March 18, 2016

Mr. Steve Hatten, President
Lost Creek ISR, LLC
5880 Enterprise Dr., Suite 200
Casper, WY 82609

SUBJECT: AMENDMENT 4, SOURCE AND BYPRODUCT MATERIALS LICENSE SUA-1598, LOST CREEK IN SITU RECOVERY PROJECT, SWEETWATER COUNTY, WY, REMOVAL OF LICENSE CONDITIONS 12.10, 12.11, AND 12.12 (TAC J00717).

Dear Mr. Hatten:

Enclosed, please find the U.S. Nuclear Regulatory Commission (NRC) Staff's "*Safety Evaluation Report, Materials License SUA-1598, Amendment 4, Removal of License Conditions 12.10, 12.11, and 12.12, Lost Creek In Situ Recovery (ISR) Project, Sweetwater County, Wyoming*" and License SUA-1598, Amendment 4.

By letter dated July 12, 2013 (NRC's Agencywide Documents Access and Management System (ADAMS) Accession No. ML13282A381), Lost Creek ISR, LLC (Lost Creek or LCI) submitted to the NRC a request to remove license conditions (LCs) 12.10, 12.11 and 12.12. On November 3, 2014, NRC staff issued a technical evaluation report on that part of the LCI submittal pertaining to LC 12.10 (ADAMS Accession No. ML14289A073). The staff found that the information provided by LCI was insufficient and requested additional information within 30 days. On January 16, 2015, LCI submitted a revised response to License Condition 12.10 (ADAMS Accession No. ML15029A423). By letter dated May 21, 2015, NRC staff issued a request for additional information (RAI) (ADAMS Accession No. ML15125A090). By letter dated July 28, 2015, LCI provided its reply to the NRC staff's RAI (ADAMS Accession No. ML15218A055). By letter dated December 8, 2015, NRC staff issued an additional RAI (ADAMS Accession No. ML15308A392) on LCs 12.10 A) and 12.11. By letter dated January 26, 2016, LCI provided its reply to the additional RAI (ADAMS Accession No. ML16043A365).

Based on a review of the submitted information, the NRC staff approves of the license amendment request to remove License Conditions 12.10, 12.11, and 12.12. The NRC staff documented the justification for its actions in the attached Safety Evaluation Report (Enclosure 1). Amendment 4 to Source and Byproduct Materials License SUA-1598 is attached as Enclosure 2. This license action meets the criterion for a categorical exclusion pursuant to 10 CFR 51.22.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice and Procedure," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of ADAMS. ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

If you have any questions regarding this action, please contact Mr. John Saxton, the Project Manager for the Byproduct and Source Materials License SUA-1598, at 301-415-0697 or, by e-mail, at John.Saxton@nrc.gov.

Sincerely,

/RA/

Andrea L. Kock, Deputy Director
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket No.: 040-09068
License No.: SUA-1598

Enclosures:

1. Safety Evaluation Report
for Amendment 4, License SUA-1598
2. Amendment No. 4, Source
and Byproduct Materials License SUA-1598

cc: B. Wood, WDEQ
M. Newman, BLM

If you have any questions regarding this action, please contact Mr. John Saxton, the Project Manager for the Byproduct and Source Materials License SUA-1598, at 301-415-0697 or, by e-mail, at John.Saxton@nrc.gov.

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ML15279A559 (Ltr and SER); ML15279A561 (Amendment 4); ML15279A572 (Pkg)

OFC	DUWP	DUWP	DUWP	DUWP	OGC	DUWP
NAME	DBrown	JSaxton	SAchten	BVonTill	NLO IIrvin	AKock
DATE	2/17/16	2/18/16	2/22/16	2/26/16	3/11/16	3/18/16

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Safety Evaluation Report, Materials License SUA-1598, Amendment 4, Removal of License Conditions 12.10, 12.11, and 12.12, Lost Creek In Situ Recovery Project, Sweetwater County, Wyoming

Docket No. 040-09068; TAC J00717

Background

By letter dated June 13, 2013, (LCI 2013a), Lost Creek ISR, LLC (LCI, or the licensee) provided a response to License Conditions 12.10, 12.11 and 12.12 of its Source Materials License SUA-1598 (NRC 2013a).

License Conditions (LCs) 12.10, 12.11, and 12.12 state (NRC 2015b):

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.

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.

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 limits in 10 CFR Part 20, Subpart C.

The licensee subsequently withdrew its June 13, 2013, response and replaced it in its entirety with its response dated July 12, 2013 (LCI 2013b). On November 15, 2013, LCI submitted its standard operating procedures (SOPs) referenced in its July 12, 2013, response (LCI 2013c). On November 3, 2014, NRC staff issued a technical evaluation report on the LCI submittals pertaining to LC 12.10 (NRC 2014). The staff found that the information provided by LCI was insufficient and requested additional information within 30 days. On January 16, 2015, LCI submitted a revised response to License Condition 12.10 (LCI 2015a). By letter dated May 21, 2015, NRC staff issued a request for additional information (RAI) on LCI's responses to LC 12.10 (NRC 2015a). By letter dated July 28, 2015, LCI provided its reply to the NRC staff's RAI (LCI 2015c). On December 8, 2015, NRC staff issued an additional RAI regarding LCI's responses to LC 12.10(A) and 12.11 (NRC 2015c). By letter dated January 26, 2016, LCI responded to the NRC staff's December 8, 2015, RAI (LCI 2016).

Evaluation

The following is the NRC staff's evaluation of LCI's letters dated July 12, 2013 (LCI 2013b), January 16, 2015 (LCI 2015a), July 28, 2015 (LCI 2015c), and January 26, 2016 (LCI 2016), which address LCs 12.10, 12.11, and 12.12.

LC 12.10(A)

By letter dated January 16, 2015, LCI provided a revised monitoring plan to describe how it proposes to determine the quantity of principal radionuclides released from all point and diffuse sources in accordance with 10 CFR 40.65 (LCI 2015a). LCI stated it will measure the concentrations of principal radionuclides at various point and diffuse sources at the central processing plant, well field, and header houses and multiply the measured concentrations by the total volume of air discharged from these sources to determine the total activity of each principal radionuclide released.

In its January 16, 2015, letter, LCI explained that the principal radionuclides in air effluent at the Lost Creek ISR Project are natural isotopes of uranium, radon-222 (radon), and radon daughters (LCI 2015a). In its January 26, 2016, letter, LCI committed to also include measurements of thorium-230, radium-226, and lead-210 in its annual assessment of principal radionuclides in air effluent from the Lost Creek ISR Project (LCI 2016). The NRC staff finds that measurements of these principal radionuclides is consistent with Regulatory Position 2.1.1 of Regulatory Guide 4.14 (NRC 1980) and is, therefore, acceptable.

In its January 16, 2015, revised monitoring plan, LCI addresses two types of air effluent releases from the central processing plant: 1) air effluent from occupied spaces that vent through the plant's wall vent on the west side (which the staff will refer to hereafter as the plant west wall vent); and 2) process equipment vents. Table 1 of LCI's revised monitoring plan summarizes a plan to sample radon, radon daughters, and uranium in air effluent from the plant west wall vent. LCI explained that the dryer vent discharges through a HEPA filter before the exhaust is released into the occupied spaces of the central processing plant (CPP). Therefore, sampling of the plant west wall vent will capture uranium releases from the dryer vent. LCI showed the locations of its sampling points on Figures 1 and 2 included in its January 16, 2015, letter (LCI 2015a). However, in its January 16, 2015, plan, LCI did not explain how it would estimate the volume of air discharged from the plant (i.e., plant general ventilation), including periods when the rollup doors are open or closed. By letter dated May 21, 2015, NRC staff asked LCI to explain how it proposes to estimate the flow rate or total volume of air discharged from the plant wall vent (Monitoring Site No. E1) to calculate effluent quantities of uranium, radon, and radon progeny. NRC staff also asked LCI to explain how it proposes to estimate the quantity of radionuclides released from other plant vents and rollup doors, including periods when the rollup doors are open or closed (NRC 2015a). By letter dated July 28, 2015, LCI stated that flow rates at the plant west wall vent will be measured on a quarterly basis using a Davis Instruments A/2 4 Vane Anemometer or similar device (LCI 2015c). LCI also explained that plant doors (man doors and bay doors) will remain closed during normal operations and that LCI will perform air sampling to determine effluent quantities when all doors are closed. The NRC staff finds that LCI has adequately described how it will measure air flow rates from occupied spaces in the central processing plant in order to estimate quantities of principal radionuclides released to the air.

As stated above, LCI's monitoring plan also includes sampling and measuring radon concentrations in air effluent from process equipment vents. Process equipment vents include the following equipment or circuits: precipitation (Monitoring Site No. E2); elution (Monitoring Site No. E3); waste water (Monitoring Site No. E4); resin transfer (Monitoring Site No. E5); and the shaker deck (Monitoring Site No. E6). LCI explained that process vents are part of a wet process that creates no opportunity for uranium in the form of particulate matter. Therefore, LCI did not propose to measure uranium concentrations in wet process vents. LCI will monitor radon concentrations in each vent three times per quarter, except for the shaker deck vent (Monitoring Site No. E6), which will be monitored once per quarter. LCI also explained that, because the ion exchange (IX) column vents are not used except for emergencies, it will not monitor IX column vents. By letter dated May 21, 2015, NRC staff asked LCI to explain how it proposes to estimate the quantity of radionuclides released from plant vents (NRC 2015a). By letter dated July 28, 2015, LCI explained that the five tank exhaust fans described above will be monitored by data loggers that will monitor when each fan is operating and for how long (LCI 2015c). LCI also stated that each of the process vents (Monitoring Site No. E2 through E6) will be equipped with a digital manometer, or similar device, to estimate air velocity in the polyvinylchloride (PVC) vents, from which LCI will calculate an air flow rate. The NRC staff finds that LCI has adequately described how it will measure air flow rates from process vents in order to estimate quantities of principal radionuclides released to the air. NRC staff also evaluated the information contained in LCI's application (LCI 2008) regarding LCI's process and concurs that the vents identified by LCI are the likely sources of radon effluent from its facility.

With regard to estimating effluent quantities of radon progeny, LCI stated in its January 16, 2015, and July 28, 2015, letters that it will assume that radon daughters are in equilibrium with radon at the plant west wall vent and process equipment vents (LCI 2015a, 2015c). The staff finds that the assumption that radon progeny are in equilibrium will conservatively estimate the quantity of radon daughters present at the points of release. This finding of the staff is conservative because only a few minutes may have elapsed between the moment radon escapes the process vessels and when it is released from the plant, by which time equilibrium between radon and its progeny may not be complete. Nonetheless, the staff finds this assumption is reasonably conservative and appropriate for estimating radon and radon progeny effluent from the CPP.

For the wellfields, LCI proposed to measure radon daughter concentrations outside three injection and three production wellhead covers. In its January 16, 2015, letter, LCI did not explain how it would estimate air flow rates in order to calculate quantities released from wellhead covers (LCI 2015a). By letter dated May 21, 2015, NRC staff asked LCI to explain how it would estimate flow rate or total volume discharged from wellhead covers (NRC 2015a). By letter dated July 28, 2015, LCI stated that it would measure air flows from wells with the wellhead barrel removed using a digital anemometer once per quarter (LCI 2015c). These measurements will be used to estimate quantities of radon released. LCI proposes to sample 3 injection wells (Monitoring Site No. E8) and three production wells (Monitoring Site No. E9) each quarter.

For the header houses, LCI also plans to take radon, radon daughter, and uranium concentration measurements in 20% of all header houses and use direct measurements of header house ventilation fan flow rates, or design flow rates if measurements cannot be made, to estimate quantities of significant radionuclides released. The NRC staff finds that LCI has adequately described how it will measure air flow rates from wellhead covers, and estimate air flow rates from header houses, in order to estimate quantities of principal radionuclides released to the air.

LCI proposes to use the most recently determined assay for production or recovery fluids to estimate the amounts of radionuclides contained in the liquid effluents as a result of spills. NRC staff finds that this is an acceptable method for estimating liquid effluents resulting from spills.

NRC staff finds that LCI has discussed 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; thus, the requirement in license condition 12.10(A) is met.

LC 12.10(B)

LCI stated that it will demonstrate compliance with public dose limits using the method in 10 CFR 20.1302(b)(1), in which it must show, by measurement or calculation, that the total effective dose equivalent (TEDE) to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit. LCI evaluated doses to public visitors to its controlled area and restricted areas and members of the public who remain outside these areas. LCI determined that the maximally exposed members of the public are either a package delivery driver, who is assumed to visit the site for 173 hours per year, or an onsite contractor, who visits the site for up to 3 work days (24 hours per year).

LCI will estimate the TEDE to the package delivery driver by taking into account quarterly gamma exposure rate measurements and quarterly samples of radon, radon progeny, and uranium concentrations in air in the warehouse. LCI committed to reevaluating the sample frequency after one year and will reduce the sample frequency to one sample per year if measurement results are not distinguishable from background. NRC staff notes that LCI's July 28, 2015, submittal regarding its 2014 ALARA Audit and Public Dose Calculation (LCI 2015d) includes an estimate of 2014 annual TEDE to the package delivery driver. In that letter, LCI stated that the 2014 TEDE to a delivery package driver was about 0.167 mrem per year.

For the onsite contractors, LCI stated in its January 16, 2015, letter that the dose will be estimated by assuming the contractors visit the plant for 24 hours per year and receive a dose rate equivalent to that of the highest occupational dose received at the plant, exclusive of the dryer operator. LCI stated that this approach is very conservative because contractors at the plant would normally be considered to receive an occupational dose and would receive radiation worker training. NRC staff notes that LCI's July 28, 2015, submittal regarding its 2014 ALARA Audit and Public Dose Calculation (LCI 2015d) includes an estimate of 2014 annual TEDE to the onsite contractor. LCI stated that the public dose to a contract worker is about 50 mrem per year.

LCI also committed to conduct surveys to ensure the limit in 10 CFR 20.1301(a)(2) is not exceeded in any unrestricted area.

LCI evaluated doses to other members of the public outside a controlled or restricted area. LCI stated that public occupancy outside the controlled area immediately to the east of the Central Processing Plant (CPP), in the prevailing downwind direction, and near the holding ponds, is likely to remain less than 4 hours per year. Based on this low occupancy, LCI concluded that the potential TEDE at this location is very low and will not be the location of the maximally exposed member of the public.

To confirm that individuals near the facility are not receiving the highest dose from the licensed operation, LCI committed to downwind air sampling at seven stations, including existing sample station HV-2, plus the soda ash silo and propane tank for a total of nine locations. Measurements at these locations include quarterly radon by track-etch device, quarterly radon progeny by modified Kusnetz, quarterly gamma exposure rate measurements, and quarterly air particulate samples for uranium. LCI will reduce the sampling frequency to semiannual after one year if measurements results cannot be distinguished from background.

As stated above, LCI has identified individuals likely to receive the highest dose from licensed operations (package delivery drivers and short-term onsite contractors) and has evaluated and committed to verifying that no other locations onsite would likely result in higher exposures. Therefore, NRC staff finds that LCI has developed a written plan for determining individuals likely to receive the highest dose from licensed operations in accordance with 10 CFR 20.1302, and the requirement in license condition 12.10(B) is met.

LC 12.10(C)

As stated above under 12.10(B), LCI committed to factor radon progeny into its public dose estimates by using measurements of radon progeny (i.e., working levels) at each location where members of the public are likely to receive the highest exposures in accordance with 10 CFR 20.1302. Therefore, NRC staff finds that LCI has discussed and identified how radon progeny will be accounted for in analyzing public dose, and the requirement in license condition 12.10(C) is met.

LC 12.10(D)

In its January 16, 2015, letter, LCI explained how it addresses occupational dose throughout the licensed area. To measure exposure to gamma radiation (i.e., external dose), LCI uses optically stimulated luminescence (OSL) dosimeters on all employees that work in the CPP and on select employees in other work areas. Internal dose is calculated from the results of air samplers for both radon and long-lived radionuclides in the CPP, office areas, header houses and disposal well pump houses, as described in Section 5.7 of the Technical Report (LCI 2008). LCI also collects breathing zone air samples in areas with elevated airborne activity, such as dryer areas or in areas for which breathing zone samples are specified by radiation work permit. LCI explained it uses bioassays to verify that procedures for protection from inhalation and ingestion are adequate and being followed.

The staff previously found acceptable LCI's external radiation exposure monitoring program and its in-plant airborne radiation monitoring program (NRC 2011a). LCI stated that additional outdoor surveys for occupational dose were not necessary because dose and environmental measurements have shown that the dose contributions outside the plant and header houses are insignificant. LCI did not explain what dose and environmental measurements have been taken to show that dose contributions are insignificant. To independently verify LCI's claim, NRC staff examined LCI's semi-annual effluent and environmental monitoring reports for the second half of 2014 and first half of 2015, which were provided to NRC by LCI by letters dated February 24, 2015 (LCI 2015b), and August 27, 2015 (LCI 2015e). NRC staff examined both natural uranium and radon concentrations at outdoor locations onsite near the CPP.

With regard to natural uranium concentrations in the air, Table 1 of LCI's semi-annual effluent and environmental monitoring reports indicate that the annual average background concentrations of natural uranium in the air from four successive quarterly measurements, measured at sample location HV-3 located three miles southwest (upwind) of the CPP is about 2.5×10^{-16} µCi/mL. The annual average concentration of natural uranium in the air at location HV-2 located 50 feet east of the CPP is about 1.6×10^{-14} µCi/mL, or about 65 times higher than the background. The derived air concentration (DAC) for Class W natural uranium is 3×10^{-10} µCi/mL. Therefore, the maximum possible dose for a 2,000-hour occupational exposure to airborne uranium at sample location HV-2 is about 0.1 DAC-hours or 0.25 mrem per year. This is about 0.005% of the occupational dose limit, which confirms that occupational dose contributions from outdoor concentrations of natural uranium would be insignificant.

NRC staff also reviewed Table 6 of LCI's semi-annual effluent and environmental monitoring reports for the second half of 2014 and the first half of 2015, which includes results for passive radon monitoring. The annual average radon concentrations measured at all onsite stations downwind of the plant were less than the background concentration at sample location PR-2, which NRC staff calculated to be 1.8×10^{-9} µCi/mL. There was one elevated quarterly result (3.42×10^{-8} µCi/mL) for the second quarter of 2015 for the S Pond East monitor located at the fence on the east end of the Storage Pond area downwind of the plant. However, LCI noted in its report that this sampler was found on the ground, instead of a fixed location on the fence above the ground, which invalidates the results. Therefore, NRC staff agrees that there would be no occupational dose assigned from outdoor radon measurements.

NRC staff finds that LCI has discussed 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. Therefore, the requirement in license condition 12.10(D) is met.

LC 12.11

In its letter dated July 12, 2013, LCI provided, as an attachment to the letter, a table of minimum detectable activities (MDAs) and minimum detectable concentrations (MDCs) for representative Lost Creek Site Survey Instruments (LCI 2013b). LCI stated that the Ludlum Model 43-93 detector with a Ludlum Model 2360 data logger is the main instrument used for contamination release surveys. LCI stated that this instrument is used for personnel survey procedures for release, where the release limit to unrestricted areas is 1,000 dpm per 100 cm^2. LCI also stated that the Ludlum Model 3 survey meter with 44-9 pancake GM detector and the Ludlum Model 26 integrated GM pancake frisker have higher MDA and MDC values and will be used for surveying items in the plant and wellfield, such as 11e.(2) byproduct material. LCI's method for calculating instrument MDCs is provided in its Standard Operating Procedure No. SOP_LC_HP-004, "Radiation Detection Instrumentation" (LCI 2013c). By letter dated December 8, 2015, NRC staff issued a request for additional information regarding LCI's proposed approach to calculating MDAs and MDCs (NRC 2015c). By letter dated January 26, 2016, LCI revised its previous response to address the NRC staff's December 8, 2015, request for additional information (LCI 2016).

In its evaluation below, the NRC staff, as provided in NUREG-1569, Acceptance Criterion 5.7.6.3(8), considered the guidance contained in NUREG-1575, Revision 1 (NRC 2000). This NRC staff evaluation focuses on four factors important to ensuring that radiation-survey equipment, and methods for, are sufficiently sensitive to detect contamination at acceptably low levels. These factors are: (1) accounting for mixtures of radionuclides; (2) estimating counting efficiencies of survey equipment; (3) the energy of radiation emitted from calibration sources; and (4) the use of both scans (i.e., sweeping the detector across a contaminated surface) and static (i.e., fixed) surveys to detect contamination.

Mixtures of radionuclides

By letter dated December 8, 2015, NRC staff asked LCI to provide additional information regarding mixtures of radionuclides likely to be present at the LCI Project, including, at a minimum, mixtures contained in lixiviant and yellowcake (NRC 2015c). By letter dated January 26, 2016, LCI stated that it had sampled its production circuit fluid to determine the mixtures of alpha-emitting and beta-emitting radionuclides contained in pregnant lixiviant (LCI 2016). LCI accounted for over 97% of the measured gross alpha concentration as follows: uranium (93 percent of gross alpha measurement); radium-226 (4 percent of gross alpha measurement); polonium-210 (< 0.007 percent); radium-228 (< 0.003 percent); and thorium-230 (< 0.002 percent). LCI also determined by measurement that the gross beta concentration in its pregnant lixiviant is 9,700 pCi/L. LCI's analysis of specific beta-emitting radionuclides accounted for about 24 percent of the gross beta concentration as follows: thorium-234 (24 percent); and lead-210 (< 0.2 percent). LCI also noted in Table 3a-3 of its January 26, 2016, response, that protactium-234m would be present in secular equilibrium with thorium-234, thorium-231 would be present in secular equilibrium with uranium-235, and bismuth-210 would be present in secular equilibrium with lead-210, thus accounting for about another 37 percent of the measured gross beta concentration. The NRC staff notes that, because the measured concentration of radium-226 in the pregnant lixiviant is 2,700 pCi/L, short-lived beta-emitting daughters of radon-222, such as lead-214 and bismuth-214, are likely to account for the remainder of gross beta concentrations measured in the pregnant lixiviant.

LCI also analyzed the alpha-emitting and beta-emitting radionuclides contained in its aged yellowcake. LCI determined concentrations of alpha-emitting and beta-emitting radionuclides theoretically by assuming that uranium progeny with short half-lives is in secular equilibrium with uranium. As a result, LCI calculated that the mixture of alpha-emitting radionuclides in aged yellowcake is: uranium-238 (48.5 percent); uranium-234 (48.5 percent); and uranium-235 (2.2 percent). LCI's estimate of the mixture of beta-emitting radionuclides in aged yellowcake is: thorium-234 (48.9 percent); protactinium-234m (48.9 percent); and thorium-231 (2.2 percent).

LCI's characterization of mixtures of radionuclides likely to be present in contamination at the Lost Creek ISR Project is acceptable because it is consistent with NRC guidance in NUREG-1575, Supplement 1 (e.g., see Table 3.1 of NRC 2009).

Counting efficiency of Ludlum Model 43-93 (Fixed and Removable Contamination)

In its January 26, 2016, letter, LCI explained how it would determine counting efficiencies of its Ludlum Model 43-93 survey instrument (LCI 2016). LCI stated that it would apply default surface efficiencies recommended in International Organization for Standardization's (ISO)

Guide 7503-1, “Evaluation of Surface Contamination,” (ISO 1988a). The ISO approach defines the counting efficiency for alpha and beta particles as the product of the instrument efficiency, ε_i, and the source efficiency, ε_s. In the ISO approach, the instrument efficiency (ε_i) is the ratio of the instrument’s net reading (in counts per minute, or cpm) to the surface (2π) emission rate of a source for radiation of a given energy under given geometric conditions. The source efficiency (ε_s) is the ratio of the surface emission rate of a source to the radiation production rate in the source. The product of the instrument efficiency and the source efficiency ($\varepsilon_i \times \varepsilon_s$) describes the counting efficiency of the instrument.

LCI’s approach is acceptable because the NRC staff has previously endorsed the ISO 7503-1 (ISO 1988a) approach for assigning default surface efficiencies based on particle type (alpha or beta) and energy (beta only) (NRC 2006, 1998). Specifically, the ISO 7503-1 recommendation is to use a source efficiency of 0.5 for maximum beta energies ($E_{\beta max}$) exceeding 0.4 megaelectronvolts (MeV) and to use a source efficiency of 0.25 for $E_{\beta max}$ between 0.15 and 0.4 MeV and for alpha-emitters (ISO 1988a). Source efficiencies may be determined experimentally or simply selected from the guidance contained in ISO 7503-1 (NRC 1998).

Calibration sources

LCI explained its use of calibration sources for the Ludlum Model 43-93 survey instrument. In its letter dated July 12, 2013, LCI stated that it has purchased a thorium-230 alpha calibration source which emits alpha particles with energies of 4.68 MeV (76%) and 4.62 MeV (24%) and a strontium-90 beta calibration source with a maximum beta energy associated with its short-lived yttrium-90 progeny of 2,270 keV. The thorium-230 emission energies are between the major emission energies for uranium-234 (4.77 MeV) and uranium-238 (4.20 MeV). The strontium-90 / yttrium-90 $E_{\beta max}$ is nearly the same as the $E_{\beta max}$ for protactinium-234m (bold-faced in Table 2), the predominant short-lived beta-emitting progeny of uranium-238.

In its letter dated January 26, 2016, LCI explained that it did not have a carbon-14 calibration source for determining the instrument efficiency of the Ludlum Model 43-93 for low energy beta-emitting radionuclides. Therefore, it assumed a counting efficiency of zero for low energies and estimated the weighted counting efficiency of the Ludlum Model 43-93 assuming that only protactinium-234m ($E_{\beta max}$ of 2.29 MeV) and bismuth-210 ($E_{\beta max}$ of 1.161 MeV) would be detected. Using this approach, LCI calculated weighted counting efficiencies for the Ludlum Model 43-93 of surfaces contaminated with pregnant lixiviant of 0.093 for beta-emitting radionuclides and 0.07 for alpha-emitting radionuclides.

This approach is acceptable because the NRC staff previously recommended that calibration sources should be selected that emit alpha or beta radiation with energies similar to those expected of the contaminant in the field (NRC 1998). In addition, the most representative calibration source would be one prepared from the radioactive material being assessed in the field (NRC 1998). ISO-8769, "Reference Sources for the Calibration of Surface Contamination Monitors," provides recommendations on calibration source characteristics (ISO 1988b).

The NRC staff endorsed (NRC 2006, 1993b) previous versions of the American National Standards Institute (ANSI) standard N323AB–2013, “Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.” (ANSI 2013). ANSI standard N323AB–2013 recommends that single point calibrations be only valid for applications to field measurement energies that are greater than the calibration energy (ANSI 2013).

The NRC staff finds that the radiation emission energy of the thorium-230 and strontium-90 calibration sources selected by LCI are close to the emission energies of isotopes of uranium and its short-lived progeny to calibrate the Ludlum Model 43-93 for use at an ISR facility. However, the strontium-90 source is not appropriate for calibrating the Ludlum 43-93 for detection of beta particles with lower maximum emission energies than that of protactinium-234m, such as the beta particles from decay of thorium-234 and thorium-231. Therefore, because LCI is not using either an alternative source or an appropriate additional source (e.g., carbon-14 with an $E_{\beta max\ x}$ of 156 keV) to calibrate the Ludlum 43-93 at those energies, it did not credit the instrument's response to those energies when estimating minimum detectable concentrations and surface contamination levels. Not crediting the instrument's response to lower energy beta particles has the effect of discounting the counting efficiency of the detector.

Alpha Scans and Static Surveys

In its January 26, 2016, letter, LCI estimated the minimum detectable concentration (MDC) for the Ludlum Model 43-93 for both alpha-emitting and beta-emitting contamination. LCI's estimates are based on the methodology for calculating MDC for alpha scan and static surveys outlined in NUREG-1507 (NRC 1998) and Abelquist (2014).

For alpha-emitting radionuclides, the scan MDC takes into account that the background response of most alpha detectors is very close to zero. At these low count rates, the probability of detecting alpha-emitting surface contamination is calculated using Poisson summation statistics. Equation 6-12 of NUREG-1575 describes the probability of observing a single count while passing the detector over a contaminated area. Abelquist (2014) defined the minimum alpha activity that can be detected by solving Equation 6-12 for "G", resulting in:

$$Alpha\ scan\ MDC = \frac{\left[-\ln\left(1 - P(n \geq 1)\right)\right] * 60}{\varepsilon_i \varepsilon_s t}$$

Where P(n≥1) is the probability of detecting a single count, ε_i is the instrument efficiency, ε_s is the surface efficiency, and t is the scan time in seconds. LCI estimated the alpha scan MDC by assuming a P(n≥1) = 90% probability of detecting 1 count; a counting efficiency ($\varepsilon_i \times \varepsilon_s$) of 0.07 (7 percent); and a scan time of 7 seconds. Using these parameter values, LCI estimated the alpha scan MDC to be 282 dpm per 100 cm^2. This value is acceptable because it is lower than the 500 dpm per 100 cm^2 value for the lower limit of detection specified in Table 3, "Summary of Survey Frequencies," of NRC Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities" (NRC 2002).

LCI evaluated the MDC for static surveys using the same formula by Strom and Stansbury (1992):

$$MDC = \frac{3 + 3.29\sqrt{\mathrm{R}_b t_g (1 + t_g/t_b)}}{(\text{counting efficiency})(t_g)}$$

Assuming a Ludlum Model 43-93 alpha background count rate of 9 cpm, a counting efficiency of 0.07, and a background and survey count time of 0.8 minutes, LCI calculated an MDC of about 314 dpm per 100 cm^2. This value is acceptable because it is less than the 500 dpm per 100 cm^2 value for the lower limit of detection specified in Table 3, "Summary of Survey

Frequencies," of NRC Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities." (NRC 2002).

Beta Scans and Static Surveys

LCI used the methodology for calculating MDC for beta scan surveys is outlined in NUREG-1575 (NRC 2009) and Abelquist (2014). Equation 6-10 of NUREG-1575 provides a formula for estimating the scan MDC for beta-gamma-emitting radionuclides on structure surfaces:

$$Beta - Gamma\ Scan\ MDC = \frac{MDCR}{\sqrt{p}\varepsilon_i\varepsilon_s \frac{probe\ area, cm^2}{100\ cm^2}}$$

Where MDCR (minimum detectable count rate) is determined using equations 6-8 and 6-9 of NUREG-1575 (NRC 2009), p is the surveyor efficiency, ε_i is the instrument efficiency, ε_s is the surface efficiency, and the probe area is characteristic of the instrument. The open probe area of the Ludlum 43-93 is 88 cm^2. For a false positive rate of 0.60 (60 percent); true positive proportion of 0.95 (95 percent); a surveyor efficiency of 0.5; a counting efficiency ($\varepsilon_i \times \varepsilon_s$) of 0.093 (9.3 percent); a 7 second scan; and 158 cpm background count rate, LCI estimated the beta scan MDC to be 881 dpm per 100 cm^2. This estimated MDC is below the applicable removable surface contamination limit of 1,000 dpm per 100 cm^2 in Table 1 of Policy and Guidance Directive FC 83-23 (NRC 1993). The NRC staff evaluated the Beta-Gamma Scan MDC using a higher background count rate for the Ludlum Model 43-93 of 198 cpm, as stated by LCI on page 8 of its January 26, 2016, letter (LCI 2016). The NRC staff's estimate is approximately 990 dpm per 100 cm^2, which is still below applicable removable surface contamination limit of 1,000 dpm per 100 cm^2 in Table 1 of Policy and Guidance Directive FC 83-23 (NRC 1993). LCI noted that the highest background count rate that would be acceptable, assuming all other parameter values remained the same, is 205 cpm.

LCI calculated a beta static survey MDC using a Ludlum Model 43-93 beta background count rate of 198 cpm, a counting efficiency of 9.3 percent, and a background and survey count time of 1 minute. Using these parameter values, LCI calculated a beta static survey MDC of 884 dpm per 100 cm^2. This value is acceptable because it is below the regulatory limit for release of equipment and materials (e.g., the removable beta contamination limit of 1,000 dpm per 100 cm^2).

Parameters controlled by procedures and included in training programs

On the basis of its analysis presented in its January 26, 2016, letter LCI committed to ensuring the following important parameters are controlled to ensure acceptable MDCs using a Ludlum Model 43-93, and will be addressed in appropriate training programs: (1) residence time; (2) background count rate; (3) and source to detector window distance.

The NRC staff finds that LCI has adequately described its monitoring equipment sensitivity, calibration methods and frequency, and planned use, in accordance with LC 12.11.

LC 12.12

In its letter dated July 12, 2013, LCI provided its procedure SOP_LC_HP-019, "Determining Dose of Unmonitored Employees" (LCI 2013b). By e-mail dated November 15, 2013, LCI provided four additional environmental monitoring procedures and 14 health physics procedures, some of which are referenced in SOP_LC_HP-019 (LCI 2013c). The NRC staff evaluated SOP_LC_HP-019 and the additional procedures referenced therein.

In SOP_LC_HP-019, LCI describes a method for monitoring work spaces and representative employees to ensure that TEDE to unmonitored employees will be less than 10% of the 10 CFR Part 20 occupational dose limits for radiation workers. The NRC staff summary of procedure SOP_LC_HP-019 is provided in Table 1 of this SER.

External radiation dose monitoring

For unmonitored employees working in plant offices and the laboratory, procedure SOP_LC_HP-019 provides for TLDs placed at four locations throughout the first floor plant office on walls shared with the adjacent process areas. This practice is consistent with Regulatory Guide 8.34, Regulatory Position C.1.1, "Evaluation of Likely Annual Occupational Dose," which states "Surveys of dose rates and estimates of occupancy times may be used to estimate expected external doses." (NRC 1992)

Procedure SOP_LC_HP-019 also provides for individual monitoring devices (TLDs) on representative members of unmonitored work crews. This practice is consistent with Regulatory Guide 8.34, Regulatory Position C.1.2, "Establishing Categories of Workers for Monitoring," which states, "If groups or categories of workers are exposed to similar radiological conditions, a single evaluation may be used to determine the need for monitoring."

SOP_LC_HP-019 also provides for individual monitoring of unmonitored employees working in areas with increased external radiation dose rates. This practice is consistent with Regulatory Guide 8.34, Regulatory Position C.1.3, "Change in Exposure Conditions," which states, "If an individual's radiation exposure conditions change during the year, the need to provide individual monitoring should be reevaluated." As described above, the procedures for evaluating external dose rates is consistent with regulatory positions in Regulatory Guide 8.34. Therefore, the staff finds these practices acceptable for monitoring external radiation doses acceptable for purposes of evaluating whether unmonitored employees will exceed 10 percent of the dose limits in 10 CFR Part 20, Subpart C.

Internal radiation dose monitoring

In its safety evaluation for the Lost Creek ISR Project License Application (NRC 2011a), the NRC staff explained that the licensee did not describe the frequency that it will monitor the survey data used to ensure that external radiation exposures are less than 10 percent of the occupational dose limit for all unmonitored workers. This finding was the reason for NRC imposing LC 12.12. In the procedures LCI provided to NRC in 2013, LCI commits to measuring airborne radon progeny and particulate matter radionuclides in spaces occupied by unmonitored employees once per 2 weeks for the first 6 months and once per month thereafter. Radon measurements would also be performed quarterly for the first year. LCI proposes to use the Landauer Radtrak track-etch method for radon-222, Kusnetz method for radon-222 progeny, and glass fiber filter sampling of particulate matter in the air. Given that the first indication of excessive airborne radionuclides would likely be in operational areas of the plant (restricted areas), the staff finds that surveys for airborne radionuclides at a frequency of once per 2 weeks is sufficient to ensure that radiation exposures to unmonitored employees will be less than 10 percent of the annual occupational dose limit.

Table 1. Summary of LCI's plan to ensure TEDE to unmonitored employees will be less than 10% of the 10 CFR Part 20 occupational dose limits for radiation workers.

Location/Personnel	Dose Type	Measurement	Frequency
Plant offices, on walls adjacent to process areas in 4 locations	External	TLD (occupancy = 0.25)	Quarterly
Plant offices and laboratory, 5 locations	Internal (Radon)	Radtrak	Quarterly for first year
	Internal (Radon progeny)	Kusnetz	Once per 2 weeks for 6 months, once per month thereafter, for first year
	Internal (Particulate matter)	Air Samplers	Once per 2 weeks for 6 months, once per month thereafter
Unmonitored employees that routinely work outside plant offices 1. Wellfield operators 2. Wellfield maintenance 3. Construction crew 4. Casing crew 5. Geologists	External	TLD on representative member of the crew	Quarterly
	Internal (Radon)	Radtrak (7 monitors at boundary of CPP and in the ore trend area)	Quarterly
Unmonitored employee working in areas with increased external radiation dose rates	External	TLD	Quarterly

<u>Conclusion</u>

The NRC has evaluated LCI's submittals dated January 16, 2015 (LCI 2015a), July 28, 2015, (LCI 2015c), and January 26, 2016 (LCI 2016) and finds: (1) LCI has developed written procedures in accordance with LC 12.10 that describe how it will determine effluent quantities in accordance with 10 CFR 40.65 and evaluate public dose to the member of the public likely to receive the highest exposure in accordance with 10 CFR 20.1302; (2) the public dose procedures address radon progeny; and (3) additional procedures described by LCI discuss how, in accordance with 10 CFR 20.1501, LCI will determine occupational dose received throughout the license area from licensed operations. With regard to LC 12.11, the NRC staff finds that the licensee has adequately described its monitoring equipment sensitivity, calibration methods and frequency, and planned use. With regard to LC 12.12, the staff finds that the licensee has established appropriate criteria to ensure that unmonitored employees will not exceed 10 percent of the dose limits in 10 CFR Part 20, Subpart C. Therefore, the requirements of LCs 12.10, 12.11, and 12.12 are satisfied.

<u>Categorical Exclusion and Consultations</u>

In accordance with 10 CFR 51.22(b), the NRC staff has determined that an environmental assessment or environmental impact statement is not required for this action because it is an amendment that is procedural in nature, which is included in the list of categorical exclusions in

10 CFR 51.22(c). Specifically, 10 CFR 51.22(c)(11) describes the following category of action that is categorically excluded:

> Issuance of amendments to licenses for fuel cycle plants and radioactive waste disposal sites and amendments to materials licenses identified in [10 CFR] 51.60(b)(1) which are administrative, organizational, or procedural in nature, or which result in a change in process operations or equipment, provided that (i) there is no significant change in the types or significant increase in the amounts of any effluents that may be released offsite, (ii) there is no significant increase in individual or cumulative occupational radiation exposure, (iii) there is no significant construction impact, and (iv) there is no significant increase in the potential for or consequences from radiological accidents.

The staff evaluated the four conditions contained in 10 CFR 51.22(c)(11)(i) through 10 CFR 51.22(c)(11)(iv). This administrative and procedural amendment allows LCI to report quantities of principal radionuclides released in accordance with 10 CFR 40.65, estimate public dose to members of the public and occupational dose to workers, and perform surveys for beta-gamma contamination. These measurements and associated calculations have no bearing on plant operations, air effluents, or liquid waste processing activities. Therefore, there can be no significant changes or increases in the types or amounts of effluent released offsite. Measurements of radionuclides and calculations of effluent quantities, contamination surveys, and assessments of public and occupational dose provide reasonable assurance that there will be no significant increase in individual or cumulative occupational radiation exposure. Additionally, because these surveys do not require new facilities or structures, there is no significant construction impact. Finally, because these measurements and associated calculations would not increase radiation exposure, there is no significant increase in the potential for or consequence from radiological accidents.

The NRC staff has determined that a Section 7 consultation prescribed by the Endangered Species Act of 1973 is not required because the proposed action is administrative/procedural in nature and will not affect listed species or critical habitat. The NRC staff has also determined that the proposed action is not a type of activity that has the potential to cause effects on historic properties because it is administrative/procedural action. Therefore, no further consultation is required under Section 106 of the National Historic Preservation Act.

Proposed License Condition

In its letter dated July 12, 2013, LCI proposed to remove LCs 12.10, 12.11, and 12.12. In this amendment, NRC staff is removing LCs 12.10, 12.11, and LC 12.12 and revising LC 9.2 to add LCI's commitments, representations, and statements, contained in LCI letters dated January 16, 2015 (LCI 2015a), July 28, 2015 (LCI 2015c), and January 26, 2016 (LCI 2016).

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Enclosure 2

NRC Materials License SUA-1598

Amendment 4