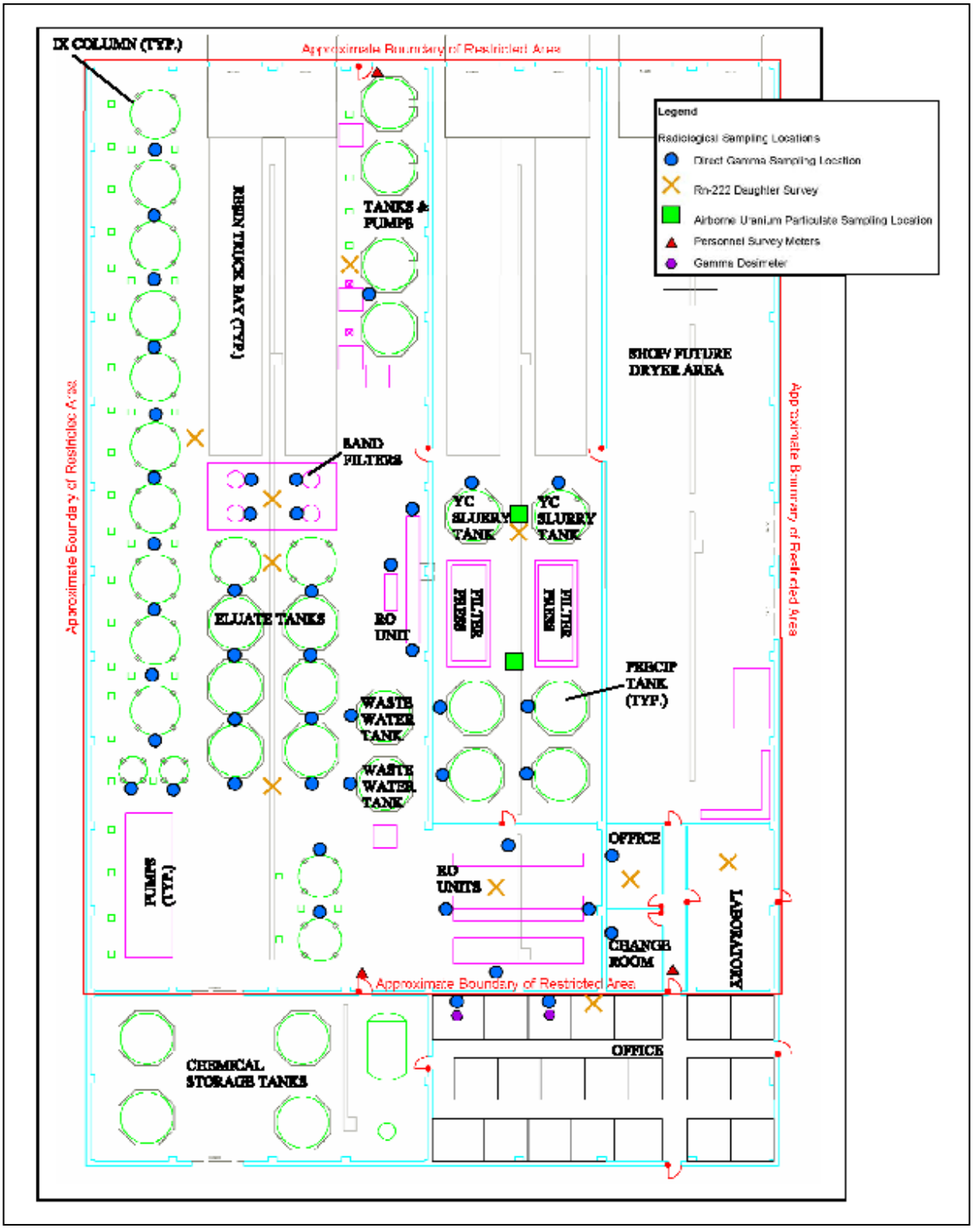
NRC, 2011b. U.S. Nuclear Regulatory Commission, "Letter to Wayne Heili, LCI, Regarding Second Draft Materials License, Lost Creek ISR, LLC, Lost Creek In Situ Recovery Project, Sweetwater County, Wyoming (TAC No. J00559)," May 5, 2011, ADAMS Accession No. ML111120307.

NRC, 2011c. U.S. Nuclear Regulatory Commission, "Letter to Wayne Heili, LCI, Regarding Lost Creek ISR, LLC, Lost Creek In Situ Recovery Facility, Sweetwater County, Wyoming, Summary of May 31, 2011, Teleconference - (TAC NO. J00559)," July 11, 2011, ADAMS Accession No. ML111890482.



LCI, 2010a; Hoy, 2010a) (Source: Adapted from Figure 5.1-1 in technical report)

Figure 5.1-1: Lost Creek ISR, LLC Organization Chart



(LCI, 2010a) (Source: Adapted from Figure 5.7-1 in technical report)

Figure 5.7-1: In-Plant Sampling Locations

6.0 GROUND WATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 PLANS AND SCHEDULES FOR GROUNDWATER RESTORATION

6.1.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed plans and schedules for groundwater quality restoration for the Lost Creek Project meet the requirements of 10 CFR 40.32(c), 10 CFR 40.42, and 10 CFR Part 40, Appendix A, Criterion 5B(5).

6.1.2 REGULATORY ACCEPTANCE CRITERIA

Staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the review procedures in Section 6.1.2 and acceptance criteria in Section 6.1.3 of the Standard Review Plan (SRP) (NRC, 2003a).

6.1.3 STAFF REVIEW AND ANALYSIS

This section discusses the applicant's proposed plans for restoration activities at the Lost Creek Project. This discussion includes proposed restoration standards, restoration methods, restoration effectiveness, estimates of the number of pore volumes needed to complete restoration, restoration and stability monitoring, wastewater disposal, well plugging and abandonment, and the preliminary restoration schedule.

6.1.3.1 Restoration Standards and Restoration Target Values

Unless otherwise stated, the information in SER Section 6.1.3 is from Section 6.2 of the technical report (LCI, 2008c, 2010a). In Section 6.2.2 of the technical report, the applicant committed to using the standards identified in 10 CFR Part 40, Appendix A, Criterion 5B(5) for restoration of the production aquifer following operations (LCI, 2010a). Those standards are the Commission-approved background values in the table in Criterion 5C of 10 CFR Part 40, Appendix A, or an alternate concentration limit (ACL) established by the NRC in accordance with Criterion 5B(6). The Commission–approved background values consist of the baseline values discussed in SER Section 5.7.9. The baseline values are commonly referred to in the uranium recovery industry as the Restoration Target Values (RTV). Use of Criterion 5B(5) for restoration is a regulatory requirement applicable to ISR facilities (NRC, 2009i). The staff finds that the applicant's commitment satisfies this regulatory requirement, and will include this requirement as a standard license condition (LC) (see LC 10.6 in Appendix A).

The applicant did not specifically state that the wells it would use to determine restoration success would be those that it used to establish the baseline values. Acceptance criterion (3) in Section 6.1.3 of the SRP recommends using the same wells for both establishing baseline values and determining compliance with the NRC's groundwater restoration standards. Furthermore, sampling the same wells for both baseline and restoration provides the statistically robust data necessary to confirm that the groundwater has been restored to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) and for the NRC to make its determination under 10 CFR Part 40, Appendix A, Criterion 5D regarding the completion of groundwater restoration.

Therefore, the staff will include a license condition requiring the applicant to use the same wells for restoration success that it used to establish the baseline values (see SER Section 5.7.9.4 and LC 11.3(A) in Appendix A).

6.1.3.2 Restoration Methods

The information presented in SER Section 6.1.3.2, unless stated otherwise, is from Section 6.2 of the application (LCI, 2008c, 2010a). The applicant stated that groundwater restoration methods will consist of: (a) groundwater sweep; (b) groundwater treatment; (c) groundwater circulation; and (d) stabilization (LCI, 2010a).

Groundwater sweep is a process in which groundwater is pumped from the wellfield without injecting water back into the wellfield, creating an influx of baseline water quality into the wellfield. The goal of this method is to remove and dilute residual lixiviant-impacted groundwater in the production zone, reduce elevated levels of salts, and capture flares along the perimeter of the production zone. In the application, the applicant stated that the sweep will remove oxidized groundwater within the production zone, as well as drawing in any affected water from the perimeter of the wellfield (LCI, 2010a).

Groundwater treatment will occur either after or simultaneous with the groundwater sweep (LCI, 2010a). During groundwater treatment, the applicant will pump groundwater from the production zone, treat the groundwater at the surface using ion exchange (IX) and reverse osmosis (RO), and then re-inject the clean portion into the production aquifer. RO is a high-pressure filtration process that reduces contaminants in the affected groundwater producing a clean permeate (re-inject water) and concentrated brine (waste). The applicant proposes a two-step process for RO: the first process results in a 75:25 ratio of permeate to brine, and the second step is a polish of the rejected brine from the first step resulting in a 50:50 ratio of permeate to brine product. The applicant will reinject clean water and send the brine from the treatment to deep disposal wells (LCI, 2010a).

Groundwater recirculation consists of pumping groundwater from a portion of the production zone and re-injecting that water into another portion of the production zone without any treatment. The applicant will use recirculation to homogenize the water quality throughout the production zone (LCI, 2010a). The applicant proposed that a reductant may be applied at any time during the restoration process depending upon site conditions (in particular, depending upon the levels of trace metals that have been mobilized due to the increase in oxidation state from the production activities) (LCI, 2010a). In Section 6.2.3 of the technical report, the applicant committed to (a) prepare a Comprehensive Safety Plan for use of chemical reductant, and (b) obtain NRC approval prior to use of any biorestoration. The applicant will implement the safety plan only after review by the Safety Environmental Review Panel (SERP) (LCI, 2010a). The applicant stated that it is more likely to use sodium sulfide, instead of hydrogen sulfide, due to the increased chemical hazards associated with the latter (LCI, 2010a). The staff finds that this statement is consistent with the ALARA process. In addition, because the applicant did not include an accident analysis involving use, storage, handling, and transport of hydrogen sulfide, nor provided discussions on meeting regulatory requirements for use of hydrogen sulfide (e.g., 40 CFR 68.130 and Appendix A to 6 CFR Part 27), per LC 9.4(B) and (C), the applicant is required to amend this license prior to using hydrogen sulfide during restoration.

Staff reviewed the restoration methods proposed by the applicant and finds that these methods, excluding biorestoration, are acceptable as they reflect historical ISR industry restoration practices that have achieved the groundwater protection standards of 10 CFR Part 40,

Appendix A, Criterion 5B(5) and are included as acceptable methods in acceptance criterion (3) in SRP Section 6.1.3. The staff finds that such practices have provided NRC-approved restorations that provided a high degree of certainty that water quality in the surrounding aquifers, which might be an underground source of drinking water, will have a negligible potential to be impacted in the foreseeable and extended future (generally up to 300 years) and longer. The staff finds that routine use of chemical reductants to accelerate the restoration process at existing ISR facilities have been effective, and reductant use and on-site storage have not adversely affected workers' or the public's health or the environment. Effectiveness of such reductants depends on the geochemical setting, and thus, the staff finds that the decision to use a chemical reductant at a specific wellfield is best made by the SERP.

The staff notes that ISR facilities have used biorestoration in the past, but it remains an unproven technology as its methodologies for implementation have not been established. Results of past pilot-test scale operations have been mixed (i.e., the desired outcome for a specific element might or might not have been achieved and the treatment might have resulted in an unanticipated adverse impact on another element). Therefore, use of biorestoration should require NRC staff review and approval, as the applicant committed to obtain in Section 6.2.3 of the technical report. Therefore, the staff concludes that the proposed restoration methods, excluding biorestoration, are acceptable because they are consistent with acceptance criterion (3) of SRP Section 6.1.3, as the application described the proposed processes, such as circuits, treatment methods, methods for disposal, or treatment of wastes; chemical additives and their effects; and alternate methods that could be utilized if primary plans are not effective.

The applicant stated that restoration would proceed on a wellhead-by-wellhead basis in lieu of the entire wellfield (LCI, 2010a). A portion of the wellfield will immediately start restoration once production is completed for wells at a particular wellhead. The applicant further stated that the production and restoration processes within a wellfield may be buffered by one or two well houses. In Section 3.2.2, "Mine Unit Design," of the application, the applicant stated that it would sequence the restoration process within a wellfield that has multiple mineralizations within the production aquifer. Production will proceed from the lowest mineralization to the uppermost mineralization. The applicant committed to having areas with multiple vertical production zones undergo restoration after production of the last zone (LCI, 2010a).

The applicant will determine the sequence of restoration activities during operations based on experience at other ISR facilities and at the Lost Creek Project (LCI, 2010a). The applicant stated that it is possible that not all phases of restoration will be necessary for all mine units to achieve restoration per NRC's 10 CFR Part 40, Appendix A, Criterion 5B(5) standards. NRC staff reviewed the proposed restoration plans and finds that they follow a risk-informed, performance-based approach by not specifying the exact sequencing of restoration methods. The staff finds that the applicant's plans meet acceptance criterion (3) of SRP Section 6.1.3, which states that the NRC allows flexibility and innovation in approaches to restoration, and that applicants are not limited to using one restoration method for all wellfields. Therefore, the staff finds that the applicant's restoration plans are acceptable because the applicant described the sequential phases of restoration that it could use and the most likely restoration scenario, based on research and development (R&D) results and the restoration experience of its staff, as recommended in acceptance criterion (3) of SRP Section 6.1.3.

Should restoration of a wellfield not achieve the primary restoration target values, then the staff will expect the applicant to demonstrate with any ACL application that the levels of constituents in the ore zone aquifer after restoration are ALARA. Additionally, the staff will expect the applicant to demonstrate that the restoration methods employed were the best available

technology (BAT) and that the remaining constituent levels do not pose a risk to the surrounding aquifers that might be underground sources of drinking water.

6.1.3.3 Effectiveness of Groundwater Restoration Methods

In Attachment 6.2-1 of the technical report, the applicant provided a technical memorandum produced by its contractor that documents similarities between the hydrogeologic and geochemical setting at the proposed Lost Creek Project and the hydrogeologic and geochemical settings at two analogous existing ISR facilities where similar restoration methods were utilized to achieve NRC's groundwater protection standards (LCI, 2010a). NRC staff reviewed the memorandum and agrees that the proposed analogues are appropriate because of the similarities in hydrogeologic and geochemical settings and the proposed restoration methodologies. Analyzing analogous restoration programs provides the staff with reasonable assurance that the same restoration program can achieve NRC's groundwater protection standards at the Lost Creek Project. The applicant committed to using the BAT to achieve the restoration goals and perform wellfield restoration within a timely manner. The applicant indicated that it might seek ACLs if it does not achieve the primary standards (LCI, 2010a).

Staff reviewed the applicant's evaluation of the effectiveness of its proposed restoration methods. The staff finds that the technical memorandum summarizes both the similarities and differences in the geology and geochemistry settings for the facilities compared, and makes reasonable arguments that the analogues are appropriate for its proposed methods. NRC staff reviewed the memorandum and the applicant's commitments. The staff finds that the analogues presented by the applicant and the applicant's proposed methods meet acceptance criterion (3) in SRP Section 6.1.3 because the proposed methods are consistent with those used to achieve restoration of wellfields at existing and former R&D facilities, and have been shown to be protective of human health and safety and the environment. The applicant committed (LCI, 2010a) to performing restoration in the most efficient manner in order to achieve its restoration goals as soon as possible, consistent with the ALARA approach. Therefore, the staff finds that these methods are acceptable.

6.1.3.4 Pore Volume Estimates

In Section 6.2.3 of the technical report (LCI, 2008c, 2010a), the applicant presented its method to determine pore volume (PV) as the thickness of the ore sand multiplied by the pattern area, effective porosity, horizontal flare factor, and vertical flare factor. Thickness of the ore sand and pattern area are readily measurable. Effective porosity is determined from site-specific hydrogeologic information. Flare factors are assumed values based on operational flow rates, locations of injection wells relative to production (withdrawal) wells within a wellfield, and the extent of vertical anisotropy of the hydraulic conductivity within the ore zone aquifer (NRC, 2003a).

The applicant had estimated that both initial flare factors (one factor for the horizontal direction and the other factor in the vertical direction) were 20 percent of the volume of the wellfield volume (LCI, 2010a). The staff finds this estimate is consistent with flare factors used at existing ISR facilities in Wyoming. Staff reviewed the flare factors and finds them acceptable because they are used to estimate pore volumes at existing ISR facilities with similar hydrogeologic and geochemical settings. The staff finds those pore volume estimates have been suitable for use in the calculations to estimate costs for financial assurance purposes.

In Table 6.8-1 of the application (LCI, 2010a), the applicant calculated a pore volume for Mine Unit 1 of 129 million L (34.2 million g) (using a wellfield area of 9.82 m^2 (24.28 acres [a]), average completion thickness of 12 feet, porosity of 25 percent, and flare factors equal to 20 percent). The calculations represent only 50 percent of the total Mine Unit 1 (LCI, 2010a). Staff reviewed the applicant's calculations and input values and finds that they accurately reflect site conditions.

The applicant's input values consist of wellfield area, completion thickness, porosity value, and flare factors. The wellfield area value is consistent with staff's estimation of one-half the area for Mine Unit 1 as depicted on Plate 2.6-2b in the application (LCI, 2010a). The completion thickness is based largely on the applicant's estimate; the staff finds that this estimate is consistent with the ore zone depicted on the various cross-sections prepared by the applicant. As stated in Section 2.6.2.3 of the application, completion thickness of the ore mineralization ranges from 5 to 28 feet, and the average thickness is 16 feet (LCI, 2010a). The porosity value was based on laboratory analysis of a site-specific subsurface core sample and was found by staff to be consistent with values used for similar geologic regimes in Wyoming (LCI, 2010a). Therefore, the staff finds that the methodology and calculations used by the applicant for the pore volume calculation are acceptable because they are consistent with SRP Section 6.1.3 acceptance criterion (2), and the applicant used site-specific information, which the staff found acceptable, as discussed above.

The applicant estimated that six pore volumes (PVs) are required for restoration of Mine Unit 1, as specified in Section 6.2 of the technical report (LCI, 2010a). The applicant provided justification for its PV estimates in Attachment 6.2-1 of the application (LCI, 2010a). In addition, the applicant proposed a strategy to adjust the PV estimates as needed. The applicant committed to using best practicable technology (BPT) to return groundwater quality in the production zone to baseline values (LCI, 2010a). One factor that the NRC staff will consider should the applicant submit an application for an ACL as a restoration goal, is information on BATs or BPTs that the applicant has used. In addition to using BPT, the applicant committed to adjusting the estimated number of pore volumes needed for restoration of future mine units as the applicant gains experience (LCI, 2010a).

Staff reviewed the applicant's estimated pore volumes and finds that this information is adequate because it meets the acceptance criterion (3) in SRP Section 6.1.3, which states:

> *"[Pore volume] estimations may be based on historical results obtained from research and development sites or experience in other well fields having similar hydrologic and geochemical characteristics."*

Staff's review of the applicant's calculations for the financial assurance indicated that the applicant's estimate that six PV's are required for restoration was for the groundwater treatment (i.e., RO) phase of the restoration, and that the applicant also included a 0.3 PV for the groundwater sweep phase of the restoration. Staff notes that the applicant provided a summary of restoration activities at two existing licensed facilities (LCI, 2010a). The range in total PVs used during the past restorations was between 6 and 18.4 PVs; the majority of the reported PVs for the past restorations were for the groundwater treatment phase (i.e., RO), which consisted of between 4.5 and 13.2 PVs or approximately 75 percent of the total number of PVs used for the past restorations (LCI, 2010a). Staff notes that not all of the past restorations used in the applicant's analysis have received final approval of completion by the NRC.

The applicant evaluated the timing and effectiveness of each phase used in the analogue examples, and determined that the past restorations contained inefficiencies (e.g., delay in start of restoration) that contributed to the need for additional restoration activities (LCI, 2010a). The applicant stated that those inefficiencies will be eliminated at the Lost Creek facility, and that the estimated 6.3 PV for restoration is more appropriate for the proposed operation (LCI, 2010a). Staff agrees that the past restoration activities contained inefficiencies and that additional management might contribute to reducing the effort to achieve the restoration goal.

The applicant stated (LCI, 2010a) that the estimated six PVs was "*an industry standard that has been accepted in the past and continues to be used by many licensees*." Staff found that the estimated PVs required for remediation (based on financial assurance calculations) by the existing licensees to be as follows:

Facility	Restoration Phase		
	Sweep	Treatment	Recirculation
Uranium One (Willow Creek)	1	5	1 (w/reductant)
PRI (Smith Ranch)	1	8	0
PRI (Highland Uranium Project)	1	8	0
CBR (Crow Butte)	3	6	2

In addition, in other recent NRC applications, the estimated restorations are as follows:

Facility	Restoration Phase		
	Sweep	Treatment	Recirculation
Uranium One (Moore Ranch)	1	5	0
Uranerz (Hank and Nichols Ranch)	1	6	0

Staff's assessment is that the applicant's estimate of 6.3 PV's is on the low end, but still within the range of NRC-accepted values. Staff finds the applicant's estimate to be acceptable because (a) the estimate is within the range currently used by industry, and (b) the applicant's commitments to minimize inefficiencies and to adjust the estimate based on future experience. Similar restoration methodologies have been used successfully at previous ISR facilities and have been shown to be protective of human health and the environment. Pursuant to 10 CFR Part 40, Appendix A, Criterion 5D, the applicant will provide "data from the ground-water monitoring program and other information" for the staff to make a determination that the groundwater restoration program achieved the NRC's groundwater protection standards. This information will be in the form of a report submitted to the staff for its approval, and such approval is required prior to any wellfield reclamation and decommissioning activities. Staff also notes that if the applicant submits an application for an ACL, staff will examine, at that time, whether the applicant was faithful to its commitments. The staff will not approve an ACL unless and until the applicant adequately proves that its restoration was ALARA, regardless of whether 6.3 PVs or more of restoration activities were performed at the Lost Creek Project.

6.1.3.5 Groundwater Restoration Monitoring

In Section 6.2.5 of the technical report (LCI, 2008c, 2010a), the applicant committed to conducting daily, weekly, and monthly analyses to track the production zone aquifer restoration progress. The applicant stated it will sample all monitoring wells (the perimeter wells, overlying and underlying aquifer wells, and production zone wells) at the end of the active restoration phase for the baseline parameters listed in SER Table 5.7-2. The applicant stated that the values at the end of restoration will be compared to the baseline average on a well-by-well basis

for the perimeter wells and overlying and underlying aquifer wells or to the wellfield average for the production zone (LCI, 2010a).

In Section 6.2 of the technical report (LCI, 2010a), the applicant committed to restore the production zone aquifer to standards in Criterion 5B(5) in Appendix A of 10 CFR Part 40. The applicant stated that if the baseline or Maximum Contaminant Level (MCL) standards cannot be achieved after using the best practicable technology (BPT), an alternate concentration limit (ACL) will be requested. Furthermore, the applicant committed to having a sampling frequency for excursion monitoring during the restoration period similar to that used during operations (i.e., semi-monthly sampling with a minimum 10-day interval between sampling events at all monitoring wells along the perimeter ring and in the overlying and underlying aquifers). Corrective actions to be undertaken for an excursion that occurs during restoration will be similar to those taken for an excursion that occurred during operations (see SER Section 5.7.9) (LCI, 2010a).

Staff reviewed the applicant's proposed restoration monitoring and finds it acceptable because similar programs have been conducted at existing ISR facilities and have provided sufficient data to demonstrate that these operations were operated safely. These operations also safely restored groundwater to levels that are protective of the environment, and provided early detection of unwanted contaminant migration in order to apply appropriate and timely corrective actions.

6.1.3.6 Wellfield Bleed during Restoration Stage

In Section 6.1 of the application (LCI, 2010a), the applicant committed to maintaining a hydrologic bleed sufficient to control the migration of process or restoration solutions from the production zone until active restoration is completed. The applicant will maintain the hydrologic bleed during all phases, including any hiatus in production (LCI, 2010a). The staff finds this commitment acceptable because it meets the requirements of 10 CFR 40.41(c), which requires licensees to confine source and byproduct materials to authorized locations. A standard license condition will enforce this commitment (see LC 10.6 in Appendix A).

6.1.3.7 Restoration Wastewater Disposal

In Section 4.2.5 of the technical report (LCI, 2008c, 2010a), the applicant provided detailed information on the restoration wastewater disposal well and pond capacity, the water disposal water balance, and contingency plans if any of the wells or ponds were to become inoperable. The wastewater generated during restoration is the brine solution from the treatment phase (i.e., RO treatment). The applicant calculated a maximum anticipated wastewater production rate of 492 Lpm (130 gpm) and designed the proposed wastewater disposal system for this maximum rate (LCI, 2010a). NRC staff reviewed the applicant's maximum anticipated wastewater production rate and finds it adequate (see SER section 3.1.3.1 and 4.2.3.1) because the maximum anticipated wastewater production rate includes a component adequate to accommodate the proposed restoration wastewater rate. NRC finds that the anticipated wastewater production can be adequately met by the estimates of the waste disposal capacity for the five Class I deep disposal wells as permitted by Wyoming. Therefore, staff finds that the applicant's plans for disposing of restoration wastewater are acceptable.

6.1.3.8 Restoration Stabilization Monitoring

In Section 6.2.4 of the technical report, the applicant commits to a groundwater stabilization-monitoring program (LCI, 2010a). This monitoring program will begin upon completion of active restoration. The applicant committed to using some or all of the production monitoring wells to evaluate restoration success. Four quarterly samples will be collected at the end of active restoration (beginning of stabilization period), and then again for three additional quarterly sampling events during the subsequent 9-month period. The applicant will sample wells for the parameters listed in SER Table 5.7-2 (LCI, 2003a).

The staff finds that the applicant did not specifically state that the wells that it will use to determine restoration stabilization would be those that it used to establish the baseline values. For the reasons stated and consistent with the regulations cited in SER Section 6.1.3.1, the staff will include a license condition requiring the applicant to use the same wells for stabilization that it used to determine baseline values (see SER Section 5.7.9.4 and LC 11.3 A in Appendix A).

The applicant committed to performing a linear regression analysis for temporal trends in each parameter for the production zone monitoring wells and using established statistical methods to determine the significance of any trend (LCI, 2010a). If an increasing concentration trend is evident, the applicant proposed additional actions that it would take, such as resuming active restoration or extending the stabilization-monitoring period. If the analytical results meet the appropriate standards and do not exhibit significant increasing trends, the applicant committed to submitting a restoration report with the supporting documentation to the NRC for its review and approval (LCI, 2010a). Based on staff's review of the applicant's proposed procedures, the staff finds them consistent with those in use at existing licensed facilities that have shown to provide adequate protection of public health and safety and the environment.

The applicant proposed (LCI, 2010a) methods to identify, evaluate, and provide correct actions, if warranted, for "hot spots." A "hot spot" is identified as elevated residual concentrations of a parameter after restoration at an isolated well or location. The applicant adapted NRC guidance in identifying a hot spot as a concentration exceeding two standard deviations from the mean production zone value. The applicant proposed additional evaluations to determine the impact on the surrounding aquifers if it identified a hot spot, including additional water quality analyses, trend analyses, or flow and transport modeling. The applicant stated that if warranted, corrective actions might include additional restoration or stabilization monitoring (LCI, 2010a).

In Section 6.2.5 of the application (LCI, 2008c, 2010a), the applicant stated that if the data meet appropriate standards and do not exhibit significant increasing trends, the applicant will request the mine unit be declared restored. The applicant also stated that following agency approval, it would perform mine unit reclamation and the plugging and abandonment of the wells. In Section 6.3.2 application, the applicant was more specific stating that well abandonment will proceed once the NRC and the WDEQ review and approve the applicant's assessment that restoration is complete (LCI, 2008c, 2010a).

Staff reviewed the restoration stabilization monitoring information provided by the applicant and finds it acceptable because it is consistent with the acceptance criteria (3) and (5) of SRP Section 6.1.3 because the applicant described (a) wellfield restoration plans that included stabilization monitoring schedules and constituents and (b) the post-restoration stability monitoring program. The proposed stabilization-monitoring program is consistent with NRC-

approved monitoring programs that licensees currently or have used at existing ISR facilities that have shown to be protective of human health and safety and the environment.

6.1.3.9 Well Plugging and Abandonment

In Section 6.3.2 of the application (LCI, 2008c, 2010a), the applicant stated that wellfield plugging and abandonment will be initiated once the regulatory agencies concur that groundwater in a wellfield has been adequately restored and is stable. The applicant committed to plugging and abandonment of all wells in accordance with State of Wyoming requirements (LCI, 2010a). NRC staff reviewed the applicant's proposed plugging and abandonment procedures and finds them to be acceptable because they meet the acceptance criterion (7) in SRP Section 6.1.3, which states that plugging and abandonment procedures that are "codified in State regulations or rules are considered acceptable." Furthermore, proper abandonment of the wells meets, in part, requirements of criterion 6(7) of Appendix a, 10 CFR Part 40, which states that

> *"To the extent necessary to prevent threats to human health and the environment, the licensee should control, minimize or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to the ground or surface waters or to the atmosphere."*

Although this regulation was written for mill tailings, specifically the tailing disposal area, the criterion is also applicable to ISR facilities. After termination of the license (post-closure), any existing well will potentially provide a conduit to subsurface for contaminated rainwater. Therefore, the applicant's commitment to plug and abandoned wells pursuant to the State of Wyoming regulations is acceptable to staff.

6.1.3.10 Restoration Schedule

The applicant presented a general production, restoration and decommissioning schedule for its proposed ISR operations in Figure 3.1-3 of the application (LCI, 2010a). The staff notes that this schedule indicates that production at the first mine unit will begin immediately after construction of the processing plant, production in the other mine units will start sequentially thereafter, and production for a specific mine unit will last almost two years. Restoration will begin immediately after production, and will consist of one year of groundwater sweep, followed by approximately one year of reverse osmosis and finally a short period of recirculation (LCI, 2010a). Restoration stability monitoring will begin immediately following completion of the active restoration activities (e.g., groundwater treatment, groundwater recirculation), and will last for just less than a year; the applicant committed to four quarterly sampling for stability monitoring. Decommissioning will commence in a mine unit at the end of restoration. The applicant noted that these are proposed timelines, which will be updated as necessary (LCI, 2008c, 2010a). NRC staff reviewed the proposed restoration schedule and stability monitoring program and finds the proposed schedule meets acceptance criterion (6) of SRP Section 3.1.3 provided that the applicant updates the schedule as needed in order to comply with the requirements of 10 CFR 40.42.

The staff notes that any change to the schedule that requires more than 24 months to complete decommissioning activities will require NRC approval of an alternate schedule pursuant to 10 CFR 40.42, which requires that decommissioning activities be completed within 24 months of initiation of decommissioning. Paragraph g(2) of 10 CFR 40.42 permits the NRC to approve a

request for an alternate schedule for completion of decommissioning under certain circumstances. The staff finds that permanent cessation of lixiviant injection in a wellfield would signify intent to shift from the principal activity of uranium production to the initiation of groundwater restoration. The requirement for the applicant to submit a request for an alternate schedule will be included in a standard license condition (see LC 10.6 in SER Appendix A).

6.1.4 EVALUATION FINDINGS

The NRC staff has completed its review of the plans and schedules for groundwater quality restoration proposed for use at the proposed Lost Creek ISR Project. This review included an evaluation of the methods that the applicant proposed to use to develop the groundwater restoration program and schedules using the review procedures in the SRP Section 6.1.2 and the acceptance criteria in the SRP Section 6.1.3.

The applicant's plans and schedules for groundwater restoration are acceptable to the staff, except that the applicant did not specify that wells sampled to determine restoration completion and restoration stabilization will be the same as those sampled to establish baseline quality (see the license condition in SER Section 5.7.9.4). Based on its review of the information provided in the application, the staff is reasonably assured that the applicant will restore groundwater to the NRC's restoration standards of 10 CFR Part 40, Appendix A, Criterion 5B(5) and will provide the information for the NRC's determination required per 10 CFR Part 40, Appendix A, Criterion 5D, contingent upon the applicant's fulfillment of the license condition discussed in SER Section 5.7.9.4. The staff also finds these procedures to be acceptable because they meet the applicable acceptance criteria in SRP Section 6.1.3 (NRC, 2003a) and requirements of 10 CFR 40.32(c), 10 CFR 40.42, and Criteria 5B(5) and 6(7) of Appendix A to 10 CFR Part 40 by:

- Committing to adopt wellfield groundwater restoration standards that are representative of background conditions;
- Committing to maintaining a hydrologic gradient during restoration;
- Committing to perform restoration using methods consistent with the ALARA approach;
- Providing estimates of pore volumes based on appropriate measured or estimated parameter values;
- Providing an acceptable list of indicator constituents and procedures to be used to establish statistically valid data sets to measure restoration success and stabilization;
- Documenting standards to be used to plug and abandon wells properly after the ISR operations are complete; and
- Establishing an acceptable schedule for restoration.

Staff will include standard license conditions regarding groundwater restoration activities in the license (see LC 10.6, 10.7, and 11.3 in SER Appendix A). LC 10.6 states the groundwater restoration requirements and the groundwater restoration standards of 10 CFR Part 40, Appendix A, Criterion 5B(5). LC 10.7 states the need to maintain an inward hydrologic gradient to control source and byproduct per 10 CFR 40.41(c). LC 11.3 states the procedures for determining baseline or Commission-approved background values, which is a primary groundwater restoration standard per 10 CFR Part 40, Appendix A, Criterion 5B(5).

6.1.5 REFERENCE

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "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."

40 CFR Part 68. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 68, "Chemical Accident Prevention Provisions," Table 1 to § 68.130, "List of Regulated Toxic Substances and Threshold Quantities for Accidental Release Prevention."

6 CFR Part 27. *Code of Federal Regulations*, Title 6, *Domestic Security*, Part 27, "Chemical Facility Anti-Terrorism Standards," Appendix A, "Department of Homeland Security Chemicals of Interest."

LCI, 2008c. Lost Creek ISR, LLC, "Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. Lost Creek ISR, LLC, "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2003a. "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report", NUREG-1569, Washington, DC, June 2003.

NRC, 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 – Final Report", NUREG-1620, Revision 1, Washington, DC, June 2003.

NRC, 2009i, U. S. Nuclear Regulatory Commission Regulatory Issue Summary (RIS) 2009-05, Uranium recovery policy regarding: (1) the process for scheduling licensing reviews of applications for new uranium recovery facilities and (2) the restoration of groundwater at licensed uranium in situ recovery facilities, April 29, 2009, 7 pp.

6.2 PLANS FOR RECLAIMING DISTURBED LANDS

6.2.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed plans for reclaiming disturbed lands for the Lost Creek Project meet the requirements of 10 CFR 40.42 and Criteria 6(6) and 6(7) of Appendix A to 10 CFR Part 40.

6.2.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in Section 6.2.3 of the Standard Review Plan (SRP) (NRC, 2003a).

6.2.3 STAFF REVIEW AND ANALYSIS

The applicant discusses the various aspects of reclamation of disturbed lands in Section 6.3 (Mine Unit Reclamation), Section 6.5 (Post-Reclamation and Decommissioning Radiological Surveys), and Section 6.6 (Soil Replacement and Revegetation) of the technical report (LCI, 2010a). The staff based its review on information from these sections of the application. Reclamation activities will consist of pre-reclamation radiological surveys, well abandonment, excavation of buried pipe, removal of buildings, topsoil replacement, and revegetation (LCI, 2010a). Radiological surveys used during reclamation will be similar to the surveys used to identify the baseline radiological conditions (LCI, 2010a). SER Section 2.6 discusses the baseline radiological survey.

The applicant will also review spill records to identify locations that could warrant additional surveys (LCI, 2010a). The applicant will survey locations impacted by a spill on a 1-m (3.3 ft) grid to verify that it has met the decommissioning criteria. The applicant will survey areas where it may have contaminated soils to verify cleanup, such as along pipelines, beneath the storage ponds, and near the header houses. The applicant has committed to following the cleanup criteria in Criterion 6 of Appendix A to 10 CFR Part 40 and to using the benchmark dose approach to determine the soil cleanup criteria for radionuclides other than radium-226. The applicant has provided a description of the techniques that it will use to compare the pre-operational and post-operational radiological surveys to identify potential areas of contamination (LCI, 2010a). The staff finds that the applicant's description is consistent with acceptance criteria (2) and (3) of SRP Section 6.2.3 because the applicant describes the survey program in sufficient detail, will perform pre-operational and pre-reclamation surveys in a similar manner, and developed plans to compare baseline (pre-operational) survey data to pre-reclamation data to determine areas requiring cleanup. Therefore, the staff finds the applicant's survey program to be acceptable.

The staff finds that the decommissioning, decontamination, and reclamation procedures provided in the application are acceptable to the staff, except for the applicant's omission of soil cleanup criteria for uranium or other radionuclides, excluding radium-226, which are otherwise required per 10 CFR Part 40, Appendix A, Criterion 6(6). Soil cleanup criteria are necessary to determine the extent to which soil reclamation is required and when reclamation is achieved. The staff finds that cleanup following spills should not rely solely on radiation measurements with a survey meter because uranium-238 (specific activity (SA) = 3.3×10^{-7} Ci/g), unlike radium-226 (SA = 1 Ci/g), emits low energy gamma radiation. The low energy gamma radiation emitted might not exceed background radiation exposure readings (e.g. mR/hr) in soils that contain uranium concentrations (e.g. µCi/g) that exceed background uranium concentrations; whereas increases in radium-226 concentrations in soils usually are indicated by higher gamma radiation readings with survey meters. The omission of soil cleanup criteria will be addressed in a license condition presented in SER Section 6.4.4.

Any future changes to the approved plan required under the aforementioned license condition would be submitted to the staff for review and approval prior to implementation in accordance with 10 CFR 40.42(d) and (g)(1). The staff will include a license condition, presented in SER

Section 6.2.4, that will require the applicant to submit a revised decommissioning plan prior to any final site decommissioning in accordance with 10 CFR 40.42(d) and (g)(1). The license condition will require that the applicant base the revised decommissioning plan on the as-built and operational history of the facility This is a standard license condition and is listed in SER Appendix A (see LC 10.3).

The applicant stated that soil replacement would approximate the pre-operational contours, which will include re-establishing drainage features (LCI, 2010a). Goals of surface restoration will be to restore the lands disturbed by operations to pre-extraction land use for livestock grazing and wildlife habitat. The applicant will remove surface features, such as buildings, roads, wells, and storage ponds, and it will reclaim the disturbed areas, unless it obtains prior approval from the NRC and WDEQ to leave the facilities in place (LCI, 2010a). The staff finds that these practices reflect accepted practices for NRC-licensed ISR operations and have shown to be protective of the environment and the public's health and safety. The applicant's description of its soil replacement plan is consistent with acceptance criterion (4) of SRP Section 6.2.3 because it includes discussion of surface pre-construction surface contours and planned activities for surface restoration. Based on its review of the applicant's decommissioning, decontamination, and reclamation procedures, the staff is reasonably assured that the applicant will appropriately decommission its facility because it has addressed the necessary procedures for decommissioning the Lost Creek Project. This reasonable assurance determination is contingent upon the license condition presented in SER Section 6.4.4 that requires the applicant to submit soil cleanup criteria to the NRC staff for review and approval.

All solid byproduct material will be disposed of offsite at a facility licensed by the NRC or an Agreement State (LCI, 2010a). SER Section 4.2.4 discusses disposal of solid byproduct material. The staff finds that this approach is consistent with 10 CFR Part 40, Appendix A, Criterion 2, which requires that byproduct material from ISR operations be properly disposed of at existing mill tailings disposal sites, with limited exceptions.

The applicant stated that it would prepare a decommissioning plan for each mine unit (LCI, 2010a). The applicant committed to submitting a final decommissioning plan for structures remaining until the end of the active life of the facility 12 months before the planned decommissioning of the facilities. This final detailed decommissioning plan will reflect as-built conditions at the facility, which might differ slightly from the initial licensing plans. The detailed decommissioning plan will also reflect the operational history of the site and should account for items such as spills, areas of radionuclide deposition, and unanticipated groundwater restoration (LCI, 2010a). The staff finds the applicant's commitments are consistent with acceptance criteria (7) and (9) of SRP Section 6.2.3 because the applicant committed to provide a final decommissioning plan at least 12 months before the planned reclamation of a wellfield commences, and the plan will include a quality assurance program. Therefore, the staff finds the applicant's plans for submitting a final decommissioning plan acceptable. As discussed, the staff requires the applicant to submit an updated decommissioning plan 12 months prior to implementation in standard LC 10.3 in accordance with 10 CFR 40.42(g)(1) (see SER Appendix A).

The applicant (LCI, 2010a) has discussed decommissioning aspects of non-radiological hazardous constituents, as required by 10 CFR Part 40, Appendix A, Criterion 6(7). The applicant has committed to storing hazardous wastes generated at the facility in accordance with applicable OSHA and EPA standards; a licensed contractor will dispose these wastes of offsite. Sanitary wastes generated at the facility will be disposed of at a licensed landfill located

in Rawlins or another nearby town. The applicant has indicated that it may seek a permit to develop an on-site landfill for disposal of non-radiologically contaminated construction material (LCI, 2010a). As the on-site landfill would contain construction debris, not radiologically contaminated material, the staff notes that the applicant would need to obtain approval for the on-site landfill from WDEQ and BLM. The staff finds the applicant's discussion of non-radiological hazards meets acceptance criterion (8) of SRP Section 6.2.3. For this reason and because the applicant included procedures to ensure the health and safety of workers, the public, and the environment, the staff finds the discussion acceptable.

The applicant will perform pre-reclamation radiation surveys using instruments and techniques similar to the pre-operational survey used to establish baseline site conditions (LCI, 2010a). This is acceptable to the staff as it reduces the possibility of errors resulting from using different techniques. Areas that the applicant will evaluate include wellfield surfaces, structures in process and storage areas, on-site transportation routes, and historical spill areas. This is acceptable to the staff because the applicant has identified the areas that are most likely to be contaminated.

6.2.4 EVALUATION FINDINGS

The staff reviewed the plans for reclaiming disturbed lands of the proposed Lost Creek Project in accordance with SRP Section 6.2.3 (NRC, 2003a). The applicant described various aspects of reclamation activities at the site, including plugging and abandoning all wells, surveying for contaminated soils and removing contaminated soils to a licensed disposal facility, performing final surveys, recontouring disturbed areas, salvaging and replacing topsoil, and revegetating disturbed areas.

The staff finds that the applicant's plans for reclaiming disturbed lands are acceptable and consistent with the acceptance criteria in SRP Section 6.2.3, except acceptance criterion (1). Contrary to acceptance criterion (1), however, the applicant omitted soil cleanup criteria for radionuclides other than radium-226. The staff is requiring the applicant to submit the soil cleanup criteria to the NRC for review and approval, by the license condition presented in SER Section 6.4.4.

Because the applicant's plan is pre-operational, the applicant cannot account for actual future facility build-out conditions, which might differ from initial licensing plans due to the dynamic nature of ISR operations. To address the effect of facility changes during the life of the Lost Creek Project, the applicant committed to submitting a final decommissioning plan consistent with acceptance criteria (7) and (9) of SRP Section 6.2.3 and pursuant to 10 CFR 40.42(g)(1). Because of the applicant's proposed decommissioning, decontamination, and reclamation plans and commitments to provide detailed final plans, the staff is reasonably assured that the applicant will properly decommission the Lost Creek Project. This reasonable assurance determination is contingent upon the applicant's fulfillment of the following standard license condition and the license condition presented in SER Section 6.4.4.

> At least 12 months prior to initiation of any planned final site decommissioning, the licensee shall submit a detailed decommissioning plan for NRC review and approval. The plan shall represent as-built conditions at the Lost Creek Project.

This standard license condition is to ensure that the applicant submits a detailed decommissioning plan prior to final site decommissioning in accordance with 10 CFR 40.42(d). .

6.2.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "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."

Eisenbud, Merril. 1987. *Environmental Radioactivity from Natural, Industrial and Military Sources*, 3rd ed., Academic Press, San Diego, CA.

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 1993d. Policy and Program Guidance, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety, Washington, DC, April 1993, ADAMS Accession No. ML003745526.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

6.3 REMOVAL AND DISPOSAL OF STRUCTURES, WASTE MATERIAL, AND EQUIPMENT

6.3.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the proposed plans for removal and disposal of structures, waste material and equipment for the Lost Creek Project meet the requirements of 10 CFR 40.32(c).

6.3.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in Section 6.3.3 of the Standard Review Plan (SRP) (NRC, 2003a).

6.3.3 STAFF REVIEW AND ANALYSIS

The applicant stated in Section 6.4 of the application that the following equipment may require reclamation and decommissioning: tanks, filters, ion exchange (IX) columns, pipes, pumps, processing buildings, administrative buildings, shipping areas, deep disposal wells, buried

pipes, culverts, and roads (LCI, 2010a). Upon completion of operations, the applicant will remove all features associated with the facility that have not been approved for post-operational use. The applicant will transfer long-term maintenance and ultimate disposable responsibility for any features remaining to landowner or lessee. The applicant will obtain the required approvals from BLM and WDEQ for equipment or structures that will remain for post-operational use (LCI, 2010a).

As described in Section 5.7.6 of the application, the applicant will maintain a contamination control program in place to control residual contamination (LCI, 2010a). This contamination control program will be consistent with the program used during operations, but will focus on structures and equipment to identify potential hazards prior to decommissioning. This program will include radiological surveys on all facilities prior to dismantling and disposal. The applicant will measure radioactivity levels at locations where contamination could accumulate, such as traps, low points, or access locations. The applicant will consider any items that it cannot check for contamination because of its size or shape, as contaminated and disposed of at either an NRC- or Agreement State-licensed facility (LCI, 2010a). The staff finds that the applicant's contamination control program is consistent with acceptance criteria (1), (2), and (3) of SRP Section 6.3.3 by (a) having a program to control residual contamination on structures and equipment; (b) including surveying of interior surfaces of pipes, drain lines, and duct work in the program; and (c) presuming inaccessible surfaces for purposes of measurement to be contaminated in excess of release limits.

The staff finds that the applicant has developed a radiation survey program to properly release structures, materials, and equipment using per the NRC-approved alpha contamination release limits, which is, in part, consistent with acceptance criterion (4) of SRP Section 6.3.3. However, the applicant has not addressed beta-gamma contamination surveys in the decommissioning, decontamination, and reclamation plan. Because it is possible that beta-gamma contamination will remain at the facility during decommissioning, this plan will need to include a contamination control program for beta-gamma radiation to comply with 10 CFR 20.1501(a)(2)(i), which requires licensees to conduct surveys that are reasonable to evaluate the magnitude and extent of radiation levels. A license condition, presented in SER Section 6.4.4, will ensure that the applicant has beta-gamma release criteria in the decommissioning, decontamination, and reclamation plan.

As discussed in section 6.4.2 of the technical report, the applicant will decontaminate all equipment as necessary before demolition of buildings (LCI, 2010a). Screening processes for identifying contaminated materials will be an alpha survey. The staff finds that the applicant has identified acceptable limits for alpha radiation that are consistent with NRC guidance. Equipment that cannot be decontaminated to these limits will be re-used on-site or sent to an NRC-licensed facility for disposal (LCI, 2010a). In Section 6.4.2 of technical report, the applicant indicates that decontaminated and non-contaminated materials will be removed for salvage, removed for disposal at a licensed solid waste disposal facility, or buried on-site at a designated location and depth. In Section 6.4.2 of the technical report, the applicant has indicated that it may develop an on-site landfill for burial of construction materials. Disposal of waste materials on BLM or State owned land may require separate approvals (LCI, 2010a). The staff notes that only materials meeting the release standards for alpha, beta, and gamma contamination identified in standard license condition LC 9.6 would be buried on-site (SER Appendix A).

The staff finds that the applicant has developed acceptable plans for measurements of alpha radioactivity on the interior surfaces of pipes, drain lines, and ductwork. These plans are

acceptable to the staff because the applicant will make appropriate measurements at all traps and other access points where contamination is likely to be representative of system-wide contamination. Additionally, the applicant will consider all premises, equipment, or scrap likely to be contaminated. The applicant will assume that premises, equipment, or scrap that cannot be measured are contaminated in excess of limits and will treat these materials. However, the applicant will need to ensure that surveys for beta-gamma radioactivity are also applied to these procedures to comply with 10 CFR Part 20, Subpart F. For all premises, equipment, or scrap contaminated in excess of specified limits, the applicant will provide detailed, specific information describing the premises, equipment, or scrap in terms of extent and degree of radiological contamination (LCI, 2010a). The applicant plans to conduct a comprehensive radiation survey to establish that any contamination is within limits specified before the release of the premises, equipment, or scrap (LCI, 2010a). The staff is reasonably assured that the applicant's plans for release surveys will comply with 10 CFR 20.1501 if the applicant fulfills the standard license condition 9.6 (see SER Appendix A) with regard to beta and gamma contamination, which requires appropriate surveys of materials, equipment, and packages prior to removing them from a restricted area.

6.3.4 Evaluation Findings

The staff reviewed the procedures for removing and disposing of structures and equipment at the Lost Creek Project per SRP Section 6.3.3 (NRC, 2003a). The applicant has established an acceptable program for the measurement and control of residual alpha contamination on structures and equipment, consistent with SRP Section 6.3.3. However, the applicant has not addressed beta contamination survey and release criteria in accordance with Subpart F in 10 CFR Part 20 and as recommended by Policy and Program Guidance (NRC, 1993d). Because standard condition 9.6 (in SER Appendix A) requires compliance with release survey procedures specified in the aforementioned guidance document, the staff is reasonably assured that the applicant will properly release structures, materials, and equipment for unrestricted use, contingent upon the fulfillment of standard license condition 9.6 (in SER Appendix A). Therefore, the staff determined that the information provided in Section 6.4.2 of the application, as supplemented with the noted standard license condition, is acceptable, in compliance with 10 CFR 40.32(c), and consistent with acceptance criteria in SRP Section 6.3.3.

6.3.5 References

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "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."

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 1993d. Policy and Program Guidance, “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material,” Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety, Washington, DC, April 1993, ADAMS Accession No. ML003745526.

NRC, 2003a. NUREG-1569, “Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report,” Washington, DC, June 2003.

6.4 POST RECLAMATION AND DECOMMISSIONING RADIOLOGICAL SURVEYS

6.4.1 REGULATORY REQUIREMENTS

The staff determines if Lost Creek ISR, LLC (LCI or the applicant) has demonstrated that the applicant’s proposed methodologies for conducting post reclamation and decommissioning radiological surveys for the Lost Creek Project meet the requirements of Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.4.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria in Section 6.4.3 of the Standard Review Plan (SRP) (NRC, 2003a).

6.4.3 STAFF REVIEW AND ANALYSIS

6.4.3.1 Cleanup Methodology and Criteria

The applicant committed to meeting the soil cleanup criteria established in 10 CFR Part 40, Appendix A, Criterion 6 in Section 6.4.1 of the technical report (LCI, 2010a). LCI will follow the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC, 2000), to conduct a “historical” site assessment and characterization survey prior to development of a decommissioning plan, as stated in Section 6.5.1 of the technical report. The applicant committed, in Section 6.5.2 of the technical report, to statistically demonstrating that it would reclaim soils to the soil cleanup standards required under 10 CFR Part 40, Appendix A, Criterion 6, and reclamation would occur by either excavation or treatment (LCI, 2010a). Although the applicant has committed to meeting the regulatory cleanup criteria using the methodology required in Criterion 6 of Appendix A to 10 CFR Part 40, the applicant has not yet developed the soil cleanup criteria, as discussed in SER Section 6.2.3. However, as stated in SER Section 6.2.3, the staff is reasonably assured that the applicant will develop the appropriate soil cleanup criteria prior to initiating cleanup activities and will reclaim soils to meet the cleanup standards based upon the decommissioning information provided in the application and upon the license condition discussed in SER Section 6.4.4.

6.4.3.2 Uranium Chemical Toxicity Assessment

Acceptance Criterion (1) in SRP Appendix E, Guidance to the U.S. Nuclear Regulatory Commission Staff on the Radium Benchmark Dose Approach, Section E2.2.3, recommends that in modeling the soil cleanup criteria, the natural uranium source term input is represented as percent activity of the uranium isotopes (e.g., 48.9 percent U-238, 48.9 percent U-234, and 2.2 percent U-235). Also, the uranium chemical toxicity is considered in deriving a soil concentration limit if soluble forms of uranium are present (NRC, 2003a). Because the applicant did not provide soil cleanup criteria, uranium chemical toxicity was not addressed. However, the staff will review uranium toxicity analyses during its review and approval of the soil cleanup criteria, the submission of which is required prior to cleanup activities by the license condition discussed in Section 6.4.4.

6.4.4 EVALUATION FINDINGS

The staff reviewed the methodologies for conducting post-reclamation and decommissioning radiological surveys for the proposed Lost Creek Project in accordance with SRP Section 6.4.3 (NRC, 2003a). Although the applicant has provided its decommissioning, decontamination, and reclamation plans for the Lost Creek Project, it has not included soil cleanup criteria for radionuclides other than radium in the decommissioning, decontamination, and reclamation plan in accordance with 10 CFR 20.1501 and 10 CFR Part 40, Appendix A, Criterion 6(6). The staff reiterates its reasonable assurance determination that the applicant will decommission the Lost Creek Project appropriately because of its decommissioning plans and commitment to submit final plans prior to final mine unit and facility decommissioning (SER Section 6.2.3). The staff's reasonable assurance determination is contingent upon the fulfillment of the following license condition, which, among other things, requires the applicant to include soil cleanup criteria in its revised decommissioning plan:

> The applicant will submit to the NRC for review and approval a revised decommissioning, decontamination, and reclamation plan within 90 days of receipt of license. The revised plan will include soil cleanup criteria for radionuclides other than radium based on the radium benchmark dose method, as well as procedures to monitor for beta-gamma contamination on equipment, structures, and material released for unrestricted use. The soil cleanup criteria, based on the radium benchmark dose methodology for U and other radionuclides, will demonstrate that residual radioactivity in soil meets the criteria in 10 CFR Part 40, Appendix A, Criterion 6(6).

Based upon the review conducted by the staff as indicated above, the information provided in the application, as supplemented by this license condition, meets the applicable acceptance criteria of SRP Section 6.4.3 and the requirements of 10 CFR 20.1501 and 10 CFR Part 40, Appendix A, Criterion 6(6).

6.4.5 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "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."

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. "Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142," April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

NRC, 2000b. NUREG-1575, Revision 1, "Multi-Agency Radiation Survey and Site Investigation Manual," Washington, DC: NRC, August 2000.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

6.5 FINANCIAL ASSURANCE

6.5.1 REGULATORY REQUIREMENTS

The staff determines if the proposed financial assurance for the Lost Creek Project submitted by Lost Creek ISR, LLC (LCI or the applicant) meets the requirements of 10 CFR Part 40, Appendix A Criterion 9.

6.5.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for consistency with the applicable regulations in 10 CFR Part 40 using the acceptance criteria in Section 6.5.3 of the Standard Review Plan (SRP) (NRC, 2003a).

6.5.3 STAFF REVIEW AND ANALYSIS

Unless otherwise stated, the information in SER Section 6.5.3 is from Section 6.8 of the technical report (LCI, 2008c, 2010a). The applicant has provided a decommissioning cost estimate of $6,772,488 (LCI, 2010b); this estimate consists of 47 pages of itemized costs for surface reclamation of all facilities and groundwater restoration of the first mine unit. The proposed amount includes costs for groundwater restoration, decommissioning and surface reclamation, equipment removal and disposal, building demolition and disposal, wellfield building and equipment removal and disposal, well abandonment, wellfield surface reclamation, soil excavation and disposal, topsoil replacement and revegetation, soil surveying and analyses, and other miscellaneous reclamation costs. The decommissioning cost estimate also includes operational costs, such as environmental sampling, that would need to be included during groundwater restoration and surface reclamation (LCI, 2010a). The staff finds that the decommissioning cost estimate provided by the applicant is consistent with the outline in Appendix C of the Standard Review Plan (NRC, 2003a) and is acceptable to the staff because the estimate contains the appropriate items and reasonable costs. The initial license will have a standard license condition requiring submittal of an updated decommissioning cost estimate prior to the commencement of operations, as described in SER Section 6.5.4 (see LC 9.5 in

SER Appendix A). This condition is included in the license to ensure that an updated decommissioning cost estimate based on current dollars is reviewed prior to commencement of operations.

Financial assurance documentation includes a breakdown of costs, the basis for cost estimates, and a 15-percent contingency (LCI, 2010a). The applicant has committed to the following administrative issues related to financial assurance:

- Providing an annual adjustment of the decommissioning cost estimate and the technical basis for this estimate at least 90 days prior to any major construction that has not been previously addressed in the estimate.
- Automatically extending the financial assurance instrument if the NRC has not approved the proposed revision 30 days before the expiration date.
- Revising the financial assurance arrangement within 3 months of NRC approval of a revised closure (decommissioning) plan if estimated costs exceed the amount of the existing arrangement.
- Providing the NRC with a copy of WDEQ's review and final financial assurance arrangement.

Groundwater restoration costs are based on treatment of one pore volume (PV) for groundwater sweep and five PV for reverse osmosis (RO) (LCI, 2010a). As discussed in SER Section 6.1, the applicant has provided adequate technical information for the NRC staff to agree with this PV estimate for groundwater restoration at this time. The technical information provided by the applicant includes an analog study comparing restoration efforts at other ISR facilities, as well as a commitment to follow timely and efficient restoration practices (LCI, 2010a). The staff reviewed the cost estimate and determined that the activities included in the applicant's reclamation cost estimate are consistent with what is planned for and what is known about the site.

As discussed in SER Section 4.2, the applicant has adequately described the quantities of liquid byproduct material that will be disposed of through deep well injection. The applicant anticipates installing between 2 and 4 deep disposal wells to handle the expected volumes of liquid byproduct material at the facility. The NRC staff reviewed the proposed water balance and agrees that adequate liquid disposal capacity is available at the site.

The applicant's proposed restoration schedule stated that groundwater restoration will require approximately 24 months (LCI, 2010a). This schedule accounts for higher predicted groundwater pumping rates at the project site that will allow for quicker restoration of groundwater than has typically been observed at ISR facilities, according to the applicant. If, during the course of operations, the applicant identifies that the proposed restoration schedule cannot be achieved, it will request a revised schedule in the form of a license amendment (LCI, 2010a).

The staff finds that the decommissioning cost estimate does not identify specific costs related to the cleanup of spills in the wellfields. The applicant has committed to the cleanup of spills at the time of detection (LCI, 2010a). The cleanup area will include the spill area itself as well as the surrounding affected area (LCI, 2010a). Through a standard license condition (see LC 9.5 in SER Appendix A), the financial assurance amount will be reviewed on an annual basis by the staff; this will provide the staff with the ability to review and revise this portion of the amount to reflect the performance of the facility as it relates to spill prevention and cleanup. This is

consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 9, and thus, acceptable to the staff.

The staff finds that the applicant has established an acceptable decommissioning cost estimate based on the requirements in 10 CFR Part 40, Appendix A, Criterion 9. Sufficient funds would be available for completion of the reclamation plan by an independent contractor. The staff reviewed the information in the decommissioning cost estimate and notes that all the activities in the reclamation plan or in SRP Sections 6.1–6.3 (NRC, 2003a) have been addressed by the applicant's financial analyses as presented in Table 6.8-1 of the technical report (LCI, 2010a). Financial assurance assumptions are based on analyses of on-site conditions, including experiences with generally accepted industry practices, research and development at the site. The staff finds that the values used in the financial assurance analysis are based on 2010 dollars and that reasonable costs for the required reclamation activities are defined by the applicant. The applicant has not proposed a financial assurance instrument at this time. The applicable regulations in 10 CFR Part 40, Appendix A require that the financial assurance arrangement be established prior to commencement of operations. Therefore, the staff will include the standard license condition presented in SER Section 6.5.4 to address this issue.

6.5.4 EVALUATION FINDINGS

Based on the information provided in the application and the staff's detailed review of the decommissioning cost estimate for the Lost Creek Project, the staff concludes that the amount of the proposed financial assurance and its methods of estimation are acceptable and consistent with 10 CFR Part 40, Appendix A, Criterion 9, which requires that financial assurance arrangements be established by each operator. As maintaining adequate financial assurance is an important aspect of the facility, compliance with the applicable regulations will be required through the following standard license condition:

> Financial Assurance. The licensee shall maintain an NRC-approved financial surety arrangement, consistent with 10 CFR Part 40, Appendix A, Criterion 9, adequate to cover the estimated costs, if accomplished by a third party, for decommissioning and decontamination, which includes offsite disposal of radioactive solid process or evaporation pond residues, and ground-water restoration as warranted. The surety shall also include the costs associated with all soil and water sampling analyses necessary to confirm the accomplishment of decontamination.
>
> Proposed annual updates to the financial assurance amount, consistent with 10 CFR Part 40, Appendix A, Criterion 9, shall be provided to the NRC 90 days prior to the anniversary date. The financial assurance anniversary date for the Lost Creek Project will be the date on which the first surety instrument is submitted to the NRC. If the NRC has not approved a proposed revision 30 days prior to the expiration date of the existing financial assurance arrangement, the licensee shall extend the existing arrangement, prior to expiration, for 1 year. Along with each proposed revision or annual update of the financial assurance estimate, the licensee shall submit supporting documentation, showing a breakdown of the costs and the basis for the cost estimates with adjustments for inflation, maintenance of a minimum 15-percent contingency of the financial assurance estimate, changes in engineering plans, activities performed, and any other conditions affecting the estimated costs for site closure.

Within 90 days of NRC approval of a revised closure (decommissioning) plan and its cost estimate, the licensee shall submit, for NRC review and approval, a proposed revision to the financial assurance arrangement if estimated costs exceed the amount covered in the existing arrangement. The revised financial assurance instrument shall then be in effect within 30 days of written NRC approval of the documents.

At least 90 days prior to beginning construction associated with any planned expansion or operational change that was not included in the annual financial assurance update, the licensee shall provide, for NRC review and approval, an updated estimate to cover the expansion or change. The licensee shall also provide the NRC with copies of financial assurance-related correspondence submitted to the State of Wyoming, a copy of the State's financial assurance review, and the final approved financial assurance arrangement. The licensee also must ensure that the financial assurance instrument, where authorized to be held by the State, identifies the NRC-related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of offsite disposal of solid byproduct material, soil, and water sample analyses, and groundwater restoration associated with the site. The basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or decommissioning plan cost estimates and annual updates should follow the outline in Appendix C, "Recommended Outline for Site-Specific In Situ Leach Facility Reclamation and Stabilization Cost Estimates," to NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report."

The licensee shall continuously maintain an approved surety instrument for the Lost Creek Project, in favor of the State of Wyoming. The initial surety estimate shall be submitted for NRC review and approval within 90 days of license issuance, and the surety instrument shall be submitted for NRC review and approval 90 days prior to commencing operations.

These evaluation findings are based on the understanding that the conditions discussed in this section are included in the license issued to LCI.

6.5.5 REFERENCES

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "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."

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

LCI, 2010a. “Letter to NRC, Regarding Lost Creek Project Responses to November and December 2009 Technical Comments Docket No. 40-9068 TAC No. LU0142,” April 22, 2010, ADAMS Accession No. ML102100241, ML102100263.

LCI, 2010b. “Letter to NRC, Regarding Lost Creek Project, Clarifications to technical report Docket No. 40-9068 TAC No. LU0142, May 14, 2010, ADAMS Accession No. ML101600528.

NRC, 2003a. NUREG-1569, “Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report,” Washington, DC, June 2003.

7.0 ACCIDENTS

7.1 REGULATORY REQUIREMENTS

The staff determines if the applicant has addressed potential accidents at the proposed Lost Creek Project and has demonstrated that the facility will meet the requirements of 10 CFR 40.32(c), which requires that the applicant's proposed procedures be adequate to protect public health and minimize danger to life or property should an accident occur.

7.2 REGULATORY ACCEPTANCE CRITERIA

The staff reviewed the application for consistency with applicable regulations of 10 CFR Part 40 using review procedures in Section 7.5.2 and acceptance criteria in Section 7.5.3 of the Standard Review Plan (SRP) (NRC, 2003a).

7.3 STAFF REVIEW AND ANALYSIS

Unless otherwise stated, the information in SER Section 7.3 is from Section 7.4 of the technical report (LCI, 2008c, 2010a). This chapter describes the effects of potential accidents that could occur at the proposed Lost Creek Project and the accident reporting and cleanup criteria that the applicant would follow in the event of an accident. The staff's review included an evaluation using the areas of review, review procedures, and acceptance criteria as described in Sections 7.5.1, 7.5.2, and 7.5.3 of the Standard Review Plan, respectively.

The applicant described what the applicant considered to be credible accidents and followed guidance provided in NUREG/CR-6733. However, Section 7.5.1 of the Standard Review Plan states that the NRC has evaluated the effects of accidents at ISR facilities and determined that the consequences are minor for most credible potential accidents, provided that effective emergency procedures and properly trained personnel are used. Nevertheless, consequences that could be significant are:

- radon releases from process streams
- yellowcake dryer explosions
- lixiviant leaks in buried piping between the wellfields and the processing facility
- chemical accidents

The Lost Creek Project will not have a dryer; therefore, only three of the four consequences described above could apply at the proposed Lost Creek Project. The applicant states that all of the accident scenarios described will require reporting to various regulatory agencies and might require immediate notification depending on the severity of the accident. In Section 7.4 of the technical report (LCI, 2010a), the applicant commits to preparing an Emergency Response Standard Operating Procedure (SOP), which will clearly state the reporting requirements and the agencies involved in compliance with 10 CFR 20.2202 and 2203 and other applicable regulations.

Section 10 CFR 20.1101 specifies that a radiation protection program commensurate with the scope and extent of the licensed activities and sufficient to ensure compliance with 10 CFR Part 20 be developed, documented and implemented by a licensee. If, after staff's detailed review of information supplied by applicant in an application, staff is reasonable assured that the

applicant, by training, experience and expertise, is capable of developing, documenting and implementing an adequate program, staff may, by a pre-operational license condition, accept the documentation immediately prior to its implementation.

Any spill resulting in soil concentrations exceeding the decommissioning standards for radioactive material in Criterion (6) of Appendix A to 10 CFR Part 40 and the limits for hazardous materials in 40 CFR Part 268 will be remediated to prevent adverse effects to personnel or the environment. Additionally, In Section 7.4 of the technical report (LCI, 2010a), the applicant commits to complying with Wyoming Department of Environmental Quality soil contamination standards.

NRC staff reviewed the potential accident analysis and commitments made by the applicant for responses to those potential accidents. The staff finds that this information is acceptable because it is consistent with requirements of Part 20, current industry standard practices and historical accidents at existing NRC-licensed facilities. The number of accidents historically at ISR facilities has been low and often not related to radiological materials; however, response to the historical accidents have demonstrated that the programs, similar to that proposed for the Lost Creek Project, have provided emergency responses that have been protective of workers and public safety and the environment. The applicant will be required to meet its commitments for preparing the Emergency Response SOP prior to operations, and during operations through routine inspections to be performed by NRC staff during operations, the applicant will be required to continually update the SOPs continually to reflect future conditions.

7.3.1 CHEMICAL ACCIDENTS

The applicant did not address the potential for accidents in the plant or header houses involving chemicals to be used on site. The applicant discussed the use of the following chemicals in various sections of the technical report:

- hydrochloric acid (Section 3)
- hydrogen sulfide/sodium sulfide (Section 6)
- caustic soda (Section 3)
- sulfuric acid (Section 3)
- hydrogen peroxide (Section 3)
- hydrogen sulfide/sodium sulfide (Section 3)
- sodium carbonate/sodium bicarbonate (Section 3)
- salt (Section 3)
- oxygen (Section 3)
- carbon dioxide (Section 3)
- slurry (Section 3)

In Section 7 of the technical report, the applicant discussed the effects of accidents, including those involve in transportation, for the following chemicals:

- hydrochloric acid

- caustic soda (sodium hydroxide)
- hydrogen peroxide
- salt
- sodium carbonate/sodium bicarbonate
- oxygen
- carbon dioxide
- slurry

The applicant provided a comprehensive evaluation of the potential accidents (LCI, 2010a). However, notably absent in the discussion of accidents are sulfuric acid, hydrogen sulfide and anhydrous ammonia. Because of the lack of an adequate accident analysis for sulfuric acid, hydrogen sulfide and anhydrous ammonia, the applicant will not be able to use these compounds at the Lost Creek Project without prior NRC approval.

The applicant stated that all of the buildings will be adequately ventilated to minimize radon exposure, which will also reduce the opportunity for buildup of explosive gases, such as oxygen in the plant and header houses. Additionally, in Section 7.4 of the technical report (LCI, 2010a), the applicant committed to remediating hazardous material spills onto soils to limits established in 40 CFR Part 268. To comply with the SRP, the applicant should address designs and measures for each chemical to prevent the occurrence of an accident and the development of emergency response procedures in the event of an accident. As part of the standard license conditions, the applicant will be required to develop emergency procedures to include accidents and spills involving chemicals. A copy of the current written procedures will be required to be kept in the area(s) of the production facility where they are utilized.

7.3.2 RADIOLOGICAL RELEASE ACCIDENTS

The applicant identified tank and plant pipe failures as potential accidents that could pose radiological risk. The applicant stated that the central plant building structure and concrete curb will contain spills from tanks and leaks from pipes. The floor sump system will direct liquids to other tanks or to a lined storage pond. Section 3.2.7.1 in the technical report provides information on the operation and shutdown mechanisms that will be used if a piping failure occurs (LCI, 2010a). Furthermore, emergency stop buttons will be used within the plant and outside the doors located at the office main entrance and the entrance at the rear of the plant. If any one of these buttons is pushed, the entire plant will shut down and the valves will close; only instrumentation will remain operational. Additionally, the applicant stated that an Emergency Response Standard Operating Procedure (SOP) will be developed that will define under what circumstances reporting is required and to which agency(ies). The SOP will provide guidance on how to determine the doses that require reporting under 10 CFR 20.2202 and 2203.

NRC staff reviewed the potential radiological release accident scenarios and commitments made by the applicant and finds the information is acceptable because it is consistent with requirements of Part 20, current industry standard practices, and historical release accidents at existing facilities. The number of accidents historically at ISR facilities has been low and often not related to radiological materials. Results of the worker's health and safety, the effluent and environmental monitoring programs have shown that practices at the existing facilities, similar to

those proposed for the Lost Creek Project, are protective of workers and public safety and the environment.

The applicant will be required to meet its commitments for preparing SOPs to address any release prior to operation and during operations, through routine inspections to be performed by NRC staff, the applicant will be required to update continually the SOPs to reflect future conditions.

7.3.3 GROUNDWATER CONTAMINATION

The applicant describes the prevention and mitigation of excursions using systems that include monitoring injection and production rates, maintaining the appropriate bleed rate, measuring water levels, and monitoring ground water quality by sampling for specific parameters. The applicant presented information on its operational controls in Section 3.2 of the application and monitoring programs in Sections 4.2.5.4 and 5.7.8 of the application. SER Sections 3.2.2 and 3.2.7 discuss the control systems in detail and staff's analysis. SER Sections 2.4, 4.2, 5.7.9 discuss the groundwater monitoring programs and control of excursions and staff's analysis.

In brief, the applicant will have to maintain controls on fluid migration and several monitoring programs for the early detection of a release. The monitoring programs consist of a leak detection system for the on-site ponds which is design to detect a loss of integrity of the primary liner system before the integrity of the secondary liner is compromised which would than result in a pathway to the environment. The primary groundwater monitoring program is the excursion monitoring program, which requires frequent (in essence, every two weeks) at wells surrounding a wellfield. This program provides early detection of a potential release by measuring for the more highly mobile constituents in close proximity to a wellfield. Staff has reviewed the applicant's proposed control systems and monitoring programs and finds them to be protective of worker and public health and safety and the environment.

7.3.4 WELLFIELD SPILLS

The applicant stated that pond failure or rupture of an injection or recovery line in a wellfield or between a wellfield and the plant could contaminate the ground in area of the break. SER Sections 3.1 and 4.2 discuss the applicant's designs of the wellfield infrastructure proposed to minimize the likelihood of this type of accident and the methodologies to detect leaks. The applicant stated that it will develop a response plan for wellfield spills that will include procedures for notification, spill containment and recovery, post-spill sampling and cleanup, and reporting.

NRC staff reviewed the commitments by the applicant to prepare a response plan, and finds that the information is adequate because it meets the requirements of 10 CFR Part 20 as it is consistent with current industry standard practices. 10 CFR Part 20 requires the establishment of a adequate radiation safety protection program for the protection of public and worker's safety. The programs currently employed by existing ISR facilities have been shown to be protective of worker's and public health and safety and also promotes the ALARA principle and provides protection of the environment in the realm of loss of integrity of near-surface equipment. The applicant will be required to meet its commitments for preparing SOPs to address any spill prior to operations and during operations, through routine inspections to be performed by NRC staff, the applicant will be required to update the SOPs continually to reflect future conditions.

7.3.5 TRANSPORTATION ACCIDENTS

The applicant considered the potential for transportation accidents involving shipments of ion exchange resins, yellow cake slurry, chemicals, fuels, and radioactive wastes. The applicant identified several procedures and actions to prevent transportation accidents, including maintaining vehicles in good operating condition, using properly trained and licensed drivers, inspecting vehicles prior to shipment, and following DOT hazardous materials shipping provisions.

7.3.6 FIRES AND EXPLOSIONS

The applicant discussed the potential for fires and explosions at the Lost Creek Project. The applicant stated that the hazard of fire or explosion is minimal because the plant will not use flammable liquids in the recovery process and building and the pressure vessels will have pressure relief valves. The applicant stated that an accumulation of natural gas to be used for heating or gaseous oxygen in a header house would be a potential source for a fire or explosion. As stated earlier, the applicant stated that buildings will be adequately ventilated to reduce the opportunity for buildup of explosive gases in the buildings. In addition, the applicant stated a variety of safe practices for the storage, handling and use of oxygen at the facility. NRC staff reviewed the information provided by the applicant and finds it acceptable because the proposed handling and storage of the natural gas and oxygen follow the best management practices for an industrial setting, at which similar materials are used.

7.3.7 NATURAL EVENTS

The applicant concluded that the most significant risk from natural events at the proposed Lost Creek Project is a tornado that dispersed yellowcake. However, because a dryer is not planned for the pending license action, the yellowcake would be in a slurry form and the potential environmental effects would be relatively low. Should the applicant decide to add a dryer to the facility, the applicant would have to request a license amendment and staff will have to perform an additional safety evaluation report to address any proposed change. The probability of a tornado occurring at the site is low (about one per 100,000 years). The applicant did not state that it will develop emergency procedures to include notification of personnel of potential severe weather, evacuation procedures, damage inspection and reporting, and cleanup and mitigation of spills. The applicant did state that all personnel will be trained for emergency responses to spill scenarios involving chemicals to be used at the facility.

NRC staff reviewed the information provided by the applicant and finds it acceptable because it is risk-informed and reflects best management practices for such industrial facilities. The training for emergency responses will have to include emergency procedures. Any release or spill involving radiological exposures will have to be reported and evaluated by the applicant pursuant to requirements in Part 20 regardless of whether spill or release was a result of a man-made incident or natural events.

7.4 EVALUATION FINDINGS

The staff reviewed potential accidents that could occur at the Lost Creek project in accordance with acceptance criteria in SRP Section 7.5.3. The applicant cites information in NUREG-0706 and NUREG/CR-6733 as the bases for the accident consequences at the Lost Creek project. The staff concludes that these accident consequences analyses are applicable to the Lost Creek project.

Based on the information provided in the application and the detailed review conducted by the staff as indicated above, the applicant's designs, plans, and training are acceptable and are in compliance with 10 CFR 40.32(c), which requires that the applicant's proposed equipment, facilities, and procedures be adequate to protect health and minimize danger to life or property. NRC staff could not determine that SOP's have been developed for emergency response to accidents, and a requirement to develop SOP's has been incorporated into a standard license condition.

7.5 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection against Radiation."

10 CFR Part 40. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, "Domestic Licensing of Source Material."

10 CFR Part 40, Appendix A. *Code of Federal Regulations*, Title 10, *Energy*, Part 40, Appendix A, "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."

LCI, 2008c. "Lost Creek ISR, LLC, Lost Creek Project South-Central Wyoming, Technical Report," Casper, WY, March 31, 2008, ADAMS Accession Nos. ML081060503, ML081060504, ML081060505, ML081060507, ML081060509, and ML081060510.

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LCI, 2010b. "Letter to NRC, Regarding Lost Creek Project, Clarifications to technical report Docket No. 40-9068 TAC No. LU0142, May 14, 2010, ADAMS Accession No. ML101600528.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report," Washington, DC, June 2003.

APPENDIX A

Standard License Conditions

License Condition	SER Section	Administrative Conditions
9.1	Intro 1.3	The authorized place of use shall be the licensee's Lost Creek Project in Sweetwater County, Wyoming. The licensee shall conduct operations within the license area boundaries shown in Figure 1.3-1 of the approved license application.
9.2	Intro	The licensee shall conduct operations in accordance with the commitments, representations, and statements contained in the license application dated March 31, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML081060525), which is supplemented by the submittals dated December 12, 2008 (ML090080451), January 16, 2009 (ML090360163), February 27, 2009 (ML090840399), August 5, 2009 (ML092310728), April 22, 2010 (ML102100263, ML102420249), May 14, 2010 (ML101600528), June 17, 2010 (ML101720161), and June 24, 2010 (ML101820155). The approved application and supplements are, hereby, incorporated by reference, except where superseded by specific conditions in this license. The licensee must maintain the approved license application on site. Whenever the word "will" or "shall" is used in the above referenced documents, it shall denote a requirement.
9.3	§ 40.5(a)(1)	All written notices and reports sent to the U.S. Nuclear Regulatory Commission (NRC) as required under this license and by regulation shall be addressed as follows: ATTN: Document Control Desk, Director, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. An additional copy shall be submitted to: Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate, Division of Waste Management and Environmental Protection, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission, Mail Stop T-8F5, 11545 Rockville Pike, Two White Flint North, Rockville, MD 20852-2738. Incidents and events that require telephone notification shall be made to the NRC Operations Center at (301) 816-5100 (collect calls accepted).
9.4	5.1.3 5.2.3 6.1.3.2	Change, Test and Experiment License Condition A) The licensee may, without obtaining a license amendment pursuant to 10 CFR 40.44, and subject to conditions specified in (B) of this condition: i. Make changes in the facility as described in the license application (as updated); ii. Make changes in the procedures as described in the license application (as updated); and iii. Conduct tests or experiments not described in the license application (as updated). B. The licensee shall obtain a license amendment pursuant to 10 CFR

License Condition	SER Section	Administrative Conditions
		40.44 prior to implementing a proposed change, test, or experiment if the change, test, or experiment would: i. Result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated); ii. Result in more than a minimal increase in the likelihood of occurrence of a malfunction of a facility structure, equipment, or monitoring system (SEMS) important to safety previously evaluated in the license application (as updated); iii. Result in more than a minimal increase in the consequences of an accident previously evaluated in the license application (as updated); iv. Result in more than a minimal increase in the consequences of a malfunction of an SEMS previously evaluated in the license application (as updated); v. Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated); vi. Create a possibility for a malfunction of an SEMS with a different result than previously evaluated in the license application (as updated); vii. Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report (FSER), environmental impact statement (EIS), environmental assessment (EA) or technical evaluation reports (TERs) or other analysis and evaluations for license amendments. viii. For purposes of this paragraph as applied to this license, SEMS means any SEMS that has been referenced in a staff SER, TER, EA, or EIS and supplements and amendments thereof. C) Additionally, the licensee must obtain a license amendment unless the change, test, or experiment is consistent with the NRC's previous conclusions, or the basis of or analysis leading to those conclusions, regarding actions, designs, or design configurations analyzed and selected in the site or facility SER, TER, and EIS or EA. This includes all supplements and amendments, and SERs, TERs, EAs, and EISs issued with amendments to this license. D) The licensee's determinations concerning (B) and (C) of this condition shall be made by a Safety and Environmental Review Panel (SERP). The SERP shall consist of a minimum of three individuals. One member of the SERP shall have expertise in management (e.g., a Plant Manager) and shall be responsible for financial approval for changes; one member shall have expertise in operations and/or construction and shall have responsibility for implementing any operational changes; and one member shall be the radiation safety officer (RSO) or equivalent, with the responsibility of assuring

License Condition	SER Section	Administrative Conditions
		changes conform to radiation safety and environmental requirements. Additional members may be included in the SERP, as appropriate, to address technical aspects such as groundwater or surface water hydrology, specific earth sciences, and other technical disciplines. Temporary members or permanent members, other than the three above-specified individuals, may be consultants. E) The licensee shall maintain records of any changes made pursuant to this condition until license termination. These records shall include written safety and environmental evaluations made by the SERP that provide the basis for determining changes are in compliance with (B) of this condition. The licensee shall furnish, in an annual report to the NRC, a description of such changes, tests, or experiments, including a summary of the safety and environmental evaluation of each. In addition, the licensee shall annually submit to the NRC changed pages, which shall include both a change indicator for the area changed (e.g., a bold line vertically drawn in the margin adjacent to the portion actually changed) and a page change identification (date of change, change number, or both), to the operations plan and reclamation plan of the approved license application (as updated) to reflect changes made under this condition.
9.5	6.5.4	Financial Assurance. The licensee shall maintain an NRC-approved financial surety arrangement, consistent with 10 CFR Part 40, Appendix A, Criterion 9, adequate to cover the estimated costs, if accomplished by a third party, for decommissioning and decontamination, which includes offsite disposal of radioactive solid process or evaporation pond residues, and ground-water restoration as warranted. The surety shall also include the costs associated with all soil and water sampling analyses necessary to confirm the accomplishment of decontamination. Proposed annual updates to the financial assurance amount, consistent with 10 CFR Part 40, Appendix A, Criterion 9, shall be provided to the NRC 90 days prior to the anniversary date. The financial assurance anniversary date for the Lost Creek Project will be the date on which the first surety instrument is submitted to the NRC. If the NRC has not approved a proposed revision 30 days prior to the expiration date of the existing financial assurance arrangement, the licensee shall extend the existing arrangement, prior to expiration, for 1 year. Along with each proposed revision or annual update of the financial assurance estimate, the licensee shall submit supporting documentation, showing a breakdown of the costs and the basis for the cost estimates with adjustments for inflation, maintenance of a minimum 15-percent contingency of the financial assurance estimate, changes in engineering plans, activities performed, and any other conditions affecting the estimated costs for site closure. Within 90 days of NRC approval of a revised closure (decommissioning) plan and its cost estimate, the licensee shall submit, for NRC review and approval, a proposed revision to the financial assurance arrangement if estimated costs exceed the amount covered in the existing arrangement. The revised

License Condition	SER Section	Administrative Conditions
		financial assurance instrument shall then be in effect within 30 days of written NRC approval of the documents. At least 90 days prior to beginning construction associated with any planned expansion or operational change that was not included in the annual financial assurance update, the licensee shall provide, for NRC review and approval, an updated estimate to cover the expansion or change. The licensee shall also provide the NRC with copies of financial-assurance-related correspondence submitted to the State of Wyoming, a copy of the State's financial assurance review, and the final approved financial assurance arrangement. The licensee also must ensure that the financial assurance instrument, where authorized to be held by the State, identifies the NRC related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of offsite disposal of solid byproduct material, soil, and water sample analyses, and groundwater restoration associated with the site. The basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or decommissioning plan cost estimates and annual updates should follow the outline in Appendix C, "Recommended Outline for Site-Specific In Situ Leach Facility Reclamation and Stabilization Cost Estimates," to NUREG 1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." The licensee shall continuously maintain an approved surety instrument for the Lost Creek Project, in favor of the State of Wyoming. The initial surety estimate shall be submitted for NRC review and approval within 90 days of license issuance, and the surety instrument shall be submitted for NRC review and approval 90 days prior to commencing operations.
9.6	6.3.4 6.4.4	Release or removal of surficially contaminated equipment, materials, or packages from restricted areas shall be in accordance with the NRC guidance document entitled "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated April 1993 (ADAMS Accession No. ML003745526) or suitable alternative procedures approved by the NRC prior to any such release or removal. The licensee shall document their survey of equipment, materials, or packages prior to removing them from a restricted area. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides shall apply independently.
9.7	5.3.3 5.3.4 5.4.3	The licensee shall follow the guidance set forth in NRC Regulatory Guides 8.22, "Bioassay at Uranium Mills" (as revised), and 8.30, "Health Physics Surveys in Uranium Recovery Facilities" (as revised), or NRC-approved equivalent. The licensee shall follow the guidance set forth in Regulatory Guide 8.31, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable"

License Condition	SER Section	Administrative Conditions
		(as revised), or NRC-approved equivalent, with the following exception: The licensee may identify a qualified designee(s) to perform daily inspections in the occasional absence of the RSO and health physics technician(s) (HPT). The qualified designee(s) will have health physics training, and the licensee will specify the training program and submit it to the NRC for review and verification prior to commencement of operations at the Lost Creek Project. The qualified designee(s) may perform daily inspections on weekends, holidays, and times when both the RSO and HPT(s) must both be absent (e.g. illness or offsite training). A designee(s) shall not perform daily inspections for more than two consecutive days except in the event of a Federal or company holiday, whereby no more than three consecutive days will be exceeded. Reports will be reviewed by the RSO or HPT as soon as practical, but not later than 3 hours from the beginning of the next work day following an absence, weekend, or holiday. The licensee will also have the RSO or HPT available by telephone while the qualified designee(s) is performing the daily inspections. Notwithstanding the License Condition (LC) 9.4 change process, no additional exceptions to the guidance will be implemented without written NRC verification that the criteria in LC 9.4 do not require a license amendment.
9.8	5.2.3	Cultural Resources. Before engaging in any developmental activity not previously assessed by the NRC, the licensee shall administer a cultural resource inventory if such survey has not been previously conducted and submitted to the NRC. All disturbances associated with the proposed development will be completed in compliance with the National Historic Preservation Act (as amended) and its implementing regulations (36 CFR 800), and the Archaeological Resources Protection Act (as amended) and its implementing regulations (43 CFR 7). In order to ensure that no unapproved disturbance of cultural resources occurs, any work resulting in the discovery of previously unknown cultural artifacts shall cease. The artifacts shall be inventoried and evaluated in accordance with 36 CFR Part 800, and no disturbance of the area shall occur until the licensee has received authorization from the NRC. The licensee shall comply with the stipulations for cultural resource protection in the Memorandum of Agreement dated October 4, 2010, provided in the NRC letter to the Advisory Council on Historic Preservation dated January 13, 2011.
9.9	1.3 4.24	The licensee shall dispose of solid byproduct material from the Lost Creek Project at a site that is authorized by NRC or an NRC Agreement State to receive byproduct material. The licensee's approved solid byproduct material disposal agreement shall be maintained on site. In the event that the agreement expires or is terminated, the licensee shall notify the NRC within seven working days after the date of expiration or termination. A new agreement shall be submitted for NRC review within 90 days after expiration or termination, or the licensee will be prohibited from further lixiviant injection.

License Condition	SER Section	Administrative Conditions
9.10	5.2.4	The results of the following activities, operations, or actions shall be documented: sampling; analyses; surveys or monitoring; survey/ monitoring equipment calibrations; reports on audits and inspections; all meetings and training courses; and any subsequent reviews, investigations, or corrective actions required by NRC regulation or this license. Unless otherwise specified in a license condition or applicable NRC regulation, all documentation required by this license shall be maintained until license termination, and is subject to NRC review and inspection.
9.11	10 CFR 40.5(a)(1)	The licensee is hereby exempted from the requirements of 10 CFR 20.1902(e) for areas within the facility, provided that all entrances to the facility are conspicuously posted with the words, "CAUTION: ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."

License Condition	SER Section	Operations, Controls, Limits, and Restrictions
10.1	3.1.3 3.1.4	The licensee shall use a lixiviant composed of native groundwater, carbon dioxide, sodium carbonate sodium bicarbonate, hydrogen peroxide, or oxygen, as specified in the licensee's approved license application and supplements.
10.2	3.1.4	Facility Throughput. The Lost Creek processing facility throughput shall not exceed an average daily flow rate equivalent to 6,000 gallons per minute or a maximum instantaneous flow rate of 6,300 gallons per minute, excluding restoration flow. The annual production of yellowcake slurry shall not exceed 1 million pounds equivalent of dried yellowcake product.
10.3	6.2.3 6.2.4	At least 12 months prior to initiation of any planned final site decommissioning, the licensee shall submit a detailed decommissioning plan for NRC review and approval. The plan shall represent as-built conditions at the Lost Creek Project.
10.4	4.2.3.1.1.2 7.3	The licensee shall develop and implement written standard operating procedures (SOPs) prior to operation for: A) All operational activities involving radioactive and non-radioactive materials associated with licensed activities that are handled, processed, stored, or transported by employees; B) All non operational activities involving radioactive materials, including in plant radiation protection, quality assurance for the respirator program, and environmental monitoring; and C) Emergency procedures for potential accident/unusual occurrences, including significant equipment or facility damage, pipe breaks and spills, loss or theft of yellowcake or sealed sources, significant fires, and other natural disasters. D) The SOPs shall include appropriate radiation safety practices to be followed in accordance with 10 CFR Part 20. SOPs for operational activities shall enumerate pertinent radiation safety practices to be followed. A copy of the current written procedures shall be kept in the area(s) of the production facility where they are utilized.

License Condition	SER Section	Operations, Controls, Limits, and Restrictions
		These SOPs are subject to all inspections, including the preoperational inspection specified in LC 12.3.
10.5	3.1.3 3.1.4	Mechanical Integrity Tests (MITs). The licensee shall construct all wells in accordance with methods described in Sections 3.2.4 and 3.2.5 of the licensee's approved license application. The licensee shall perform well MITs on each injection and production well before the wells are utilized and on wells that have been serviced with equipment or procedures that could damage the well casing. Additionally, the licensee shall retest each well at least once every 5 years. The licensee shall perform MITs in accordance with Section 3.2.5 of the licensee's approved license application. Any failed well casing that cannot be repaired to pass the MIT shall be appropriately plugged and abandoned in accordance with Section 6.3.2 of the approved license application.
10.6	6.1.3	Groundwater Restoration. The licensee shall conduct groundwater restoration activities in accordance with Section 6.2.3 of the approved license application. Permanent cessation of lixiviant injection in a wellfield would signify the licensee's intent to shift from the principal activity of uranium production to the initiation of groundwater restoration and decommissioning for any particular production area. If the licensee determines that these activities are expected to exceed 24 months for any particular production area, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR 40.42. Hazardous constituents in the groundwater shall be restored to the numerical groundwater protection standards as required by 10 CFR Part 40, Appendix A, Criterion 5(B)(5). In submitting any license amendment application requesting review and approval of proposed alternate concentration limits (ACLs) pursuant to Criterion 5(B)(6), the licensee must also show that it has first made reasonable effort to restore the specified hazardous constituents to the background or maximum contaminant levels (whichever is greater). Notwithstanding the LC 9.4 change process, the licensee shall not implement any changes to groundwater restoration or post-restoration monitoring plans without written NRC verification that the criteria in LC 9.4 do not require a license amendment. The licensee shall submit all changes to groundwater restoration or post-restoration monitoring plans to the NRC at least 60 days prior to groundwater restoration in a production area.
10.7	3.1.4	The licensee shall maintain an inward hydraulic gradient in each individual production area, starting when lixiviant is first injected into the production zone and continuing until the restoration target values (RTVs) have been reached.
10.8	3.1.4 4.2.4 5.3.3	The licensee is permitted to construct and operate two lined Storage Ponds, as described in Section 4.2.5 of the approved license application. The ponds will be used for storage of liquid byproduct material prior to disposal in a deep disposal well, as described in Section 4.2.5 of the approved application. Routine pond inspections will be conducted in accordance with procedures defined in Section 5.3.2 of the approved license application. The

License Condition	SER Section	Operations, Controls, Limits, and Restrictions
		inspections include: A) Daily Inspections. The licensee will perform daily inspections in accordance with Section 5.3.2.1 of the approved license application. The inspections will include visual inspections of the piping, berms, diversion ditches, freeboard and leak detection systems. The minimum freeboard is 3 feet. If during the daily inspections a fluid height in any of the standpipes for the pond leak detection system is found to be in excess of 6 vertical inches, then the licensee will collect a sample of the fluid for analysis of specific conductance. If the specific conductance of the fluid in the leak detection system is in excess of 50 percent of the specific conductance of fluids in the pond, then it is concluded that a leak has occurred in the pond primary liner and the licensee will perform mitigative and corrective actions. The corrective actions include notifying the NRC Project Manager by telephone or email within 48 hours and lowering the water level in the pond sufficiently to eliminate the leak. If the licensee does not complete corrective actions within 60 days, the licensee will not use the pond to store byproduct material until qualified personnel, as discussed in subsection D, inspect the liner. The licensee will submit a report to the NRC upon completion of the corrective actions, including documentation of all pond repairs. The licensee will maintain routine daily inspections reports on-site for NRC staff to review during routine inspections. B) Weekly Inspections. The licensee will conduct weekly inspections in accordance with Section 5.3.2.2 of the approved license application. The inspections will include visual inspection of the entire area, including perimeter fencing. The Manager of EHS and Regulatory Affairs, and the Operations Manager, will review the inspection report. Routine weekly inspections reports will be maintained on-site by the RSO for NRC staff to review during inspections. C) Quarterly Inspections. The licensee will conduct quarterly inspections in accordance with Section 5.3.2.3 of the approved license application. The inspections will also include sampling of the designated groundwater monitoring system. Results of the quarterly inspections will be included the quarterly report submitted to the NRC as discussed in LC 11.1(A). Water levels at the wells in the groundwater monitoring system will be monitored quarterly. Should water levels rise in the wells, the licensee shall institute an investigation. The investigation will evaluate whether or not the increased water levels are attributed to natural infiltration of surface water or infiltration of fluids from the pond. If the source of the water is attributed to the pond leakage, then the licensee will immediately perform corrective action to eliminate the leak and any appropriate remedial actions including characterization of impacts to shallow soils and water in the uppermost aquifer. Results of the

License Condition	SER Section	Operations, Controls, Limits, and Restrictions
		quarterly inspections will be submitted to the NRC for review. D) Annual Technical Inspection. The licensee will conduct annual inspections in accordance with Section 5.3.2.4 of the approved license application. The annual inspection will include a review of the previous year's daily, weekly, and quarterly inspections, assessment of the hydraulic and hydrologic capacities, and a survey of the embankment by qualified personnel. The licensee will submit a copy of the report to the NRC for review.
10.9	3.1.4 5.7.8.4 5.7.9.4	The licensee shall establish and conduct an effluent and environmental monitoring program in accordance with those programs described in Section 5.7.8.2 (Surface Water Monitoring, Private Well Monitoring, and Life-of-Mine Wells) and Section 5.7.7.1 (radon, air particulate, direct radiation, and soil) of the approved license application.

License Condition	SER Section	Monitoring, Recording, and Bookkeeping Requirements
11.1	4.1.4 5.1.3 5.7.1.1 5.3.3	In addition to reports required to be submitted to NRC or maintained on-site by Title 10 of the Code of Federal Regulations, the licensee shall prepare the following reports related to operations at the facility: A) A quarterly report that includes a summary of the weekly excursion indicator parameter values, corrective actions taken, and the results obtained for all wells that were on excursion status during that quarter. This report shall be submitted to the NRC within 30 days following completion of the reporting period. B) A semi-annual report that discusses status of wellfields in operation (including last date of lixiviant injection), status of production areas in restoration, status of any long term excursions, and a summary of MITs during the reporting period. This report shall be submitted to the NRC within 30 days following completion of the reporting period. C) Quarterly report summarizing daily flow rates for each injection and production well and pressures for each injection manifold within the operating system. The flow rates should be measured and recorded daily for each injection and production well and injection manifold pressures on the entire system. This report shall be made available for inspection upon request. D) Consistent with Regulatory Position 2 of Regulatory Guide 4.14 (as revised), a semiannual report that summarizes the results of the operational effluent and environmental monitoring program.
11.2	4.1.4 5.7.8.4	The licensee shall submit the results of the annual review of the radiation protection program content and implementation performed in accordance with 10 CFR 20.1101(c). These results shall include an analysis of dose to individual members of the public consistent with 10 CFR 20.1301 and 10 CFR 20.1302.
11.3	5.7.9.3 5.7.9.4	Establishment of Background Water Quality. Prior to injection of lixiviant in each production area, the licensee shall establish background groundwater quality data for the ore zone, and overlying and underlying aquifers. The

License Condition	SER Section	Monitoring, Recording, and Bookkeeping Requirements
		background water quality will be used to define the background groundwater protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5) for the ore zone aquifer and surrounding aquifers. Water quality sampling shall provide representative pre-operational groundwater quality data and restoration criteria as described in Section 5.7.8.1 of the approved license application. The data for each wellfield shall consist, at a minimum, of the following sampling and analyses: A) Ore Zone. Samples shall be collected from production and injection wells at a minimum density of one production or injection well per 4 acres. A minimum of six wells will be required for the baseline data per mine unit. The data for subhorizons may be combined if the licensee demonstrates that the grouping of data is statistically valid. Wells selected for the baseline data will be those used to determine when restored groundwater meets the NRC's groundwater protection standards in 10 CFR Part 40, Appendix A, Criterion 5B(5). B) Perimeter Monitoring Wells. Samples shall be collected from all perimeter monitoring wells that will be used for excursion monitoring in the HJ Horizon. Perimeter wells will be installed for a mine unit in accordance with information presented in Section 3.2.2.2 of the approved license application. In no case will the perimeter monitoring wells be installed outside of the UIC permit area approved by the Wyoming Department of Environmental Quality. If the production patterns include multiple subhorizons within the HJ Horizon, the above requirements will be applicable to all subhorizons. C) Overlying and Underlying Aquifers. Samples shall be collected from all monitoring wells in the first overlying and first underlying aquifer at a minimum density of one well per 4 acres of production area. D) Sampling and Analyses. Four samples shall be collected from each well to establish background levels. Consecutive sampling events shall be at least 14 days apart. The samples shall be analyzed for parameters listed in Table 6.2-1 of the approved license application. The licensee can reduce the list of parameters analyzed in the third and fourth sampling events. The parameters that can be deleted from analysis are those that measure below the minimum analytical detection limits (MDL) during the first and second sampling events, provided the MDLs meet the data quality objectives for the sampling. E) Background Water Quality. For the perimeter monitoring wells (LC 11.3(B)) and monitoring wells in the overlying and underlying aquifers (LC 11.3(C)), the background levels shall be the mean values on a parameter-by-parameter per well-by-well basis in

License Condition	SER Section	Monitoring, Recording, and Bookkeeping Requirements
		accordance with Section 6.2.2 of the approved license application. For the ore zone monitoring wells, the background levels shall be established on a parameter-by-parameter basis using either the wellfield or well-specific mean value. The restoration target value (RTV) for each parameter shall be established using the mean value plus a statistically valid factor to account for spatial variability in the data.
11.4	5.7.9.3 5.7.9.4	Establishment of UCLs. Prior to injection of lixiviant into a wellfield, the licensee shall establish excursion control parameters and their respective upper control limits (UCLs) in designated overlying aquifer, underlying aquifer, and perimeter monitoring wells in accordance with Section 5.7.8.2 of the approved license application. Unless otherwise determined, the default excursion parameters are chloride, conductivity, and total alkalinity. The UCLs shall be established for each excursion control parameter and for each well based on the mean plus five standard deviations of the data collected for LC 11.3. The UCL for chloride can be set at the sum of the background mean concentration and either (a) five standard deviations or (b) 15 mg/L, whichever sum provides the higher limit.
11.5	3.1.4 5.7.9.3.1.4	Excursion Monitoring. Monitoring for excursions shall be conducted twice monthly (semi-monthly) and at least 10 days apart for wells installed under LC 11.3B and C) at all production areas. If, for any well during a semi-monthly sampling event, the concentrations of any two-excursion indicator parameters exceed their respective UCL or any one excursion indicator parameter exceeds its UCL by 20 percent, then the excursion criterion is exceeded and a verification sample shall be taken from that well within 48 hours after results of the first analyses are received. If the verification sample confirms that the excursion criterion is exceeded, then the well is placed on excursion status. If the verification sample does not confirm that the excursion criterion, the licensee shall collect a third sample within 48 hours after the verification sampling. If the third sample shows that the excursion criterion is exceeded, the well on is placed on excursion status. If the third sample does not show that the excursion criterion is exceeded, the first sample shall be considered to be an error and routine excursion monitoring is resumed (the well is not placed on excursion status). Upon confirmation of an excursion, the licensee shall notify NRC, as discussed below, implement corrective action, and increase the sampling frequency for the excursion indicator parameters at the well on excursion status to at least once every seven days. Corrective actions for confirmed excursions may be, but are not limited to, those described in Section 5.7.8.2 of the approved license application. An excursion is considered corrected when concentrations of all indicator parameters are below the concentration levels defining the excursion for three consecutive weekly samples. If an excursion is not corrected within 60 days of confirmation, the licensee shall either (a) terminate injection of lixiviant within the wellfield until an excursion is corrected; or (b) increase the surety in an amount to cover the full third-party cost of correcting and cleaning up the

License Condition	SER Section	Monitoring, Recording, and Bookkeeping Requirements
		excursion. The surety increase shall remain in force until the NRC has verified that the excursion has been corrected and cleaned up. The written 60-day excursion report shall identify which course of action the licensee is taking. Under no circumstances does this condition eliminate the requirement that the licensee must remediate the excursion to meet groundwater protection standards as required by LC 10.7 for all constituents established per LC 11.3. The licensee shall notify the NRC Project Manager (PM) by telephone or email within 24 hrs of confirming a lixiviant excursion, and by letter within 7 days from the time the excursion is confirmed, pursuant to LC 11.6 and 9.3. A written report describing the excursion event, corrective actions taken, and the corrective action results shall be submitted to the NRC within 60 days of the excursion confirmation. For all wells that remain on excursion after 60 days, the licensee shall submit a report as discussed in LC 11.1(A).
11.6	5.2.4	Until license termination, the licensee shall maintain documentation on unplanned releases of source or byproduct materials (including process solutions) and process chemicals. Documented information shall include, but not be limited to, the date, spill volume, total activity of each radionuclide released, radiological survey results, soil sample results (if taken), corrective actions, results of postremediation surveys (if taken), a map showing the spill location and the impacted area, and an evaluation of NRC reporting criteria. The licensee shall have written procedures for evaluating the consequences of the spill or incident/event against 10 CFR Part 20, Subpart M, “Reports,” and 10 CFR 40.60 reporting criteria. If the criteria are met, then the licensee shall report to the NRC Operations Center as required. If the licensee is required to report any production area excursions and spills of source material, byproduct material, or process chemicals that may have an impact on the environment, or any other incidents/events, to any State or other Federal agencies, a report shall be made to the NRC Headquarters Project Manager (PM) by telephone or electronic mail (e-mail) within 24 hours. This notification shall be followed, within 30 days of the notification, by submittal of a written report to NRC Headquarters, as per LC 9.3, detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved.

License Condition	SER Section	Preoperational Conditions
12.1	1.3	Prior to commencement of operations in any production area, the licensee shall obtain all necessary permits and licenses from the appropriate regulatory authorities. The licensee shall submit a copy of all permits for its Class I and Class II underground injection wells to the NRC.
12.2	7.3.1	Prior to commencement of operations, the licensee shall coordinate emergency response requirements with local authorities, fire department, medical facilities, and other emergency services. The licensee shall document these coordination activities and maintain such documentation on-

License Condition	SER Section	Preoperational Conditions
		site.
12.3	5.4.10.4	The licensee shall not commence operations until the NRC performs a preoperational inspection to confirm, in part, that written operating procedures and approved radiation safety and environmental monitoring programs are in place, and that preoperational testing is complete. The licensee should notify the NRC, at least 90 days prior to the expected commencement of operations, to allow the NRC sufficient time to plan and perform the preoperational inspection.
12.4	Intro 1.3	The licensee shall identify the location, screen depth, and estimated pumping rate of any new groundwater wells or new use of an existing well within the license area and within 2 kilometers (1.25 miles) of any proposed production area since the application was submitted to the NRC. The licensee shall evaluate the impact of ISR operations to potential groundwater users and recommend any additional monitoring or other measures to protect groundwater users. The evaluation shall be submitted to the NRC for review within 6 months of discovery of such well use.
12.5	5.4.3 5.4.4	Prior to commencement of operations, the licensee shall submit the qualifications of radiation safety staff members for NRC review.
12.6	4.2.4	Prior to commencement of operations, the licensee shall submit a copy of the solid byproduct material disposal agreement to the NRC.

APPENDIX B

Activity and Exposure Rate Calculations (MicroShield® Version 5.05)

MicroShield v5.05 (5.05-00274)
US NRC

Page: 1
DOS File: Case1
Run Date: May 24, 2010
Run Time: 1:17:42 PM
Duration: 00:00:00

File Ref: Lost Creek
Date: 5-24-2010
By: Jim Webb
Checked: _____

Case Title: Case 1
Description: Case 1
Geometry: 1 - Point

Dose Points

	X	Y	Z
X #1	1.83e+05 cm	0 cm	0 cm
	6003 ft	0.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Shield 1	6000.0 ft	Carbon	1.76
Air Gap		Air	0.00122

Source Input
Grouping Method: Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015 : Excluded
Library:Grove

Nuclide	curies	becquerels
Bi-214	1.0000e+002	3.7000e+012
Ra-226	1.0000e+002	3.7000e+012

Buildup
The material reference is: Shield 1

Results

Energy MeV	Activity Photons/sec	Fluence Rate MeV/cm²/sec With No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr With No Buildup	Exposure Rate mR/hr With Buildup
0.08	6.340e+10	0.000e+00	9.943e-23	0.000e+00	1.573e-25
0.1	5.022e+09	0.000e+00	1.039e-23	0.000e+00	1.589e-26
0.2	1.214e+11	0.000e+00	2.244e-22	0.000e+00	3.960e-25
0.3	6.819e+09	0.000e+00	1.448e-24	0.000e+00	2.746e-27
0.4	3.907e+10	0.000e+00	1.607e-24	0.000e+00	3.132e-27
0.5	2.114e+10	0.000e+00	1.069e-24	0.000e+00	2.098e-27
0.6	1.770e+12	0.000e+00	5.285e-23	0.000e+00	1.032e-25
0.8	2.869e+11	0.000e+00	3.799e-24	0.000e+00	7.226e-27
1.0	1.158e+12	0.000e+00	1.156e-23	0.000e+00	2.131e-26
1.5	7.044e+11	0.000e+00	3.689e-24	0.000e+00	6.207e-27
2.0	9.902e+11	0.000e+00	4.381e-24	0.000e+00	6.775e-27
TOTALS:	5.167e+12	0.000e+00	4.146e-22	0.000e+00	7.219e-25