Response to RAI-11 Regarding Background Radiological Characteristics

TETRA TECH

Technical Memorandum
Response to November 16, 2017 Public Meeting Conference Call to Discuss RAI Responses with Lost Creek ISR: RAI-11 (b, c, d)

December 11, 2017

1.0 INTRODUCTION

Tetra Tech Inc. (Tetra Tech) and Keystone Scientific Inc. have prepared this technical memorandum in response to a request for additional information (RAI) provided by the U.S. Nuclear Regulatory Commission (NRC) during a November 16, 2017 public meeting conference call. The slides from this public meeting are presented in NRC ML17324B356. The purpose of the meeting was to discuss and clarify certain aspects of Lost Creek ISR, LLC's responses to NRC Staff RAIs on the Lost Creek East Amendment Application. RAI-1 through RAI-15 were issued by NRC on July 27, 2017 (ML17199F574); RAI-16 through RAI-19 were issued by NRC on August 28, 2017 (ML17227A312), and RAI-20 through RAI-26 were issued by NRC on October 30, 2017 (ML17298B724). Lost Creek ISR, LLC responded to RAI-1 through RAI-19 on September 25, 2017 (ML17275A674). NRC noted that some of the responses, specifically RAI-2, RAI-8, RAI-11, RAI-15, RAI-16, and RAI-19, were inadequate; additional information was requested in the November 16 public meeting.

There were specific RAI sections which referred to work Tetra Tech had performed at the Lost Creek and Lost Creek East site in 2006 and 2012, respectively. Additional clarification was requested for RAI-11(b) – *Gamma scans,* part of RAI-11, Background Radiological Characteristics. RAI-11(b) *Gamma scans* specifically stated:

(1) UTV-based gamma scans for exposure rate measurements need to use properly calibrated survey instruments.
(2) The correlation between previous UTV-based gamma scans (2008 Tech Report volume 2 section 2.9) and the 2013 UTV-based scans (2017 Tech Report section 3.12 and D-10) is not well documented.

Additionally, the NRC requested additional information on the calibration of the UTV-based radiation measurements, Ra-226 soil radioactivity measurement locations, and characterization of radioactivity levels for several radionuclides.

The purpose of this technical memorandum is to present additional information to Lost Creek ISR, LLC in support of their response to these portions of RAI-11.

2.0 BACKGROUND INFORMATION

This section presents background information concerning the two primary baseline studies conducted by Tetra Tech at Lost Creek (2006) and Lost Creek East (2012). The associated reports are the Baseline Gamma Survey and Radiological Soil Sampling Results for the Lost Creek Claim Area [2007 Baseline Report] (by Tetra Tech) and the Baseline Radiological Study Report [2013 Baseline Report] (by MFG/Tetra Tech). A graphic showing the mine claim boundary areas scanned in 2006 and 2013, including the land area used for survey comparisons to be discussed here, is presented as Exhibit A as an attachment to this technical memorandum.

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2007 Baseline Study Report:

Tetra Tech submitted the 2007 Baseline Report on June 30, 2007 to Ur-Energy and AATA International in support of a permitting application for an *in-situ* leach (ISL) uranium mining project in Sweetwater County, Wyoming. The Lost Creek ISL claim area (about 4,400 acres) is located in the Great Divide Basin, approximately 15 miles southwest of the town of Bairoil, Wyoming. Baseline environmental studies at the Lost Creek claim area began in January 2006. As part of the study, Tetra Tech (formerly MFG, Inc.) performed a radiation baseline survey of naturally occurring gamma exposure rates and soil radionuclide concentrations. These surveys in the Lost Creek claim area began in late August, 2006. The report submitted to Ur-Energy and AATA International describes the methods, activities, and results of these surveys for the claim area. The 2007 report covered the following activities:

- Gamma surveying and mapping utilizing utility terrain vehicle (UTV) mobile GPS-based scanning systems.
- Cross-calibration of sodium iodide (NaI) Detectors against a high pressure ionization chamber (HPIC).
- A soil sampling and gamma radiation correlation study.

The report submitted to Ur-Energy and AATA International was then used by the client to generate Section 2.9 of the Technical Report submitted to the NRC in October 2007. This report was revised and resubmitted to the NRC in 2008.

2013 Baseline Study Report:

Tetra Tech submitted the 2013 Baseline Report to Lost Creek ISR, LLC on September 6, 2013, in support of radioactive materials license and permit applications with the NRC and the Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD) for the Lost Creek East in-situ recovery (ISR) project. The work involves expansion of the original Lost Creek project, utilizing the uranium recovery facility already operating at the adjacent site. The Tetra Tech report was prepared to be an addendum to the expansion permit application. The scope of work was limited to conducting a gamma radiation survey only, utilizing a mobile GPS-based gamma scan system similar to the system used five years previously.

The scope of work for the 2012 expansion application study by Tetra Tech, as specified by Lost Creek ISR, LLC, did not include surface soil samples, subsurface soil samples or sediment samples (all performed during the 2006 survey). Also, the 2012 work did not include cross-calibration onsite to an energy independent system (a high pressure ionization chamber [HPIC]) (as performed during the 2006 survey). These scope differences were specified by Lost Creek staff assuming that the 2006 soil onsite sampling/correlation and HPIC correlation data could be extended to cover the 2012 survey work, given that the land areas are adjacent. The report submitted to Lost Creek ISR, LLC was then used by Lost Creek ISR, LLC to generate Section 2.9 of the Technical Report submitted to NRC in 2017.

The following sections present Tetra Tech responses to the RAI sections associated with the work performed by Tetra Tech.

3.0 TETRA TECH RESPONSE #1: RAI-11(B) *QUALITY ASSURANCE*

The NRC requested additional information on the calibration of the UTV-based radiation measurements. Specifically, RAI-11(b) *Gamma scans* specifically stated: *(1) UTV-based gamma scans for exposure rate measurements need to use properly calibrated survey instruments.*

Response: The survey instruments were properly calibrated. When conducting radiological site surveys or investigations, Tetra Tech adheres to a strict quality assurance program, as recommended by the Multi-Agency Radiation Survey Site Investigation Manual [MARSSIM] (NRC 2000) and other NRC guidance. The quality assurance/quality control (QA/QC) protocols are initiated at the beginning of each such Tetra Tech project, and are integrated into all surveys as data is collected. Instrument calibration documents and the results of the application of these QA/QC protocols are presented in the two Tetra Tech reports.

The 2007 Baseline Report and the 2013 Baseline Report each provide detailed information related to the quality control procedures used to ensure that all survey/correlation instruments are properly calibrated. Section 2.4 of the 2007 Baseline Report presents a discussion concerning the study's data QA application and results, and the quantification of data quality control QC procedures, used by Tetra Tech during the 2006 surveys. This information is presented in Section 2.9.1.1 of the 2007 Lost Creek Project Technical Report. Section 4.3 of the 2013 Baseline Report similarly presents a discussion of the data QA/QC procedures, including results and data uncertainty. A detailed presentation and analysis of the gamma radiation survey QA/QC data are included in the report's Appendix B.

Both the 2006 and 2012 gamma radiation surveys followed Tetra Tech's quality control protocols, to ensure that the survey results were accurate and that sources of uncertainty were identified and controlled to the extent feasible. Tetra Tech utilized the same types of radiation detection instrumentation (Ludlum 44-10 2" NaI gamma radiation detectors with 2350-1 dataloggers) in the 2006 and the 2012 surveys. The instruments were factory calibrated, with calibration document copies provided within the Tetra Tech reports. Tetra Tech utilizes its field experience to regularly modify and improve the systems used for such work; the 2013 scanning systems utilized a somewhat different configuration/geometry, compared to the 2006 project, as discussed in the following section (see Figure 1). The differences seen in the gamma radiation detection rates between the 2006 and 2012 studies are primarily related to this change in detector configuration.

4.0 TETRA TECH RESPONSE #2: RAI-11(B)

Tetra Tech's Response #2 is related to the NRC's request on Page 11 of ML17324B356 for additional information related to the calibration of the UTV-based radiation measurement instruments. RAI-11(b) *Gamma scans* specifically states: *(2) The correlation between previous UTV-based gamma scans (2008 Tech Report volume 2 section 2.9) and the 2013 UTV-based scans (2017 Tech Report section 3.12 and D-10) is not well documented.* The NRC requested Lost Creek ISR, LLC to provide additional information concerning the calibration of the UTV-based radiation measurement instruments used for exposure rate measurements. The request also notes that characterization of background radioactivity levels is needed for several radionuclides in addition to radium-226.

Response: Although the detector instrument types used in both surveys remained the same, the scan system geometry used for the 2006 vs. the 2012 gamma radiation surveys differed (see Figure 1). Orientation of the 2" NaI detectors was changed to provide a more stable and protective mounting system for the detectors. In Section 5.0 of the 2013 Baseline Report, Tetra Tech provided a discussion describing how the gamma exposure rate measurements collected in 2012 were normalized to the 2006 scan data. The purpose of this current memorandum is to provide additional information concerning this normalization process.

Figure 1. Comparison of Scan System Geometry: 2006 (vertical detectors) vs. 2013 (horizontal detectors)

Because modifying a detector's mounting system and orientation introduces changes in shielding and radiation detection efficiency (and because radon daughter product gamma radiation intensity varies over time as a result of environmental factors including soil moisture and recent barometric pressure history), a comparison study plot was scanned in 2012 to compare 2006 and 2012 instrument readings. The results of this comparison study were presented in Section 5.0 of the 2013 report, and were used to develop a ratio between the two sets of data, allowing them to be plotted and analyzed together. Performing a direct comparison in the field in this manner provides a reasonably sound basis for normalization of the results of the two studies.

Discussion: In ground-based surveys, a person carrying a detector may intercept and attenuate as much as 30% of the gamma radiation that would otherwise interact with the detector (Johns and Cunningham 1983). A similar observation applies to UTV-based surveys: attenuation occurs via the materials in the body of the UTV and the detector mounting system. The orientation (vertical vs. horizontal) of the cylindrical 2" NaI detector element also affects its radiation detection effectiveness: a vertically transmitted gamma ray entering the vertical cylinder detector "sees" a different detector shape, on average, than does a similar ray entering a horizontal cylinder. It has become standard practice for Tetra Tech to utilize test plots to develop a relationship between, for example, backpack systems and UTV-based systems being utilized for radiation surveys at the same site. (These two different systems may be used at the same site when terrain does not allow UTV access, for example.) Typically, cross-correlations are performed between a specific scanning system and an HPIC, to provide data to normalize gamma exposure rates. The energy-independent HPIC correlation data can be used later, in the event other radiation detector types are employed many years in the future (for example, during a site remediation process). In the Lost Creek East case, however, a different approach was applied to provide normalization, since the 2012 work scope did not include onsite HPIC correlation. Tetra Tech utilized parallel-track data from the two studies to develop a normalization factor.

As shown in Figure 1, the 2012 detector system was positioned slightly closer to the ground surface (3 feet) compared to the 2006 systems (3.28 feet); additionally, the 2006 setup used an extension with added reach away from the body of the UTV; This would change the attenuating effects of the UTV body material. As noted, there were also differences in the detector orientation between the 2006 (vertical) and 2013 (horizontal) formats, and in the proximity of detector mounting hardware. The net result on overall radiation detection efficiency would be difficult to predict. Thus, a parallel track correlation study was performed in 2012 to correct for the various changes from 2006. In order to ascertain the differences between the 2006 and 2013 systems, Tetra Tech conducted scanning along a rectangular strip covering approximately 5.6 acres. Exhibit A, attached, presents a graphic showing the locations of the two mine claim boundaries and the land area used for the comparison.

Tetra Tech concluded in Section 5.0 of the 2013 Baseline Study Report that the difference between the average of measurements (2006 and 2012) was 13.8%. Therefore, the gamma exposure rates were corrected by this normalization factor to allow direct comparison of the data sets. The purpose of normalizing the data in this way is to allow use of the 2006 HPIC and gamma-soil-radium correlations, which could then be applied site wide to meet the objectives of the scope of work. An analysis was performed to show the distribution of 2006 vs. 2012 gamma measurements. Figures 2 and 3 present the normal probability and frequency histograms comparing the two surveys.

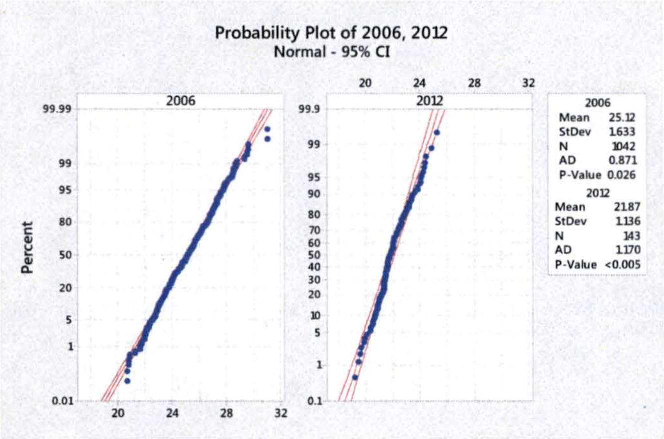

Figure 2. Probability Plots of the 2006 and 2013 Gamma Survey Data

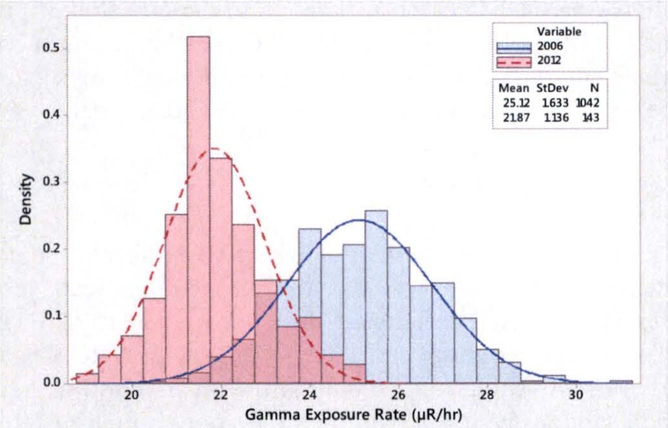

Figure 3. Frequency Histograms of the 2006 and 2013 Gamma Survey Data

The analysis that resulted in 13.8% difference utilized the data sets within the comparison land area; it did not compare direct measurements based on geospatial location. In some cases, points were as many as 50+ feet apart (still within the comparison plot area). To re-evaluate this approach, Tetra Tech examined the differences between points that were within 2 meters of each other, performing a regression analysis. The result of this analysis showed that similarly located data pairs showed consistently higher values for the

2006 data. This observation confirms that the difference between the comparison plot data sets is real, not an artifact.

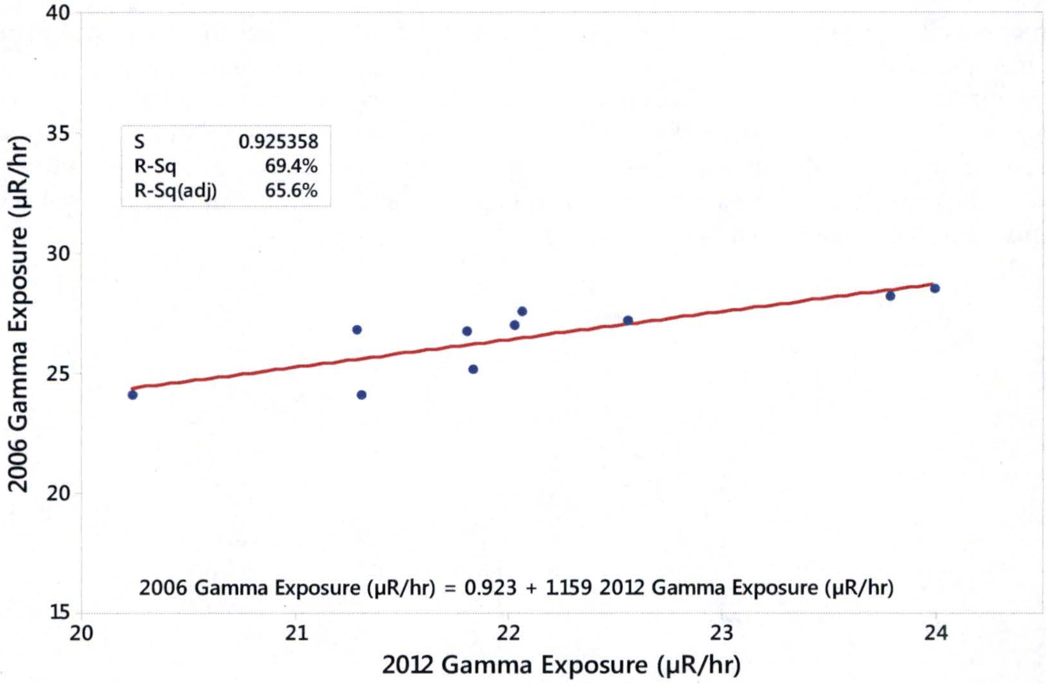

Figure 4. Regression Analysis of 2006 and 2013 Gamma Survey Data within 2 m Proximity

In retrospect, the need to apply parallel-track normalization to the two studies performed five years apart could have been avoided had additional soil radium and HPIC correlations been completed during the 2012 survey. However, the alternate approach developed to compare the data is reasonable, and the determination to adjust the data set by the 13.8% correction factor appears to be justified.

5.0 TETRA TECH RESPONSE: RAI-11(C & D)

The NRC stated that data gaps were present in the LC East (LCE) information concerning preoperational monitoring. Discussion during the November 16, 2017 conference call provided additional detail concerning the NRC observation. NRC staff noted that, while the original Lost Creek report (2006) provided data for a set of soil samples complying (as feasible) with NRC Regulatory Guide (RG) 4.14 (1980), the LCE data (2012) listed samples taken only at the air monitoring station locations. The NRC requested that additional soil samples be taken over the LCE area, using a system and number of samples to be proposed by Lost Creek/Tetra Tech staff.

RG 4.14 specifies that preoperational "Surface-soil samples (to a depth of five centimeters) should be collected using a consistent technique at 300-meter intervals in each of the eight compass directions out to a distance of 1500 meters from the center of the milling area. The center is defined as the point midway between the proposed mill and the tailings area." The guidance further specifies that "Surface-soil samples should also be collected at each of the locations chosen for air particulate samples", that "Subsurface samples (to a depth of 1 meter) should be collected at the center of the milling area and at a distance of 750 meters in each of the four compass directions", and that "All soil samples should be analyzed for radium-226. Soil samples collected at air particulate sampling locations and ten percent of all other soil samples (including at least one subsurface set) should be analyzed for natural uranium, thorium-230, and lead-210."

Because the LCE expansion area will contain no facility corresponding to a "mill" (liquids extracted from the LCE area will be processed at the facility located in the original LC area), the RG 4.14 guidance cannot be applied to the LCE area. Therefore, to develop the requested additional soil sampling regime, we propose instead to utilize the 2013 report's LCE gamma scanning data set to identify locations of interest for soil sampling. This approach focuses sampling on areas that indicate the presence of naturally occurring radioactive material. Data from such locations may prove to be of value in later years, during site closure operations. Figure 5 presents the raw gamma exposure rate data from the 2013 LCE report. Figure 6 presents the proposed soil sampling locations.

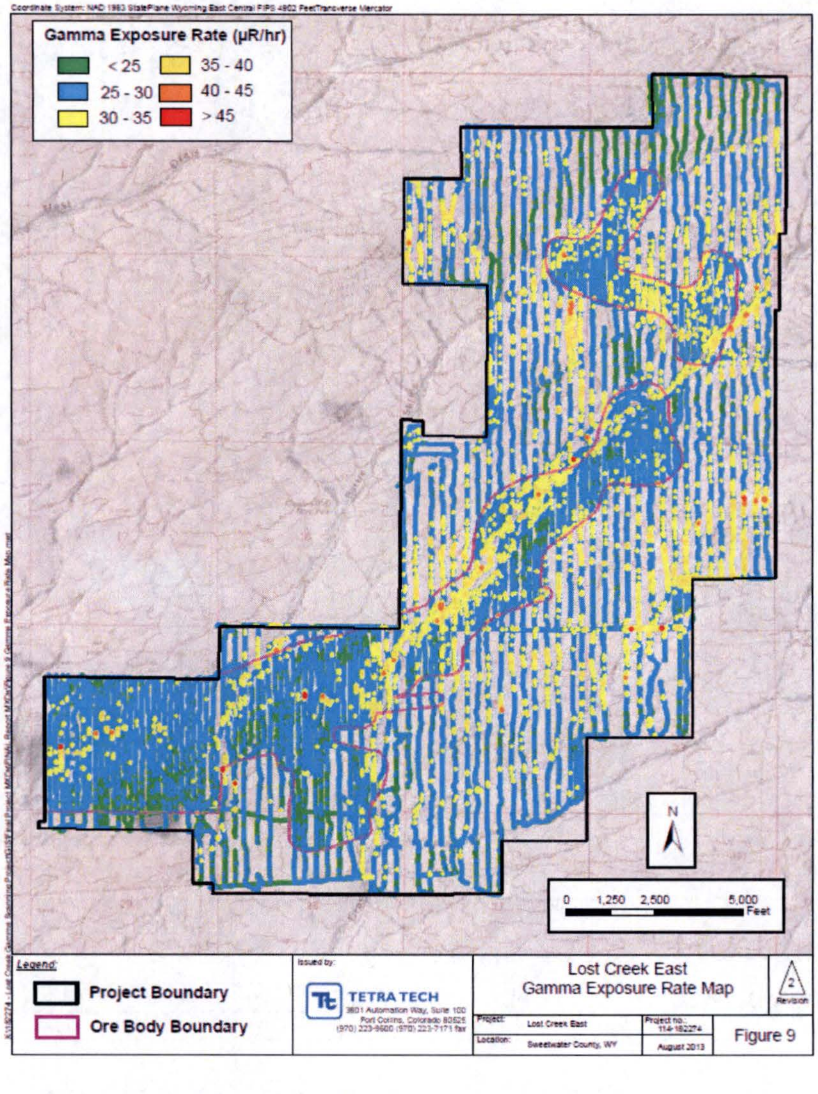

Figure 5. LCE Gamma Exposure Rates (2012 Scan Results)

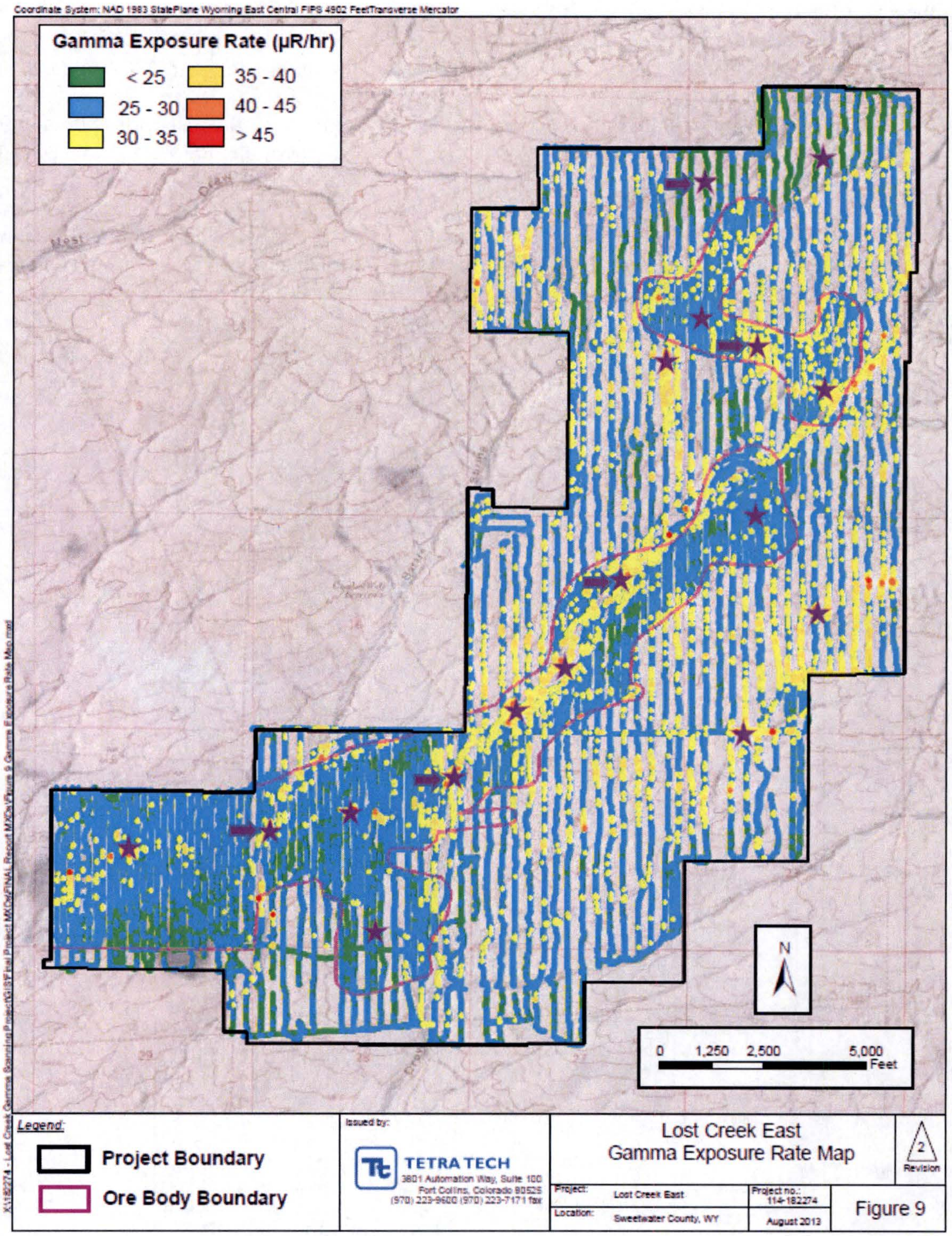

Figure 6. Proposed Soil Sample Locations. (Arrows indicate additional 1-m samples)

Note that the proposed sampling locations include 14 placed at Figure 6 (starred) areas showing relatively high gamma exposure rates. An additional 3 samples would be taken in the starred areas where background

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(relatively low) levels of naturally occurring radiation are indicated. These background locations include two at the top and one at the bottom of Figure 6. The locations shown are approximate; a handheld 2" NaI detector would be used to precisely locate the highest radiation levels proximate to the 14 higher exposure locations, and to locate the lowest radiation levels proximate to the three background locations. In addition, per RG 4.14, five samples, composited from soil extracted to 1 m depth, will be taken at those locations indicated in Figure 6 by adjacent arrows.

If this protocol is determined by NRC staff to be appropriate, sampling and laboratory analysis would be performed in accordance with the RG 4.14 specifications (noted above), including analysis of some samples, as specified, for the full set of radionuclides identified in the Regulatory Guide. However, for this special study, the number of samples to be analyzed for the full set of radionuclides would be increased beyond the RG 4.14 specifications: Five of the surface samples (rather than 10%), including one of the surface background samples, and two of the 1-m composite samples (rather than one), will be analyzed for the full RG 4.14 set of radionuclides. The remaining samples will be analyzed for Ra-226 only.

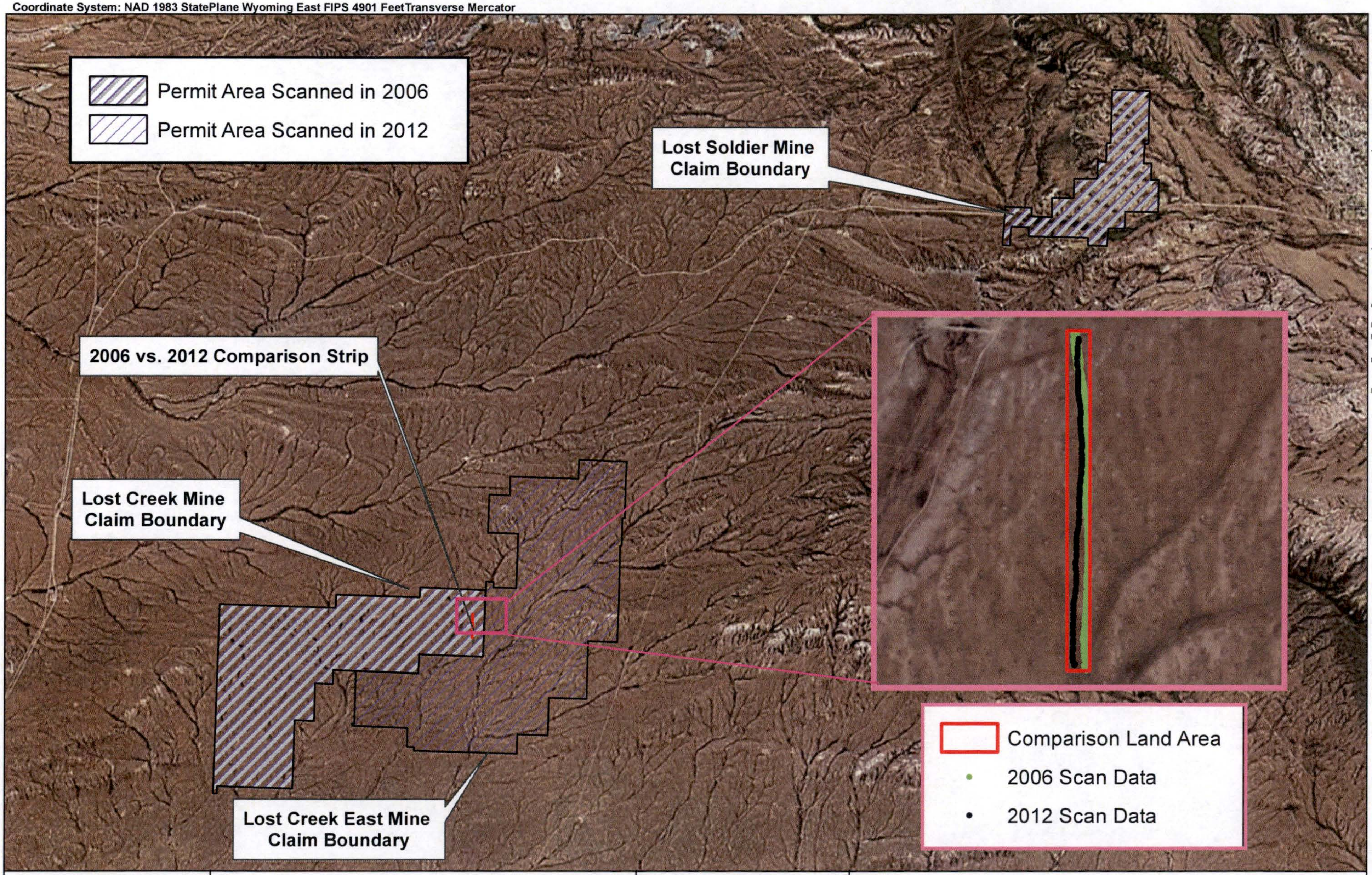
6.0 REFERENCES

Johns, H.E., Cunningham, J.R., 1983. Physics of Radiology, fourth ed. Charles C. Thomas Publishing, Springfield, Illinois, USA.

Tetra Tech. 2007. Baseline Gamma Survey and Radiological Soil Sampling Results for the Lost Creek Claim Area. June 30.

Tetra Tech. 2013. Baseline Radiological Survey Report Lost Creek East In-Situ Uranium Mine Sweetwater County, Wyoming. September 6.

Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 FeetTransverse Mercator



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LOST CREEK ISR MINE CLAIM BOUNDARY MAP

Project: RILEY PASS URANIUM MINE	Project no.: NRC RAI	Exhibit A
Location: SWEETWATER COUNTY, WY	Date: 12/2017	