Bluff B Subsurface and Supplemental Surface Investigation Report Final

Riley Pass Uranium Mines Site
North Cave Hills Area – Custer Gallatin National Forest, South Dakota

September 21, 2022

TETRA TECH

Bluff B Subsurface and Supplemental Surface Investigation Report

Contract No. 12035518D0001
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Submitted to
USDS Forest Service
Custer Gallatin National Forest
10 E. Babcock Street
Bozeman, MT 59715

Submitted by
Tetra Tech, Inc.
825 W. Custer Avenue
Helena, MT 59602

TETRA TECH

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ACRONYMS AND ABBREVIATIONS

Ac-228	Actinium-228
ags	Above ground surface
ALS	ALS Environmental Laboratories
amsl	Above mean sea level
ASTM	ASTM International
AUM	Abandoned uranium mine
bgs	Below ground surface
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cs-137	Cesium-137
DSM	Digital surface model
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
ICP-MS	Inductively coupled plasma-mass spectrometry
ID	Identification
IDW	Inverse distance weighted
J	Estimated value
K-40	Potassium-40
LiDAR	Light detecting and ranging
m^2	Square meter
MARLAP	*Multi-Agency Radiological Laboratory Analytical Protocols Manual*
mg/kg	Milligrams per kilogram
m/s	Meters per second
MST	Mountain Standard Time
NAD	North American Datum
NaI(TI)	Sodium iodide thallium-laced
NFS	National Forest Service
NHD	National Hydrography Dataset
NORM	Naturally occurring radioactive material
pCi/g	Picocuries per gram
ppm	Parts per million
QA	Quality assurance
QC	Quality control

R^2	Statistical measure of how close data come to a fitted regression line (also known as the coefficient of determination)
Ra-226	Radium-226
RPD	Relative percent difference
RTK	Real-Time Kinematic
SAP	Sampling and Analysis Plan
TENORM	Technologically enhanced naturally occurring radioactive material
Tetra Tech	Tetra Tech, Inc.
Th-232	Thorium-232
TPU	Total propagated uncertainty
Tronox	Tronox Worldwide, LLC
µCi	Microcurie
µR/hr	Microroentgens per hour
U	Not detected
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
UAV	Unmanned aerial vehicle
UPL	Upper confidence limit
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WSS	Web Soil Survey
XRF	X-ray fluorescence

EXECUTIVE SUMMARY

The Riley Pass Uranium Mines Site (the Site) is within the North Cave Hills area of the U.S. Department of Agriculture (USDA) Forest Service (USFS) Custer Gallatin National Forest in northwest South Dakota. The Site is approximately 25 miles north of Buffalo, South Dakota. Most reclamation activities completed at the Site have proceeded according to the U.S. Environmental Protection Agency's (EPA) Guidance on Conducting Non-Time-Critical Removal Actions Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA 1993). The primary environmental issues at the Site involve impacts of mining activities from the 1950s to the early 1960s. Hazards include high walls, unstable overburden, materials with elevated radioactivity, heavy metals (arsenic, molybdenum, thorium, radium-226, and uranium), and mass transport by erosion.

Preparation of this investigation report occurred under a contract between Tetra Tech, Inc. (Tetra Tech) and USFS (12035518D0001 Task Order No. 19,1240LU21F0038).

Ten abandoned uranium mines (AUMs) within the Site (Bluffs A, B, "CDE", F, G, H, I, J, K, and L) span 300+ acres. This report focuses on a subsurface and supplemental surface investigation at Bluff B. It also summarizes and ties in results from the 2020 subsurface investigation at the Site. This investigation included the following tasks:

- An **aerial gamma flyover survey pilot study** during the 2021 field investigation to delineate gamma radiation levels in areas along the tortuous cliffs at the eastern side of Bluff B previously deemed inaccessible to a ground crew survey because of safety concerns or difficulties of access. The study involved use of an innovative unmanned aerial vehicle (UAV) or "drone" scanning system with radiation detection instrumentation and Real-Time Kinematic (RTK) Global Positioning System (GPS).
- A **lateral delineation survey** during the 2021 field investigation at edges of the Bluff B boundary involving more than 35,000 gamma radiation measurements during ground based, mobile, GPS backpack gamma surveys, as well as collection of eight discrete soil samples across 49.2 acres—with intent to delineate surface soil concentrations of Radium-226 (Ra-226) and arsenic below their action levels in order to further delineate lateral extents of mining-related contamination.
- A **gamma-radium correlation study** during the 2021 field investigation involving 15 soil correlation plots to evaluate the relationship between gamma exposure rate (collimated and uncollimated) and soil Ra-226 concentration in order to develop a model useful for estimates of Ra-226 concentrations in soil at Bluff B. Previous gamma-radium correlation studies have been performed across multiple Riley Pass study areas to develop prediction models for Ra-226 using gamma (MSE 2009, Tetra Tech 2013b). A gamma-radium correlation is necessary to assist with waste characterization and clean-up verification. However, it has been found that a unique correlation developed specific to an individual site (i.e., site-specific) may be more useful than comparing correlations from multiple sites together (e.g., one example is Bluff A [Tetra Tech 2019a]). A strong linear relationship between these datasets became evident, and evaluations of different models (by application of a 95 percent [%] upper confidence limit (UPL) for the linear regression) occurred to identify the model that would be most appropriate statistically and would incur the least cost and risk. Application of that approach led to recognition of a gamma cutoff of

48 microroentgens per hour (μR/hr) for use in all future efforts to identify areas at Bluff B of Ra-226 concentrations in soils at or below 30 picocuries per gram (pCi/g) with a 95 percent confidence level. Ability to identify these areas will be useful for planning, cleanup, risk analysis, and decision-making pertaining to future remediation efforts at Bluff B.

- A **subsurface investigation** during the 2021 field investigation involving screening and sampling of subsurface soils via advancements of test pits with a track-mounted excavator in 15 different areas of Bluff B. Of the 15 test pits completed, 13 of these test pits were located on the bluff top where depth to bedrock was easily determined. Purposes of this were to increase understanding of depths of contamination and to delineate vertical extents of mine waste in order to estimate volumes for reclamation design. The slopes below the bluff edge were too steep to safely conduct a subsurface investigation, rather a UAV gamma survey was conducted to measure radiation activity.

Some primary conclusions from the report are as follows:

- The cleanup area at Bluff B wherein arsenic concentrations in surface soil exceed the action level of 142 milligrams per kilogram (mg/kg) is 25.6 acres.
- The cleanup area at Bluff B wherein Ra-226 concentrations in surface soil exceed the action level of 30 pCi/g is 15.6 acres.
- The total combined area at Bluff B wherein either Ra-226 or arsenic concentrations in surface soil exceed the action level is 29.6 acres. This is the area that should be used for remedial engineering design and excavation planning.
- Vertical extents of waste material have been delineated across 69% of the surficial contamination zones of the Site. The information from the test pits collected so far may be useful to characterize the remainder of waste volumes on the bluff top. Contamination levels for waste on slopes below the bluff edge are limited to surface readings (see **Section 2.1**).

Figure ES-1 is an arsenic soil concentration map identifying areas of exceedance of the action level of 142 mg/kg for the Site. **Figure ES-2** is a gamma radiation map that also identifies areas where Ra-226 concentrations exceed the action level of 30 pCi/g for the Site. **Figure ES-3** is a map showing waste contours identified at Bluff B; it was developed by combining data from the 2020 and 2021 subsurface investigations.

To summarize, the 2020 and 2021 field investigations achieved success at: (1) identifying an estimated bedrock contact (as elevation) with respect to unconsolidated materials (native, mine spoils, and mine waste)—useful for estimating volumes of waste material within contamination zones on the top of Bluff B; (2) completing dozens of test pits and identifying vertical extents of contaminant profiles across Bluff B; (3) identifying potential borrow sources useful for remediation design efforts; (4) completing a site-specific correlation between gamma exposure rates from a sodium iodide thallium-laced (NaI[Tl]) detector (shielded and unshielded) and Ra-226 soil concentrations—useful for characterization, remediation design, remedial action surveys, and verification surveys (final status surveys); (5) acquiring photogrammetric information for topographic mapping and high-resolution aerial imagery—useful for remediation design; and (6) filling in remaining data gaps in lateral extents of radiological contamination across Bluff B by application of both aerial and ground based radiological surveying methods.

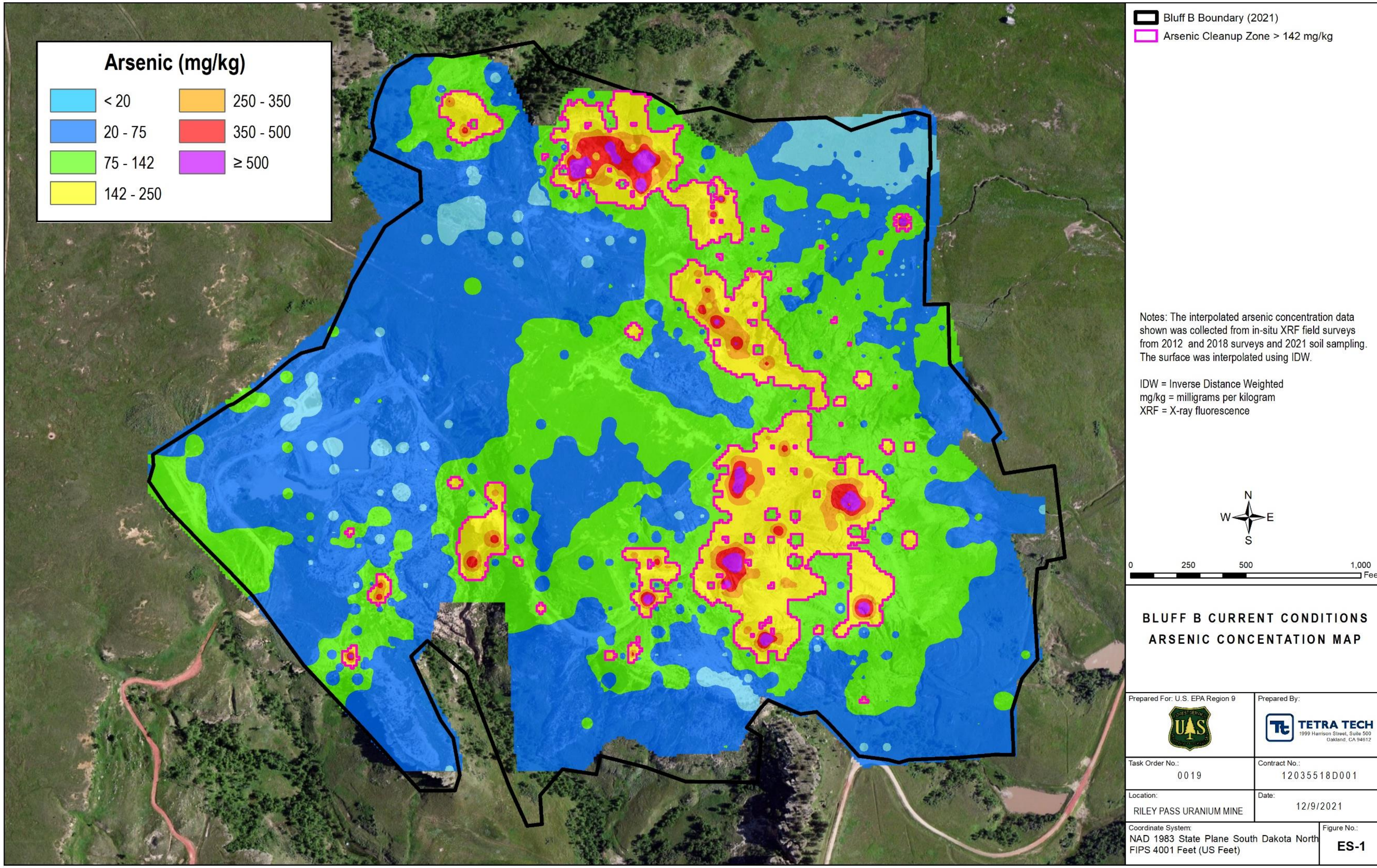

Figure ES-1: Bluff B Current Conditions Arsenic Concentration Map

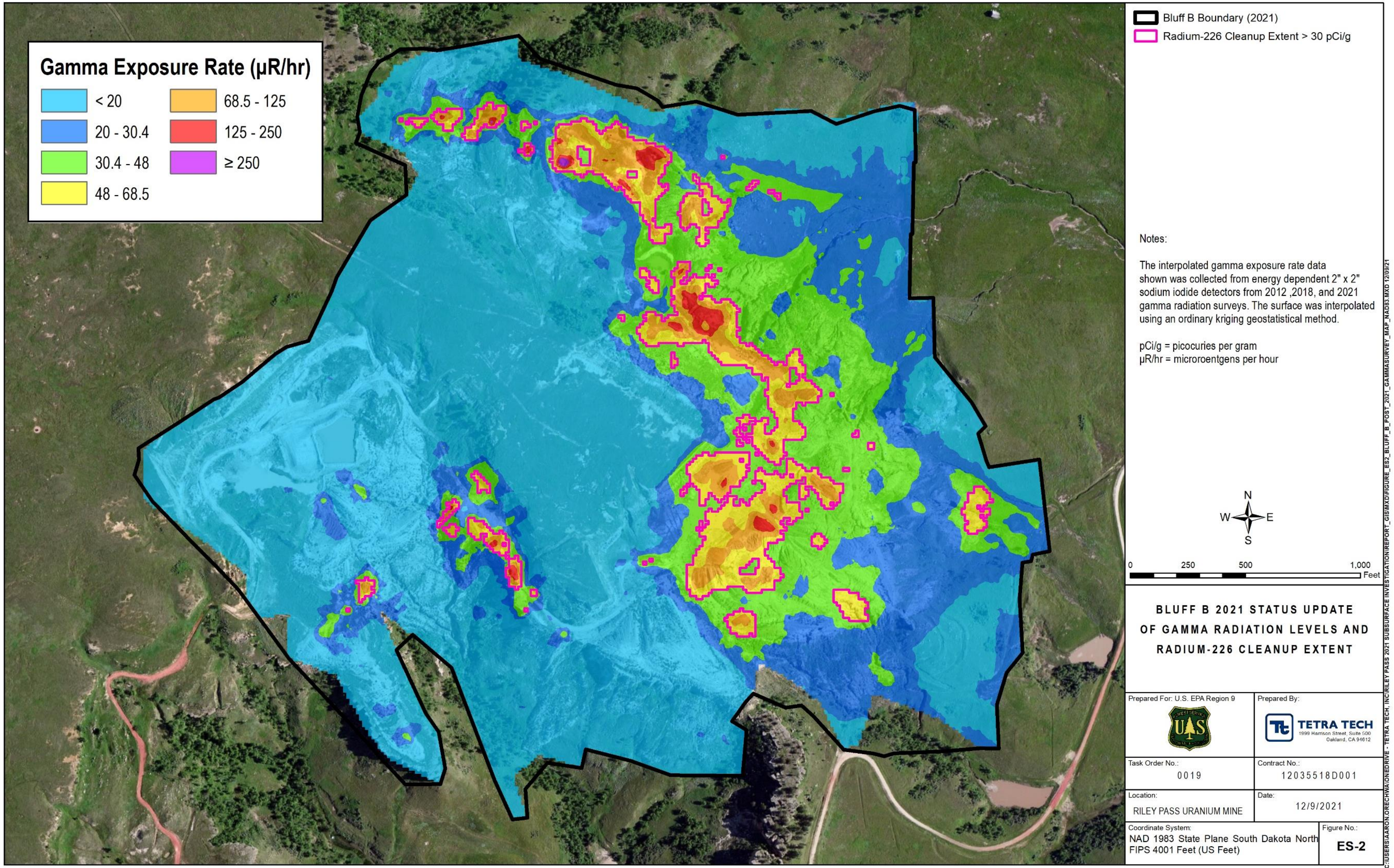

Figure ES-2: Bluff B Current Conditions Gamma Radiation Map

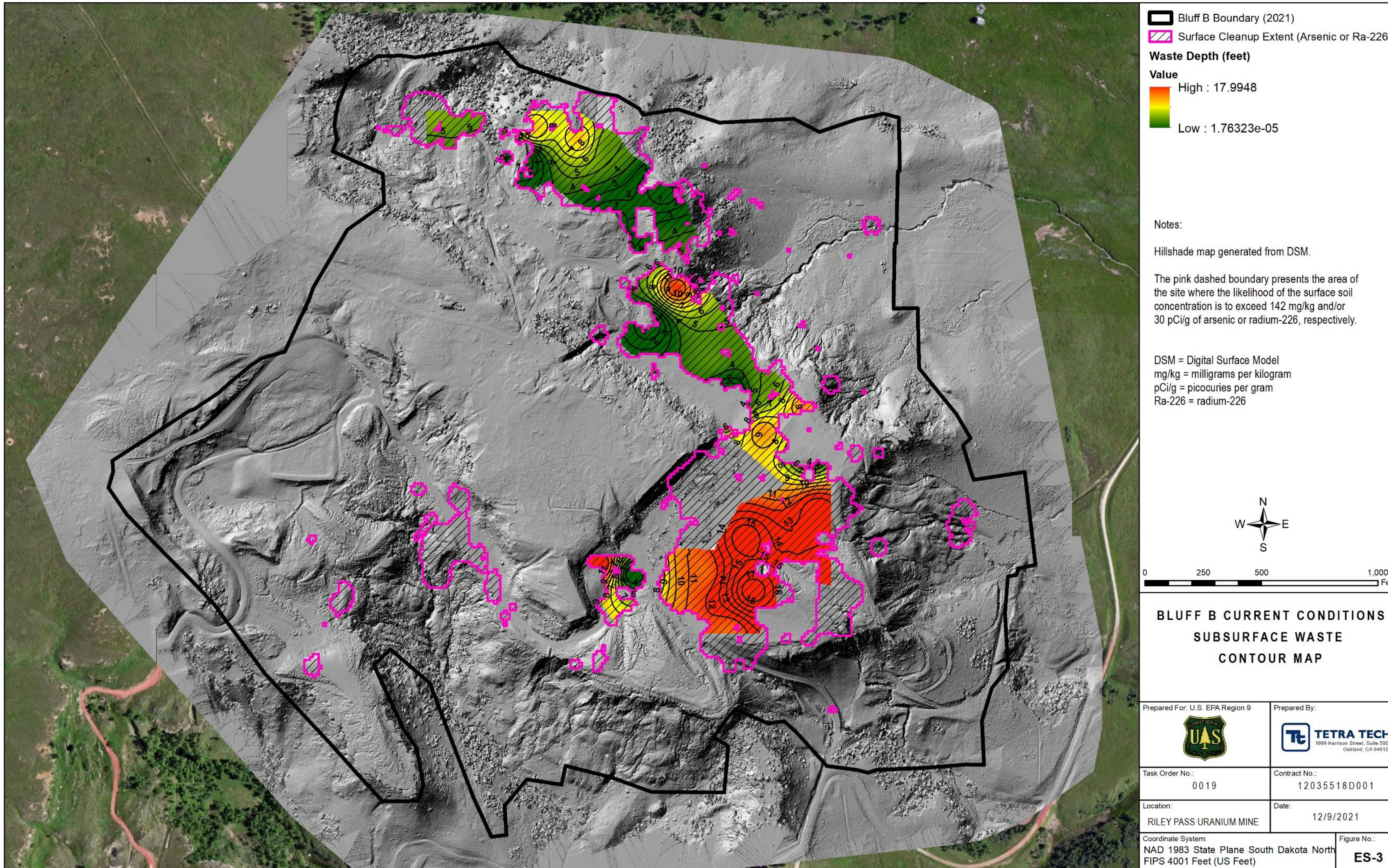

Figure ES-3: Bluff B Current Conditions – Subsurface Waste Contour Map

1.0 INTRODUCTION

The U.S. Forest Service (USFS) requested a subsurface and supplemental surface investigation to support ongoing remediation design at Bluff B abandoned uranium mine (AUM) within the Riley Pass Uranium Mines Site (the Site). In previous years, the USFS and its contractors have applied arbitrary excavation depths to reclamation activities, for example, at Bluff G, Bluff F, and Bluff I (Tetra Tech 2017) a uniform excavation depth was applied. For Bluff B, the goal is to bring more precision into reclamation design by improving knowledge of contamination stratification within the waste column, volume estimates and excavation strategies. Reclamation activities completed at the Site have proceeded according to the U.S. Environmental Protection Agency's (EPA) Guidance on Conducting Non-Time-Critical Removal Actions Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA 1993). Tetra Tech, Inc. (Tetra Tech) conducted this task under a contract between Tetra Tech and USFS (Contract 12035518D0001, Task Order No. 19) in accordance with the Sampling and Analysis Plan (SAP) – Subsurface and Supplemental Surface Investigation for Bluff B (Tetra Tech 2021). The purpose of this report is to summarize the purpose, methods, and results of field work during the 2021 field season at Bluff B.

The following are specifications of purpose and descriptions of Tetra Tech activities (in accordance with the USFS-approved SAP) during the 2021 field investigation (June to August) at Bluff B:

- An **aerial gamma flyover survey pilot study** to delineate gamma radiation levels in areas along the tortuous cliffs at the eastern side of Bluff B previously deemed inaccessible to a ground crew survey because of safety concerns or difficulties of access. The study involved use of an innovative unmanned aerial vehicle (UAV) or "drone" scanning system with radiation detection instrumentation and Real-Time Kinematic (RTK) Global Positioning System (GPS).

- A **lateral delineation survey** at edges of the Bluff B boundary involving more than 35,000 gamma radiation measurements during ground based, mobile, GPS backpack gamma surveys, as well as collection of eight discrete soil samples across 49.2 acres—with intent to delineate surface soil concentrations of radium-226 (Ra226) and arsenic below their action levels, 142 milligrams per kilogram (mg/kg) for arsenic and 30 picocuries per gram (pCi/g) for Ra-226 (Action Memo 2016), in order to further delineate lateral extents of mining-related contamination. Bluff B was initially characterized by Tetra Tech in 2013 (Tetra Tech 2013b) within the USFS specified boundary. At that time, surveying outside the Bluff B boundary was either too dangerous and/or was outside of the Scope of Work. In the Waste Characterization Evaluation Report (Tetra Tech 2015) recommended additional characterization be conducted on the northeast and eastern boundary of the initial study area. The goal of the lateral delineation survey was to address those recommendations per the request of the USFS.

- Ra-226 requires a lengthy laboratory gamma spectroscopy analysis to accurately quantify; therefore, Ra-226 cannot be directly measured in the field. Since the Riley Pass clean-up limits are based on a concentration of Ra-226 (pCi/g) at the site, a **gamma-radium correlation study** is needed to establish a meaningful site-specific correlation between a radiation detection meter's measurement (microroentgens/hour [μR/hr]) and a site-specific Ra-226 soil concentration (pCi/g). This is due to several independent factors. These include instrument variations, such as varying High Voltage settings or manufacturing tolerances in detection volume (i.e. scintillation crystals, ionization chamber volume). Site specific factors include geological variations in Naturally Occurring Radioactive Material (NORM) like uranium, thorium, and potassium, local radon concentrations due to geological porosity and barometric pressure, and localized cosmic radiation. Specifically, regarding a sites NORM content, areas with high thorium or potassium concentrations will have more gamma radiation not attributed to Ra-226 that must be accounted for. To account for these uncontrollable factors affecting detector response at Bluff B, a site-specific gamma-radium correlation study was performed at Bluff B which involved 15 soil correlation plots to evaluate the relationship between gamma exposure rates (in μR/hr) -and soil Ra226 concentrations (pCi/g) in order to develop a model useful for estimating Ra-226. A model was selected which uses the 95 percent (%) upper confidence limit (UPL) for the linear regression, as the most appropriate statistically, and would incur the least cost and risk. Application of that approach led to recognition of a gamma cutoff of 48 μR/hr for use in all future efforts to identify areas at Bluff B of Ra-226 concentrations in soils at or below 30 picocuries per gram (pCi/g) with a 95 percent confidence level. Ability to identify these areas will be useful for planning, cleanup, risk analysis, and decision-making pertaining to future remediation efforts at Bluff B.

- A **subsurface investigation** involving screening and sampling of subsurface soils via advancements of test pits with a track-mounted excavator in 15 different areas of Bluff B. Purposes of this were to increase understanding of depths of contamination and to delineate vertical extents of mine waste in order to estimate volumes for reclamation design.

The following subsections specify the location of the Site, convey the history of the Site, discuss the project background, describe the Site, indicate Site conditions prior to this field investigation, and lay out the organization of this report.

1.1 SITE LOCATION AND HISTORY

The following subsections specify the location of the Site, recount the history of mining at the Site, summarize the history of the project, and convey cleanup levels for the Site.

1.1.1 Site Location

The Site is in the North Cave Hills land unit of the USFS Custer Gallatin National Forest in Harding County, South Dakota. Most of the Site is on National Forest Service (NFS) land managed by USFS. Ten AUMs within the Site (Bluffs A, B, “CDE”, F, G, H, I, J, K, and L) span 300+ acres. This report focuses on Bluff B. **Figure 1** is a map showing the bluffs, including Bluff B, and the USFS Custer Gallatin administrative boundary. This map also shows drainage flowlines obtained from the National Hydrography Dataset (NHD) and sedimentation ponds (U.S. Geological Survey [USGS] 2021). Bluff B is in Township 22 North, Range 5 East, Sections 22, 23, 26, and 27; its 2021 boundary surrounds approximately 170 acres. Waste materials (mine waste, mine spoils, and overburden) have been a major source of sedimentation to Pete’s Creek east of Bluff B, and to Schleichart Draw to the southeast. The bluffs are all present within Township 22 North, Range 5 East of the Black Hills Meridian. **Table 1** lists legal descriptions and land ownership of uranium mines within the Site, and the following **Figure 1** is a regional map showing locations of those uranium mines.

Table 1 Legal Descriptions and Land Ownership of Riley Pass Uranium Mines

Uranium Mine Study Area	Legal Description	Land Ownership
Bluff A	T22N, R5E, Section 22	U.S. Forest Service (USFS)
Bluff B	T22N, R5E, Section 22	USFS
	T22N, R5E, Section 23	
	T22N, R5E, Section 26	
	T22N, R5E, Section 27	
Bluff CDE	T22N, R5E, Section 26	Part USFS, Part Private
Bluff E	T22N, R5E, Section 35	USFS
Bluff F	T22N, R5E, Section 35	USFS
Bluff G	T22N, R5E, Section 36	USFS
Bluff H	T22N, R5E, Section 25	USFS, Part Private
	T22N, R5E, Section 36	
Bluff I	T22N, R5E, Section 35	USFS
Bluff J	T22N, R5E, Section 20	USFS
Bluff K	T22N, R5E, Section 21	USFS
Bluff L	T22N, R5E, Section 20	USFS

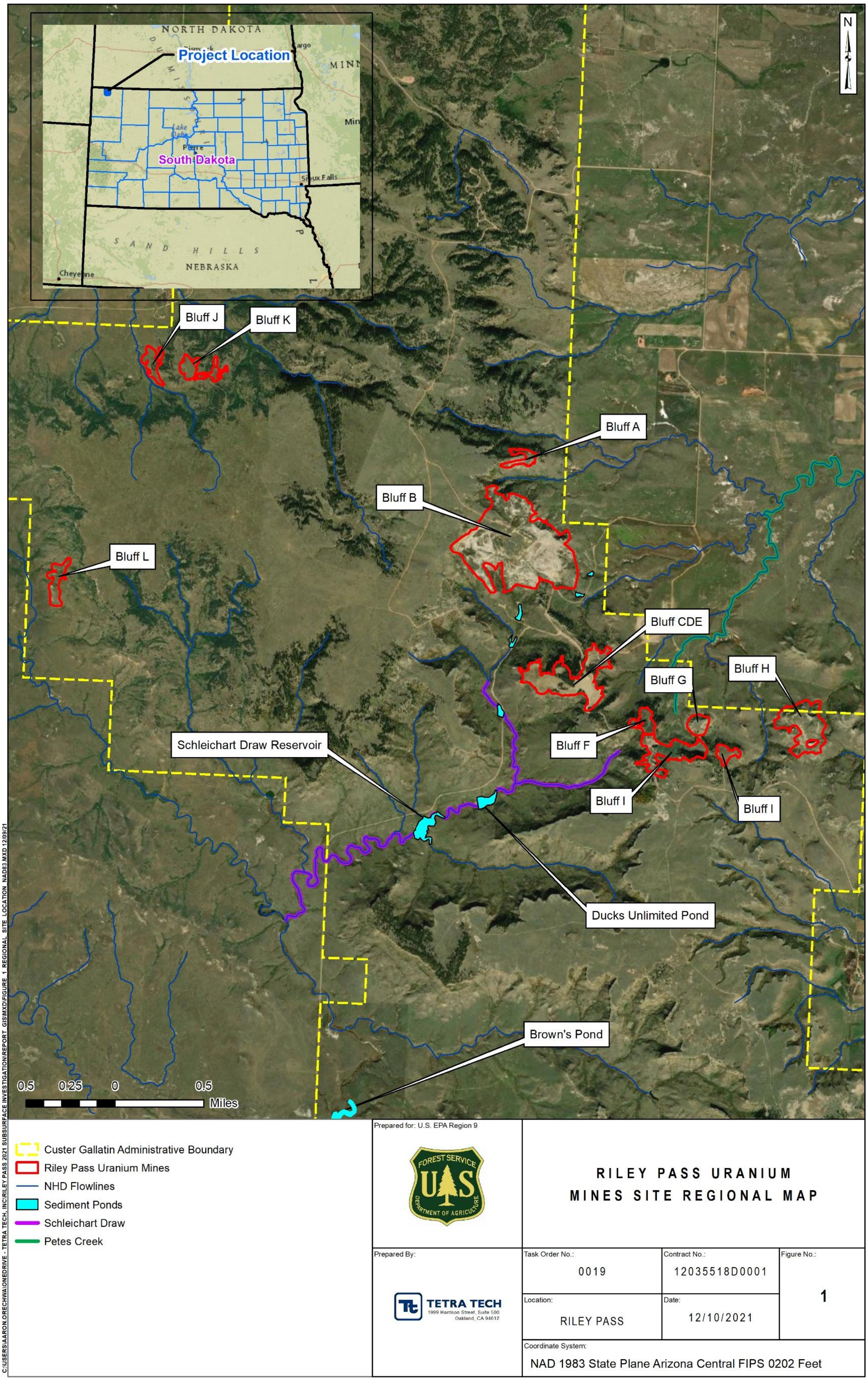

Figure 1 Riley Pass Uranium Mines Site Regional Map

1.1.2 Mining History

The Cave Hills area is one of several areas in the northern Great Plains region hosting uranium known to occur in carbonaceous rocks of the Fort Union Formation (Pipiringos, Chisholm, and Kepferle 1965). Uranium exploration began in the North Cave Hills in 1954, followed by extensive mining in the early 1960s to supply resources required by uranium contracts. All mining in the area had ceased by 1964.

The uranium mines in this region were developed in lignite coal beds on tops of buttes. In conformance to the General Mining Laws of the Atomic Energy Act of 1946 and Public Law 357, strip mining occurred within the North Cave Hills during the 1950s and 1960s. Mining involved removal of uranium-bearing lignite coal beds and push of mining waste spoils over edges of the buttes onto the steep slopes below the rimrocks of those edges. The methods applied during mining resulted in acute environmental degradation and erosion of contaminated soils. Documented mine sites, mine spoils, and surface disturbances associated with exploration activities cover almost 1,000 acres within the North Cave Hills. The estimated disturbed area within the Site (300+ acres) includes high walls, pit floors, and spoil piles. Mining occurred without requirements for either environmental restoration or establishment of responsibility for post-mining land surface reclamation (Pioneer Technical Services, Inc. 2006).

Figure 2 below is aerial imagery from 1954, obtained from the National Archives in Washington DC, showing pre-mining conditions at Bluff B. **Figure 3** below is aerial imagery obtained during the 2021 field investigation via a UAV photogrammetry survey by Dundas Geomatics, Inc., which also performed the aerial gamma flyover survey.

Among the 10 AUMs at Riley Pass, Bluff B contributes the largest load of sediment (estimated to be greater than 4,400 tons per year per Orechwa [2015]) to nearby drainages. Tronox Worldwide, LLC (Tronox) and USFS implemented erosion prevention actions at Bluff B, although no removal action has occurred (USDA, USFS 2016). Most of Bluff B is either barren or sparsely vegetated and shows signs of severe erosion by wind and surface water. Sediment from the eastern half of the Site currently is carried off site and deposited on the adjoining private property. Sedimentation ponds have been installed and maintained by USFS in Upper Pete's Creek and Schleichart Draw, as shown on **Figure 1**. USFS also installed and maintained small sediment ponds on the top of Bluff B. Because of the amount of sediment eroding from the Site, frequent maintenance of the sedimentation ponds is required. The predominant fine-grain soil types present, sandy clay and silty clay, have allowed development of soil piping and tunneling as geomorphological features from soil erosion, with occasional development of sink holes.

Piping and large gullies are most prevalent in areas where the overburden was placed along or below the bluff cliffs at locations with steep slopes (*see example in Exhibit 1 below*). Some soil pipes that have formed are 10 to 15 feet in diameter. Gullies as deep as 25 feet have formed in places. Most mined-out areas of Bluff B are at or near contact with sandstone bedrock; and at some locations along the mined margins, spoils were placed along the bluff margins that subsequently eroded to the lands below the bluffs. In other areas of Bluff B, small shallow ponds have formed on the exposed mined-out bedrock surface, creating small retention basins that during snowmelt and small storm events, assist in control of some of the surface water erosion. During the summer, water from these ponds likely evaporates or seeps through the bedrock. Fine-grained sediment that collects in these retention basins forms desiccated hardpan mud surfaces after the runoff water evaporates or infiltrates.

Tetra Tech estimated extents of mine-related disturbances at Bluff B by combining aerial imageries from 1954 and 2021 and referencing field observations during site reconnaissance and field investigations over the years. **Figure 4** is a map showing estimated lateral extents of mine-related disturbances.

Exhibit 1: Example of Piping and Steep Slopes on Bluff B Eastern Boundary

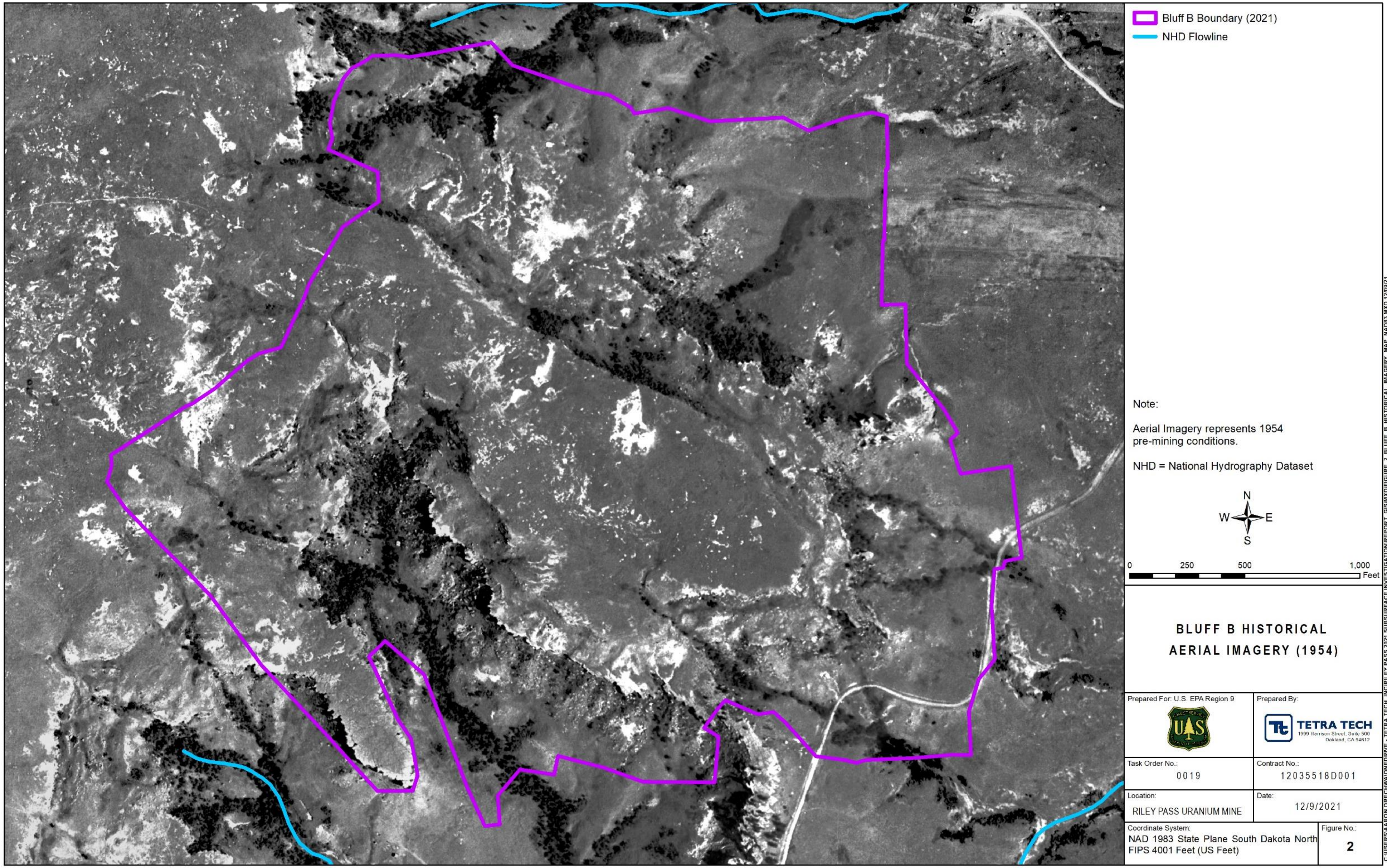

Figure 2 Bluff B Historical Aerial Imagery (1954)

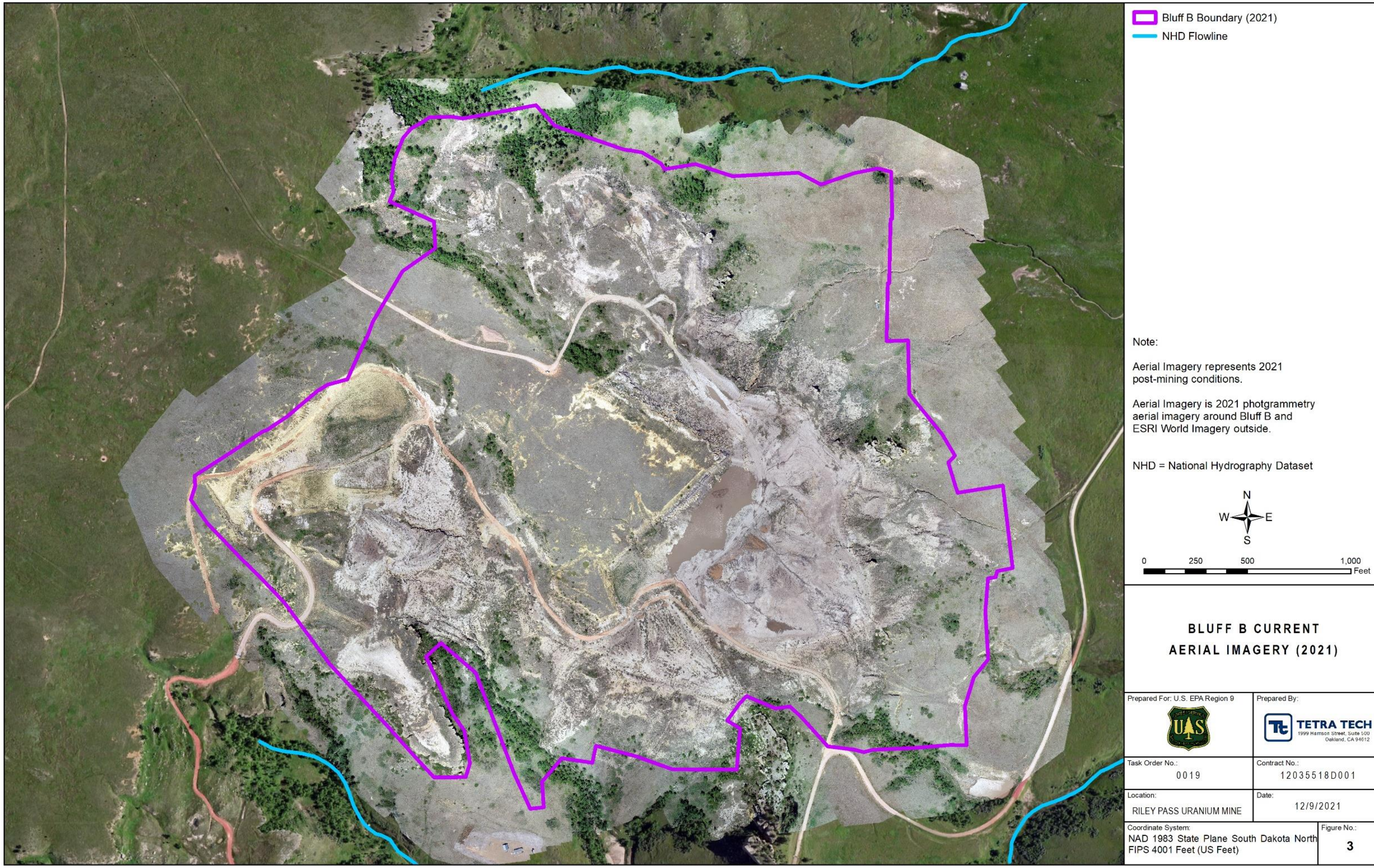

Figure 3 Bluff B Current Aerial Imagery (2021)

Figure 4 Estimated Extent of Mining-Related Disturbance at Bluff B

1.1.3 Project History and Cleanup Levels

Bluff B, under the administrative authority of USFS Region 1, is on NFS land within the Sioux Ranger District, Custer Gallatin National Forest, in Harding County, South Dakota. From numerous investigations at Bluff B starting in 1990 through 2021, Tetra Tech identified 34 reports associated with Site investigations there on behalf of USFS or the potentially responsible party, Tronox. **Table 2** summarizes the documents related to Bluff B.

A release, or a significant threat of a release, has occurred or is occurring at Riley Pass Bluff B, based on results from numerous previous investigations and as documented in a 2016 Action Memorandum (USDA, USFS 2016). This existing condition is the basis for this CERCLA action. Mining legacy environmental hazards present at the Site include high walls, unstable overburden, elevated radioactive materials, metals (arsenic, molybdenum, thorium, and uranium), and mass sediment transport resulting from erosion. Cleanup levels for the Site are **142 mg/kg** for arsenic and **30 pCi/g** for Ra-226 (Action Memo 2016). These values are applied throughout this report to determine extents of contamination at Bluff B.

Table 2 Summary of Previous Bluff B Investigations and Documents

Document Title	Prepared By	Prepared For	Year
Riley Pass Reclamation Study Harding County, South Dakota	Denver Knight Piesold	U.S. Department of Agriculture (USDA) U.S. Forest Service (USFS)	1990
Final Sampling and Analysis Plan for the Riley Pass, South Dakota Uranium Mines Site Investigation	Pioneer Technical Services, Inc	USDA USFS	1999
Final Site Investigation Report for the Riley Pass Uranium Mines, Harding County, South Dakota	Pioneer Technical Services, Inc.	USDA USFS	2002
Riley Pass Mine Site Sediment Management Bluff B Area Conceptual (35 Percent) Design	Knight Piesold and Co	Kerr-McGee Corporation	2003
Time Critical CERCLA Removal Action Commented at Riley Pass Abandoned Uranium Mines [Action Memorandum]	USDA USFS	Regional Forester	2004
Final Human Health and Ecological Risk Assessment for the Riley Pass Uranium Mines in Harding County, South Dakota	Portage Environmental, Inc.	USDA USFS	2005
Draft Scope of Work for Removal Action, Riley Pass Uranium Mine Site	ENSR International	Tronox Worldwide, LLC (Tronox)	2006
Baseline Human Health and Ecological Risk Assessments	USDA USFS		2006
Final Engineering Evaluation/Cost Analysis (EE/CA) for the Abandoned Uranium Mines, Harding County, South Dakota	Pioneer Technical Services, Inc.	USDA USFS	2006
Final Human Health and Ecological Risk Assessment for the Riley Pass Uranium Mines in Harding Co, SD	Portage Environmental, Inc.	USDA USFS	2006
Delineation of Vegetationally Stabilized Areas and Preliminary Revegetation Testing on Bluff B (Draft)	ENSR Corporation	Tronox	2007
Phase I – Initial Actions Work Plan, Riley Pass Uranium Mines Site, Custer National Forest, Harding County, South Dakota	ENSR Corporation	Tronox	2007
Supplemental Field Sampling Plan Expanded Characterization of Bluff B Materials to Support Revegetation Planning (Draft)	ENSR Corporation	Tronox	2007
Final Report: North Cave Hills Abandoned Uranium Mines Impact Investigation	South Dakota School of Mines and Technology	USDA USFS	2007
Riley Pass Uranium Mines Site Removal Action within the North Cave Hills Land Unit, Custer National Forest, Sioux Ranger District, Harding County, South Dakota (Action Memorandum)	USDA USFS		2007
2007 End of Year Completion Report; Riley Pass Uranium Mines Site, Custer National Forest, North Cave Hills, Harding County, South Dakota (Draft)	ENSR Corporation	Tronox	2008
2008 Design Work 30% Design Submittal, Riley Pass Uranium Mines Site, Custer National Forest, North Cave Hills, Harding County, South Dakota	ENSR Corporation	Tronox	2008
2008 Supplemental Field Sampling Report – Field and Laboratory Analysis; Riley Pass Uranium Mine Sites	ENSR Corporation	Tronox	2008
Bluffs B and H Category 3 Material Consolidation Units Site Selection Process and Preliminary Design Basis, Riley Pass Abandoned Uranium Mines Site, Harding County, South Dakota	ENSR Corporation	Tronox	2008
Riley Pass Uranium Mines Site Adjacent Off-Site Areas Risk Assessment (Draft)	ENSR Corporation	Tronox	2008
Work Plan for Greenhouse Re-Vegetation Testing; Fall 2008/Spring 2009, Riley Pass Uranium Mines Site	ENSR Corporation	Tronox	2008
Supplemental Geotechnical Investigation Program Bluffs B and H Consolidation Unit Locations, Custer National Forest, North Cave Hills (Draft)	AECOM Environment	Tronox.	2008
Work Plan for Greenhouse Re-Vegetation Testing; Fall 2008/Spring 2009, Riley Pass Uranium Mines Site. Revision 1	AECOM Environment	Tronox	2009
Radiological Survey Results for the Uranium Mining Bluffs near Riley Pass, North Cave Hills, Harding County, South Dakota	Tetra Tech, Inc. (Tetra Tech)	USDA USFS	2009
Tronox Bluffs Waste Characterization Sampling and Analysis Plan, Riley Pass Uranium Mines Site (North Cave Hills), Harding County, South Dakota	Tetra Tech	USDA USFS	2012
SDSMT activities for Uranium and Arsenic investigations in the Northwest and Black Hills regions of South Dakota	Shagla, C.K.	USDA USFS	2013
Tronox Bluff Waste Characterization Report, Riley Pass Abandoned Uranium Mines Site, North Cave Hills, Harding County, South Dakota	Tetra Tech	USDA USFS	2013
Final Verification Sampling Plan, Riley Pass Uranium Mines Site (North Cave Hills), Harding County, South Dakota	Tetra Tech	USDA USFS	2015
Final Waste Characterization Evaluation Report, Riley Pass Uranium Mines Site (North Cave Hills), Harding County, South Dakota	Tetra Tech	USDA USFS	2015
Riley Pass Uranium Mines Site Removal Action within the North Cave Hills Land Unit, Custer National Forest, Sioux Ranger District, Harding County, South Dakota (Action Memorandum)	USDA USFS		2016
Riley Pass Site Investigation and Data Collection Report, Custer Gallatin National Forest, Sioux Ranger District, North Cave Hills Unit	Allied Engineering Services, Inc.	USDA USFS	2017
Riley Pass Sediment Pond Cleanout Design Conceptual Design Report	Allied Engineering Services, Inc.	USDA USFS	2017
2018 Riley Pass Abandoned Uranium Mine Waste Characterization Sampling Report – FINAL Bluff B Proposed Sediment Pond	Tetra Tech	USDA USFS	2019
Final Existing Conditions Report	Tetra Tech	USDA USFS	2020
Final Existing Conditions Report – Revision 1	Tetra Tech	USDA USFS – Custer Gallatin National Forest	2020

1.2 SITE DESCRIPTION

The following subsections describe topography, hydrology, geology, soils, and vegetation at and in the vicinity of Bluff B.

1.2.1 Topography

Bluff B is a large, cliff-bounded plateau with areas of irregular topography and high slope and erosion potential because of the cliff edges and gullies/drainage patterns (*see Exhibit 1*). A light detecting and ranging (LiDAR) survey occurred in 2012 which has been used for design and survey control for reclamation to this point. However, because of possible changes in site conditions over the years, Dundas Geomatics, Inc. performed a photogrammetric survey via UAV as part of the aerial gamma flyover survey in July 2021. This involved acquisition of higher resolution aerial imagery and application of a digital surface model (DSM) to indicate elevations at the Site (without discerning differences in vegetation as had the LiDAR survey). Photogrammetry does not discern between vegetation being present or ground level, but LiDAR will measure the true ground surface – since Bluff B is quite barren this is not a significant difference. Resolution of the DSM developed for the Site was a grid cell size of 0.1121 by 0.1121 foot. The 2021 UAV photogrammetry survey served to enhance previous LiDAR image resolution and extend coverage beyond the pre-2021 site elevation boundaries.

Elevations at Bluff B range between 3,085.85 and 3,414.38 feet above mean sea level (amsl), based on the 2021 DSM. **Figure 5** shows digitally obtained surface elevations overlying a hillshade map, useful to indicate locations of cliffs and outcrops at Bluff B. Slopes were calculated from the DSM, and **Figure 6** shows variability and spatial extents of slopes.

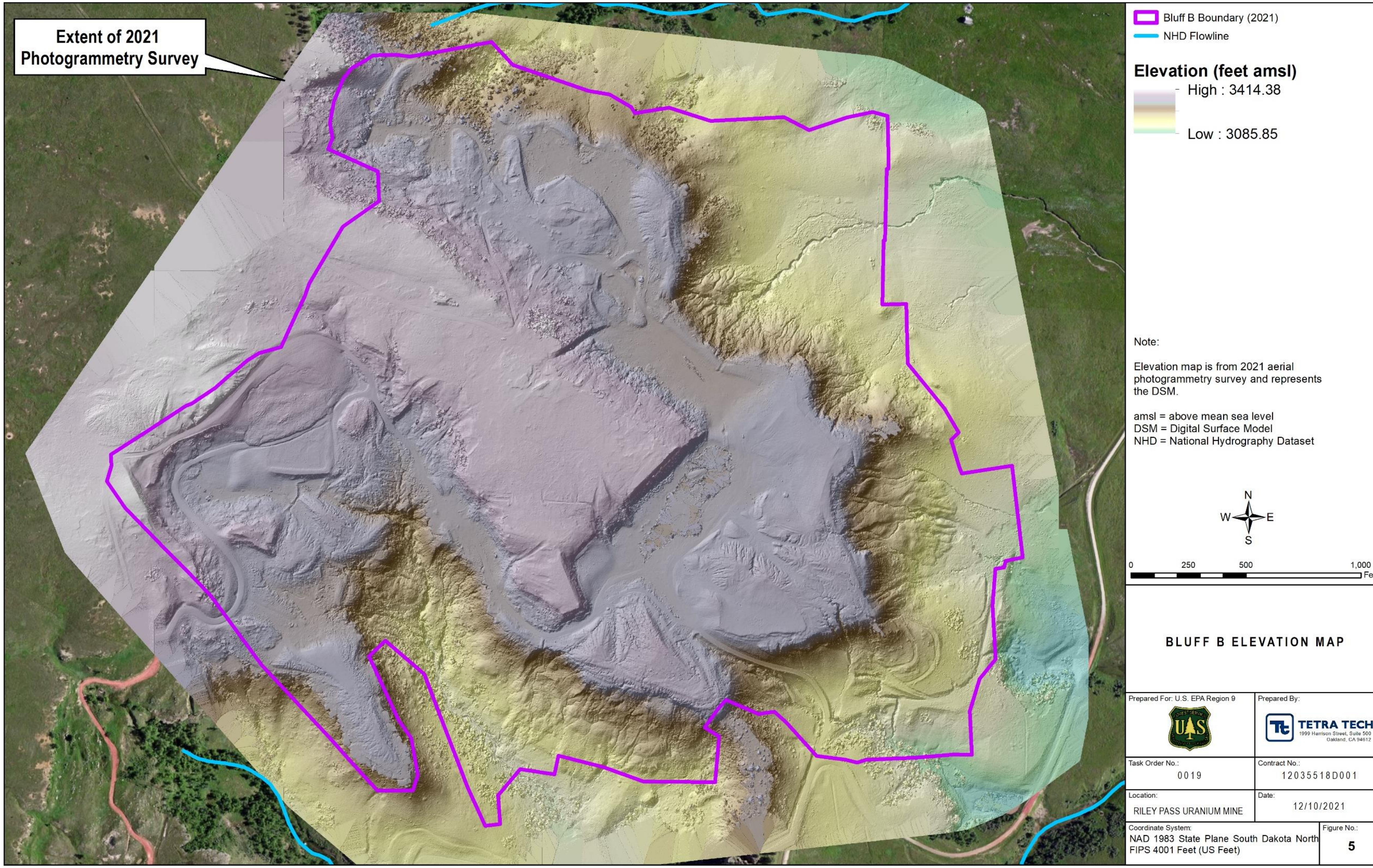

Figure 5 Bluff B Elevation Map

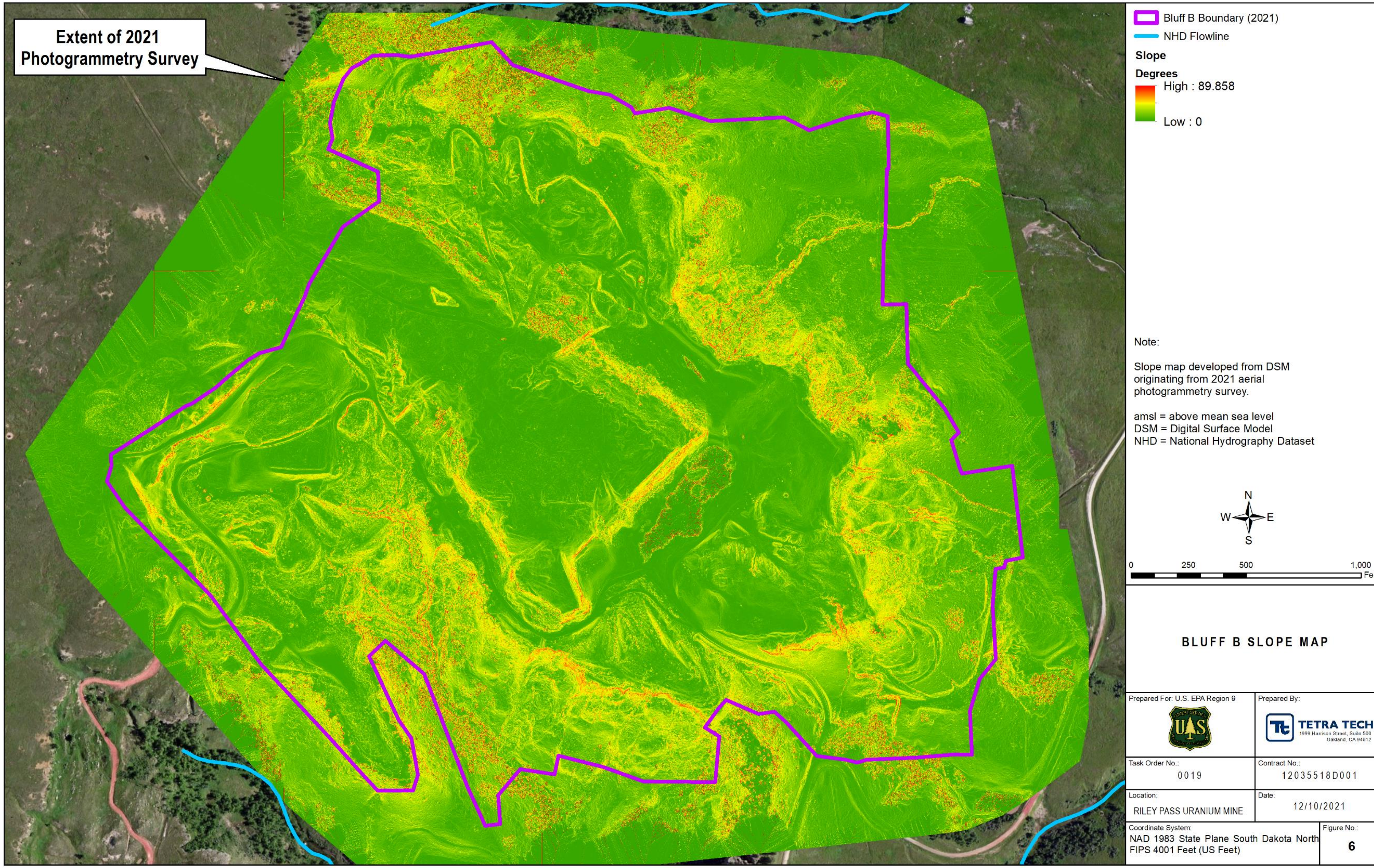

Figure 6 Bluff B Slope Map

1.2.2 Hydrology

Using the DSM developed from the 2021 UAV photogrammetry survey, Tetra Tech delineated subwatersheds and drainage lines at Bluff B. Tetra Tech identified seven subwatersheds totaling 232.69 acres that could be delineated based on the available extent of the 2021 DSM. **Table 3** lists the watersheds and drainages at Bluff B, and indicates which watersheds drain to which sediment ponds.

Table 3 Summary of Bluff B Watersheds

Watershed Name	Acres	Receiving Sediment Pond
West	86	SP3 and SP4
South	8.2	SP3 and SP4
Southeast	46	SP2
East	23	SP1
Northeast	41	None
North	9.0	None
Northwest	20	None

At Bluff B, the seven primary post-mining watersheds encompass a drainage area of approximately 233 acres. Four USFS-maintained sediment ponds receive runoff from Bluff B (SP1, SP2, SP3, and SP4). These sediment ponds capture spoils and mine waste that originated in the east, southeast, south, and west watersheds of Bluff B. No sediment ponds are present to capture eroding sediments from the north, northeast, and northwest watersheds. **Figure 7** is a hydrologic setting map showing the seven primary watersheds, drainage paths, and sediment ponds for Bluff B.

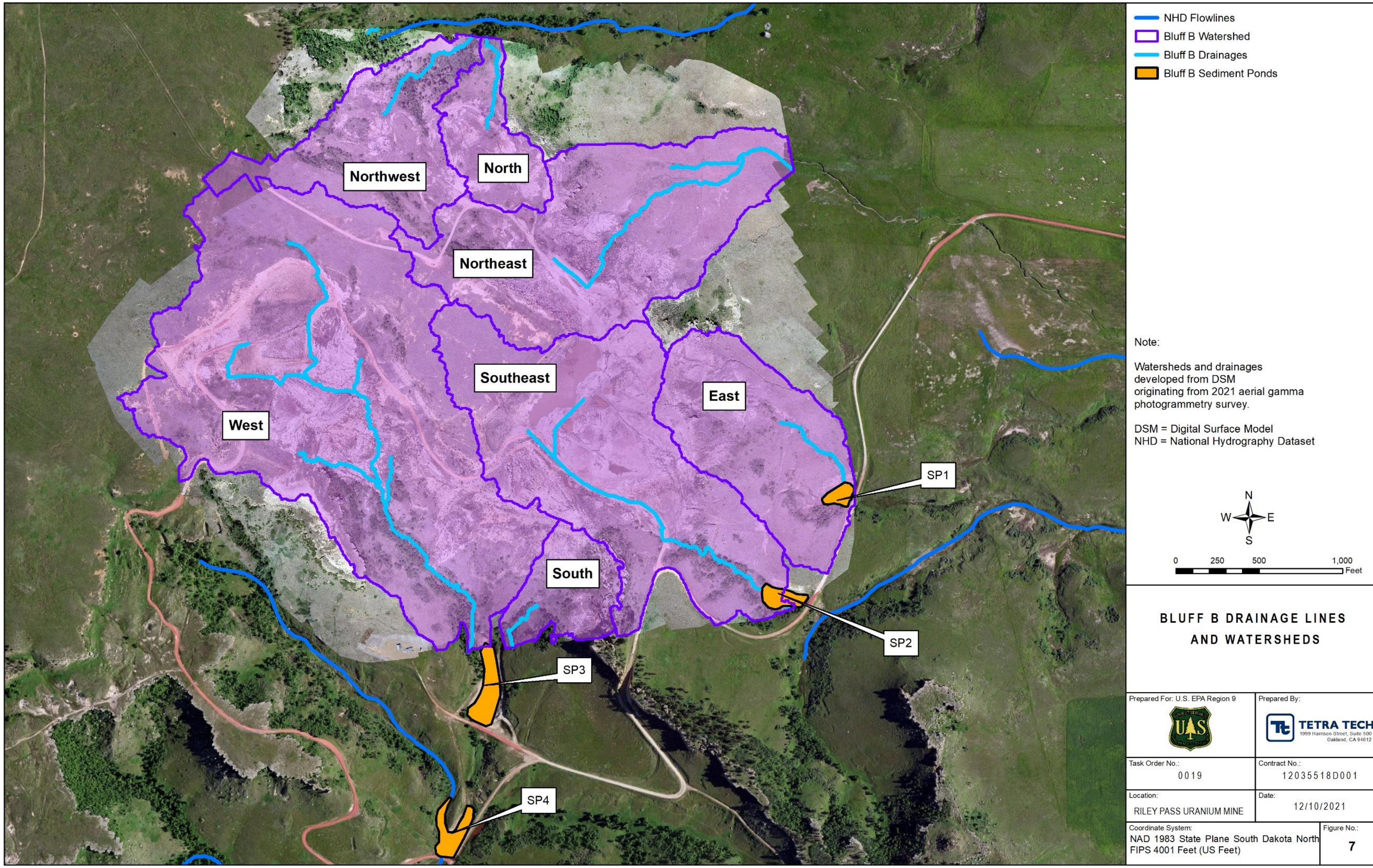

Figure 7 Bluff B Drainages and Watersheds

1.2.3 Geology

The geology of the North Cave Hills area is characterized by flat-topped buttes capped by thick beds of yellow, brown, and moderate pink sandstones of the Ludlow Member and the overlying Tongue River Member of the Fort Union Formation from the Paleocene Epoch. These rocks are nearly horizontal sedimentary rocks consisting of clay shale, siltstone, fine-grained sandstone, and beds of coal and coaly shale. Locally, weathering of the sandstone results in a honeycombed surface and many small caves from which the North and South Cave Hills derive their names.

The North Cave Hills area hosts abundant uranium ore deposits, primarily in coal beds within the Upper Paleocene Fort Union Formation. Geological maps showing rock types and geological ages are not available because the surface geology of Bluff B is mapped as “disturbed” as a result of mining activity.

Coal beds in the upper 100 feet of the Ludlow Member of the Fort Union Formation contain most uranium deposits in the North Cave Hills, with a lesser amount found in the lower part of the Tongue River Member of the Fort Union Formation. The Hell Creek Formation underlies the Fort Union Formation and is exposed in stream valleys between the buttes. General descriptions of the three relevant geological units appear below in descending stratigraphic order (Pipiringos, Chisholm, and Kepferle 1965):

- **Tongue River Member of the Fort Union Formation (Paleocene):** White, gray, buff, and tan massive, locally crossbedded, sandstone with thinner interbedded gray to green claystone and clayey siltstone. The sandstone forms cliffs and ledges; the claystone and siltstone form slopes and re-entrants. Thin impure coal beds are present in a claystone and siltstone sequence 110-150 feet above the base of the member, with the E and F coal beds containing the only ore-grade uranium concentrations in the Tongue River Member.

- **Ludlow Member of the Fort Union Formation (Paleocene):** Gray clay shale, greenish-gray siltstone, gray fine-grained sandstone that weathers yellowish gray, and beds of coal. Some of the sandstone beds are well indurated locally by calcite and analcite, and they weather to slabby ledges. Contains the thickest coal beds of the Fort union Formation. Coal beds in the upper 100 feet of the Ludlow Member contain the majority of the uraniferous coal deposits. The Ludlow Member conformably underlies the Tongue River Member and is well exposed at the southern end of the North Cave Hills. Rocks of the Ludlow Member are interpreted, for the most part, as having been deposited in fluviatile and paludal environments.

- **Hell Creek Formation (Late Cretaceous):** Clay shale, carbonaceous shale, siltstone, and sandstone. Outcrops are exposed within stream valleys. The Hell Creek Formation does not contain uranium deposits.

1.2.4 Soils

Tetra Tech obtained soil data from USDA’s Web Soil Survey (WSS) (USDA 2019) over the area within the Bluff B watersheds identified in **Section 1.2.2**. The WSS identified seven primary soil types within the Bluff B watershed. **Table 4** summarizes those USDA soil types, associated symbols, and total area of the watershed occupied by each soil type in acres and percent of the watershed. The WSS database indicates “Dumps, mine” (referring to spoils and waste materials at

Bluff B) within 122 acres of the watershed. **Figure 8** is a map showing the distribution of these soil types across Bluff B.

Table 4 Summary of USDA Soil Database from Web Soil Survey for Bluff B

U.S. Department of Agriculture (USDA) Soil Type	Symbol	Portion of Watershed (Acres)	Portion of Watershed (%)
Dumps, mine	Du	122	52
Cohagen fine sandy loam, 15 to 50% slopes	CoE	69.8	30
Rhoades-Daglum complex, 0 to 6% slope	RnB	24.0	10
Cohagen-Rock outcrop-Cabba variant complex	CrF	9.58	4
Cabbart loam, 6 to 60% slope, extremely stony	CcE	6.64	3
Bullock-Cabbart complex, 6 to 25 percent slopes	BoD	0.57	< 1
Parchin-Bullock fine sandy loams, 2 to 9 % slopes	PbB	0.356	< 1

Based on limited available data, non-disturbed soils adjacent to the mined bluffs are shallow (less than 20 inches deep), have loamy textures, neutral to alkaline pH and high specific conductivity and sodium adsorption ratios (SAR)). These soils present challenges as a growth medium, however they are representative of the surrounding area and do support vegetation.

Soils classified by USDA as “Dumps” (Du) are defined as waste or spoils based on site-specific criteria. Chemical and physical properties vary, but these materials typically have low concentrations of nitrate, calcium, and magnesium and high concentrations of sodium. Consequently, saline-sodic conditions exist in and near disturbance areas. in excess of soil suitability criteria. Spoil and waste pH varies from acidic to strongly alkaline. Arsenic, radium, and other constituents of concern are elevated more than three times, relative to their background concentrations in native soils. In short, the spoils and waste materials are not suitable growth media without soil amendments.

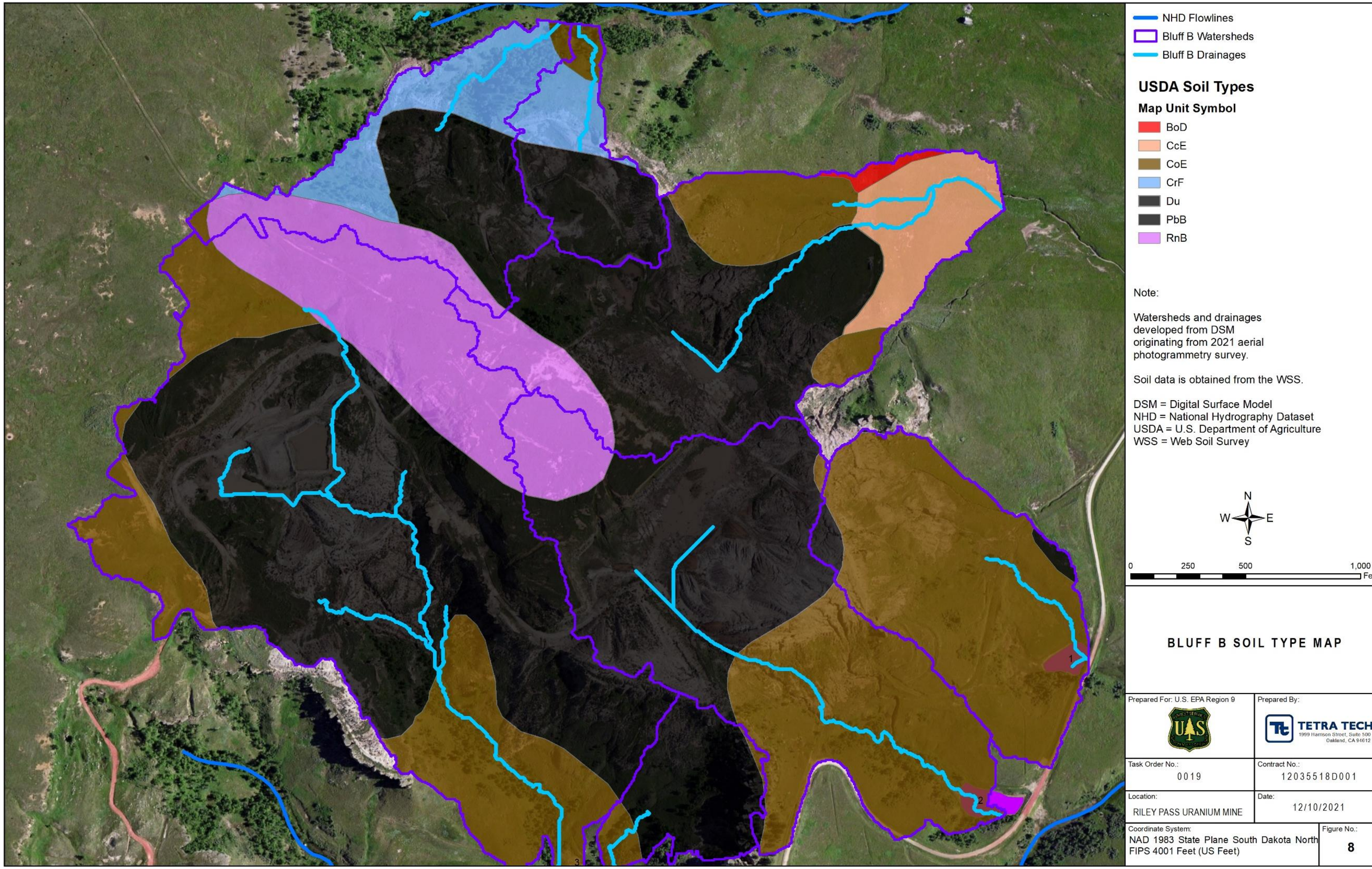

Figure 8 Bluff B Web Soil Survey Map

1.2.5 Vegetation

Vegetation in undisturbed areas of the North Cave Hills is typical of that in the western Great Plains (AESI 2017). Forested areas are dominated by ponderosa pine, with Rocky Mountain juniper and creeping juniper often co-occurring. Numerous shrub species in forested areas include skunkbrush, creeping Oregon grape, western snowberry, chokecherry, and others. Yarrow, silky lupine, smooth aster, and other species of forbs are present across the area. A variety of grasses and sedges are common, including little bluestem, sun sedge, prairie June-grass, western wheatgrass, and green needlegrass. Woody draws are dominated by green ash with occurrences of box elder and aspen; shrub components include western snowberry, chokecherry, and silver buffaloberry.

Based on results of a qualitative survey of vegetation success on disturbed areas of other bluffs at Riley Pass, vegetation from natural seeding possibly expected at disturbed areas of Bluff B may include native species such as rubber rabbitbrush, western wheatgrass, Wyoming big-sagebrush, silver sagebrush, and prairie June-grass (ENSR 2007). Invasive species including yellow sweet-clover and Japanese brome may also establish, with wide distribution of Japanese brome across the entirety of Bluff B. Vegetation growth, noted in a discontinuous mosaic pattern, was most successful where growth media were influenced by sediment stockpiles, and in erosion-related depositional areas where fine-grained soil textures were present. With that, areas undergoing erosion, mine spoils, or areas with little to no growth media cover are sparsely vegetated or non-vegetated. Similar conditions were noted on Bluff CDE where non-eroded slopes and piles of unclassified material support dense vegetation surrounded by trees, grasses, and shrubs, while spoils and exposed bedrock support little or no vegetation (KC Harvey 2012).

By use of LiDAR data from 2012, a map (**Figure 9**) was generated showing vegetation within the Bluff B watersheds. Vegetation on this map is shown by height intervals of 1-2 feet above ground surface (ags), 2 to 5 feet ags, and above 5 feet ags. Information regarding vegetation was important for planning the aerial gamma flyover surveys.

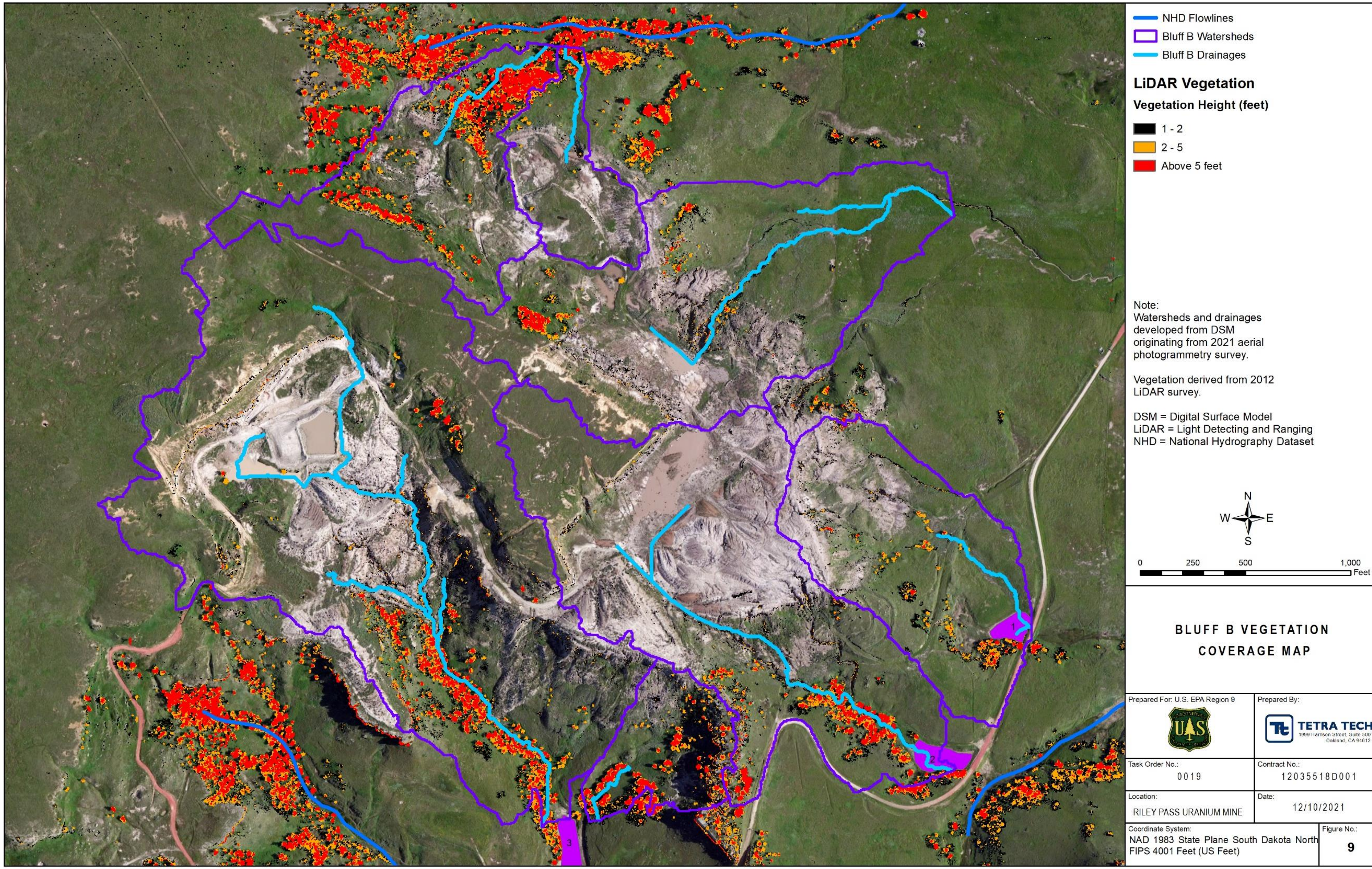

Figure 9 Bluff B Vegetation Coverage Map

1.3 PRE-2021 FIELD INVESTIGATION CONDITIONS

Prior to the 2021 subsurface and supplemental surface investigations, Tetra Tech performed investigations to determine which areas of the Site needed further surface-level investigation for arsenic or gamma radiation. The following are investigations by Tetra Tech at Bluff B:

- In 2012, Tetra Tech conducted site waste characterization to map spatial extents of contamination at Bluff B in more detail, and documented Ra-226 activity ranging from 0.56 to 1,846 picocuries per gram (pCi/g) and arsenic concentrations ranging from 3 to 2,838 milligrams per kilogram (mg/kg) (Tetra Tech 2013a). Lateral extents of contamination at Bluff B were conveyed in a Tronox Bluff Waste Characterization Report (Tetra Tech 2013b) and again in the 2015 Final Waste Characterization Evaluation Report, Riley Pass Uranium Mines Site prepared by Tetra Tech (2015).
- Additional lateral waste characterization occurred in 2018 at the Northeast section of Bluff B, as summarized in the 2018 Riley Pass Abandoned Uranium Mine Waste Characterization Sampling Report Bluff B Sediment Pond (Tetra Tech 2019b).
- Tetra Tech evaluated vertical extents of contamination in the northeast section of Bluff B in 2020 and presented the results in the 2020 Subsurface Investigation for Northeast Area of Bluff B Riley Pass Uranium Mines Site (Tetra Tech 2020).

Following completion of the 2012 and 2018 surficial waste characterization investigations the arsenic and gamma radiation levels of the easily accessible areas of the Site, such as bluff tops, were well characterized at Bluff B. Data gaps remained on site either due to inaccessibility issues or misidentified boundaries of contamination, especially on the steep slopes below the bluff edges. **Figure 10** is a map showing the interpolated gamma radiation levels at Bluff B. Appearing on this map are “data gap areas” with respect to gamma radiation where additional information would be necessary to fully delineate extents of lateral radiological contamination at Bluff B. Need for data from these areas led to the 2021 field investigation aerial gamma flyover survey and lateral delineation surveys.

Similarly, **Figure 11** is a map showing pre-2021 arsenic concentrations. On this map are interpolated arsenic concentrations, with areas in purple expected to exceed the action level of 142 mg/kg. Unlike the gamma radiation, arsenic concentrations were well characterized across the Site; only one small potential data gap area exists to the north. Therefore, the 2021 field investigation focused primarily on gamma radiation surveys and soil sampling, not x-ray fluorescence (XRF) field surveys.

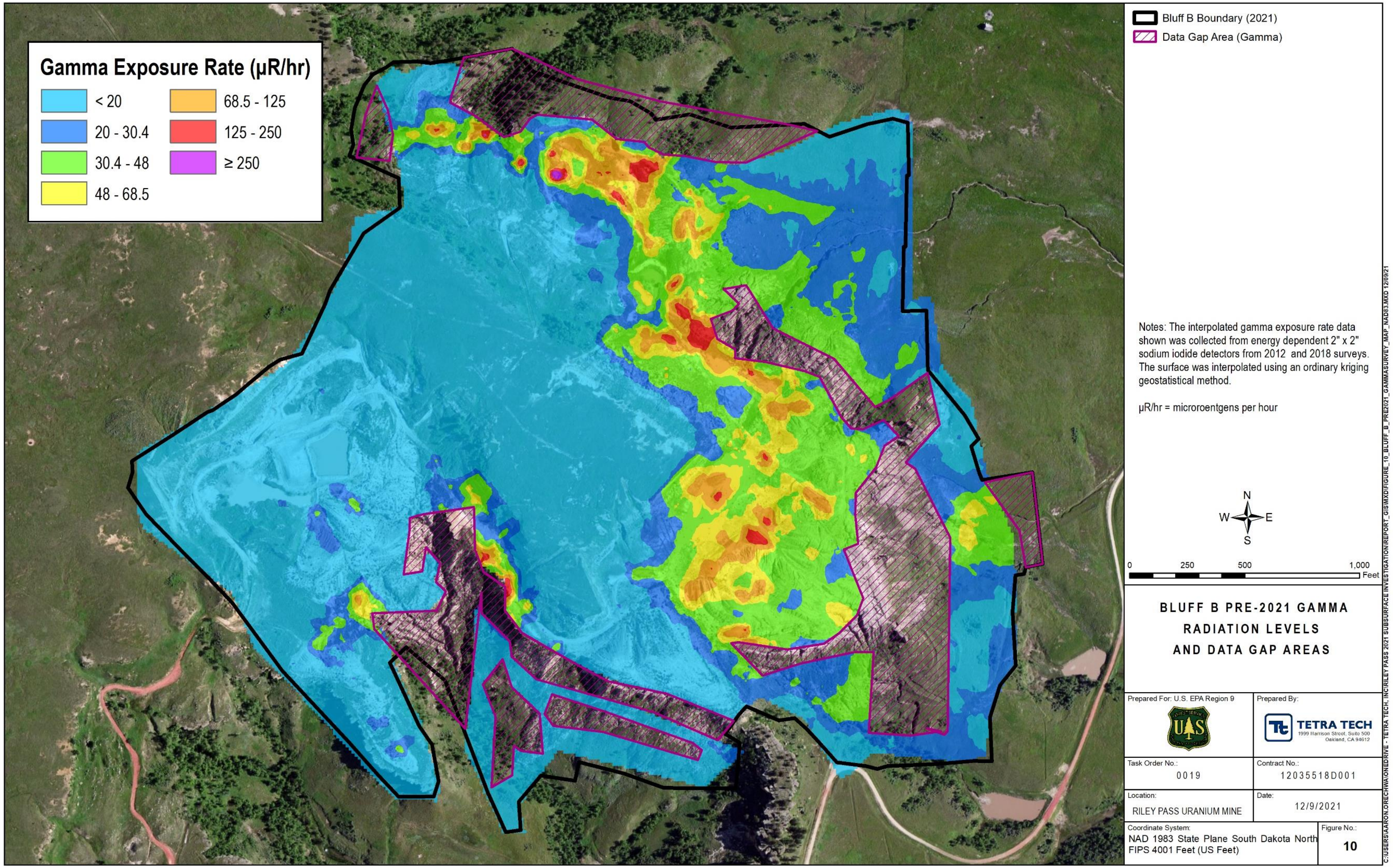

Figure 10 Bluff B Pre-2021 Gamma Radiation Levels and Data Gap Areas

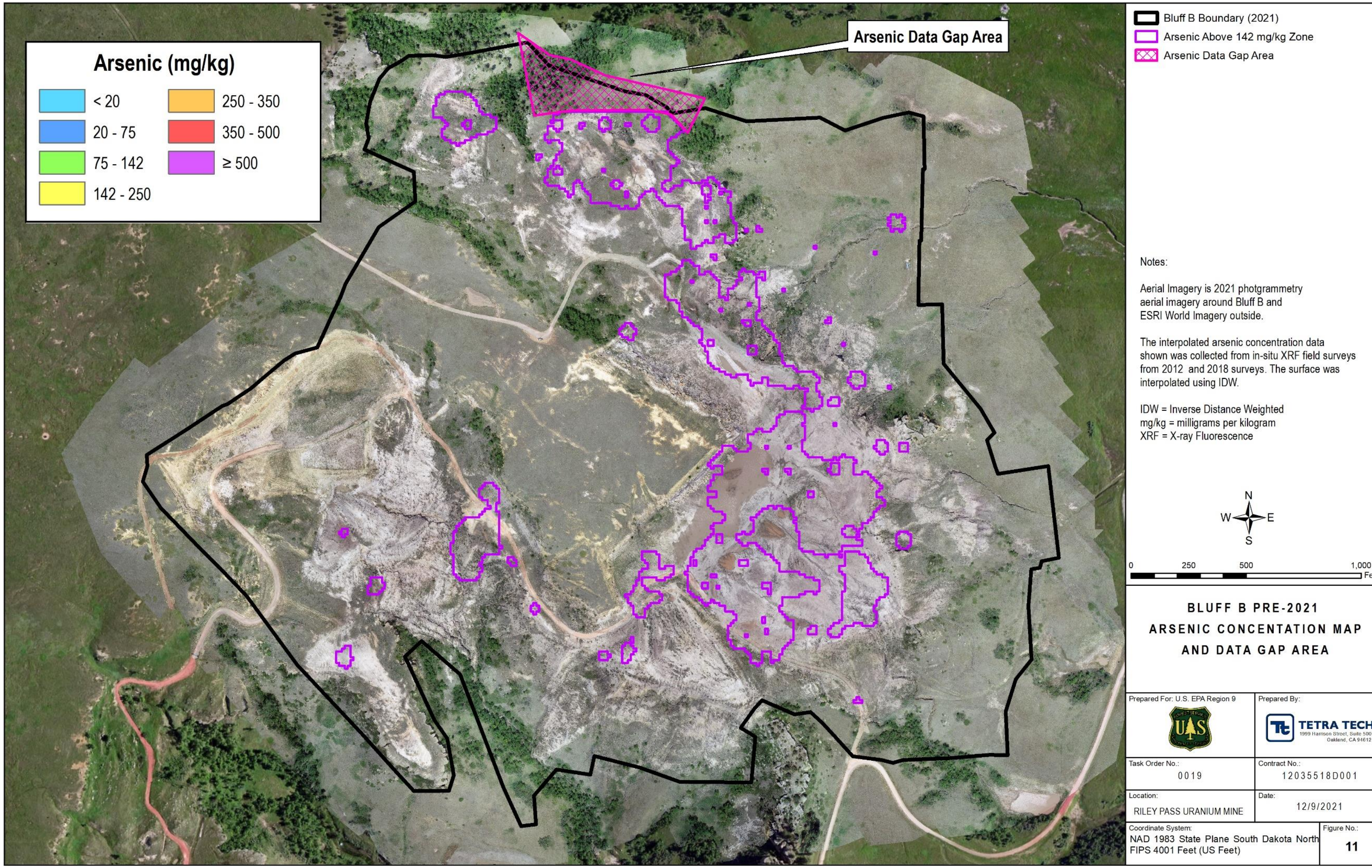

Figure 11 Bluff B Pre-2021 Arsenic Concentration Map and Data Gap Area

1.4 REPORT ORGANIZATION

In this report, Tetra Tech presents a project background summary, methods of and results from field and laboratory analyses, and interpretations and recommendations for how this site investigation will inform the approach to design remedial activities at Bluff B. This report is organized as follows:

- **Section 1.0** includes the introduction; summaries of mining history, project history, and previous investigations on Bluff B; and descriptions of the Site.
- **Section 2.0** specifies the project purpose of each field activity.
- **Section 3.0** lays out the methods for each field investigation.
- **Section 4.0** presents results of the field investigations, including a data quality assessment of information acquired during the investigations.
- **Section 5.0** provides a 2021 Status Update of vertical and lateral mine contamination mapping at Bluff B.
- **Section 6.0** presents conclusions of the investigations.
- **Section 7.0** lists sources referenced during preparation of this report.

Additionally, the following Appendices are included to support results and conclusions presented in this report:

- **Appendix A 2021 Field Investigation Photographic Logs** – includes photgraphic logs of the 2021 field investigations.
- **Appendix B UAV Summary Report** – summarizes details of the UAV field study performed as part of the 2021 field investigations.
- **Appendix C Laboratory Reports** – includes laboratory analytical reports related to soil sampling at Bluff B.
- **Appendix D Soil Data Validation**– summarizes technical data validation reports associated with soil analytical sampling aspects of the project.
- **Appendix E In-Field Gamma Validation and Verification**– summarizes data validation and verifies appropriate quality assurance (QA)/quality control (QC) of aspects of the project pertaining to gamma radiation.
- **Appendix F Scanned Field Logbook and Field Forms** – includes scanned copies of field forms and the field logbook for the 2021 field investigations.
- **Appendix G Gamma Correlation Study** – describes the methods applied in the gamma correlation study and summarizes that study.
- **Appendix H Gamma Geodatabase Reconciliation** – provides the steps on how the geodatabase was developed for gamma survey data from the different field events.
- **Appendix I Full Analytical Results for Soil Samples** – provides full tables of lab results.

2.0 PURPOSE

This section specifies the purpose of each activity pertaining to the 2021 field investigation at Bluff B.

2.1 AERIAL GAMMA FLYOVER SURVEY PURPOSE

The terrain is quite extreme in certain areas of Bluff B, particularly on the eastern cliff edges, as shown on **Figure 12** below. Elevation and slope maps appear on **Figure 5** and **Figure 6**, respectively, providing more perspective on the topographic relief of Bluff B. As described in **Section 1.3**, the 2012 and 2018 radiological surveys at Bluff B failed to access these areas of extreme terrain due to limitations on physical access and safety concerns (i.e., vertical cliffs or deep drainages, etc.). The areas considered inaccessible appear on **Figure 10**, a map of pre-2021 gamma radiation survey results. As seen on **Figure 10**, these areas previously had not been scanned. With advances in UAV technology, it is now possible to survey these dangerous areas by use of innovative solutions. The purpose of the aerial gamma flyover survey was to acquire gamma radiation data from the dangerous areas of the Eastern portion of Bluff B. Tetra Tech subcontracted Dundas Geomatics, Inc., out of Grass Valley, California, to complete this innovative pilot study during the 2021 field investigations. It was important to perform the aerial gamma flyover to help fill in coverage data gaps prior to the subsurface field investigation. The aerial gamma flyover survey methodology is discussed in **Section 3.1**.

Figure 12 Steep Cliffs on Eastern Side of Bluff B

2.2 LATERAL DELINATION SURVEY PURPOSE

In 2012 and 2018, Tetra Tech evaluated lateral extents of contamination at Bluff B via ground-based gamma radiation surveys, XRF field surveys, and surface soil sampling. The 2012 results were conveyed in the Tronox Bluff Waste Characterization Report (Tetra Tech 2013b) and in the

Final Waste Characterization Evaluation Report, Riley Pass Uranium Mines Site (Tetra Tech 2015a). Additional lateral characterization occurred in 2018, at the Northeast section of Bluff B, as summarized in the 2018 Riley Pass Abandoned Uranium Mine Waste Characterization Sampling Report Bluff B Sediment Sampling Pond (Tetra Tech 2019b). Maps showing pre-2021 gamma radiation levels and arsenic soil concentrations are on **Figure 10** and **Figure 11**, respectively. As shown on these maps, areas at Bluff B primarily lacked coverage for delineations of lateral extents of contamination, mainly in part by inability to access treacherous terrain due to physical inaccessibility and/or safety concerns. In June and July 2021, additional surveys (both aerial and ground) were performed to capture areas where data gaps existed. Some of these areas were addressed during the aerial gamma flyover survey and other areas were addressed with additional lateral delineations via gamma radiation surveys and opportunistic soil sampling. To fully investigate lateral extents of contamination outside the former study area boundary identified during previous surveys, Tetra Tech conducted additional surface gamma scanning coupled with opportunistic soil sampling. As the site continues to be reclaimed and more sampling is done, it is possible additional hotspots outside the previously investigated inbounds of contamination may be found. **Section 3.2** discusses the methodology for conducting the 2021 lateral delineations.

2.3 GAMMA-RADIUM CORRELATION STUDY PURPOSE

Gamma-radium correlation studies have been performed at Riley Pass (MSE 2009, Tetra Tech 2013b) in the past. Based on past experience evaluating and validating correlations between gamma radiation and Ra-226, it has been found that site-specific correlations are typically the most successful and accurate for estimating Ra-226 from gamma. To date, no site-specific Bluff B gamma-radium correlation study has occurred that could be referenced to achieve more efficient remedial planning and design or guidance for future cleanup verification efforts at Bluff B. The purpose of the 2021 gamma-radium correlation study on Bluff B was to determine the site-specific relationship between gamma radiation levels (in μR/hr) and Ra-226 soil concentrations (pCi/g) due to the numerous uncontrollable manufacturing and environmental factors that make a generalized correlation impossible. Furthermore, it is both timely and costly to measure Ra-226 in pCi/g through a laboratory; therefore, the ability to utilize an in-situ method, such as gamma radiation surveys, greatly improves our ability to cleanup uranium mines. A linear relationship between these datasets could be applied to estimate Ra-226 soil concentrations, based on gamma radiation survey data, in order to identify areas of Bluff B where Ra-226 concentrations exceed its’ action level (30 pCi/g) for remediation engineering design and for cleanup verification purposes.

2.4 SUBSURFACE INVESTIGATION PURPOSE

Prior to 2020, field investigations at Bluff B involved evaluation and characterization of surface materials via gamma radiation surveys, XRF field surveys, and soil sampling. These investigation techniques are useful for delineating lateral extents of arsenic and Ra-226 contamination but are not able to provide information on vertical extents of contamination necessary for effective remediation engineering design. Therefore, in 2020, USFS contracted Tetra Tech to conduct a pilot subsurface investigation program at the northeastern portion of Bluff B by following a test pitting approach involving excavation of waste materials by use of a track hoe excavator, in conjunction with downhole gamma logging and XRF screening, to guide collections of subsurface soil samples in order to evaluate vertical extents of mine waste. Fifteen test pits were excavated in 2020 to maximum depth of approximately 20 feet below ground surface (bgs), and the program was successful at identifying waste volumes within the northeast portion of Bluff B. Results of that subsurface investigation appear in the report titled Subsurface Investigation for Northeast Area of Bluff B (Tetra Tech 2020).

The purpose of the 2021 subsurface investigation was to delineate vertical extents of arsenic and Ra-226 contamination via a test pitting approach, across areas at Bluff B farther to the south of the 2020 northeast Bluff B site investigation. Screening tools (XRF and downhole gamma) were used to guide soil sampling.

The SAP (Tetra Tech 2021) identified test pit locations; however, flexibility (in-field judgement) was necessary to successfully complete this program in 2021. Flexibility of the 2021 subsurface survey and sampling design allowed the field team to assess potentially natural features and known mining waste features.

3.0 METHODS

This section presents the methodology for the different activities performed during the 2021 field investigation at Bluff B.

3.1 AERIAL GAMMA FLYOVER SURVEY METHODS

Section 2.1 specifies the purpose of the aerial gamma flyover survey, which occurred at Bluff B in June and July 2021, via use of a high-precision UAV able to measure gamma radiation and terrain. **Figure 13** and **Figure 14**, below, are photographs of the gamma drone team preparing the drone and the scanning drone in action at Bluff B, respectively. Additional photographs of the aerial gamma flyover survey are in **Appendix A**. The basic principle of a gamma scanning drone is to couple existing commercially available UAV technology with a radiation detector, equivalent to those used in backpack surveys (e.g., a 2- by 2-inch, sodium iodide thallium-laced [NaI(Tl)] Ludlum Model 44-10 with a Ludlum datalogger), and to fly at greater heights across larger areas and convert the data back to ground-level-equivalent data. The system utilizes terrain-following software that essentially “talks” to the drone and allows the drone to accurately follow the terrain and essentially “hug” the ground.

Prior to the aerial gamma flyover survey, the terrain had been mapped by use of a smaller land surveying drone that conducted a photogrammetry survey, terrain mapping output derived from application of a highly accurate (i.e., less than 2 inches in horizontal and vertical precision) DSM. The UAV was equipped with high-precision RTK GPS and high-resolution photography and video cameras; it also was integrated with radiation sensing technology. The system was able to follow a user-specified height and velocity over the duration of the survey. Numerous tests were performed outside the limits needed to evaluate the easternmost cliffs at Bluff B. The gamma drone was flown at either 5 or 10 meters ags, and the data were then converted to 1-meter-equivalent readings by application of correction techniques developed by Tetra Tech from pilot studies at Riley Pass and at another site (details presented later).

The target area for the aerial gamma flyover survey encompassed 37.6 acres, as shown on **Figure 15** below. The UAV was flown at a height of 5 or 10 meters ags across the UAV scan area at a speed of 1 meter per second (m/s). Conversion of the data, to 1-meter-equivalent gamma exposure rate readings, ensued by following the approach presented in **Appendix B**. The data were validated with ground-based data and found to be very accurate. The UAV Summary Report (**Appendix B**) provides information on the methodology and model validation methods.

In addition to the goal of acquiring gamma radiation data during the aerial gamma flyover, acquisition of high-resolution aerial imagery and photogrammetric digital terrain mapping was attained. This information will be used for remedial engineering design.

Results from the UAV helped the Tetra Tech field team refine locations and the approach to the subsurface test pit investigation, as specified in the SAP (Tetra Tech 2021). **Section 4.1** conveys results of the aerial gamma flyover survey.

Figure 13 Dundas Geomatics, Inc. Preparing Drone for Flight

Figure 14 Gamma Drone in Action at Bluff B

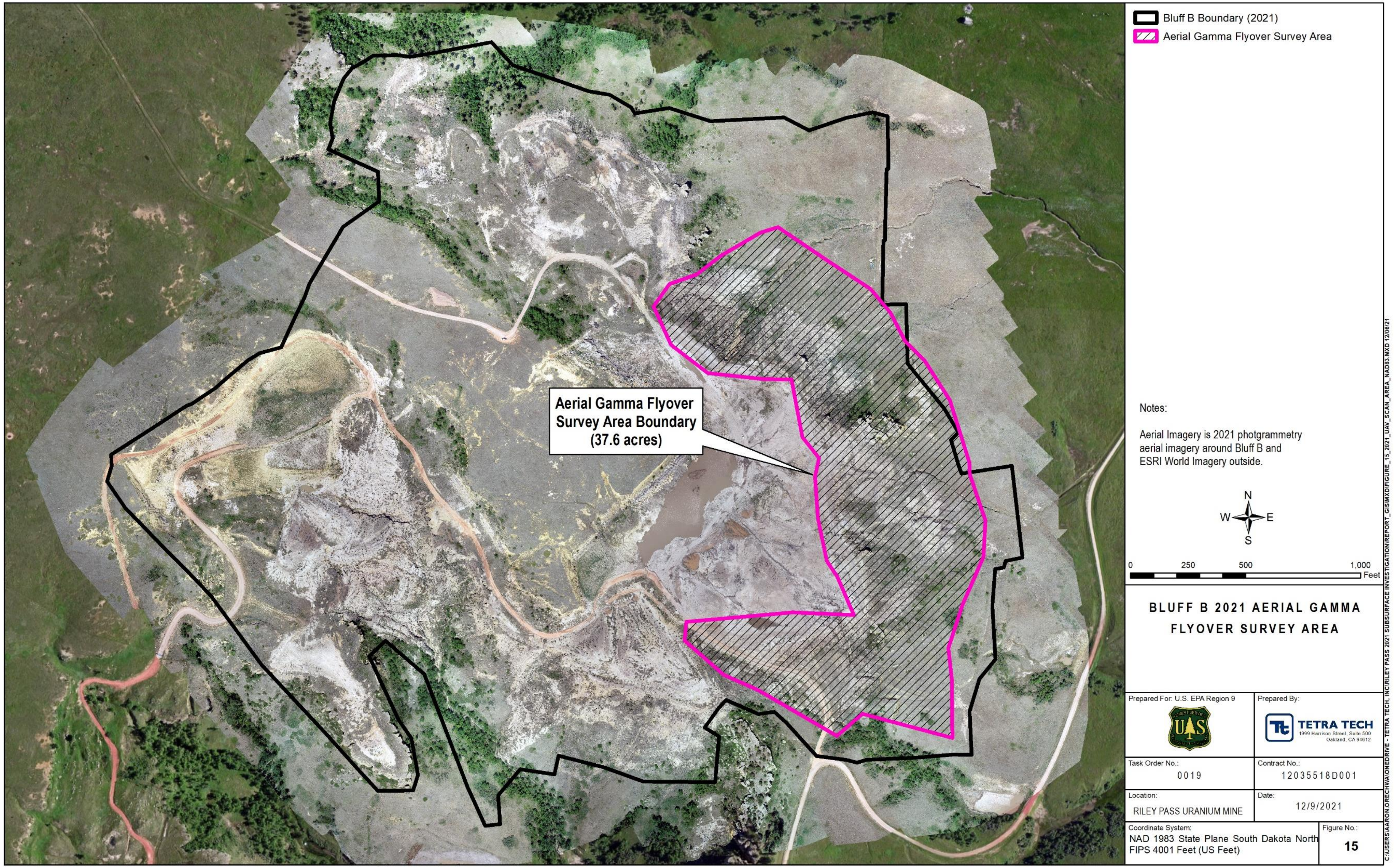

Figure 15 Bluff B 2021 Aerial Gamma Flyover Survey Area

3.2 LATERAL DELINEATION SURVEY METHODS

Section 2.2 specifies the purpose of the opportunistic soil sampling and gamma radiation surveys for support of lateral delineations at Bluff B. This investigation occurred in August 2021 to attempt full characterization of lateral extents of radiological and arsenic contamination at Bluff B, and to ensure complete determinations of soil concentrations across the Site.

Gamma radiation surveys occurred in three main areas of Bluff B: (1) Northern Goback Scan Area (19.3 acres), (2) Eastern Goback Scan Area (3.1 acres), and (3) Southern Goback Scan Area (26.7 acres). In total, 49.1 acres were scanned at varying scan densities specified below. **Figure 16** shows the ground-based scanning areas.

The gamma radiation surveys occurred at these areas following the methods outlined in the SAP (Tetra Tech 2021). Field staff used mobile scanning systems with Ludlum Model 44-10 (2- by 2-inch) sodium iodide (NaI) gamma scintillation detectors coupled to Ludlum Model 2221 ratemeters/scalers set in ratemeter mode. The detectors were coupled to ERG Model 105 GPS units. The ERG Model 105 GPS unit consists of a Juniper Mesa 2 field computer and geode GPS receiver. The gamma radiation survey within the Eastern Goback Scan Area occurred at maximum spacing of 2-meter transect widths. However, the Northern Goback Scan Area and Southern Goback Scan Area was extremely vegetated and steep with uneven terrain; therefore, spacing at these areas may deviate from the 2-meter transects. Detector height was 1-meter ags, as prescribed in the SAP (Tetra Tech 2021). The "field of view" of the NaI detector, in this configuration (2-meter transects and 1-meter height), provides 100 percent (%) coverage of land areas. Therefore, a 2-meter transect was selected in an attempt to achieve 100 percent (%) scan coverage. Gamma count rate measurements, and associated geospatial coordinates, were recorded every 1 second. **Section 4.2** presents results of the lateral delineation gamma radiation surveys.

During the 2021 field investigations, Tetra Tech also collected eight opportunistic, discrete soil samples within 0 to 6 inches bgs, following the methods outlined in the SAP (Tetra Tech 2021). Each sample was collected into a stainless-steel bowl. Debris and organic matter were removed, the sample was homogenized, and then was placed in a plastic bag and into the project cooler. Sampling tools were decontaminated following collection of each sample. The field team took photographs of each sampling location **Table 5**, below, lists sampling information including geospatial coordinates of each location and respective laboratory sample numbers. **Figure 16,** below, shows locations of these soil samples. The soil samples were analyzed for Ra-226, actinium-228 (Ac-228), and potassium-40 (K-40) via gamma spectroscopy (E901.1), and for arsenic and thorium via inductively coupled plasma-mass spectrometry (ICP-MS). **Table 6,** below, summarizes laboratory analysis information regarding the opportunistic samples.

A photographic log of the opportunistic soil sampling is in **Appendix A**. Laboratory reports regarding the opportunistic soil sampling are in **Appendix C**. Validation of data in the laboratory data package is conveyed in **Appendix D**. **Appendix E** summarizes verification and validation of data from instrumentation used in the opportunistic field investigation gamma radiation survey. Scanned copies of the field logbook and field forms are in **Appendix F**. **Section 4.2** discusses results of the lateral delineations.

Table 5 Summary of Information Regarding Opportunistic Soil Samples

Sample ID	Laboratory Sample Number	Date Collected	Sample Type	Sample Depth (feet)	Northing[1] (US Feet)	Easting (US Feet)
OPP-1-080421	2108183-1	8/4/2021	Primary	0 - 0.5	755,688.86	1,079,306.54
OPP-2-080421	2108183-2	8/4/2021	Primary	0 - 0.5	753,674.55	1,081,723.60
OPP-3-080421	2108183-3	8/4/2021	Primary	0 - 0.5	754,133.77	1,081,762.26
OPP-4-080421	2108183-4	8/4/2021	Primary	0 - 0.5	753,731.02	1,082,392.24
OPP-5-080421	2108183-5	8/4/2021	Primary	0 - 0.5	753,635.53	1,082,506.18
OPP-6-080421	2108183-6	8/4/2021	Primary	0 - 0.5	754,172.16	1,082,182.36
OPP-7-080421	2108183-7	8/4/2021	Primary	0 - 0.5	753,233.95	1,082,774.92
OPP-8-080421	2108183-8	8/4/2021	Primary	0 - 0.5	753,217.21	1,082,871.59
OPP-DUP-080421	2108183-9	8/4/2021	Field Duplicate	0 - 0.5	-	-

Notes:
[1] Spatial coordinates are in North American Datum (NAD) 1983 State Plane South Dakota N FIPS 4001 (US Feet).
ID Identification

Table 6 Summary of Laboratory Analyses of Opportunistic Soil Samples

Analytical Parameter	Abbreviation	CAS Number	Laboratory Method
Actinium-228	Ac-228	14331-83-0	EPA 901.1
Potassium-40	K-40	13966-00-2	EPA 901.1
Radium-226	Ra-226	13982-63-3	EPA 901.1
Arsenic	As	7440-38-2	EPA SW-846 6020B SW3050B
Thorium	Th	7440-29-1	EPA SW-846 6020B SW3050B

Notes:
CAS Chemical Abstracts Service
EPA U.S. Environmental Protection Agency

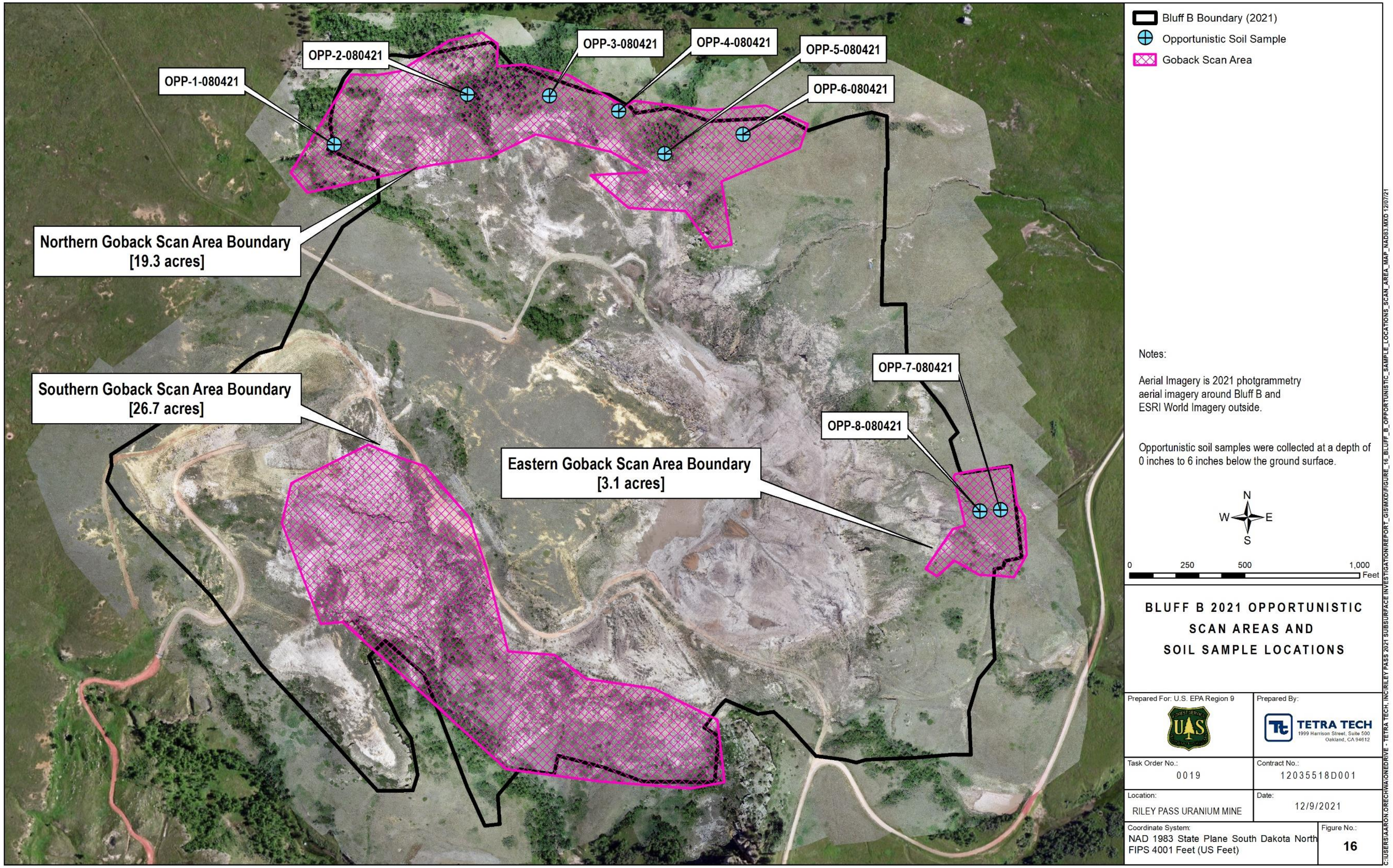

Figure 16 Bluff B 2021 Opportunistic Scan Areas and Soil Sample Locations

3.3 GAMMA-RADIUM RADIATION CORRELATION STUDY METHODS

This section specifies the purpose of the gamma-radium correlation study on August 5, 2021, which involved acquisition of gamma survey data and collection of composite soil samples from 15 soil correlation plots, each encompassing approximately 100 square meters (m^2), selected within, or near, the Bluff B boundary.

Gamma-radium correlation studies allow staff to use readily available radiation detection equipment (i.e., scintillation detectors) to estimate the radium concentration in the ground during field investigations rather than waiting for laboratory test results. This relationship is dependent on numerous uncontrollable factors ranging from the radiation detector's manufacturing process to environmental influences, like cosmic rays, elevated levels of natural thorium and potassium, radon interference dependent upon barometric pressure, and soil gas transport (dependent upon the geology of the soil). It is, therefore, necessary to take several radiation measurements in the area of interest and correlate it with laboratory results.

Prior to the field investigation, the soil correlation plots had been pre-selected during a desktop study, based on historical gamma data, and were evaluated by Tetra Tech during aerial gamma flyover survey field investigation trips in June and July 2021 to determine if the plots were suitable for the final sampling during the August trip. The goal is to have correlation plots with gamma radiation levels that span the range of radiation levels found across a site and bound the selected cleanup level. The selection process involved evaluation of gamma levels across the pre-selected locations and examination of soils within the plots. Some plots were eliminated, and other plots were selected depending on field observations. The final soil correlation plot locations were selected prior to the August field investigation. On August 5, 2021, the field team went to each plot location to mark the corners of the plot area. The team then collected a composite soil sample consisting of nine aliquots of similar sample mass collected within 0 to 6 inches bgs and evenly distributed across the plot area.

Table 7, below, lists sampling information regarding each soil correlation sample including field sample identification (ID), laboratory sample number, sample date, sample time, geospatial coordinates, vertical elevation, and surface area of each plot. The soil samples were analyzed for Ac-228, K-40, and Ra-226 via gamma spectroscopy (E901.1); for isotopic uranium and isotopic thorium via ASTM D3972; and for arsenic and thorium via ICP-MS. **Table 8**, below, summarizes laboratory analysis information regarding the gamma-radiation soil correlation samples.

Two gamma radium surveys were performed: (1) shielded or collimated by use of a high-density customized tungsten shield, and (2) unshielded. In areas of high gamma interference, whether it be from cosmic or natural thorium or potassium, it may help to shield the detector around its sides to reduce unnecessary interference and detector deadtime. Procedures for measurements during the gamma-radium survey were the same as applied during the lateral delineation gamma radiation surveys. Fifteen gamma-radium correlation plots were selected for the soil sampling/gamma-radium correlation study. **Figure 17**, below, is a map showing locations of the gamma-radium correlation study plots. All but one correlation study plot (CORR01) was within the boundary of Bluff B. CORR01 was selected as a background correlation plot, in an area well outside the disturbance area, to represent natural background conditions.

A photographic log of the soil sampling/gamma-radium correlation study is in **Appendix A**. Laboratory reports regarding this are in **Appendix C**. Data validation of the laboratory data package is conveyed in **Appendix D**. **Appendix E** summarizes verification and validation of data from instrumentation used during the soil sampling/gamma-radium correlation study. **Appendix F** includes scanned copies of the field logbook and field forms. **Appendix G** contains a report providing more detail on the methodology, results, and data interpretation of the study to correlate results of soil sampling to measured gamma radiation. **Section 4.3** presents results of the soil sampling/gamma-radium correlation study.

Table 7 Summary of Gamma-Radium Correlation Plots and Soil Sampling Information

Sample ID	Laboratory Sample Identification	Date Collected	Sample Type	Northing (US Feet)	Easting (US Feet)	Vertical Elevation (feet amsl)	Surface Area of Correlation Plot (m^2)
CORR01-080521	2108184-1	8/5/2021	Primary	755,688.86	1,079,306.54	-	96
CORR02-080521	2108184-3	8/5/2021	Primary	753,674.55	1,081,723.60	3,376.3	80
CORR03-080521	2108184-4	8/5/2021	Primary	754,133.77	1,081,762.26	3,327.7	83
CORR04-080521	2108184-5	8/5/2021	Primary	753,731.02	1,082,392.24	3,310.4	80
CORR05-080521	2108184-6	8/5/2021	Primary	753,635.53	1,082,506.18	3,309.7	70
CORR06-080521	2108184-7	8/5/2021	Primary	754,172.16	1,082,182.36	3,312.4	111
CORR07-080521	2108184-8	8/5/2021	Primary	753,233.95	1,082,774.92	3,320.4	105
CORR08-080521	2108184-9	8/5/2021	Primary	753,217.21	1,082,871.59	3,323.9	112
CORR09-080521	2108184-10	8/5/2021	Primary	753,154.10	1,082,907.81	3,323.1	147
CORR10-080521	2108184-11	8/5/2021	Primary	753,274.81	1,082,943.00	3,328.1	133
CORR11-080521	2108184-12	8/5/2021	Primary	752,872.85	1,082,392.04	3,322.0	63
CORR12-080521	2108184-13	8/5/2021	Primary	752,798.02	1,082,521.98	3,322.7	27
CORR13-080521	2108184-14	8/5/2021	Primary	752,997.11	1,081,405.20	3,313.9	118
CORR14-080521	2108184-15	8/5/2021	Primary	752,701.04	1,082,018.72	3,326.4	107
CORR15-080521	2108184-16	8/5/2021	Primary	752,774.21	1,082,142.86	3,315.9	153
CORR-(DUP1)-080521	2108184-2	8/5/2021	Duplicate	-	-	-	-

Notes:
Spatial coordinates are in NAD 1983 State Plane South Dakota N FIPS 4001 (US Feet).
No vertical elevation is provided for CORR01-080521 because the location of this plot is outside of the digital elevation model for the Site.

amsl Above mean sea level
"-" Data not available
MST Mountain Standard Time
m^2 Square meter
NAD North American Datum

Table 8 Summary of Laboratory Analyses of Gamma-Radium Correlation Soil Samples

Analytical Parameter	Abbreviation	CAS Number	Laboratory Method
Actinium-228	Ac-228	14331-83-0	EPA 901.1
Potassium-40	K-40	13966-00-2	EPA 901.1
Radium-226	Ra-226	13982-63-3	EPA 901.1
Thorium-228	Th-228	14274-82-9	ASTM D3972 Modified
Thorium-230	Th-230	14269-63-7	ASTM D3972 Modified
Thorium-232	Th-232	7440-63-7	ASTM D3972 Modified
Uranium-234	U-234	13966-29-5	ASTM D3972 Modified
Uranium-235	U-235	15117-96-1	ASTM D3972 Modified
Uranium-238	U-238	7440-61-1	ASTM D3972 Modified
Arsenic	As	7440-38-2	EPA SW-846 6020B SW3050B
Thorium	Th	7440-29-1	EPA SW-846 6020B SW3050B
Uranium	U	7440-61-1	EPA SW-846 6020B SW3050B

Notes:
amsl Above mean sea level
"-" Data not available

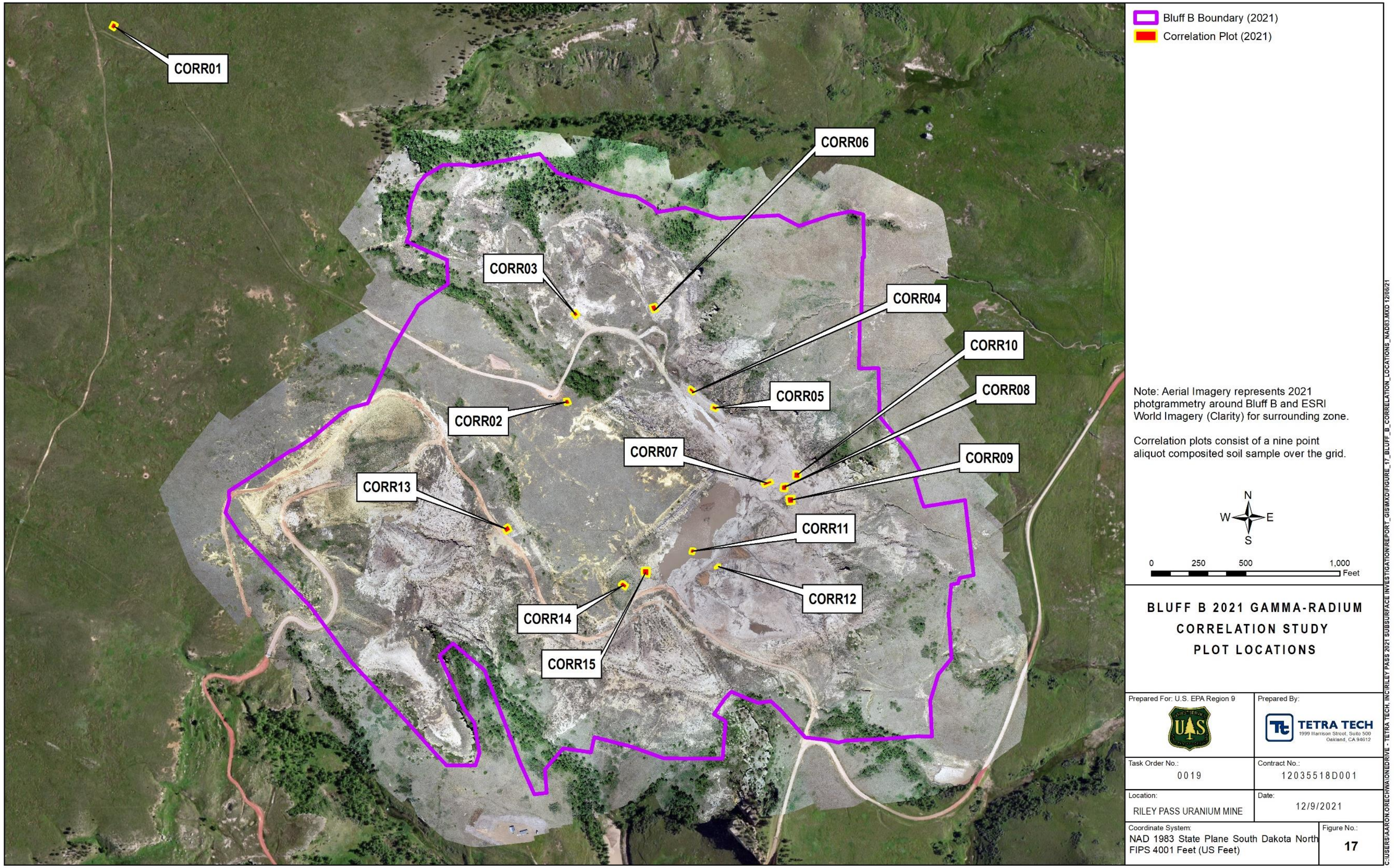

Figure 17 Bluff B 2021 Gamma-Radium Correlation Study Plot Locations

3.4 SUBSURFACE INVESTIGATION METHODS

Twenty test pit locations were specified in the SAP (Tetra Tech 2021); however, field judgement ultimately was applied to select final locations of the test pits, and only 15 test pits were excavated. Young Gun Construction, LLC, of Ludlow, South Dakota, excavated the test pits using a 21-ton tracked backhoe with 20-foot reach boom and 1-yard bucket. Tetra Tech field personnel consisted of radiation specialist and engineer Aaron Orechwa, P.E., of Fort Collins, Colorado, and geologist and hydrogeologist William Craig of Missoula, Montana. Test pit procedures generally followed the methodologies described in the SAP (Tetra Tech 2021), with minor exceptions or modifications based on field decisions by the field crew. Any pertinent deviations from the SAP are described in **Section 3.5.1.4**. Prior to excavation of each test pit, field personnel implemented the following procedure at that location:

- Upon identification of a test pit location in the field, GPS coordinates were obtained by use of a sub-foot handheld Trimble 7XH. Final GPS coordinates were determined after post-processing by use of GPS Pathfinder Office.
- A gamma radiation reading (in microroentgens per hour [μR/hr]) at 1-meter ags was recorded in the field logbook. The radiation instrumentation used consisted of a 44-10 NaI[Tl] scintillation detector coupled to a handheld Model 3000 datalogger.
- An in-situ XRF measurement was recorded at soil surface by use of a Niton XL3t XRF spectrometer, and arsenic concentration in parts per million (ppm) was also recorded in the field logbook.
- A soil sample was collected at the centroid of this test pit to be excavated within 0 to 6 inches bgs. This, and similar samples from centroids of other test pits, were labeled as follows: for example, for TP-01 collected on August 3, 2021, "TP01-(SURF)-080321."
- Field photographs and/or videos were recorded at most test pit locations by use of handheld cameras and/or a mini drone with 4k video capability.
- Notes were recorded in the field logbook to specify the purpose of the test pit and any other important items worth noting.

After completion of this procedure, the operator initiated excavation of the test pit. Test pits were excavated to the maximum depth achievable by the equipment, refusal of excavation due to encounter with bedrock, or depth determined by results of field screening. Subsurface soil samples were collected at the discretion of the field team based on field screening results and soil logging. The approach to subsurface soil sampling was to collect discrete samples in 1-foot intervals where waste materials were present or where major lithological changes were observed (i.e., waste material transitioning to native material).

Field personnel implemented the following procedures after excavation of a test pit:

- Field engineers lowered the NaI(Tl) scintillator, via a custom downhole rope and pulley system, into the test pit and took measurements at 1-foot intervals to the bottom of the test pit. The measurements were recorded in a field logbook.
- A Tetra Tech geologist logged material types on a test pit field form.

- Soil grab samples were collected, as determined by the field team, and the operator was directed where to collect the sample. The field team used engineering tape measuring to confirm sampling within the correct interval. Sample intervals are approximate.
- XRF measurements of arsenic concentrations from the sampled material were recorded in the field logbook.
- Photographs of test pit walls were taken.
- Excavated test pit material was placed back in the hole, compacted, and closed out.

Each test pit soil sample was placed in a sample bag, and a chain of custody for that sample was filled out. Sampling equipment was decontaminated following work at each test pit. **Section 4.4** summarizes for each test pit, rationale for methodology at that test pit and field team decisions, evaluation of the mine waste profile, results of field screening, laboratory analyses, and test pit logging.

Table 9 lists test pit locations and sampling information. Applying the DSM developed from the aerial gamma flyover survey, the Extract Values by Point tool was used in ArcMap to determine the approximate surface elevation of each test pit. This information was useful to determine at which surface elevation bedrock was encountered at a test pit location. Surface elevations of the 2021 test pits ranged between 3,190.52 feet amsl and 3,349.52 feet amsl, a difference of 169 feet. Average surface elevation was 3,309.00 feet amsl. **Figure 18**, below, is a map showing the final test pit locations. **Table 10** and **Table 11**, below, list sampling information and identifications of test pit samples collected during the subsurface investigation. **Table 12** summarizes laboratory analysis information regarding the test pit samples.

A photographic log of the subsurface investigation is in **Appendix A.** Laboratory reports regarding the subsurface investigation are in **Appendix C**. Validation of data in this laboratory data package is conveyed in **Appendix D**. Scanned copies of the field logbook and field forms, including the test pit logs, are in **Appendix F**. **Section 4.4** presents results of the subsurface investigation.

Table 9 Summary of Test Pit Location Information

Sample ID	Date	Northing (US Feet)	Easting (US Feet)	Vertical Surface Elevation (feet amsl)	Number of Soil Samples Collected	Maximum Depth of Test Pit (feet bgs)
TP-01	8/3/2021	752,726.7569	1,082,451.6172	3,324.0	3	11
TP-02	8/3/2021	752,863.4655	1,082,637.9965	3,326.6	3	16
TP-03	8/3/2021	752,982.2896	1,082,949.4930	3,330.2	3	17
TP-04	8/3/2021	752,738.5719	1,083,002.8425	3,338.0	3	17
TP-05	8/3/2021	752,639.8572	1,082,668.9509	3,331.8	2	19
TP-06	8/3/2021	752,457.6612	1,082,569.7817	3,331.7	3	19
TP-07	8/3/2021	752,711.6860	1,082,160.9142	3,315.0	1	2
TP-08	8/3/2021	752,754.1868	1,082,014.6253	3,328.3	2	10
TP-09	8/3/2021	753,076.8210	1,081,235.7025	3,310.0	2	18
TP-10	8/3/2021	753,191.5534	1,080,819.7901	3,332.3	3	19
TP-11	8/4/2021	753,402.7793	1,080,761.0871	3,349.5	2	17
TP-12	8/4/2021	752,575.5699	1,080,908.9635	3,307.7	2	19
TP-13	8/4/2021	752,287.0706	1,080,886.8901	3,323.4	2	13.5
TP-14	8/4/2021	753,862.3185	1,082,902.4717	3,195.9	2	14
TP-15	8/4/2021	753,752.6228	1,083,134.9494	3,190.5	2	9

Notes:
Spatial coordinates are in NAD 1983 State Plane South Dakota N FIPS 4001 (US Feet).
amsl Above mean sea level
bgs Below ground surface
ID Identification
NAD North American Datum

Table 10 Test Pit Soil Samples (1 of 2)

Sample ID	Test Pit ID	Date	Laboratory Sample Number	Sample Type	Depth Type	Depth (feet bgs)
TP-(DUP)-01-080321	-	8/3/2021	2108329-10	Field Duplicate	-	-
TP-(DUP)-02-080421	-	8/4/2021	2108329-30	Field Duplicate	-	-
TP01-(5'-6')-080321	TP-01	8/3/2021	2108329-2	Primary	Subsurface	5 - 6
TP01-(7.5'-8.0')-080321	TP-01	8/3/2021	2108329-3	Primary	Subsurface	7.5 - 8
TP01-SURF-080321	TP-01	8/3/2021	2108329-1	Primary	Surface	0 - 0.5
TP02-(10'-11')-080321	TP-02	8/3/2021	2108329-6	Primary	Subsurface	10 - 11
TP02-(3'-4')-080321	TP-02	8/3/2021	2108329-5	Primary	Subsurface	3 - 4
TP02-SURF-080321	TP-02	8/3/2021	2108329-4	Primary	Surface	0 - 0.5
TP03-(14'-15')-080321	TP-03	8/3/2021	2108329-9	Primary	Subsurface	14 - 15
TP03-(5'-6')-080321	TP-03	8/3/2021	2108329-8	Primary	Subsurface	5 - 6
TP03-(SURF)-080321	TP-03	8/3/2021	2108329-7	Primary	Surface	0 - 0.5
TP04-(15'-16')-080321	TP-04	8/3/2021	2108329-13	Primary	Subsurface	15 - 16
TP04-(5'-6')-080321	TP-04	8/3/2021	2108329-12	Primary	Subsurface	5 - 6
TP04-(SURF)-080321	TP-04	8/3/2021	2108329-11	Primary	Surface	0 - 0.5
TP05-(18'-19')-080321	TP-05	8/3/2021	2108329-15	Primary	Subsurface	18 - 19
TP05-(SURF)-080321	TP-05	8/3/2021	2108329-14	Primary	Surface	0 - 0.5
TP06-(11'-12')-080321	TP-06	8/3/2021	2108329-17	Primary	Subsurface	11 - 12
TP06-(17'-18')-080321	TP-06	8/3/2021	2108329-18	Primary	Subsurface	17 - 18
TP06-(SURF)-080321	TP-06	8/3/2021	2108329-16	Primary	Surface	0 - 0.5
TP07-(SURF)-080321	TP-07	8/3/2021	2108329-19	Primary	Surface	0 - 0.5
TP08-(9'-10')-080321	TP-08	8/3/2021	2108329-21	Primary	Subsurface	9 - 10
TP08-(SURF)-080321	TP-08	8/3/2021	2108329-20	Primary	Surface	0 - 0.5

Table 11 Test Pit Soil Samples (2 of 2)

Sample ID	Test Pit ID	Date	Laboratory Sample Number	Sample Type	Depth Type	Depth (feet bgs)
TP09-(6'-7')-080321	TP-09	8/3/2021	2108329-23	Primary	Subsurface	6 - 7
TP09-(SURF)-080321	TP-09	8/3/2021	2108329-22	Primary	Surface	0 - 0.5
TP10-(15'-16')-080421	TP-10	8/4/2021	2108329-26	Primary	Subsurface	15 - 16
TP10-(6'-7')-080421	TP-10	8/4/2021	2108329-25	Primary	Subsurface	6 - 7
TP10-(SURF)-080421	TP-10	8/4/2021	2108329-24	Primary	Surface	0 - 0.5
TP11-(5'-6')-080421	TP-11	8/4/2021	2108329-28	Primary	Subsurface	5 - 6
TP11-(SURF)-080421	TP-11	8/4/2021	2108329-27	Primary	Surface	0 - 0.5
TP12-(SURF)-080421	TP-12	8/4/2021	2108329-29	Primary	Surface	0 - 0.5
TP13-(6'-7')-080421	TP-13	8/4/2021	2108329-32	Primary	Subsurface	6 - 7
TP13-(SURF)-080421	TP-13	8/4/2021	2108329-31	Primary	Surface	0 - 0.5
TP14-(4'-5')-080421	TP-14	8/4/2021	2108329-34	Primary	Subsurface	4 - 5
TP14-(SURF)-080421	TP-14	8/4/2021	2108329-33	Primary	Surface	0 - 0.5
TP15-(3'-4')-080421	TP-15	8/4/2021	2108329-36	Primary	Subsurface	3 - 4
TP15-(8'-9')-080421[a]	TP-15	8/4/2021	2108329-37	Primary	Subsurface	8 - 9
TP15-(SURF)-080421	TP-15	8/4/2021	2108329-35	Primary	Surface	0 - 0.5

Notes:
[a] Sample TP12-(8’-9’)-080421 was mislabeled as TP15-(8’-9’)-080421.
bgs Below ground surface
ID Identification

Table 12 Summary of Laboratory Analyses of Test Pit Soil Samples

Analytical Parameter	Abbreviation	CAS Number	Laboratory Method
Actinium-228	Ac-228	14331-83-0	EPA 901.1
Potassium-40	K-40	13966-00-2	EPA 901.1
Radium-226	Ra-226	13982-63-3	EPA 901.1
Arsenic	As	7440-38-2	EPA SW-846 6020B SW3050B
Cadmium	Cd	7440-43-9	EPA SW-846 6020B SW3050B
Copper	Cu	7440-50-8	EPA SW-846 6020B SW3050B
Lead	Pb	7439-92-1	EPA SW-846 6020B SW3050B
Thorium	Th	7440-29-1	EPA SW-846 6020B SW3050B
Zinc	Zn	7440-66-6	EPA SW-846 6020B SW3050B

Notes:
CAS Chemical Abstracts Service
EPA U.S. Environmental Protection Agency

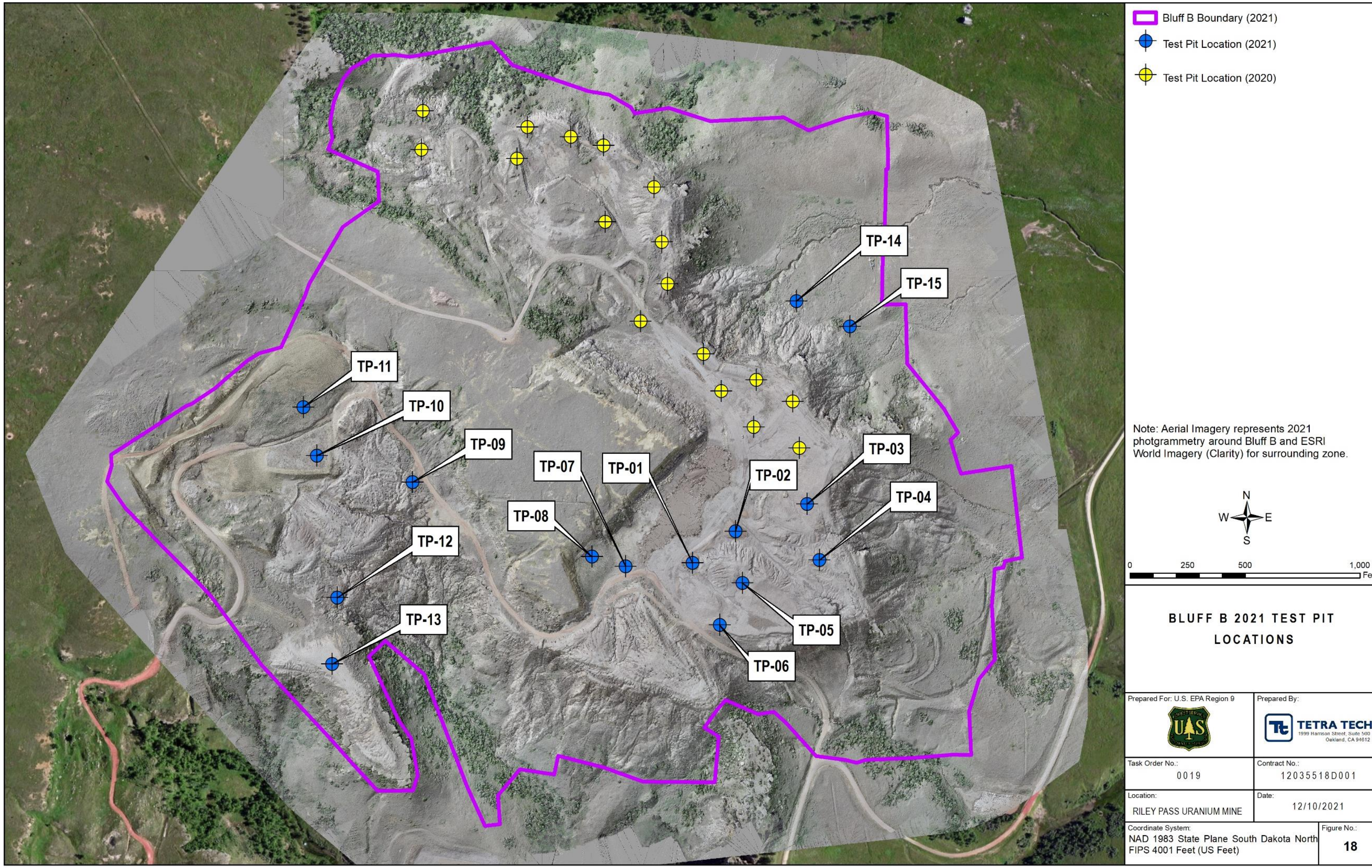

Figure 18 Bluff B 2021 Test Pit Locations

3.5 DATA QUALITY PROCEDURES

The following subsections describe field QA/QC procedures and data validation procedures.

3.5.1 Field QA/QC Procedures

3.5.1.1 Gamma Scanning Quality Assurance/Quality Control Procedures

All radiation instrumentation used for the ground-based gamma radiation surveys were calibrated by the rental company, as documented on the certificate of calibration for each instrument included in **Appendix E**. Upon receipt, each instrument was inspected for damage, verified within the calibration dates, and underwent pre-trip survey measurements. Additionally, following completion of the field investigation, post-trip survey measurements were taken. Results of the pre-trip and post-trip survey QC measurements are in **Appendix E**. The pre-trip measurements served as an instrument comparability check to ensure interchangeability of the instruments in the field (the relative percent difference [RPD] between the average of 1,000 static background and 1,000 static source check readings was less than 10%).

Field staff established QC limits for the instruments used and verified these limits prior to and after field work each day during lateral delineation surveys and the gamma-radium correlation study. They established QC limits by taking 10 readings from each of two instruments for a static background check, from a static source (a 10-microcurie [μCi] source of cesium-137 [Cs-137]), and a background field strip. The average deviation and standard deviation of readings from those two instruments were calculated and used to set the acceptable limits for the duration of the trip. The QC checks occurred daily in Bowman, North Dakota, at the same location each day (parking lot of the Bowman Lodge and Convention Center). The instruments used for downhole measurements were checked periodically at the USFS trailer to ensure they were reading properly, but because those data were used only for screening purposes, the QC requirements were not as stringent.

Upper and lower QC limits were calculated as described in **Appendix E**. Each day the detectors were verified for compliance with the static background check, Cs-137 source check, and the background field strip check. If a detector failed either QC limit, it was rechecked, and if it continued to fail, it was removed from service. This did not occur throughout the field activities.

A summary of all QA/QC methods including validation and verification of the in-field gamma radiation survey measurements is in **Appendix E**.

3.5.1.2 Soil Sampling Quality Assurance/Quality Control

Collection of all soil samples accorded with the USFS-approved SAP (Tetra Tech 2021).

3.5.1.2.1 Sampling Equipment and Preparation

Sampling equipment used during this project included:

- Disposable nitrile gloves.
- A stainless-steel shovel and stainless-steel bowl to collect samples of surface and subsurface soils.
- A 21-ton tracked backhoe with 20-foot reach boom and an excavator 1-yard bucket to collect subsurface samples.

3.5.1.2.2 Sample Containers

All soil samples were collected into clean plastic bags and kept in a cooler over the duration of the project.

3.5.1.2.3 Sample Collection for Laboratory Analysis

All soil samples were hand-delivered to ALS Environmental Laboratories (ALS) in Fort Collins, Colorado, immediately following completion of the field investigation on August 6, 2021.

3.5.1.2.4 Decontamination

Stainless-steel mixing bowls and trowels were cleaned and rinsed after each sample collection.

3.5.1.2.5 Sample Handling and Custody Requirements

Most sample handling and chain-of-custody procedures conformed to the SAP. Any exceptions are noted in **Section 4.4**.

3.5.1.2.6 Field Logbooks and Records

The lead radiological field engineer maintained field logbooks. Field forms for various soil sampling activities were used, where applicable. Test pit forms were collected during the subsurface investigation. All copies of scanned field logbook and field forms are in **Appendix F**.

3.5.1.3 XRF

The XRF spectrometer used in the field was the same model utilized to develop the XRF field survey correlation for Riley Pass; it was only a screening tool, and no definitive level data were collected. Therefore, the QC requirements were minimal and included daily calibration checks (not recorded) and daily system calibration and performance checks.

3.5.1.4 Deviations from the Sampling and Analysis Plan

The following deviations from the SAP (Tetra Tech 2021) occurred:

- The exact number of test pit excavations did not match that specified in the SAP due to excavator field staff limitations. Due to unsafe terrain, the number of test pits excavated was reduced.
- Exact locations and number of gamma-radium correlation soil samples did not match those specified in the SAP.
- The field team used a “blind” approach to collection of field duplicates.
- As part of the data verification process, the planning documents were reviewed for completeness by comparing sampling conducted to sampling planned.
- Only eight opportunistic soil samples were collected out of the proposed 12 samples.
- Downhole gamma measurements proceeded by use only of an unshielded detector.
- Not all the 20 test pits proposed in the SAP were excavated during the subsurface component of the 2021 field investigation. Fifteen locations of the proposed test pits were selected for excavation during the 2021 field investigation. Rationales for individual test pit methodology and field team decisions are included in **Section 4.4**. While not all proposed locations were investigated, due to access limitations in culturally sensitive areas or due to safety constraints pertaining to the excavation equipment, Tetra Tech feels that

these 15 locations were adequate to achieve the objectives and scope of the subsurface investigation.

- Shielded gamma screening did not occur during the subsurface investigation in 2021 due to generally homogeneous soil types and consistent unshielded gamma readings. Tetra Tech feels that shielded gamma versus unshielded gamma comparisons would not provide any additional information for the purpose of assessing "what is waste"; therefore, this deviation from the SAP is not considered a data gap.
- Selection of discrete grab samples for XRF screening was based primarily on gamma and visual identification of material types, not on prescribed sampling intervals. Tetra Tech feels that field decisions with respect to XRF screening and sampling were justifiable, and that sampling at predetermined sample intervals or depths was not necessary as this would not have provided any additional useful information; therefore, the decision to selectively screen and sample is not considered a data gap.

3.5.2 Data Validation Procedures

Soil samples were submitted to ALS in Fort Collins, Colorado, and were analyzed for metals, gamma radiation, and isotopic thorium and uranium. The four data packages submitted by ALS underwent Stage 2A validation in accordance with the EPA Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (EPA 2009). Analytical data for metals were evaluated in general accordance with the EPA National Functional Guidelines (NFGs) for Inorganic Superfund Methods Data Review (EPA 2020), and gamma radiation data and isotopic thorium and uranium data were evaluated in general accordance with EPA's *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP) (EPA 2004).

No data points in this set required rejection based on the validation performed, and all of the data may be used with the qualifications applied during the validation effort. These qualifications and the associated definitions are as follows:

- J – The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample.
- U – The analyte was not detected at concentration at or above the associated value (reporting limit).
- UJ – The analyte was not detected at concentration at or above the associated value (reporting limit), which is considered approximate due to deficiencies in one or more QC criteria.

Refer to the individual data validation reports in **Appendix D** for more specific explanations of qualifications applied to the data set. In-field gamma radiation data validation and verification are presented in **Appendix E**.

4.0 RESULTS

This section presents results from each activity during the 2021 field investigation at Bluff B.

4.1 AERIAL GAMMA FLYOVER SURVEY RESULTS

An aerial gamma flyover survey at Bluff B occurred in two phases during summer 2021 — the first phase in June and the second phase in July. More detailed descriptions of the methods and results of the aerial gamma flyover survey appear in the UAV Summary Report in **Appendix B**. As described in the report, a conversion was used to estimate 1-meter-equivalent gamma data across the 37.6 acres subjected to the aerial gamma flyover survey.

A total of 11,204 gamma measurements were taken within the scan area. The 1-meter-equivalent gamma exposure rate ranged between 16.5 and 302 µR/hr, with an average and standard deviation of 33.6 and 26.4 µR/hr, respectively. **Table 13** summarizes statistics of the 1-meter-equivalent aerial gamma flyover data acquired in 2021.

Table 13 Summary Statistics of Raw Gamma Survey Results (1-m Equivalent)

Statistic	Units	Result
Survey Area	Acres	37.6
Number of Measurements	#	11,204
Average	µR/hr	33.6
Median	µR/hr	28.6
Minimum	µR/hr	16.5
Maximum	µR/hr	302
Standard Deviation	µR/hr	26.4
90^{th} Percentile	µR/hr	43.0
95^{th} Percentile	µR/hr	59.0
99^{th} Percentile	µR/hr	195

Note:
µR/hr Microroentgens per hour

Figure 19, below, is a map showing the raw gamma measurements. UAV gamma transects were performed at 10 meters for 5-meter-high flights and 20 meters for 10-meter-high flights. The basis for selecting the transect spacing was twice the height of the detector, similar to ground-based scanning at 1-meter height with 2-meter transect spacing. There are no industry standards yet for radiometric UAV surveys for scan spacing and height; however, the results of the UAV survey, when corrected to estimated 1-meter above ground level measurements, match the ground-based survey results well, as described in **Appendix B**. For purposes of visualization and analysis, the raw gamma data measurements were interpolated by application of an ordinary kriging method to develop a continuous surface of gamma exposure rates across the 37.6-acre aerial gamma flyover scan area. The interpolated map of the aerial gamma flyover scan area appears on **Figure 20**, below. The yellow areas on **Figure 20** are estimated to be above 48 µR/hr, corresponding to the anticipated 95% upper prediction limit of the soil Ra-226 cutoff of 30 pCi/g, as described later in in **Section 4.3**. In general, the survey results show that much of the scan area is below the Ra-226 cutoff criteria. However, some isolated areas exceeded the Ra-226 cutoff, which should be considered during remedial design and excavation planning. Gamma radiation data acquired during the aerial gamma flyover survey were integrated into the main project geodatabase, according to the procedures outlined in **Appendix H**.

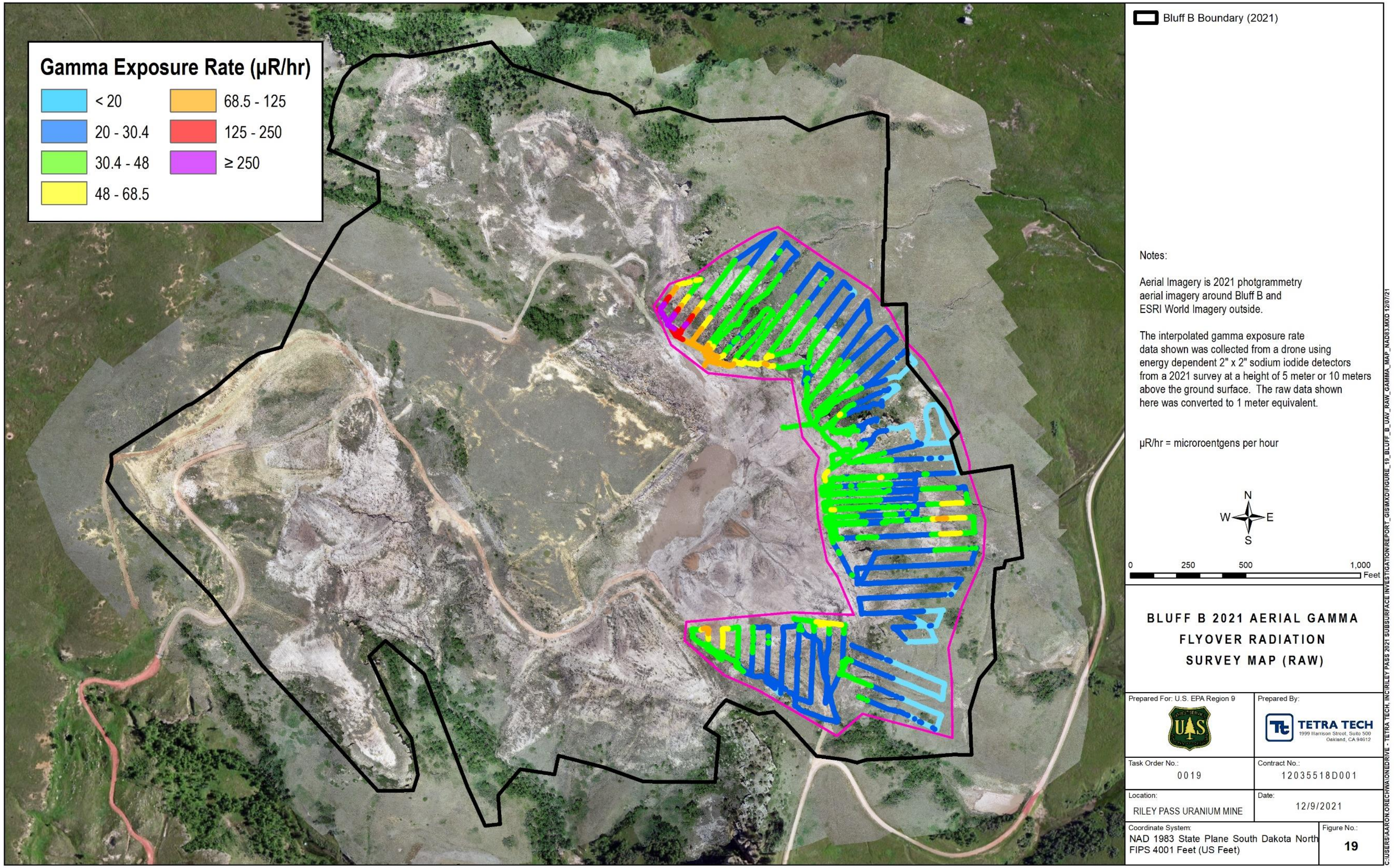

Figure 19 Bluff B 2021 Aerial Gamma Flyover Gamma Radiation Survey Map (Raw)

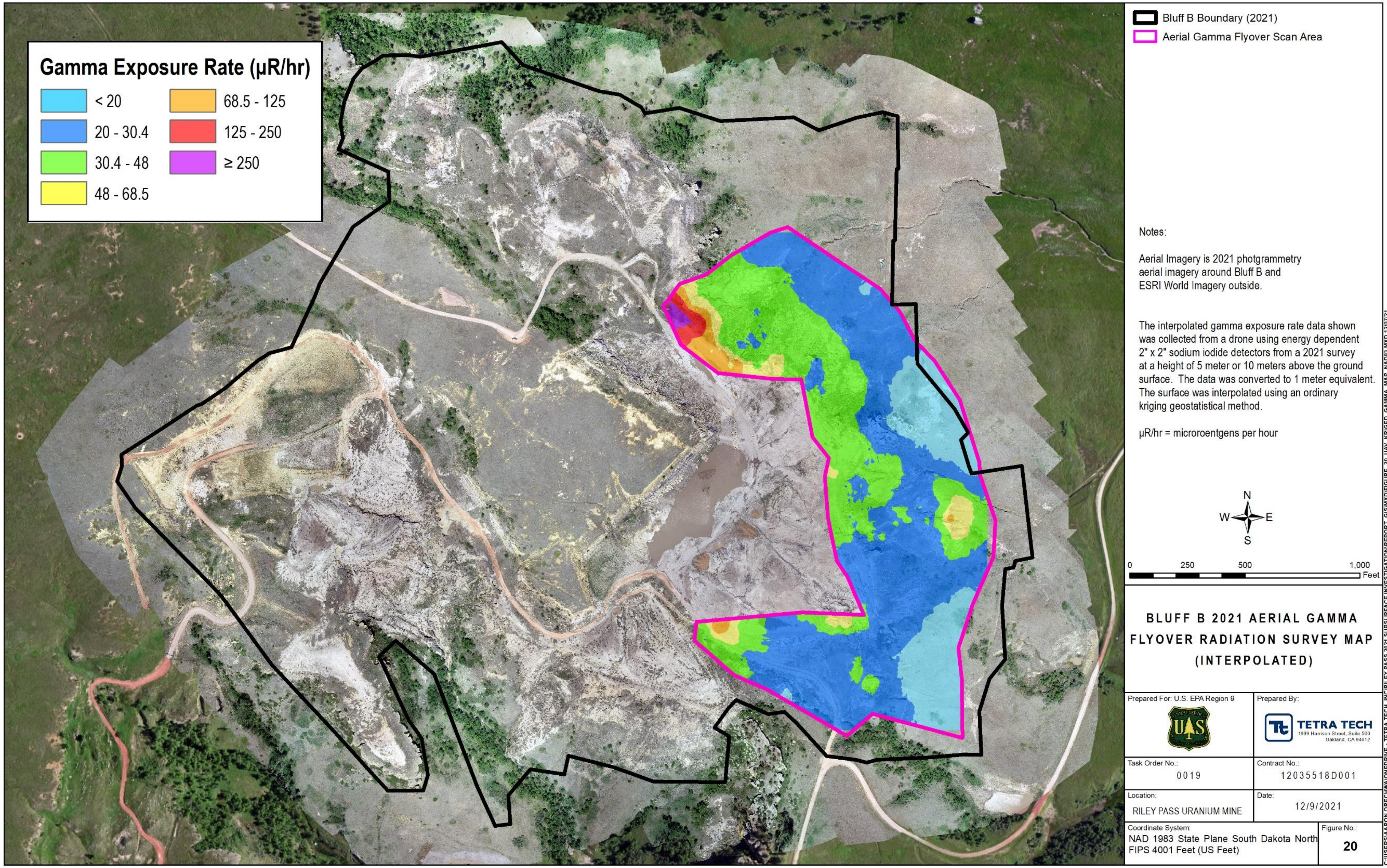

Figure 20 Bluff B 2021 Aerial Gamma Flyover Gamma Radiation Survey Map (Interpolated)

4.2 LATERAL DELINATION SURVEY RESULTS

Lateral delineation surveys occurred during the 2021 field investigation in August. These surveys included "Goback" ground-based, mobile, GPS-based, backpack gamma radiation surveys, and opportunistic soil sampling, according to the methods discussed in **Section 3.2**. Goback surveys were needed since there were limited or no data available in these areas from previous investigations. The goal of the Site opportunistic soil sampling and Goback gamma radiation surveys was to determine the area of soil contamination related to mining activities at Bluff B within the areas not previously sampled and to bound the lateral extent of contamination.

As described in **Section 3.2**, scan density differed according to level of access and safety of terrain. The eastern area was scanned at 100% density, while scans of the northern and southern areas were much less dense. For less dense scan areas, the scan coverage is not as great and hot spots may be missed. Ideally, this can be mitigated during removal action activities by having a technician in the field conducting real-time radiation testing and guiding cleanup as to not miss any hotspots. **Table 14** summarizes statistics of the gamma radiation survey results by scan area. A total of 35,066 gamma exposure rate measurements were acquired, ranging between 10.0 and 345 µR/hr, with an average and standard deviation of 21.6 and 12.9 µR/hr, respectively. **Figure 21**, below, shows the raw gamma radiation survey results. Due to the scan density issues, the raw gamma data measurements were interpolated. However, the gamma data obtained during the lateral delineation surveys were integrated into the main project geodatabase, according to the procedures outlined in **Appendix H**.

Table 14 Summary Statistics of the Goback Gamma Radiation Surveys

Statistic	Units	All	Eastern	Northern	Southern
Survey Area	Acres	49.2	3.1	19.3	26.7
Number of Measurements	#	35,066	7,398	10,917	16,751
Average	µR/hr	21.6	25.9	21.8	19.6
Median	µR/hr	17.7	26.0	18.0	16.1
Minimum	µR/hr	10.0	12.9	10.4	10.0
Maximum	µR/hr	345	57	310	345
Standard Deviation	µR/hr	12.9	7.3	13.9	13.6
90^{th} Percentile	µR/hr	32.0	34.5	29.9	26.7
95^{th} Percentile	µR/hr	39.1	38.6	37.7	40.2
99^{th} Percentile	µR/hr	69.2	46.2	81.6	70.4

Notes:
Gamma radiation data were acquired by use of energy-dependent, 2- by 2-inch NaI(Tl) detectors
NaI(Tl) Sodium iodide thallium laced
µR/hr Microroentgens per hour

In addition to the Goback lateral delineation gamma radiation surveys, eight opportunistic soil samples were collected on August 4, 2021. Analytical results are displayed over the raw gamma radiation survey results on **Figure 21**. **Table 15**lists soil sampling results for arsenic and Ra-226 from the eight opportunistic soil samples. **Table 16** summarizes statistics of the arsenic and Ra-226 results. All results from the opportunistic soil samples indicated soil concentrations of both arsenic and Ra-226, well below their action levels. Additional analytes were evaluated (**Table 6**), but not presented here. Tables of the full analytical suite for the opportunistic soil samples are in **Appendix I**.

Table 15 Analytical Results from Opportunistic Soil Samples

Sample ID	Arsenic (mg/kg)	Qualifier	Radium-226 (pCi/g)	TPU +/-	Qualifier
OPP-1-080421	37		1.7	0.38	J
OPP-2-080421	16		3.8	0.58	J
OPP-3-080421	44		2.52	0.44	J
OPP-4-080421	39		5.5	0.76	J
OPP-5-080421	39		7.08	0.93	J
OPP-6-080421	25		4.5	0.67	J
OPP-7-080421	18		3.07	0.49	J
OPP-8-080421	22		3.12	0.49	J
OPP-DUP-080421	25		4.39	0.65	J

Notes:

ID Identification
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram
TPU Total propagated uncertainty

Table 16 Summary Statistics of Opportunistic Soil Samples

Statistic	Units	Arsenic	Units	Radium-226
Number of Samples	#	8	#	8
Average	mg/kg	30.0	pCi/g	4.0
Median	mg/kg	31.0	pCi/g	3.8
Minimum	mg/kg	16.0	pCi/g	1.7
Maximum	mg/kg	44.0	pCi/g	7.1
Standard Deviation	mg/kg	10.9	pCi/g	1.6
90th Percentile	mg/kg	40.5	pCi/g	5.8
95th Percentile	mg/kg	42.3	pCi/g	6.4
99th Percentile	mg/kg	43.7	pCi/g	7.0

Notes:

mg/kg Milligrams per kilogram
pCi/g Picocuries per gram

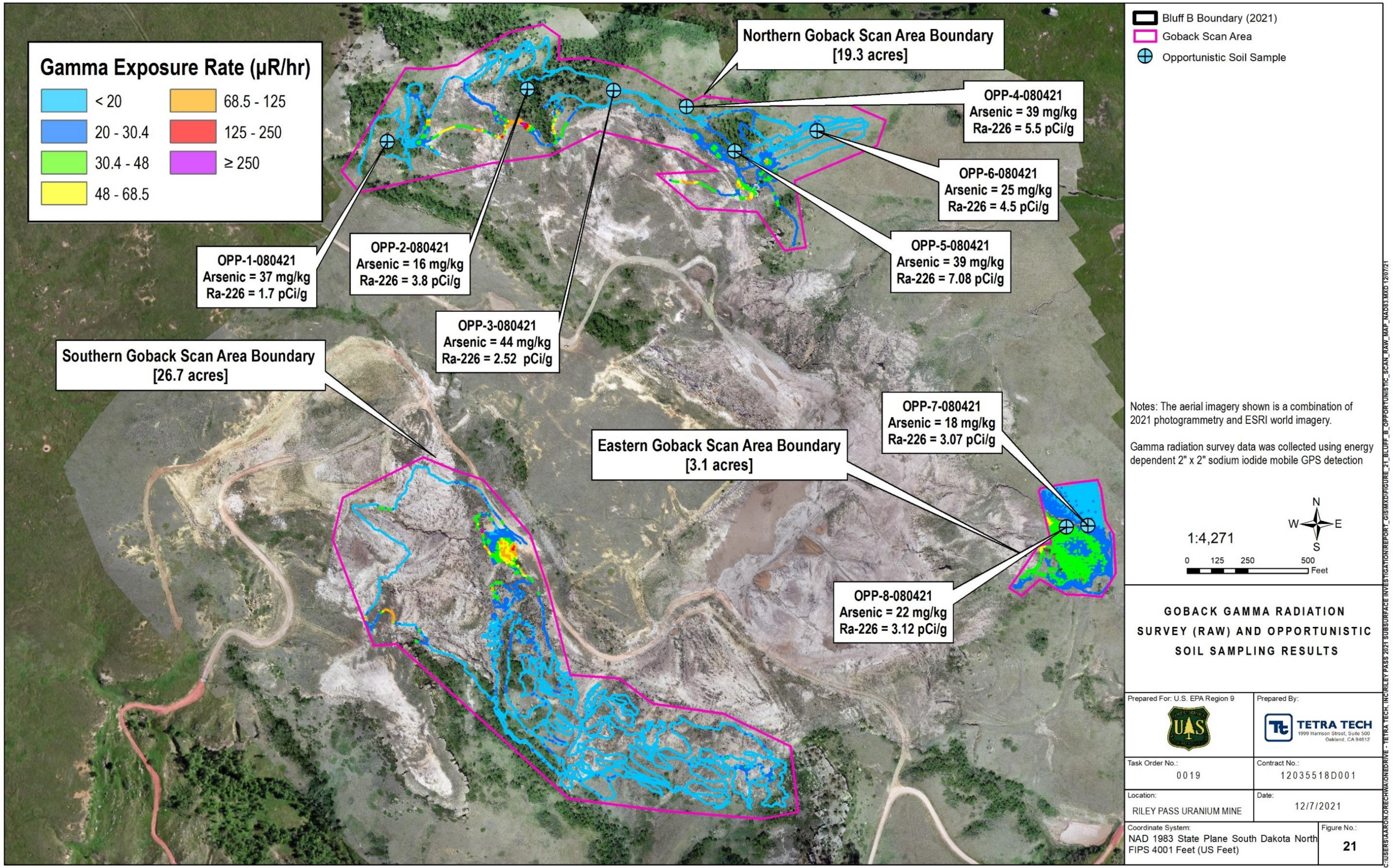

Figure 21 Goback Gamma Radiation Survey (Raw) and Opportunistic Soil Sampling Results

4.3 GAMMA-RADIUM CORRELATION STUDY RESULTS

A site-specific gamma-radium correlation study occurred at Bluff B on August 5, 2021, according to the methods outlined in **Section 3.3**. Fifteen soil correlation plots were scanned for gamma radiation and sampled for a suite of analytes, including Ra-226. Locations of the 15 soil correlation plots are on **Figure 17,** above. The Gamma-Radium Correlation Study Report, in **Appendix G**, provides detail on the analysis and evaluation to indicate how the final regression model applied for this study was developed and presented herein, including model validation results.

Table 17 lists the average unshielded gamma exposure rate (μR/hr) and the Ra-226 soil concentration (pCi/g) within each of the 15 soil correlation plots. Evaluations are presented, in **Appendix G,** of multiple different models associated with the full dataset and outlier analysis. Sample "CORR12-080521" was an influential outlier, and it was removed from the final regression shown on **Figure 22**, below. This regression includes the main linear regression equation for the entire dataset (less "CORR12-080521"), as well as the 95% UPL linear regression model and associated equation. This approach is discussed in Abelquist (2014) (Eric Abelquist is a lead author of MARSSIM [USEPA 2000]), the intention is to capture the clean-up contamination with 95% confidence by using a more conservative gamma cutoff value compared to using the main regression line. Use of the regression equation for 95% UPL resulted in a gamma exposure rate of 48 μR/hr, equating to 30 pCi/g. Following the 95% UPL approach for remedial design and verification purposes ensures a conservative approach to identification of removal action areas. That is, likelihood is 95% that the areas identified with a gamma exposure rate of 48 μR/hr, or below, would be at, or below, the cutoff of 30 pCi/g of Ra-226 in the soils.

Table 17 Gamma-Radium Correlation Study Results

Sample ID	Unshielded Average Gamma Exposure Rate (µR/hr)	Radium-226 (pCi/g)	TPU (+/-)	Qualifier
CORR01-080521	12.3	1.6	0.4	J
CORR02-080521	14.5	1.7	0.3	J
CORR03-080521	17.3	4.7	0.7	
CORR04-080521	62.3	21.9	2.6	J
CORR05-080521	66.0	27.7	3.4	J
CORR06-080521	37.5	11.6	1.4	
CORR07-080521	49.5	23.1	2.9	J
CORR08-080521	33.9	10.5	1.4	J
CORR09-080521	31.3	11.9	1.5	J
CORR10-080521	37.6	12.7	1.6	J
CORR11-080521	45.6	18.4	2.2	J
CORR12-080521	104.9	93.0	11.0	J
CORR13-080521	43.4	30.0	3.6	
CORR14-080521	22.0	10.1	1.3	J
CORR15-080521	18.6	2.9	0.5	J
CORR-(DUP1)-080521	-	1.1	0.3	J

Notes:

µR/hr	Microroentgens per hour
ID	Identification
J	Estimated value
pCi/g	Picocuries per gram
TPU	Total propagated uncertainty

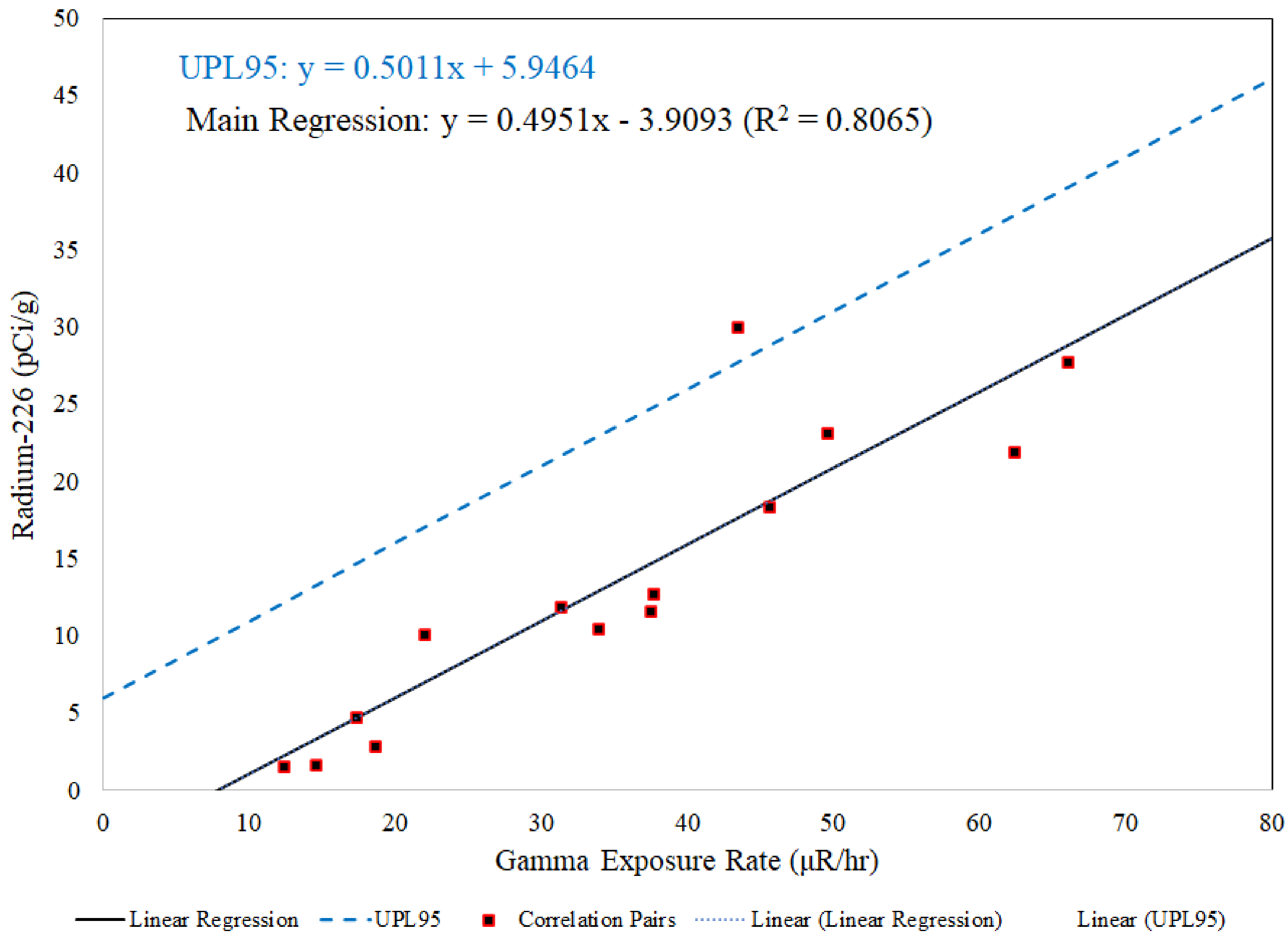

Figure 22 Bluff B Gamma-Radium Correlation Linear Regression Models

4.4 SUBSURFACE INVESTIGATION RESULTS

This section presents results from the subsurface investigation during the 2021 field investigations. Fifteen test pits were excavated as part of this investigation according to the methods described in **Section 3.4**. Soil samples were collected at each test pit, where screening measurements from a downhole gamma detector and hand-held XRF spectrometer also occurred. The following subsections summarize, for each test pit, analytical results, screening results, and photographs, and discuss findings from that test pit. A location map of the 2021 test pits that appears on **Figure 18** above can be used as a reference when reviewing the data and discussion presented herein. A more detailed photographic log of the subsurface investigation is in **Appendix A**. Boring forms filled out for all test pits are in **Appendix F**.

4.4.1 Summarized Results from TP-01

TP-01 was excavated at 0830 MST on August 3, 2021. TP-01 was east of the southern access road onto the top of Bluff B and adjacent to the seasonal pond. The surface elevation of TP-01 was measured at 3,324.0 feet amsl. TP-01 was selected because it was on a prominent mine waste pile on top of Bluff B surrounded by horizontally bedded sandstone outcrop. Aside from characterizing concentrations of constituents of concern and radiation levels, the test pit was used to assess depth of mine waste material above competent bedrock. An aerial photograph of TP-01 is shown on **Figure 23**.

Figure 23 Aerial Photograph of TP-01

The subsurface lithology of TP-01 is described as mine waste extending from the surface to 7.5 feet bgs, followed by bed of lignite coal intermixed with grey clay from 7.5 to 8 feet bgs. The mine waste material consisted of fine to medium sand with abundant ferricrete rock fragments of cemented sand and sandstone with a distinct orangish rock appearance. A mixture of lignite and fine-grained silt and sand, possibly mixed waste, extended from 8 feet bgs to contact with competent bedrock at 11 feet bgs (approximately 3,313 feet amsl). The lignite seam encountered could be native material that exhibits lower arsenic and lower-level radioactivity (i.e., low uranium content) compared to other lignite seams encountered at Bluff B.

A summary of the surface and downhole gamma readings, XRF readings, and soil sample results from TP-01 is in **Table 18**. All downhole gamma readings were unshielded. **Figure 24** is a graphical display of the downhole gamma readings at TP-01 but does not include the 1-meter surface reading because of geometry differences.

Downhole gamma readings decreased steadily from 1-foot bgs (107 µR/hr) to 4 feet bgs (77 µR/hr), where they remained constant until the final measurement at 10 feet bgs (77 µR/hr). Arsenic concentrations, based on raw XRF screening, ranged from 805 ppm (not converted) at ground surface; 1,138 ppm in mine waste collected at 5-6 feet bgs; to 220 ppm in the lignite seam.

Samples were collected at TP1 within 0-6 inches bgs [TP01-SURF-080321], 5-6 feet bgs [TP01-(5'-6')-080321], and 7.5-8 feet bgs [TP01-(7.5'-8')-080321]. The arsenic laboratory concentration was 790 ppm at ground surface and 1,500 mg/kg in mine waste sampled within 5 to 6 feet bgs. A sample collected in this lignite seam indicated the material has low radiological signature, as Ra-226 concentration was 3.7 pCi/g, approximately 35 times lower than the measurement in the surface soil sample.

Based on the detected Ra-226 and arsenic concentrations, and uncertainty whether the lignite was native or intermixed with waste, we consider TP-01 to have revealed waste material from the surface to 11 feet bgs (3,313 feet amsl).

Table 18 Summary of Downhole Gamma Readings at TP-01

Depth (feet bgs)	Downhole Gamma (µR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface	113	805	TP01-SURF-080321	790	131
1	107				
2	92				
3	87				
4	77				
5	73	1138	TP01-(5'-6')-080321	1,500	46.8
6	75				
7	70	220	TP01-(7.5'-8.0')-080321	71	3.7
8	68				
9	72				
10	77				

Notes:

µR/hr	Microroentgens per hour	mg/kg	Milligrams per kilogram	XRF	X-ray fluorescence
bgs	Below ground surface	pCi/g	Picocuries per gram		
ID	Identification	ppm	Parts per million		

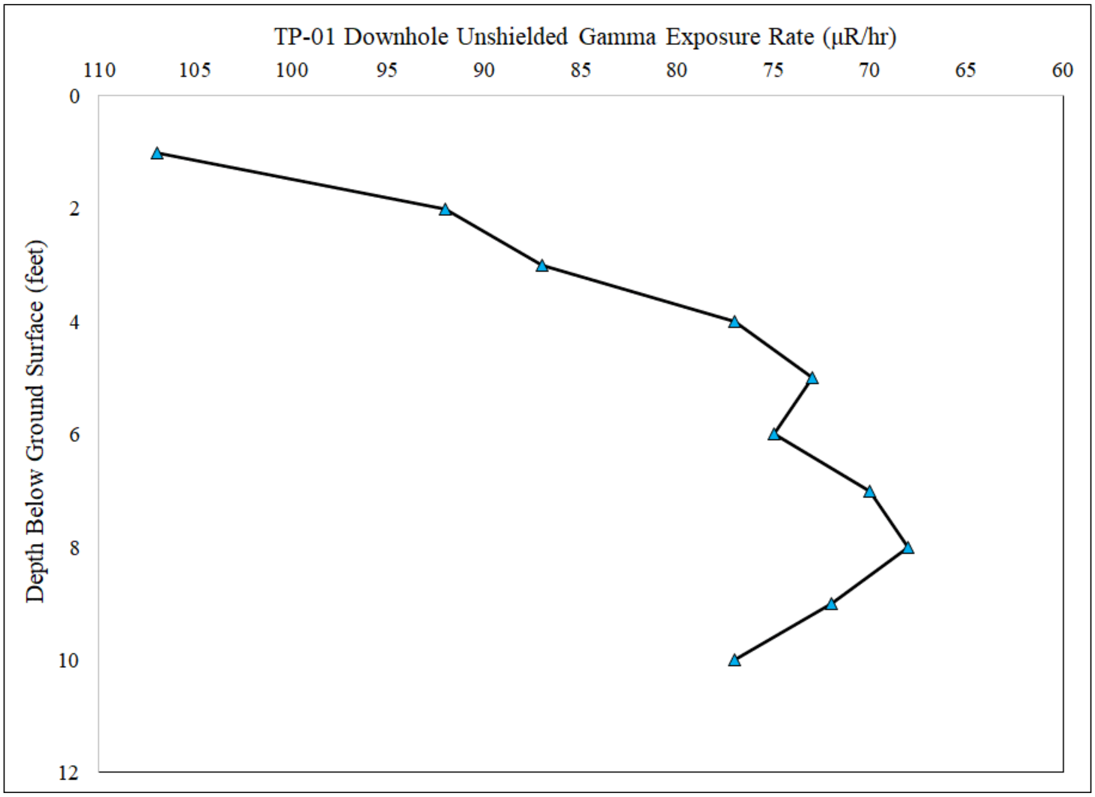

Figure 24 Summary of Downhole Gamma Readings at TP-01

4.4.2 Summarized Results from TP-02

TP-02 was excavated at 0930 MST on August 3, 2021, into waste material similar in appearance to that of TP-01 but approximately 228 feet to the northeast. Expectation was that depth of this test pit would mimic the depth of TP-01 because of its proximity and presence of horizontally bedded sandstone outcrop; however, this test pit depth extended to 16 feet bgs before encounter with competent bedrock. This result indicates that the erosional or "top" surface of the bedrock sandstone is irregular at this location. The approximate surface elevation of the TP-02 test pit was 3,326.6 feet amsl, indicating estimation of the bedrock at 3,310.6 feet amsl (16 feet less than assumed surface elevation). Compared to TP-01, the estimated bedrock surface elevation at TP-02 is 3.6 feet lower. An aerial photograph of TP-02 is on **Figure 25**.

Figure 25 Aerial Photograph of TP-02

The subsurface lithology of TP-02 was similar to TP-01, with the orangish-brown oxidized mine waste material (loose silty/clayey sand and oxidized sandstone rock fragments) at ground surface, grading to brown silty sand to a depth of approximately 5 feet bgs, followed by increasing clay/silt content of mine waste to total depth of 16 feet bgs. Material in the test pit had a mixed or homogenized appearance, indicating it was likely a dumped or mixed mine waste. Results of field screening support this hypothesis.

A summary of the surface and downhole gamma readings, XRF readings, and soil sample results from TP-02 is in **Table 19**. All downhole gamma readings were unshielded. **Figure 26** is a graphical display of the downhole gamma readings at TP-02 but does not include the 1-meter surface reading because of geometry differences.

The 1-meter surface gamma reading at TP-02 was higher (157 μR/hr) than at TP-01 (113 μR/hr). Surface Ra-226 concentration was 130 pCi/g, close to the 131 pCi/g measured at the surface of TP-01. Surface XRF-determined arsenic concentration (non-converted) was 575 ppm, well above the action level for the Site. Downhole gamma readings occurred from 1-foot bgs (264 μR/hr) to 5 feet bgs (225 μR/hr) before dropping off at 6 feet bgs (175 μR/hr) and remaining relatively constant until the final measurement at 16 feet bgs (168 μR/hr). XRF readings ranged from 575 ppm at the surface to 501 ppm within the 3-4 feet bgs interval to 117 ppm at 10-11 feet bgs. Soil samples from TP-02 were collected at the surface within 0-6 inches bgs [TP02-SURF-080321], at 3-4 feet bgs [TP02-(3'-4')-080321], and at 10-11 feet bgs [TP02-(10'-11')-080321]. Subsurface samples were collected to characterize the two layers observed based on downhole gamma readings and field observations.

TP-01 and TP-02 are distinct oxidized mine waste piles or dumps in an area surrounded by notably greyish spoils or waste material on top of Bluff B. Based on gamma readings, TP-02 appeared to reveal a relatively elevated layer of radioactive waste material from 0-5 feet bgs and a less elevated layer of waste material from 5-16 feet bgs until encounter with bedrock. Both Ra-226 and arsenic levels appeared to drop off below 5 feet bgs; however, the entire test pit (0-16 feet bgs) can be classified as waste material based on site waste classification criteria.

Table 19 Summary of Downhole Gamma Readings at TP-02

Depth (feet bgs)	Downhole Gamma (μR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	157	575	TP02-SURF-080321	520	130
1	264				
2	275				
3	294	501	TP02-(3'-4')-080321	730	141
4	225				
5	225				
6	175				
7	166				
8	155				
9	150				
10	125	117	TP02-(10'-11')-080321	140	16.2
11	112				
12	111				
13	146				
14	123				
15	121				
16	168				

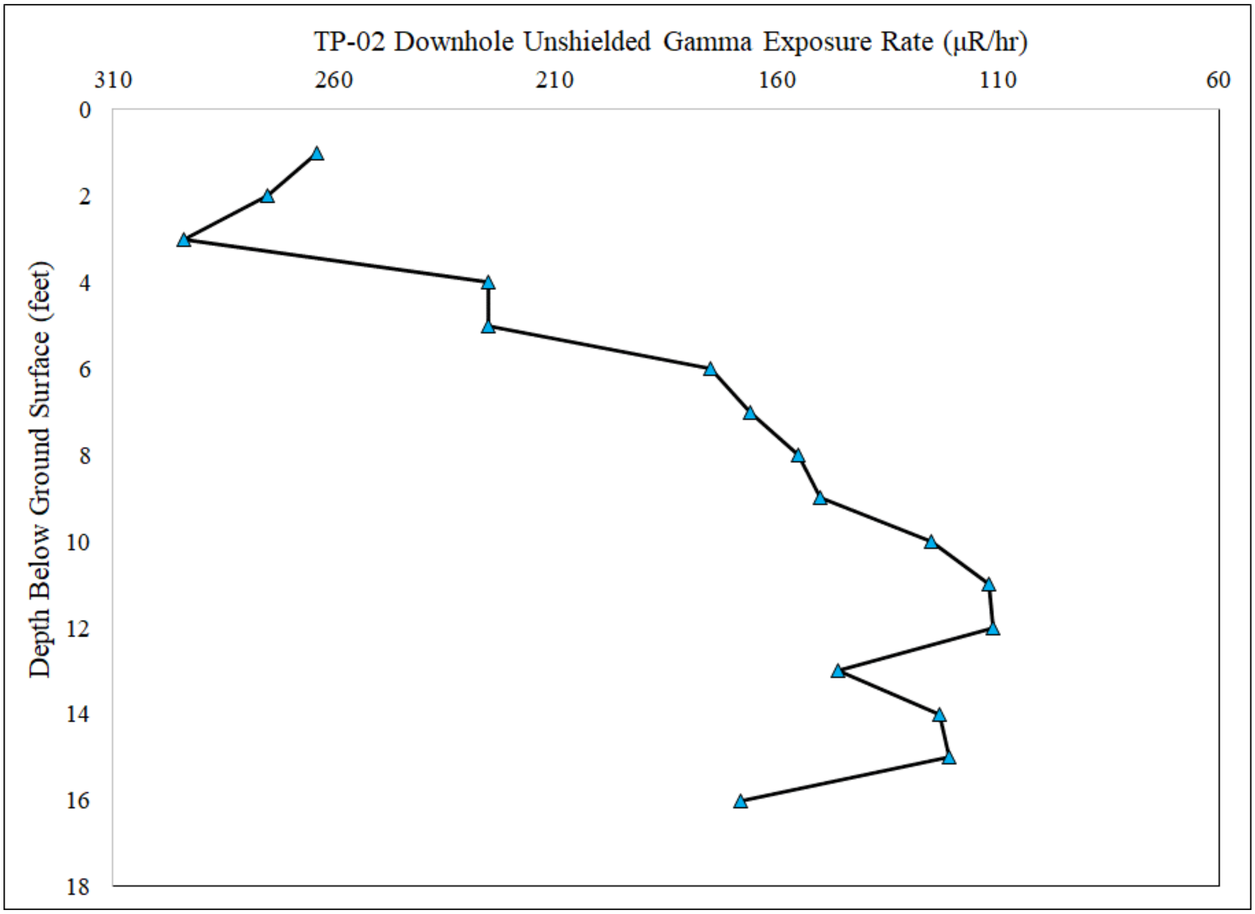

Figure 26 Summary of Downhole Gamma Readings at TP-02

4.4.3 Summarized Results from TP-03

TP-03, excavated at 1020 MST on August 3, 2021, was approximately 330 feet to the northeast of TP-02 at a location not previously proposed in the SAP. TP-03 was selected in a spoils area of interest on top of Bluff B to provide additional coverage between the 2020 subsurface investigation and the 2021 subsurface investigation. The surface elevation of TP-03 was measured at 3,330.2 feet amsl. Bedrock was not encountered to the maximum reach of the excavator (approximately 16 feet to 17 feet bgs). An aerial photograph of TP-03 is on **Figure 27**.

Figure 27 Aerial Photograph of TP-03

The subsurface lithology of TP-03 included materials that consisted of grey silt/clay with broken grey mudstone and siltstone fragments to 4 feet bgs, underlain by a mixture of lignite and silty clay mine waste or spoils to 14 feet bgs, underlain by unconsolidated yellowish tan sandy silt (likely native) to maximum excavation depth of 16 to 17 feet bgs.

A summary of the surface and downhole gamma readings, XRF readings, and soil sample results from TP-03 is in **Table 20**. All downhole gamma readings were unshielded. **Figure 28** is a graphical display of downhole gamma readings at TP-03 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma reading at TP-03 was 43 μR/hr, and XRF-determined arsenic concentration was 232 ppm.

Downhole gamma readings increased from ground surface (43 μR/hr) to a maximum of 82 μR/hr in mine waste at 6 feet bgs, and then gradually diminished with depth to a low reading of 34 μR/hr at 19 feet bgs. XRF readings ranged from 232 ppm at the surface, to 262 ppm at the 5-6 feet bgs interval, to a low of 23 ppm at 14-15 feet bgs.

Soil samples from TP-03 were collected at the surface 0-6 inches bgs [TP03-SURF-080321], at 5 to 6 feet bgs [TP03-(5'-6')-080321], and at 14 to 15 feet bgs [TP03-(14'-15')-080321]. A blind field duplicate [TP-(DUP)-01-080321] was collected from the same grab sample material as [TP03-(14'-15')-080321]. Subsurface samples were collected to characterize the mine waste where the XRF reading for arsenic was highest and where native sand material at depth indicated lowest impact. The highest arsenic concentration in the lab samples (290 mg/kg) corresponded to the highest XRF arsenic reading (262 ppm) at 5 to 6 feet bgs.

Based on a visual change in material type, detected arsenic concentrations, and downhole gamma readings, TP-03 revealed waste material to 14 feet bgs (3,316 feet amsl).

Table 20 Summary of Downhole Gamma Readings at TP-03

Depth (feet bgs)	Downhole Gamma (µR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	43		TP03-(SURF)-080321	240	16.5
1	47				
2	53				
3	65				
4	70				
5	75		TP03-(5'-6')-080321	290	85
6	82				
7	72				
8	73				
9	55				
10	53				
11	53				
12	50				
13	51				
14	38		TP03-(14'-15')-080321	29	0.98
15	34				
16	34				

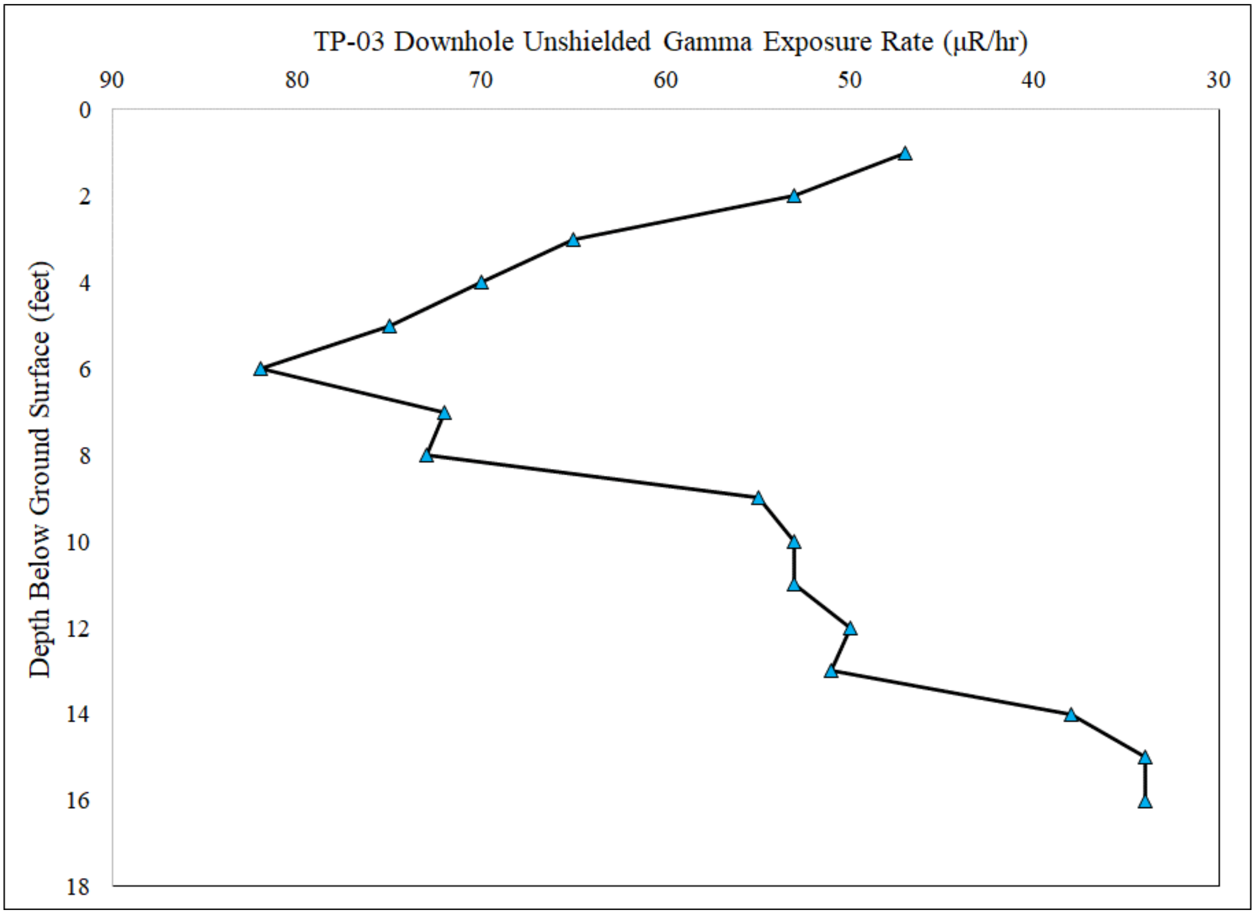

Figure 28 Summary of Downhole Gamma Readings at TP-03

4.4.4 Summarized Results from TP-04

TP-04, excavated at 1115 MST on August 3, 2021, was approximately 240 feet southeast from TP-03, and located in spoils or mine waste, but closer to the southeastern cliff face on top of Bluff B. Surface elevation of TP-04 was measured at 3,338.0 feet amsl. Bedrock was not encountered to the maximum reach of the excavator (approximately 17 feet bgs). An aerial photograph of TP-04 is on **Figure 29**.

Figure 29 Aerial Photograph of TP-04

Subsurface lithology at TP-04 consisted of grey silt/clay with broken grey mudstone and siltstone fragments at ground surface underlain by brown loosely compacted mine waste consisting of brown sandy silt with rock fragments to 15 feet bgs, underlain by light brown to tan very fine sand with silt (possibly native material).

A summary of the surface and downhole gamma readings, XRF readings, and soil sample results from TP-04 is in **Table 21**. All downhole gamma readings were unshielded. **Figure 30** is a graphical display of the downhole gamma readings at TP-04 but does not include the 1-meter surface reading due to geometry differences.

The surface gamma reading at TP-04 was 28 μR/hr, and the XRF-determined arsenic concentration was 147 ppm. Downhole gamma readings increased slightly from 1-foot bgs (38 μR/hr) to 5-foot bgs (59 μR/hr), remained fairly steady, and then dropped off at 15 feet bgs (48 μR/hr) when native contact assumedly occurred. XRF readings ranged from 147 ppm at the surface, to 91 ppm at the 5 to 6 feet bgs interval, to a low of 46 ppm at 15 to 16 feet bgs.

Soil samples from TP-04 were collected at the surface 0-6 inches bgs [TP04-SURF-080321], at 5 to 6 feet bgs [TP04-(5'-6')-080321], and at 15 to 16 feet bgs [TP04-(15'-16')-080321]. The subsurface samples were collected from mine waste where the gamma reading was highest (at 5 to 6 feet bgs) and from the presumed native sandy silty clay material at depth representing the lowest impact. The highest arsenic concentration in the lab samples (180 mg/kg at 5 to 6 feet bgs) did not correspond to the highest XRF arsenic reading (147 ppm at ground surface).

Based on a detected surface arsenic concentration and downhole gamma readings, TP-04 should be considered to have revealed waste material to 15 feet bgs.

Table 21 Summary of Downhole Gamma Readings at TP-04

Depth (feet bgs)	Downhole Gamma (μR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	28	147	TP04-(SURF)-080321	150	5.53
1	38				
2	30				
3	45				
4	45				
5	59	91	TP04-(5'-6')-080321	180	8.9
6	53				
7	58				
8	61				
9	55				
10	65				
11	71				
12	65				
13	59				
14	53				
15	48	46	TP04-(15'-16')-080321	44	3.62
16	47				

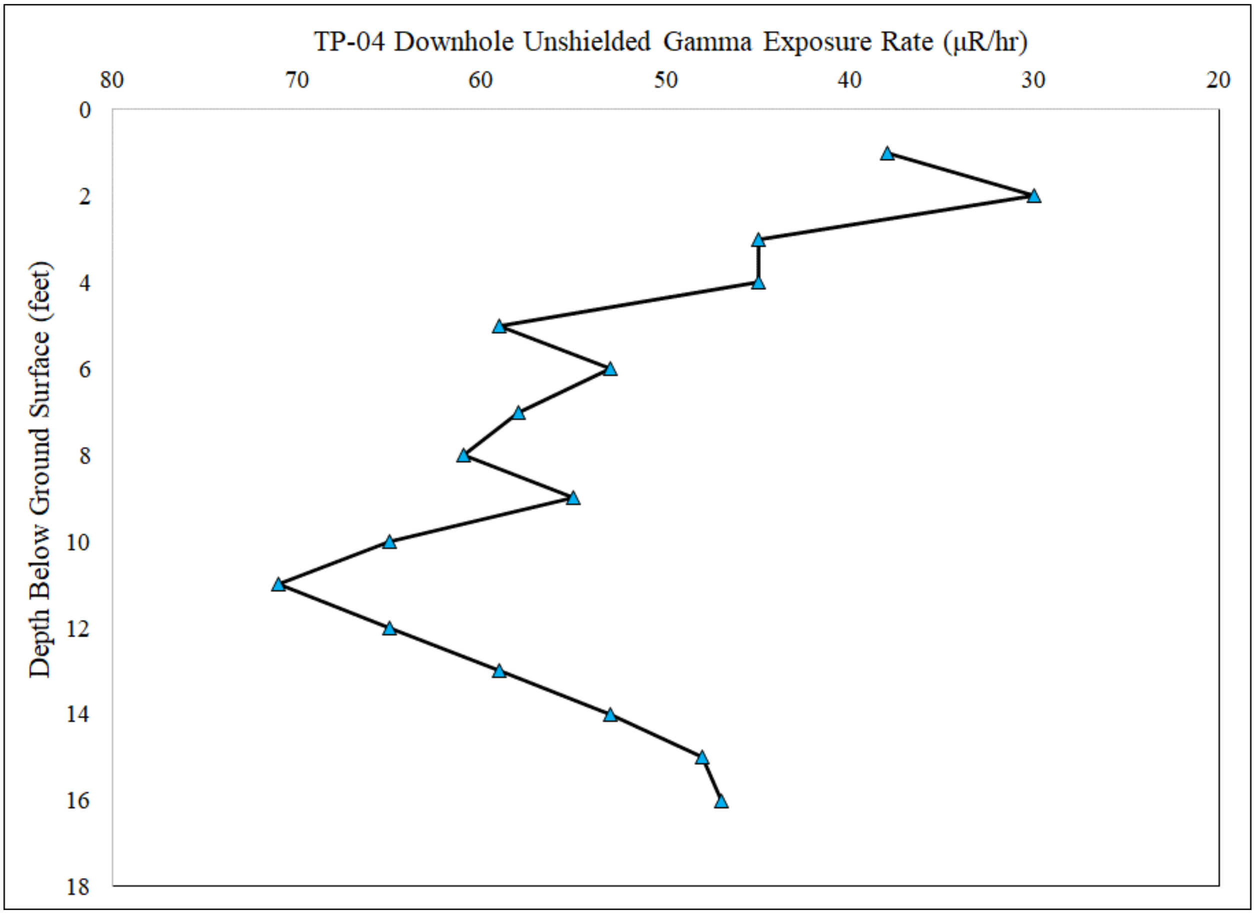

Figure 30 **Summary of Downhole Gamma Readings at TP-04**

4.4.5 Summarized Results from TP-05

TP-05, excavated at 1230 MST on August 3, 2021, was 345 feet west of TP-04 and still located in mine waste material on top of Bluff B. Surface elevation of TP-05 was measured at 3,331.8 feet amsl. Bedrock was encountered at approximately 19 feet bgs—estimated at 3,312.8 feet amsl (19 feet less than assumed surface elevation). An aerial photograph of TP-05 is on **Figure 31**.

Figure 31 Aerial Photograph of TP-05

Subsurface lithology at TP-05 can be described as materials consisting of a mixture of grey silt/clay and lignite at the ground surface underlain by greyish brown silty clay with alternating thin deposits of dark grey to black lignite and silty clay mixtures to 18 feet bgs. The material type changed to a yellowish tan sand at 18 feet bgs, grading to reddish tan sandstone bedrock (native) at 19 feet bgs.

A summary of the surface and downhole gamma readings, XRF readings, and soil sample results from TP-05 is in **Table 22**. All downhole gamma readings were unshielded. **Figure 32** is a graphical display of the downhole gamma readings at TP-05 but does not include the 1-meter surface reading because of geometry differences.

Surface gamma exposure rate at TP-05 was 108 μR/hr. Surface XRF-determined arsenic concentration was 283 ppm. Downhole gamma readings increased from 1-foot bgs (168 μR/hr) to a maximum of 500 μR/hr in mine waste at 7 feet bgs, before rapidly tapering off to 78 μR/hr at 16 feet bgs. Soil samples from TP-05 were collected at the surface 0-6 inches bgs [TP05-SURF-080321], and at the base of the excavation at 18 to 19 feet bgs [TP05-(18'-19')-080321]. The surface soil samples were collected to represent the materials in the entire test pit from the surface to 18 feet bgs before encounter with native material. Based on a surface arsenic concentration and downhole gamma readings, TP-05 is considered to have revealed waste material to contact with bedrock at 18 feet bgs.

Table 22 Summary of Downhole Gamma Readings at TP-05

Depth (feet bgs)	Downhole Gamma (μR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	108	283	TP05-(SURF)-080321	310	111
1	168				
2	210				
3	217				
4	194				
5	221				
6	333				
7	500				
8	256				
9	263				
10	388				
11	285				
12	179				
13	138				
14	115				
15	87				
16	78				
17	-				
18	-	34	TP05-(18'-19')-080321	43	14.7
19	-				

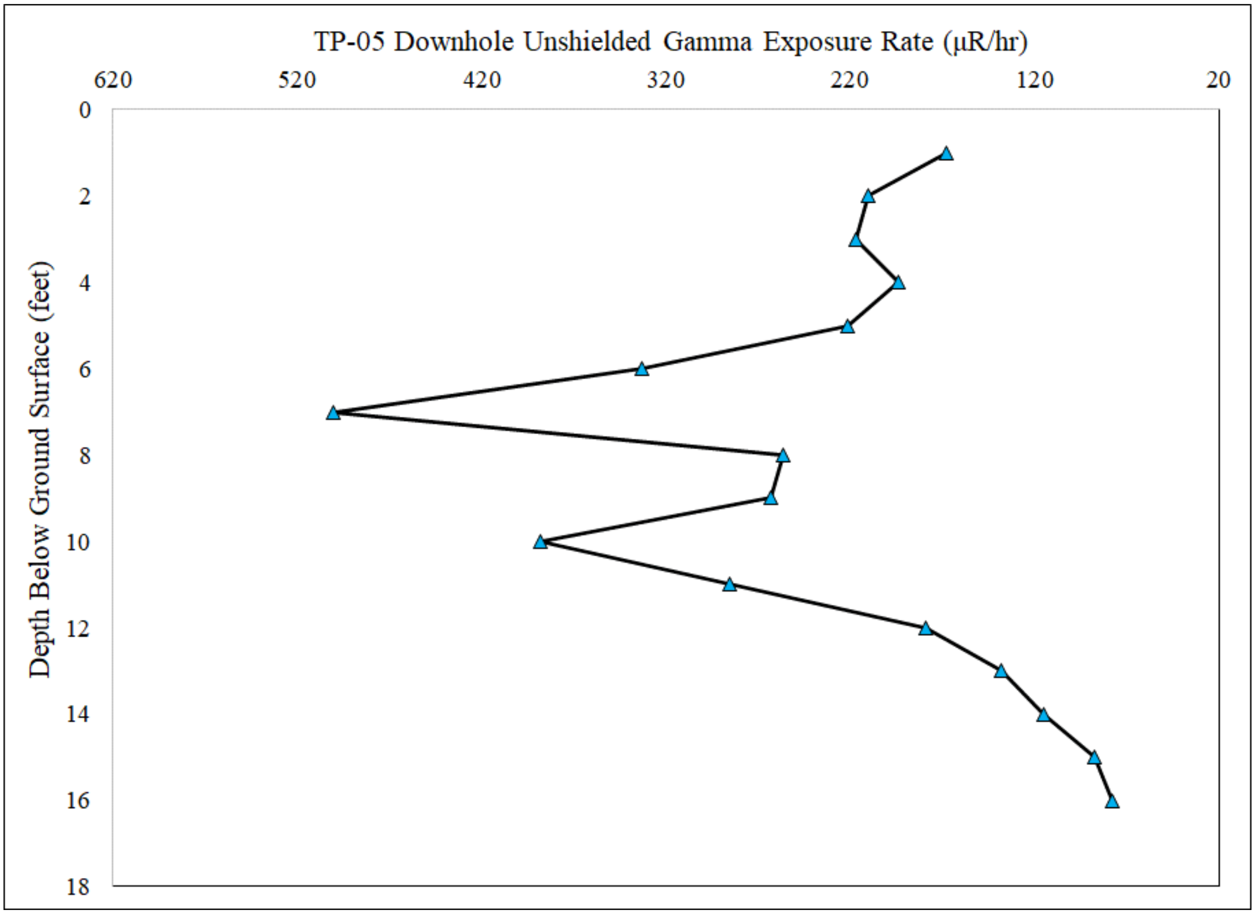

Figure 32 Summary of Downhole Gamma Readings at TP-05

4.4.6 Summarized Results from TP-06

TP-06, excavated at 1330 MST on August 3, 2021, was 211 feet southwest of TP-05, close to the edge of Bluff B within a spoils/mine waste material zone and near the access road to the top of Bluff B. Surface elevation of TP-06 was 3,331.7 feet amsl. Bedrock was not encountered to the full reach of the excavator. An aerial photograph of TP-06 is on **Figure 33**.

Figure 33 Aerial Photograph of TP-06

Subsurface lithology of TP-06 consisted of mine waste/spoils mixture of sand, silt/clay, and rock fragments of sandstone and siltstone to 12 feet bgs, underlain by a seam of mixed lignite and clay to 17 feet bgs, underlain by native silty sand and weakly cemented sandstone to the maximum depth of reach at 19 feet bgs.

A summary of surface and downhole gamma readings, XRF readings, and soil sample results from TP-06 is in **Table 23**. All downhole gamma readings were unshielded. **Figure 34** is a graphical display of the downhole gamma readings at TP-06 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma exposure rate at 1-meter ags was 69 μR/hr, and the XRF-determined arsenic concentration was 117 ppm. Gamma readings were elevated at 1-foot bgs (239 μR/hr), declined steadily to 14 feet bgs (133 μR/hr) and continued to decline until the last measurement at 16 feet bgs. XRF-determined arsenic concentrations ranged from 117 ppm at ground surface to a low of 17 ppm at the base of the excavation at 17 to 18 feet bgs.

Soil samples from TP-06 were collected at the surface 0 to 6 inches bgs [TP06-SURF-080321], at 11 to 12 feet bgs in the lignite seam [TP06-(11’-12’)-080321], and in native sand and sandstone 17 to 18 feet bgs [TP06-(17’-18’)-080321].

Based on field observations and downhole gamma readings, TP-06 should be considered to have revealed waste material to total depth of excavation at 11 feet bgs, where an elevated lignite seam was encountered.

Table 23 Summary of Downhole Gamma Readings at TP-06

Depth (feet bgs)	Downhole Gamma (μR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	69	117	TP06-(SURF)-080321	100	10.8
1	239				
2	298				
3	280				
4	233				
5	229				
6	238				
7	188				
8	165				
9	155				
10	148				
11	163		TP06-(11'-12')-080321	15	1.83
12	258				
13	232				
14	133				
15	92				
16	82				
17	-		TP06-(17'-18')-080321	18	1.25
18	-				
19	-				

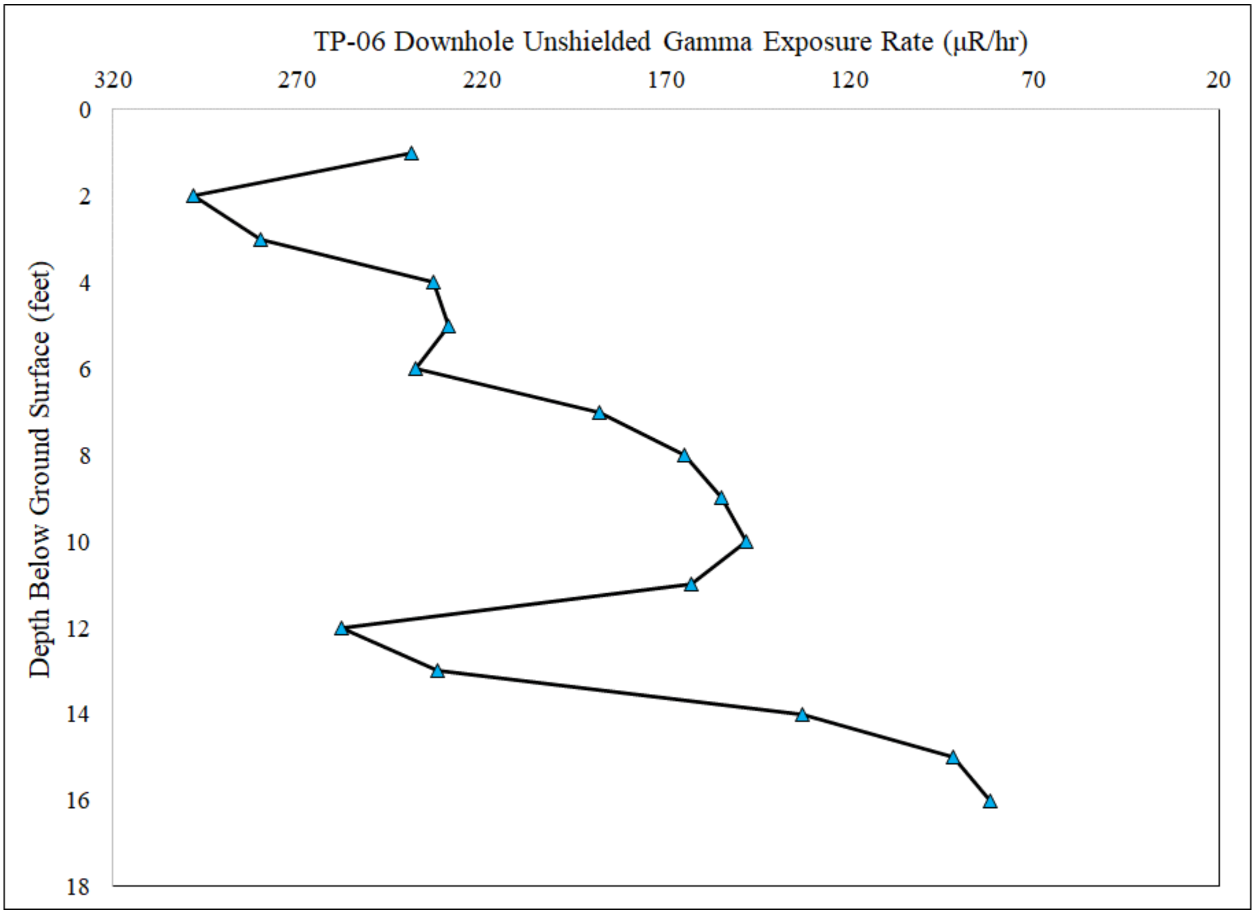

Figure 34 Summary of Downhole Gamma Readings at TP-06

4.4.7 Summarized Results from TP-07

TP-07, excavated at 1500 MST on August 3, 2021, was at the edge of the seasonal pond off the access road. Surface elevation of TP-07 was 3,315 feet amsl. Competent bedrock in TP-07 was encountered at 2 feet bgs, indicating bedrock elevation at 3,313 feet amsl (2 feet less than assumed surface elevation). This is the identical elevation encountered at TP-01 295 feet east of TP-07. The 2-foot depth of material encountered consisted of brown sandy silt spoils mixed with brown lignite. An aerial photograph of TP-07 is on **Figure 35**.

Figure 35 Aerial Photograph of TP-07

Only a surface soil sample was collected at this location [TP07-(SURF)-080321]. Ra-226 soil concentration at this location was 10.1 pCi/g, much higher than background but less than the project action level for Ra-226 (30 pCi/g). However, arsenic concentration was 340 mg/kg at this location. Based on laboratory results from this sample indicating elevated arsenic concentration, depth of removal should be assumed 2 feet bgs (at bedrock).

4.4.8 Summarized Results from TP-08

TP-08, excavated at 1515 MST on August 3, 2021, was slightly uphill from TP-07 within an area of possible (1) vegetated spoils, and (2) materials placed from previous construction activities or sediment pond excavation activities. Surface elevation at TP-08 was measured at 3,328.3 feet amsl, 13 feet higher than at TP-07. The material type encountered consisted of saturated dark brown silt and clay spoils, confirming that the deposit derived from pond sediments. An aerial photograph of TP-08 is on **Figure 36**.

Figure 36 Aerial Photograph of TP-08

The first excavation at this location started collapsing at 9 to 10 feet bgs due to liquefaction within the predominantly moist soils encountered beneath the surface. No downhole gamma survey or XRF field screen sample collection for vertical profiling occurred due to safety concerns. However, two samples for laboratory analysis were quickly collected at ground surface and within the 9- to 10-feet bgs interval before the pit collapsed. A second test pit at this location was advanced to 3 feet bgs for collection of sidewall samples in order to field-screen shallow subsurface material.

The surface soil sample collected at this location [TP08-(SURF)-080321] contained Ra-226 at 9 pCi/g, below the action level. However, the surface sample also contained an arsenic concentration of 350 mg/kg and compared to the field screened XRF result of 235 ppm. The subsurface lab sample collected at this location [TP08-(9'-10')-080321] contained Ra-226 at 4.5 pCi/g and arsenic at 29 mg/kg—both below their action levels. However, this area of Bluff B may contain intermixed waste and should be considered contaminated to 13 feet bgs or deeper.

4.4.9 Summarized Results from TP-09

TP-09, the last test pit excavated at 1620 MST on August 3, 2021, was in the west central portion of Bluff B, immediately south of the access road at the edge of erosional badland topography. The test pit was advanced into what appeared to be a mine waste/spoils dump, superimposed over native badland material, at the head end of Schleichart Draw. Surface elevation at TP-09 was measured at 3,310.0 feet amsl. Bedrock was not encountered to the full reach of the excavator (18 feet bgs). An aerial photograph of TP-01 is on **Figure 37**.

Figure 37 Aerial Photograph of TP-09

Subsurface lithology at TP-09 consisted of spoils mixture of dark brown sandy silt spoils with angular rock fragments to 2.5 feet bgs, underlain by yellowish brown sandy silty clay to at least 18 feet bgs.

A summary of the surface and downhole gamma readings, XRF readings, and soil sample results from TP-09 is in **Table 24**. All downhole gamma readings were unshielded. **Figure 38** is a graphical display of the downhole gamma readings at TP-09 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma reading was 26 µR/hr, and the XRF-determined arsenic concentration was 163 ppm. Downhole gamma readings remained consistent with depth, ranging from 26 to 22 µR/hr. Soil samples from TP-09 were collected at the surface 0-6 inches bgs [TP09-SURF-080321] and at 6- to 7-feet bgs in mine waste/spoils [TP09-(6'-7')-080321]. The laboratory sample from the surface contained 9.3 mg/kg Ra-226 and 220 mg/kg arsenic. The laboratory sample from 6- to 7-feet bgs contained 1.8 pCi/g Ra-226 and 64 mg/kg arsenic. The XRF arsenic reading at 6- to 7- feet bgs was 39 ppm. While Ra-226 and gamma exposure were low here, the arsenic concentration in the upper dumped material to 2.5 feet bgs exceeded the Site screening criterion; thus, that material from ground surface to 2.5 feet bgs (3,307.5 feet amsl) should be considered waste. The potential for mine waste mixed with dumped mine spoils exists anywhere along the former cliff face on Bluff B, so this dump profile should not necessarily be representative of the dumped material in Schleichart Draw.

Table 24 Summary of Downhole Gamma Readings at TP-09

Depth (feet bgs)	Downhole Gamma (µR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	26	163	TP09-(SURF)-080321	220	9.3
1	26				
2	24				
3	22				
4	22				
5	24				
6	23	39	TP09-(6'-7')-080321	64	1.82
7	24				
8	25				
9	25				
10	24				
11	25				
12	25				
13	26				
14	26				
15	26				

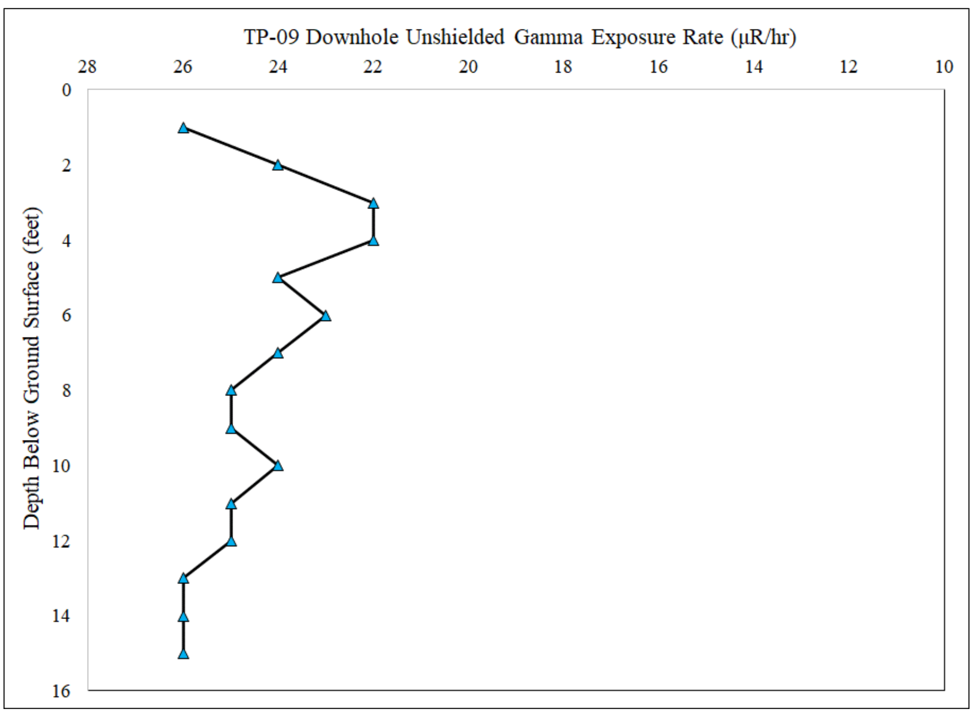

Figure 38 Summary of Downhole Gamma Readings at TP-09

4.4.10 Summarized Results from TP-10

TP-10, the first test pit excavated on August 4, 2021, at 0815 MST, was in an area of Bluff B presumed constructed as a waste rock repository of non-native material from previous pond cleanouts or reclamation activities. Surface elevation at TP-10 was 3,332.3 feet amsl, and bedrock was not encountered during the excavation to the maximum reach depth of 19 feet bgs. An aerial photograph of TP-10 is on **Figure 39**, with the outline of the trapezoidal-shaped pond sediment repository clearly visible in the near background.

Figure 39 Aerial Photograph of TP-10

Subsurface lithology at TP-10 consisted of dry loosely compacted waste rock/spoils from ground surface to 2.5 feet bgs, underlain by the same material with increasing moisture and compaction level to 15 feet bgs, underlain by a 1-foot-thick black lignite seam from 15 to 16 feet bgs, underlain by moist brown sand with silt to the maximum reach of the excavator at 19 feet bgs.

A summary of surface and downhole gamma readings, XRF readings, and soil sample results from TP-10 is in **Table 25**. All downhole gamma readings were unshielded. **Figure 40** is a graphical display of the downhole gamma readings at TP-10 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma exposure rate was 26 μR/hr and surface XRF-determined arsenic concentration was 22 ppm, both indicating low-level contamination. The surface soil sample [TP10-SURF-080421] at this location confirmed this assumption, yielding an arsenic concentration of 24 mg/kg and a Ra-226 concentration of 2.71 pCi/g. Downhole gamma measurements slowly increased until encounter with the lignite seam at 15 feet bgs. Another soil sample, collected in the spoils at 6 to 7 feet bgs [TP10-(6’-7’)-080421], also yielded low concentrations of arsenic and Ra-226, respectively at 19 and 5.04 pCi/g. A third sample, [TP10-(15’-16’)-080421], collected at the lignite seam, yielded elevated concentrations of arsenic (280 mg/kg) and Ra-226 (189 pCi/g).

Based on downhole gamma readings and laboratory arsenic results, TP-10 should be considered to have revealed spoils material with low contaminant concentrations to the naturally occurring lignite seam at 15 feet bgs. The lignite seam was found to contain elevated gamma radiation and arsenic levels that exceed action levels, which may require evaluation if the pond repository is relocated during Site reclamation activities. Because this area of the Site indicated potential presence of intermixed mine waste material containing elevated concentrations, TP-11 was advanced near TP-10.

Table 25 Summary of Downhole Gamma Readings at TP-10

Depth (feet bgs)	Downhole Gamma (µR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	16	22	TP10-(SURF)-080421	24	2.71
1	26				
2	30				
3	33				
4	37				
5	42				
6	48		TP10-(6'-7')-080421	19	5.04
7	51				
8	56				
9	66				
10	75				
11	86				
12	102				
13	125				
14	166				
15	303	320	TP10-(15'-16')-080421	280	189
16	120				

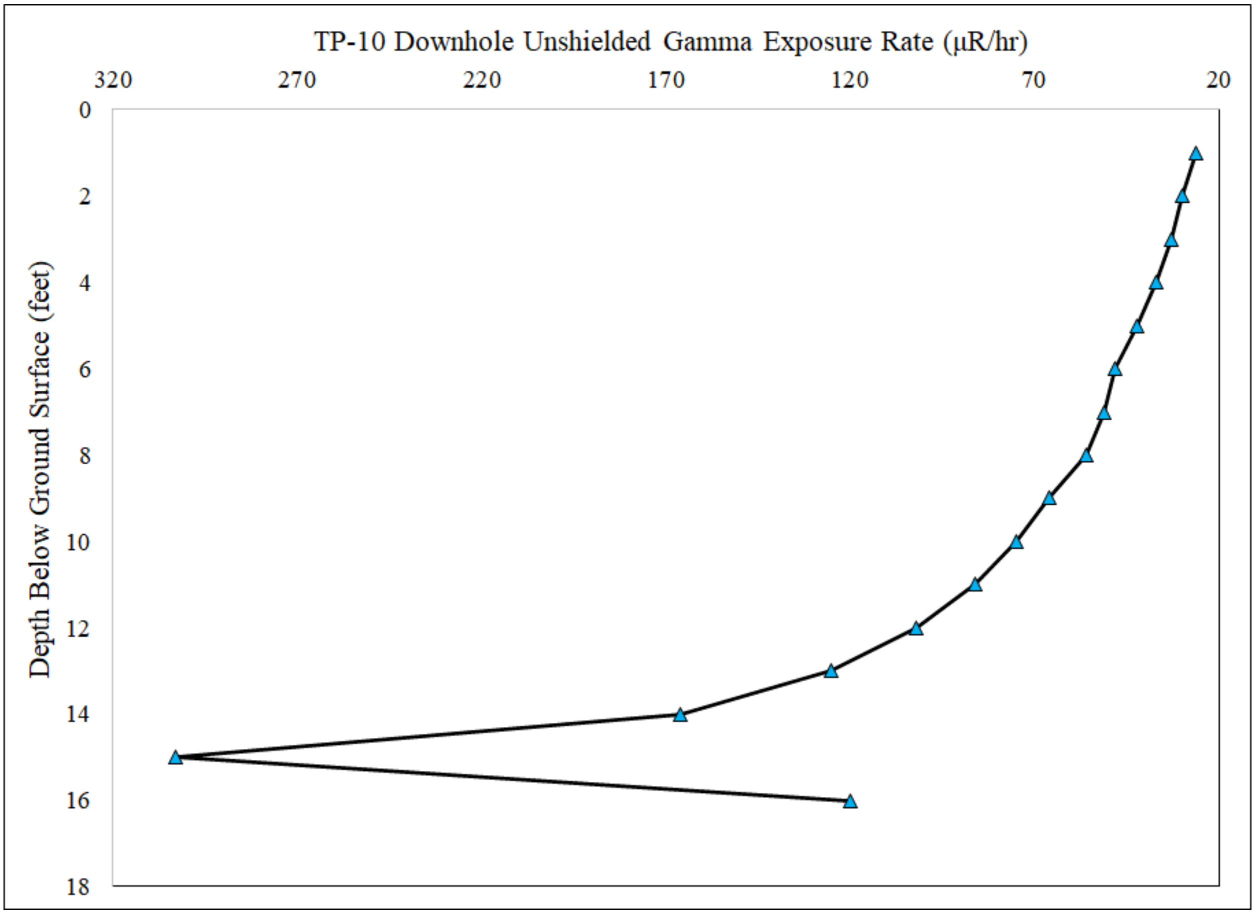

Figure 40 Summary of Downhole Gamma Readings at TP-10

4.4.11 Summarized Results from TP-11

TP-11, excavated at 0930 MST on August 4, 2021, was 211 feet north of TP-10 in an area of Bluff B also presumed to host a constructed waste rock repository of non-native material from previous pond cleanouts or reclamation activities. Surface elevation of TP-11 was measured at 3,349.5 feet amsl, 17.2 feet higher than the surface elevation of TP-10. Competent bedrock was not encountered to the maximum depth of excavation. Saturated conditions and sloughing limited the excavation depth to 17 feet bgs. An aerial photograph of TP-11 is on **Figure 41**.

Figure 41 Aerial Photograph of TP-11

Similar to TP-10, the lithology at TP-11 consisted of dry, loosely compacted mine waste/spoils from ground surface to 3.5 feet bgs, underlain by black moist to saturated clay (possibly pond sediments) to 17 feet bgs. Due to the higher elevation here, the natural lignite seam was not encountered.

A summary of surface and downhole gamma readings, XRF readings, and soil sample results from TP-11 is in **Table 26**. All downhole gamma readings were unshielded. **Figure 42** is a graphical display of the downhole gamma readings at TP-11 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma exposure rate was 16 μR/hr, and the surface XRF-determined arsenic concentration was 49 ppm—both indicating low-level contamination. The surface soil sample [TP11-SURF-080421] at this location confirmed this assumption, yielding an arsenic concentration of 25 mg/kg and a Ra-226 concentration of 3.34 pCi/g. Downhole gamma measurements were consistently low to 15 feet bgs. Another soil sample collected in the spoils at 5-6 feet bgs [TP11-(5'-6')-080421] also yielded low concentrations of arsenic and Ra-226, respectively at 7.5 and 1.61 pCi/g.

Based on laboratory and field screening results, material in this area of Bluff B should be considered clean (containing contaminant concentrations less than maximum soil screening concentrations). However, similar to TP-10, this area could host intermixed waste materials with elevated contaminant concentrations, although no sample collected at TP-10 or TP-11 induced an elevated reading.

Table 26 Summary of Downhole Gamma Readings at TP-11

Depth (feet bgs)	Downhole Gamma (µR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	15	49	TP11-(SURF)-080421	25	3.34
1	19				
2	20				
3	20				
4	21				
5	22	< 10	TP11-(5'-6')-080421	7.5	1.61
6	22				
7	24				
8	27				
9	27				
10	28				
11	26				

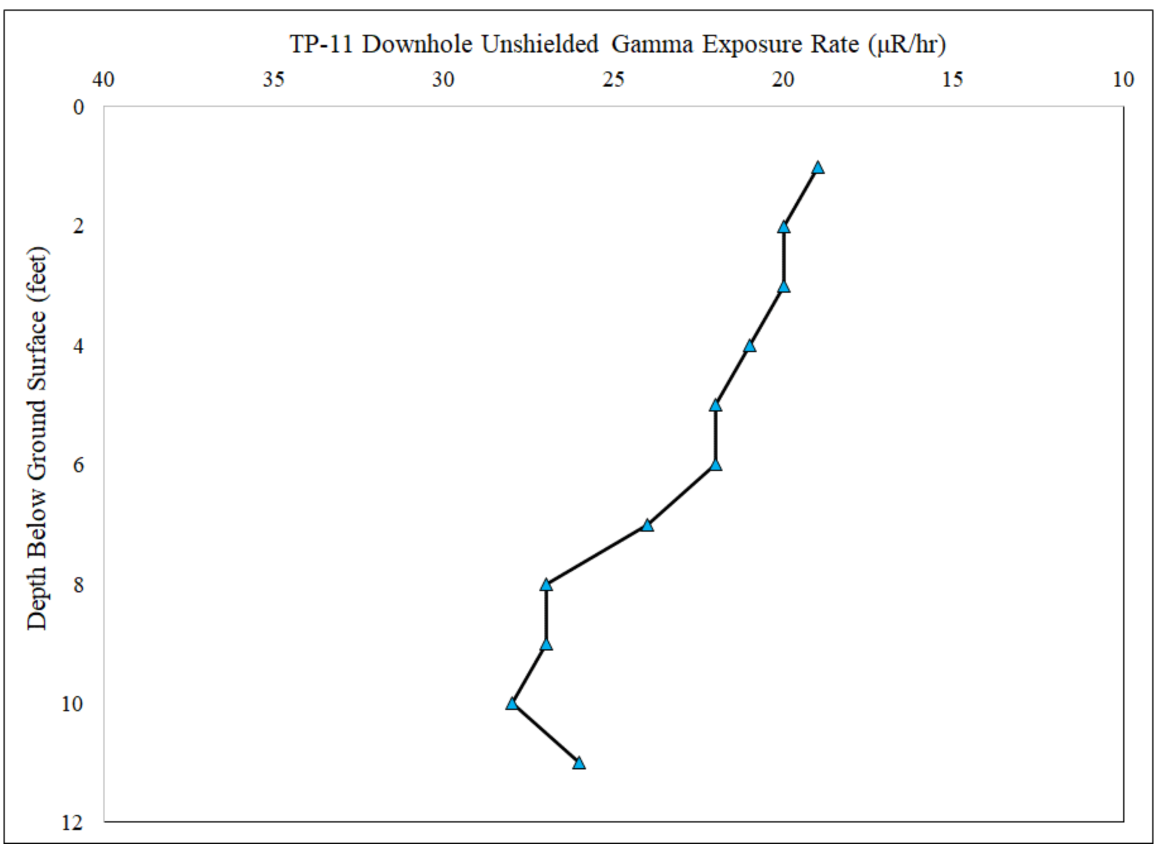

Figure 42 Summary of Downhole Gamma Readings at TP-11

4.4.12 Summarized Results from TP-12

TP-12 was excavated at 1045 MST on August 4, 2021, to investigate a possible waste rock dump on the edge of a cliff sloping down into badland sediments in the headwater of Schleichart Draw upstream of the USFS office location (southwest portion of Bluff B). Surface elevation of TP-12 was measured at 3,307.7 feet amsl, and bedrock was not encountered during the excavation to the maximum depth of 19 feet bgs. Bedrock was not encountered to the maximum reach of the excavator. An aerial photograph of TP-12 is on **Figure 43**.

Figure 43 Aerial Photograph of TP-12

The lithology at TP-12 consisted of brown silt, broken rock mine waste material to 4 feet bgs, followed by yellowish tan silt/clay with embedded angular gravel to the bottom of the pit at 19 feet bgs. The yellowish tan silt and clay sediment below 4 feet bgs appeared stratified or thinly bedded, implying native material.

A summary of surface and downhole gamma readings, XRF readings, and soil sample results from TP-12 is in **Table 27**. All downhole gamma readings were unshielded. **Figure 44** is a graphical display of the downhole gamma readings at TP-12 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma exposure rate was 122 μR/hr and the XRF-determined arsenic concentration was 440 ppm. The surface soil sample collected at TP-12 [TP12-SURF-080421] yielded an arsenic concentration of 470 mg/kg and a Ra-226 concentration of 192 pCi/g. This sample was intended to represent the waste material observed between the surface and 4 feet bgs, where native material induced low-level arsenic and gamma readings. Downhole elevated gamma measurements remained relatively constant between 1 foot bgs and 4 feet bgs, and then dropped off sharply to the end of the test pit. Another sample collected within 8-9 feet bgs [TP12-(8'-9')-080421 was labeled as TP15-(8'-9')-080421 in the lab report by mistake]; it yielded an arsenic concentration of

38 mg/kg and Ra-226 concentration of 7.6 pCi/g, confirming dropoff of levels of contamination beyond 4 feet bgs.

Based on laboratory and field screening results, this area of Bluff B should be considered to host mine waste to 4 feet bgs (approximately 3,304 feet amsl), and clean material underneath.

Table 27 Summary of Downhole Gamma Readings at TP-12

Depth (feet bgs)	Downhole Gamma (μR/hr)	XRF Arsenic (ppm)	Soil Sample ID[1]	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	122	440	TP12-(SURF)-080421	470	192
1	175				
2	142				
3	138				
4	175				
5	107				
6	88				
7	70				
8	58	42	TP12-(8'-9')-080421	38	7.6
9	49				
10	47				
11	47				
12	45				
13	51				
14	51				
15	53				

Note:
[1] Sample TP12-(8’-9’)-080421 was mislabeled as TP15-(8’-9’)-080421.

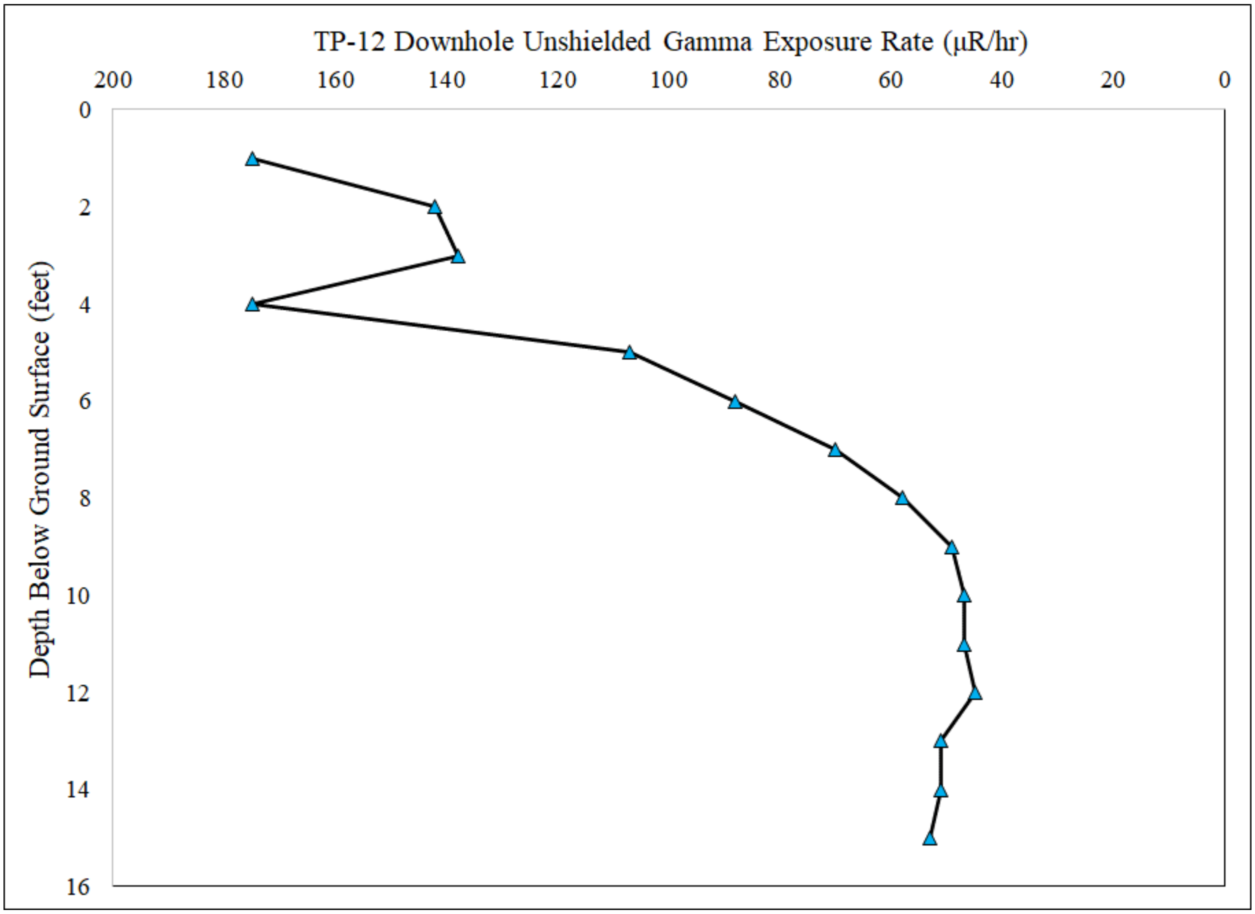

Figure 44 Summary of Downhole Gamma Readings at TP-12

4.4.13 Summarized Results from TP-13

TP-13, excavated at 1150 MST on August 4, 2021, was on a finger mesa off Bluff B near the head of Schleichart Draw suspected to a mine spoils dump area with low surficial radiological and arsenic levels. The test pit was advanced at this location to explore subsurface conditions. Other areas at Bluff B could be similar to this, where surface contaminant concentrations appear low, but waste materials containing elevated contaminant concentrations are present in the subsurface. Surface elevation of TP-13 was measured at 3,323.4 feet amsl, and bedrock was encountered at 14.5 feet bgs (3,308.9 feet amsl). An aerial photograph of TP-13 is on **Figure 45**.

Figure 45 Aerial Photograph of TP-13

Subsurface lithology at TP-13 consisted of low-level (arsenic and Ra-226) mine spoils (dry and somewhat loosely compacted) to 3.5 feet bgs, underlain by what appeared to be more elevated (from downhole gamma) mine waste consisting of silty clay with sand and angular rock fragments to 14.5 feet bgs, where sandstone bedrock was encountered.

A summary of surface and downhole gamma readings, XRF readings, and soil sample results from TP-13 is in **Table 28**. All downhole gamma readings were unshielded. **Figure 46** is a graphical display of the downhole gamma readings at TP-13 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma exposure rate was 18 μR/hr, and the surface XRF arsenic reading was 51 ppm—both below action levels. This was confirmed by analytical results from the surface soil sample [TP13-SURF-080421], which indicated an arsenic concentration of 53 mg/kg and Ra-226 concentration of 4.82 pCi/g.

The downhole gamma reading at 1-foot bgs was 43 μR/hr, increasing steadily to 527 μR/hr at 13 feet bgs. This indicated possible presence of material containing high concentrations of contaminants within the subsurface environment. Analytical results from a soil sample collected within 6-7 feet bgs [TP13-(6'-7')-080421] indicated an arsenic concentration of 88 mg/kg and Ra-226 concentration of 2.73 pCi/g. While these values were below the action levels for the Site, based on downhole gamma measurements, presence of mine waste containing elevated contaminant concentrations is suspected in the subsurface environment of this test pit.

These findings indicate apparent use of this area of Bluff B as a small repository of mine waste; and other locations on the Site could have been used for similar purpose, now perhaps hosting low surface gamma and arsenic but contamination at depth (below cap material). Materials at this location should be considered waste rock from the surface to 14 feet bgs (3,310 feet amsl).

Table 28 Summary of Downhole Gamma Readings at TP-13

Depth (feet bgs)	Downhole Gamma (µR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	18	51	TP13-(SURF)-080421	53	4.82
1	43				
2	59				
3	101				
4	95				
5	96				
6	101		TP13-(6'-7')-080421	88	2.73
7	115				
8	136				
9	157				
10	200				
11	242				
12	300				
13	527				

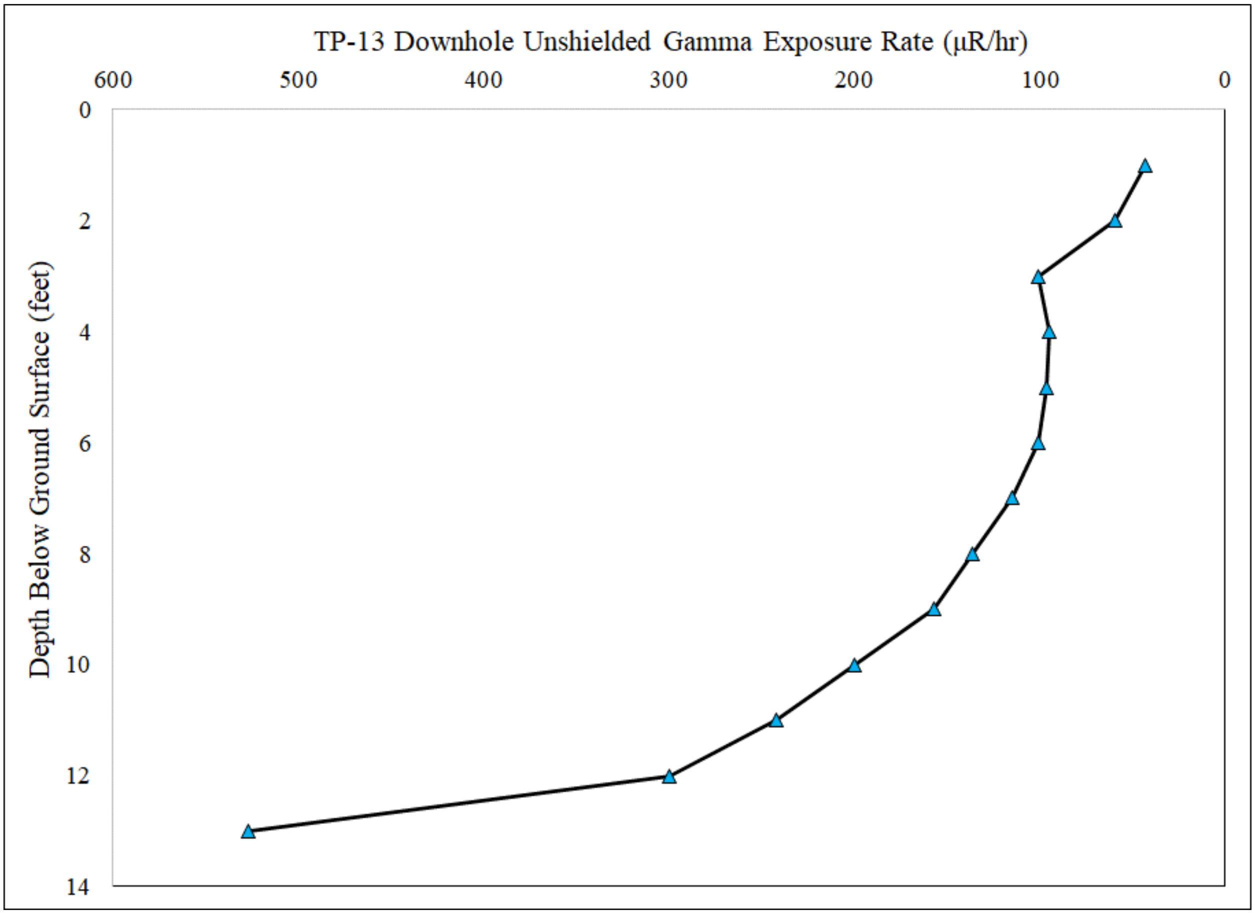

Figure 46 Summary of Downhole Gamma Readings at TP-13

4.4.14 Summarized Results from TP-14

TP-14, excavated at 1500 MST on August 4, 2021, was on the base of the eastern side of Bluff B—where the interface of contaminated versus clean material was expected based on the lateral extent of contamination. Surface elevation of TP-14 was 3,195 feet amsl. An aerial photograph of TP-14 is on **Figure 47**.

Figure 47 Aerial Photograph of TP-14

Subsurface lithology at TP-14 to 2.5 feet bgs consisted of low-level (below the action levels for arsenic and Ra-226) mine waste colluvium (from the cliff face dump area to the west), underlain by loose yellowish-brown silty sand (slightly moist to moist)—likely native sand—to deeper than 6 feet bgs. Bedrock was not encountered in this excavation.

A summary of surface and downhole gamma readings, XRF readings, and soil sample results from TP-14 is in **Table 29**. All downhole gamma readings were unshielded. **Figure 48** is a graphical display of the downhole gamma readings at TP-14 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma exposure rate was 28 μR/hr, and the surface XRF-determined arsenic concentration was 69 ppm. The surface soil sample [TP14-SURF-080421] yielded an arsenic concentration of 60 mg/kg and a Ra-226 concentration of 9.7 pCi/g. Downhole gamma readings remained constant over the entire test pit depth to 6 feet bgs. Another soil sample [TP14-(4'-5')-080421], collected within 4-5 feet bgs, was to represent the native material underlying the 2.5-foot depth layer of mine waste colluvium; it yielded an arsenic concentration of 9.1 mg/kg and a Ra-226 concentration of 2.21 pCi/g, indicating background conditions well below the action levels for the Site.

These findings indicate possible impact on this area outside of Bluff B by mine waste from colluvial outwash from the dump face of the eastern bluff; but laboratory results indicated contaminant concentrations below action levels for the Site. Therefore, the lateral extent of contamination mapping appears to be accurate at this area of the Site.

Table 29 Summary of Downhole Gamma Readings at TP-14

Depth (feet bgs)	Downhole Gamma (μR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	28	69	TP14-(SURF)-080421	60	9.7
1	29				
2	28				
3	27				
4	28	9	TP14-(4'-5')-080421	9.1	2.21
5	29				
6	29				

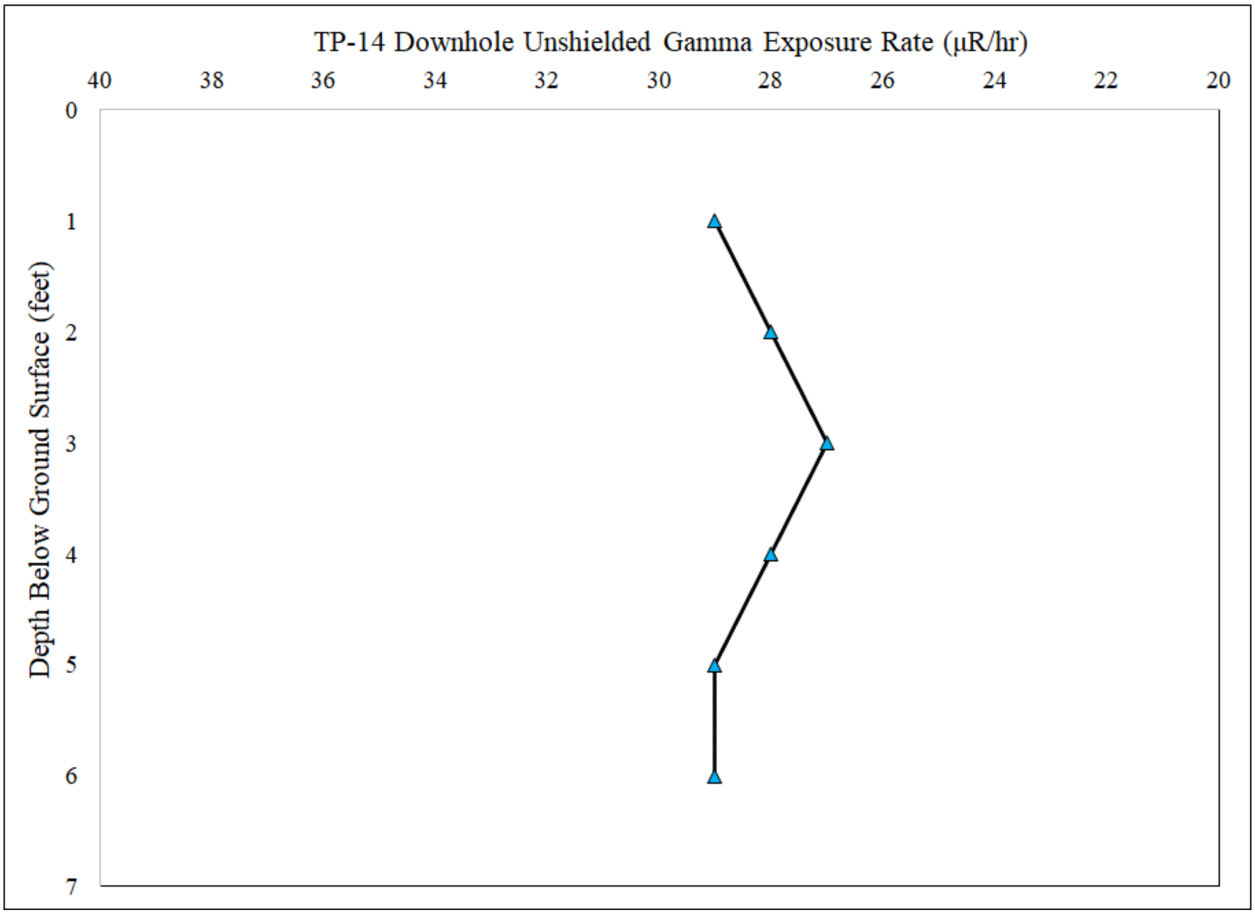

Figure 48 Summary of Downhole Gamma Readings at TP-14

4.4.15 Summarized Results from TP-15

TP-15, excavated at 1550 MST on August 4, 2021, was the second test pit advanced at the eastern base of Bluff B. TP-15 was 261 feet southeast from TP-14 at the same position along the eastern cliff edge at the assumed interface of contaminated and uncontaminated materials. Surface elevation of TP-15 was measured at 3,190.5 feet amsl. An aerial photograph of TP-15 is on **Figure 49**.

Figure 49 Aerial Photograph of TP-15

Subsurface lithology at TP-15 was nearly identical to that at TP-14. The surficial mine waste deposited as outwash from the dump face of the eastern bluff of Bluff B was encountered from ground surface to 2.5 feet bgs. Yellowish-tan native silty sand was encountered below 2.5 feet bgs to a depth greater than 4 feet bgs.

A summary of surface and downhole gamma readings, XRF readings, and soil sample results from TP-15 is in **Table 30**. All downhole gamma readings were unshielded. **Figure 50** is a graphical display of the downhole gamma readings at TP-15 but does not include the 1-meter surface reading because of geometry differences.

The surface gamma exposure rate was 30 μR/hr and the surface XRF-determined arsenic concentration was 61 ppm. The surface soil sample [TP15-SURF-080421] yielded an arsenic concentration of 55 mg/kg and a Ra-226 concentration of 11.8 pCi/g. Downhole gamma readings remained constant over the entire depth of the test pit to 5 feet bgs. Another soil sample [TP15-(3'-4')-080421] was collected within 3-4 feet bgs to represent the native material underlying the 2.5-foot depth layer of mine waste colluvium. It yielded an arsenic concentration of 14 mg/kg and a Ra-226 concentration of 1.88 pCi/g, indicating background conditions well below the action levels for the Site and nearly identical to those encountered at TP-14.

These findings indicate possible impact on this area outside of Bluff B by mine spoils from colluvial outwash from the dump face of the eastern bluff; but laboratory results indicated contaminant concentrations below action levels for the Site. Therefore, the lateral extent of contamination mapping appears to be accurate at this area of the Site.

Table 30 Summary of Downhole Gamma Readings at TP-15

Depth (feet bgs)	Downhole Gamma (µR/hr)	XRF Arsenic (ppm)	Soil Sample ID	Soil Arsenic (mg/kg)	Soil Ra-226 (pCi/g)
Surface (1 meter)	30	61	TP15-(SURF)-080421	55	11.8
1	28				
2	25				
3	26	< 9	TP15-(3'-4')-080421	14	1.88
4	27				
5	25				

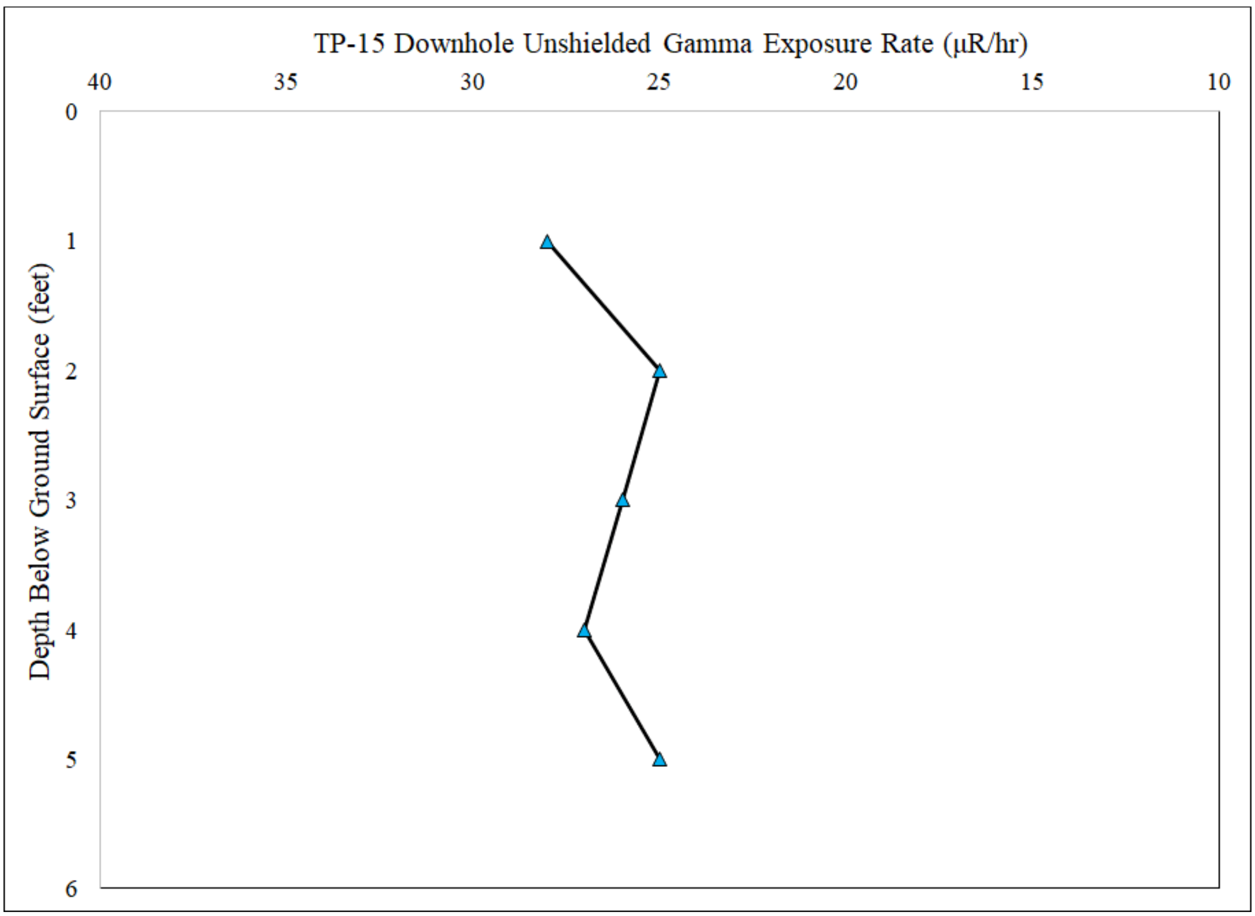

Figure 50 Summary of Downhole Gamma Readings at TP-15

5.0 BLUFF B 2021 STATUS UPDATE

This section ties together results from the 2021 field investigations and previous findings at Bluff B in 2012, 2018, and 2020 to update lateral and vertical extents of contamination in surface and subsurface soils/materials at the Site.

5.1 FINAL SURFACE INVESTIGATION

Surface soil metals and radionuclides contamination at Bluff B had been characterized during previous investigations by application of in situ methods (e.g., gamma radiation surveys and XRF field surveys) supplemented by analytical soil sampling. This section presents a status update of surficial cleanup extents for arsenic and Ra-226, and the combined cleanup areas at Bluff B when considering all available data from the Site.

5.1.1 Bluff B Arsenic Concentrations

Tetra Tech developed a 2021 status update map of surficial lateral extents of arsenic concentrations and cleanup extent related to arsenic at Bluff B, shown on **Figure 51**. Developers of this map used all past arsenic data acquired by Tetra Tech since 2021, including the following datasets:

- XRF field survey data acquired at Bluff B in 2012 during the Tronox Bluff characterization project (Tetra Tech 2013b). This includes 804 in situ XRF measurements converted to lab-equivalent arsenic concentrations. The shape file "Bluff_B_XRF_Data_2012_NAD83.shp" was used for this dataset.
- XRF field survey data acquired during the Northeast Bluff B Sediment Pond characterization project (Tetra Tech 2019b). This includes 668 in situ XRF measurements converted to lab equivalent concentrations. The file "Bluff_B_XRF_Data_2018_NAD83.shp" was used for this dataset.
- Surface soil samples (0 to 6 inches bgs) analyzed for arsenic during the 2021 field investigation, which included eight opportunistic soil samples collected to the north and 15 surface soil samples analyzed for arsenic collected at each test pit location.

A total of 1,495 measurements were used to develop the status update dataset. These data points were combined into the final project geodatabase, and the point arsenic values were interpolated by following an inverse distance weighted (IDW) deterministic geospatial modeling approach. The Geostatistical Analyst tool in ArcMap was used to model the data. The estimated 2021 status updated arsenic cleanup area at Bluff B is 25.6 acres, as shown on **Figure 51**. This is a 7% increase from the previous estimate of 23.9 acres prior to the 2021 investigations.

Note: Much arsenic data from the Site was obtained in 2012. Notably, conditions at the Site may have changed due to erosion, or movement of soil, or construction activities. Moreover, density of sampling in 2012 was not the same as that in 2018, and additional arsenic contamination in small discrete pockets that have not been mapped may be present at Bluff B.

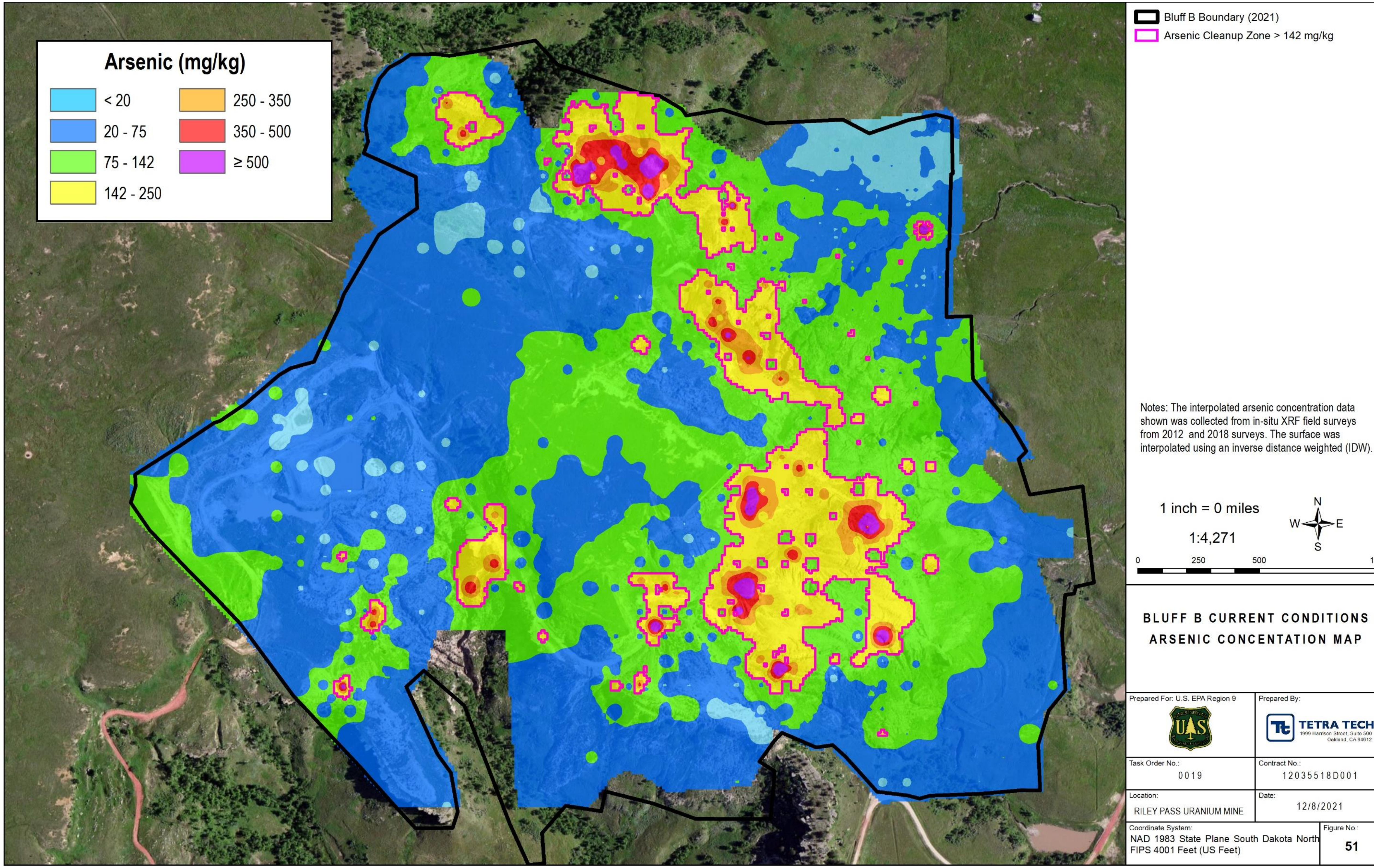

Figure 51 Bluff B 2021 Status Update Map of Arsenic Soil Concentrations

5.1.2 Bluff B Radiological Status

Tetra Tech developed a 2021 status update map of surficial lateral extents of gamma radiation levels and the estimated cleanup extent related to Ra-226 at Bluff B, shown on **Figure 52**. Developers of this map used all gamma radiation data obtained by Tetra Tech in and prior to 2021, including the following datasets:

- Gamma radiation survey in 2012 across the entirety of Bluff B and summarized in Tronox Bluffs Waste Characterization Report (Tetra Tech 2013b).
- Gamma radiation survey in 2018 across the northeast portion of Bluff B and summarized in the 2018 Riley Pass Abandoned Uranium Mine Waste Characterization Sampling Report: Bluff B Proposed Sediment Pond (Tetra Tech 2019b).
- Gamma radiation surveys as part of the 2021 field investigations, as described in this report (results are conveyed within **Section 4.2**).
- A site-specific gamma-radium correlation study at Bluff B as part of the 2021 field investigations, as described in this report (results are conveyed within **Section 4.3**).

A final gamma measurement dataset from the geodatabase was used to develop a continuous surface of gamma radiation across Bluff B by use of all data acquired at the Site in 2012, 2018, and 2021. The detailed process for developing this geodatabase is described in **Appendix H**. An ordinary kriging method was applied to the dataset, and the data were clipped to a boundary layer that best represents where the gamma radiation measurement data were obtained. *Note the kriging interpolation method is more appropriate for the sampling density of radiological data when compared to the IDW method which is more appropriate for less dense sampling points with the arsenic data.* By use of a cutoff value of 48 μR/hr as the gamma cutoff (**Section 4.3** of this report and **Appendix G**), a geospatial analysis occurred to determine the surficial extent of Ra-226 concentrations above the action level. The final cleanup extent for Ra-226 is 15.6 acres, as shown on **Figure 52**.

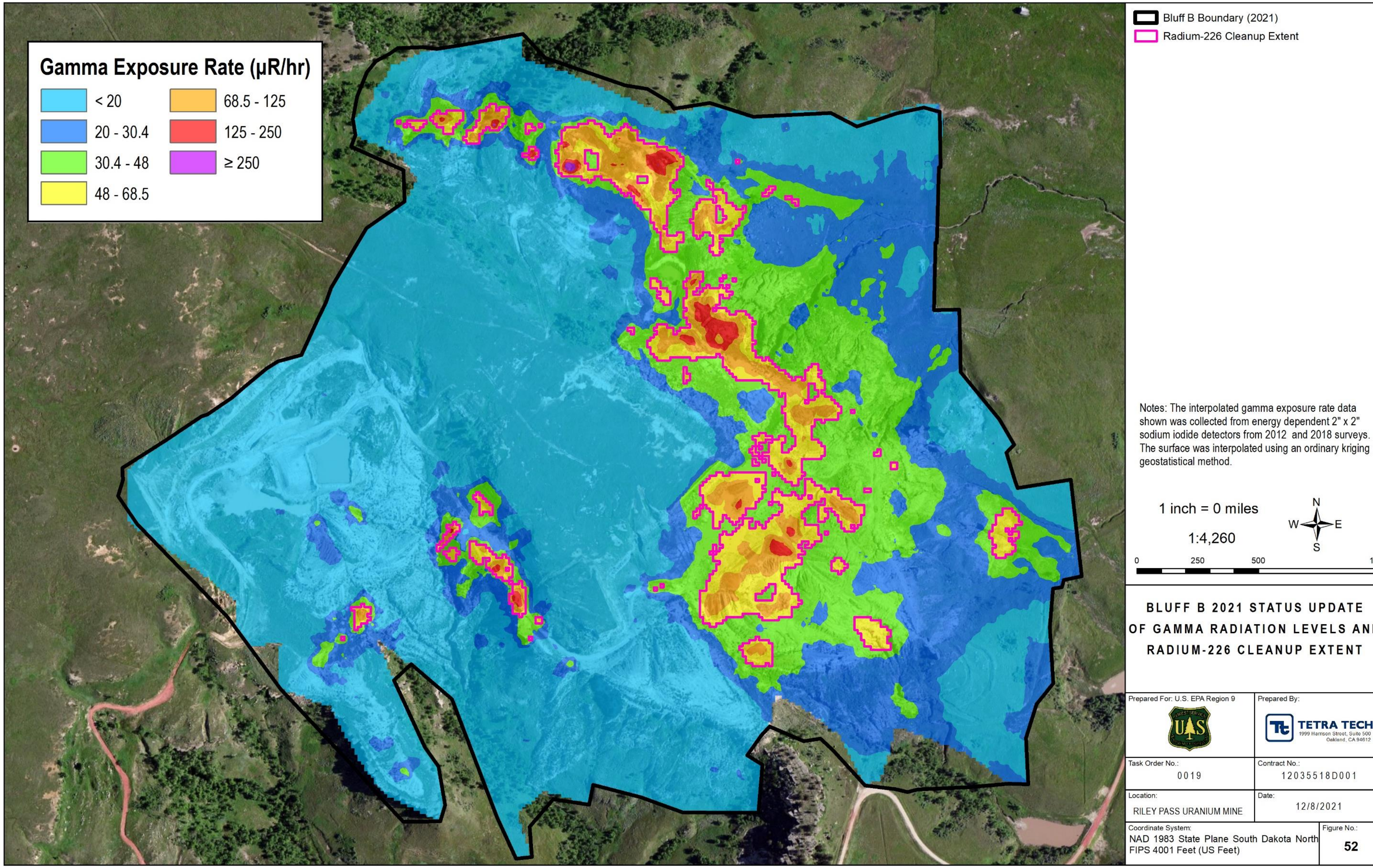

Figure 52 Bluff B 2021 Status Update of Gamma Radiation Levels and Radium-226 Cleanup Extent

5.1.3 Bluff B Final Surficial Contamination (Combined)

Action level exceedance boundaries of arsenic and Ra-226 at Bluff B are not always collocated. For example, 13.9 acres of the Site exceed the arsenic action level but fall below the Ra-226 action level. Similarly, 4.0 acres of the Site exceed the Ra-226 action level but fall below the arsenic action level. This has been the assumption for many years, based on the initial investigation at Bluff B in 2012 (Tetra Tech 2013b). This was further confirmed and documented during the 2021 field investigations. This information is useful to confirm the importance of using both in situ XRF and gamma radiation surveys as tools to support characterization surveys, remedial action surveys during cleanup, and verification surveys, as well as additional soil sampling.

Tetra Tech developed a final estimated surface cleanup extent boundary by merging and dissolving the two overlapping boundaries of arsenic and Ra-226 cleanup extents into one boundary. The total estimated cleanup extent for arsenic and Ra-226 at Bluff B is 29.6 acres. This extent is shown as a yellow dashed boundary on **Figure 53**. This extent represents areas of the Site where soil concentrations of arsenic and/or Ra-226 are more than likely to exceed 142 mg/kg or 30 pCi/g, respectively. This boundary should be used for remedial engineering design and for excavation planning. Notably, this clearly does not preclude presence of contamination in surfaces or subsurfaces outside of this region; however, depth to contamination is of particular interest within this region of the Site.

Other important outcomes of this analysis are well-bounded and documented lateral extents of contamination at Bluff B. These do not apply to off-site migration through drainage pathways, which would require separate investigations, as specified in the recommendations section.

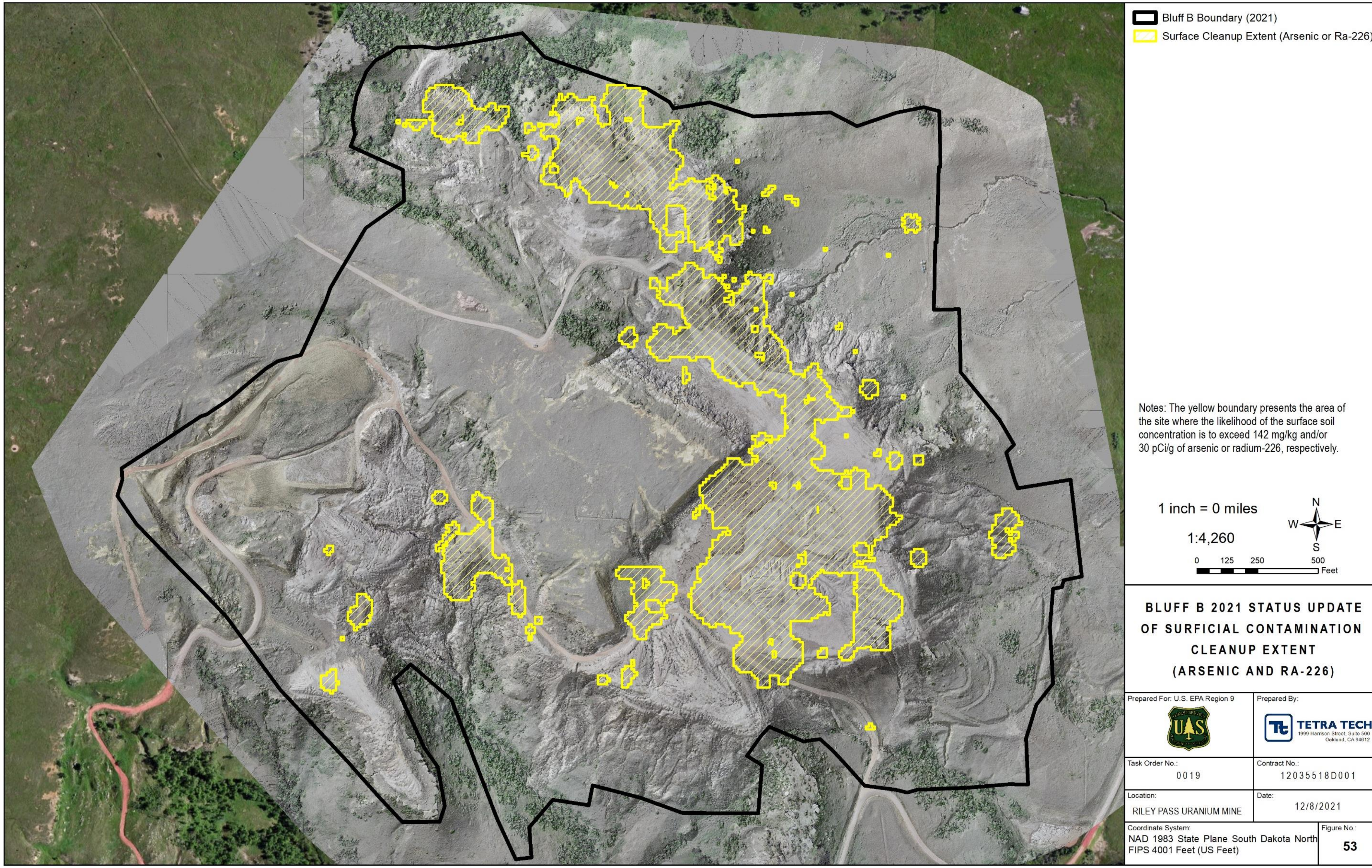

Figure 53 Bluff B 2021 Status Update of Surficial Contamination Cleanup Extent (Arsenic and Ra-226)

5.2 BLUFF B FINAL SUBSURFACE CONTAMINATION

The following subsections summarize findings regarding subsurface contamination at Bluff B.

5.2.1 Bluff B Subsurface Contamination (2021 data only)

Tetra Tech generated a map (**Figure 54**, below) summarizing 2021 subsurface investigation results discussed in **Section 4.4**. This map shows the Bluff B boundary, surface cleanup extent boundary, 2020 test pit locations, and 2021 test pit locations and results. The 2020 test pit locations are conveyed in Tetra Tech (2020). The 2021 test pits are identified on **Figure 54** as “red” (contamination found or suspected based on screening results) or “blue” (no contamination found or suspected). Depth range of contamination is shown for each test pit where contamination was found or suspected to be present.

All test pits where contamination starts at the surface are within the final surface cleanup boundary for the Site. One test pit, TP-13, revealed no contamination at the surface but revealed suspected contamination in the subsurface environment. The remaining test pits (TP-10, TP-11, TP-14, and TP-15) revealed no measured contamination above action levels. However, and notably, TP-10 and TP-11 were within an area where sediments from previous pond cleaning work were removed from the ponds below and placed above. Additionally, TP-14 and TP-15 revealed no evidence of soil concentrations exceeding action levels, but the waste materials on the cliffs above them could contain arsenic concentrations exceeding the action level—density of sampling for analysis for arsenic along the cliff areas directly above these two test pits was limited.

To summarize, the 2021 subsurface investigation was successful at filling in estimates of depths of contamination within areas of Bluff B not previously investigated—specifically within the southeastern portion of the Site. This investigation also (1) confirmed that spoils areas to the west (TP-10 and TP-11) hosted no and/or low-level contamination but may not be suitable for cover material (likely because of physical or chemical limitations of the material as a growth medium as well as the potential for contamination) and should be carefully considered for inclusion in future excavation planning; (2) uncovered evidence of areas hosting contaminant concentrations on the surface below action levels for the Site, but containing buried waste with contaminant concentrations that may exceed action levels—as evidenced at TP-13; and (3) as shown at TP-14 and TP-15, if migration of contamination is occurring off site to east or northeast of the Site, this is surficial and the contamination does not move far via overland flow. The following subsection presents an updated contamination contour map that incorporates both the 2020 and 2021 subsurface investigation data.

This section lays out the variability in both surface and subsurface contamination. Some of the variability may be attributed to material being from sediment ponds or washed down from slopes above. Arsenic and Ra-226 is often concentrated in naturally occurring lignite beds and mining removed most of this. However, remnant lignite and/or materials stratigraphically close to the lignite beds may also carry contamination which was likely mixed into spoils where it either: (a) buried at depth as part of the mining process; or (b) randomly scattered and spread across the surface, leaving no discernable pattern to contamination. Furthermore, even a small piece of lignite can emit elevated radiation. This may explain, in part, the randomness of contamination and why there are areas of concentrated contamination juxtaposed against barren areas. Finally, there are small areas of contamination far removed from any other contamination, and then other areas of contamination at depth but not at the surface (for example TP-13).

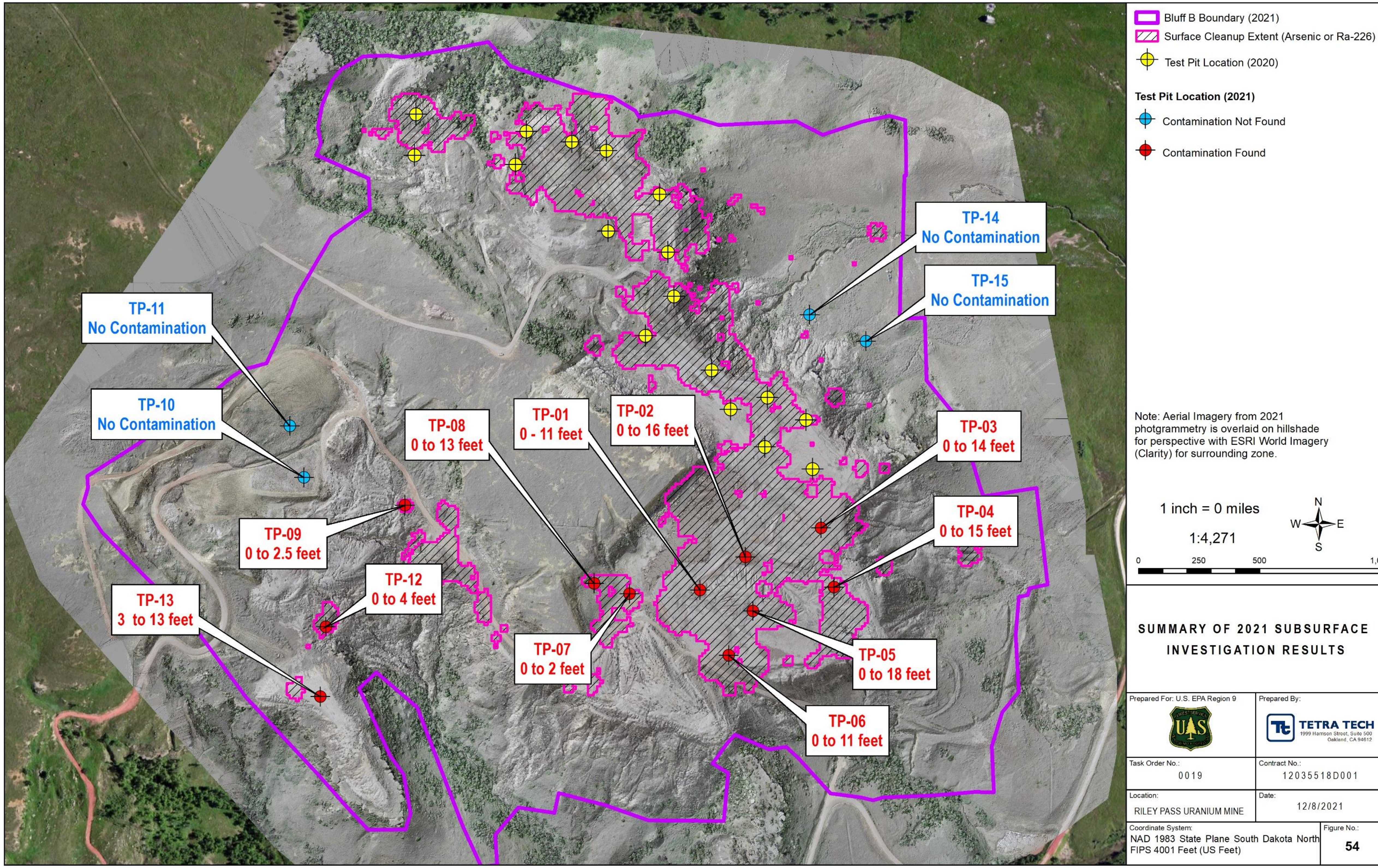

Figure 54 Summary of 2021 Subsurface Investigation Results

5.2.2 Bluff B Final Subsurface Contamination (2020 and 2021)

A contour map showing contamination depths was developed by integrating depths of contamination from both the 2020 and 2021 subsurface investigations. Developers of the waste contour map used data from all test pits obtained during the 2020 investigation and data from nearby test pits acquired during the 2021 investigation, which included data from TP-01 through TP-08 and excluded data from the westernmost test pits (TP-10, TP-11, TP-12) and the easternmost test pits (TP-14 and TP-15). A boundary of extent was drawn around the included test pits, and the area of contamination within that zone was clipped. An IDW interpolation of waste depths occurred, and the resulting raster was developed along with 1-foot contours. This waste contour map covers approximately 20.4 acres or 69% of the surface cleanup area identified at Bluff B. **Figure 55** is the waste contour map for Bluff B.

The remaining 31% of the Site for which waste contour depths are not provide due to insufficient data points and due to the following five categories, and are labeled on **Figure 55**:

- Category #1: Areas identified as hosting surficial contamination within areas difficult or impossible to access safely for test pits.
- Category #2: Cliff faces on the eastern and southern edges of Bluff B that may contain subsurface contamination even if the evidence indicates absence of surficial contamination; excavations at these areas may be necessary. Estimates of volume can occur by use of bedrock elevations and applications of available digital surface elevation models of the Site.
- Category #3: Small pockets of elevated hot spots across the Site that may require further investigation or should be included in the remedial engineering design. One example is shown on **Figure 55**.
- Category #4: A number of elevated regions, particularly on the east portion of Bluff B, that host waste materials on bedrock; estimates of volumes can occur easily by evaluating bedrock elevations in the area.
- Category #5: Areas identified at TP-123 on the finger mesa on the southwestern portion of Bluff B where surface contamination was not detected could host buried waste material in the subsurface; these areas should be considered for remedial engineering design and plans for excavation.

To summarize, the 2020 and 2021 subsurface investigations were successful in identifying waste contours over most of Bluff B. However, the Site is very complex topographically, and waste contours have not been identified for the entire site.

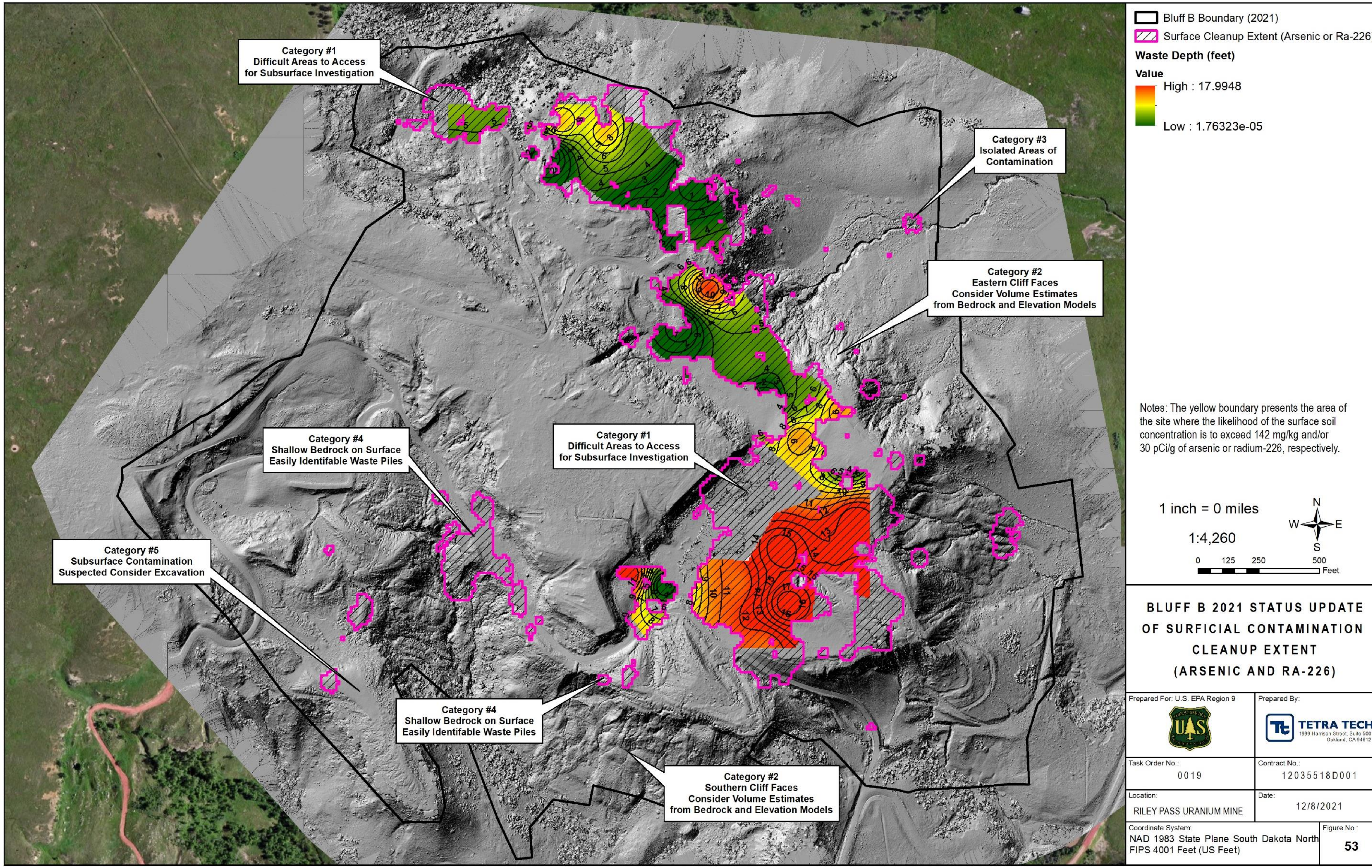

Figure 55 Bluff B 2021 Status Update Waste Contour Map

6.0 CONCLUSIONS AND RECOMMENDATIONS

The subsurface and supplemental investigation program conducted by Tetra Tech in 2021 involved a variety of site investigation field activities to support further data acquisition intended to inform the approach to engineering design of Bluff B. Several conclusions seemed evident based on results and data evaluation from these field activities:

- The 2021 UAV photogrammetry survey was successful in recording high-resolution aerial imagery and developing digital surface models of Bluff B useful for remediation design purposes.
- The UAV gamma survey to estimate 1-meter-equivalent gamma readings from higher altitudes proved useful, and the accuracy was confirmed via model validation of ground-based data. The data from the lateral delineation gamma radiation surveys were useful in validating the aerial gamma flyover survey model. The aerial gamma flyover survey was successful in characterizing radiological conditions within 37.6 acres of the Site deemed inaccessible during prior investigations. aerial gamma flyover showed promise for future characterization purposes in logistically challenging environments, and also as a tool for verification surveys post construction removal or final closure.
- The lateral delineation surveys were successful at finalizing understanding of lateral extents of contamination across Bluff B with respect to off-site migration and potential cleanup boundaries. The exception being delineation of mine waste contamination migrating offsite in the major drainages as well as the numerous small gullies and rills that have developed on the dump face surfaces.
- The gamma-radium correlation study increased understanding of the relationship between soil Ra-226 concentrations and gamma exposure rate measurements across Bluff B. This information can be used for remediation design purposes and for remedial action surveys and final status (verification) surveys following cleanup of mine waste.
- The surficial cleanup area of arsenic concentrations exceeding the action level of 142 mg/kg at Bluff B is 25.6 acres. The surficial cleanup area of Ra-226 concentrations exceeding the action level of 30 pCi/g at Bluff B is 15.6 acres. The total combined surficial area of surface soils at the Site exceeding the action level of either arsenic or Ra-226 is 29.6 acres. This is the final area that should be used for remedial engineering design and excavation planning. The exception being the Category #5 waste characterization areas where additional engineering design and planning may be warranted due to erosion potential of buried mine waste or USFS's desire to consolidate mine waste and pond sediments into one large repository.
- Respective areas of exceedances of arsenic and Ra-226 action levels are not always collocated. A total of 13.9 acres of the Site exceeds the arsenic action level but falls below the Ra-226 action level. A total of 4.0 acres of the Site exceeds the Ra-226 action level but falls below the arsenic action level. This information is useful to confirm the importance of using both in situ XRF and gamma radiation surveys as tools to support characterization surveys, remedial action surveys during cleanup, and verification surveys, as well as soil sampling.
- The subsurface investigation at Bluff B was successful in covering most areas of the Site (69%) identified as hosting arsenic and/or Ra-226 surficial contamination. Data acquired from these investigations can be used for other areas of the Site where vertical extents have not yet

been characterized. The top of Bluff B is well characterized for depth of contamination, but remaining areas are not fully characterized.

- Many test pit excavations encountered natural lignite seams. The investigation showed that some lignite seams contain low levels of arsenic and Ra-226, or elevated levels of arsenic but low levels of Ra-226, or elevated levels of both arsenic and Ra-226. TP-10 and TP-11 were advanced in a zone of known deposits of sediment pond materials over the years for runoff control purposes. These areas hosted low levels of spoils with intermixed mine waste rock; however, contaminant concentrations in these test pits were not above action levels for this region. TP-13 provided evidence of areas at the Site that may host arsenic and Ra-226 concentrations below their action levels but may contain waste materials beneath with elevated concentrations of these above action levels. Test pits TP-14 and TP-15 were the only test pits on the eastern cliff base of Bluff B. Data from these test pits confirmed accuracies of lateral extents of contamination and indicated presence of surface contamination at a distance from where waste materials are pushed off the cliffs; however, the concentrations fall below action levels fairly quickly outside the Site.
- No test pits were advanced on the eastern cliff faces of Bluff B, but alternate methods are available for estimating volumes in this region of the Site. Extrapolations of angles of repose and bedrock contacts will be necessary for volume estimations at the eastern and southwestern cliffs.

The following are recommendations or discussion points related to the 2021 subsurface investigations:

- In many cases at Bluff B, there is utility for estimating volumes of materials based solely on knowledge of where bedrock exists at the Site. Conduct a bedrock analysis and integrate the findings into the remedial design of Bluff B. A bedrock analysis would solely be a desktop exercise utilizing existing bedrock depths to estimate the depth of material in areas where no bedrock data was collected through geospatial analysis.
- Some lignite seams may contain extremely elevated arsenic and Ra-226 concentrations; however, some materials showing the same physical characteristics contain much lower arsenic and Ra-226 concentrations. A further evaluation of lignite geology in the region should be considered during the remedial design of Bluff B. If native sediments that exceed waste criteria are to be removed then a much more extensive subsurface investigation focused on NORM not just TENORM needs to be performed.
- Data obtained from the UAV photogrammetry can be used for engineering design, including erosion and sediment transport modeling, if necessary.
- Moving forward, the gamma cutoff action level is 48 μR/hr for Bluff B.
- Develop a scope of work on how to further discussion and design considerations for the evaluation of the southern and eastern cliffs.
- While overland flow erosion is a pathway for off-site migration, most off-site transport appears to be via drainage pathways. Further investigation into off-site buildup of transported waste should be considered.
- The southern and northern areas of the Site cannot be easily scanned at high density, through traditional ground-based surveys, due to difficulty of access, highly vegetated areas, or

steep/dangerous terrain. Nonetheless, the data acquired from these areas by UAV indicate surface contaminant concentrations below action levels. Areas still remain in the south where spoils or mine waste has not yet been investigated and could contain contaminant concentrations exceeding action levels. These areas should be included in remedial engineering design and evaluated based on the historical photo and developed AutoCAD surface.

- Given the non-colocation between arsenic and Ra-226 concentrations at Bluff B, both XRF field surveys and gamma radiation surveys should be incorporated into future characterization and verification activities at Riley Pass.
- Further investigation may be warranted in the spoils region identified near TP-10 and TP-11, or care must be taken when considering these areas as sources of borrow materials. Furthermore, the moist soils in this area appeared to be unsuitable for engineer repository design due to the liquefaction observed.
- Because site conditions may have changed since the 2012 (and 2018) XRF field surveys and gamma radiation surveys, screening technology should be used during excavations and cleanup operations.

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APPENDIX A
2021 FIELD INVESTIGATION PHOTOGRAPHIC LOGS

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Photo 2 Troubleshooting at Drone Ground Base Station

Photo 3 Close Up Photograph of Gamma Scanning UAV

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Photo 7 Photogrammetry UAV Preparing for Flight

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Photo 34 Aerial Photograph of TP-01

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Photo 40 Downhole Photograph of TP-02

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Photo 42 Aerial Photograph of TP-03

Photo 43 Photograph of TP-03 Prior to Excavation

Photo 44 Downhole Photograph of TP-03

Photo 45 Aerial Photograph of TP-04

Photo 46 Aerial Photograph of TP-04

Photo 47 Aerial Photograph of TP-04

Photo 48 Aerial Photograph of TP-04

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APPENDIX B

UAV SUMMARY REPORT

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ACRONYMS AND ABBREVIATIONS

μR/hr	Microroentgens per hour
ags	Above ground surface
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
AUM	Abandoned uranium mine
cpm	Counts per minute
DOE	U.S. Department of Energy
DSM	Digital surface model
EPA	U.S. Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
GPS	Global Positioning System
IAEA	International Atomic Energy Agency
m^2	Square meter
m/s	Meters per second
NaI(TI)	Sodium iodide thallium-doped
R^2	Statistical measure of how close data come to a fitted regression line (also known as the coefficient of determination)
RPD	Relative percent difference
RSD	Relative standard deviation
RTK	Real-Time Kinematic
SOW	Scope of Work
Tetra Tech	Tetra Tech, Inc.
UMTRA	Uranium Mine Tailing Remedial Action
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service

1.0 INTRODUCTION

This Appendix B to the Bluff B Subsurface and Supplemental Surface Investigation Report (hereafter referred to as the main report) presents methods and results of aerial gamma flyover surveys of Bluff B within the Riley Pass Uranium Mine complex in South Dakota. The objective of this study was to collect aerial gamma survey data within areas previously deemed inaccessible by ground based field teams using an unmanned aerial vehicle scanning technique. Discussions of the gamma height correction methodology applied during these surveys appear as well. Preceding and essential to this work were numerous activities and events that the following paragraphs summarize.

In 2005, the Tetra Tech, Inc. (Tetra Tech) radiation team out of the Fort Collins, Colorado office (formerly MFG-Inc.), led by Dr. Janet Johnson and Dr. Robert Meyer, first developed and published information regarding a Global Positioning System (GPS)-based scanning technique suitable for initial radiological surveys of sites at large, in-situ-leach, uranium mines in Eurasia and Texas (Meyer, Shields, and Green 2005). Since then, Tetra Tech has performed hundreds of GPS-based gamma radiation surveys at uranium mines and mills across the world. This technology has evolved over the last 16 years, but still involves the same basic principles of large-scale data acquisition by use of a GPS-based vehicle or backpack-mounted mobile radiation detection system. In addition to ground systems, aerial systems have also aided screening or geological mapping via detections of radiological sources across even larger land areas—historically by use of fixed-wing airplanes or helicopters. As reported in 1997, the U.S. Department of Energy (DOE) had performed more than 300 aerial radiological surveys since 1982 at DOE sites, commercial nuclear power plants, Formerly Utilized Sites Remedial Action Program (FUSRAP), Uranium Mine Tailing Remedial Action (UMTRA) sites, contaminated industrial areas, and nuclear accident sites (Proctor 1997). DOE has conducted additional aerial characterization programs since the 1997 report, including a notable project involving aerial radiological surveys by helicopter across 41 geographical areas in the Navajo Nation between 1994 and 1999 (Bechtel Nevada 2001). Figure B1 is a concept image of the DOE scan system.

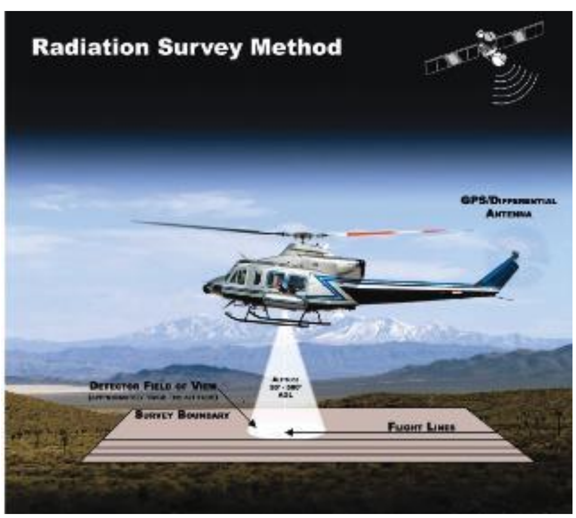


Figure B1: DOE Helicopter-Based Scanning System Concept

The U.S. Environmental Protection Agency (EPA), through its Aerial Spectral Photometric Environmental Collection Technology (ASPECT) program, has also undertaken more than 100 aerial radiological characterization deployments since 2001 (EPA 2021). Figure B2 is a photograph of the ASPECT aerial scanning platform. Moreover, aerial surveys using fixed-wing aircraft or helicopters also have occurred internationally for other federal governments in Israel, UK, Finland, and many others. The International Atomic Energy Agency (IAEA) published Guidelines for Radioelement Mapping Using Gamma Ray Spectrometry Data in July 2003 (IAEA 2003).

Figure B2: ASPECT Gamma Detection Fixed Wing Platform (EPA 2021)

The aerial systems described above are expensive and require funding from federal programs. Additionally, data acquired during surveys of these types are useful for screening purposes only, as survey height, speed, and transect spacing usually render detections of smaller sources of radioactive contamination difficult or impossible; but that level of detail is necessary for any abandoned uranium mine (AUM) cleanup project.

Technological advancements pertaining to unmanned aerial vehicles (UAVs) or “drones” during the past decade have increased interest in utilization of commercially available UAVs for autonomous detection of radiation. A literature review by Tetra Tech found more than 100 published documents regarding this. Only one of these publications involved gamma-scanning UAVs at an AUM—titled “The use of unmanned aerial systems for the mapping of legacy uranium mines” by Martin and others (2015), this appeared to be the first publication of its kind regarding a low-height, gamma-scanning, UAV survey at an AUM. The uranium mine in that study was in Cornwall, England, where significant amounts of legacy radiological contamination are still present across numerous AUMs (Martin and others 2015).

This report presents the results of the first federally funded AUM survey performed by way of low altitude radiometric UAV scanning in the United States.

1.1 PROJECT LOCATION

Bluff B hosts the largest extent of surficial contamination and volume of waste of all AUMs within the Riley Pass Uranium Mine complex. For details on the location and description of Bluff B, refer to the main report. The terrain is quite extreme in certain areas of Bluff B, particularly on the eastern cliff edges. As described in the main report, the 2012 and 2018 radiological surveys at Bluff B omitted these areas of extreme terrain due to limitations on physical access and safety concerns (vertical cliffs or deep drainages, etc.). These inaccessible areas had not been scanned by any application of a traditional ground-based method. Figure B3, below, (east is closest to the reader on that map) illustrates the previous lack of scanning coverage of these areas. With advances in UAV technology, however, a survey of these areas became possible.

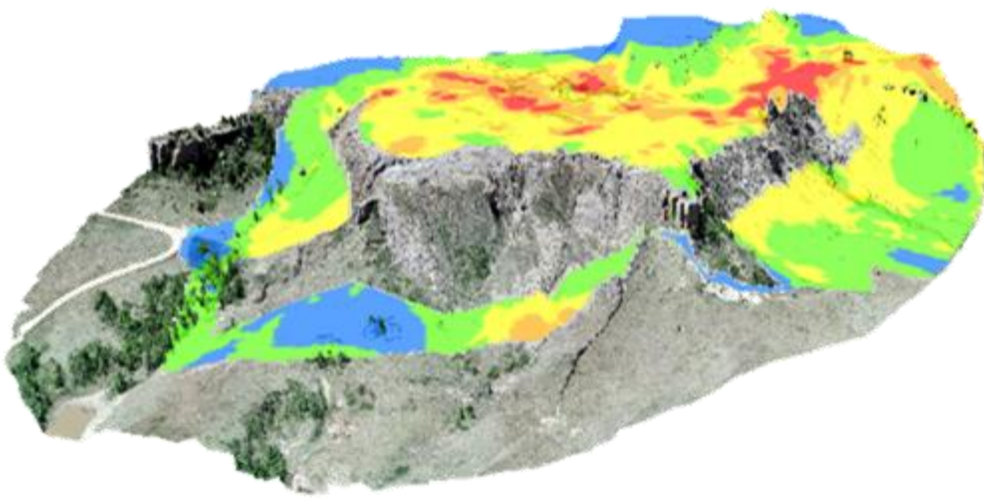


Figure B3: Gamma Scanning Coverage at Bluff B

1.2 PURPOSE AND SCOPE

The purpose of the aerial gamma flyover surveys of the eastern cliffs of Bluff B was to acquire gamma radiation data from areas of the eastern portion of Bluff B that are inaccessible on foot due to cliffs with steep slopes that pose a threat of injury to staff due to slips, trips, and falls. Gamma radiation survey data was collected using a UAV gamma scanning platform at different heights and a height correction factor developed from this pilot study and a previous pilot study were utilized to ensure the data presented is equivalent to the typical ground-based gamma radiation surveys.

Tetra Tech subcontracted Dundas Geomatics, Inc., out of Grass Valley, California, to complete this pilot study during the 2021 field investigation season. Data from the aerial gamma flyover would be important for filling in coverage data gaps prior to the subsurface field investigation. The scope of work (SOW) was to perform aerial radiation surveys at the eastern cliffs of Bluff B where previous scan coverage had been limited. The initial SOW specified a scanning height of 5 meters above ground surface (ags) with 10-meter transect spacing. However, because this investigation was a pilot study, deviations in the field were necessary to achieve project success—including application of those initially specified scanning parameters to a limited area, with most of the cliffs of Bluff B scanned at 10 meters ags with 20-meter transect spacing. The higher a detector ags, the larger its field of view; therefore, a wider line spacing typically is chosen for an aerial survey at higher distance ags (Sinclair 2016). Moreover, the SOW did not include any scope for low-density or medium-density height comparison pilot studies, but this was necessary to develop a height-correction for the end use data in order to achieve a 1-meter ags equivalence, and as a continuation of the pilot study in Utah, which is discussed in the next section. For the purposes of this study at Bluff B, low density is 10-meter height at 20 meter transect spacing and a medium-density is 5-meter height at 10 meter transects. High density would refer to 1 meter or 2 meter heights with 2 meter scan transects.

2.0 HEIGHT COMPARISON PILOT STUDIES

The following subsections convey the concept of high-density and medium- and low-density gamma flyover surveys, describe the equipment used during these, and relate information about performances of these in Utah and South Dakota.

2.1 OVERVIEW

Two types of height comparison studies were necessary to determine a height-correction factor for data from an aerial gamma flyover survey:

1. High-density surveys involving 1- and 5-meter ags crossover surveys performed at 1 m/s velocity. Cross over surveys are surveys not parallel to each other and which require an interpolation analysis for comparison rather than a direct grid overlay analysis.
2. Medium- and low-density surveys involving 5- and 10-meter ags crossover surveys. These were performed at 2 m/s velocity,

The two pilot studies at AUMs occurred within the United States: (1) in Grand County, Utah, during summer 2019; and (2) at the top of Bluff B uranium mine at Riley Pass during summer 2021 The first AUM was a former uranium and vanadium mine within the Yellowcat mining district in Grand County, Utah. The second AUM was at Bluff B at the Riley Pass Uranium Mine complex. Figure B4 is a map showing locations of the two pilot studies. Dundas Geomatics and Aaron Orechwa, from Tetra Tech, conducted the studies. The first study was self-funded, and the second study was partially USFS-funded and partially self-funded. This section presents the general methods, results, and findings of those two studies.

Figure B4: Location of UAV Pilot Studies

2.2 CONCEPT

These height comparison studies compared radiation data acquired at lower heights with radiation data obtained at a greater heights, by applications of methods for acquiring high-precision data and geospatial techniques for post-processing. Goals of the studies included acquisition of data at greater heights and wider scan widths (which would allow larger coverage area), and conversion of those data into ground-level equivalents (i.e., 1-meter-ags equivalent gamma measurements).

Descriptions of the study experiments in the field are as follows:

- Experiment #1 – Conduct high-density (2-meter transect spacing) gamma surveys by use of an autonomous, terrain-following gamma UAV at 1 meter and 5 meters ags moving at 1 meter per second (m/s). The survey area (not to exceed 0.5 acre) was chosen at a uranium mine and had to contain radioactive material emitting gamma radiation above background levels. The surveys were to occur back to back at the same survey area, allowing geospatial analysis by application of a grid block averaging approach.
- Experiment #2 – Conduct a medium-density (10-meter spacing) gamma survey at 5 meters ags moving at 2 m/s at a given area at a uranium mine hosting radioactive material emitting gamma radiation above background levels. Conduct a low-density (20-meter spacing) gamma survey at 10 meters ags moving at 2 m/s across the same area subjected to the 5-meter ags survey. The differing scan densities precluded a grid block approach to geospatial analysis; therefore, an interpolation method was applied to generate a grid average for comparison purposes.

These two experiments (among others) occurred during the Utah Pilot Study and the South Dakota Pilot Study.

2.3 EQUIPMENT

A Ludlum Model 44-10 with a thallium-doped, 2- by 2-inch sodium iodide (NaI[Tl]) detector, was attached to a UAV with a Ludlum datalogger. The datalogger read counts per minute (cpm), which could be converted to microroentgens per hour (μR/hr) by use of internal detector calibration constants. For this evaluation, the data remained in cpm and later were translated into μR/hr to maintain consistency with the units of data from the Riley Pass site. The UAV was a commercially available DJI M300 with real-time kinematic (RTK) GPS capability. A system that essentially talked to the receiver base station, thus allowing the pilot to send preprogrammed flight information for the UAV to fly manually or autonomously, resulted from numerous custom tweaks via electrical engineering and software programming. A flight control software provided capability to convey mission information to the home base. Figure B5 and Figure B6, respectively, are photographs of the drone team equipping the UAV with the gamma detector, and the gamma detector itself.

Figure B5: Ron Dundas Equipping UAV with Detector

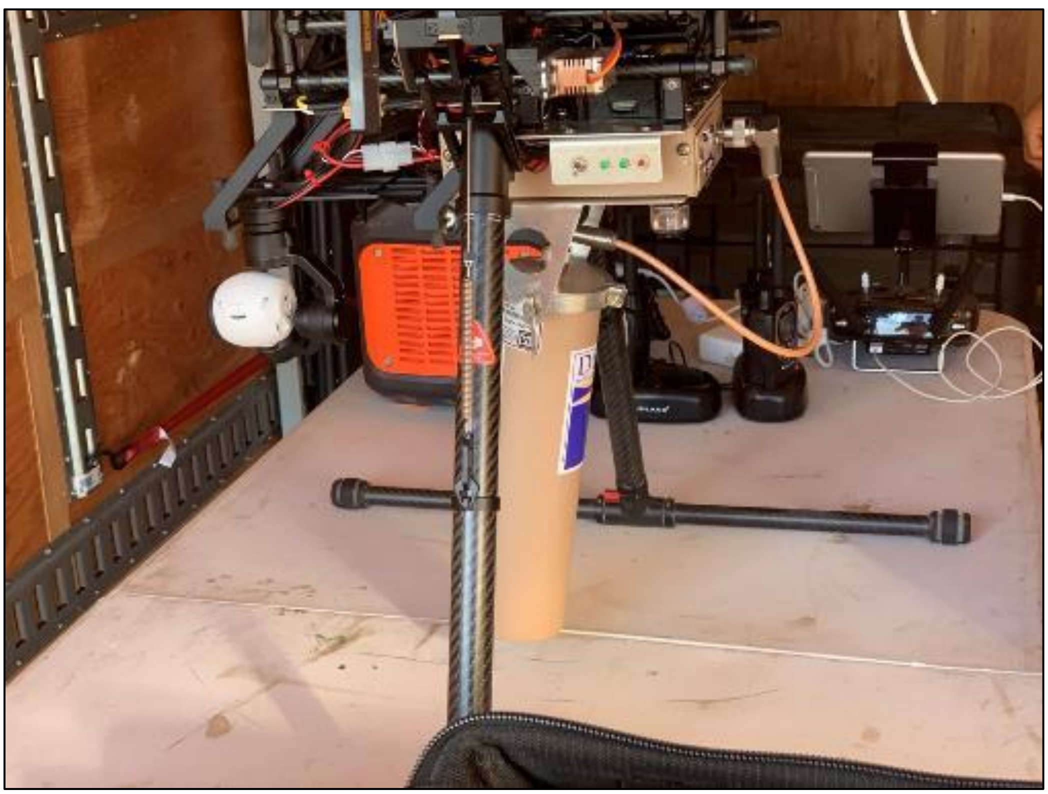


Figure B6: Closeup of Gamma Detector Equipped to UAV

2.4 EXPERIMENT #1: HIGH-DENSITY SURVEYS

The following subsections describe and evaluate the Utah and South Dakota pilot studies:

2.4.1 Utah Pilot Study

The Utah Pilot Study occurred during summer 2019 at a uranium mine in Grand County, Utah, within Bureau of Land Management land. After a traditional GPS-based, ground-based gamma survey of the AUM, a small survey area of approximately 0.25 acre was selected for a high-density gamma radiation survey by use of the gamma scanning UAV. That area had limited vegetation and had induced a range of radiation measurements from approximate background levels to 10 times background levels where mine contamination was present.

The first UAV gamma radiation survey in the Utah Pilot Study occurred at a scan height of 5 meters ags with 2-meter transect spacing between scan lines and moved at a constant velocity of 1 m/s. A total of 1,354 measurements ranged between 11,981 and 68,281 cpm. A map showing raw scan results of this survey is on the left panel of Figure B7 below. A 2.5- by 2.5-meter (6.25-square meter [m^2]) grid fishnet was overlain across the scan data, and a statistical analysis ensued of measurements obtained within each grid. On the right panel of Figure B7 is a grid-averaged map showing the same color scheme for gamma count rate as for the raw data. Each grid is color coded based on the average of the gamma count rate measurements obtained within that grid, and each grid cell is labeled with a grid identification number and the average gamma count rate in cpm. Table B1 lists descriptive statistics from the 5-meter UAV gamma radiation survey of both the raw gamma data and 6.25-m^2 grid measurements.

The second UAV gamma radiation survey in the Utah Pilot Study occurred at a scan height of 1-meter ags with 2-meter transect spacing between scan lines and moved at a constant velocity of 1 m/s. A total of 1,360 measurements ranged between 11,092 and 99,949 cpm. A map showing raw scan results of this survey is on the left panel of Figure B8 below. A 6.25-m^2 grid fishnet was overlain across the scan data, and a statistical analysis ensued of measurements obtained within each grid. On the right panel of Figure B8 is a grid-averaged map showing the same color scheme for gamma count rate as for the raw data. Each grid is color coded based on the average of the gamma count rate measurements obtained within each grid, and each grid is labeled with a grid identification number and the average gamma count rate in cpm. Table B2 lists descriptive statistics from the 5-meter UAV gamma radiation survey—of both the raw gamma data and the 6.25 m^2 grid measurements.

Evaluation of the descriptive statistics in Table B1 and Table B2 revealed a nearly identical number of raw measurements in both surveys (relative percent different [RPD] ~ 0%)—indicating the same number of measurements obtained at identical locations during both surveys, no matter the scan height. Also, at 5-meter scan height, measured gamma radiation levels on average were lower (27,953 cpm) than at the 1-meter scan height (30,283 cpm). The closer the detector is to the ground, the smaller both the field of view and interference from photons from farther distances. The 1-meter scan yielded values lower (blue dots at southwest corner) and much higher (burgundy dots at northeast corner) than that for the 5-meter scan height. Nonetheless, those differences were subtle, and it was still possible to derive a relationship between the datasets from the two detector heights that would allow development of a data conversion factor from 5 to 1-meter ags.

No significant difference in the descriptive statistics resulted from comparing the raw to grid-averaged data from both flights; however, the intent of using the grid system was to develop a relationship across an area covered from each of the flight heights. Figure B9 below shows a comparison of the grid-averaged gamma count rate at 5-meter ags to that at 1-meter ags obtained during the Utah Pilot Study. A quadratic regression with an R^2 of 0.9661 fitted the data. This polynomial model was developed by comparing the 162 data pairs from 5- and 1-meter ags obtained at each 6.25 m^2 grid.

Table B1: Descriptive Statistics of High-Density Utah Pilot Study at 5 Meters ags for Raw and Grid-Averaged Gamma Data (6.25-m^2 grid)

Statistic	Units	Raw Scan Data (5-meter)	Grid Average Scan Data (5-meter)
Number of Measurements	#	1,354	162
Average	Counts per minute (cpm)	27,953	27,527
Median	cpm	24,470	23,052
Minimum	cpm	11,981	12,350
Maximum	cpm	68,281	65,823
Standard Deviation	cpm	13,732	14,086
Relative Standard Deviation	cpm	49%	51%
90th Percentile	cpm	49,416	51,898
95th Percentile	cpm	56,831	58,666
99th Percentile	cpm	63,098	63,496

Table B2: Descriptive Statistics of High-Density Utah Pilot Study at 1 Meter ags for Raw and Grid-Averaged Gamma Data (6.25-m^2 grid system)

Statistic	Units	Raw Scan Data (1 meter)	Grid Average Scan Data (1 meter)
Number of Measurements	#	1,360	162
Average	Counts per minute (cpm)	30,283	29,827
Median	cpm	21,718	21,102
Minimum	cpm	11,092	11,371
Maximum	cpm	99,949	96,751
Standard Deviation	cpm	20,689	21,151
Relative Standard Deviation	cpm	68%	71%
90th Percentile	cpm	63,523	62,952
95th Percentile	cpm	79,738	81,242
99th Percentile	cpm	91,173	89,937

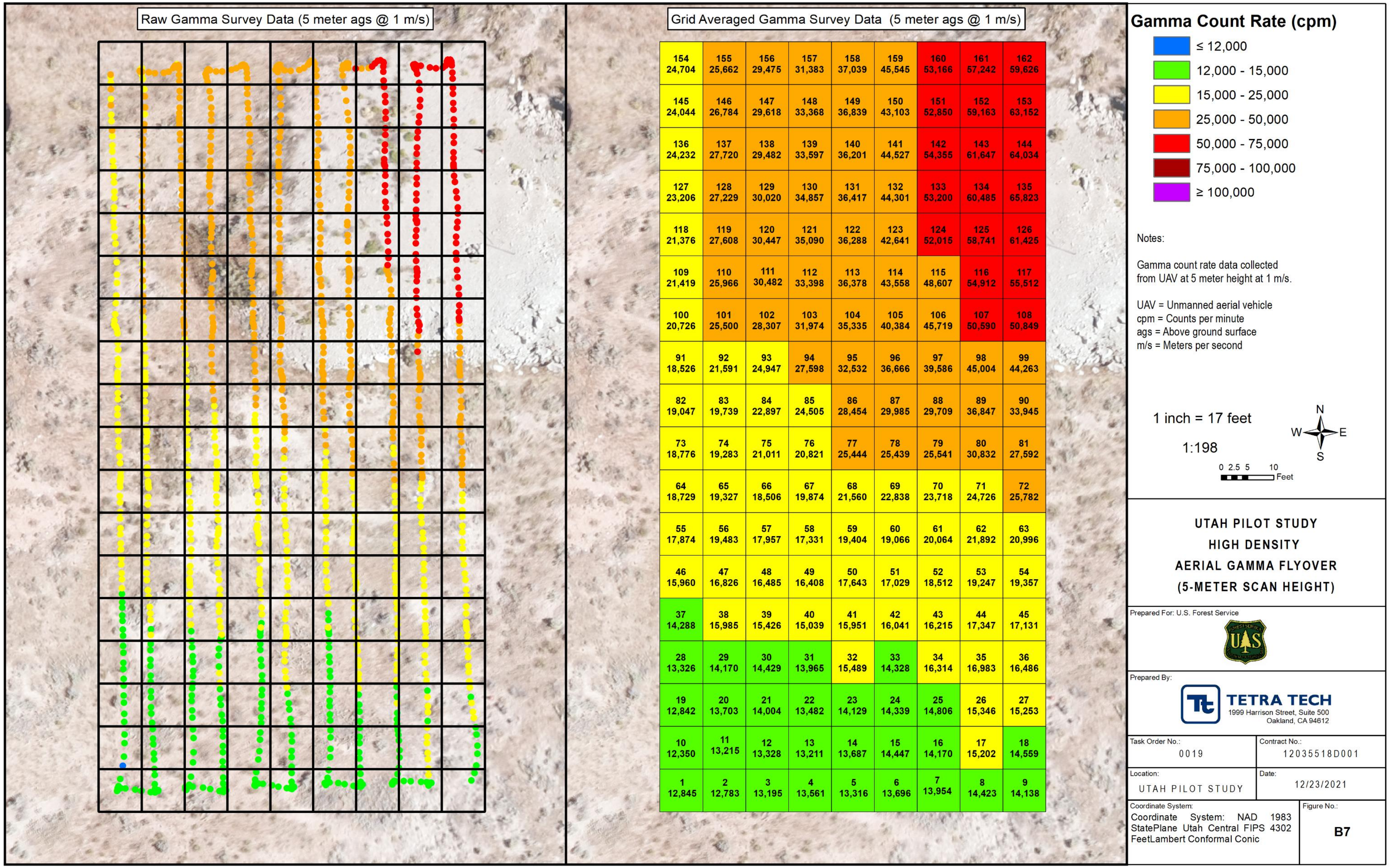


Figure B7: Utah Pilot Study High-Density Aerial Gamma Flyover (5-Meter ags Scan Height)

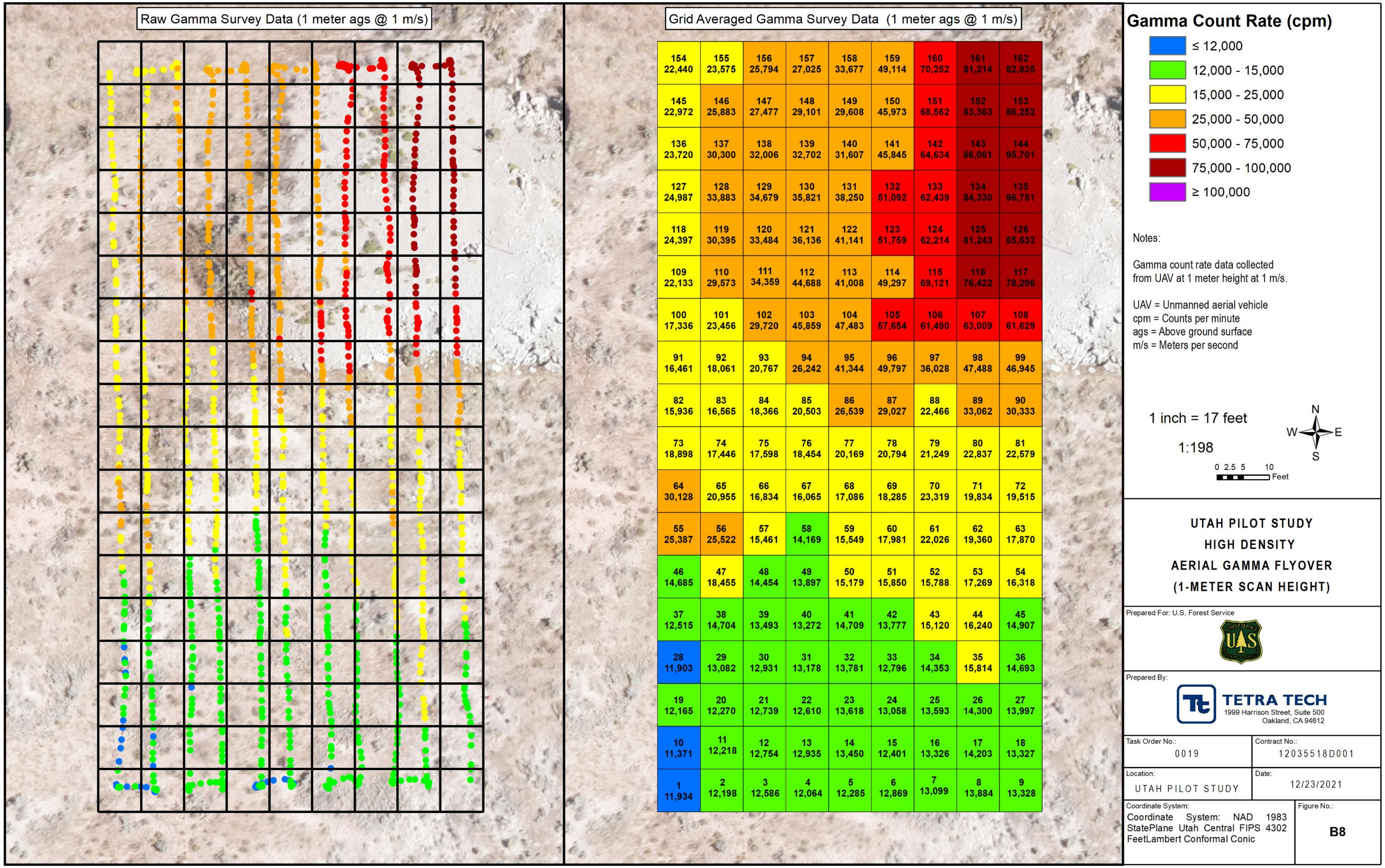


Figure B8: Utah Pilot Study High-Density Aerial Gamma Flyover (1-Meter ags Scan Height)

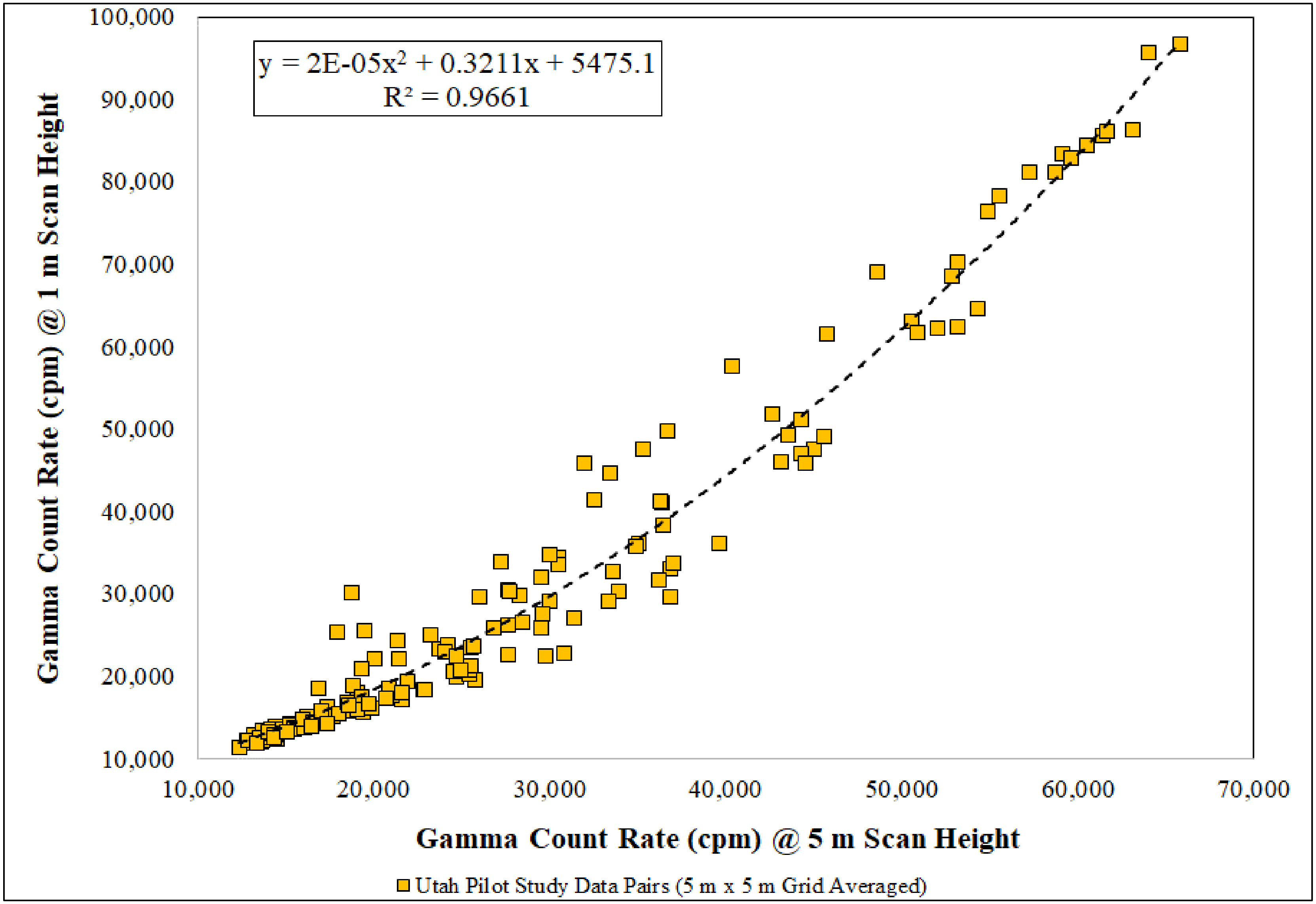


Figure B9: Grid-Averaged Gamma Count Rate at 1 Meter Above Ground Surface (ags) (Y-Axis) Versus 5 Meters ags (X-axis)

2.4.2 South Dakota Pilot Study

The South Dakota Pilot Study occurred during summer 2021 at the top of Bluff B. A small survey area of less than 0.25 acre was selected for a high-density gamma radiation survey by use of the gamma-scanning UAV. That area had limited vegetation and had yielded a range of radiation measurements from four to 10 times background levels.

The first UAV gamma radiation survey in the South Dakota Pilot Study occurred at a scan height of 5 meters ags with 2-meter transect spacing between scan lines and moved at a constant velocity of 1 m/s. A total of 818 measurements ranged between 40,040 and 74,756 cpm. A map showing raw scan results of this survey is on the left panel of Figure B10 below. The color-coding schema for the South Dakota Pilot Study differs from that for the Utah Pilot Study because these studies yielded different magnitudes and spreads of radiation levels. A 6.25-m^2 grid fishnet was overlain across the scan data, and a statistical analysis ensued of measurements obtained within each grid. On the right panel of Figure B10 is a grid-averaged map showing the same color scheme for gamma count rate as for the raw data. Each grid is color coded based on the average of the gamma count rate measurements obtained within that grid, and each grid cell is labeled with a grid identification number and the average gamma count rate in cpm.

Table B3 lists descriptive statistics from the 5-meter UAV gamma radiation survey—of both the raw gamma data and 6.25-m^2 grid measurements.

The second UAV gamma radiation survey in the South Dakota Pilot Study occurred at a scan height of 1-meter ags with 2-meter transect spacing between scan lines and moved at a constant velocity of 1 m/s. A total of 832 measurements ranged from 35,257 to 165,642 cpm. A map showing raw scan results of this survey is on the left panel of Figure B11 below. A 6.25-m^2 grid fishnet was overlain across the scan data, and a statistical analysis ensued of measurements obtained within each grid. On the right panel of Figure B11 is a grid-averaged map showing the same color scheme for gamma count rate as for the raw data. Each grid is color coded based on the average of the gamma count rate measurements obtained within each grid, and each grid is labeled with a grid identification number and the average gamma count rate in cpm. Table B4 lists descriptive statistics from the 5-meter UAV gamma radiation survey—of both the raw gamma measurements and the 6.25-m^2 grid measurements.

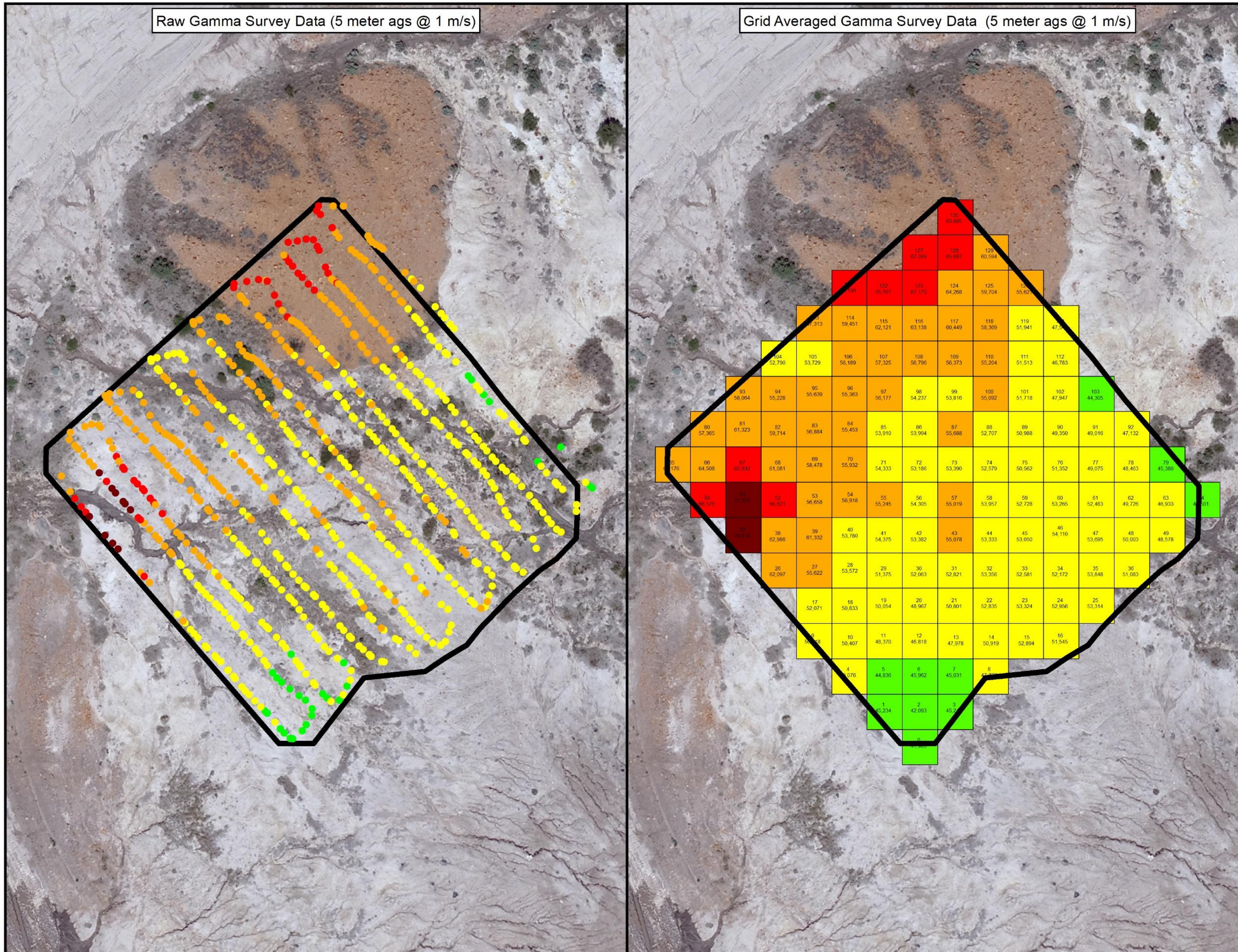
Evaluation of the descriptive statistics in Table B3 and Table B4 revealed variability (as measured by the relative standard deviation [RSD]) significantly higher on the 1-meter survey (28%) than the 5-meter survey (11%)—similar to the Utah Study (~70% and 50%). Still, a relationship was evident between the grid averages from the 5-meter survey and the 1-meter survey. Figure B12 below shows the grid averages from the two survey heights with a quadratic regression indicating an R^2 of 0.7879. Notably, this dataset does not include as great a range of lower-level grids yielding less than 38,000 cpm as in the Utah Pilot Study; however, the trend in the dataset from South Dakota study is similar to that from the Utah study as described in Section 2.4.3,below.

Table B3: Descriptive Statistics of High-Density South Dakota Pilot Study at 5 Meters ags for Raw and Grid-Averaged Gamma Data (6.25-m^2 grid system)

Statistic	Units	Raw Scan Data (5 meter)	Grid Average Scan Data (5 meter)
Number of Measurements	#	818	131
Average	cpm	54,571	54,378
Median	cpm	53,837	53,572
Minimum	cpm	40,040	41,905
Maximum	cpm	74,756	71,373
Standard Deviation	cpm	6,101	5,968
Relative Standard Deviation	cpm	11%	11%
90th Percentile	cpm	63,449	63,138
95th Percentile	cpm	66,270	65,809
99th Percentile	cpm	70,126	69,721

Table B4: Descriptive Statistics of High-Density South Dakota Pilot Study at 1 Meter ags for Raw and Grid-Averaged Gamma Data (6.25-m^2 grid system)

Statistic	Units	Raw Scan Data (1 meter)	Grid Average Scan Data (1 meter)
Number of Measurements	#	832	131
Average	cpm	60,879	60,007
Median	cpm	56,601	56,844
Minimum	cpm	35,257	38,479
Maximum	cpm	165,642	148,316
Standard Deviation	cpm	17,102	15,457
Relative Standard Deviation	cpm	28%	26%
90th Percentile	cpm	84,059	80,582
95th Percentile	cpm	97,434	93,784
99th Percentile	cpm	121,835	111,295



Gamma Count Rate (cpm)

- ≤ 40,000
- 40,000 - 45,000
- 45,000 - 55,000
- 55,000 - 65,000
- 65,000 - 70,000
- 70,000 - 100,000
- ≥ 100,000

Notes:

Gamma count rate data collected from UAV at 5 meter height at 1 m/s.

UAV = Unmanned aerial vehicle
cpm = Counts per minute
ags = Above ground surface
m/s = Meters per second

1 inch = 22 feet

1:266

0 2.5 5 10 Feet

N W E S

SOUTH DAKOTA PILOT STUDY
HIGH DENSITY
AERIAL GAMMA FLYOVER
(5-METER SCAN HEIGHT)

Prepared For: U.S. Forest Service

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
0019	12035518D001
Location: UTAH PILOT STUDY	Date: 12/23/2021
Coordinate System: Coordinate System: NAD 1983 StatePlane South Dakota North FIPS 4001 FeetLambert Conformal Conic	Figure No.: B10

Figure B10: South Dakota Pilot Study High-Density Aerial Gamma Flyover (5-Meter Scan Height)

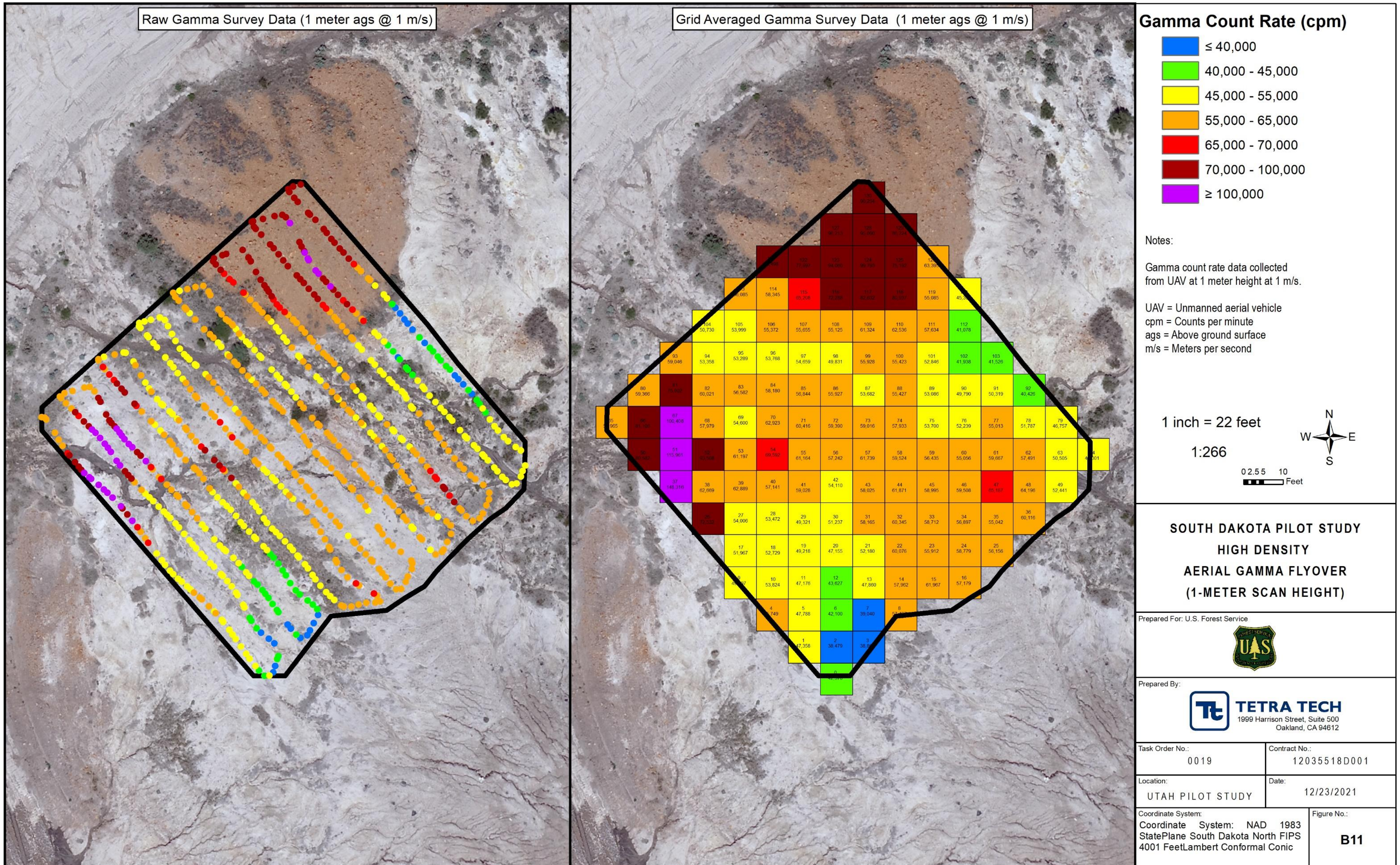


Figure B11: South Dakota Pilot Study High-Density Aerial Gamma Flyover (1-Meter Scan Height)

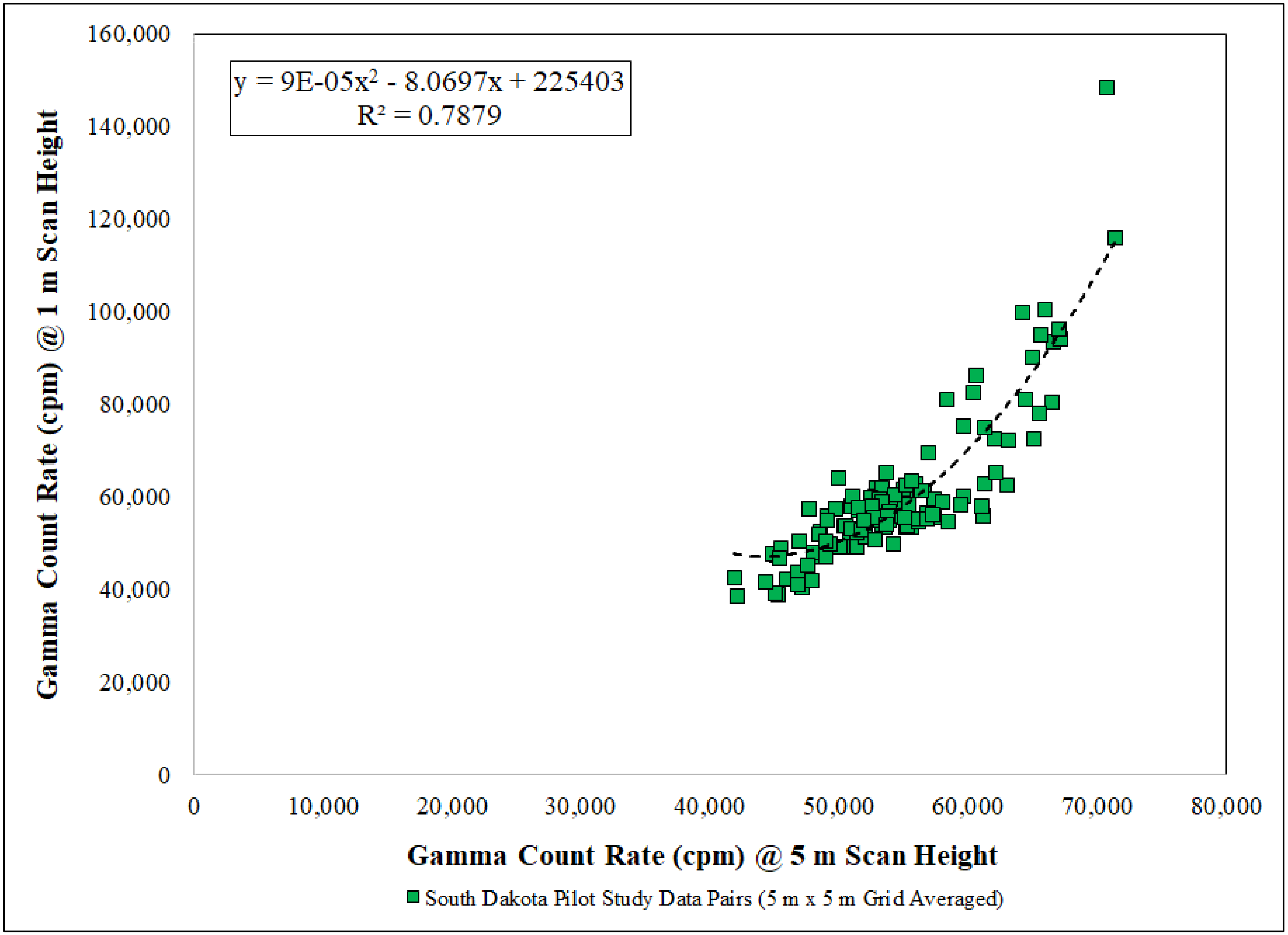


Figure B12: Grid-Averaged Gamma Count Rate at 1 Meter Above Ground Surface (ags) (Y-Axis) versus 5 Meters ags (X-axis)

2.4.3 Evaluation of Both Pilot Studies

The datasets from the high-density gamma scanning UAV surveys during the Utah Pilot Study and the South Dakota Pilot Study were combined for an attempt to identify a relationship between them. Figure B13 below shows both datasets (Utah Pilot Study data pairs in yellow and South Dakota Pilot Study data pairs in green). The R^2 of the quadratic model is 0.9127, meaning 91.27% of variation in the 1-meter grid can be explained by the regression model. The datasets cover well the range of interest for radiation levels, the model properly fits curvature of the data, and the line fits well within the area of special interest (i.e., lower values of radiation). The resulting conclusion is that this model can be applied to convert 5-meter-ags gamma count rate measurements from a gamma-scanning UAV to equivalent 1-meter-ags gamma count rate measurements according to the following Equation 1:

Equation 1: $$[\mathbf{1}\boldsymbol{m}] = \mathbf{12,157} - \mathbf{0.0591}[\mathbf{5}\boldsymbol{m}] + \mathbf{0.000018}[\mathbf{5}\boldsymbol{m}]^{\mathbf{2}}$$

Where:

[1m] = 1-meter "equivalent" gamma count rate in cpm

[5m] = 5-meter gamma count rate measured in cpm from the gamma-scanning UAV

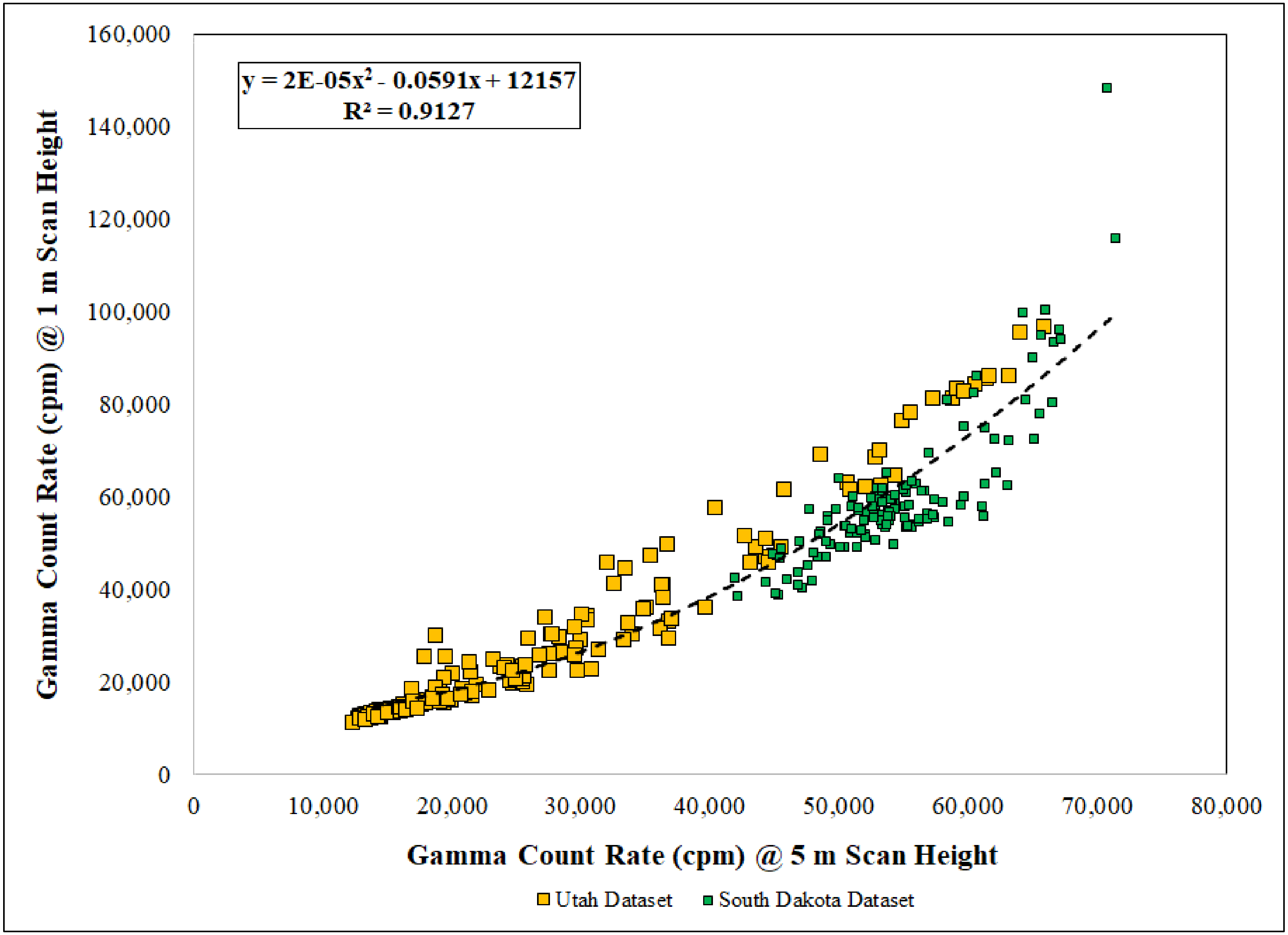


Figure B13: Pilot Study Combined Data From 5- and 1-Meter High-Density UAV Gamma Scans – Quadratic Model

An evaluation was done to assess the extent that the accuracy of a gamma-scanning was impacted by sudden topographic changes. Prior to the aerial flyover surveys, an aerial photogrammetric survey was conducted over each pilot study area to develop a digital surface model (DSM). The gamma scanning UAV also measured height ags with each gamma count rate measurement. Using both the data from the aerial photogrammetric and the gamma-scanning UAV, a spatial analysis was performed to compare heights ags measured by the detector during both pilot studies and both flight missions with the programmed heights ags of 1 meter and 5 meters at the corresponding locations in the DSM.

Figure B14, from the Utah Pilot Study, is a histogram of measured elevation at the time of each gamma count rate measurement during the 1-meter ags, high-density survey. Similarly, Figure B15, from the South Dakota Pilot Study, shows the measured elevation at the time of each gamma count rate measurement during the 1-meter-ags, high-density survey. The data indicate a normal distribution of elevation measurements with a mean slightly above the 1-meter programmed elevation for both pilot studies.

Figure B16, from the Utah Pilot Study, is a histogram of measured elevation at the time of each gamma count rate measurement during the 5-meter ags, high-density survey. Similarly, Figure B17, from the South Dakota Pilot Study, shows the measured elevation at the time of each gamma count rate measurement during the 5-meter-ags, high-density survey. The data indicate a normal distribution of elevation measurements with a mean slightly above the 5-meter programmed elevation for both pilot studies.

Overall, the results show that the gamma UAV functioned properly but tended to fly slightly higher than the programmed elevation for both height programming modes (1 meter and 5 meters ags). Resolution of this is to lower the programmed elevation by 0.05 meter (2 inches) during future flight missions.

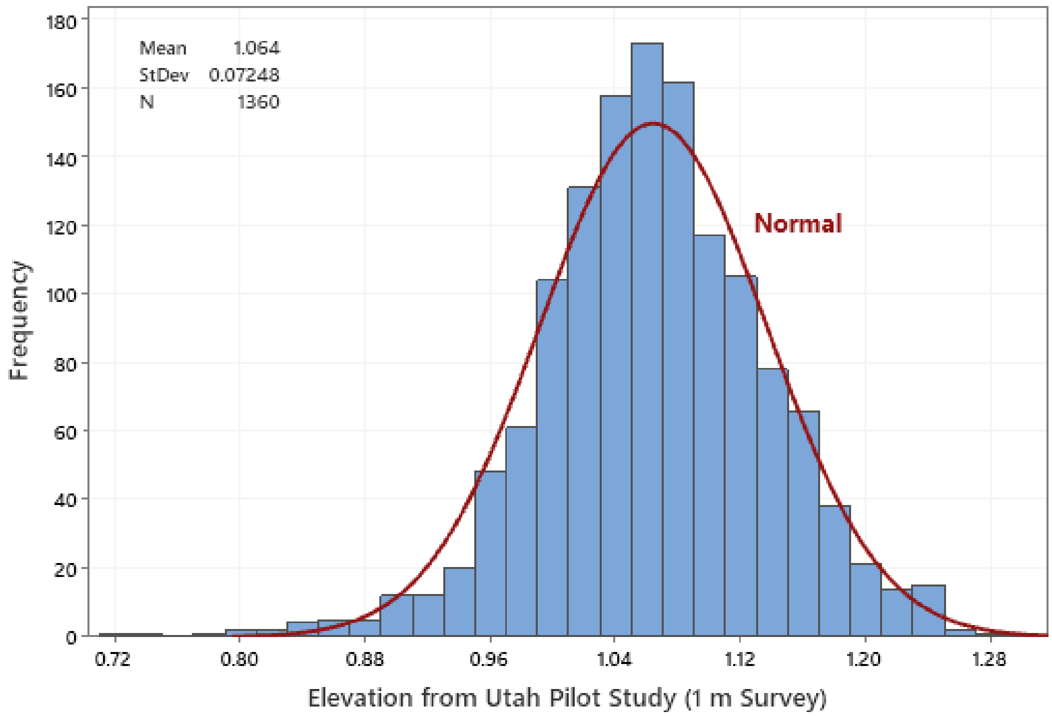


Figure B14: Histogram of Elevation Data from 1-Meter ags UAV Gamma Survey Measurements (Utah Pilot Study)

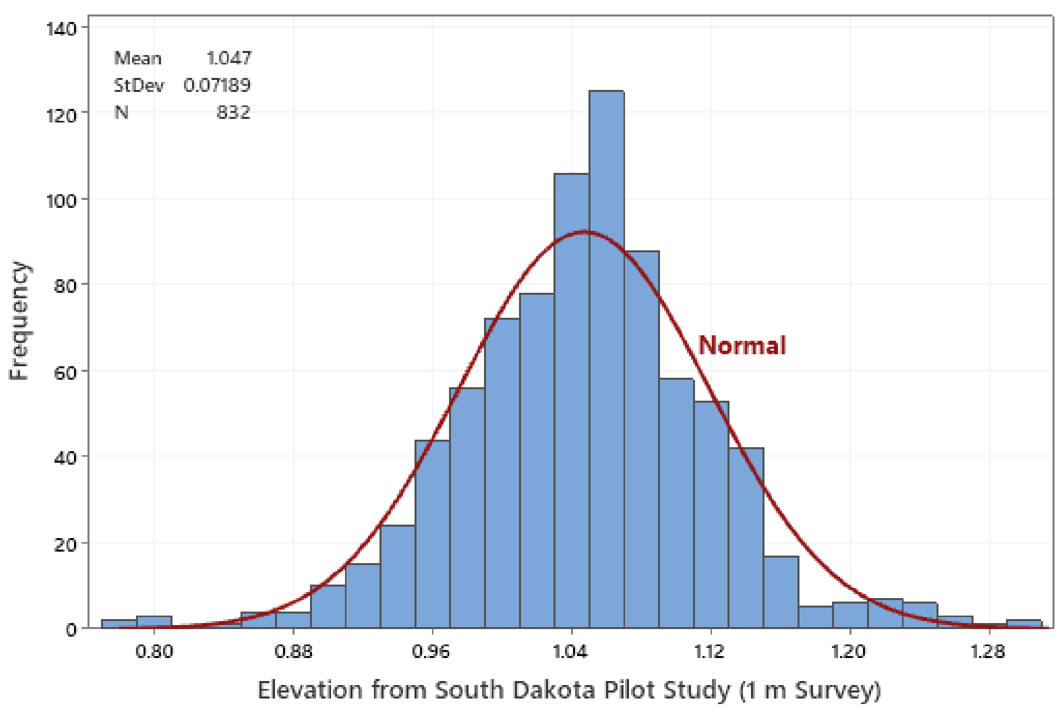


Figure B15: Histogram of Elevation Data from 1-Meter ags UAV Gamma Survey Measurements (South Dakota Pilot Study)

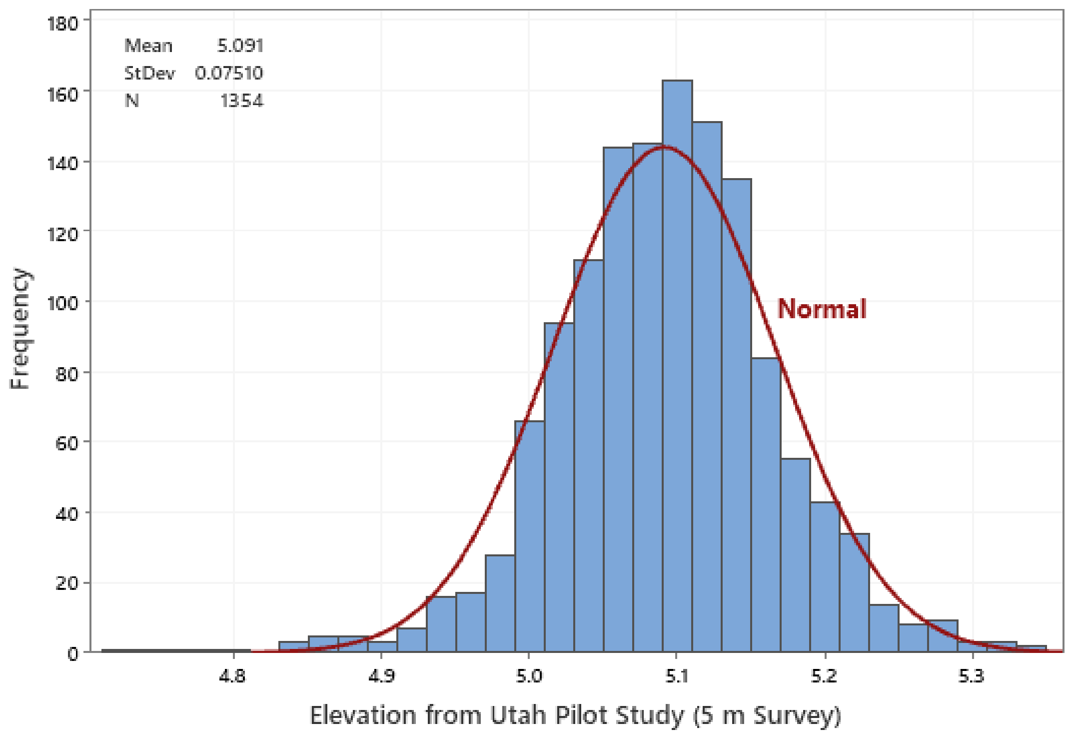


Figure B16: Histogram of Elevation Data from 5-Meter ags UAV Gamma Survey Measurements (Utah Pilot Study)

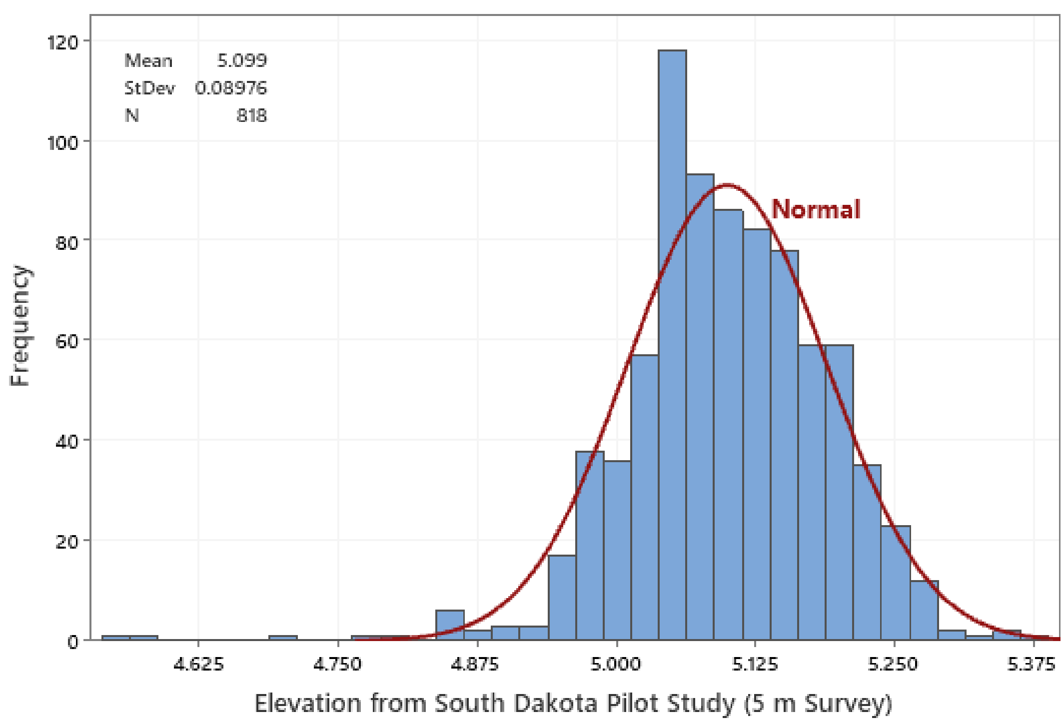


Figure B17: Histogram of Elevation Data from 5-Meter ags UAV Gamma Survey Measurements (South Dakota Pilot Study)

2.5 EXPERIMENT #2: MEDIUM- AND LOW-DENSITY UAV SURVEYS

The following subsections discuss medium- and low-density UAV surveys during the Utah and South Dakota pilot studies. The importance of the medium and low-density surveys is to be able to bring the 10-meter height data down to an estimated 5-meter height data – which can then be converted to an estimate at a 1 meter height using the medium to high density relationships.

2.5.1 Utah Pilot Study

The Utah Pilot Study included a medium-density UAV survey at a scan height of 5 meters ags with 10-meter transects, and moved at 2 m/s. Within the same region occurred a lower density UAV survey at a scan height of 10 meters ags with 20-meter transects moving at 2 m/s. Figure B18 shows the 10-meter ags gamma count rate measurements (green dots) and the 5-meter ags gamma count rate measurements (blue dots). The crossover area (encompassing 1.4 acres) is where the blue and green dots intersect. The crossover area is of interest to determine whether a relationship exists between the 10- and 5-meter ags measurements, similar to that determination between the 5- and 1-meter ags measurements.

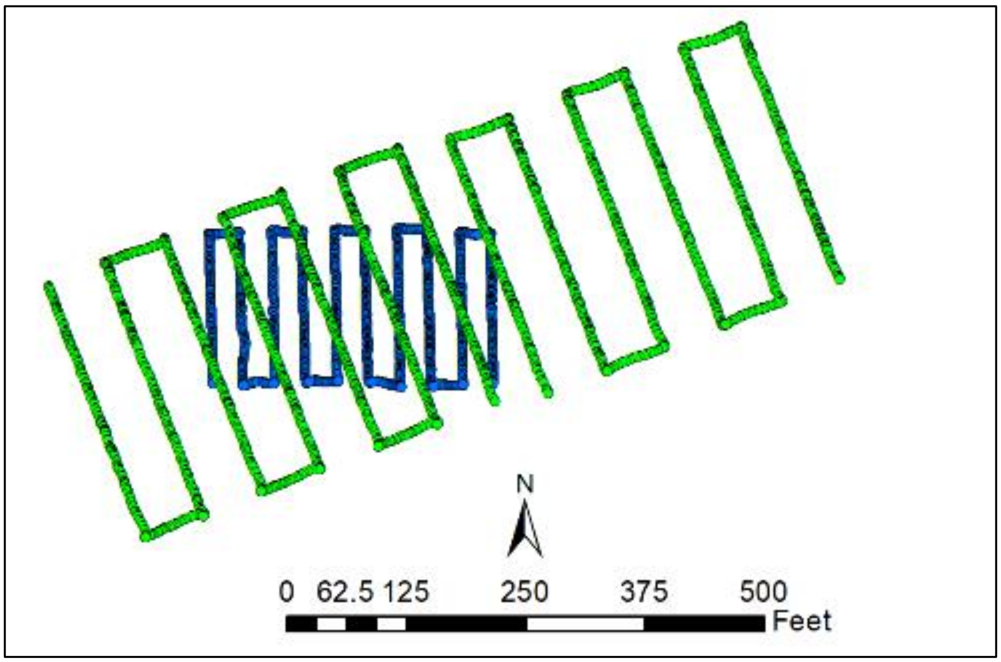


Figure B18: 10-Meter ags (Green) and 5-Meter ags (Blue) Measurements (Utah Pilot Study)

Because these surveys differed in scan lines or transect spacing (unlike the high-density surveys that proceeded with the same scan lines or transect spacing), an alternative method of comparison was necessary. Each dataset underwent a geostatistical analysis, shown on Figure B19. A raster surface was generated and converted into equally spaced points for both the 10- and 5-meter datasets, allowing a direct comparison. Generation of these data pairs was followed by a regression analysis. These data pairs are shown on Figure B20. A power function used for the regression resulted in an R^2 of 0.9385.

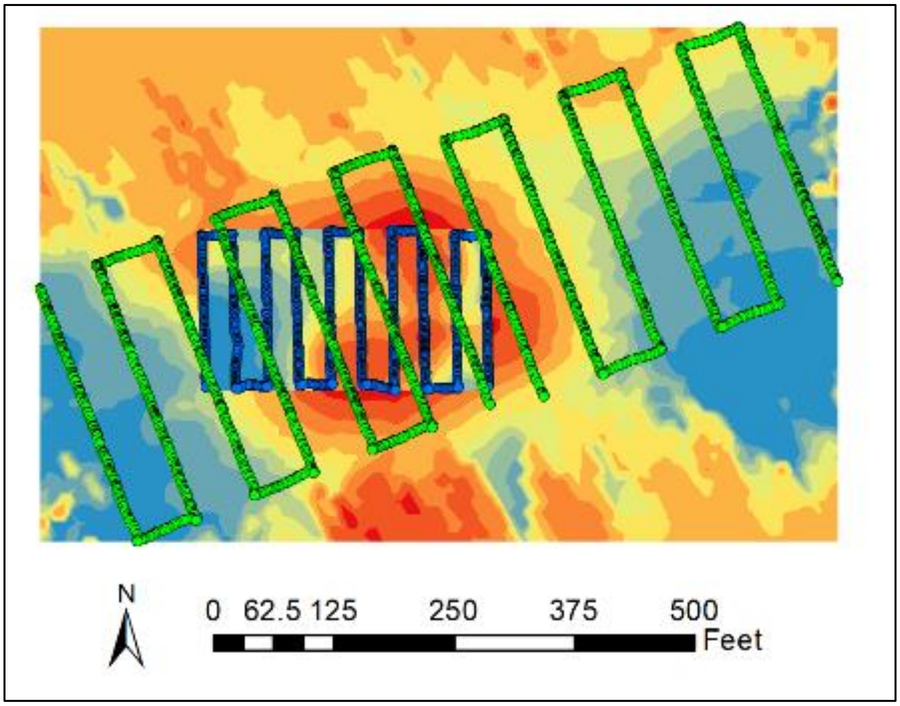


Figure B19: Geostatistical Interpolation of Utah Pilot Study Medium and Low-Density Survey Data

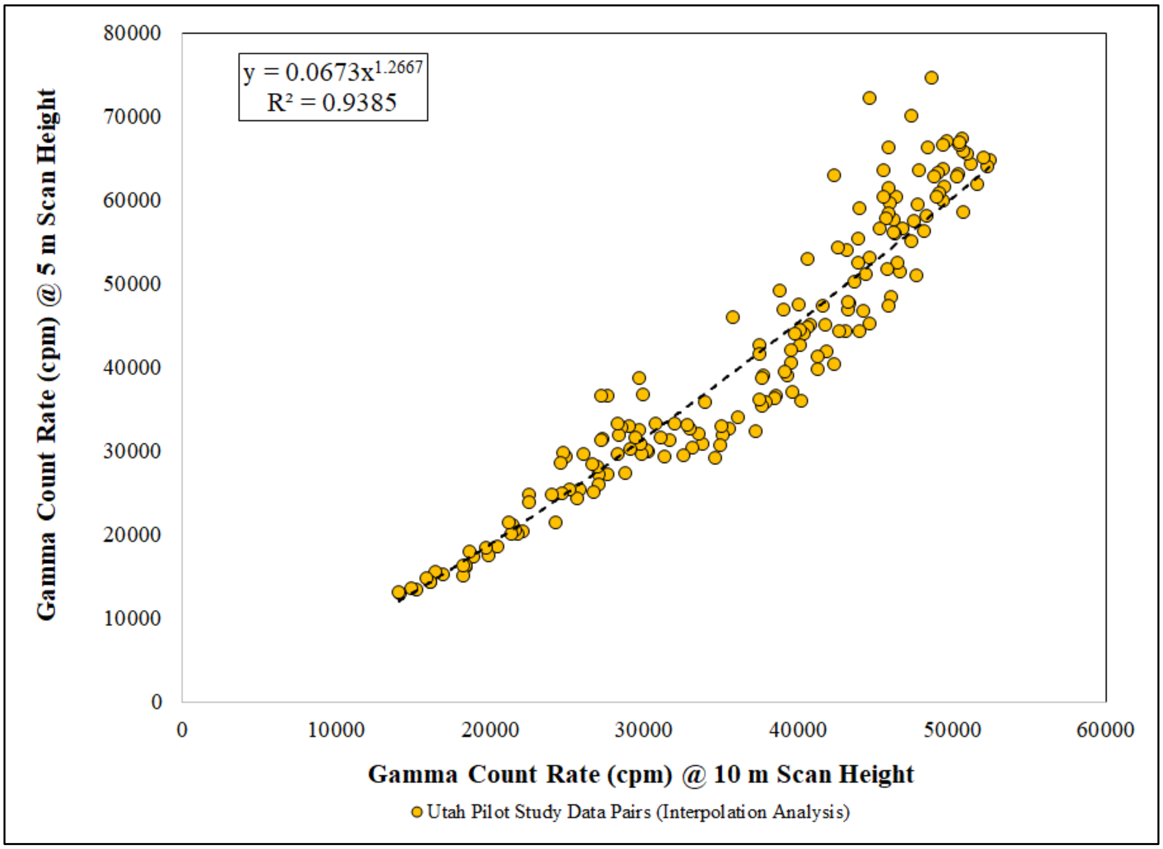


Figure B20: Relationship of 10- and 5-Meter ags Data Pairs Via Interpolation Analysis (Utah Pilot Study)

2.5.2 South Dakota Pilot Study

An identical approach was followed to determine a relationship between data acquired at 10- and 5-meter-ags scan heights during medium- and low-density surveys flown at 2 m/s in the South Dakota Pilot Study, by use of the same parameters and application of the same interpolation techniques. Figure B21 shows the 10-meter ags (green) and 5-meter ags (blue) gamma count measurements and the associated interpolations performed for each. Each dataset underwent a geostatistical analysis, shown on the figure. A raster surface was generated and converted into equally spaced points for both the 10- and 5-meter datasets, allowing a direct comparison. Generation of these data pairs was followed by a regression analysis. These data pairs are shown on Figure B22.

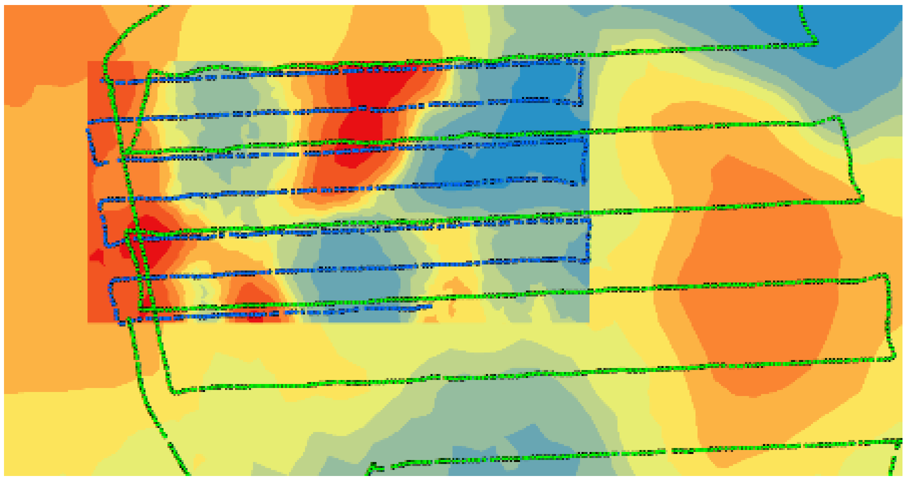


Figure B21: Geostatistical Interpolation of South Dakota Pilot Study Medium- and Low-Density Survey Data - 10-Meter ags (Green) and 5-Meter ags (Blue) Measurements

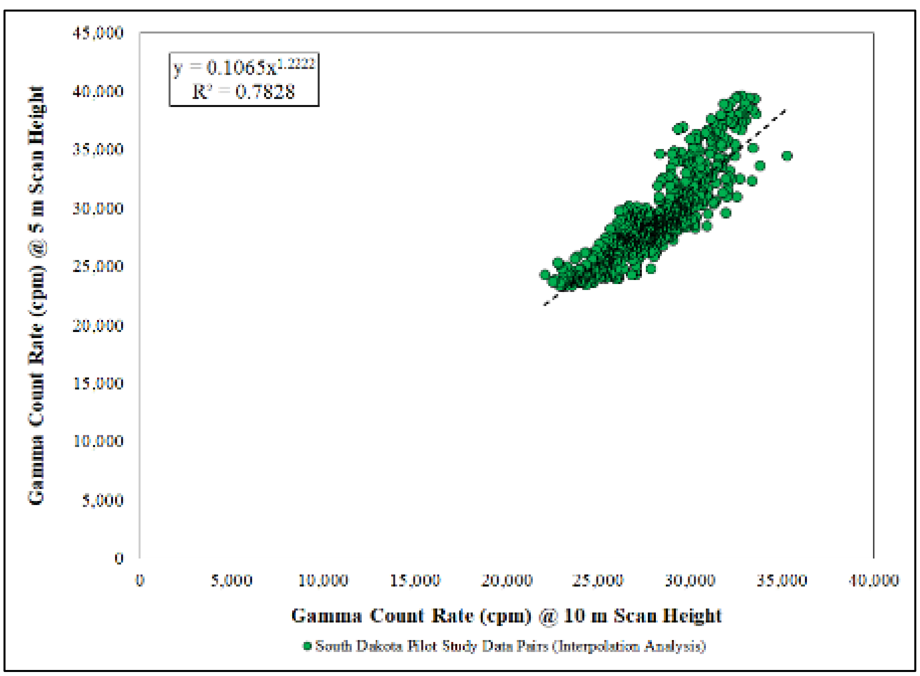


Figure B22: Relationship Between 10- and 5-Meter ags Data Pairs Via Interpolation Analysis (South Dakota Pilot Study)

2.5.3 Evaluation of both Pilot Studies

The previous subsections presented datasets and regression analyses by use of a power function that pertain to the low- and medium-density gamma scanning UAV surveys during both pilot studies. Data pairs were generated that included "simulated" grid cells through interpolation analysis of data from 10- and 5-meter ags crossover areas which were developed for each pilot study. A total of 180 data pairs were generated during the Utah Pilot Study within the 1.4-acre crossover region. A total of 766 data pairs were generated during the South Dakota Pilot Study within the 2.1-acre crossover region. The difference in number of data pairs per surface area density was an artifact of grid cell selection. The higher density during the South Dakota Pilot Study, allowed because of the arrangement and directional pattern of the gamma scanning UAV, permitted a more detailed cross comparison. In the future, a consistent scan pattern and grid cell size should be applied to similar analyses.

A statistical analysis of the combined dataset generated from each pilot study occurred by applying a power function to all the data pairs combined. Figure B23 below shows both datasets—10-meter-ags gamma count rate (x-axis) and 5-meter-ags gamma count rate (y-axis) from the Utah Pilot Study (orange dots), and from the South Dakota Pilot Study (green dots). The R^2 of the power function model is 0.9201. The datasets cover the range of interest well for radiation levels, the model properly fits curvature of the data, and the line fits well in the area of special interest (i.e., lower values of radiation). Therefore, conclusion is that this model can be applied to use 10-meter-ags gamma count rate measurements taken from a gamma-scanning UAV to estimate 5-meter-ags equivalent gamma count rate measurements, according to Equation 2:

$$\textbf{Equation 2:} \quad [\mathbf{5}\boldsymbol{m}] = \mathbf{0.0761} * [\mathbf{10}\boldsymbol{m}]^{\mathbf{1.2551}}$$

Where:

[5m] = 5-meter "equivalent" gamma count rate

[10m] = 10-meter gamma count rate measured from the gamma-scanning UAV

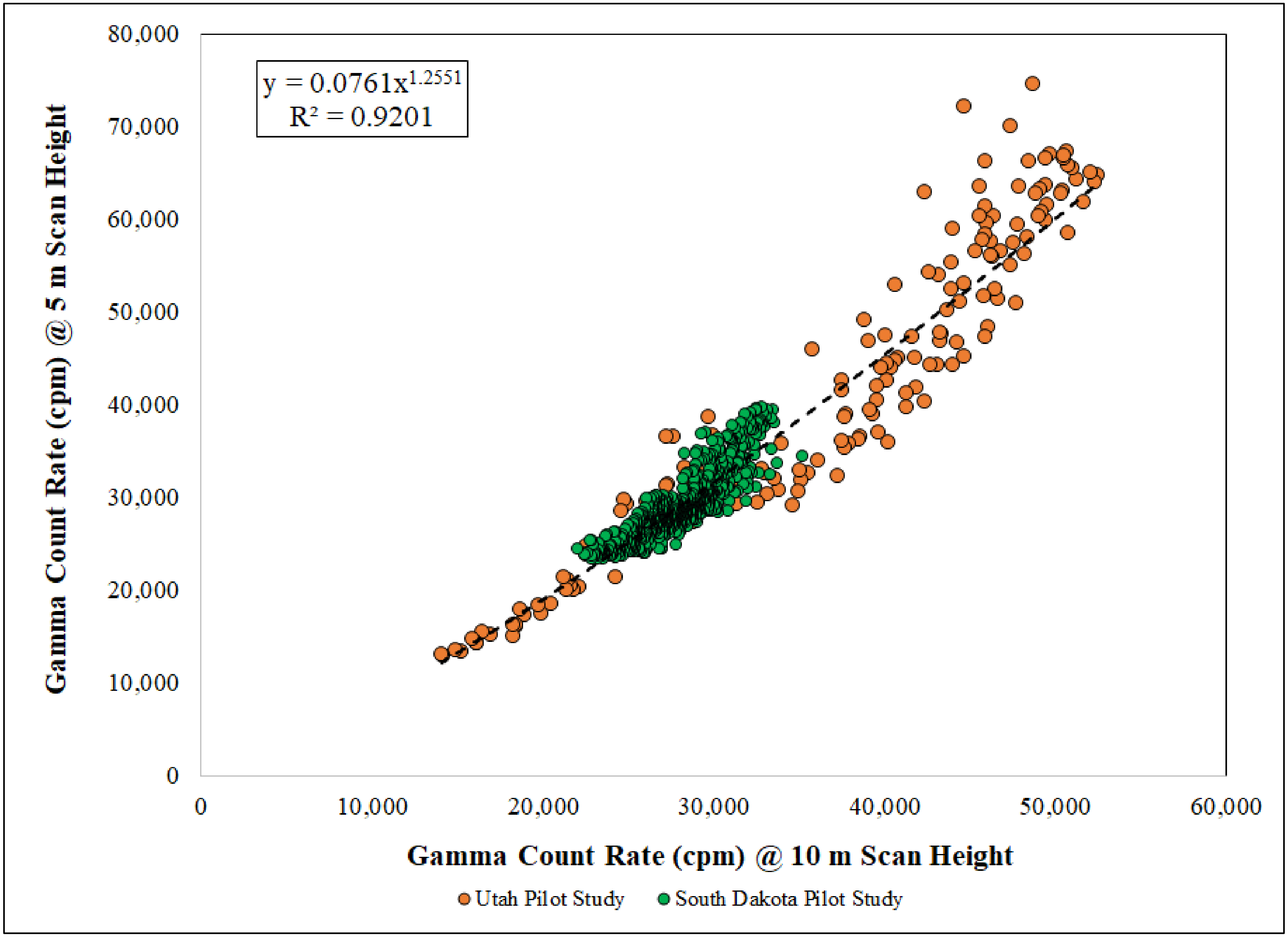


Figure B23: Comparison of 10- and 5-Meter ags Gamma Count Rates from both Pilot Studies (Data Pairs Generated Via Interpolation Analysis)

3.0 BLUFF B AERIAL GAMMA FLYOVER SURVEY

The aerial gamma flyover survey at Bluff B involved gamma count rate measurements taken from a gamma-scanning UAV. The surveys occurred mostly at 10-meter ags during flight missions, with a small area scanned at 5 meters ags for experimental purposes. This section (1) briefly describes the approach to convert gamma count rates measured at greater heights to 1-meter "equivalent" gamma count rates, and (2) describes validation of the model.

3.1 Gamma Height-Correction Approach

Gamma count rate data obtained during the gamma-scanning UAV missions were classified based on scan detector height (10 or 5 meters ags). An analysis of elevations during the low- and medium-density surveys presented in Section 2.4.3 yielded nearly identical results (in terms of precision and accuracy of height of detector along the cliffs). The following approach was followed to generate a final dataset of 1-meter-equivalent gamma count rate measurements:

(1) Equation 2 was used to convert all count rates measured at 10 meters ags from the gamma-scanning UAV to 5-meter-equivalent ags gamma count rates.

(2) Equation 1 was used to convert all count rates measured at 5 meters ags from the gamma-scanning UAV and/or 5-meter-equivalent ags gamma count rate measurements (converted) to 1-meter-equivalent ags gamma count rates.

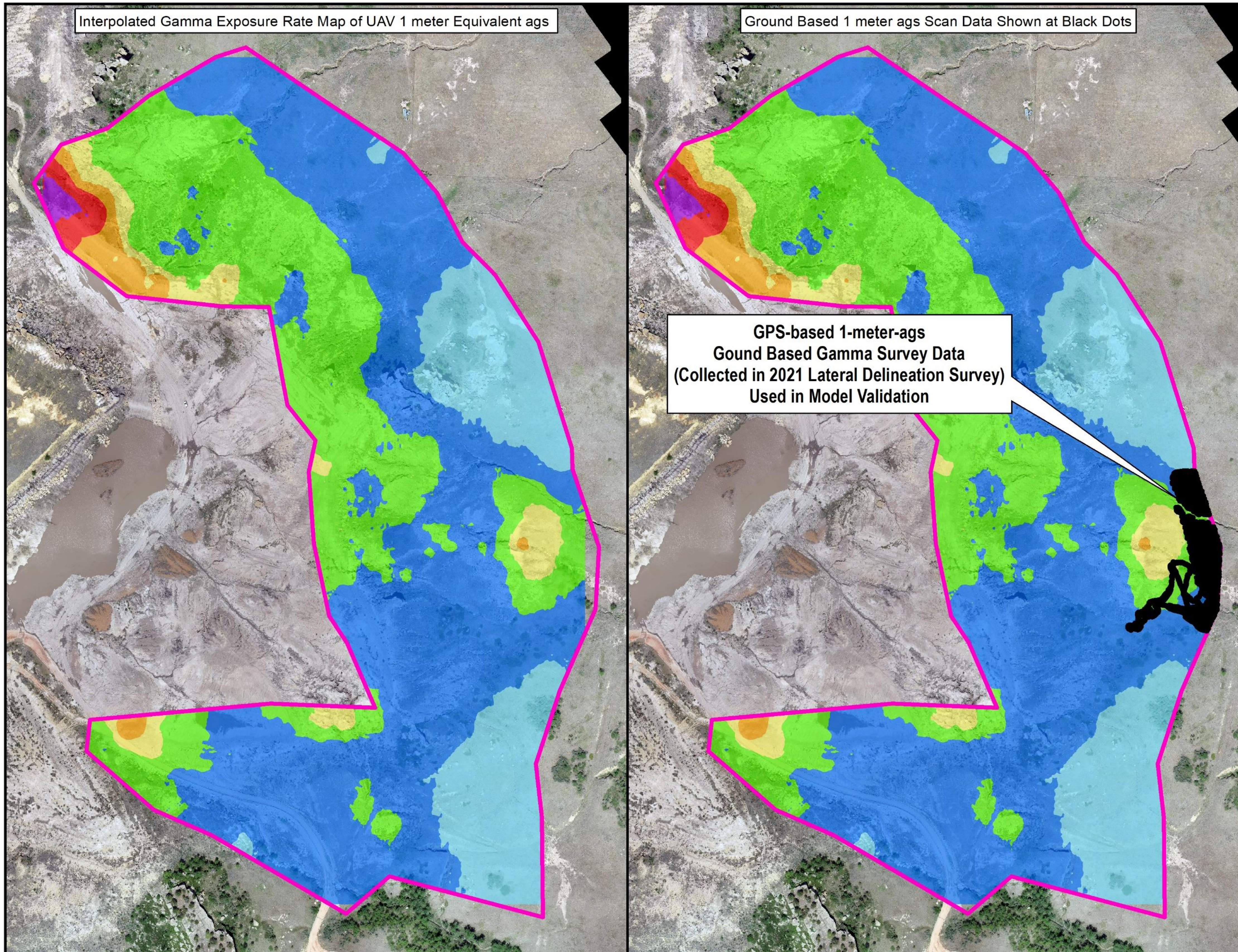
All count rates in the final dataset, then, were 1-meter-equivalent ags gamma count rates. A comparison of these data to data from the backpack instruments occurred. All the data were converted from cpm to μR/hr by use of instrument-specific calibration constants, discussed further in Appendix E to the main report.

3.2 Model Validation

The aerial gamma flyover survey occurred at 10 meters ags and/or 5 meters ags across the UAV scan area of the eastern cliffs of Bluff B. The gamma count rates were converted to 1-meter-ags equivalent readings in cpm, and then were converted to gamma exposure rate in μR/hr by application of the procedures described in Section 3.1, above.

A model validation was performed to assess how well the predicted 1-meter-ags equivalent data from the UAV compared to gamma exposure rates measured at 1 meter ags on the ground by use of a GPS-based backpack system during the 2021 lateral delineation gamma radiation surveys within crossover areas of the UAV scan area. This proceeded via interpolation of the gamma-scanning UAV data (1-meter-equivalent gamma exposure rate data as an independent data set) and generation of a continuous surface by use of ArcGIS and application of an ordinary kriging method (as shown on the left panel of Figure B24). The 2021 GPS-based backpack scan data, obtained at a 1-meter-ags scan height, were clipped to the crossover area, as shown on the right panel of Figure B24.

The 1-meter-ags scan data acquired from the ground were compared to predicted 1-meter-ags equivalent scan data from the UAV by application of an extraction method. Figure B25 shows predicted (x-axis) versus ground-acquired (y-axis) data pairs. A direct linear relationship appears between predicted and ground-acquired data pairs. The linear regression line (black dotted line) is nearly parallel to the line of unity representing a perfect alignment of predicted and measured data pairs. The data pairs included 2,600+ ground-based measurements with extracted, simulated, estimated, 1-meter-ags equivalent measurements at the same locations. The average RPD between predicted and observed is 10%. This value is acceptable for the purposes of the data quality objectives. While these data evaluated came from only a portion of the walkable region of the UAV scan area, they appear to validate the procedure of flying at greater heights with larger spacing to estimate ground-based conditions at or around the cleanup value for Bluff B.



Gamma Exposure Rate (μR/hr)

- < 20
- 20 - 30.4
- 30.4 - 48
- 48 - 68.5
- 68.5 - 125
- 125 - 250
- ≥ 250

Aerial Gamma Flyover Survey Area

Notes:

Aerial Imagery is 2021 photgrammetry aerial imagery around Bluff B and ESRI World Imagery outside.

The interpolated gamma exposure rate data shown were obtained by drone by use of energy dependent 2" x 2" sodium iodide detectors during a 2021 survey at a height of 5 meters ags or 10 meters ags. The data were converted to 1-meter-ags equivalent. The surface was interpolated by application of an ordinary kriging geostatistical method.

ags = Above ground surface
μR/hr = Microroentgens per hour

1 inch = 244 feet

1:2,926

N W E S

0 50 100 200 Feet

INTERPOLATED 1 METER AGS UAV GAMMA SCAN DATA (LEFT) AND 1 METER AGS BACKPACK SCAN DATA WITHIN CROSSOVER REGION (RIGHT)

Prepared For: U.S. Forest Service

Prepared By:

TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.:	Contract No.:
0019	12035518D001
Location: UTAH PILOT STUDY	Date: 12/23/2021
Coordinate System: Coordinate System: NAD 1983 StatePlane South Dakota North FIPS 4001 FeetLambert Conformal Conic	Figure No.: B24

Figure B24: Interpolated 1-Meter UAV Gamma Scan Data (Left) and 1-Meter Walkover Scan Data Within Crossover Region (Right)

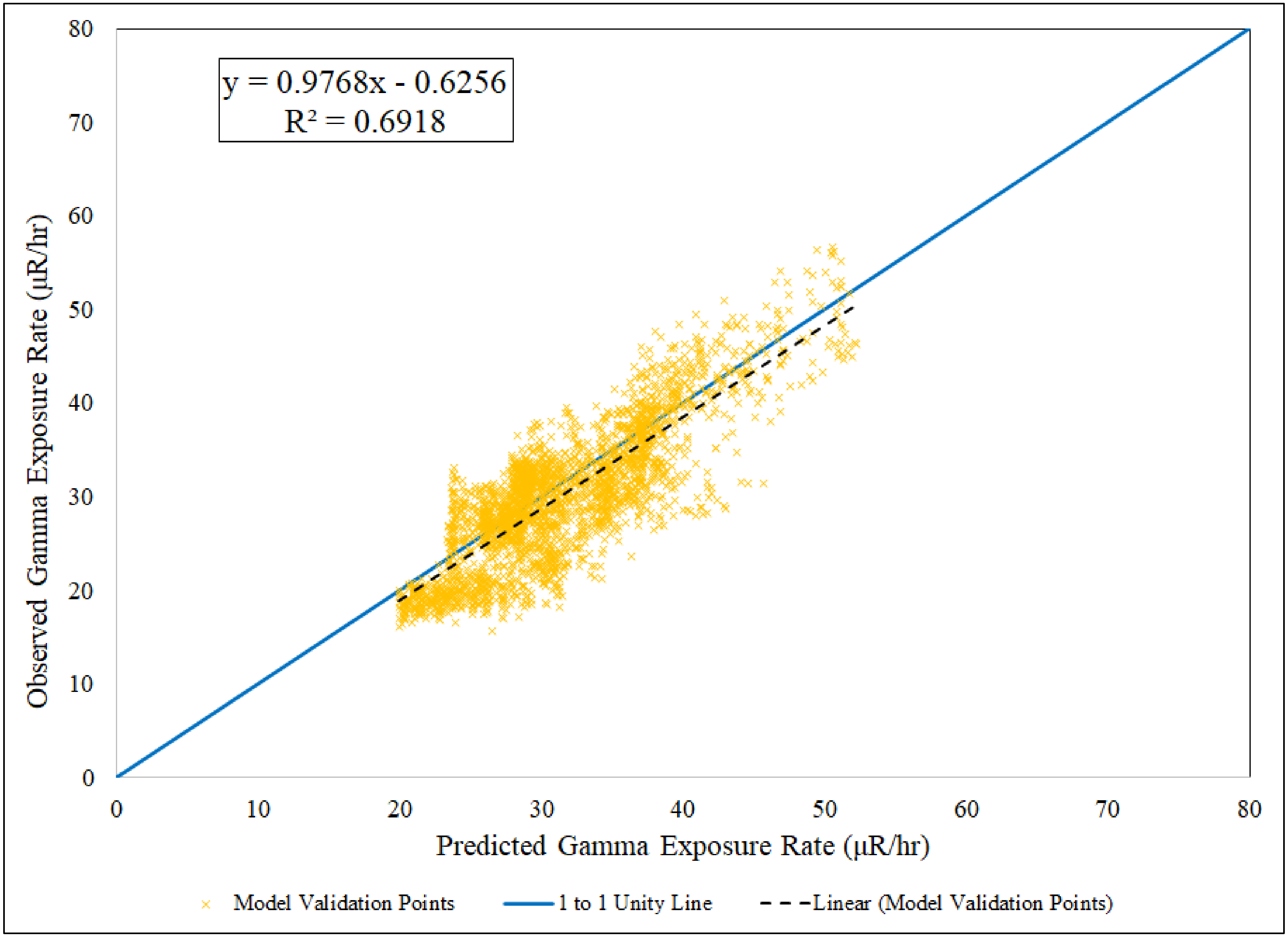


Figure B25: Predicted Gamma Exposure Rates (UAV 1-Meter-ags Equivalent) Versus Ground-measured Gamma Exposure Rates (1-Meter ags Walkover Scan Data)

4.0 CONCLUSIONS

This Appendix B summarized some investigations during pilot studies by use of a gamma scanning UAV. The purpose of the aerial gamma flyover surveys of the eastern cliffs of Bluff B was to acquire gamma radiation data from areas of the eastern portion of Bluff B that are inaccessible on foot due to cliffs with steep slopes that pose a threat of injury to staff due to slips, trips, and falls.

The approach used was to generate a height-correction methodology and evaluate accuracy and precision of actual versus preprogrammed elevations during gamma scanning UAV missions at different scan heights.

Findings of the pilot studies, via model validation, indicated the UAV was successful at meeting the purpose of the study by collecting high quality data in areas that are inaccessible to ground surveys. This study also showed that flying a radiation scanning UAV at higher altitude flights and using a height correction method led to the conclusion this approach was successful at developing screening level data to identify contaminated areas (within 20 percent) of ground level-collected data. This can be useful for assessment and cleanup operations.

Additional conclusions are as follows: application of height-correction methodologies for converting scan data obtained at 10 meters ags or 5 meters ags into 1-meter-ags equivalent data yielded an average RPD between predicted and measured scan data of 10% across 2,600 measurements, with most of the data within 20% accuracy. This indicates that data obtained at 10-meter ags and 5-meter ags scan heights can be converted reliably to 1-meter-ags equivalent gamma radiation levels for purposes of screening to aid remedial engineering design. Additionally, scan heights during all missions were accurate and precise, allowing reproducibility among scan heights and comparability with existing traditional methods.

5.0 REFERENCES

Bechtel Nevada. 2001. An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation, Surveys Conducted in Arizona, New Mexico, and Utah, Date of Surveys: 1994-1999. DOE/NV/11718-602. Remote Sensing Laboratory operated by Bechtel Nevada for U.S. Department of Energy (DOE), National Nuclear Security Administration, Las Vegas, Nevada.

International Atomic Energy Agency (IAEA). 2003. Guidelines for radioelement mapping using gamma ray spectrometry data. IAEA-TECDOC-1363.

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Meyer, R., M. Shields, and S. Green. 2005. "A GPS-based system for preliminary or remedial action gamma scanning." *Proceedings of the American Nuclear Society Topical Meeting on Decommissioning, Decontamination, & Reutilization*. Denver, Colorado (August 7-11, 2005). La Grange Park, Illinois: American Nuclear Society. Pages 131-134.

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U.S. Environmental Protection Agency (EPA). 2021. Airborne Spectral Photometric Environmental Collection Technology (ASPCT) Fact Sheet. Accessed December 2021. https://www.epa.gov/system/files/documents/2021-11/aspect-fact-sheet-2021.pdf.

APPENDIX C
LABORATORY REPORTS

C-1 OPPORTUNISTIC SAMPLES

Monday, September 27, 2021

Aaron Orechwa
Tetra Tech, Inc.
3801 Automation Way, Suite 100
Fort Collins, CO 80525

Re: ALS Workorder: 2108183
Project Name: Bluff B Opportunity Samples
Project Number:

Dear Mr. Orechwa:

Nine soil samples were received from Tetra Tech, Inc., on 8/6/2021. The samples were scheduled for the following analyses:

Gamma Spectroscopy
Metals

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Environmental.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,

ALS Environmental
Katie M. OBrien
Project Manager

Accreditations: ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
California (CA)	2926
Colorado (CO)	CO01099
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
PJ-LA (DoD ELAP/ISO 170250)	95377
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO010992018-1
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	TN02976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280

40 CFR Part 136: All analyses for Clean Water Act samples are analyzed using the 40 CFR Part 136 specified method and include all the QC requirements.

2108183

Metals:

The samples were analyzed following SW-846, 3rd Edition procedures. Analysis by ICPMS followed method 6020B and the current revision of SOP 827.

All acceptance criteria were met.

Gamma Spectroscopy:

The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713.

These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans and stored for at least 21 days prior to analysis.

All remaining acceptance criteria were met.

ADDRESS 225 Commerce Drive, Fort Collins Colorado 80524 USA | PHONE +1 970 490 1511 | FAX +1 970 490 1522
ALS GROUP USA, CORP. Part of the ALS Group An ALS Limited Company

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 2108183
Client Name: Tetra Tech, Inc.
Client Project Name: Bluff B Opportunity Samples
Client Project Number:
Client PO Number:

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
OPP-1-080421	2108183-1		SOIL	04-Aug-21	12:45
OPP-2-080421	2108183-2		SOIL	04-Aug-21	13:00
OPP-3-080421	2108183-3		SOIL	04-Aug-21	13:05
OPP-4-080421	2108183-4		SOIL	04-Aug-21	13:15
OPP-5-080421	2108183-5		SOIL	04-Aug-21	13:30
OPP-6-080421	2108183-6		SOIL	04-Aug-21	13:35
OPP-7-080421	2108183-7		SOIL	04-Aug-21	13:40
OPP-8-080421	2108183-8		SOIL	04-Aug-21	13:50
OPP-DUP-080421	2108183-9		SOIL	04-Aug-21	

ALS Laboratory Group

225 Commerce Drive, Fort Collins, Colorado 80524
TF: (800) 443-1511 PH: (970) 490-1511 FX: (970) 490-1522

Chain-of-Custody

210

Form 202r8

WORKORDER # 2108183-C

		SAMPLER	Shane Matolyak / Bill Craig	DATE	8/4/21	PAGE	1 of 1
PROJECT NAME	~~Riley Pass~~ ~~Cliff B~~	SITE ID		TURNAROUND		DISPOSAL	By Lab or Return to Client
PROJECT No.		EDD FORMAT					
		PURCHASE ORDER					
COMPANY NAME	Tetra Tech	BILL TO COMPANY					
SEND REPORT TO		INVOICE ATTN TO					
ADDRESS		ADDRESS					
CITY / STATE / ZIP		CITY / STATE / ZIP					
PHONE		PHONE					
FAX		FAX					
E-MAIL		E-MAIL					

Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles	Pres.	QC	ARSENIC SW-846	THORIUM SW-846	RADIUM-226 901.1	POTASSIUM-40 901.1	ACTINIUM-228 901.1
1	OPP-1-080421	S	8/4/21	12:45	1			X	X	X	X	X
2	OPP-2-080421	S	8/4/21	13:00	1							
3	OPP-3-080421	S	8/4/21	13:05	1							
4	OPP-4-080421	S	8/4/21	13:15	1							
5	OPP-5-080421	S	8/4/21	13:30	1							
6	OPP-6-080421	S	8/4/21	13:35	1							
7	OPP-7-080421	S	8/4/21	13:40	1							
8	OPP-8-080421	S	8/4/21	13:50	1							
9	OPP-DUP-080421	S	8/4/21	—	1							

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

For metals or anions, please detail analytes below.

Comments:

Please contact Aaron Oberhoff before beginning analysis.

QC PACKAGE (check below)
- LEVEL II (Standard QC)
- LEVEL III (Std QC + forms)
- LEVEL IV (Std QC + forms + raw data)

Preservative Key: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY	[signature]	William Craig	8/5/21	16:30
RECEIVED BY	[signature]	Amy Kephart	8/6/21	10:00
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

5 of 16

Project Name "BLUFF B OPPORTUNITY SAMPLES"

ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: TETRA TECH-FC   Workorder No: 2108183

Project Manager: KMO   Initials: AXK   Date: 08/11/2021

		N/A	YES	NO
1.	Are airbills / shipping documents present and/or removable? Tracking number:	X		
2.	Are custody seals on shipping containers intact?	X		
3.	Are custody seals on sample containers intact?	X		
4.	Is there a COC (chain-of-custody) present?		X	
5.	Is the COC in agreement with samples received? (IDs, dates, times, # of samples, # of containers, matrix, requested analyses, etc.)		X	
6.	Are short-hold samples present?			X
7.	Are all samples within holding times for the requested analyses?		X	
8.	Were all sample containers received intact? (not broken or leaking)		X	
9.	Is there sufficient sample for the requested analyses?		X	
10.	Are samples in proper containers for requested analyses? (form 250, *Sample Handling Guidelines*)		X	
11.	Are all aqueous samples preserved correctly, if required? (excluding volatiles)	X		
12.	Are all samples requiring no headspace (VOC, GRO, RSK/MEE, radon) free of bubbles > 6 mm (1/4 inch) diameter? (i.e. size of green pea)	X		
13.	Were the samples shipped on ice?			X
14.	Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #5	RAD ONLY		X

Cooler #:	1	1	1				
Temperature (°C):	AMB	AMB	AMB				
# of custody seals on cooler:	0	0	0				
External µR/hr reading:	-	-	-				
Background µR/hr reading:	10	10	10				

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES (If no, see Form 008.)

* Please provide details here for NO responses to boxes above - for 2 thru 5 & 7 thru 12, notify PM & continue w/ login.

Were unpreserved bottles pH checked? NA   All client bottle ID's vs ALS lab ID's double-checked by: AK

If applicable, was the client contacted? YES / NO / NA Contact: ______ Date/Time: ______

Project Manager Signature / Date: [signature] 8/23/21

Form 201r30.xls
03/18/2021

*IR Gun #5, VWR SN 192272629

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-1-080421	**Lab ID:**	2108183-1
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 12:45	**Percent Moisture:**	2.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**1.07 (+/- 0.5)**	G,TI	**0.92**	**pCi/g**	NA		9/23/2021 06:14
K-40	**19.2 (+/- 4.6)**	G	**4.2**	**pCi/g**	NA		9/23/2021 06:14
Ra-226	**1.7 (+/- 0.38)**	M3,G	**0.59**	**pCi/g**	NA		9/23/2021 06:14
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**37**		**0.2**	**MG/KG**	10	0.049	9/24/2021 14:57
THORIUM	**4.6**		**0.02**	**MG/KG**	10	0.008	9/24/2021 14:57

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-2-080421	**Lab ID:**	2108183-2
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 13:00	**Percent Moisture:**	2.6

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**0.86 (+/- 0.55)**	G,TI	**0.79**	**pCi/g**	NA		9/23/2021 06:15
K-40	**15.4 (+/- 3.8)**	G	**3.2**	**pCi/g**	NA		9/23/2021 06:15
Ra-226	**3.8 (+/- 0.58)**	M3,G	**0.55**	**pCi/g**	NA		9/23/2021 06:15
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**16**		**0.19**	**MG/KG**	10	0.047	9/24/2021 15:00
THORIUM	**3.6**		**0.019**	**MG/KG**	10	0.0077	9/24/2021 15:00

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-3-080421	**Lab ID:**	2108183-3
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 13:05	**Percent Moisture:**	4.9

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**0.93 (+/- 0.38)**	G	**0.87**	**pCi/g**	NA		9/23/2021 06:14
K-40	**12.3 (+/- 3.2)**	G	**2.9**	**pCi/g**	NA		9/23/2021 06:14
Ra-226	**2.52 (+/- 0.44)**	M3,G	**0.53**	**pCi/g**	NA		9/23/2021 06:14
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**44**		**0.2**	**MG/KG**	10	0.049	9/24/2021 15:03
THORIUM	**4.7**		**0.02**	**MG/KG**	10	0.008	9/24/2021 15:03

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.		**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples		**Work Order:**	2108183
Sample ID:	OPP-4-080421		**Lab ID:**	2108183-4
Legal Location:			**Matrix:**	SOIL
Collection Date:	8/4/2021 13:15		**Percent Moisture:**	4.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**0.94 (+/- 0.45)**	G,TI	**0.8**	**pCi/g**	NA		9/23/2021 06:15
K-40	**12.5 (+/- 3)**	G	**2.3**	**pCi/g**	NA		9/23/2021 06:15
Ra-226	**5.5 (+/- 0.76)**	M3,G	**0.51**	**pCi/g**	NA		9/23/2021 06:15
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**39**		**0.2**	**MG/KG**	10	0.05	9/24/2021 15:06
THORIUM	**3.4**		**0.02**	**MG/KG**	10	0.0082	9/24/2021 15:06

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-5-080421	**Lab ID:**	2108183-5
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 13:30	**Percent Moisture:**	8.3

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**0.82 (+/- 0.54)**	G,TI	**0.78**	**pCi/g**	NA		9/23/2021 06:15
K-40	**16.3 (+/- 3.5)**	G	**2.4**	**pCi/g**	NA		9/23/2021 06:15
Ra-226	**7.08 (+/- 0.93)**	G	**0.47**	**pCi/g**	NA		9/23/2021 06:15
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**39**		**0.21**	**MG/KG**	10	0.052	9/24/2021 15:09
THORIUM	**3.3**		**0.021**	**MG/KG**	10	0.0085	9/24/2021 15:09

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-6-080421	**Lab ID:**	2108183-6
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 13:35	**Percent Moisture:**	5.0

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**1.04 (+/- 0.66)**	G,NQ	**0.95**	**pCi/g**	NA		9/23/2021 06:15
K-40	**7.5 (+/- 2.8)**	G	**3.2**	**pCi/g**	NA		9/23/2021 06:15
Ra-226	**4.5 (+/- 0.67)**	M3,G	**0.6**	**pCi/g**	NA		9/23/2021 06:15
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**25**		**0.19**	**MG/KG**	10	0.047	9/24/2021 15:12
THORIUM	**2.9**		**0.019**	**MG/KG**	10	0.0077	9/24/2021 15:12

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-7-080421	**Lab ID:**	2108183-7
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 13:40	**Percent Moisture:**	6.3

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**0.79 (+/- 0.54)**	G,TI	**0.77**	**pCi/g**	NA		9/23/2021 07:10
K-40	**13 (+/- 3.2)**	G	**2.4**	**pCi/g**	NA		9/23/2021 07:10
Ra-226	**3.07 (+/- 0.49)**	M3,G	**0.53**	**pCi/g**	NA		9/23/2021 07:10
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**18**		**0.21**	**MG/KG**	10	0.052	9/24/2021 15:15
THORIUM	**2.8**		**0.021**	**MG/KG**	10	0.0084	9/24/2021 15:15

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-8-080421	**Lab ID:**	2108183-8
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 13:50	**Percent Moisture:**	4.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	**0.86 (+/- 0.41)**	G,TI	**0.7**	**pCi/g**	NA		9/23/2021 07:10
K-40	**11.5 (+/- 3)**	G	**2.7**	**pCi/g**	NA		9/23/2021 07:10
Ra-226	**3.12 (+/- 0.49)**	M3,G	**0.51**	**pCi/g**	NA		9/23/2021 07:10
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**22**		**0.2**	**MG/KG**	10	0.049	9/24/2021 15:18
THORIUM	**2.6**		**0.02**	**MG/KG**	10	0.0079	9/24/2021 15:18

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-DUP-080421	**Lab ID:**	2108183-9
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021	**Percent Moisture:**	5.6

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed
GAMMA SPECTROSCOPY RESULTS			**SOP 713**		Prep Date: **9/1/2021**		PrepBy: **JCP**
Ac-228	0.76 (+/- 0.47)	U,G	0.95	pCi/g	NA		9/23/2021 07:10
K-40	**9.2 (+/- 3.2)**	G	**3.8**	**pCi/g**	NA		9/23/2021 07:10
Ra-226	**4.39 (+/- 0.65)**	M3,G	**0.62**	**pCi/g**	NA		9/23/2021 07:10
ICPMS METALS			**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**25**		**0.21**	**MG/KG**	10	0.05	9/24/2021 15:21
THORIUM	**2.9**		**0.021**	**MG/KG**	10	0.0082	9/24/2021 15:21

Client:	Tetra Tech, Inc.	**Date:**	*27-Sep-21*
Project:	Bluff B Opportunity Samples	**Work Order:**	2108183
Sample ID:	OPP-DUP-080421	**Lab ID:**	2108183-9
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021	**Percent Moisture:**	5.6

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	MDL	Date Analyzed

Explanation of Qualifiers

Radiochemistry:

- "Report Limit" is the MDC

U or ND - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.

Y2 - Chemical Yield outside default limits.

W - DER is greater than Warning Limit of 1.42

* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.

- Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.

G - Sample density differs by more than 15% of LCS density.

D - DER is greater than Control Limit

M - Requested MDC not met.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS, Matrix Spike Recovery within control limits.

N - Matrix Spike Recovery outside control limits

NC - Not Calculated for duplicate results less than 5 times MDC

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Inorganics:

B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).

U or ND - Indicates that the compound was analyzed for but not detected.

E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.

M - Duplicate injection precision was not met.

N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.

Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.

* - Duplicate analysis (relative percent difference) not within control limits.

S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

Organics:

U or ND - Indicates that the compound was analyzed for but not detected.

B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.

E - Analyte concentration exceeds the upper level of the calibration range.

J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).

A - A tentatively identified compound is a suspected aldol-condensation product.

X - The analyte was diluted below an accurate quantitation level.

* - The spike recovery is equal to or outside the control criteria used.

+ - The relative percent difference (RPD) equals or exceeds the control criteria.

G - A pattern resembling gasoline was detected in this sample.

D - A pattern resembling diesel was detected in this sample.

M - A pattern resembling motor oil was detected in this sample.

C - A pattern resembling crude oil was detected in this sample.

4 - A pattern resembling JP-4 was detected in this sample.

5 - A pattern resembling JP-5 was detected in this sample.

H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.

L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.

Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
- gasoline
- JP-8
- diesel
- mineral spirits
- motor oil
- Stoddard solvent
- bunker C

Batch ID: **GS210901-2-2** Instrument ID **GAMMA** Method: **Gamma Spectroscopy Results**

DUP Sample ID: **2108183-8** Units: **pCi/g** Analysis Date: **9/23/2021 07:10**

Client ID: **OPP-8-080421** Run ID: **GS210901-2A** Prep Date: **9/1/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
Ra-226	3.42 (+/- 0.49)	0.36						3.12	0.9	3	G
Ac-228	0.91 (+/- 0.36)	0.67						0.86	0.09		G,TI
Cs-137	0.66 (+/- 0.16)	0.14						0.47	0.8	2.1	G
K-40	12.5 (+/- 2.7)	1.8						11.5	0.2	2.1	G

LCS Sample ID: **GS210901-2A** Units: **pCi/g** Analysis Date: **9/23/2021 08:28**

Client ID: Run ID: **GS210901-2A** Prep Date: **9/1/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
Ra-226	463 (+/- 54)	3	467.6		99	85-115					P,M3

LCS Sample ID: **GS210901-2** Units: **pCi/g** Analysis Date: **9/23/2021 08:28**

Client ID: Run ID: **GS210901-2A** Prep Date: **9/1/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
Am-241	495 (+/- 60)	15	503.1		98.4	85-115					P
Co-60	210 (+/- 25)	1	208.4		101	85-115					P
Cs-137	168 (+/- 20)	1	170.8		98.6	85-115					P

MB Sample ID: **GS210901-2A** Units: **pCi/g** Analysis Date: **9/23/2021 07:11**

Client ID: Run ID: **GS210901-2A** Prep Date: **9/1/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
Ra-226	-0.01 (+/- 0.16)	0.29									U
Ac-228	-0.07 (+/- 0.27)	0.53									U
Cs-137	0.012 (+/- 0.064)	0.118									U
K-40	-0.4 (+/- 0.74)	1.63									U

The following samples were analyzed in this batch:

2108183-1	2108183-2	2108183-3
2108183-4	2108183-5	2108183-6
2108183-7	2108183-8	2108183-9

Client: Tetra Tech, Inc.
Work Order: 2108183
Project: Bluff B Opportunity Samples

QC BATCH REPORT

Batch ID: **IP210922-5-2** Instrument ID **ICPMS2** Method: **SW6020**

LCS Sample ID: **IM210922-5** Units: **MG/KG** Analysis Date: **9/24/2021 13:52**
Client ID: Run ID: **IM210924-10A2** Prep Date: **9/22/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref	RPD	RPD Limit	Qual
ARSENIC	9.32	0.2	10		93	80-120				20	
THORIUM	0.914	0.02	1		91	80-120				20	

MB Sample ID: **IP210922-5** Units: **MG/KG** Analysis Date: **9/24/2021 13:49**
Client ID: Run ID: **IM210924-10A2** Prep Date: **9/22/2021** DF: **10**

Analyte	Result	ReportLimit	MDL	Qual
ARSENIC	ND	0.2	0.049	
THORIUM	ND	0.02	0.008	

The following samples were analyzed in this batch:

2108183-1	2108183-2	2108183-3
2108183-4	2108183-5	2108183-6
2108183-7	2108183-8	2108183-9

C-2 CORRELATION SAMPLES

Thursday, September 30, 2021

Aaron Orechwa
Tetra Tech, Inc.
3801 Automation Way, Suite 100
Fort Collins, CO 80525

Re: ALS Workorder: 2108184
Project Name: 2021 Bluff B Correlation Study
Project Number:

Dear Mr. Orechwa:

Sixteen soil samples were received from Tetra Tech, Inc., on 8/6/2021. The samples were scheduled for the following analyses:

Gamma Spectroscopy
Isotopic Thorium
Isotopic Uranium
Metals

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Environmental.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,

For,

ALS Environmental
Katie M. OBrien
Project Manager

Accreditations: ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
California (CA)	2926
Colorado (CO)	CO01099
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
PJ-LA (DoD ELAP/ISO 170250)	95377
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO010992018-1
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	TN02976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280

40 CFR Part 136: All analyses for Clean Water Act samples are analyzed using the 40 CFR Part 136 specified method and include all the QC requirements.

2108184

Metals:
The samples were analyzed following SW-846, 3rd Edition procedures. Analysis by ICPMS followed method 6020B and the current revision of SOP 827.

All acceptance criteria were met.

Gamma Spectroscopy:
The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713.

These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans and stored for at least 21 days prior to analysis.

All remaining acceptance criteria were met.

Isotopic Uranium:
The samples were analyzed for the presence of isotopic uranium according to the current revision of SOP 714.

All remaining acceptance criteria were met.

Isotopic Thorium:
The samples were analyzed for the presence of isotopic thorium according to the current revision of SOP 714.

All remaining acceptance criteria were met.

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 2108184
Client Name: Tetra Tech, Inc.
Client Project Name: 2021 Bluff B Correlation Study
Client Project Number:
Client PO Number:

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
CORR01-080521	2108184-1		SOIL	05-Aug-21	10:15
CORR-(DUP1)-080521	2108184-2		SOIL	05-Aug-21	
CORR02-080521	2108184-3		SOIL	05-Aug-21	10:50
CORR03-080521	2108184-4		SOIL	05-Aug-21	11:10
CORR04-080521	2108184-5		SOIL	05-Aug-21	11:40
CORR05-080521	2108184-6		SOIL	05-Aug-21	12:10
CORR06-080521	2108184-7		SOIL	05-Aug-21	12:25
CORR07-080521	2108184-8		SOIL	05-Aug-21	12:40
CORR08-080521	2108184-9		SOIL	05-Aug-21	12:55
CORR09-080521	2108184-10		SOIL	05-Aug-21	13:05
CORR10-080521	2108184-11		SOIL	05-Aug-21	13:15
CORR11-080521	2108184-12		SOIL	05-Aug-21	13:30
CORR12-080521	2108184-13		SOIL	05-Aug-21	13:50
CORR13-080521	2108184-14		SOIL	05-Aug-21	14:10
CORR14-080521	2108184-15		SOIL	05-Aug-21	14:30
CORR15-080521	2108184-16		SOIL	05-Aug-21	14:45

ALS Laboratory Group

225 Commerce Drive, Fort Collins, Colorado 80524
TF: (800) 443-1511 PH: (970) 490-1511 FX: (970) 490-1522

study ~~Sampling~~

2021 Bluff B Correlation

Chain-of-Custody

2108184

Form 202r8

WORKORDER # 2108184-C

PROJECT NAME	~~Bluff B Subsurface~~	**SAMPLER**	Bill Craig	**DATE**	8/5/21
PROJECT No.		**SITE ID**		**TURNAROUND**	4 weeks
		EDD FORMAT		**PAGE**	1 of 2
COMPANY NAME	Tetra Tech	**PURCHASE ORDER**		**DISPOSAL**	By Lab or Return to Client
SEND REPORT TO		**BILL TO COMPANY**			
ADDRESS		**INVOICE ATTN TO**			
CITY / STATE / ZIP		**ADDRESS**			
PHONE		**CITY / STATE / ZIP**			
FAX		**PHONE**			
E-MAIL		**FAX**			
		E-MAIL			

Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles	Pres.	QC	Arsenic SW-846	Thorium SW-846	Uranium SW-846	Isotopic Uranium D3972	Isotopic Thorium D3972	Radium-226 E901.1	Potassium-40 E901.1	Actinium-228 E901.1
1	CORR01-080521	S	8/5/21	10:15	1			X	X	X	X	X	X	X	X
2	CORR-(DUP1)-080521	S	8/5/21	–	1			X	X	X	X	X	X	X	X
3	CORR02-080521	S	8/5/21	10:50	1			X	X	X	X	X	X	X	X
4	CORR03-080521	S	8/5/21	11:10	1			X	X	X	X	X	X	X	X
5	CORR04-080521	S	8/5/21	11:40	1			X	X	X	X	X	X	X	X
6	CORR05-080521	S	8/5/21	12:10	1			X	X	X	X	X	X	X	X
7	CORR06-080521	S	8/5/21	12:25	1			X	X	X	X	X	X	X	X
8	CORR07-080521	S	8/5/21	12:40	1			X	X	X	X	X	X	X	X
9	CORR08-080521	S	8/5/21	12:55	1			X	X	X	X	X	X	X	X
10	CORR09-080521	S	8/5/21	13:05	1			X	X	X	X	X	X	X	X

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

For metals or anions, please detail analytes below.

Comments:
please contact Aaron Orechwa before analyzing 970-420-9395

QC PACKAGE (check below)
- LEVEL II (Standard QC)
- LEVEL III (Std QC + forms)
- LEVEL IV (Std QC + forms + raw data)

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY	Wm Craig	William Craig	8/5/21	16:00
RECEIVED BY	Amy Kephart	Amy Kephart	8/6/21	1600
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

Preservative Key: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

5 of 9

ALS Laboratory Group

225 Commerce Drive, Fort Collins, Colorado 80524
TF: (800) 443-1511 PH: (970) 490-1511 FX: (970) 490-1522

Chain-of-Custody

Form 202r8

WORKORDER #					
SAMPLER	Bill Craig	DATE	8/5/21	PAGE	2 of 2
PROJECT NAME	Bluff B Subsurface	SITE ID		TURNAROUND	
DISPOSAL	By Lab or Return to Client				
PROJECT No.		EDD FORMAT			
		PURCHASE ORDER			
COMPANY NAME	Tetra Tech	BILL TO COMPANY			
SEND REPORT TO		INVOICE ATTN TO			
ADDRESS		ADDRESS			
CITY / STATE / ZIP		CITY / STATE / ZIP			
PHONE		PHONE			
FAX		FAX			
E-MAIL		E-MAIL			

Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles	Pres.	QC	ARSENIC SW-846	THORIUM SW-846	URANIUM SW-846	ISOTOPIC URANIUM D3972	ISOTOPIC THORIUM D3972	RADIUM-226 E901.1	POTASSIUM-40 E901.1	ACTINIUM-228 E901.1
11	CORR10-080521	S	8/5/21	13:15	1			X	X	X	X	X	X	X	X
12	CORR11-080521	S	8/5/21	13:30	1										
13	CORR12-080521	S	8/5/21	13:50	1										
14	CORR13-080521	S	8/5/21	14:10	1										
15	CORR14-080521	S	8/5/21	14:30	1										
16	CORR15-080521	S	8/5/21	14:45	1										

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

For metals or anions, please detail analytes below.

Comments:

See Sheet #1

QC PACKAGE (check below)
- LEVEL II (Standard QC)
- LEVEL III (Std QC + forms)
- LEVEL IV (Std QC + forms + raw data)

Preservative Key: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY	[signature]	William Craig	8/5/21	16:00
RECEIVED BY	[signature]	Amy Kephart	8/6/21	1600
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: TETRA TECH-FC Workorder No: 2108184

Project Manager: KMO Initials: AXK Date: 08/11/2021

		N/A	YES	NO
1.	Are airbills / shipping documents present and/or removable? Tracking number:	X		
2.	Are custody seals on shipping containers intact?	X		
3.	Are custody seals on sample containers intact?	X		
4.	Is there a COC (chain-of-custody) present?		X	
5.	Is the COC in agreement with samples received? (IDs, dates, times, # of samples, # of containers, matrix, requested analyses, etc.)		X	
6.	Are short-hold samples present?			X
7.	Are all samples within holding times for the requested analyses?		X	
8.	Were all sample containers received intact? (not broken or leaking)		X	
9.	Is there sufficient sample for the requested analyses?		X	
10.	Are samples in proper containers for requested analyses? (form 250, *Sample Handling Guidelines*)		X	
11.	Are all aqueous samples preserved correctly, if required? (excluding volatiles)	X		
12.	Are all samples requiring no headspace (VOC, GRO, RSK/MEE, radon) free of bubbles > 6 mm (1/4 inch) diameter? (i.e. size of green pea)	X		
13.	Were the samples shipped on ice?			X
14.	Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #5	RAD ONLY		X

Cooler #:	1	1	1				
Temperature (°C):	AMB	AMB	AMB				
# of custody seals on cooler:	0	0	0				
External µR/hr reading:	-	-	-				
Background µR/hr reading:	10	10	10				

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES (If no, see Form 008.)

* Please provide details here for NO responses to boxes above - for 2 thru 5 & 7 thru 12, notify PM & continue w/ login.

Were unpreserved bottles pH checked? NA All client bottle ID's vs ALS lab ID's double-checked by: AK

If applicable, was the client contacted? YES / NO / NA Contact: ______ Date/Time: ______

Project Manager Signature / Date: [signature] 8/23/21

Form 201r30.xls
03/18/2021

*IR Gun #5, VWR SN 192272629

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Project: 2021 Bluff B Correlation Study
Sample ID: CORR01-080521
Legal Location:
Collection Date: 8/5/2021 10:15

Date: *30-Sep-21*
Work Order: 2108184
Lab ID: 2108184-1
Matrix: SOIL
Percent Moisture: 2.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	0.75 (+/- 0.41)	U,G	0.92	pCi/g	NA	9/24/2021 06:05
K-40	**14.1 (+/- 3.7)**	G	**3.6**	**pCi/g**	NA	9/24/2021 06:05
Ra-226	**1.57 (+/- 0.35)**	G	**0.48**	**pCi/g**	NA	9/24/2021 06:05
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**67**		**0.19**	**MG/KG**	10	9/24/2021 15:36
THORIUM	**3.3**		**0.019**	**MG/KG**	10	9/24/2021 15:36
URANIUM	**0.87**		**0.019**	**MG/KG**	10	9/24/2021 15:36
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*63.3*		*30-110*	*%REC*	DL = NA	9/16/2021 14:57
Th-228	**1.01 (+/- 0.22)**	M3	**0.13**	**pCi/g**	NA	9/16/2021 14:57
Th-230	**1.07 (+/- 0.23)**	M3	**0.11**	**pCi/g**	NA	9/16/2021 14:57
Th-232	**0.85 (+/- 0.18)**		**0.03**	**pCi/g**	NA	9/16/2021 14:57
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*80.3*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**0.67 (+/- 0.15)**		**0.04**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.061 (+/- 0.038)**		**0.033**	**pCi/g**	NA	9/18/2021 18:21
U-238	**0.77 (+/- 0.17)**		**0.05**	**pCi/g**	NA	9/18/2021 18:21

Client: Tetra Tech, Inc.
Project: 2021 Bluff B Correlation Study
Sample ID: CORR-(DUP1)-080521
Legal Location:
Collection Date: 8/5/2021

Date: *30-Sep-21*
Work Order: 2108184
Lab ID: 2108184-2
Matrix: SOIL
Percent Moisture: 2.9

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**0.89 (+/- 0.4)**	G,TI	**0.67**	**pCi/g**	NA	9/24/2021 06:05
K-40	**18.3 (+/- 3.3)**	G	**1.9**	**pCi/g**	NA	9/24/2021 06:05
Ra-226	**1.14 (+/- 0.26)**	G	**0.43**	**pCi/g**	NA	9/24/2021 06:05
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**62**		**0.2**	**MG/KG**	10	9/24/2021 15:39
THORIUM	**3.4**		**0.02**	**MG/KG**	10	9/24/2021 15:39
URANIUM	**0.8**		**0.02**	**MG/KG**	10	9/24/2021 15:39
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*69.5*		*30-110*	*%REC*	DL = NA	9/16/2021 14:57
Th-228	**0.87 (+/- 0.2)**	M3	**0.14**	**pCi/g**	NA	9/16/2021 14:57
Th-230	**0.93 (+/- 0.2)**	M3	**0.11**	**pCi/g**	NA	9/16/2021 14:57
Th-232	**0.84 (+/- 0.18)**		**0.03**	**pCi/g**	NA	9/16/2021 14:57
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*78.6*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**0.73 (+/- 0.17)**		**0.05**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.043 (+/- 0.033)**		**0.035**	**pCi/g**	NA	9/18/2021 18:21
U-238	**0.74 (+/- 0.17)**		**0.03**	**pCi/g**	NA	9/18/2021 18:21

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR02-080521	**Lab ID:**	2108184-3
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 10:50	**Percent Moisture:**	2.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**1.27 (+/- 0.38)**	G	**0.73**	**pCi/g**	NA	9/24/2021 06:05
K-40	**17.4 (+/- 3.4)**	G	**2.1**	**pCi/g**	NA	9/24/2021 06:05
Ra-226	**1.68 (+/- 0.3)**	G	**0.43**	**pCi/g**	NA	9/24/2021 06:05
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**63**		**0.2**	**MG/KG**	10	9/24/2021 15:42
THORIUM	**4.9**		**0.02**	**MG/KG**	10	9/24/2021 15:42
URANIUM	**1.7**		**0.02**	**MG/KG**	10	9/24/2021 15:42
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*31.9*		*30-110*	*%REC*	DL = NA	9/16/2021 14:57
Th-228	**1.02 (+/- 0.28)**	M3	**0.19**	**pCi/g**	NA	9/16/2021 14:57
Th-230	**1.42 (+/- 0.34)**	M3	**0.16**	**pCi/g**	NA	9/16/2021 14:57
Th-232	**1.03 (+/- 0.26)**		**0.09**	**pCi/g**	NA	9/16/2021 14:57
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*81.9*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**1.02 (+/- 0.21)**		**0.01**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.05 (+/- 0.033)**		**0.014**	**pCi/g**	NA	9/18/2021 18:21
U-238	**1.19 (+/- 0.24)**		**0.03**	**pCi/g**	NA	9/18/2021 18:21

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR03-080521	**Lab ID:**	2108184-4
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 11:10	**Percent Moisture:**	2.9

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**1.2 (+/- 0.59)**	TI	**0.78**	**pCi/g**	NA	9/24/2021 06:05
K-40	**11.8 (+/- 3)**		**2.6**	**pCi/g**	NA	9/24/2021 06:05
Ra-226	**4.7 (+/- 0.66)**		**0.43**	**pCi/g**	NA	9/24/2021 06:05
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**22**		**0.21**	**MG/KG**	10	9/24/2021 15:45
THORIUM	**6**		**0.021**	**MG/KG**	10	9/24/2021 15:45
URANIUM	**7.5**		**0.021**	**MG/KG**	10	9/24/2021 15:45
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*55.8*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.08 (+/- 0.24)**	M3	**0.16**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**2.76 (+/- 0.5)**	M3	**0.12**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.08 (+/- 0.22)**		**0.05**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*88.3*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**3.11 (+/- 0.55)**		**0.05**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.156 (+/- 0.061)**		**0.014**	**pCi/g**	NA	9/18/2021 18:21
U-238	**2.75 (+/- 0.49)**		**0.04**	**pCi/g**	NA	9/18/2021 18:21

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR04-080521	**Lab ID:**	2108184-5
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 11:40	**Percent Moisture:**	3.1

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**1.13 (+/- 0.45)**	G	**0.96**	**pCi/g**	NA	9/24/2021 06:06
K-40	**13 (+/- 3.1)**	G	**3.1**	**pCi/g**	NA	9/24/2021 06:06
Ra-226	**21.9 (+/- 2.6)**	M3,G	**0.6**	**pCi/g**	NA	9/24/2021 06:06
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**120**		**0.2**	**MG/KG**	10	9/24/2021 15:48
THORIUM	**5.9**		**0.02**	**MG/KG**	10	9/24/2021 15:48
URANIUM	**49**		**0.02**	**MG/KG**	10	9/24/2021 15:48
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*59.2*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.23 (+/- 0.26)**	M3	**0.17**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**21.7 (+/- 3.5)**	M3	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.02 (+/- 0.21)**		**0.03**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*73.3*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**21.2 (+/- 3.5)**		**0**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.8 (+/- 0.19)**		**0.04**	**pCi/g**	NA	9/18/2021 18:21
U-238	**19.8 (+/- 3.3)**		**0.1**	**pCi/g**	NA	9/18/2021 18:21

Client: Tetra Tech, Inc. **Date:** *30-Sep-21*
Project: 2021 Bluff B Correlation Study **Work Order:** 2108184
Sample ID: CORR05-080521 **Lab ID:** 2108184-6
Legal Location: **Matrix:** SOIL
Collection Date: 8/5/2021 12:10 **Percent Moisture:** 2.5

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	1.18 (+/- 0.78)	U,M,G	1.18	pCi/g	NA	9/24/2021 06:06
K-40	**14.3 (+/- 3.9)**	G	**4.2**	**pCi/g**	NA	9/24/2021 06:06
Ra-226	**27.7 (+/- 3.4)**	M3,G	**0.8**	**pCi/g**	NA	9/24/2021 06:06
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**140**		**0.2**	**MG/KG**	10	9/24/2021 15:51
THORIUM	**5.5**		**0.02**	**MG/KG**	10	9/24/2021 15:51
URANIUM	**47**		**0.02**	**MG/KG**	10	9/24/2021 15:51
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*46.1*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.09 (+/- 0.26)**	M3	**0.2**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**17.2 (+/- 2.9)**	M3	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.05 (+/- 0.23)**		**0.06**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*79.6*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**15 (+/- 2.5)**		**0.1**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.7 (+/- 0.16)**		**0.01**	**pCi/g**	NA	9/18/2021 18:21
U-238	**14.8 (+/- 2.5)**		**0**	**pCi/g**	NA	9/18/2021 18:21

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Date: *30-Sep-21*
Project: 2021 Bluff B Correlation Study
Work Order: 2108184
Sample ID: CORR06-080521
Lab ID: 2108184-7
Legal Location:
Matrix: SOIL
Collection Date: 8/5/2021 12:25
Percent Moisture: 2.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	0.53 (+/- 0.3)	U	0.64	pCi/g	NA	9/24/2021 06:06
K-40	**13.1 (+/- 2.5)**		**1.6**	**pCi/g**	NA	9/24/2021 06:06
Ra-226	**11.6 (+/- 1.4)**		**0.3**	**pCi/g**	NA	9/24/2021 06:06
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**71**		**0.2**	**MG/KG**	10	9/24/2021 15:54
THORIUM	**4.3**		**0.02**	**MG/KG**	10	9/24/2021 15:54
URANIUM	**23**		**0.02**	**MG/KG**	10	9/24/2021 15:54
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*61.5*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**0.79 (+/- 0.19)**	M3	**0.15**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**9 (+/- 1.5)**	M3	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**0.87 (+/- 0.19)**		**0.01**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*74.6*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**8.6 (+/- 1.5)**		**0**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.35 (+/- 0.1)**		**0.04**	**pCi/g**	NA	9/18/2021 18:21
U-238	**7.9 (+/- 1.3)**		**0**	**pCi/g**	NA	9/18/2021 18:21

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR07-080521	**Lab ID:**	2108184-8
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 12:40	**Percent Moisture:**	4.6

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	1.15 (+/- 0.64)	U,M,G	1.27	pCi/g	NA	9/24/2021 07:03
K-40	**15.7 (+/- 3.9)**	G	**3.7**	**pCi/g**	NA	9/24/2021 07:03
Ra-226	**23.1 (+/- 2.9)**	M3,G	**0.9**	**pCi/g**	NA	9/24/2021 07:03
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**130**		**0.19**	**MG/KG**	10	9/24/2021 16:24
THORIUM	**4.9**		**0.019**	**MG/KG**	10	9/24/2021 16:24
URANIUM	**71**		**0.019**	**MG/KG**	10	9/24/2021 16:24
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*60*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.11 (+/- 0.24)**	M3	**0.12**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**20 (+/- 3.3)**	M3	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**0.95 (+/- 0.2)**		**0.01**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*68.3*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**19.1 (+/- 3.2)**		**0.1**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.9 (+/- 0.21)**		**0.02**	**pCi/g**	NA	9/18/2021 18:21
U-238	**19 (+/- 3.2)**		**0**	**pCi/g**	NA	9/18/2021 18:21

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Date: *30-Sep-21*
Project: 2021 Bluff B Correlation Study
Work Order: 2108184
Sample ID: CORR08-080521
Lab ID: 2108184-9
Legal Location:
Matrix: SOIL
Collection Date: 8/5/2021 12:55
Percent Moisture: 4.3

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**1.06 (+/- 0.47)**	G,TI	**0.84**	**pCi/g**	NA	9/24/2021 07:03
K-40	**14.7 (+/- 3)**	G	**2.2**	**pCi/g**	NA	9/24/2021 07:03
Ra-226	**10.5 (+/- 1.4)**	M3,G	**0.7**	**pCi/g**	NA	9/24/2021 07:03
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**160**		**0.2**	**MG/KG**	10	9/24/2021 16:27
THORIUM	**6**		**0.02**	**MG/KG**	10	9/24/2021 16:27
URANIUM	**26**		**0.02**	**MG/KG**	10	9/24/2021 16:27
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*53.3*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.11 (+/- 0.25)**	M3	**0.17**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**8.6 (+/- 1.5)**	M3	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.07 (+/- 0.23)**		**0.05**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*69.2*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**9.1 (+/- 1.6)**		**0.1**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.52 (+/- 0.14)**		**0.05**	**pCi/g**	NA	9/18/2021 18:21
U-238	**8.7 (+/- 1.5)**		**0**	**pCi/g**	NA	9/18/2021 18:21

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR09-080521	**Lab ID:**	2108184-10
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 13:05	**Percent Moisture:**	2.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**1.26 (+/- 0.5)**	G,TI	**0.85**	**pCi/g**	NA	9/24/2021 07:03
K-40	**11 (+/- 2.9)**	G	**3.1**	**pCi/g**	NA	9/24/2021 07:03
Ra-226	**11.9 (+/- 1.5)**	M3,G	**0.6**	**pCi/g**	NA	9/24/2021 07:03
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**110**		**0.19**	**MG/KG**	10	9/24/2021 16:30
THORIUM	**6.1**		**0.019**	**MG/KG**	10	9/24/2021 16:30
URANIUM	**25**		**0.019**	**MG/KG**	10	9/24/2021 16:30
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*27.3*	Y2	*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.19 (+/- 0.35)**	Y2,M3	**0.32**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**8.3 (+/- 1.6)**	Y2,M3	**0.2**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.02 (+/- 0.27)**	Y2	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*70.7*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**9 (+/- 1.5)**		**0**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.37 (+/- 0.11)**		**0.04**	**pCi/g**	NA	9/18/2021 18:21
U-238	**9.3 (+/- 1.6)**		**0**	**pCi/g**	NA	9/18/2021 18:21

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR10-080521	**Lab ID:**	2108184-11
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 13:15	**Percent Moisture:**	4.1

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/2/2021**	PrepBy: **JCP**
Ac-228	**0.97 (+/- 0.52)**	G,TI	**0.88**	**pCi/g**	NA	9/24/2021 07:04
K-40	**14.6 (+/- 4)**	G	**4.1**	**pCi/g**	NA	9/24/2021 07:04
Ra-226	**12.7 (+/- 1.6)**	M3,G	**0.7**	**pCi/g**	NA	9/24/2021 07:04
ICPMS Metals		**SW6020**			Prep Date: **9/22/2021**	PrepBy: **WJS**
ARSENIC	**180**		**0.2**	**MG/KG**	10	9/24/2021 16:33
THORIUM	**6.8**		**0.02**	**MG/KG**	10	9/24/2021 16:33
URANIUM	**33**		**0.02**	**MG/KG**	10	9/24/2021 16:33
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**			Prep Date: **9/7/2021**	PrepBy: **SDW**
Tracer: Th-229	*49.3*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.64 (+/- 0.34)**	M3	**0.16**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**12.8 (+/- 2.2)**	M3	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.21 (+/- 0.25)**		**0.05**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**			Prep Date: **9/7/2021**	PrepBy: **SDW**
Tracer: U-232	*78.4*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**12.8 (+/- 2.1)**		**0.1**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.63 (+/- 0.16)**		**0.01**	**pCi/g**	NA	9/18/2021 18:21
U-238	**13 (+/- 2.2)**		**0**	**pCi/g**	NA	9/18/2021 18:21

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Project: 2021 Bluff B Correlation Study
Sample ID: CORR11-080521
Legal Location:
Collection Date: 8/5/2021 13:30

Date: *30-Sep-21*
Work Order: 2108184
Lab ID: 2108184-12
Matrix: SOIL
Percent Moisture: 8.0

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/2/2021**	PrepBy: **JCP**
Ac-228	**1.53 (+/- 0.53)**	M3,G	**1**	**pCi/g**	NA	9/24/2021 07:04
K-40	**17.5 (+/- 3.7)**	G	**3.2**	**pCi/g**	NA	9/24/2021 07:04
Ra-226	**18.4 (+/- 2.2)**	M3,G	**0.6**	**pCi/g**	NA	9/24/2021 07:04
ICPMS Metals		**SW6020**			Prep Date: **9/22/2021**	PrepBy: **WJS**
ARSENIC	**150**		**0.21**	**MG/KG**	10	9/24/2021 16:36
THORIUM	**8.7**		**0.021**	**MG/KG**	10	9/24/2021 16:36
URANIUM	**32**		**0.021**	**MG/KG**	10	9/24/2021 16:36
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**			Prep Date: **9/7/2021**	PrepBy: **SDW**
Tracer: Th-229	*48.8*		*30-110*	*%REC*	DL = NA	9/19/2021 12:10
Th-228	**1.81 (+/- 0.37)**	M3	**0.12**	**pCi/g**	NA	9/19/2021 12:10
Th-230	**12.8 (+/- 2.2)**	M3	**0.1**	**pCi/g**	NA	9/19/2021 12:10
Th-232	**1.44 (+/- 0.3)**		**0.06**	**pCi/g**	NA	9/19/2021 12:10
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**			Prep Date: **9/7/2021**	PrepBy: **SDW**
Tracer: U-232	*75.5*		*30-110*	*%REC*	DL = NA	9/18/2021 18:21
U-234	**12.2 (+/- 2)**		**0**	**pCi/g**	NA	9/18/2021 18:21
U-235	**0.68 (+/- 0.17)**		**0.05**	**pCi/g**	NA	9/18/2021 18:21
U-238	**12.8 (+/- 2.1)**		**0**	**pCi/g**	NA	9/18/2021 18:21

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR12-080521	**Lab ID:**	2108184-13
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 13:50	**Percent Moisture:**	3.5

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	1.3 (+/- 1.3)	U,M,G	2.1	pCi/g	NA	9/24/2021 07:04
K-40	**11.4 (+/- 5.3)**	G	**7.7**	**pCi/g**	NA	9/24/2021 07:04
Ra-226	**93 (+/- 11)**	M3,G	**2**	**pCi/g**	NA	9/24/2021 07:04
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**540**		**0.19**	**MG/KG**	10	9/24/2021 16:39
THORIUM	**7.2**		**0.019**	**MG/KG**	10	9/24/2021 16:39
URANIUM	**220**		**0.019**	**MG/KG**	10	9/24/2021 16:39
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*21.7*	Y2	*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**2.01 (+/- 0.51)**	Y2,M3	**0.35**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**112 (+/- 20)**	Y2,M3	**0**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.65 (+/- 0.4)**	Y2,M3	**0.1**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*55.9*		*30-110*	*%REC*	DL = NA	9/18/2021 18:22
U-234	**97 (+/- 17)**		**0**	**pCi/g**	NA	9/18/2021 18:22
U-235	**4.46 (+/- 0.84)**		**0.05**	**pCi/g**	NA	9/18/2021 18:22
U-238	**97 (+/- 17)**		**0**	**pCi/g**	NA	9/18/2021 18:22

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR13-080521	**Lab ID:**	2108184-14
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 14:10	**Percent Moisture:**	1.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**0.72 (+/- 0.3)**		**0.71**	**pCi/g**	NA	9/24/2021 07:04
K-40	**11.1 (+/- 2.4)**		**2.2**	**pCi/g**	NA	9/24/2021 07:04
Ra-226	**30 (+/- 3.6)**		**0.4**	**pCi/g**	NA	9/24/2021 07:04
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**72**		**0.2**	**MG/KG**	10	9/24/2021 16:42
THORIUM	**4.3**		**0.02**	**MG/KG**	10	9/24/2021 16:42
URANIUM	**72**		**0.02**	**MG/KG**	10	9/24/2021 16:42
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*35.4*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**0.75 (+/- 0.24)**	M3	**0.24**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**20.5 (+/- 3.6)**	M3	**0.2**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**0.75 (+/- 0.19)**		**0.02**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*74.3*		*30-110*	*%REC*	DL = NA	9/18/2021 18:22
U-234	**26.2 (+/- 4.4)**		**0**	**pCi/g**	NA	9/18/2021 18:22
U-235	**1.36 (+/- 0.29)**		**0.05**	**pCi/g**	NA	9/18/2021 18:22
U-238	**26.2 (+/- 4.4)**		**0.1**	**pCi/g**	NA	9/18/2021 18:22

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Date: *30-Sep-21*
Project: 2021 Bluff B Correlation Study
Work Order: 2108184
Sample ID: CORR14-080521
Lab ID: 2108184-15
Legal Location:
Matrix: SOIL
Collection Date: 8/5/2021 14:30
Percent Moisture: 4.8

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/2/2021**	PrepBy: **JCP**
Ac-228	**1.39 (+/- 0.54)**	M3,G	**1.06**	**pCi/g**	NA	9/24/2021 08:01
K-40	**12.2 (+/- 3.6)**	G	**4.1**	**pCi/g**	NA	9/24/2021 08:01
Ra-226	**10.1 (+/- 1.3)**	M3,G	**0.7**	**pCi/g**	NA	9/24/2021 08:01
ICPMS Metals		**SW6020**			Prep Date: **9/22/2021**	PrepBy: **WJS**
ARSENIC	**310**		**0.19**	**MG/KG**	10	9/24/2021 17:02
THORIUM	**7.1**		**0.019**	**MG/KG**	10	9/24/2021 17:02
URANIUM	**21**		**0.019**	**MG/KG**	10	9/24/2021 17:02
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**			Prep Date: **9/7/2021**	PrepBy: **SDW**
Tracer: Th-229	*36.7*		*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.51 (+/- 0.35)**	M3	**0.22**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**8.6 (+/- 1.5)**	M3	**0.2**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.14 (+/- 0.26)**		**0.02**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**			Prep Date: **9/7/2021**	PrepBy: **SDW**
Tracer: U-232	*78.1*		*30-110*	*%REC*	DL = NA	9/18/2021 18:22
U-234	**7.2 (+/- 1.2)**		**0**	**pCi/g**	NA	9/18/2021 18:22
U-235	**0.303 (+/- 0.099)**		**0.049**	**pCi/g**	NA	9/18/2021 18:22
U-238	**7.3 (+/- 1.3)**		**0.1**	**pCi/g**	NA	9/18/2021 18:22

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR15-080521	**Lab ID:**	2108184-16
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 14:45	**Percent Moisture:**	2.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/2/2021**		PrepBy: **JCP**
Ac-228	**1.59 (+/- 0.5)**	G,TI	**0.72**	**pCi/g**	NA	9/24/2021 08:01
K-40	**13.2 (+/- 3)**	G	**2.3**	**pCi/g**	NA	9/24/2021 08:01
Ra-226	**2.9 (+/- 0.45)**	G	**0.43**	**pCi/g**	NA	9/24/2021 08:01
ICPMS Metals		**SW6020**		Prep Date: **9/22/2021**		PrepBy: **WJS**
ARSENIC	**40**		**0.19**	**MG/KG**	10	9/24/2021 17:05
THORIUM	**6.2**		**0.019**	**MG/KG**	10	9/24/2021 17:05
URANIUM	**3.3**		**0.019**	**MG/KG**	10	9/24/2021 17:05
Isotopic Thorium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: Th-229	*23.7*	Y2	*30-110*	*%REC*	DL = NA	9/17/2021 15:53
Th-228	**1.28 (+/- 0.39)**	Y2,M3	**0.37**	**pCi/g**	NA	9/17/2021 15:53
Th-230	**2.09 (+/- 0.49)**	Y2,M3	**0.19**	**pCi/g**	NA	9/17/2021 15:53
Th-232	**1.13 (+/- 0.3)**	Y2,M3	**0.11**	**pCi/g**	NA	9/17/2021 15:53
Isotopic Uranium by Alpha Spectroscopy		**SOP 714**		Prep Date: **9/7/2021**		PrepBy: **SDW**
Tracer: U-232	*72.3*		*30-110*	*%REC*	DL = NA	9/18/2021 18:22
U-234	**1.88 (+/- 0.37)**		**0.04**	**pCi/g**	NA	9/18/2021 18:22
U-235	**0.053 (+/- 0.04)**		**0.043**	**pCi/g**	NA	9/18/2021 18:22
U-238	**1.71 (+/- 0.34)**		**0.05**	**pCi/g**	NA	9/18/2021 18:22

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Correlation Study	**Work Order:**	2108184
Sample ID:	CORR15-080521	**Lab ID:**	2108184-16
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/5/2021 14:45	**Percent Moisture:**	2.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed

Explanation of Qualifiers

Radiochemistry:

- "Report Limit" is the MDC

U or ND - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.

Y2 - Chemical Yield outside default limits.

W - DER is greater than Warning Limit of 1.42

* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.

- Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.

G - Sample density differs by more than 15% of LCS density.

D - DER is greater than Control Limit

M - Requested MDC not met.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS, Matrix Spike Recovery within control limits.

N - Matrix Spike Recovery outside control limits

NC - Not Calculated for duplicate results less than 5 times MDC

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Inorganics:

B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).

U or ND - Indicates that the compound was analyzed for but not detected.

E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.

M - Duplicate injection precision was not met.

N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.

Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.

* - Duplicate analysis (relative percent difference) not within control limits.

S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

Organics:

U or ND - Indicates that the compound was analyzed for but not detected.

B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.

E - Analyte concentration exceeds the upper level of the calibration range.

J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).

A - A tentatively identified compound is a suspected aldol-condensation product.

X - The analyte was diluted below an accurate quantitation level.

* - The spike recovery is equal to or outside the control criteria used.

+ - The relative percent difference (RPD) equals or exceeds the control criteria.

G - A pattern resembling gasoline was detected in this sample.

D - A pattern resembling diesel was detected in this sample.

M - A pattern resembling motor oil was detected in this sample.

C - A pattern resembling crude oil was detected in this sample.

4 - A pattern resembling JP-4 was detected in this sample.

5 - A pattern resembling JP-5 was detected in this sample.

H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.

L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.

Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
- gasoline
- JP-8
- diesel
- mineral spirits
- motor oil
- Stoddard solvent
- bunker C

ALS -- Fort Collins

Date: *9/30/2021 5:04:3*

Client: Tetra Tech, Inc.

Work Order: 2108184

Project: 2021 Bluff B Correlation Study

QC BATCH REPORT

Batch ID: **AS210826-18-3** Instrument ID: **AlphaSpec2** Method: **Isotopic Uranium by Alpha Spec**

DUP Sample ID: **2108184-4** Units: **pCi/g** Analysis Date: **9/18/2021 18:21**

Client ID: **CORR03-080521** Run ID: **AS210826-18UR** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
U-234	3.27 (+/- 0.6)	0.04						3.11	0.20	2.13	
U-235	0.158 (+/- 0.071)	0.058						0.156	0.03	2.13	
U-238	2.96 (+/- 0.55)	0.04						2.75	0.29	2.13	
Tracer: U-232	2.99	0.07	4.335		69	30-110		3.85			

LCS Sample ID: **AS210826-18** Units: **pCi/g** Analysis Date: **9/18/2021 18:22**

Client ID: Run ID: **AS210826-18UR** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
U-234	1.06 (+/- 0.18)	0.01	1.088		97	82-122					P
U-238	1.03 (+/- 0.18)	0.01	1.131		91.5	82-122					P
Tracer: U-232	1	0.02	1.145		87.3	30-110					

MB Sample ID: **AS210826-18** Units: **pCi/g** Analysis Date: **9/18/2021 18:22**

Client ID: Run ID: **AS210826-18UR** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
U-234	0.0065 (+/- 0.0069)	0.0106									U
U-235	0.0004 (+/- 0.0056)	0.0087									U
U-238	0.0003 (+/- 0.0047)	0.0074									U
Tracer: U-232	1.04	0.02	1.145		91.2	30-110					

The following samples were analyzed in this batch:

2108184-1	2108184-2	2108184-3
2108184-4	2108184-5	2108184-6
2108184-7	2108184-8	2108184-9
2108184-10	2108184-11	2108184-12
2108184-13	2108184-14	2108184-15
2108184-16		

Client: Tetra Tech, Inc.
Work Order: 2108184
Project: 2021 Bluff B Correlation Study

QC BATCH REPORT

Batch ID: **AS210826-19-2** Instrument ID: **AlphaSpec2** Method: **Isotopic Thorium by Alpha Spec**

DUP Sample ID: **2108184-3** Units: **pCi/g** Analysis Date: **9/16/2021 14:58**
Client ID: **CORR02-080521** Run ID: **AS210826-19TH** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Th-228	1.09 (+/- 0.25)	0.16						1.02	0.19	2.13	M3
Th-230	1.74 (+/- 0.34)	0.13						1.42	0.66	2.13	M3
Th-232	0.95 (+/- 0.21)	0.04						1.03	0.24	2.13	
Tracer: Th-229	2.38	0.02	4.412		54	30-110		1.42			

LCS Sample ID: **AS210826-19** Units: **pCi/g** Analysis Date: **9/17/2021 15:55**
Client ID: Run ID: **AS210826-19TH** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Th-230	1.37 (+/- 0.23)	0.03	1.232		111	85-121					P
Tracer: Th-229	0.92	0.01	1.167		78.9	30-110					

MB Sample ID: **AS210826-19** Units: **pCi/g** Analysis Date: **9/17/2021 15:55**
Client ID: Run ID: **AS210826-19TH** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Th-228	0.012 (+/- 0.018)	0.03									U
Th-230	0.02 (+/- 0.017)	0.027									U
Th-232	-0.0027 (+/- 0.0071)	0.0152									U
Tracer: Th-229	0.92	0.01	1.167		78.9	30-110					

The following samples were analyzed in this batch:

2108184-1	2108184-2	2108184-3
2108184-4	2108184-5	2108184-6
2108184-7	2108184-8	2108184-9
2108184-10	2108184-11	2108184-12
2108184-13	2108184-14	2108184-15
2108184-16		

Client: Tetra Tech, Inc.
Work Order: 2108184
Project: 2021 Bluff B Correlation Study

QC BATCH REPORT

Batch ID: **GS210902-1-1** Instrument ID: **GAMMA** Method: **Gamma Spectroscopy Results**

DUP Sample ID: **2108184-15** Units: **pCi/g** Analysis Date: **9/24/2021 08:01**
Client ID: **CORR14-080521** Run ID: **GS210902-1A** Prep Date: **9/2/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	12.4 (+/- 1.5)	0.6						10.1	2.24	3	M3,G
Ac-228	0.92 (+/- 0.38)	0.84						1.39	0.72		G
Cs-137	-0.07 (+/- 0.11)	0.21						-0.02	0.26	2.13	U,G
K-40	13.8 (+/- 2.9)	2.2						12.2	0.35	2.13	G

LCS Sample ID: **GS210902-1A** Units: **pCi/g** Analysis Date: **9/24/2021 08:02**
Client ID: Run ID: **GS210902-1A** Prep Date: **9/2/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	484 (+/- 57)	4	467.6		103	85-115					P,M3

LCS Sample ID: **GS210902-1** Units: **pCi/g** Analysis Date: **9/24/2021 08:02**
Client ID: Run ID: **GS210902-1A** Prep Date: **9/2/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Am-241	512 (+/- 61)	8	503.1		102	85-115					P
Co-60	175 (+/- 21)	1	208.4		84.2	85-115					L
Cs-137	172 (+/- 20)	1	170.8		100	85-115					P

MB Sample ID: **GS210902-1** Units: **pCi/g** Analysis Date: **9/24/2021 08:02**
Client ID: Run ID: **GS210902-1A** Prep Date: **9/2/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	-0.07 (+/- 0.18)	0.34									U
Ac-228	-0.05 (+/- 0.28)	0.55									U
Cs-137	-0.049 (+/- 0.064)	0.136									U
K-40	-0.2 (+/- 1.1)	2.1									U

The following samples were analyzed in this batch:

2108184-1	2108184-2	2108184-3
2108184-4	2108184-5	2108184-6
2108184-7	2108184-8	2108184-9
2108184-10	2108184-11	2108184-12
2108184-13	2108184-14	2108184-15
2108184-16		

Client: Tetra Tech, Inc.
Work Order: 2108184
Project: 2021 Bluff B Correlation Study

QC BATCH REPORT

Batch ID: **IP210922-5-3** Instrument ID: **ICPMS2** Method: **SW6020**

LCS Sample ID: **IM210922-5** Units: **MG/KG** Analysis Date: **9/24/2021 13:52**
Client ID: Run ID: **IM210924-11A2** Prep Date: **9/22/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	8.9	0.2	10		89	80-120				20	
THORIUM	0.914	0.02	1		91	80-120				20	
URANIUM	0.905	0.02	1		90	80-120				20	

MB Sample ID: **IP210922-5** Units: **MG/KG** Analysis Date: **9/24/2021 13:49**
Client ID: Run ID: **IM210924-11A2** Prep Date: **9/22/2021** DF: **10**

Analyte	Result	ReportLimit	Qual
ARSENIC	ND	0.2	
THORIUM	ND	0.02	
URANIUM	ND	0.02	

The following samples were analyzed in this batch:

2108184-1	2108184-2	2108184-3
2108184-4	2108184-5	2108184-6
2108184-7		

Client: Tetra Tech, Inc.
Work Order: 2108184
Project: 2021 Bluff B Correlation Study

QC BATCH REPORT

Batch ID: **IP210922-6-1** Instrument ID: **ICPMS2** Method: **SW6020**

LCS Sample ID: **IM210922-6** Units: **MG/KG** Analysis Date: **9/24/2021 16:56**
Client ID: Run ID: **IM210924-11A2** Prep Date: **9/22/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.84	0.2	10		98	80-120				20	
THORIUM	0.925	0.02	1		93	80-120				20	
URANIUM	0.987	0.02	1		99	80-120				20	

LCSD Sample ID: **IM210922-6** Units: **MG/KG** Analysis Date: **9/24/2021 16:18**
Client ID: Run ID: **IM210924-11A2** Prep Date: **9/22/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.71	0.2	10		97	80-120		9.84	1	20	
THORIUM	0.919	0.02	1		92	80-120		0.925	1	20	
URANIUM	0.98	0.02	1		98	80-120		0.987	1	20	

MB Sample ID: **IP210922-6** Units: **MG/KG** Analysis Date: **9/24/2021 16:09**
Client ID: Run ID: **IM210924-11A2** Prep Date: **9/22/2021** DF: **10**

Analyte	Result	ReportLimit	Qual
ARSENIC	ND	0.2	
THORIUM	ND	0.02	
URANIUM	ND	0.02	

The following samples were analyzed in this batch:

2108184-8	2108184-9	2108184-10
2108184-11	2108184-12	2108184-13
2108184-14	2108184-15	2108184-16

C-3 SUBSURFACE SAMPLES

Thursday, September 30, 2021

Aaron Orechwa
Tetra Tech, Inc.
3801 Automation Way, Suite 100
Fort Collins, CO 80525

Re: ALS Workorder: 2108329
Project Name: 2021 Bluff B Subsurface Sampling
Project Number:

Dear Mr. Orechwa:

Thirty seven soil samples were received from Tetra Tech, Inc., on 8/6/2021. The samples were scheduled for the following analyses:

Gamma Spectroscopy
Metals

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Environmental.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,

For,

ALS Environmental
Katie M. OBrien
Project Manager

ADDRESS 225 Commerce Drive, Fort Collins, Colorado, USA 80524 | PHONE +1 970 490 1511 | FAX +1 970 490 1522
ALS GROUP USA, CORP. Part of the ALS Laboratory Group An ALS Limited Company

Accreditations: ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
California (CA)	2926
Colorado (CO)	CO01099
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
PJ-LA (DoD ELAP/ISO 170250)	95377
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO010992018-1
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	TN02976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280

40 CFR Part 136: All analyses for Clean Water Act samples are analyzed using the 40 CFR Part 136 specified method and include all the QC requirements.

2108329

Metals:
The samples were analyzed following SW-846, 3rd Edition procedures. Analysis by ICPMS followed method 6020B and the current revision of SOP 827.

All acceptance criteria were met.

Gamma Spectroscopy:
The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713.

These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans and stored for at least 21 days prior to analysis.

All remaining acceptance criteria were met.

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 2108329
Client Name: Tetra Tech, Inc.
Client Project Name: 2021 Bluff B Subsurface Sampling
Client Project Number:
Client PO Number:

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
TP01-SURF-080321	2108329-1		SOIL	03-Aug-21	8:45
TP01-(5'-6')-080321	2108329-2		SOIL	03-Aug-21	9:00
TP01-(7.5'-8.0')-080321	2108329-3		SOIL	03-Aug-21	9:10
TP02-SURF-080321	2108329-4		SOIL	03-Aug-21	9:30
TP02-(3'-4')-080321	2108329-5		SOIL	03-Aug-21	9:55
TP02-(10'-11')-080321	2108329-6		SOIL	03-Aug-21	10:00
TP03-(SURF)-080321	2108329-7		SOIL	03-Aug-21	10:20
TP03-(5'-6')-080321	2108329-8		SOIL	03-Aug-21	10:55
TP03-(14'-15')-080321	2108329-9		SOIL	03-Aug-21	11:10
TP-(DUP)-01-080321	2108329-10		SOIL	03-Aug-21	
TP04-(SURF)-080321	2108329-11		SOIL	03-Aug-21	11:45
TP04-(5'-6')-080321	2108329-12		SOIL	03-Aug-21	12:05
TP04-(15'-16')-080321	2108329-13		SOIL	03-Aug-21	12:15
TP05-(SURF)-080321	2108329-14		SOIL	03-Aug-21	12:30
TP05-(18'-19')-080321	2108329-15		SOIL	03-Aug-21	13:10
TP06-(SURF)-080321	2108329-16		SOIL	03-Aug-21	13:35
TP06-(11'-12')-080321	2108329-17		SOIL	03-Aug-21	12:35
TP06-(17'-18')-080321	2108329-18		SOIL	03-Aug-21	14:00
TP07-(SURF)-080321	2108329-19		SOIL	03-Aug-21	15:05
TP08-(SURF)-080321	2108329-20		SOIL	03-Aug-21	15:20
TP08-(9'-10')-080321	2108329-21		SOIL	03-Aug-21	15:40
TP09-(SURF)-080321	2108329-22		SOIL	03-Aug-21	16:23
TP09-(6'-7')-080321	2108329-23		SOIL	03-Aug-21	16:40
TP10-(SURF)-080421	2108329-24		SOIL	04-Aug-21	8:25
TP10-(6'-7')-080421	2108329-25		SOIL	04-Aug-21	8:45
TP10-(15'-16')-080421	2108329-26		SOIL	04-Aug-21	8:50
TP11-(SURF)-080421	2108329-27		SOIL	04-Aug-21	9:30
TP11-(5'-6')-080421	2108329-28		SOIL	04-Aug-21	9:50
TP12-(SURF)-080421	2108329-29		SOIL	04-Aug-21	10:45
TP-(DUP)-02-080421	2108329-30		SOIL	04-Aug-21	

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 2108329
Client Name: Tetra Tech, Inc.
Client Project Name: 2021 Bluff B Subsurface Sampling
Client Project Number:
Client PO Number:

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
TP13-(SURF)-080421	2108329-31		SOIL	04-Aug-21	11:50
TP13-(6'-7')-080421	2108329-32		SOIL	04-Aug-21	12:15
TP14-(SURF)-080421	2108329-33		SOIL	04-Aug-21	15:00
TP14-(4'-5')-080421	2108329-34		SOIL	04-Aug-21	15:15
TP15-(SURF)-080421	2108329-35		SOIL	04-Aug-21	15:45
TP15-(3'-4')-080421	2108329-36		SOIL	04-Aug-21	16:00
TP15-(8'-9')-080421	2108329-37		SOIL	04-Aug-21	11:20

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Chain-of-Custody SW3050B

2108329-C

Form 202r8

PROJECT NAME	Bluff B Subsurface	SAMPLER	Bill Craig	DATE	8/3/21
PROJECT No.	8021 Subsurface	SITE ID		TURNAROUND	
		EDD FORMAT		PAGE	1 of 4
		PURCHASE ORDER		DISPOSAL	By Lab or Return to Client
COMPANY NAME	Tetra Tech	BILL TO COMPANY			
SEND REPORT TO		INVOICE ATTN TO			
ADDRESS		ADDRESS			
CITY / STATE / ZIP		CITY / STATE / ZIP			
PHONE		PHONE			
FAX		FAX			
E-MAIL		E-MAIL			

Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles	Pres.	QC	6020B As, Cd, Cu, Pb, Th, Zn	901.1 K-40, Ra-226, Ac-228
1 8	TP01 - SURF - 080321	S	8/3/21	08:45	1			X	X
2 9	TP01 - (5'-6') - 080321	S	8/3/21	9:00	1			X	X
3 10	TP01 - (7.5'-8.0') - 080321	S	8/3/21	9:10	1			X	X
4 11	TP02 - (SURF) - 080321	S	8/3/21	9:30	1			X	X
5 12	TP02 - (3'-4') - 080321	S	8/3/21	9:55	1			X	X
6 13	TP02 - (10'-11') - 080321	S	8/3/21	10:00	1			X	X
7 14	TP03 - (SURF) - 080321	S	8/3/21	10:20	1			X	X
8 15	TP03 - (5'-6') - 080321	S	8/3/21	10:55	1			X	X
9 16	TP03 - (14'-15') - 080321	S	8/3/21	11:[illegible]	1			X	X
10 17	TP - (DUP) - 01 - 080321	S	~~8/3~~	—	1			X	X

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

For metals or anions, please detail analytes below.

Comments:

Please contact Aaron Orechwa at 970-420-9395 before analysis

QC PACKAGE (check below)	
	LEVEL II (Standard QC)
	LEVEL III (Std QC + forms)
	LEVEL IV (Std QC + forms + raw data)

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY				
RECEIVED BY	Amy Kephart	Amy Kephart	8/6/21	1600
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

Preservative Key: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

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Chain-of-Custody

Form 202r8

SW30508

		SAMPLER	Bill Craig	DATE	8/3/21	PAGE	2 of 4
PROJECT NAME	Bluff B Subsurface	SITE ID		TURNAROUND		DISPOSAL	By Lab or Return to Client
PROJECT No.		EDD FORMAT				WORKORDER #	
		PURCHASE ORDER					
COMPANY NAME	Tetra Tech	BILL TO COMPANY					
SEND REPORT TO		INVOICE ATTN TO					
ADDRESS		ADDRESS					
CITY / STATE / ZIP		CITY / STATE / ZIP					
PHONE		PHONE					
FAX		FAX					
E-MAIL		E-MAIL					

Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles	Pres.	QC	As, Cd, Cu, Pb, Th, 6020B	K-40, Ra-226, Ac-228, 901.1
11 18	TP04-(SURF)-080321	S	8/3/21	11:45	1			X	X
12 19	TP04-(5'-6')-080321	S	8/3/21	12:05	1			X	X
13 20	TP04-(15'-16')-080321	S	8/3/21	12:18	1			X	X
14 21 AK	TP05-(SURF)-080321	S	8/3/21	12:30	1			X	X
15 22	TP05-(18'-19')-080321	S	8/3/21	13:10	1			X	X
16 23	TP06-(SURF)-080321	S	8/3/21	13:35	1			X	X
17 24	TP06-(11'-12')-080321	S	8/3/21	13:50	1			X	X
18 25	TP06-(17'-18')-080321	S	8/3/21	14:00	1			X	X
19 26	TP07-(SURF)-080321	S	8/3/21	15:05	1			X	X
20 27	TP08-(SURF)-080321	S	8/3/21	15:20	1			X	X

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

For metals or anions, please detail analytes below.

Comments:

See sheet #1

QC PACKAGE (check below)	
	LEVEL II (Standard QC)
	LEVEL III (Std QC + forms)
	LEVEL IV (Std QC + forms + raw data)

Preservative Key: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY				
RECEIVED BY	Amy Kephart	Amy Kephart	8/6/21	16:00
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

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2108329

Form 202r8

		SAMPLER	Bill Craig	DATE	8/3/21	PAGE	3 of 4
PROJECT NAME	Bluff B Subsurface	SITE ID		TURNAROUND		DISPOSAL	By Lab or Return to Client
PROJECT No.		EDD FORMAT					
		PURCHASE ORDER					
COMPANY NAME	Tetra Tech	BILL TO COMPANY					
SEND REPORT TO		INVOICE ATTN TO					
ADDRESS		ADDRESS					
CITY / STATE / ZIP		CITY / STATE / ZIP					
PHONE		PHONE					
FAX		FAX					
E-MAIL		E-MAIL					

Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles	Pres.	QC	As, Cd, Cu, Pb, Tl, Zn (6020B SW3050)	K-40, Ra-226 (901.1), Ac-228
21 ~~28~~	TP08-(9'-10')-080321	S	8/3/21	15:40	1			X	X
22 29	TP09-(SURF)-080321	S	8/3/21	16:25	1			X	X
23 30	TP09-(6'-7')-080321	S	8/3/21	16:40	1			X	X
24 31	TP10-(SURF)-080421	S	8/4/21	8:25	1			X	X
25 32	TP10-(6'-7')-080421	S	8/4/21	8:45	1			X	X
26 33	TP10-(15'-16')-080421	S	8/4/21	8:50	1			X	X
27 34	TP11-(SURF)-080421	S	8/4/21	09:30	1			X	X
28 35	TP11-(5'-6')-080421	S	8/4/21	09:50	1			X	X
29 36	TP12-(SURF)-080421	S	8/4/21	10:45	1			X	X
30 37	TP-(DUP)-02-080421	S	N/A	N/A	1			X	X

Time

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract F = filter

For metals or anions, please detail analytes below.

Comments:

See Sheet #1

QC PACKAGE (check below)	
	LEVEL II (Standard QC)
	LEVEL III (Std QC + forms)
	LEVEL IV (Std QC + forms + raw data)

Preservative Key: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY				
RECEIVED BY	Amy Kephart	Amy Kephart	8/6/21	1600
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

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Chain-of-Custody

Form 202r8

WORKORDER #	
PAGE	4 of 4
DISPOSAL	By Lab or Return to Client

		SAMPLER	Bill Craig	DATE	8/4/21
PROJECT NAME	Bluff B Subsurface	SITE ID		TURNAROUND	
PROJECT No.		EDD FORMAT			
		PURCHASE ORDER			
COMPANY NAME	Tetra Tech	BILL TO COMPANY			
SEND REPORT TO		INVOICE ATTN TO			
ADDRESS		ADDRESS			
CITY / STATE / ZIP		CITY / STATE / ZIP			
PHONE		PHONE			
FAX		FAX			
E-MAIL		E-MAIL			

Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles	Pres.	QC	As, Cd, Cu, Pb, Th, Zn (6020B/SW3050)	K-40, Ra-226 (901.1) Ac-228
31 1	TP13-(SURF)-080421	S	8/4/21	11:50	1			X	X
32 2	TP13-(6'-7')-080421	S	8/4/21	12:15	1			X	X
33 3	TP14-(SURF)-080421	S	8/4/21	15:00	1			X	X
34 4	TP14-(4'-5')-080421	S	8/4/21	15:15	1			X	X
35 5	TP15-(SURF)-080421	S	8/4/21	15:45	1			X	X
36 6	TP15-(3'-4')-080421	S	8/4/21	16:00	1			X	X
37 7	TP12-(8'-9')-080421	S	8/4/21	11:20	1			X	X

*Time Zone (Circle): EST CST MST PST Matrix: O = oil S = soil NS = non-solid W = water L = liquid E = extract F = filter

For metals or anions, please detail analytes below.

Comments:

See sheet #1

QC PACKAGE (check below)	
	LEVEL II (Standard QC)
	LEVEL III (Std QC + forms)
	LEVEL IV (Std QC + forms + raw data)

Preservative Key: 1-HCl 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

	SIGNATURE	PRINTED NAME	DATE	TIME
RELINQUISHED BY				
RECEIVED BY	Amy Kephart	Amy Kephart	8/6/21	1600
RELINQUISHED BY				
RECEIVED BY				
RELINQUISHED BY				
RECEIVED BY				

ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: TETRE TECH   Workorder No: 2108329

Project Manager: KMO   Initials: AXK   Date: 08/17/2021

		N/A	YES	NO
1.	Are airbills / shipping documents present and/or removable? Tracking number:	X		
2.	Are custody seals on shipping containers intact?	X		
3.	Are custody seals on sample containers intact?	X		
4.	Is there a COC (chain-of-custody) present?		X	
5.	Is the COC in agreement with samples received? (IDs, dates, times, # of samples, # of containers, matrix, requested analyses, etc.)		X	
6.	Are short-hold samples present?			X
7.	Are all samples within holding times for the requested analyses?		X	
8.	Were all sample containers received intact? (not broken or leaking)		X	
9.	Is there sufficient sample for the requested analyses?		X	
10.	Are samples in proper containers for requested analyses? (form 250, *Sample Handling Guidelines*)		X	
11.	Are all aqueous samples preserved correctly, if required? (excluding volatiles)	X		
12.	Are all samples requiring no headspace (VOC, GRO, RSK/MEE, radon) free of bubbles > 6 mm (1/4 inch) diameter? (i.e. size of green pea)	X		
13.	Were the samples shipped on ice?			X
14.	Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #5	RAD ONLY		X

Cooler #:	1						
Temperature (°C):	AMB						
# of custody seals on cooler:	0						
External µR/hr reading:	-						
Background µR/hr reading:	13						

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES (If no, see Form 008.)

* Please provide details here for NO responses to boxes above - for 2 thru 5 & 7 thru 12, notify PM & continue w/ login.

Were unpreserved bottles pH checked? NA   All client bottle ID's vs ALS lab ID's double-checked by: AK

If applicable, was the client contacted? YES / NO / NA Contact: ______ Date/Time: ______

Project Manager Signature / Date: [signature] 8/23/21

Form 201r30.xls
03/18/2021

*IR Gun #5, VWR SN 192272629

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP01-SURF-080321	**Lab ID:**	2108329-1
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 08:45	**Percent Moisture:**	4.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	1.9 (+/- 1.2)	U,M,G	2.3	pCi/g	NA	9/29/2021 06:22
K-40	**16.2 (+/- 5.1)**	G	**6.7**	**pCi/g**	NA	9/29/2021 06:22
Ra-226	**131 (+/- 15)**	M3,G	**1**	**pCi/g**	NA	9/29/2021 06:22
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**790**		**0.2**	**MG/KG**	10	9/24/2021 20:40
CADMIUM	**0.88**		**0.2**	**MG/KG**	10	9/24/2021 20:40
COPPER	**15**		**2**	**MG/KG**	10	9/24/2021 20:40
LEAD	**23**		**0.2**	**MG/KG**	10	9/24/2021 20:40
THORIUM	**8.3**		**0.02**	**MG/KG**	10	9/24/2021 20:40
ZINC	**72**		**10**	**MG/KG**	10	9/24/2021 20:40

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Project: 2021 Bluff B Subsurface Sampling
Sample ID: TP01-(5'-6')-080321
Legal Location:
Collection Date: 8/3/2021 09:00

Date: *30-Sep-21*
Work Order: 2108329
Lab ID: 2108329-2
Matrix: SOIL
Percent Moisture: 14.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	**1.59 (+/- 0.73)**	M3,G,TI	**1.29**	**pCi/g**	NA	9/29/2021 06:22
K-40	**11.4 (+/- 4.2)**	G	**5.7**	**pCi/g**	NA	9/29/2021 06:22
Ra-226	**46.8 (+/- 5.6)**	M3,G	**1.1**	**pCi/g**	NA	9/29/2021 06:22
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**1500**		**2.1**	**MG/KG**	100	9/26/2021 14:04
CADMIUM	**1.1**		**0.21**	**MG/KG**	10	9/24/2021 20:43
COPPER	**21**		**2.1**	**MG/KG**	10	9/24/2021 20:43
LEAD	**37**		**0.21**	**MG/KG**	10	9/24/2021 20:43
THORIUM	**9.5**		**0.021**	**MG/KG**	10	9/24/2021 20:43
ZINC	**59**		**11**	**MG/KG**	10	9/24/2021 20:43

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP01-(7.5'-8.0')-080321	**Lab ID:**	2108329-3
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 09:10	**Percent Moisture:**	15.2

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	1.31 (+/- 0.42)	G	0.68	pCi/g	NA	9/29/2021 06:23
K-40	7.6 (+/- 2.2)	G	2.2	pCi/g	NA	9/29/2021 06:23
Ra-226	3.7 (+/- 0.54)	G	0.47	pCi/g	NA	9/29/2021 06:23
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	71		0.23	MG/KG	10	9/24/2021 20:46
CADMIUM	0.69		0.23	MG/KG	10	9/24/2021 20:46
COPPER	13		2.3	MG/KG	10	9/24/2021 20:46
LEAD	13		0.23	MG/KG	10	9/24/2021 20:46
THORIUM	6.1		0.023	MG/KG	10	9/24/2021 20:46
ZINC	85		12	MG/KG	10	9/24/2021 20:46

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP02-SURF-080321	**Lab ID:**	2108329-4
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 09:30	**Percent Moisture:**	5.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	1.56 (+/- 0.99)	U,M,G	1.94	pCi/g	NA	9/29/2021 06:23
K-40	**16.4 (+/- 5.3)**	G	**7**	**pCi/g**	NA	9/29/2021 06:23
Ra-226	**130 (+/- 15)**	M3,G	**1**	**pCi/g**	NA	9/29/2021 06:23
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**520**		**0.21**	**MG/KG**	10	9/24/2021 20:49
CADMIUM	**0.44**		**0.21**	**MG/KG**	10	9/24/2021 20:49
COPPER	**12**		**2.1**	**MG/KG**	10	9/24/2021 20:49
LEAD	**23**		**0.21**	**MG/KG**	10	9/24/2021 20:49
THORIUM	**6.3**		**0.021**	**MG/KG**	10	9/24/2021 20:49
ZINC	**41**		**11**	**MG/KG**	10	9/24/2021 20:49

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP02-(3'-4')-080321	**Lab ID:**	2108329-5
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 09:55	**Percent Moisture:**	13.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	1.4 (+/- 1.1)	U,M,G	2	pCi/g	NA	9/29/2021 06:23
K-40	**15.9 (+/- 4.4)**	G	**5.6**	**pCi/g**	NA	9/29/2021 06:23
Ra-226	**141 (+/- 17)**	M3,G	**1**	**pCi/g**	NA	9/29/2021 06:23
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**730**		**0.23**	**MG/KG**	10	9/24/2021 20:52
CADMIUM	**0.71**		**0.23**	**MG/KG**	10	9/24/2021 20:52
COPPER	**16**		**2.3**	**MG/KG**	10	9/24/2021 20:52
LEAD	**23**		**0.23**	**MG/KG**	10	9/24/2021 20:52
THORIUM	**8**		**0.023**	**MG/KG**	10	9/24/2021 20:52
ZINC	**43**		**11**	**MG/KG**	10	9/24/2021 20:52

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP02-(10'-11')-080321	**Lab ID:**	2108329-6
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 10:00	**Percent Moisture:**	13.8

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	**1.08 (+/- 0.36)**	G	**0.74**	**pCi/g**	NA	9/29/2021 06:23
K-40	**15.9 (+/- 2.9)**	G	**1.8**	**pCi/g**	NA	9/29/2021 06:23
Ra-226	**16.2 (+/- 2)**	G	**0.4**	**pCi/g**	NA	9/29/2021 06:23
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**140**		**0.22**	**MG/KG**	10	9/24/2021 20:55
CADMIUM	**0.33**		**0.22**	**MG/KG**	10	9/24/2021 20:55
COPPER	**8.9**		**2.2**	**MG/KG**	10	9/24/2021 20:55
LEAD	**11**		**0.22**	**MG/KG**	10	9/24/2021 20:55
THORIUM	**4.9**		**0.022**	**MG/KG**	10	9/24/2021 20:55
ZINC	**34**		**11**	**MG/KG**	10	9/24/2021 20:55

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP03-(SURF)-080321	**Lab ID:**	2108329-7
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 10:20	**Percent Moisture:**	5.8

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	**1.48 (+/- 0.67)**	M3,G,TI	**1.15**	**pCi/g**	NA	9/29/2021 07:27
K-40	**18.1 (+/- 4.6)**	G	**4.8**	**pCi/g**	NA	9/29/2021 07:27
Ra-226	**16.5 (+/- 2.1)**	M3,G	**0.8**	**pCi/g**	NA	9/29/2021 07:27
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**240**		**0.21**	**MG/KG**	10	9/24/2021 20:58
CADMIUM	**0.19**	J	**0.21**	**MG/KG**	10	9/24/2021 20:58
COPPER	**15**		**2.1**	**MG/KG**	10	9/24/2021 20:58
LEAD	**23**		**0.21**	**MG/KG**	10	9/24/2021 20:58
THORIUM	**8.3**		**0.021**	**MG/KG**	10	9/24/2021 20:58
ZINC	**69**		**10**	**MG/KG**	10	9/24/2021 20:58

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP03-(5'-6')-080321	**Lab ID:**	2108329-8
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 10:55	**Percent Moisture:**	23.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	0.63 (+/- 0.73)	U,M,G	1.2	pCi/g	NA	9/29/2021 07:27
K-40	**9.6 (+/- 3.1)**	G	**3.8**	**pCi/g**	NA	9/29/2021 07:27
Ra-226	**85 (+/- 10)**	M3,G	**1**	**pCi/g**	NA	9/29/2021 07:27
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**290**		**0.24**	**MG/KG**	10	9/24/2021 21:00
CADMIUM	**0.4**		**0.24**	**MG/KG**	10	9/24/2021 21:00
COPPER	**16**		**2.4**	**MG/KG**	10	9/24/2021 21:00
LEAD	**13**		**0.24**	**MG/KG**	10	9/24/2021 21:00
THORIUM	**5.2**		**0.024**	**MG/KG**	10	9/24/2021 21:00
ZINC	**36**		**12**	**MG/KG**	10	9/24/2021 21:00

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP03-(14'-15')-080321	**Lab ID:**	2108329-9
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 11:10	**Percent Moisture:**	6.5

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	0.75 (+/- 0.34)	G,TI	0.67	pCi/g	NA	9/29/2021 07:27
K-40	14.1 (+/- 2.9)	G	1.7	pCi/g	NA	9/29/2021 07:27
Ra-226	0.98 (+/- 0.23)	G	0.4	pCi/g	NA	9/29/2021 07:27
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	29		0.2	MG/KG	10	9/24/2021 21:03
CADMIUM	0.13	J	0.2	MG/KG	10	9/24/2021 21:03
COPPER	20		2	MG/KG	10	9/24/2021 21:03
LEAD	7.3		0.2	MG/KG	10	9/24/2021 21:03
THORIUM	5.4		0.02	MG/KG	10	9/24/2021 21:03
ZINC	28		10	MG/KG	10	9/24/2021 21:03

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP-(DUP)-01-080321	**Lab ID:**	2108329-10
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021	**Percent Moisture:**	6.1

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	**1.23 (+/- 0.41)**	G	**0.77**	**pCi/g**	NA	9/29/2021 07:27
K-40	**16.9 (+/- 3.7)**	G	**2.4**	**pCi/g**	NA	9/29/2021 07:27
Ra-226	**1.29 (+/- 0.3)**	G	**0.47**	**pCi/g**	NA	9/29/2021 07:27
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**30**		**0.2**	**MG/KG**	10	9/24/2021 21:06
CADMIUM	**0.14**	J	**0.2**	**MG/KG**	10	9/24/2021 21:06
COPPER	**20**		**2**	**MG/KG**	10	9/24/2021 21:06
LEAD	**8**		**0.2**	**MG/KG**	10	9/24/2021 21:06
THORIUM	**5.8**		**0.02**	**MG/KG**	10	9/24/2021 21:06
ZINC	**33**		**10**	**MG/KG**	10	9/24/2021 21:06

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP04-(SURF)-080321	**Lab ID:**	2108329-11
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 11:45	**Percent Moisture:**	3.9

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	**1.17 (+/- 0.38)**	G	**0.66**	**pCi/g**	NA	9/29/2021 07:27
K-40	**18.1 (+/- 3.6)**	G	**2.7**	**pCi/g**	NA	9/29/2021 07:27
Ra-226	**5.53 (+/- 0.74)**	G	**0.47**	**pCi/g**	NA	9/29/2021 07:27
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**150**		**0.2**	**MG/KG**	10	9/24/2021 21:21
CADMIUM	**0.89**		**0.2**	**MG/KG**	10	9/24/2021 21:21
COPPER	**13**		**2**	**MG/KG**	10	9/24/2021 21:21
LEAD	**14**		**0.2**	**MG/KG**	10	9/24/2021 21:21
THORIUM	**6.8**		**0.02**	**MG/KG**	10	9/24/2021 21:21
ZINC	**98**		**9.8**	**MG/KG**	10	9/24/2021 21:21

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Date: *30-Sep-21*
Project: 2021 Bluff B Subsurface Sampling
Work Order: 2108329
Sample ID: TP04-(5'-6')-080321
Lab ID: 2108329-12
Legal Location:
Matrix: SOIL
Collection Date: 8/3/2021 12:05
Percent Moisture: 14.6

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	0.94 (+/- 0.56)	U,M,G	1.02	pCi/g	NA	9/29/2021 07:28
K-40	**13.7 (+/- 3.9)**	G	**4.2**	**pCi/g**	NA	9/29/2021 07:28
Ra-226	**8.9 (+/- 1.2)**	M3,G	**0.7**	**pCi/g**	NA	9/29/2021 07:28
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**180**		**0.22**	**MG/KG**	10	9/24/2021 21:24
CADMIUM	**0.52**		**0.22**	**MG/KG**	10	9/24/2021 21:24
COPPER	**11**		**2.2**	**MG/KG**	10	9/24/2021 21:24
LEAD	**16**		**0.22**	**MG/KG**	10	9/24/2021 21:24
THORIUM	**6**		**0.022**	**MG/KG**	10	9/24/2021 21:24
ZINC	**56**		**11**	**MG/KG**	10	9/24/2021 21:24

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP04-(15'-16')-080321	**Lab ID:**	2108329-13
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 12:15	**Percent Moisture:**	12.8

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	**0.79 (+/- 0.3)**	G	**0.55**	**pCi/g**	NA	9/29/2021 07:28
K-40	**14.9 (+/- 2.9)**	G	**1.7**	**pCi/g**	NA	9/29/2021 07:28
Ra-226	**3.62 (+/- 0.5)**	G	**0.31**	**pCi/g**	NA	9/29/2021 07:28
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**44**		**0.21**	**MG/KG**	10	9/24/2021 21:27
CADMIUM	**0.065**	J	**0.21**	**MG/KG**	10	9/24/2021 21:27
COPPER	**4.2**		**2.1**	**MG/KG**	10	9/24/2021 21:27
LEAD	**6.9**		**0.21**	**MG/KG**	10	9/24/2021 21:27
THORIUM	**3.6**		**0.021**	**MG/KG**	10	9/24/2021 21:27
ZINC	**21**		**10**	**MG/KG**	10	9/24/2021 21:27

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP05-(SURF)-080321	**Lab ID:**	2108329-14
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 12:30	**Percent Moisture:**	12.0

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	1.5 (+/- 1.1)	U,M,G	2.2	pCi/g	NA	9/29/2021 08:26
K-40	0.5 (+/- 3.2)	U,G	5.7	pCi/g	NA	9/29/2021 08:26
Ra-226	**111 (+/- 13)**	M3,G	**2**	**pCi/g**	NA	9/29/2021 08:26
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**310**		**0.21**	**MG/KG**	10	9/24/2021 21:30
CADMIUM	**0.41**		**0.21**	**MG/KG**	10	9/24/2021 21:30
COPPER	**33**		**2.1**	**MG/KG**	10	9/24/2021 21:30
LEAD	**21**		**0.21**	**MG/KG**	10	9/24/2021 21:30
THORIUM	**7.9**		**0.021**	**MG/KG**	10	9/24/2021 21:30
ZINC	**72**		**11**	**MG/KG**	10	9/24/2021 21:30

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP05-(18'-19')-080321	**Lab ID:**	2108329-15
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 13:10	**Percent Moisture:**	11.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	**1.23 (+/- 0.4)**	G	**0.69**	**pCi/g**	NA	9/29/2021 08:26
K-40	**11.4 (+/- 2.7)**	G	**2.5**	**pCi/g**	NA	9/29/2021 08:26
Ra-226	**14.7 (+/- 1.8)**	M3,G	**0.6**	**pCi/g**	NA	9/29/2021 08:26
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**43**		**0.22**	**MG/KG**	10	9/24/2021 22:03
CADMIUM	**0.095**	J	**0.22**	**MG/KG**	10	9/24/2021 22:03
COPPER	**14**		**2.2**	**MG/KG**	10	9/24/2021 22:03
LEAD	**17**		**0.22**	**MG/KG**	10	9/24/2021 22:03
THORIUM	**7.9**		**0.022**	**MG/KG**	10	9/24/2021 22:03
ZINC	**32**		**11**	**MG/KG**	10	9/24/2021 22:03

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP06-(SURF)-080321	**Lab ID:**	2108329-16
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 13:35	**Percent Moisture:**	6.3

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	0.67 (+/- 0.38)	U,G	0.71	pCi/g	NA	9/29/2021 08:26
K-40	**17.9 (+/- 3.7)**	G	**2.7**	**pCi/g**	NA	9/29/2021 08:26
Ra-226	**10.8 (+/- 1.4)**	M3,G	**0.5**	**pCi/g**	NA	9/29/2021 08:26
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**100**		**0.21**	**MG/KG**	10	9/24/2021 22:06
CADMIUM	**0.75**		**0.21**	**MG/KG**	10	9/24/2021 22:06
COPPER	**14**		**2.1**	**MG/KG**	10	9/24/2021 22:06
LEAD	**16**		**0.21**	**MG/KG**	10	9/24/2021 22:06
THORIUM	**7.3**		**0.021**	**MG/KG**	10	9/24/2021 22:06
ZINC	**88**		**10**	**MG/KG**	10	9/24/2021 22:06

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP06-(11'-12')-080321	**Lab ID:**	2108329-17
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 12:35	**Percent Moisture:**	16.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	**1.66 (+/- 0.53)**	TI	**0.81**	**pCi/g**	NA	9/29/2021 08:27
K-40	**17.1 (+/- 3.7)**		**2.7**	**pCi/g**	NA	9/29/2021 08:27
Ra-226	**1.83 (+/- 0.35)**		**0.46**	**pCi/g**	NA	9/29/2021 08:27
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**15**		**0.23**	**MG/KG**	10	9/24/2021 22:09
CADMIUM	**0.18**	J	**0.23**	**MG/KG**	10	9/24/2021 22:09
COPPER	**19**		**2.3**	**MG/KG**	10	9/24/2021 22:09
LEAD	**16**		**0.23**	**MG/KG**	10	9/24/2021 22:09
THORIUM	**9.6**		**0.023**	**MG/KG**	10	9/24/2021 22:09
ZINC	**43**		**12**	**MG/KG**	10	9/24/2021 22:09

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Project: 2021 Bluff B Subsurface Sampling
Sample ID: TP06-(17'-18')-080321
Legal Location:
Collection Date: 8/3/2021 14:00

Date: *30-Sep-21*
Work Order: 2108329
Lab ID: 2108329-18
Matrix: SOIL
Percent Moisture: 7.9

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/7/2021**	PrepBy: **AML**
Ac-228	1.01 (+/- 0.33)		0.59	pCi/g	NA	9/29/2021 08:27
K-40	14.8 (+/- 3)		2.1	pCi/g	NA	9/29/2021 08:27
Ra-226	1.25 (+/- 0.25)		0.33	pCi/g	NA	9/29/2021 08:27
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	18		0.22	MG/KG	10	9/24/2021 22:12
CADMIUM	0.053	J	0.22	MG/KG	10	9/24/2021 22:12
COPPER	11		2.2	MG/KG	10	9/24/2021 22:12
LEAD	14		0.22	MG/KG	10	9/24/2021 22:12
THORIUM	7.6		0.022	MG/KG	10	9/24/2021 22:12
ZINC	23		11	MG/KG	10	9/24/2021 22:12

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Project: 2021 Bluff B Subsurface Sampling
Sample ID: TP07-(SURF)-080321
Legal Location:
Collection Date: 8/3/2021 15:05

Date: *30-Sep-21*
Work Order: 2108329
Lab ID: 2108329-19
Matrix: SOIL
Percent Moisture: 5.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	**1.66 (+/- 0.55)**	G	**0.92**	**pCi/g**	NA	9/29/2021 08:27
K-40	**15.1 (+/- 4)**	G	**4.1**	**pCi/g**	NA	9/29/2021 08:27
Ra-226	**10.3 (+/- 1.4)**	M3,G	**0.7**	**pCi/g**	NA	9/29/2021 08:27
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**340**		**0.21**	**MG/KG**	10	9/24/2021 22:15
CADMIUM	**0.36**		**0.21**	**MG/KG**	10	9/24/2021 22:15
COPPER	**20**		**2.1**	**MG/KG**	10	9/24/2021 22:15
LEAD	**20**		**0.21**	**MG/KG**	10	9/24/2021 22:15
THORIUM	**8.7**		**0.021**	**MG/KG**	10	9/24/2021 22:15
ZINC	**50**		**10**	**MG/KG**	10	9/24/2021 22:15

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP08-(SURF)-080321	**Lab ID:**	2108329-20
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 15:20	**Percent Moisture:**	3.8

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/7/2021**		PrepBy: **AML**
Ac-228	**1.3 (+/- 0.33)**	G	**0.43**	**pCi/g**	NA	9/29/2021 08:27
K-40	**15.8 (+/- 2.9)**	G	**1.6**	**pCi/g**	NA	9/29/2021 08:27
Ra-226	**9 (+/- 1.1)**	G	**0.4**	**pCi/g**	NA	9/29/2021 08:27
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**350**		**0.2**	**MG/KG**	10	9/24/2021 22:18
CADMIUM	**0.49**		**0.2**	**MG/KG**	10	9/24/2021 22:18
COPPER	**14**		**2**	**MG/KG**	10	9/24/2021 22:18
LEAD	**18**		**0.2**	**MG/KG**	10	9/24/2021 22:18
THORIUM	**6.8**		**0.02**	**MG/KG**	10	9/24/2021 22:18
ZINC	**45**		**10**	**MG/KG**	10	9/24/2021 22:18

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP08-(9'-10')-080321	**Lab ID:**	2108329-21
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 15:40	**Percent Moisture:**	35.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	1.62 (+/- 0.54)	M3,G	1.24	pCi/g	NA	9/29/2021 09:33
K-40	17.5 (+/- 3.9)	G	3.1	pCi/g	NA	9/29/2021 09:33
Ra-226	4.53 (+/- 0.66)	M3,G	0.59	pCi/g	NA	9/29/2021 09:33
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	29		0.31	MG/KG	10	9/24/2021 22:21
CADMIUM	0.34		0.31	MG/KG	10	9/24/2021 22:21
COPPER	16		3.1	MG/KG	10	9/24/2021 22:21
LEAD	17		0.31	MG/KG	10	9/24/2021 22:21
THORIUM	7.4		0.031	MG/KG	10	9/24/2021 22:21
ZINC	50		16	MG/KG	10	9/24/2021 22:21

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Date: *30-Sep-21*
Project: 2021 Bluff B Subsurface Sampling
Work Order: 2108329
Sample ID: TP09-(SURF)-080321
Lab ID: 2108329-22
Legal Location:
Matrix: SOIL
Collection Date: 8/3/2021 16:23
Percent Moisture: 6.2

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	1.7 (+/- 0.45)	G	0.8	pCi/g	NA	9/29/2021 09:33
K-40	14.5 (+/- 3.1)	G	2.3	pCi/g	NA	9/29/2021 09:33
Ra-226	9.3 (+/- 1.2)	G	0.5	pCi/g	NA	9/29/2021 09:33
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	220		0.21	MG/KG	10	9/24/2021 22:36
CADMIUM	0.56		0.21	MG/KG	10	9/24/2021 22:36
COPPER	18		2.1	MG/KG	10	9/24/2021 22:36
LEAD	28		0.21	MG/KG	10	9/24/2021 22:36
THORIUM	8.4		0.021	MG/KG	10	9/24/2021 22:36
ZINC	66		10	MG/KG	10	9/24/2021 22:36

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP09-(6'-7')-080321	**Lab ID:**	2108329-23
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/3/2021 16:40	**Percent Moisture:**	13.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	**1.56 (+/- 0.52)**	G,TI	**0.83**	**pCi/g**	NA	9/29/2021 09:33
K-40	**13.2 (+/- 3.4)**	G	**3.1**	**pCi/g**	NA	9/29/2021 09:33
Ra-226	**1.82 (+/- 0.36)**	M3,G	**0.54**	**pCi/g**	NA	9/29/2021 09:33
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**64**		**0.23**	**MG/KG**	10	9/24/2021 22:39
CADMIUM	**0.36**		**0.23**	**MG/KG**	10	9/24/2021 22:39
COPPER	**21**		**2.3**	**MG/KG**	10	9/24/2021 22:39
LEAD	**16**		**0.23**	**MG/KG**	10	9/24/2021 22:39
THORIUM	**9.3**		**0.023**	**MG/KG**	10	9/24/2021 22:39
ZINC	**72**		**11**	**MG/KG**	10	9/24/2021 22:39

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP10-(SURF)-080421	**Lab ID:**	2108329-24
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 08:25	**Percent Moisture:**	4.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	**1.15 (+/- 0.29)**		**0.44**	**pCi/g**	NA	9/29/2021 09:33
K-40	**17.4 (+/- 3)**		**1.4**	**pCi/g**	NA	9/29/2021 09:33
Ra-226	**2.71 (+/- 0.38)**		**0.27**	**pCi/g**	NA	9/29/2021 09:33
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**24**		**0.19**	**MG/KG**	10	9/24/2021 22:42
CADMIUM	**0.29**		**0.19**	**MG/KG**	10	9/24/2021 22:42
COPPER	**12**		**1.9**	**MG/KG**	10	9/24/2021 22:42
LEAD	**11**		**0.19**	**MG/KG**	10	9/24/2021 22:42
THORIUM	**5.1**		**0.019**	**MG/KG**	10	9/24/2021 22:42
ZINC	**37**		**9.6**	**MG/KG**	10	9/24/2021 22:42

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP10-(6'-7')-080421	**Lab ID:**	2108329-25
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 08:45	**Percent Moisture:**	14.6

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	**0.85 (+/- 0.35)**	G	**0.62**	**pCi/g**	NA	9/29/2021 10:09
K-40	**14.5 (+/- 2.9)**	G	**1.8**	**pCi/g**	NA	9/29/2021 10:09
Ra-226	**5.04 (+/- 0.68)**	G	**0.47**	**pCi/g**	NA	9/29/2021 10:09
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**19**		**0.23**	**MG/KG**	10	9/24/2021 22:45
CADMIUM	**0.22**	J	**0.23**	**MG/KG**	10	9/24/2021 22:45
COPPER	**9.4**		**2.3**	**MG/KG**	10	9/24/2021 22:45
LEAD	**10**		**0.23**	**MG/KG**	10	9/24/2021 22:45
THORIUM	**4.8**		**0.023**	**MG/KG**	10	9/24/2021 22:45
ZINC	**36**		**12**	**MG/KG**	10	9/24/2021 22:45

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP10-(15'-16')-080421	**Lab ID:**	2108329-26
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 08:50	**Percent Moisture:**	21.5

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	0.1 (+/- 1.8)	U,M,G	3	pCi/g	NA	9/29/2021 10:31
K-40	**10.2 (+/- 5.4)**	G	**8.2**	**pCi/g**	NA	9/29/2021 10:31
Ra-226	**189 (+/- 22)**	M3,G	**2**	**pCi/g**	NA	9/29/2021 10:31
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**280**		**0.25**	**MG/KG**	10	9/24/2021 22:48
CADMIUM	**4**		**0.25**	**MG/KG**	10	9/24/2021 22:48
COPPER	**14**		**2.5**	**MG/KG**	10	9/24/2021 22:48
LEAD	**27**		**0.25**	**MG/KG**	10	9/24/2021 22:48
THORIUM	**4.1**		**0.025**	**MG/KG**	10	9/24/2021 22:48
ZINC	**51**		**12**	**MG/KG**	10	9/24/2021 22:48

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP11-(SURF)-080421	**Lab ID:**	2108329-27
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 09:30	**Percent Moisture:**	4.2

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	**1.22 (+/- 0.56)**	M3,G,TI	**1.15**	**pCi/g**	NA	9/29/2021 10:31
K-40	**15.2 (+/- 3.8)**	G	**3.4**	**pCi/g**	NA	9/29/2021 10:31
Ra-226	**3.34 (+/- 0.53)**	M3,G	**0.58**	**pCi/g**	NA	9/29/2021 10:31
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**25**		**0.21**	**MG/KG**	10	9/24/2021 22:51
CADMIUM	**0.28**		**0.21**	**MG/KG**	10	9/24/2021 22:51
COPPER	**14**		**2.1**	**MG/KG**	10	9/24/2021 22:51
LEAD	**14**		**0.21**	**MG/KG**	10	9/24/2021 22:51
THORIUM	**5.7**		**0.021**	**MG/KG**	10	9/24/2021 22:51
ZINC	**46**		**10**	**MG/KG**	10	9/24/2021 22:51

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP11-(5'-6')-080421	**Lab ID:**	2108329-28
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 09:50	**Percent Moisture:**	24.0

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	**0.99 (+/- 0.34)**	TI	**0.51**	**pCi/g**	NA	9/29/2021 10:31
K-40	**14.1 (+/- 2.9)**		**2.2**	**pCi/g**	NA	9/29/2021 10:31
Ra-226	**1.61 (+/- 0.28)**		**0.33**	**pCi/g**	NA	9/29/2021 10:31
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**7.5**		**0.25**	**MG/KG**	10	9/24/2021 22:54
CADMIUM	**0.19**	J	**0.25**	**MG/KG**	10	9/24/2021 22:54
COPPER	**9.7**		**2.5**	**MG/KG**	10	9/24/2021 22:54
LEAD	**9.1**		**0.25**	**MG/KG**	10	9/24/2021 22:54
THORIUM	**4**		**0.025**	**MG/KG**	10	9/24/2021 22:54
ZINC	**35**		**12**	**MG/KG**	10	9/24/2021 22:54

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP12-(SURF)-080421	**Lab ID:**	2108329-29
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 10:45	**Percent Moisture:**	4.9

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	0.2 (+/- 1.7)	U,M,G	2.8	pCi/g	NA	9/29/2021 10:31
K-40	**11.4 (+/- 5.3)**	G	**7.9**	**pCi/g**	NA	9/29/2021 10:31
Ra-226	**192 (+/- 23)**	M3,G	**2**	**pCi/g**	NA	9/29/2021 10:31
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**470**		**0.2**	**MG/KG**	10	9/24/2021 22:57
CADMIUM	**1.2**		**0.2**	**MG/KG**	10	9/24/2021 22:57
COPPER	**17**		**2**	**MG/KG**	10	9/24/2021 22:57
LEAD	**21**		**0.2**	**MG/KG**	10	9/24/2021 22:57
THORIUM	**8.7**		**0.02**	**MG/KG**	10	9/24/2021 22:57
ZINC	**44**		**10**	**MG/KG**	10	9/24/2021 22:57

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP-(DUP)-02-080421	**Lab ID:**	2108329-30
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021	**Percent Moisture:**	5.0

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	**2 (+/- 0.75)**	M3,G	**1.43**	**pCi/g**	NA	9/29/2021 10:31
K-40	**12.4 (+/- 3.3)**	G	**4**	**pCi/g**	NA	9/29/2021 10:31
Ra-226	**178 (+/- 21)**	M3,G	**1**	**pCi/g**	NA	9/29/2021 10:31
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**400**		**0.2**	**MG/KG**	10	9/24/2021 23:00
CADMIUM	**1.5**		**0.2**	**MG/KG**	10	9/24/2021 23:00
COPPER	**19**		**2**	**MG/KG**	10	9/24/2021 23:00
LEAD	**29**		**0.2**	**MG/KG**	10	9/24/2021 23:00
THORIUM	**9.3**		**0.02**	**MG/KG**	10	9/24/2021 23:00
ZINC	**47**		**10**	**MG/KG**	10	9/24/2021 23:00

Client: Tetra Tech, Inc. **Date:** *30-Sep-21*
Project: 2021 Bluff B Subsurface Sampling **Work Order:** 2108329
Sample ID: TP13-(SURF)-080421 **Lab ID:** 2108329-31
Legal Location: **Matrix:** SOIL
Collection Date: 8/4/2021 11:50 **Percent Moisture:** 3.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	0.94 (+/- 0.33)	G	0.61	pCi/g	NA	9/29/2021 11:00
K-40	15.7 (+/- 3)	G	1.8	pCi/g	NA	9/29/2021 11:00
Ra-226	4.82 (+/- 0.65)	G	0.43	pCi/g	NA	9/29/2021 11:00
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	53		0.2	MG/KG	10	9/24/2021 23:03
CADMIUM	0.49		0.2	MG/KG	10	9/24/2021 23:03
COPPER	11		2	MG/KG	10	9/24/2021 23:03
LEAD	12		0.2	MG/KG	10	9/24/2021 23:03
THORIUM	6.3		0.02	MG/KG	10	9/24/2021 23:03
ZINC	57		10	MG/KG	10	9/24/2021 23:03

SAMPLE SUMMARY REPORT

Client: Tetra Tech, Inc.
Date: *30-Sep-21*
Project: 2021 Bluff B Subsurface Sampling
Work Order: 2108329
Sample ID: TP13-(6'-7')-080421
Lab ID: 2108329-32
Legal Location:
Matrix: SOIL
Collection Date: 8/4/2021 12:15
Percent Moisture: 16.5

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	**1.25 (+/- 0.45)**	G,TI	**0.8**	**pCi/g**	NA	9/29/2021 11:40
K-40	**17.6 (+/- 3.6)**	G	**2.3**	**pCi/g**	NA	9/29/2021 11:40
Ra-226	**2.73 (+/- 0.43)**	G	**0.46**	**pCi/g**	NA	9/29/2021 11:40
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**88**		**0.23**	**MG/KG**	10	9/24/2021 23:18
CADMIUM	**0.32**		**0.23**	**MG/KG**	10	9/24/2021 23:18
COPPER	**15**		**2.3**	**MG/KG**	10	9/24/2021 23:18
LEAD	**15**		**0.23**	**MG/KG**	10	9/24/2021 23:18
THORIUM	**8.2**		**0.023**	**MG/KG**	10	9/24/2021 23:18
ZINC	**77**		**12**	**MG/KG**	10	9/24/2021 23:18

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP14-(SURF)-080421	**Lab ID:**	2108329-33
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 15:00	**Percent Moisture:**	1.9

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	1.16 (+/- 0.5)	TI	0.83	pCi/g	NA	9/29/2021 11:40
K-40	10.3 (+/- 2.8)		2.7	pCi/g	NA	9/29/2021 11:40
Ra-226	9.7 (+/- 1.2)		0.5	pCi/g	NA	9/29/2021 11:40
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	60		0.2	MG/KG	10	9/24/2021 23:21
CADMIUM	0.2		0.2	MG/KG	10	9/24/2021 23:21
COPPER	10		2	MG/KG	10	9/24/2021 23:21
LEAD	11		0.2	MG/KG	10	9/24/2021 23:21
THORIUM	4.9		0.02	MG/KG	10	9/24/2021 23:21
ZINC	30		9.8	MG/KG	10	9/24/2021 23:21

SAMPLE SUMMARY REPORT

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP14-(4'-5')-080421	**Lab ID:**	2108329-34
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 15:15	**Percent Moisture:**	7.8

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	**0.56 (+/- 0.21)**	G	**0.41**	**pCi/g**	NA	9/29/2021 11:40
K-40	**15.5 (+/- 2.9)**	G	**1.6**	**pCi/g**	NA	9/29/2021 11:40
Ra-226	**2.21 (+/- 0.34)**	G	**0.32**	**pCi/g**	NA	9/29/2021 11:40
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**9.1**		**0.21**	**MG/KG**	10	9/24/2021 23:24
CADMIUM	**0.083**	J	**0.21**	**MG/KG**	10	9/24/2021 23:24
COPPER	**2.9**		**2.1**	**MG/KG**	10	9/24/2021 23:24
LEAD	**4.1**		**0.21**	**MG/KG**	10	9/24/2021 23:24
THORIUM	**2.9**		**0.021**	**MG/KG**	10	9/24/2021 23:24
ZINC	**21**		**11**	**MG/KG**	10	9/24/2021 23:24

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP15-(SURF)-080421	**Lab ID:**	2108329-35
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 15:45	**Percent Moisture:**	0.7

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	**0.78 (+/- 0.36)**		**0.77**	**pCi/g**	NA	9/29/2021 11:52
K-40	**10 (+/- 2.2)**		**1.9**	**pCi/g**	NA	9/29/2021 11:52
Ra-226	**11.8 (+/- 1.5)**		**0.5**	**pCi/g**	NA	9/29/2021 11:52
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**55**		**0.2**	**MG/KG**	10	9/26/2021 12:40
CADMIUM	**0.16**	J	**0.2**	**MG/KG**	10	9/26/2021 12:40
COPPER	**7.6**		**2**	**MG/KG**	10	9/26/2021 12:40
LEAD	**8.3**		**0.2**	**MG/KG**	10	9/26/2021 12:40
THORIUM	**4.4**		**0.02**	**MG/KG**	10	9/26/2021 12:40
ZINC	**25**		**9.9**	**MG/KG**	10	9/26/2021 12:40

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP15-(3'-4')-080421	**Lab ID:**	2108329-36
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 16:00	**Percent Moisture:**	4.2

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**			Prep Date: **9/3/2021**	PrepBy: **AML**
Ac-228	**0.45 (+/- 0.29)**	G,TI	**0.4**	**pCi/g**	NA	9/29/2021 12:34
K-40	**14.1 (+/- 3)**	G	**2.1**	**pCi/g**	NA	9/29/2021 12:34
Ra-226	**1.88 (+/- 0.32)**	G	**0.36**	**pCi/g**	NA	9/29/2021 12:34
ICPMS Metals		**SW6020**			Prep Date: **9/23/2021**	PrepBy: **WJS**
ARSENIC	**14**		**0.2**	**MG/KG**	10	9/26/2021 12:43
CADMIUM	**0.23**		**0.2**	**MG/KG**	10	9/26/2021 12:43
COPPER	**2.4**		**2**	**MG/KG**	10	9/26/2021 12:43
LEAD	**4.1**		**0.2**	**MG/KG**	10	9/26/2021 12:43
THORIUM	**2.7**		**0.02**	**MG/KG**	10	9/26/2021 12:43
ZINC	**20**		**10**	**MG/KG**	10	9/26/2021 12:43

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP15-(8'-9')-080421	**Lab ID:**	2108329-37
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 11:20	**Percent Moisture:**	12.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gamma Spectroscopy Results		**SOP 713**		Prep Date: **9/3/2021**		PrepBy: **AML**
Ac-228	0.8 (+/- 0.46)	U,G	0.83	pCi/g	NA	9/29/2021 12:34
K-40	**14.1 (+/- 3.9)**	G	**3.8**	**pCi/g**	NA	9/29/2021 12:34
Ra-226	**7.6 (+/- 1)**	M3,G	**0.7**	**pCi/g**	NA	9/29/2021 12:34
ICPMS Metals		**SW6020**		Prep Date: **9/23/2021**		PrepBy: **WJS**
ARSENIC	**38**		**0.22**	**MG/KG**	10	9/26/2021 12:46
CADMIUM	**0.32**		**0.22**	**MG/KG**	10	9/26/2021 12:46
COPPER	**11**		**2.2**	**MG/KG**	10	9/26/2021 12:46
LEAD	**11**		**0.22**	**MG/KG**	10	9/26/2021 12:46
THORIUM	**5.6**		**0.022**	**MG/KG**	10	9/26/2021 12:46
ZINC	**38**		**11**	**MG/KG**	10	9/26/2021 12:46

Client:	Tetra Tech, Inc.	**Date:**	*30-Sep-21*
Project:	2021 Bluff B Subsurface Sampling	**Work Order:**	2108329
Sample ID:	TP15-(8'-9')-080421	**Lab ID:**	2108329-37
Legal Location:		**Matrix:**	SOIL
Collection Date:	8/4/2021 11:20	**Percent Moisture:**	12.4

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed

Explanation of Qualifiers

Radiochemistry:

- "Report Limit" is the MDC

U or ND - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.

Y2 - Chemical Yield outside default limits.

W - DER is greater than Warning Limit of 1.42

* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.

- Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.

G - Sample density differs by more than 15% of LCS density.

D - DER is greater than Control Limit

M - Requested MDC not met.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS, Matrix Spike Recovery within control limits.

N - Matrix Spike Recovery outside control limits

NC - Not Calculated for duplicate results less than 5 times MDC

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Inorganics:

B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).

U or ND - Indicates that the compound was analyzed for but not detected.

E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.

M - Duplicate injection precision was not met.

N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.

Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.

* - Duplicate analysis (relative percent difference) not within control limits.

S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

Organics:

U or ND - Indicates that the compound was analyzed for but not detected.

B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.

E - Analyte concentration exceeds the upper level of the calibration range.

J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).

A - A tentatively identified compound is a suspected aldol-condensation product.

X - The analyte was diluted below an accurate quantitation level.

* - The spike recovery is equal to or outside the control criteria used.

+ - The relative percent difference (RPD) equals or exceeds the control criteria.

G - A pattern resembling gasoline was detected in this sample.

D - A pattern resembling diesel was detected in this sample.

M - A pattern resembling motor oil was detected in this sample.

C - A pattern resembling crude oil was detected in this sample.

4 - A pattern resembling JP-4 was detected in this sample.

5 - A pattern resembling JP-5 was detected in this sample.

H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.

L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.

Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
- gasoline
- JP-8
- diesel
- mineral spirits
- motor oil
- Stoddard solvent
- bunker C

ALS -- Fort Collins

Client: Tetra Tech, Inc.

Work Order: 2108329

Project: 2021 Bluff B Subsurface Sampling

Date: *9/30/2021 5:32:3*

QC BATCH REPORT

Batch ID: **GS210903-2-1** Instrument ID: **GAMMA** Method: **Gamma Spectroscopy Results**

DUP Sample ID: **2108329-25** Units: **pCi/g** Analysis Date: **9/29/2021 10:09**

Client ID: **TP10-(6'-7')-080421** Run ID: **GS210903-2A** Prep Date: **9/3/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	4.36 (+/- 0.61)	0.44						5.04	1.49	3	G
Ac-228	1.01 (+/- 0.4)	0.82						0.85	0.3		G
Cs-137	0.03 (+/- 0.11)	0.19						-0.09	0.82	2.13	U,G
K-40	14.6 (+/- 3.2)	2.6						14.5	0.02	2.13	G

LCS Sample ID: **GS210903-2A** Units: **pCi/g** Analysis Date: **9/29/2021 13:17**

Client ID: Run ID: **GS210903-2A** Prep Date: **9/3/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	462 (+/- 54)	2	467.6		98.8	85-115					P,M3

LCS Sample ID: **GS210903-2** Units: **pCi/g** Analysis Date: **9/30/2021 11:26**

Client ID: Run ID: **GS210903-2A** Prep Date: **9/3/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Am-241	534 (+/- 63)	3	503.1		106	85-115					P
Co-60	210 (+/- 25)	1	207.9		101	85-115					P
Cs-137	173 (+/- 20)	1	170.7		101	85-115					P

MB Sample ID: **GS210903-2** Units: **pCi/g** Analysis Date: **9/29/2021 12:34**

Client ID: Run ID: **GS210903-2A** Prep Date: **9/3/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	-0.021 (+/- 0.093)	0.176									U
Ac-228	0.01 (+/- 0.13)	0.25									U
Cs-137	0.007 (+/- 0.037)	0.069									U
K-40	0.1 (+/- 0.57)	1.04									U

The following samples were analyzed in this batch:

2108329-21	2108329-22	2108329-23
2108329-24	2108329-25	2108329-26
2108329-27	2108329-28	2108329-29
2108329-30	2108329-31	2108329-32
2108329-33	2108329-34	2108329-35
2108329-36	2108329-37	

Client:	Tetra Tech, Inc.
Work Order:	2108329
Project:	2021 Bluff B Subsurface Sampling

QC BATCH REPORT

Batch ID: **GS210907-1-1** Instrument ID: **GAMMA** Method: **Gamma Spectroscopy Results**

DUP Sample ID: **2108329-5** Units: **pCi/g** Analysis Date: **9/29/2021 06:23**

Client ID: **TP02-(3'-4')-080321** Run ID: **GS210907-1A** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	127 (+/- 15)	2						141	1.27	3	M3,G
Ac-228	1.5 (+/- 1.4)	2.3						1.4	0.05		U,M,G
Cs-137	0.05 (+/- 0.4)	0.67						0.11	0.12	2.13	U,G
K-40	13.9 (+/- 5.6)	8.1						15.9	0.29	2.13	G

LCS Sample ID: **GS210907-1A** Units: **pCi/g** Analysis Date: **9/29/2021 09:32**

Client ID: Run ID: **GS210907-1A** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	465 (+/- 54)	3	467.6		99.4	85-115					P,M3

LCS Sample ID: **GS210907-1** Units: **pCi/g** Analysis Date: **9/30/2021 10:51**

Client ID: Run ID: **GS210907-1A** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Am-241	506 (+/- 61)	16	503.1		101	85-115					P
Co-60	207 (+/- 24)	1	207.9		99.7	85-115					P
Cs-137	171 (+/- 20)	1	170.7		100	85-115					P

MB Sample ID: **GS210907-1** Units: **pCi/g** Analysis Date: **9/29/2021 09:32**

Client ID: Run ID: **GS210907-1A** Prep Date: **9/7/2021** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	0.07 (+/- 0.19)	0.33									U
Ac-228	-0.06 (+/- 0.33)	0.63									U
Cs-137	-0.018 (+/- 0.067)	0.131									U
K-40	-0.8 (+/- 1.1)	2.3									U

The following samples were analyzed in this batch:

2108329-1	2108329-2	2108329-3
2108329-4	2108329-5	2108329-6
2108329-7	2108329-8	2108329-9
2108329-10	2108329-11	2108329-12
2108329-13	2108329-14	2108329-15
2108329-16	2108329-17	2108329-18
2108329-19	2108329-20	

Client: Tetra Tech, Inc.
Work Order: 2108329
Project: 2021 Bluff B Subsurface Sampling

QC BATCH REPORT

Batch ID: **IP210923-10-2** Instrument ID: **ICPMS2** Method: **SW6020**

LCS Sample ID: **IM210923-10** Units: **MG/KG** Analysis Date: **9/26/2021 12:28**
Client ID: Run ID: **IM210926-10A2** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.44	0.2	10		94	80-120				20	
CADMIUM	2.89	0.2	3		96	80-120				20	
COPPER	98.7	2	100		99	80-120				20	
LEAD	4.83	0.2	5		97	80-120				20	
THORIUM	0.989	0.02	1		99	80-120				20	
ZINC	181	10	200		90	80-120				20	

LCSD Sample ID: **IM210923-10** Units: **MG/KG** Analysis Date: **9/26/2021 12:34**
Client ID: Run ID: **IM210926-10A2** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.13	0.2	10		91	80-120		9.44	3	20	
CADMIUM	2.91	0.2	3		97	80-120		2.89	1	20	
COPPER	98	2	100		98	80-120		98.7	1	20	
LEAD	4.83	0.2	5		97	80-120		4.83	0	20	
THORIUM	1.06	0.02	1		106	80-120		0.989	7	20	
ZINC	189	10	200		95	80-120		181	4	20	

MB Sample ID: **IP210923-10** Units: **MG/KG** Analysis Date: **9/26/2021 12:25**
Client ID: Run ID: **IM210926-10A2** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	Qual
ARSENIC	ND	0.2	
CADMIUM	ND	0.2	
COPPER	ND	2	
LEAD	ND	0.2	
THORIUM	ND	0.02	
ZINC	ND	10	

The following samples were analyzed in this batch: 2108329-35 2108329-36 2108329-37

QC BATCH REPORT

Batch ID: **IP210923-6-1** Instrument ID: **ICPMS2** Method: **SW6020**

LCS Sample ID: **IM210923-6** Units: **MG/KG** Analysis Date: **9/24/2021 19:58**
Client ID: Run ID: **IM210924-11A4** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.8	0.2	10		98	80-120				20	
CADMIUM	3.18	0.2	3		106	80-120				20	
COPPER	102	2	100		102	80-120				20	
LEAD	5.15	0.2	5		103	80-120				20	
THORIUM	0.909	0.02	1		91	80-120				20	
ZINC	189	10	200		94	80-120				20	

LCSD Sample ID: **IM210923-6** Units: **MG/KG** Analysis Date: **9/24/2021 20:04**
Client ID: Run ID: **IM210924-11A4** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.83	0.2	10		98	80-120		9.8	0	20	
CADMIUM	3.07	0.2	3		102	80-120		3.18	3	20	
COPPER	102	2	100		102	80-120		102	0	20	
LEAD	5.12	0.2	5		102	80-120		5.15	1	20	
THORIUM	0.913	0.02	1		91	80-120		0.909	0	20	
ZINC	190	10	200		95	80-120		189	1	20	

MB Sample ID: **IP210923-6** Units: **MG/KG** Analysis Date: **9/24/2021 19:55**
Client ID: Run ID: **IM210924-11A4** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	Qual
ARSENIC	ND	0.2	
CADMIUM	ND	0.2	
COPPER	ND	2	
LEAD	ND	0.2	
THORIUM	ND	0.02	
ZINC	ND	10	

The following samples were analyzed in this batch:

2108329-1	2108329-2	2108329-3
2108329-4	2108329-5	2108329-6
2108329-7	2108329-8	2108329-9
2108329-10	2108329-11	2108329-12
2108329-13	2108329-14	

Client: Tetra Tech, Inc.
Work Order: 2108329
Project: 2021 Bluff B Subsurface Sampling

QC BATCH REPORT

Batch ID: **IP210923-9-1** Instrument ID: **ICPMS2** Method: **SW6020**

LCS Sample ID: **IM210923-9** Units: **MG/KG** Analysis Date: **9/24/2021 21:51**
Client ID: Run ID: **IM210924-11A4** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.6	0.2	10		96	80-120				20	
CADMIUM	3.04	0.2	3		101	80-120				20	
COPPER	98.5	2	100		99	80-120				20	
LEAD	5.02	0.2	5		100	80-120				20	
THORIUM	0.878	0.02	1		88	80-120				20	
ZINC	179	10	200		89	80-120				20	

LCSD Sample ID: **IM210923-9** Units: **MG/KG** Analysis Date: **9/24/2021 21:57**
Client ID: Run ID: **IM210924-11A4** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	RPD Ref Value	RPD	RPD Limit	Qual
ARSENIC	9.55	0.2	10		96	80-120		9.6	0	20	
CADMIUM	2.95	0.2	3		98	80-120		3.04	3	20	
COPPER	97	2	100		97	80-120		98.5	2	20	
LEAD	4.92	0.2	5		98	80-120		5.02	2	20	
THORIUM	0.9	0.02	1		90	80-120		0.878	2	20	
ZINC	179	10	200		89	80-120		179	0	20	

MB Sample ID: **IP210923-9** Units: **MG/KG** Analysis Date: **9/24/2021 21:48**
Client ID: Run ID: **IM210924-11A4** Prep Date: **9/23/2021** DF: **10**

Analyte	Result	ReportLimit	Qual
ARSENIC	ND	0.2	
CADMIUM	ND	0.2	
COPPER	ND	2	
LEAD	ND	0.2	
THORIUM	ND	0.02	
ZINC	ND	10	

The following samples were analyzed in this batch:

2108329-15	2108329-16	2108329-17
2108329-18	2108329-19	2108329-20
2108329-21	2108329-22	2108329-23
2108329-24	2108329-25	2108329-26
2108329-27	2108329-28	2108329-29
2108329-30	2108329-31	2108329-32
2108329-33	2108329-34	

APPENDIX D
SOIL DATA VALIDATION

D-1 OPPORTUNISTIC SAMPLES CHECKLIST AND REPORT

DATA VALIDATION CHECKLIST – STAGE 2A

Site Name	Riley Pass		**Project No.**	103IG7661
Data Reviewer (signature and date)	Aaron J. Smith 10/11/2021		**Technical Reviewer (signature and date)**	Jessica A. Vickers 11/22/2021
Laboratory Report No.	2108183		**Laboratory**	ALS Environmental – Fort Collins, CO
Analyses	Gamma emitting radionuclides by modified EPA Method 901.1 and metals by SW-846 Method 6020B			
Samples and Matrix	Nine soil samples, including one field duplicate			
Field Duplicate Pairs	OPP-6-080421/OPP-DUP-080421			
Field Blanks	None			

INTRODUCTION

This checklist summarizes the Stage 2A validation performed on the subject laboratory report, in accordance with the U.S. Environmental Protection Agency (EPA) *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (January 2009). Analytical data were evaluated in general accordance with the EPA *National Functional Guidelines (NFGs) for Inorganic Superfund Methods Data Review* (January 2020) and the Multi-Agency Radiological Laboratory Analytical Protocols Manual (July 2004).

OVERALL EVALUATION

No rejection of the data was required for this data package. The results may be used as qualified based on the findings of this validation effort.

Data completeness:

Within Criteria	Exceedance/Notes
Y	

Sample preservation, receipt, and holding times:

Within Criteria	Exceedance/Notes
Y	

DATA VALIDATION CHECKLIST – STAGE 2A

Method blanks:

Within Criteria	Exceedance/Notes
Y	

Field blanks:

Within Criteria	Exceedance/Notes
NA	

System monitoring compounds (surrogates and labeled compounds):

Within Criteria	Exceedance/Notes
NA	

MS/MSDs:

Within Criteria	Exceedance/Notes
NA	

Laboratory duplicates:

Within Criteria	Exceedance/Notes
Y	

Field duplicates:

Within Criteria	Exceedance/Notes
Y	

LCSs/LCSDs:

Within Criteria	Exceedance/Notes
N	Radionuclide results for all samples were qualified "G" by the laboratory to indicate a density more than 15% different in the sample than the LCS. As a result, all radionuclide results were qualified as estimated (flagged J/UJ).

Sample dilutions:

Within Criteria	Exceedance/Notes
Y	According to laboratory practice, all samples analyzed for metals by method SW-846 6020B were analyzed at a 10-fold dilution. Method detection limits (MDLs) and reporting limits (RLs) were adjusted accordingly.

Re-extraction and reanalysis:

Within Criteria	Exceedance/Notes
NA	

MDLs/RLs:

Within Criteria	Exceedance/Notes
N	Radionuclides: Results are reported according to activity counts for radionuclides. The radionuclide results are reported compared to their minimum detectable concentration (MDC). If the activity concentration in a sample is equal to or greater than the MDC, then there is a 95% chance that radioactive material in the sample will be detected. Radionuclides detected at concentrations below the MDC were reported as not detected (flagged U) by the laboratory and were raised to the value of the MDC by the data reviewer. The sample-specific MDCs for the radionuclide samples are provided in the attached analytical data table in the RL column. Radionuclides: The requested MDCs for Ra-226 in all samples except OPP-5-080421 were not met, but the reported activity was greater than the reported MDC. No qualifications were applied. Radionuclides: The laboratory reported the Ac-228 result for sample OPP-6-080421 with an "NQ" qualifier, indicating that the software performed a net quantification (done when no peaks are found in the peak search routine). Because this indicates that nuclides are not detected or supported above the reported MDC, the referenced result was qualified as an estimated non-detect (flagged UJ) at the reported value.

MDLs/RLs (cont'd):

Within Criteria	Exceedance/Notes
N	Metals: Analytes detected at concentrations above the MDL but below the RL were qualified as estimated (flagged J) by the laboratory. Analytes detected at concentrations below the MDL were reported as not-detected (flagged U) by the laboratory and were raised to the value of the RL by the data reviewer. MDLs and RLs are provided in the attached analytical data table.

Tentatively identified compounds:

Within Criteria	Exceedance/Notes
N	The results for Ac-228 in samples OPP-1-080421, OPP-2-080421, OPP-4-080421, OPP-5-080421, OPP-7-080421, and OPP-8-080421 were considered tentatively identified (flagged TI) by the laboratory and were qualified as estimated (flagged J) during this validation effort.

Other [Specify]:

Within Criteria	Exceedance/Notes
NA	

Overall Qualifications:

See results summary pages attached for changes to the laboratory qualifiers based upon this validation. The following is a list of qualifiers and definitions that may be used for the validation of this data package:

J	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased high.
J-	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased low.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated value is the approximate concentration of the analyte in the sample.
R	The sample result is rejected as unusable due to serious deficiencies in one or more quality control criteria. The analyte may or may not be present in the sample.
U	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit).
UJ	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit), which is considered approximate due to deficiencies in one or more quality control criteria.

RILEY PASS SOIL ANALYTICAL RESULTS SUMMARY
ALS FORT COLLINS REPORT NO. 2108183

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
OPP-1-080421	713R15	Ac-228	1.07	G,TI		0.92	pCi/g	1.07	J
OPP-1-080421	713R15	K-40	19.2	G		4.2	pCi/g	19.2	J
OPP-1-080421	713R15	Ra-226	1.7	M3,G		0.59	pCi/g	1.7	J
OPP-1-080421	SW6020	ARSENIC	37		0.049	0.2	MG/KG	37	
OPP-1-080421	SW6020	THORIUM	4.6		0.008	0.02	MG/KG	4.6	
OPP-2-080421	713R15	Ac-228	0.86	G,TI		0.79	pCi/g	0.86	J
OPP-2-080421	713R15	K-40	15.4	G		3.2	pCi/g	15.4	J
OPP-2-080421	713R15	Ra-226	3.8	M3,G		0.55	pCi/g	3.8	J
OPP-2-080421	SW6020	ARSENIC	16		0.047	0.19	MG/KG	16	
OPP-2-080421	SW6020	THORIUM	3.6		0.0077	0.019	MG/KG	3.6	
OPP-3-080421	713R15	Ac-228	0.93	G		0.87	pCi/g	0.93	J
OPP-3-080421	713R15	K-40	12.3	G		2.9	pCi/g	12.3	J
OPP-3-080421	713R15	Ra-226	2.52	M3,G		0.53	pCi/g	2.52	J
OPP-3-080421	SW6020	ARSENIC	44		0.049	0.2	MG/KG	44	
OPP-3-080421	SW6020	THORIUM	4.7		0.008	0.02	MG/KG	4.7	
OPP-4-080421	713R15	Ac-228	0.94	G,TI		0.8	pCi/g	0.94	J
OPP-4-080421	713R15	K-40	12.5	G		2.3	pCi/g	12.5	J
OPP-4-080421	713R15	Ra-226	5.5	M3,G		0.51	pCi/g	5.5	J
OPP-4-080421	SW6020	ARSENIC	39		0.05	0.2	MG/KG	39	
OPP-4-080421	SW6020	THORIUM	3.4		0.0082	0.02	MG/KG	3.4	
OPP-5-080421	713R15	Ac-228	0.82	G,TI		0.78	pCi/g	0.82	J
OPP-5-080421	713R15	K-40	16.3	G		2.4	pCi/g	16.3	J
OPP-5-080421	713R15	Ra-226	7.08	G		0.47	pCi/g	7.08	J
OPP-5-080421	SW6020	ARSENIC	39		0.052	0.21	MG/KG	39	
OPP-5-080421	SW6020	THORIUM	3.3		0.0085	0.021	MG/KG	3.3	
OPP-6-080421	713R15	Ac-228	1.04	G,NQ		0.95	pCi/g	1.04	UJ
OPP-6-080421	713R15	K-40	7.5	G		3.2	pCi/g	7.5	J
OPP-6-080421	713R15	Ra-226	4.5	M3,G		0.6	pCi/g	4.5	J
OPP-6-080421	SW6020	ARSENIC	25		0.047	0.19	MG/KG	25	
OPP-6-080421	SW6020	THORIUM	2.9		0.0077	0.019	MG/KG	2.9	
OPP-7-080421	713R15	Ac-228	0.79	G,TI		0.77	pCi/g	0.79	J
OPP-7-080421	713R15	K-40	13	G		2.4	pCi/g	13	J
OPP-7-080421	713R15	Ra-226	3.07	M3,G		0.53	pCi/g	3.07	J
OPP-7-080421	SW6020	ARSENIC	18		0.052	0.21	MG/KG	18	
OPP-7-080421	SW6020	THORIUM	2.8		0.0084	0.021	MG/KG	2.8	
OPP-8-080421	713R15	Ac-228	0.86	G,TI		0.7	pCi/g	0.86	J
OPP-8-080421	713R15	K-40	11.5	G		2.7	pCi/g	11.5	J
OPP-8-080421	713R15	Ra-226	3.12	M3,G		0.51	pCi/g	3.12	J
OPP-8-080421	SW6020	ARSENIC	22		0.049	0.2	MG/KG	22	
OPP-8-080421	SW6020	THORIUM	2.6		0.0079	0.02	MG/KG	2.6	
OPP-DUP-080421	713R15	Ac-228	0.76	U,G		0.95	pCi/g	0.95	UJ
OPP-DUP-080421	713R15	K-40	9.2	G		3.8	pCi/g	9.2	J
OPP-DUP-080421	713R15	Ra-226	4.39	M3,G		0.62	pCi/g	4.39	J
OPP-DUP-080421	SW6020	ARSENIC	25		0.05	0.21	MG/KG	25	
OPP-DUP-080421	SW6020	THORIUM	2.9		0.0082	0.021	MG/KG	2.9	

OPP-6-080421/OPP-DUP-080421

	Ac-228	K-40	Ra-226
Sample	1.04	7.5	4.5
Duplicate	0.76	9.2	4.39
STPU	0.66	2.8	0.67
DTPU	0.47	3.2	0.65
DER	0.691147373	0.799612738	0.23567521

	Sample	Duplicate	RPD
Arsenic	25	25	0
Thorium	2.9	2.9	0

D-2 CORRELATION SAMPLES CHECKLIST AND REPORT

DATA VALIDATION CHECKLIST – STAGE 2A

Site Name	Riley Pass		**Project No.**	103IG7661
Data Reviewer (signature and date)	Aaron J. Smith 11/18/2021		**Technical Reviewer (signature and date)**	Jessica A. Vickers 11/22/2021
Laboratory Report No.	2108184		**Laboratory**	ALS Environmental – Fort Collins, CO

Analyses	Gamma emitting radionuclides by modified EPA Method 901.1, isotopic thorium and uranium by ASTM method D3972, and metals by SW-846 Method 6020B
Samples and Matrix	Sixteen soil samples, including one field duplicate
Field Duplicate Pairs	CORR01-080521/CORR-(DUP1)-080521
Field Blanks	None

INTRODUCTION

This checklist summarizes the Stage 2A validation performed on the subject laboratory report, in accordance with the U.S. Environmental Protection Agency (EPA) *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (January 2009). Analytical data were evaluated in general accordance with the EPA *National Functional Guidelines (NFGs) for Inorganic Superfund Methods Data Review* (January 2020) and the Multi-Agency Radiological Laboratory Analytical Protocols Manual (July 2004).

OVERALL EVALUATION

No rejection of the data was required for this data package. The results may be used as qualified based on the findings of this validation effort.

Data completeness:

Within Criteria	Exceedance/Notes
Y	

Sample preservation, receipt, and holding times:

Within Criteria	Exceedance/Notes
Y	

Method blanks:

Within Criteria	Exceedance/Notes
Y	

Field blanks:

Within Criteria	Exceedance/Notes
NA	

System monitoring compounds (surrogates and labeled compounds):

Within Criteria	Exceedance/Notes
N	Isotopes: The tracer recoveries were below the acceptance limit for the isotopic thorium analyses for samples CORR09-080521, CORR12-080521, and CORR15-080521; therefore, the associated Th-228, Th-230, and Th-232 results were qualified as estimated (flagged J).

MS/MSDs:

Within Criteria	Exceedance/Notes
NA	

Laboratory duplicates:

Within Criteria	Exceedance/Notes
Y	

Field duplicates:

Within Criteria	Exceedance/Notes
NA	

LCSs/LCSDs:

Within Criteria	Exceedance/Notes
N	Ac-228, K-40, and Ra-226 results for all samples except CORR03-080521, CORR06-080521, and CORR13-080521 were qualified "G" by the laboratory to indicate a density more than 15% different in the sample than the LCS. As a result, detected results for these results were qualified as estimated (flagged J/UJ).

Sample dilutions:

Within Criteria	Exceedance/Notes
Y	According to laboratory practice, all samples analyzed for metals by method SW-846 6020B were analyzed at a 10-fold dilution. Method detection limits (MDLs) and reporting limits (RLs) were adjusted accordingly.

Re-extraction and reanalysis:

Within Criteria	Exceedance/Notes
NA	

MDLs/RLs:

Within Criteria	Exceedance/Notes
N	Radionuclides and Isotopes: Results are reported according to activity counts for radionuclides and isotopes. The radionuclide results are reported compared to their minimum detectable concentration (MDC). If the activity concentration in a sample is equal to or greater than the MDC, then there is a 95% chance that radioactive material in the sample will be detected. Radionuclides detected at concentrations below the MDC were reported as not detected (flagged U) by the laboratory and were raised to the value of the MDC by the data reviewer. The sample-specific MDCs for the radionuclide samples are provided in the attached analytical data table in the RL column. Radionuclides and Isotopes: The requested MDCs were not met, but the reported activity was greater than the reported MDCs for Ac-228 in samples CORR11-080521 and CORR14-080521; Ra-226 in samples CORR04-080521, CORR05-080521, CORR07-080521, CORR08-080521, CORR09-080521, CORR10-080521, CORR11-080521, CORR12-080521, and CORR14-080521; Th-228 and Th-230 in all samples; and Th-232 in samples CORR12-080521 and CORR15-080521. No qualifications were applied.

MDLs/RLs (cont'd):

Within Criteria	Exceedance/Notes
N	Radionuclides: The requested MDCs for Ac-228 in samples CORR05-080521, CORR07-080521, and CORR12-080521 were not met and the reported activity was less than the reported MDCs (flagged U). As a result, the not-detected Ac-228 results in these samples were qualified as estimated (flagged UJ). Metals: Analytes detected at concentrations above the MDL but below the RL were qualified as estimated (flagged J) by the laboratory. Analytes detected at concentrations below the MDL were reported as not-detected (flagged U) by the laboratory and were raised to the value of the RL by the data reviewer. MDLs and RLs are provided in the attached analytical data table.

Tentatively identified compounds:

Within Criteria	Exceedance/Notes
N	The results for Ac-228 in samples CORR-(DUP1)-080521, CORR03-080521, CORR08-080521, CORR09-080521, CORR10-080521, and CORR15-080521 were considered tentatively identified (flagged TI by laboratory) and were qualified as estimated (flagged J) during this validation effort.

Other [Specify]:

Within Criteria	Exceedance/Notes
NA	

Overall Qualifications:

See results summary pages attached for changes to the laboratory qualifiers based upon this validation. The following is a list of qualifiers and definitions that may be used for the validation of this data package:

J	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased high.
J-	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased low.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated value is the approximate concentration of the analyte in the sample.
R	The sample result is rejected as unusable due to serious deficiencies in one or more quality control criteria. The analyte may or may not be present in the sample.
U	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit).
UJ	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit), which is considered approximate due to deficiencies in one or more quality control criteria.

RILEY PASS SOIL ANALYTICAL RESULTS SUMMARY
ALS FORT COLLINS REPORT NO. 2108184

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
CORR-(DUP1)-080521	713R15	Ac-228	0.89	G,TI		0.67	pCi/g	0.89	J
CORR-(DUP1)-080521	713R15	K-40	18.3	G		1.9	pCi/g	18.3	J
CORR-(DUP1)-080521	713R15	Ra-226	1.14	G		0.43	pCi/g	1.14	J
CORR-(DUP1)-080521	714R15	Th-228	0.87	M3		0.14	pCi/g	0.87	
CORR-(DUP1)-080521	714R15	Th-230	0.93	M3		0.11	pCi/g	0.93	
CORR-(DUP1)-080521	714R15	Th-232	0.84			0.03	pCi/g	0.84	
CORR-(DUP1)-080521	714R15	U-234	0.73			0.05	pCi/g	0.73	
CORR-(DUP1)-080521	714R15	U-235	0.043			0.035	pCi/g	0.043	
CORR-(DUP1)-080521	714R15	U-238	0.74			0.03	pCi/g	0.74	
CORR-(DUP1)-080521	SW6020	ARSENIC	62		0.049	0.2	mg/kg	62	
CORR-(DUP1)-080521	SW6020	THORIUM	3.4		0.0081	0.02	mg/kg	3.4	
CORR-(DUP1)-080521	SW6020	URANIUM	0.8		0.0096	0.02	mg/kg	0.8	
CORR01-080521	713R15	Ac-228	0.75	U,G		0.92	pCi/g	0.92	UJ
CORR01-080521	713R15	K-40	14.1	G		3.6	pCi/g	14.1	J
CORR01-080521	713R15	Ra-226	1.57	G		0.48	pCi/g	1.57	J
CORR01-080521	714R15	Th-228	1.01	M3		0.13	pCi/g	1.01	
CORR01-080521	714R15	Th-230	1.07	M3		0.11	pCi/g	1.07	
CORR01-080521	714R15	Th-232	0.85			0.03	pCi/g	0.85	
CORR01-080521	714R15	U-234	0.67			0.04	pCi/g	0.67	
CORR01-080521	714R15	U-235	0.061			0.033	pCi/g	0.061	
CORR01-080521	714R15	U-238	0.77			0.05	pCi/g	0.77	
CORR01-080521	SW6020	ARSENIC	67		0.046	0.19	mg/kg	67	
CORR01-080521	SW6020	THORIUM	3.3		0.0075	0.019	mg/kg	3.3	
CORR01-080521	SW6020	URANIUM	0.87		0.009	0.019	mg/kg	0.87	
CORR02-080521	713R15	Ac-228	1.27	G		0.73	pCi/g	1.27	J
CORR02-080521	713R15	K-40	17.4	G		2.1	pCi/g	17.4	J
CORR02-080521	713R15	Ra-226	1.68	G		0.43	pCi/g	1.68	J
CORR02-080521	714R15	Th-228	1.02	M3		0.19	pCi/g	1.02	
CORR02-080521	714R15	Th-230	1.42	M3		0.16	pCi/g	1.42	
CORR02-080521	714R15	Th-232	1.03			0.09	pCi/g	1.03	
CORR02-080521	714R15	U-234	1.02			0.01	pCi/g	1.02	
CORR02-080521	714R15	U-235	0.05			0.014	pCi/g	0.05	
CORR02-080521	714R15	U-238	1.19			0.03	pCi/g	1.19	
CORR02-080521	SW6020	ARSENIC	63		0.048	0.2	mg/kg	63	
CORR02-080521	SW6020	THORIUM	4.9		0.0079	0.02	mg/kg	4.9	
CORR02-080521	SW6020	URANIUM	1.7		0.0094	0.02	mg/kg	1.7	
CORR03-080521	713R15	Ac-228	1.2	TI		0.78	pCi/g	1.2	J
CORR03-080521	713R15	K-40	11.8			2.6	pCi/g	11.8	
CORR03-080521	713R15	Ra-226	4.7			0.43	pCi/g	4.7	
CORR03-080521	714R15	Th-228	1.08	M3		0.16	pCi/g	1.08	
CORR03-080521	714R15	Th-230	2.76	M3		0.12	pCi/g	2.76	
CORR03-080521	714R15	Th-232	1.08			0.05	pCi/g	1.08	
CORR03-080521	714R15	U-234	3.11			0.05	pCi/g	3.11	
CORR03-080521	714R15	U-235	0.156			0.014	pCi/g	0.156	
CORR03-080521	714R15	U-238	2.75			0.04	pCi/g	2.75	
CORR03-080521	SW6020	ARSENIC	22		0.05	0.21	mg/kg	22	

RILEY PASS SOIL ANALYTICAL RESULTS SUMMARY
ALS FORT COLLINS REPORT NO. 2108184

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
CORR03-080521	SW6020	THORIUM	6		0.0082	0.021	mg/kg	6	
CORR03-080521	SW6020	URANIUM	7.5		0.0098	0.021	mg/kg	7.5	
CORR04-080521	713R15	Ac-228	1.13	G		0.96	pCi/g	1.13	J
CORR04-080521	713R15	K-40	13	G		3.1	pCi/g	13	J
CORR04-080521	713R15	Ra-226	21.9	M3,G		0.6	pCi/g	21.9	J
CORR04-080521	714R15	Th-228	1.23	M3		0.17	pCi/g	1.23	
CORR04-080521	714R15	Th-230	21.7	M3		0.1	pCi/g	21.7	
CORR04-080521	714R15	Th-232	1.02			0.03	pCi/g	1.02	
CORR04-080521	714R15	U-234	21.2			0	pCi/g	21.2	
CORR04-080521	714R15	U-235	0.8			0.04	pCi/g	0.8	
CORR04-080521	714R15	U-238	19.8			0.1	pCi/g	19.8	
CORR04-080521	SW6020	ARSENIC	120		0.049	0.2	mg/kg	120	
CORR04-080521	SW6020	THORIUM	5.9		0.0081	0.02	mg/kg	5.9	
CORR04-080521	SW6020	URANIUM	49		0.0096	0.02	mg/kg	49	
CORR05-080521	713R15	Ac-228	1.18	U,M,G		1.18	pCi/g	1.18	UJ
CORR05-080521	713R15	K-40	14.3	G		4.2	pCi/g	14.3	J
CORR05-080521	713R15	Ra-226	27.7	M3,G		0.8	pCi/g	27.7	J
CORR05-080521	714R15	Th-228	1.09	M3		0.2	pCi/g	1.09	
CORR05-080521	714R15	Th-230	17.2	M3		0.1	pCi/g	17.2	
CORR05-080521	714R15	Th-232	1.05			0.06	pCi/g	1.05	
CORR05-080521	714R15	U-234	15			0.1	pCi/g	15	
CORR05-080521	714R15	U-235	0.7			0.01	pCi/g	0.7	
CORR05-080521	714R15	U-238	14.8			0	pCi/g	14.8	
CORR05-080521	SW6020	ARSENIC	140		0.049	0.2	mg/kg	140	
CORR05-080521	SW6020	THORIUM	5.5		0.0081	0.02	mg/kg	5.5	
CORR05-080521	SW6020	URANIUM	47		0.0096	0.02	mg/kg	47	
CORR06-080521	713R15	Ac-228	0.53	U		0.64	pCi/g	0.64	U
CORR06-080521	713R15	K-40	13.1			1.6	pCi/g	13.1	
CORR06-080521	713R15	Ra-226	11.6			0.3	pCi/g	11.6	
CORR06-080521	714R15	Th-228	0.79	M3		0.15	pCi/g	0.79	
CORR06-080521	714R15	Th-230	9	M3		0.1	pCi/g	9	
CORR06-080521	714R15	Th-232	0.87			0.01	pCi/g	0.87	
CORR06-080521	714R15	U-234	8.6			0	pCi/g	8.6	
CORR06-080521	714R15	U-235	0.35			0.04	pCi/g	0.35	
CORR06-080521	714R15	U-238	7.9			0	pCi/g	7.9	
CORR06-080521	SW6020	ARSENIC	71		0.049	0.2	mg/kg	71	
CORR06-080521	SW6020	THORIUM	4.3		0.008	0.02	mg/kg	4.3	
CORR06-080521	SW6020	URANIUM	23		0.0095	0.02	mg/kg	23	
CORR07-080521	713R15	Ac-228	1.15	U,M,G		1.27	pCi/g	1.27	UJ
CORR07-080521	713R15	K-40	15.7	G		3.7	pCi/g	15.7	J
CORR07-080521	713R15	Ra-226	23.1	M3,G		0.9	pCi/g	23.1	J
CORR07-080521	714R15	Th-228	1.11	M3		0.12	pCi/g	1.11	
CORR07-080521	714R15	Th-230	20	M3		0.1	pCi/g	20	
CORR07-080521	714R15	Th-232	0.95			0.01	pCi/g	0.95	
CORR07-080521	714R15	U-234	19.1			0.1	pCi/g	19.1	
CORR07-080521	714R15	U-235	0.9			0.02	pCi/g	0.9	

RILEY PASS SOIL ANALYTICAL RESULTS SUMMARY
ALS FORT COLLINS REPORT NO. 2108184

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
CORR07-080521	714R15	U-238	19			0	pCi/g	19	
CORR07-080521	SW6020	ARSENIC	130		0.047	0.19	mg/kg	130	
CORR07-080521	SW6020	THORIUM	4.9		0.0077	0.019	mg/kg	4.9	
CORR07-080521	SW6020	URANIUM	71		0.0092	0.019	mg/kg	71	
CORR08-080521	713R15	Ac-228	1.06	G,TI		0.84	pCi/g	1.06	J
CORR08-080521	713R15	K-40	14.7	G		2.2	pCi/g	14.7	J
CORR08-080521	713R15	Ra-226	10.5	M3,G		0.7	pCi/g	10.5	J
CORR08-080521	714R15	Th-228	1.11	M3		0.17	pCi/g	1.11	
CORR08-080521	714R15	Th-230	8.6	M3		0.1	pCi/g	8.6	
CORR08-080521	714R15	Th-232	1.07			0.05	pCi/g	1.07	
CORR08-080521	714R15	U-234	9.1			0.1	pCi/g	9.1	
CORR08-080521	714R15	U-235	0.52			0.05	pCi/g	0.52	
CORR08-080521	714R15	U-238	8.7			0	pCi/g	8.7	
CORR08-080521	SW6020	ARSENIC	160		0.05	0.2	mg/kg	160	
CORR08-080521	SW6020	THORIUM	6		0.0081	0.02	mg/kg	6	
CORR08-080521	SW6020	URANIUM	26		0.0096	0.02	mg/kg	26	
CORR09-080521	713R15	Ac-228	1.26	G,TI		0.85	pCi/g	1.26	J
CORR09-080521	713R15	K-40	11	G		3.1	pCi/g	11	J
CORR09-080521	713R15	Ra-226	11.9	M3,G		0.6	pCi/g	11.9	J
CORR09-080521	714R15	Th-228	1.19	Y2,M3		0.32	pCi/g	1.19	J
CORR09-080521	714R15	Th-230	8.3	Y2,M3		0.2	pCi/g	8.3	J
CORR09-080521	714R15	Th-232	1.02	Y2		0.1	pCi/g	1.02	J
CORR09-080521	714R15	U-234	9			0	pCi/g	9	
CORR09-080521	714R15	U-235	0.37			0.04	pCi/g	0.37	
CORR09-080521	714R15	U-238	9.3			0	pCi/g	9.3	
CORR09-080521	SW6020	ARSENIC	110		0.047	0.19	mg/kg	110	
CORR09-080521	SW6020	THORIUM	6.1		0.0077	0.019	mg/kg	6.1	
CORR09-080521	SW6020	URANIUM	25		0.0092	0.019	mg/kg	25	
CORR10-080521	713R15	Ac-228	0.97	G,TI		0.88	pCi/g	0.97	J
CORR10-080521	713R15	K-40	14.6	G		4.1	pCi/g	14.6	J
CORR10-080521	713R15	Ra-226	12.7	M3,G		0.7	pCi/g	12.7	J
CORR10-080521	714R15	Th-228	1.64	M3		0.16	pCi/g	1.64	
CORR10-080521	714R15	Th-230	12.8	M3		0.1	pCi/g	12.8	
CORR10-080521	714R15	Th-232	1.21			0.05	pCi/g	1.21	
CORR10-080521	714R15	U-234	12.8			0.1	pCi/g	12.8	
CORR10-080521	714R15	U-235	0.63			0.01	pCi/g	0.63	
CORR10-080521	714R15	U-238	13			0	pCi/g	13	
CORR10-080521	SW6020	ARSENIC	180		0.05	0.2	mg/kg	180	
CORR10-080521	SW6020	THORIUM	6.8		0.0082	0.02	mg/kg	6.8	
CORR10-080521	SW6020	URANIUM	33		0.0097	0.02	mg/kg	33	
CORR11-080521	713R15	Ac-228	1.53	M3,G		1	pCi/g	1.53	J
CORR11-080521	713R15	K-40	17.5	G		3.2	pCi/g	17.5	J
CORR11-080521	713R15	Ra-226	18.4	M3,G		0.6	pCi/g	18.4	J
CORR11-080521	714R15	Th-228	1.81	M3		0.12	pCi/g	1.81	
CORR11-080521	714R15	Th-230	12.8	M3		0.1	pCi/g	12.8	
CORR11-080521	714R15	Th-232	1.44			0.06	pCi/g	1.44	

RILEY PASS SOIL ANALYTICAL RESULTS SUMMARY
ALS FORT COLLINS REPORT NO. 2108184

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
CORR11-080521	714R15	U-234	12.2			0	pCi/g	12.2	
CORR11-080521	714R15	U-235	0.68			0.05	pCi/g	0.68	
CORR11-080521	714R15	U-238	12.8			0	pCi/g	12.8	
CORR11-080521	SW6020	ARSENIC	150		0.052	0.21	mg/kg	150	
CORR11-080521	SW6020	THORIUM	8.7		0.0085	0.021	mg/kg	8.7	
CORR11-080521	SW6020	URANIUM	32		0.01	0.021	mg/kg	32	
CORR12-080521	713R15	Ac-228	1.3	U,M,G		2.1	pCi/g	2.1	UJ
CORR12-080521	713R15	K-40	11.4	G		7.7	pCi/g	11.4	J
CORR12-080521	713R15	Ra-226	93	M3,G		2	pCi/g	93	J
CORR12-080521	714R15	Th-228	2.01	Y2,M3		0.35	pCi/g	2.01	J
CORR12-080521	714R15	Th-230	112	Y2,M3		0	pCi/g	112	J
CORR12-080521	714R15	Th-232	1.65	Y2,M3		0.1	pCi/g	1.65	J
CORR12-080521	714R15	U-234	97			0	pCi/g	97	
CORR12-080521	714R15	U-235	4.46			0.05	pCi/g	4.46	
CORR12-080521	714R15	U-238	97			0	pCi/g	97	
CORR12-080521	SW6020	ARSENIC	540		0.047	0.19	mg/kg	540	
CORR12-080521	SW6020	THORIUM	7.2		0.0076	0.019	mg/kg	7.2	
CORR12-080521	SW6020	URANIUM	220		0.009	0.019	mg/kg	220	
CORR13-080521	713R15	Ac-228	0.72			0.71	pCi/g	0.72	
CORR13-080521	713R15	K-40	11.1			2.2	pCi/g	11.1	
CORR13-080521	713R15	Ra-226	30			0.4	pCi/g	30	
CORR13-080521	714R15	Th-228	0.75	M3		0.24	pCi/g	0.75	
CORR13-080521	714R15	Th-230	20.5	M3		0.2	pCi/g	20.5	
CORR13-080521	714R15	Th-232	0.75			0.02	pCi/g	0.75	
CORR13-080521	714R15	U-234	26.2			0	pCi/g	26.2	
CORR13-080521	714R15	U-235	1.36			0.05	pCi/g	1.36	
CORR13-080521	714R15	U-238	26.2			0.1	pCi/g	26.2	
CORR13-080521	SW6020	ARSENIC	72		0.048	0.2	mg/kg	72	
CORR13-080521	SW6020	THORIUM	4.3		0.0078	0.02	mg/kg	4.3	
CORR13-080521	SW6020	URANIUM	72		0.0093	0.02	mg/kg	72	
CORR14-080521	713R15	Ac-228	1.39	M3,G		1.06	pCi/g	1.39	J
CORR14-080521	713R15	K-40	12.2	G		4.1	pCi/g	12.2	J
CORR14-080521	713R15	Ra-226	10.1	M3,G		0.7	pCi/g	10.1	J
CORR14-080521	714R15	Th-228	1.51	M3		0.22	pCi/g	1.51	
CORR14-080521	714R15	Th-230	8.6	M3		0.2	pCi/g	8.6	
CORR14-080521	714R15	Th-232	1.14			0.02	pCi/g	1.14	
CORR14-080521	714R15	U-234	7.2			0	pCi/g	7.2	
CORR14-080521	714R15	U-235	0.303			0.049	pCi/g	0.303	
CORR14-080521	714R15	U-238	7.3			0.1	pCi/g	7.3	
CORR14-080521	SW6020	ARSENIC	310		0.047	0.19	mg/kg	310	
CORR14-080521	SW6020	THORIUM	7.1		0.0078	0.019	mg/kg	7.1	
CORR14-080521	SW6020	URANIUM	21		0.0092	0.019	mg/kg	21	
CORR15-080521	713R15	Ac-228	1.59	G,TI		0.72	pCi/g	1.59	J
CORR15-080521	713R15	K-40	13.2	G		2.3	pCi/g	13.2	J
CORR15-080521	713R15	Ra-226	2.9	G		0.43	pCi/g	2.9	J
CORR15-080521	714R15	Th-228	1.28	Y2,M3		0.37	pCi/g	1.28	J

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
CORR15-080521	714R15	Th-230	2.09	Y2,M3		0.19	pCi/g	2.09	J
CORR15-080521	714R15	Th-232	1.13	Y2,M3		0.11	pCi/g	1.13	J
CORR15-080521	714R15	U-234	1.88			0.04	pCi/g	1.88	
CORR15-080521	714R15	U-235	0.053			0.043	pCi/g	0.053	
CORR15-080521	714R15	U-238	1.71			0.05	pCi/g	1.71	
CORR15-080521	SW6020	ARSENIC	40		0.046	0.19	mg/kg	40	
CORR15-080521	SW6020	THORIUM	6.2		0.0075	0.019	mg/kg	6.2	
CORR15-080521	SW6020	URANIUM	3.3		0.0089	0.019	mg/kg	3.3	

CORR01-080521/CORR-(DUP1)-080521

	Ac-228	K-40	Ra-226
Sample	0.75	14.1	1.57
Duplicate	0.89	18.3	1.14
STPU	0.41	3.7	0.35
DTPU	0.4	3.3	0.26
DER	0.488826696	1.694292338	1.972456312

	Th-228	Th-230	Th-232
Sample	1.01	1.07	0.85
Duplicate	0.87	0.93	0.84
STPU	0.22	0.23	0.18
DTPU	0.2	0.2	0.18
DER	0.941741912	0.918650201	0.07856742

	U-234	U-235	U-238
Sample	0.67	0.061	0.77
Duplicate	0.73	0.043	0.74
STPU	0.15	0.038	0.17
DTPU	0.17	0.033	0.17
DER	0.52929731	0.715294533	0.249567099

	Sample	Duplicate	RPD
Arsenic	67	62	7.751937984
Thorium	3.3	3.4	2.985074627
Uranium	0.87	0.8	8.383233533

D-3 SUBSURFACE SAMPLES CHECKLIST AND REPORT

DATA VALIDATION CHECKLIST – STAGE 2A

Site Name	Riley Pass		**Project No.**	103IG7661
Data Reviewer (signature and date)	11/22/2021		**Technical Reviewer (signature and date)**	11/23/2021
Laboratory Report No.	2108329		**Laboratory**	ALS Environmental – Fort Collins, CO
Analyses	Gamma emitting radionuclides by modified EPA Method 901.1 and metals by SW-846 Method 6020B			
Samples and Matrix	Thirty-seven soil samples, including two field duplicates			
Field Duplicate Pairs	TP03-(14'-15')-080321/TP-(DUP)-01-080321 and TP12-(SURF)-080421/TP-(DUP)-02-080421			
Field Blanks	None			

INTRODUCTION

This checklist summarizes the Stage 2A validation performed on the subject laboratory report, in accordance with the U.S. Environmental Protection Agency (EPA) *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (January 2009). Analytical data were evaluated in general accordance with the EPA *National Functional Guidelines (NFGs) for Inorganic Superfund Methods Data Review* (January 2020) and the Multi-Agency Radiological Laboratory Analytical Protocols Manual (July 2004).

OVERALL EVALUATION

No rejection of the data was required for this data package. The results may be used as qualified based on the findings of this validation effort.

Data completeness:

Within Criteria	Exceedance/Notes
Y	

Sample preservation, receipt, and holding times:

Within Criteria	Exceedance/Notes
Y	

DATA VALIDATION CHECKLIST – STAGE 2A

Method blanks:

Within Criteria	Exceedance/Notes
Y	

Field blanks:

Within Criteria	Exceedance/Notes
NA	

System monitoring compounds (surrogates and labeled compounds):

Within Criteria	Exceedance/Notes
NA	

MS/MSDs:

Within Criteria	Exceedance/Notes
NA	

Laboratory duplicates:

Within Criteria	Exceedance/Notes
Y	

Field duplicates:

Within Criteria	Exceedance/Notes
Y	

LCSs/LCSDs:

Within Criteria	Exceedance/Notes
N	Ac-228, K-40, and Ra-226 results for all samples except TP06-(11'-12')-080321, TP06-(17'-18')-080321, TP10-(SURF)-080421, TP11-(5'-6')-080421, TP14-(SURF)-080421, and TP15-(SURF)-080421 were qualified "G" by the laboratory to indicate a density more than 15% different in the sample than the LCS. As a result, the associated results were qualified as estimated (flagged J/UJ).

Sample dilutions:

Within Criteria	Exceedance/Notes
Y	According to laboratory practice, all samples analyzed for metals by method SW-846 6020B were analyzed at a 10-fold dilution. Method detection limits (MDLs) and reporting limits (RLs) were adjusted accordingly.

Re-extraction and reanalysis:

Within Criteria	Exceedance/Notes
NA	

MDLs/RLs:

Within Criteria	Exceedance/Notes
N	Radionuclides: Results are reported according to activity counts for radionuclides. The radionuclide results are reported compared to their minimum detectable concentration (MDC). If the activity concentration in a sample is equal to or greater than the MDC, then there is a 95% chance that radioactive material in the sample will be detected. Radionuclides detected at concentrations below the MDC were reported as not detected (flagged U) by the laboratory and were raised to the value of the MDC by the data reviewer. The sample-specific MDCs for the radionuclide samples are provided in the attached analytical data table in the RL column.

MDLs/RLs (cont'd):

Within Criteria	Exceedance/Notes
N	Radionuclides: The requested MDCs for Ac-228 in samples TP01-(5'-6')-080321, TP03-(SURF)-080321, TP08-(9'-10')-080321, TP11-(SURF)-080421, and TP-(DUP)-02-080421; and for Ra-226 in samples TP01-(5'-6')-080321, TP01-SURF-080321, TP02-(3'-4')-080321, TP02-SURF-080321, TP03-(5'-6')-080321, TP03-(SURF)-080321, TP04-(5'-6')-080321, TP05-(18'-19')-080321, TP05-(SURF)-080321, TP06-(SURF)-080321, TP07-(SURF)-080321, TP08-(9'-10')-080321, TP09-(6'-7')-080321, TP10-(15'-16')-080421, TP11-(SURF)-080421, TP12-(SURF)-080421, TP-(DUP)-02-080421, and TP15-(8'-9')-080421 were not met, but the reported activity was greater than the reported MDCs. No qualifications were applied. Radionuclides: The requested MDCs for Ac-228 in samples TP01-SURF-080321, TP02-(3'-4')-080321, TP02-SURF-080321, TP03-(5'-6')-080321, TP04-(5'-6')-080321, TP05-(SURF)-080321, TP10-(15'-16')-080421, and TP12-(SURF)-080421 were not met and the reported activity was less than the reported MDCs (flagged U). As a result, the not-detected Ac-228 results in these samples were qualified as estimated (flagged UJ). Metals: Analytes detected at concentrations above the MDL but below the RL were qualified as estimated (flagged J) by the laboratory. Analytes detected at concentrations below the MDL were reported as not detected (flagged U) by the laboratory and were raised to the value of the RL by the data reviewer. MDLs and RLs are provided in the attached analytical data table.

Tentatively identified compounds:

Within Criteria	Exceedance/Notes
N	The results for Ac-228 in samples TP01-(5'-6')-080321, TP03-(14'-15')-080321, TP03-(SURF)-080321, TP06-(11'-12')-080321, TP09-(6'-7')-080321, TP11-(5'-6')-080421, TP11-(SURF)-080421, TP13-(6'-7')-080421, TP14-(SURF)-080421, and TP15-(3'-4')-080421 were considered tentatively identified and were qualified as estimated (flagged J) during this validation effort.

Other [Specify]:

Within Criteria	Exceedance/Notes
NA	

Overall Qualifications:

See results summary pages attached for changes to the laboratory qualifiers based upon this validation. The following is a list of qualifiers and definitions that may be used for the validation of this data package:

J	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased high.
J-	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased low.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated value is the approximate concentration of the analyte in the sample.
R	The sample result is rejected as unusable due to serious deficiencies in one or more quality control criteria. The analyte may or may not be present in the sample.
U	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit).
UJ	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit), which is considered approximate due to deficiencies in one or more quality control criteria.

RILEY PASS SOIL ANALYTICAL RESULTS SUMMARY
ALS FORT COLLINS REPORT NO. 2108329

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP01-SURF-080321	713R15	Ac-228	1.9	U,M,G		2.3	pCi/g	2.3	UJ
TP01-SURF-080321	713R15	K-40	16.2	G		6.7	pCi/g	16.2	J
TP01-SURF-080321	713R15	Ra-226	131	M3,G		1	pCi/g	131	J
TP01-SURF-080321	SW6020	ARSENIC	790		0.049	0.2	mg/kg	790	
TP01-SURF-080321	SW6020	CADMIUM	0.88		0.022	0.2	mg/kg	0.88	
TP01-SURF-080321	SW6020	COPPER	15		0.29	2	mg/kg	15	
TP01-SURF-080321	SW6020	LEAD	23		0.066	0.2	mg/kg	23	
TP01-SURF-080321	SW6020	THORIUM	8.3		0.008	0.02	mg/kg	8.3	
TP01-SURF-080321	SW6020	ZINC	72		4.1	10	mg/kg	72	
TP01-(5'-6')-080321	713R15	Ac-228	1.59	M3,G,TI		1.29	pCi/g	1.59	J
TP01-(5'-6')-080321	713R15	K-40	11.4	G		5.7	pCi/g	11.4	J
TP01-(5'-6')-080321	713R15	Ra-226	46.8	M3,G		1.1	pCi/g	46.8	J
TP01-(5'-6')-080321	SW6020	ARSENIC	1500		0.53	2.1	mg/kg	1500	
TP01-(5'-6')-080321	SW6020	CADMIUM	1.1		0.024	0.21	mg/kg	1.1	
TP01-(5'-6')-080321	SW6020	COPPER	21		0.31	2.1	mg/kg	21	
TP01-(5'-6')-080321	SW6020	LEAD	37		0.071	0.21	mg/kg	37	
TP01-(5'-6')-080321	SW6020	THORIUM	9.5		0.0086	0.021	mg/kg	9.5	
TP01-(5'-6')-080321	SW6020	ZINC	59		4.4	11	mg/kg	59	
TP01-(7.5'-8.0')-080321	713R15	Ac-228	1.31	G		0.68	pCi/g	1.31	J
TP01-(7.5'-8.0')-080321	713R15	K-40	7.6	G		2.2	pCi/g	7.6	J
TP01-(7.5'-8.0')-080321	713R15	Ra-226	3.7	G		0.47	pCi/g	3.7	J
TP01-(7.5'-8.0')-080321	SW6020	ARSENIC	71		0.056	0.23	mg/kg	71	
TP01-(7.5'-8.0')-080321	SW6020	CADMIUM	0.69		0.025	0.23	mg/kg	0.69	
TP01-(7.5'-8.0')-080321	SW6020	COPPER	13		0.33	2.3	mg/kg	13	
TP01-(7.5'-8.0')-080321	SW6020	LEAD	13		0.076	0.23	mg/kg	13	
TP01-(7.5'-8.0')-080321	SW6020	THORIUM	6.1		0.0092	0.023	mg/kg	6.1	
TP01-(7.5'-8.0')-080321	SW6020	ZINC	85		4.7	12	mg/kg	85	
TP02-(3'-4')-080321	713R15	Ac-228	1.4	U,M,G		2	pCi/g	2	UJ
TP02-(3'-4')-080321	713R15	K-40	15.9	G		5.6	pCi/g	15.9	J
TP02-(3'-4')-080321	713R15	Ra-226	141	M3,G		1	pCi/g	141	J
TP02-(3'-4')-080321	SW6020	ARSENIC	730		0.055	0.23	mg/kg	730	
TP02-(3'-4')-080321	SW6020	CADMIUM	0.71		0.025	0.23	mg/kg	0.71	
TP02-(3'-4')-080321	SW6020	COPPER	16		0.33	2.3	mg/kg	16	
TP02-(3'-4')-080321	SW6020	LEAD	23		0.074	0.23	mg/kg	23	
TP02-(3'-4')-080321	SW6020	THORIUM	8		0.009	0.023	mg/kg	8	
TP02-(3'-4')-080321	SW6020	ZINC	43		4.6	11	mg/kg	43	
TP02-SURF-080321	713R15	Ac-228	1.56	U,M,G		1.94	pCi/g	1.94	UJ
TP02-SURF-080321	713R15	K-40	16.4	G		7	pCi/g	16.4	J
TP02-SURF-080321	713R15	Ra-226	130	M3,G		1	pCi/g	130	J
TP02-SURF-080321	SW6020	ARSENIC	520		0.051	0.21	mg/kg	520	
TP02-SURF-080321	SW6020	CADMIUM	0.44		0.023	0.21	mg/kg	0.44	
TP02-SURF-080321	SW6020	COPPER	12		0.3	2.1	mg/kg	12	
TP02-SURF-080321	SW6020	LEAD	23		0.069	0.21	mg/kg	23	
TP02-SURF-080321	SW6020	THORIUM	6.3		0.0084	0.021	mg/kg	6.3	
TP02-SURF-080321	SW6020	ZINC	41		4.3	11	mg/kg	41	

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Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP02-(10'-11')-080321	713R15	Ac-228	1.08	G		0.74	pCi/g	1.08	J
TP02-(10'-11')-080321	713R15	K-40	15.9	G		1.8	pCi/g	15.9	J
TP02-(10'-11')-080321	713R15	Ra-226	16.2	G		0.4	pCi/g	16.2	J
TP02-(10'-11')-080321	SW6020	ARSENIC	140		0.055	0.22	mg/kg	140	
TP02-(10'-11')-080321	SW6020	CADMIUM	0.33		0.025	0.22	mg/kg	0.33	
TP02-(10'-11')-080321	SW6020	COPPER	8.9		0.32	2.2	mg/kg	8.9	
TP02-(10'-11')-080321	SW6020	LEAD	11		0.074	0.22	mg/kg	11	
TP02-(10'-11')-080321	SW6020	THORIUM	4.9		0.0089	0.022	mg/kg	4.9	
TP02-(10'-11')-080321	SW6020	ZINC	34		4.6	11	mg/kg	34	
TP03-(SURF)-080321	713R15	Ac-228	1.48	M3,G,TI		1.15	pCi/g	1.48	J
TP03-(SURF)-080321	713R15	K-40	18.1	G		4.8	pCi/g	18.1	J
TP03-(SURF)-080321	713R15	Ra-226	16.5	M3,G		0.8	pCi/g	16.5	J
TP03-(SURF)-080321	SW6020	ARSENIC	240		0.05	0.21	mg/kg	240	
TP03-(SURF)-080321	SW6020	CADMIUM	0.19	J	0.023	0.21	mg/kg	0.19	J
TP03-(SURF)-080321	SW6020	COPPER	15		0.3	2.1	mg/kg	15	
TP03-(SURF)-080321	SW6020	LEAD	23		0.068	0.21	mg/kg	23	
TP03-(SURF)-080321	SW6020	THORIUM	8.3		0.0082	0.021	mg/kg	8.3	
TP03-(SURF)-080321	SW6020	ZINC	69		4.2	10	mg/kg	69	
TP03-(5'-6')-080321	713R15	Ac-228	0.63	U,M,G		1.2	pCi/g	1.2	UJ
TP03-(5'-6')-080321	713R15	K-40	9.6	G		3.8	pCi/g	9.6	J
TP03-(5'-6')-080321	713R15	Ra-226	85	M3,G		1	pCi/g	85	J
TP03-(5'-6')-080321	SW6020	ARSENIC	290		0.059	0.24	mg/kg	290	
TP03-(5'-6')-080321	SW6020	CADMIUM	0.4		0.027	0.24	mg/kg	0.4	
TP03-(5'-6')-080321	SW6020	COPPER	16		0.35	2.4	mg/kg	16	
TP03-(5'-6')-080321	SW6020	LEAD	13		0.08	0.24	mg/kg	13	
TP03-(5'-6')-080321	SW6020	THORIUM	5.2		0.0097	0.024	mg/kg	5.2	
TP03-(5'-6')-080321	SW6020	ZINC	36		5	12	mg/kg	36	
TP03-(14'-15')-080321	713R15	Ac-228	0.75	G,TI		0.67	pCi/g	0.75	J
TP03-(14'-15')-080321	713R15	K-40	14.1	G		1.7	pCi/g	14.1	J
TP03-(14'-15')-080321	713R15	Ra-226	0.98	G		0.4	pCi/g	0.98	J
TP03-(14'-15')-080321	SW6020	ARSENIC	29		0.05	0.2	mg/kg	29	
TP03-(14'-15')-080321	SW6020	CADMIUM	0.13	J	0.022	0.2	mg/kg	0.13	J
TP03-(14'-15')-080321	SW6020	COPPER	20		0.3	2	mg/kg	20	
TP03-(14'-15')-080321	SW6020	LEAD	7.3		0.067	0.2	mg/kg	7.3	
TP03-(14'-15')-080321	SW6020	THORIUM	5.4		0.0081	0.02	mg/kg	5.4	
TP03-(14'-15')-080321	SW6020	ZINC	28		4.2	10	mg/kg	28	
TP-(DUP)-01-080321	713R15	Ac-228	1.23	G		0.77	pCi/g	1.23	J
TP-(DUP)-01-080321	713R15	K-40	16.9	G		2.4	pCi/g	16.9	J
TP-(DUP)-01-080321	713R15	Ra-226	1.29	G		0.47	pCi/g	1.29	J
TP-(DUP)-01-080321	SW6020	ARSENIC	30		0.05	0.2	mg/kg	30	
TP-(DUP)-01-080321	SW6020	CADMIUM	0.14	J	0.022	0.2	mg/kg	0.14	J
TP-(DUP)-01-080321	SW6020	COPPER	20		0.3	2	mg/kg	20	
TP-(DUP)-01-080321	SW6020	LEAD	8		0.067	0.2	mg/kg	8	
TP-(DUP)-01-080321	SW6020	THORIUM	5.8		0.0082	0.02	mg/kg	5.8	
TP-(DUP)-01-080321	SW6020	ZINC	33		4.2	10	mg/kg	33	

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Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP04-(SURF)-080321	713R15	Ac-228	1.17	G		0.66	pCi/g	1.17	J
TP04-(SURF)-080321	713R15	K-40	18.1	G		2.7	pCi/g	18.1	J
TP04-(SURF)-080321	713R15	Ra-226	5.53	G		0.47	pCi/g	5.53	J
TP04-(SURF)-080321	SW6020	ARSENIC	150		0.048	0.2	mg/kg	150	
TP04-(SURF)-080321	SW6020	CADMIUM	0.89		0.022	0.2	mg/kg	0.89	
TP04-(SURF)-080321	SW6020	COPPER	13		0.29	2	mg/kg	13	
TP04-(SURF)-080321	SW6020	LEAD	14		0.065	0.2	mg/kg	14	
TP04-(SURF)-080321	SW6020	THORIUM	6.8		0.0079	0.02	mg/kg	6.8	
TP04-(SURF)-080321	SW6020	ZINC	98		4	9.8	mg/kg	98	
TP04-(5'-6')-080321	713R15	Ac-228	0.94	U,M,G		1.02	pCi/g	1.02	UJ
TP04-(5'-6')-080321	713R15	K-40	13.7	G		4.2	pCi/g	13.7	J
TP04-(5'-6')-080321	713R15	Ra-226	8.9	M3,G		0.7	pCi/g	8.9	J
TP04-(5'-6')-080321	SW6020	ARSENIC	180		0.055	0.22	mg/kg	180	
TP04-(5'-6')-080321	SW6020	CADMIUM	0.52		0.025	0.22	mg/kg	0.52	
TP04-(5'-6')-080321	SW6020	COPPER	11		0.32	2.2	mg/kg	11	
TP04-(5'-6')-080321	SW6020	LEAD	16		0.074	0.22	mg/kg	16	
TP04-(5'-6')-080321	SW6020	THORIUM	6		0.0089	0.022	mg/kg	6	
TP04-(5'-6')-080321	SW6020	ZINC	56		4.6	11	mg/kg	56	
TP04-(15'-16')-080321	713R15	Ac-228	0.79	G		0.55	pCi/g	0.79	J
TP04-(15'-16')-080321	713R15	K-40	14.9	G		1.7	pCi/g	14.9	J
TP04-(15'-16')-080321	713R15	Ra-226	3.62	G		0.31	pCi/g	3.62	J
TP04-(15'-16')-080321	SW6020	ARSENIC	44		0.051	0.21	mg/kg	44	
TP04-(15'-16')-080321	SW6020	CADMIUM	0.065	J	0.023	0.21	mg/kg	0.065	J
TP04-(15'-16')-080321	SW6020	COPPER	4.2		0.3	2.1	mg/kg	4.2	
TP04-(15'-16')-080321	SW6020	LEAD	6.9		0.069	0.21	mg/kg	6.9	
TP04-(15'-16')-080321	SW6020	THORIUM	3.6		0.0084	0.021	mg/kg	3.6	
TP04-(15'-16')-080321	SW6020	ZINC	21		4.3	10	mg/kg	21	
TP05-(SURF)-080321	713R15	Ac-228	1.5	U,M,G		2.2	pCi/g	2.2	UJ
TP05-(SURF)-080321	713R15	K-40	0.5	U,G		5.7	pCi/g	5.7	UJ
TP05-(SURF)-080321	713R15	Ra-226	111	M3,G		2	pCi/g	111	J
TP05-(SURF)-080321	SW6020	ARSENIC	310		0.052	0.21	mg/kg	310	
TP05-(SURF)-080321	SW6020	CADMIUM	0.41		0.024	0.21	mg/kg	0.41	
TP05-(SURF)-080321	SW6020	COPPER	33		0.31	2.1	mg/kg	33	
TP05-(SURF)-080321	SW6020	LEAD	21		0.071	0.21	mg/kg	21	
TP05-(SURF)-080321	SW6020	THORIUM	7.9		0.0086	0.021	mg/kg	7.9	
TP05-(SURF)-080321	SW6020	ZINC	72		4.4	11	mg/kg	72	
TP05-(18'-19')-080321	713R15	Ac-228	1.23	G		0.69	pCi/g	1.23	J
TP05-(18'-19')-080321	713R15	K-40	11.4	G		2.5	pCi/g	11.4	J
TP05-(18'-19')-080321	713R15	Ra-226	14.7	M3,G		0.6	pCi/g	14.7	J
TP05-(18'-19')-080321	SW6020	ARSENIC	43		0.054	0.22	mg/kg	43	
TP05-(18'-19')-080321	SW6020	CADMIUM	0.095	J	0.024	0.22	mg/kg	0.095	J
TP05-(18'-19')-080321	SW6020	COPPER	14		0.32	2.2	mg/kg	14	
TP05-(18'-19')-080321	SW6020	LEAD	17		0.073	0.22	mg/kg	17	
TP05-(18'-19')-080321	SW6020	THORIUM	7.9		0.0088	0.022	mg/kg	7.9	
TP05-(18'-19')-080321	SW6020	ZINC	32		4.5	11	mg/kg	32	

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP06-(SURF)-080321	713R15	Ac-228	0.67	U,G		0.71	pCi/g	0.71	UJ
TP06-(SURF)-080321	713R15	K-40	17.9	G		2.7	pCi/g	17.9	J
TP06-(SURF)-080321	713R15	Ra-226	10.8	M3,G		0.5	pCi/g	10.8	J
TP06-(SURF)-080321	SW6020	ARSENIC	100		0.051	0.21	mg/kg	100	
TP06-(SURF)-080321	SW6020	CADMIUM	0.75		0.023	0.21	mg/kg	0.75	
TP06-(SURF)-080321	SW6020	COPPER	14		0.3	2.1	mg/kg	14	
TP06-(SURF)-080321	SW6020	LEAD	16		0.069	0.21	mg/kg	16	
TP06-(SURF)-080321	SW6020	THORIUM	7.3		0.0083	0.021	mg/kg	7.3	
TP06-(SURF)-080321	SW6020	ZINC	88		4.3	10	mg/kg	88	
TP06-(11'-12')-080321	713R15	Ac-228	1.66	TI		0.81	pCi/g	1.66	J
TP06-(11'-12')-080321	713R15	K-40	17.1			2.7	pCi/g	17.1	
TP06-(11'-12')-080321	713R15	Ra-226	1.83			0.46	pCi/g	1.83	
TP06-(11'-12')-080321	SW6020	ARSENIC	15		0.057	0.23	mg/kg	15	
TP06-(11'-12')-080321	SW6020	CADMIUM	0.18	J	0.026	0.23	mg/kg	0.18	J
TP06-(11'-12')-080321	SW6020	COPPER	19		0.34	2.3	mg/kg	19	
TP06-(11'-12')-080321	SW6020	LEAD	16		0.077	0.23	mg/kg	16	
TP06-(11'-12')-080321	SW6020	THORIUM	9.6		0.0093	0.023	mg/kg	9.6	
TP06-(11'-12')-080321	SW6020	ZINC	43		4.8	12	mg/kg	43	
TP06-(17'-18')-080321	713R15	Ac-228	1.01			0.59	pCi/g	1.01	
TP06-(17'-18')-080321	713R15	K-40	14.8			2.1	pCi/g	14.8	
TP06-(17'-18')-080321	713R15	Ra-226	1.25			0.33	pCi/g	1.25	
TP06-(17'-18')-080321	SW6020	ARSENIC	18		0.053	0.22	mg/kg	18	
TP06-(17'-18')-080321	SW6020	CADMIUM	0.053	J	0.024	0.22	mg/kg	0.053	J
TP06-(17'-18')-080321	SW6020	COPPER	11		0.31	2.2	mg/kg	11	
TP06-(17'-18')-080321	SW6020	LEAD	14		0.072	0.22	mg/kg	14	
TP06-(17'-18')-080321	SW6020	THORIUM	7.6		0.0087	0.022	mg/kg	7.6	
TP06-(17'-18')-080321	SW6020	ZINC	23		4.5	11	mg/kg	23	
TP07-(SURF)-080321	713R15	Ac-228	1.66	G		0.92	pCi/g	1.66	J
TP07-(SURF)-080321	713R15	K-40	15.1	G		4.1	pCi/g	15.1	J
TP07-(SURF)-080321	713R15	Ra-226	10.3	M3,G		0.7	pCi/g	10.3	J
TP07-(SURF)-080321	SW6020	ARSENIC	340		0.051	0.21	mg/kg	340	
TP07-(SURF)-080321	SW6020	CADMIUM	0.36		0.023	0.21	mg/kg	0.36	
TP07-(SURF)-080321	SW6020	COPPER	20		0.3	2.1	mg/kg	20	
TP07-(SURF)-080321	SW6020	LEAD	20		0.069	0.21	mg/kg	20	
TP07-(SURF)-080321	SW6020	THORIUM	8.7		0.0084	0.021	mg/kg	8.7	
TP07-(SURF)-080321	SW6020	ZINC	50		4.3	10	mg/kg	50	
TP08-(SURF)-080321	713R15	Ac-228	1.3	G		0.43	pCi/g	1.3	J
TP08-(SURF)-080321	713R15	K-40	15.8	G		1.6	pCi/g	15.8	J
TP08-(SURF)-080321	713R15	Ra-226	9	G		0.4	pCi/g	9	J
TP08-(SURF)-080321	SW6020	ARSENIC	350		0.05	0.2	mg/kg	350	
TP08-(SURF)-080321	SW6020	CADMIUM	0.49		0.022	0.2	mg/kg	0.49	
TP08-(SURF)-080321	SW6020	COPPER	14		0.29	2	mg/kg	14	
TP08-(SURF)-080321	SW6020	LEAD	18		0.067	0.2	mg/kg	18	
TP08-(SURF)-080321	SW6020	THORIUM	6.8		0.0081	0.02	mg/kg	6.8	
TP08-(SURF)-080321	SW6020	ZINC	45		4.2	10	mg/kg	45	

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP08-(9'-10')-080321	713R15	Ac-228	1.62	M3,G		1.24	pCi/g	1.62	J
TP08-(9'-10')-080321	713R15	K-40	17.5	G		3.1	pCi/g	17.5	J
TP08-(9'-10')-080321	713R15	Ra-226	4.53	M3,G		0.59	pCi/g	4.53	J
TP08-(9'-10')-080321	SW6020	ARSENIC	29		0.076	0.31	mg/kg	29	
TP08-(9'-10')-080321	SW6020	CADMIUM	0.34		0.034	0.31	mg/kg	0.34	
TP08-(9'-10')-080321	SW6020	COPPER	16		0.45	3.1	mg/kg	16	
TP08-(9'-10')-080321	SW6020	LEAD	17		0.1	0.31	mg/kg	17	
TP08-(9'-10')-080321	SW6020	THORIUM	7.4		0.012	0.031	mg/kg	7.4	
TP08-(9'-10')-080321	SW6020	ZINC	50		6.4	16	mg/kg	50	
TP09-(SURF)-080321	713R15	Ac-228	1.7	G		0.8	pCi/g	1.7	J
TP09-(SURF)-080321	713R15	K-40	14.5	G		2.3	pCi/g	14.5	J
TP09-(SURF)-080321	713R15	Ra-226	9.3	G		0.5	pCi/g	9.3	J
TP09-(SURF)-080321	SW6020	ARSENIC	220		0.051	0.21	mg/kg	220	
TP09-(SURF)-080321	SW6020	CADMIUM	0.56		0.023	0.21	mg/kg	0.56	
TP09-(SURF)-080321	SW6020	COPPER	18		0.3	2.1	mg/kg	18	
TP09-(SURF)-080321	SW6020	LEAD	28		0.068	0.21	mg/kg	28	
TP09-(SURF)-080321	SW6020	THORIUM	8.4		0.0083	0.021	mg/kg	8.4	
TP09-(SURF)-080321	SW6020	ZINC	66		4.2	10	mg/kg	66	
TP09-(6'-7')-080321	713R15	Ac-228	1.56	G,TI		0.83	pCi/g	1.56	J
TP09-(6'-7')-080321	713R15	K-40	13.2	G		3.1	pCi/g	13.2	J
TP09-(6'-7')-080321	713R15	Ra-226	1.82	M3,G		0.54	pCi/g	1.82	J
TP09-(6'-7')-080321	SW6020	ARSENIC	64		0.055	0.23	mg/kg	64	
TP09-(6'-7')-080321	SW6020	CADMIUM	0.36		0.025	0.23	mg/kg	0.36	
TP09-(6'-7')-080321	SW6020	COPPER	21		0.33	2.3	mg/kg	21	
TP09-(6'-7')-080321	SW6020	LEAD	16		0.075	0.23	mg/kg	16	
TP09-(6'-7')-080321	SW6020	THORIUM	9.3		0.009	0.023	mg/kg	9.3	
TP09-(6'-7')-080321	SW6020	ZINC	72		4.6	11	mg/kg	72	
TP10-(SURF)-080421	713R15	Ac-228	1.15			0.44	pCi/g	1.15	
TP10-(SURF)-080421	713R15	K-40	17.4			1.4	pCi/g	17.4	
TP10-(SURF)-080421	713R15	Ra-226	2.71			0.27	pCi/g	2.71	
TP10-(SURF)-080421	SW6020	ARSENIC	24		0.047	0.19	mg/kg	24	
TP10-(SURF)-080421	SW6020	CADMIUM	0.29		0.021	0.19	mg/kg	0.29	
TP10-(SURF)-080421	SW6020	COPPER	12		0.28	1.9	mg/kg	12	
TP10-(SURF)-080421	SW6020	LEAD	11		0.063	0.19	mg/kg	11	
TP10-(SURF)-080421	SW6020	THORIUM	5.1		0.0077	0.019	mg/kg	5.1	
TP10-(SURF)-080421	SW6020	ZINC	37		3.9	9.6	mg/kg	37	
TP10-(6'-7')-080421	713R15	Ac-228	0.85	G		0.62	pCi/g	0.85	J
TP10-(6'-7')-080421	713R15	K-40	14.5	G		1.8	pCi/g	14.5	J
TP10-(6'-7')-080421	713R15	Ra-226	5.04	G		0.47	pCi/g	5.04	J
TP10-(6'-7')-080421	SW6020	ARSENIC	19		0.057	0.23	mg/kg	19	
TP10-(6'-7')-080421	SW6020	CADMIUM	0.22	J	0.026	0.23	mg/kg	0.22	J
TP10-(6'-7')-080421	SW6020	COPPER	9.4		0.34	2.3	mg/kg	9.4	
TP10-(6'-7')-080421	SW6020	LEAD	10		0.077	0.23	mg/kg	10	
TP10-(6'-7')-080421	SW6020	THORIUM	4.8		0.0093	0.023	mg/kg	4.8	
TP10-(6'-7')-080421	SW6020	ZINC	36		4.8	12	mg/kg	36	

RILEY PASS SOIL ANALYTICAL RESULTS SUMMARY
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Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP10-(15'-16')-080421	713R15	Ac-228	0.1	U,M,G		3	pCi/g	3	UJ
TP10-(15'-16')-080421	713R15	K-40	10.2	G		8.2	pCi/g	10.2	J
TP10-(15'-16')-080421	713R15	Ra-226	189	M3,G		2	pCi/g	189	J
TP10-(15'-16')-080421	SW6020	ARSENIC	280		0.061	0.25	mg/kg	280	
TP10-(15'-16')-080421	SW6020	CADMIUM	4		0.027	0.25	mg/kg	4	
TP10-(15'-16')-080421	SW6020	COPPER	14		0.36	2.5	mg/kg	14	
TP10-(15'-16')-080421	SW6020	LEAD	27		0.082	0.25	mg/kg	27	
TP10-(15'-16')-080421	SW6020	THORIUM	4.1		0.01	0.025	mg/kg	4.1	
TP10-(15'-16')-080421	SW6020	ZINC	51		5.1	12	mg/kg	51	
TP11-(SURF)-080421	713R15	Ac-228	1.22	M3,G,TI		1.15	pCi/g	1.22	J
TP11-(SURF)-080421	713R15	K-40	15.2	G		3.4	pCi/g	15.2	J
TP11-(SURF)-080421	713R15	Ra-226	3.34	M3,G		0.58	pCi/g	3.34	J
TP11-(SURF)-080421	SW6020	ARSENIC	25		0.05	0.21	mg/kg	25	
TP11-(SURF)-080421	SW6020	CADMIUM	0.28		0.023	0.21	mg/kg	0.28	
TP11-(SURF)-080421	SW6020	COPPER	14		0.3	2.1	mg/kg	14	
TP11-(SURF)-080421	SW6020	LEAD	14		0.068	0.21	mg/kg	14	
TP11-(SURF)-080421	SW6020	THORIUM	5.7		0.0082	0.021	mg/kg	5.7	
TP11-(SURF)-080421	SW6020	ZINC	46		4.2	10	mg/kg	46	
TP11-(5'-6')-080421	713R15	Ac-228	0.99	TI		0.51	pCi/g	0.99	J
TP11-(5'-6')-080421	713R15	K-40	14.1			2.2	pCi/g	14.1	
TP11-(5'-6')-080421	713R15	Ra-226	1.61			0.33	pCi/g	1.61	
TP11-(5'-6')-080421	SW6020	ARSENIC	7.5		0.061	0.25	mg/kg	7.5	
TP11-(5'-6')-080421	SW6020	CADMIUM	0.19	J	0.027	0.25	mg/kg	0.19	J
TP11-(5'-6')-080421	SW6020	COPPER	9.7		0.36	2.5	mg/kg	9.7	
TP11-(5'-6')-080421	SW6020	LEAD	9.1		0.082	0.25	mg/kg	9.1	
TP11-(5'-6')-080421	SW6020	THORIUM	4		0.0099	0.025	mg/kg	4	
TP11-(5'-6')-080421	SW6020	ZINC	35		5.1	12	mg/kg	35	
TP12-(SURF)-080421	713R15	Ac-228	0.2	U,M,G		2.8	pCi/g	2.8	UJ
TP12-(SURF)-080421	713R15	K-40	11.4	G		7.9	pCi/g	11.4	J
TP12-(SURF)-080421	713R15	Ra-226	192	M3,G		2	pCi/g	192	J
TP12-(SURF)-080421	SW6020	ARSENIC	470		0.049	0.2	mg/kg	470	
TP12-(SURF)-080421	SW6020	CADMIUM	1.2		0.022	0.2	mg/kg	1.2	
TP12-(SURF)-080421	SW6020	COPPER	17		0.29	2	mg/kg	17	
TP12-(SURF)-080421	SW6020	LEAD	21		0.067	0.2	mg/kg	21	
TP12-(SURF)-080421	SW6020	THORIUM	8.7		0.0081	0.02	mg/kg	8.7	
TP12-(SURF)-080421	SW6020	ZINC	44		4.1	10	mg/kg	44	
TP-(DUP)-02-080421	713R15	Ac-228	2	M3,G		1.43	pCi/g	2	J
TP-(DUP)-02-080421	713R15	K-40	12.4	G		4	pCi/g	12.4	J
TP-(DUP)-02-080421	713R15	Ra-226	178	M3,G		1	pCi/g	178	J
TP-(DUP)-02-080421	SW6020	ARSENIC	400		0.05	0.2	mg/kg	400	
TP-(DUP)-02-080421	SW6020	CADMIUM	1.5		0.022	0.2	mg/kg	1.5	
TP-(DUP)-02-080421	SW6020	COPPER	19		0.3	2	mg/kg	19	
TP-(DUP)-02-080421	SW6020	LEAD	29		0.067	0.2	mg/kg	29	
TP-(DUP)-02-080421	SW6020	THORIUM	9.3		0.0082	0.02	mg/kg	9.3	
TP-(DUP)-02-080421	SW6020	ZINC	47		4.2	10	mg/kg	47	

Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP13-(SURF)-080421	713R15	Ac-228	0.94	G		0.61	pCi/g	0.94	J
TP13-(SURF)-080421	713R15	K-40	15.7	G		1.8	pCi/g	15.7	J
TP13-(SURF)-080421	713R15	Ra-226	4.82	G		0.43	pCi/g	4.82	J
TP13-(SURF)-080421	SW6020	ARSENIC	53		0.05	0.2	mg/kg	53	
TP13-(SURF)-080421	SW6020	CADMIUM	0.49		0.022	0.2	mg/kg	0.49	
TP13-(SURF)-080421	SW6020	COPPER	11		0.29	2	mg/kg	11	
TP13-(SURF)-080421	SW6020	LEAD	12		0.067	0.2	mg/kg	12	
TP13-(SURF)-080421	SW6020	THORIUM	6.3		0.0081	0.02	mg/kg	6.3	
TP13-(SURF)-080421	SW6020	ZINC	57		4.2	10	mg/kg	57	
TP13-(6'-7')-080421	713R15	Ac-228	1.25	G,TI		0.8	pCi/g	1.25	J
TP13-(6'-7')-080421	713R15	K-40	17.6	G		2.3	pCi/g	17.6	J
TP13-(6'-7')-080421	713R15	Ra-226	2.73	G		0.46	pCi/g	2.73	J
TP13-(6'-7')-080421	SW6020	ARSENIC	88		0.057	0.23	mg/kg	88	
TP13-(6'-7')-080421	SW6020	CADMIUM	0.32		0.026	0.23	mg/kg	0.32	
TP13-(6'-7')-080421	SW6020	COPPER	15		0.34	2.3	mg/kg	15	
TP13-(6'-7')-080421	SW6020	LEAD	15		0.077	0.23	mg/kg	15	
TP13-(6'-7')-080421	SW6020	THORIUM	8.2		0.0094	0.023	mg/kg	8.2	
TP13-(6'-7')-080421	SW6020	ZINC	77		4.8	12	mg/kg	77	
TP14-(SURF)-080421	713R15	Ac-228	1.16	TI		0.83	pCi/g	1.16	J
TP14-(SURF)-080421	713R15	K-40	10.3			2.7	pCi/g	10.3	
TP14-(SURF)-080421	713R15	Ra-226	9.7			0.5	pCi/g	9.7	
TP14-(SURF)-080421	SW6020	ARSENIC	60		0.048	0.2	mg/kg	60	
TP14-(SURF)-080421	SW6020	CADMIUM	0.2		0.021	0.2	mg/kg	0.2	
TP14-(SURF)-080421	SW6020	COPPER	10		0.28	2	mg/kg	10	
TP14-(SURF)-080421	SW6020	LEAD	11		0.064	0.2	mg/kg	11	
TP14-(SURF)-080421	SW6020	THORIUM	4.9		0.0078	0.02	mg/kg	4.9	
TP14-(SURF)-080421	SW6020	ZINC	30		4	9.8	mg/kg	30	
TP14-(4'-5')-080421	713R15	Ac-228	0.56	G		0.41	pCi/g	0.56	J
TP14-(4'-5')-080421	713R15	K-40	15.5	G		1.6	pCi/g	15.5	J
TP14-(4'-5')-080421	713R15	Ra-226	2.21	G		0.32	pCi/g	2.21	J
TP14-(4'-5')-080421	SW6020	ARSENIC	9.1		0.052	0.21	mg/kg	9.1	
TP14-(4'-5')-080421	SW6020	CADMIUM	0.083	J	0.023	0.21	mg/kg	0.083	J
TP14-(4'-5')-080421	SW6020	COPPER	2.9		0.31	2.1	mg/kg	2.9	
TP14-(4'-5')-080421	SW6020	LEAD	4.1		0.07	0.21	mg/kg	4.1	
TP14-(4'-5')-080421	SW6020	THORIUM	2.9		0.0085	0.021	mg/kg	2.9	
TP14-(4'-5')-080421	SW6020	ZINC	21		4.4	11	mg/kg	21	
TP15-(SURF)-080421	713R15	Ac-228	0.78			0.77	pCi/g	0.78	
TP15-(SURF)-080421	713R15	K-40	10			1.9	pCi/g	10	
TP15-(SURF)-080421	713R15	Ra-226	11.8			0.5	pCi/g	11.8	
TP15-(SURF)-080421	SW6020	ARSENIC	55		0.049	0.2	mg/kg	55	
TP15-(SURF)-080421	SW6020	CADMIUM	0.16	J	0.022	0.2	mg/kg	0.16	J
TP15-(SURF)-080421	SW6020	COPPER	7.6		0.29	2	mg/kg	7.6	
TP15-(SURF)-080421	SW6020	LEAD	8.3		0.065	0.2	mg/kg	8.3	
TP15-(SURF)-080421	SW6020	THORIUM	4.4		0.0079	0.02	mg/kg	4.4	
TP15-(SURF)-080421	SW6020	ZINC	25		4.1	9.9	mg/kg	25	

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Sample ID	Method	Analyte	Lab Result	Lab Qual	MDL	RL	Units	Val Result	Val Qual
TP15-(3'-4')-080421	713R15	Ac-228	0.45	G,TI		0.4	pCi/g	0.45	J
TP15-(3'-4')-080421	713R15	K-40	14.1	G		2.1	pCi/g	14.1	J
TP15-(3'-4')-080421	713R15	Ra-226	1.88	G		0.36	pCi/g	1.88	J
TP15-(3'-4')-080421	SW6020	ARSENIC	14		0.05	0.2	mg/kg	14	
TP15-(3'-4')-080421	SW6020	CADMIUM	0.23		0.022	0.2	mg/kg	0.23	
TP15-(3'-4')-080421	SW6020	COPPER	2.4		0.29	2	mg/kg	2.4	
TP15-(3'-4')-080421	SW6020	LEAD	4.1		0.067	0.2	mg/kg	4.1	
TP15-(3'-4')-080421	SW6020	THORIUM	2.7		0.0081	0.02	mg/kg	2.7	
TP15-(3'-4')-080421	SW6020	ZINC	20		4.2	10	mg/kg	20	
TP15-(8'-9')-080421	713R15	Ac-228	0.8	U,G		0.83	pCi/g	0.83	UJ
TP15-(8'-9')-080421	713R15	K-40	14.1	G		3.8	pCi/g	14.1	J
TP15-(8'-9')-080421	713R15	Ra-226	7.6	M3,G		0.7	pCi/g	7.6	J
TP15-(8'-9')-080421	SW6020	ARSENIC	38		0.054	0.22	mg/kg	38	
TP15-(8'-9')-080421	SW6020	CADMIUM	0.32		0.024	0.22	mg/kg	0.32	
TP15-(8'-9')-080421	SW6020	COPPER	11		0.32	2.2	mg/kg	11	
TP15-(8'-9')-080421	SW6020	LEAD	11		0.072	0.22	mg/kg	11	
TP15-(8'-9')-080421	SW6020	THORIUM	5.6		0.0087	0.022	mg/kg	5.6	
TP15-(8'-9')-080421	SW6020	ZINC	38		4.5	11	mg/kg	38	

TP03-(14’-15’)-080321/TP-(DUP)-01-080321

	Ac-228	K-40	Ra-226
Sample	0.75	14.1	0.98
Duplicate	1.23	16.9	1.29
STPU	0.34	2.9	0.23
DTPU	0.41	3.7	0.3
DER	1.802360102	1.191219763	1.640119813

	Sample	Duplicate	RPD
Arsenic	29	30	3.389830508
Cadmium	0.13	0.14	7.407407407
Copper	20	20	0
Lead	7.3	8	9.150326797
Thorium	5.4	5.8	7.142857143
Zinc	28	33	16.39344262

//

TP12-(SURF)-080421/TP-(DUP)-02-080421

	Ac-228	K-40	Ra-226
Sample	0.2	11.4	192
Duplicate	2	12.4	178
STPU	1.7	5.3	23
DTPU	0.75	3.3	21
DER	1.937472992	0.320338456	0.899025819

	Sample	Duplicate	RPD
Arsenic	470	400	16.09195402
Cadmium	1.2	1.5	22.22222222
Copper	17	19	11.11111111
Lead	21	29	32
Thorium	8.7	9.3	6.666666667
Zinc	44	47	6.593406593

APPENDIX E

IN-FIELD GAMMA VALIDATION AND VERIFICATION

TABLE OF CONTENTS

FIGURES

TABLES

TABLES (continued)

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

ANSI	American National Standards Institute
Cs-137	Cesium-137
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
MARLAP	*Multi-Agency Radiological Laboratory Analytical Protocols Manual*
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
NaI(TI)	Sodium iodide thallium-laced
QA	Quality assurance
QC	Quality control
Ra-226	Radium-226
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and Analysis Plan
Tetra Tech	Tetra Tech, Inc.
µCi	Microcurie
UAV	Unmanned aerial vehicle
USFS	U.S. Forest Service

1.0 INTRODUCTION

This Appendix E to the Bluff B Subsurface and Supplemental Surface Investigation Report (hereafter referred to as the main report) presents the data validation and verification methods and results of the 2021 field investigation in-field gamma radiation surveys performed at Bluff B within the Riley Pass Uranium Mine complex in South Dakota. Tetra Tech adhered to quality assurance and quality control (QA/QC) procedures with regards to in-field gamma measurements in accordance with the USFS-approved Sampling and Analysis Plan (SAP) – Subsurface and Supplemental Surface Investigation for Bluff B (Tetra Tech 2021) and Appendix B of the Verification Sampling Plan (Tetra Tech 2015). Quality assurance (QA) includes qualitative factors that provide confidence in the results, while quality control (QC) involves quantitative, field evidence that supports the validity of results. Tetra Tech uses data quality indicators as recommended in MARRSIM (EPA 2000) and MARLAP (EPA 2004) to ensure the data being collected with radiation instrumentation is reliable and meets the quality requirements for the intended end use of the data.

2.0 OVERVIEW OF IN-FIELD GAMMA SURVEYS

This section provides an overview of the radiation instrumentation data quality needs.

2.1 OVERVIEW OF RADIATION INSTRUMENTATION

Different radiation instrumentation setups were utilized during the 2021 field investigation. All of the instruments used consisted of Ludlum Model 44-10 (2- by 2-inch) sodium iodide thallium doped (NaI[Tl]) gamma scintillation detector coupled to some type of datalogger. The mobile scan systems were coupled to ERG Model 105 GPS units consisting of a Juniper Mesa 2 field computer and geode GPS receiver. Table E1 presents the detector and datalogger types for each instrument setup used during the field work with the corresponding serial numbers for each.

Table E1 Radiation Instrumentation Used During 2021 Field Investigation

Instrument Name	Description	Detector		Datalogger	
		Type	Serial Number	Type	Serial Number
Green System	Juniper Geode/Mesa	Ludlum 44-10	PR321872	Ludlum 3000	25018596
Yellow System	Juniper Geode/ Mesa	Ludlum 44-10	PR357752	Ludlum 3000	25020045
Downhole System	15-foot cable	Ludlum 44-10	PR373528	Ludlum 3000	25018557
	30-foot cable	Ludlum 44-10	PR295014	Ludlum 3000	25017006
Drone System	UAV Gamma System	Ludlum 44-10	PR367180	Ludlum 441	2100023

2.2 SURVEYS PERFORMED

The different surveys were intended to collect screening level or definitive level data. Screening level data were used to make assumptions which led to collecting samples or other purposes while definitive level is intended to be used to make remediation or cleanup decisions. Not all of the data collected during the 2021 field investigation required definitive level quality. The QA/QC procedures are more stringent for definitive level data.

Table E2 Scan Survey Data Quality Requirements and Instrumentation Used

Survey Name	Data Quality Level	Green System	Yellow System	Downhole System	Drone System
Lateral Delineation Surveys	Definitive	X	X		
Soil Correlation	Definitive	X	X		
Downhole Surveys	Screening			X	
Aerial Gamma Flyover	Screening				X

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

This radiological survey project incorporated data QA/QC protocols developed to achieve guidelines established by MARSSIM (EPA 2000). In general, QA includes qualitative factors that provide confidence in the results, while QC involves quantitative field evidence that supports the validity of results. Data quality indicators as recommended in MARRSIM (EPA 2000) and Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) (EPA 2004) were used to ensure the data being collected are reliable and of sufficient quality. This section presents the QA/QC methods and results.

3.1 QUALITY ASSURANCE

An important QA protocol for in-field gamma surveys include instrument calibration. All of the radiation detection equipment employed during the field work used for definitive data collection purposes should be factory calibrated within the previous 12 months. Data developed using any of the field-qualified instruments are then interchangeable, allowing instrument substitution as needed. Copies of factory calibration documentation for all of the detectors used during the survey are provided as an attachment to this document (see Attachment E1).

All Ludlum Model 44-10/2221 instrument systems used in the gamma surveys were calibrated in accordance with the *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* (American National Standards Institute [ANSI] 1997) Calibration of a detection system is required (1) prior to initial use, (2) at least annually, and (3) after any scheduled or unscheduled maintenance or repair that may affect its operation. General maintenance of detection systems, such as cleaning, painting, and changing buttons, does not include recalibration.

It is noted the Drone System detector as identified in Table E1 did not have a factory calibration within 12 months due to the complexity of the setup and the nature of the pilot survey being conducted but numerous qualitative checks were performed to ensure the drone matched the backpack system data and also the detector was brand new so there was less concern for wear and tear being used on the drone detector. Furthermore, the drone data was considered screening level as it was estimated from higher heights and converted to 1-meter equivalent gamma readings as described in Appendix B to the main report.

3.2 QUALITY CONTROL

This subsection summarizes the methods and results of the QC analyses performed for those detectors that were actually used during the survey for definitive level purposes which includes the green and yellow instrument setups (Table E1). The QC protocol involved pre-trip and post-trip calibration checks and daily instrument calibration field checks. The purpose of the QC analyses is to quantify the consistency of gamma exposure readings between detectors for instrument comparability as well as instrument consistency over time and functionality during the course of the field work. The QC data measurements were recorded only for the detectors that were planned to be utilized during the survey.

An explanation of the QC methods for the radiation instrumentation, including data validation testing, QC acceptance limits, and results of the calibration checks, is presented in the following subsections. The two primary QC methods for the gamma radiation survey outlined in the report include daily field calibration checks and pre-survey and post-survey calibration checks.

3.2.1 Pre-Trip and Post-Trip QC Checks

Pre-trip and post-trip QC instrument measurements were collected at an indoor location for each paired Ludlum 3000/44-10 (NaI[Tl]) detector that could be potentially used during the gamma radiation survey and used for definitive level data collection. The purpose of these measurements was to quantify the consistency of readings among the detectors under controlled conditions before (pre-trip) and after (post-trip) the 2021 field investigation. A minimum of 1,000 background and a 10 microcurie (µCi) cesium-137 (Cs-137) source measurements were collected both pre-trip and post-trip for each detector under the same counting conditions. The pre-trip QC checks were performed on the green and yellow instrument setups on July 30, 2021. The post-trip QC checks were performed on the green and yellow instrument setups on August 8, 2021. The QC checks were performed in the Fort Collins, Colorado Tetra Tech office using setup similar to that provided in Figure E1.

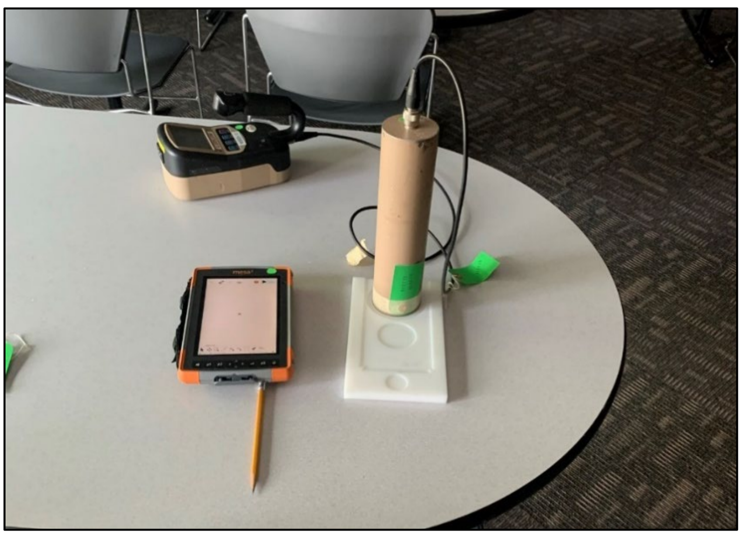


Figure E1 Photograph of Pre-Trip Background QC Check

Data validation discussion for pre-trip and post-trip QC measurements is discussed in Section 4.0. The following QC limits are proposed for data validation purposes:

- The project QC acceptance limits for pre-trip and post-trip average background and source measurements between detectors is less than 5 percent, for the instruments to be considered comparable.
- The comparison of the average background and source measurements between pre-trip and post-trip for a detector is less than 5 percent, for the data to be considered usable during the project.
- Each individual detector’s background and source measurements should be normally distributed.
- The RSD of an individual detector’s background and source measurements should be less than 10 percent.

The summary statistics for the pre-trip and post-trip background measurements for the green and yellow detectors are presented in Table E3 and Table E4, respectively. Histograms with a normal distribution fitted curve showing the pre-trip and post-trip background measurements for both detectors are provided on Figure E2 and Figure E3, respectively.

The summary statistics for the pre-trip and post-trip source measurements for the green and yellow detectors are presented in Table E5 and Table E6, respectively. Histograms with a normal distribution fitted curve showing the pre-trip and post-trip source measurements for both detectors are provided on Figure E4 and Figure E5, respectively.

A comparison summary of the pre-trip and post-trip average comparison for background and source measurements for the green detector is presented in Table E7. A comparison summary of the pre-trip and post-trip average comparison for background and source measurements for the yellow detector is presented in Table E8.

Table E3 Summary Statistics of Pre-Trip Background Readings

Statistic	Green Detector Pre-Trip Background	Yellow Detector Pre-Trip Background	RPD of Averages
# of Measurements	1,042	1,001	-
Average (µR/hr)	16.8	16.4	2.5%
Median (µR/hr)	16.8	16.4	-
Standard Deviation (µR/hr)	1.0	1.0	-
RSD	6.1%	6.3%	-

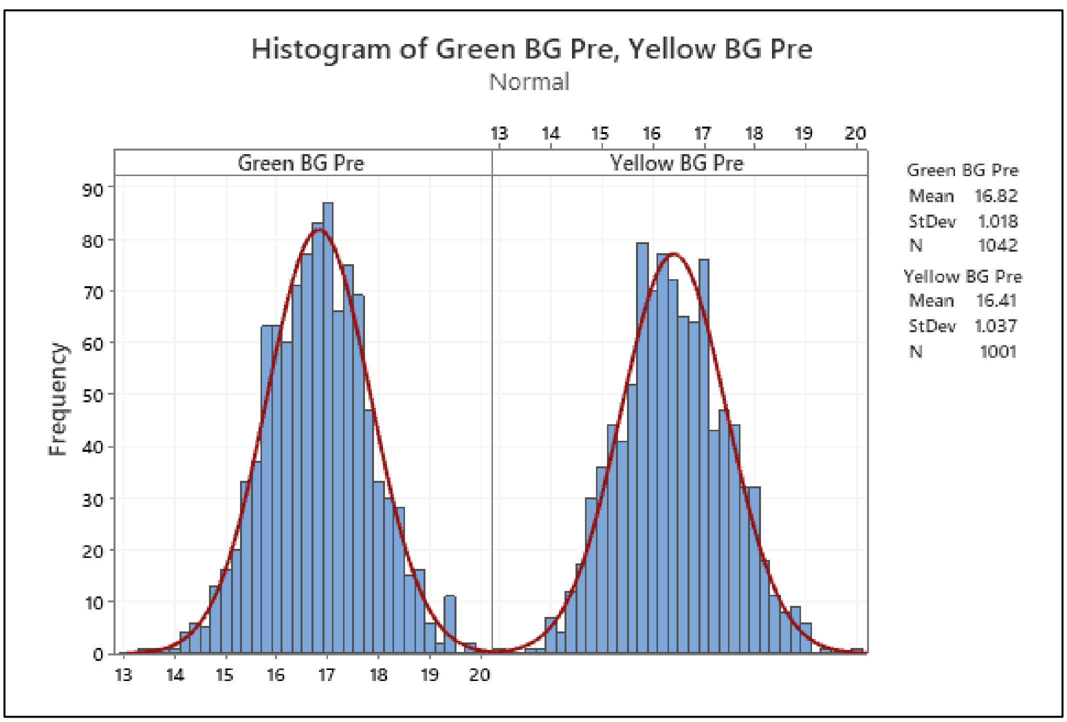


Figure E2 Histogram of Green (left) and Yellow (right) Pre-Trip Background Readings

Table E4 Summary Statistics of Post-Trip Background Readings

Statistic	Green Detector Post-Trip Background	Yellow Detector Post-Trip Background	RPD of Averages
# of Measurements	1,002	1,028	-
Average (µR/hr)	17.3	16.9	2.3%
Median (µR/hr)	17.3	16.9	-
Standard Deviation (µR/hr)	1.1	1.1	-
RSD	6.3%	6.3%	-

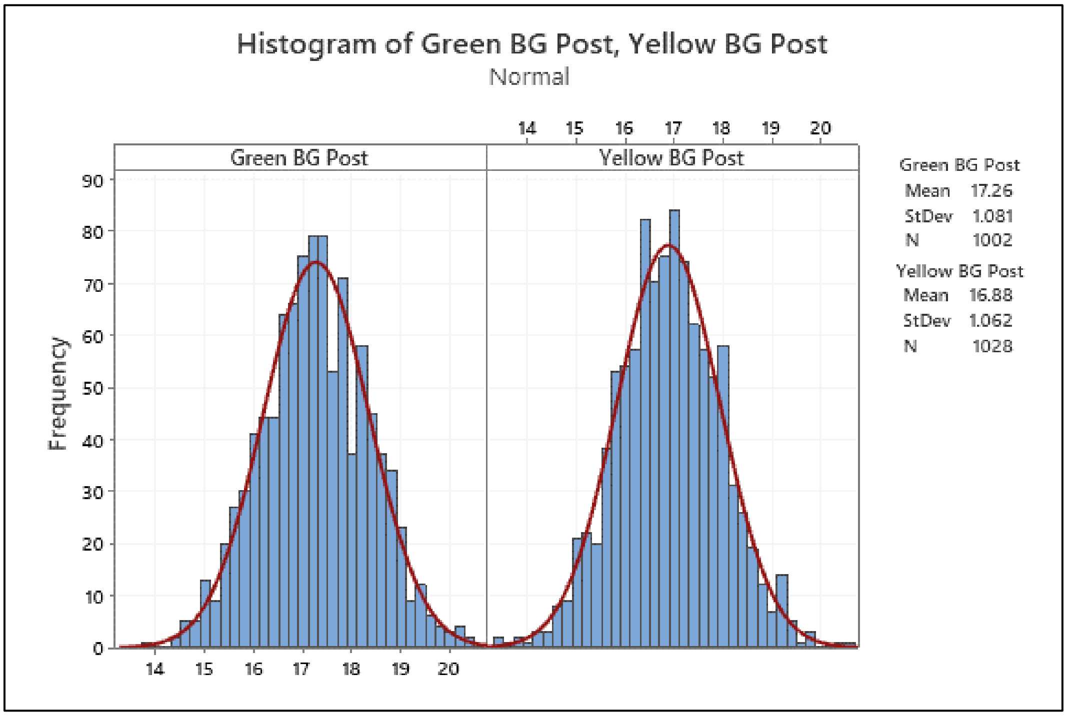


Figure E3 Histogram of Green (left) and Yellow (right) Post-Trip Background Readings

Table E5 Summary Statistics of Pre-Trip Source Readings

Statistic	Green Detector Pre-Trip Source	Yellow Detector Pre-Trip Source	RPD of Averages
# of Measurements	1,008	1,000	-
Average (µR/hr)	155.7	151.8	2.5%
Median (µR/hr)	155.6	151.8	-
Standard Deviation (µR/hr)	3.1	3.1	-
RSD	2.0%	2.0%	-

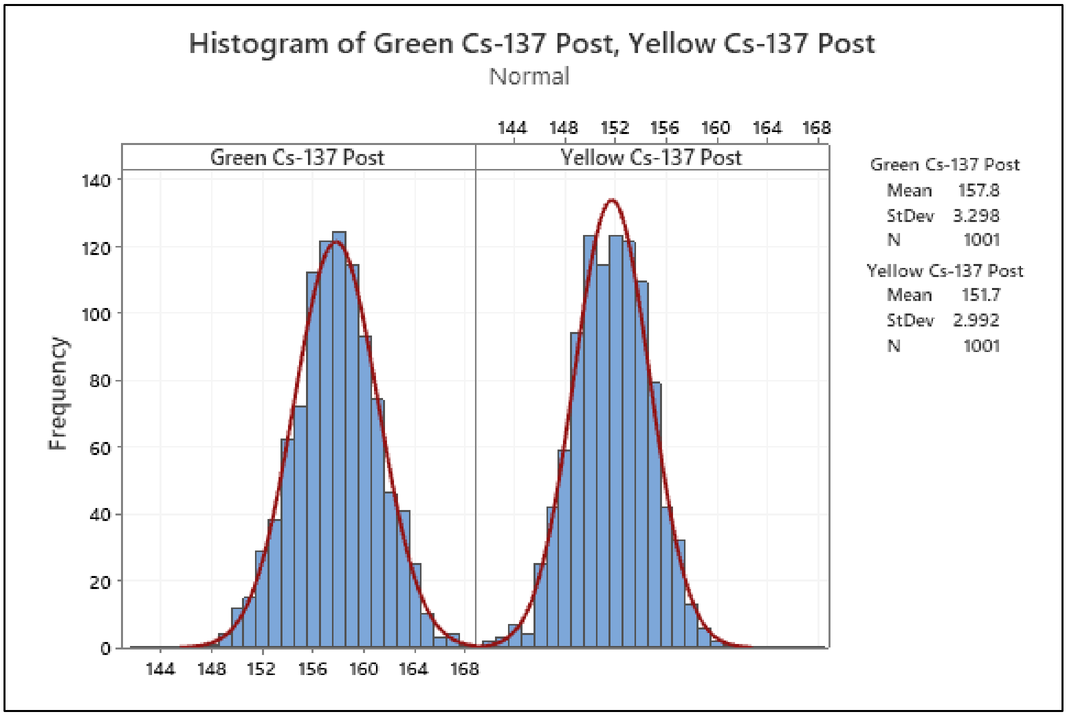


Figure E5 Histogram of Green (left) and Yellow (right) Post-Trip Source Readings

Table E7 Summary of Pre-Trip and Post-Trip Average Comparison for Green Detector

Statistic	Pre-Trip Average (Green)	Post-Trip Average (Green)	RPD of Averages
Background	16.8	17.3	2.6%
Source	155.7	157.8	1.3%

Table E8 Summary of Pre-Trip and Post-Trip Average Comparison for Yellow Detector

Statistic	Pre-Trip Average (Green)	Post-Trip Average (Green)	RPD of Averages
Background	16.4	16.9	2.8%
Source	151.8	151.7	0.1%

3.2.2 Daily Field QC Checks

Under the QC program, factory-calibrated instruments must also meet on-site field test criteria. Daily instrument function checks are measurements performed to verify instrument performance each time an instrument is used (EPA 2000). The instrument function checks consist of collecting a minimum of 10 measurements using the scan systems from a static background area, a field strip approximately 10 meters in length, and from a static Cs-137 source check performed at the same location as the static background check. These checks were performed at a pre-determined background reference area that is typically un-impacted by site activities. For this project, the field checks were performed in Bowman, North Dakota at an unpaved parking area adjacent to Bowman Lodge. The following criteria are used to assess the daily field instrument function checks:

- For normally distributed data, 99 percent of all measurements are expected to fall within ±3 standard deviations from the mean. Background, field strip, and check source standard deviation values were recalculated twice daily throughout the project. Any instrument with a QC measurement result falling outside ±3 standard deviations from the mean of all QC measurements on the field check control chart would require investigation. A detector exceeding control limits on any QC function check (background, field strip or source) would be replaced with a pre-qualified spare detector and sent back to the manufacturer for evaluation, repair, and recalibration.
- QC Field Instrument Function Checks, including a background check, field strip check, and source check were performed twice daily during the work for each scanning system in use. These checks were performed outdoors at the same time and location. The daily field strip function check provides an indication of total measurement uncertainty from turbulent movement for each mobile system being used in the field.

The daily QC checks for the green and yellow instruments for background measurements are summarized in Table E9 and Table E10. A quality control chart for the daily QC background measurements is provided in Figure E6.

The daily QC checks for the green and yellow instruments for field strip measurements are summarized in Table E11 and Table E12. A quality control chart for the daily QC field strip measurements is provided in Figure E7.

The daily QC checks for the green and yellow instruments for source measurements are summarized in Table E13 and Table E14. A quality control chart for the daily QC field strip measurements is provided in Figure E8.

Data validation discussion for daily QC checks is discussed in Section 4.0.

Table E9 Summary of Daily QC Background Measurements for Green Detector

Background Measurement #	8/2/2021		8/3/2021		8/4/2021	
	Green		Green		Green	
	Pre	Post	Pre	Post	Pre	Post
1	8.0	8.0	8.0	8.0	8.0	8.0
2	8.0	8.0	8.0	8.0	8.0	8.0
3	8.0	8.0	8.0	8.0	8.0	8.0
4	8.0	8.0	8.0	8.0	8.0	7.0
5	8.0	8.0	8.0	8.0	8.0	8.0
6	7.0	8.0	8.0	8.0	8.0	8.0
7	8.0	8.0	8.0	8.0	8.0	8.0
8	8.0	8.0	8.0	8.0	8.0	8.0
9	8.0	8.0	7.0	8.0	8.0	8.0
10	8.0	8.0	8.0	8.0	8.0	8.0
Average	**7.9**	**8.0**	**7.9**	**8.0**	**8.0**	**7.9**
Standard Deviation	**0.3**	**0.0**	**0.3**	**0.0**	**0.0**	**0.3**
RSD	**4.0%**	**0.0%**	**4.0%**	**0.0%**	**0.0%**	**4.0%**

Table E10 Summary of Daily QC Background Measurements for Yellow Detector

Background Measurement #	8/2/2021		8/3/2021		8/4/2021	
	Yellow		Yellow		Yellow	
	Pre	Post	Pre	Post	Pre	Post
1	7.0	8.0	8.0	7.0	7.0	7.0
2	8.0	8.0	9.0	8.0	8.0	8.0
3	8.0	8.0	8.0	7.0	8.0	8.0
4	8.0	8.0	8.0	7.0	8.0	7.0
5	7.0	8.0	7.0	7.0	7.0	8.0
6	8.0	8.0	8.0	8.0	8.0	8.0
7	8.0	8.0	8.0	8.0	8.0	7.0
8	7.0	8.0	8.0	8.0	8.0	8.0
9	8.0	8.0	8.0	8.0	8.0	7.0
10	8.0	8.0	8.0	9.0	8.0	7.0
Average	**7.7**	**8.0**	**8.0**	**7.7**	**7.8**	**7.5**
Standard Deviation	**0.5**	**0.0**	**0.5**	**0.7**	**0.4**	**0.5**
RSD	**6.3%**	**0.0%**	**5.9%**	**8.8%**	**5.4%**	**7.0%**

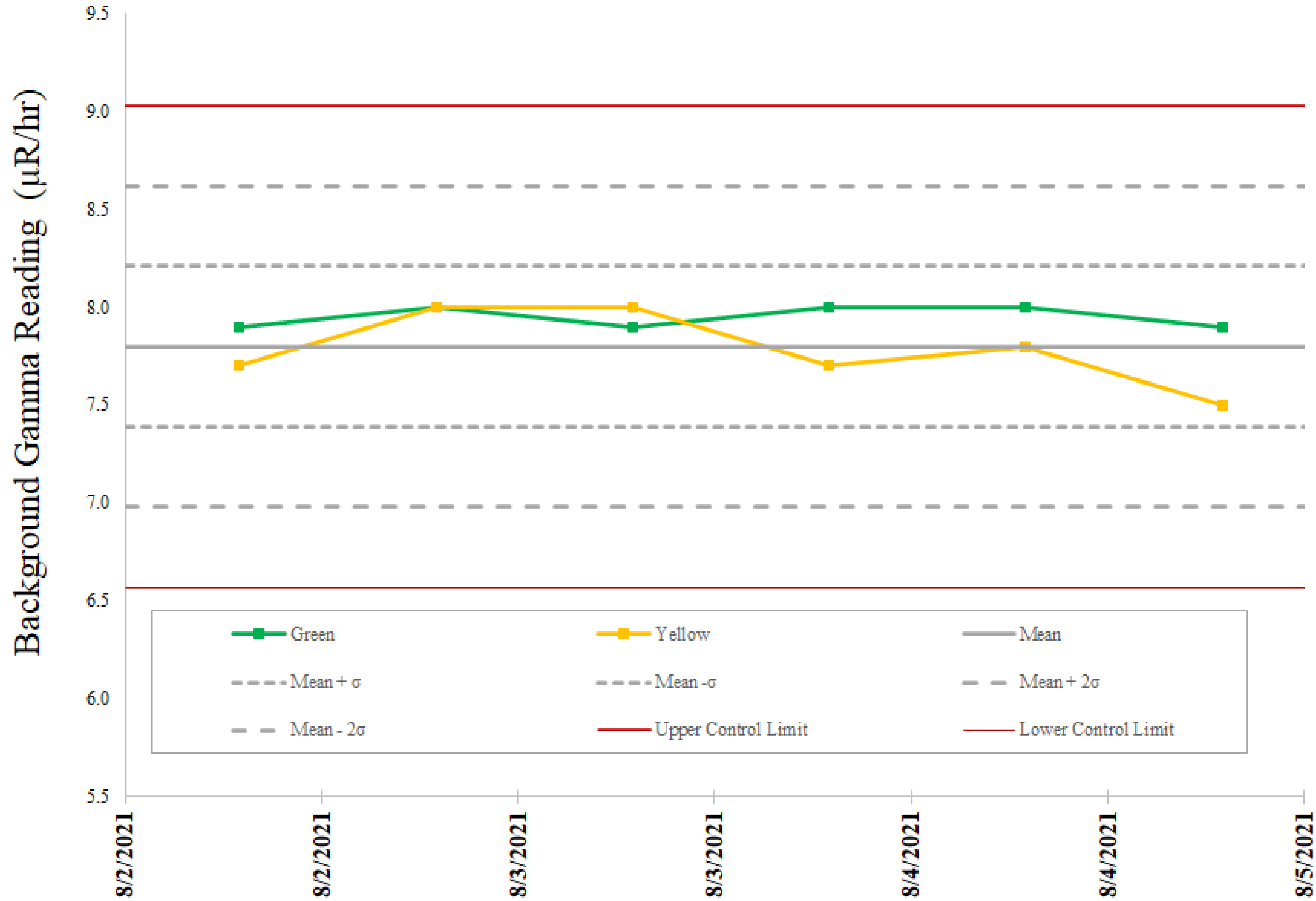


Figure E6 Daily QC Check Control Chart – Background Measurements

Table E11 Summary of Daily QC Field Strip Measurements for Green Detector

Field Strip Measurement #	8/2/2021		8/3/2021		8/4/2021	
	Green		Green		Green	
	Pre	Post	Pre	Post	Pre	Post
1	7.0	7.0	7.0	7.0	7.0	7.0
2	7.0	7.0	7.0	7.0	7.0	7.0
3	7.0	7.0	7.0	7.0	7.0	7.0
4	7.0	7.0	8.0	7.0	7.0	7.0
5	7.0	7.0	7.0	7.0	7.0	7.0
6	7.0	7.0	7.0	7.0	8.0	7.0
7	7.0	7.0	7.0	7.0	7.0	7.0
8	7.0	7.0	7.0	8.0	7.0	7.0
9	7.0	8.0	8.0	8.0	8.0	7.0
10	7.0	8.0	7.0	8.0	8.0	8.0
Average	**7.0**	**7.2**	**7.2**	**7.3**	**7.3**	**7.1**
Standard Deviation	**0.0**	**0.4**	**0.4**	**0.5**	**0.5**	**0.3**
RSD	**0.0%**	**5.9%**	**5.9%**	**6.6%**	**6.6%**	**4.5%**

Table E12 Summary of Daily QC Field Strip Measurements for Yellow Detector

Field Strip Measurement #	8/2/2021		8/3/2021		8/4/2021	
	Yellow		Yellow		Yellow	
	Pre	Post	Pre	Post	Pre	Post
1	7.0	8.0	7.0	7.0	7.0	8.0
2	8.0	7.0	7.0	7.0	6.0	8.0
3	7.0	8.0	7.0	7.0	7.0	8.0
4	7.0	8.0	7.0	7.0	7.0	7.0
5	8.0	7.0	8.0	7.0	7.0	8.0
6	7.0	7.0	7.0	7.0	7.0	8.0
7	7.0	7.0	7.0	7.0	7.0	7.0
8	7.0	7.0	8.0	7.0	7.0	7.0
9	7.0	8.0	7.0	7.0	8.0	8.0
10	7.0	8.0	7.0	7.0	7.0	7.0
Average	**7.2**	**7.5**	**7.2**	**7.0**	**7.0**	**7.6**
Standard Deviation	**0.4**	**0.5**	**0.4**	**0.0**	**0.5**	**0.5**
RSD	**5.9%**	**7.0%**	**5.9%**	**0.0%**	**6.7%**	**6.8%**

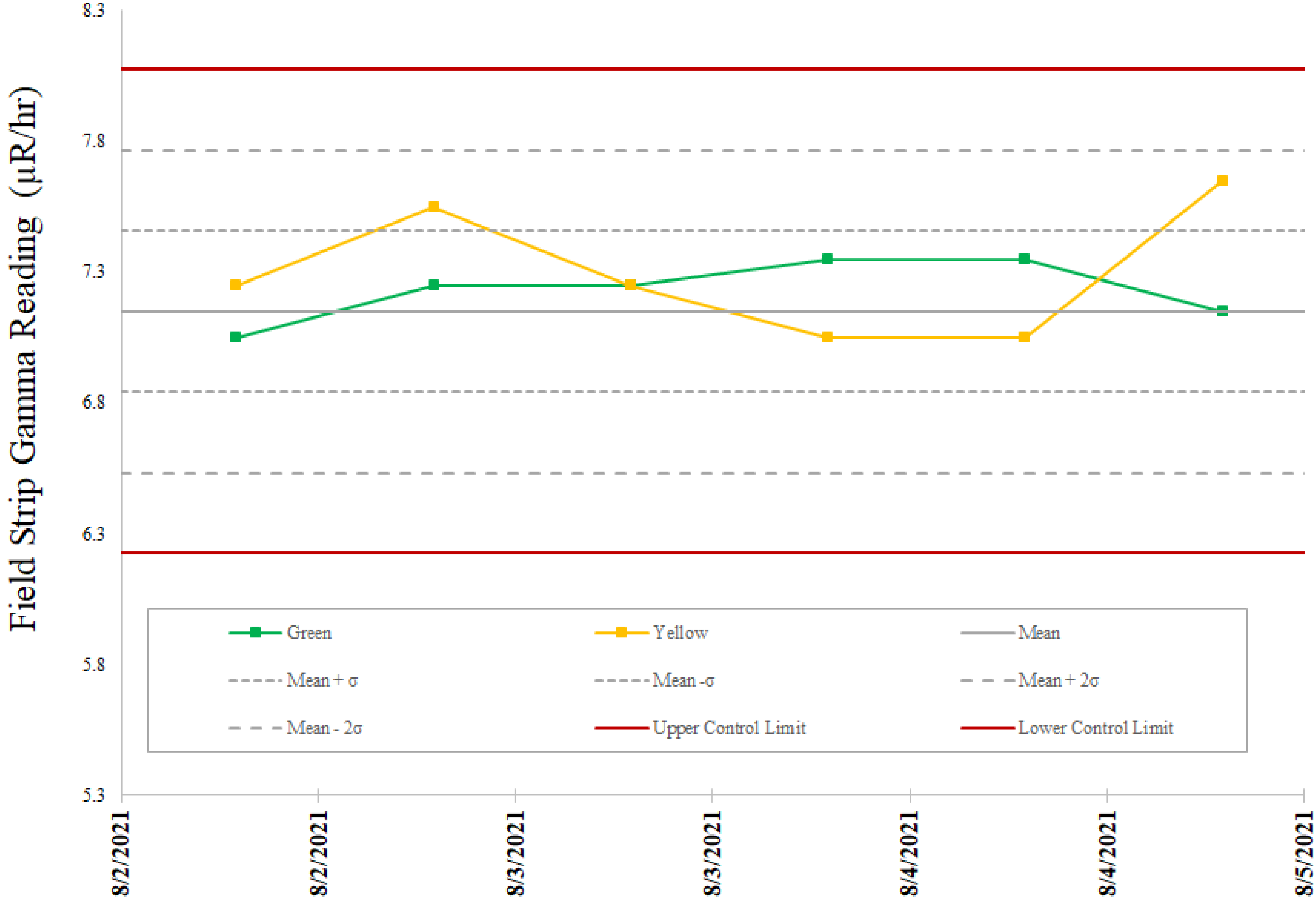


Figure E7 Daily QC Check Control Chart – Field Strip Measurements

Table E13 Summary of Daily QC Source Measurements for Green Detector

Source Measurement #	8/2/2021		8/3/2021		8/4/2021	
	Green		Green		Green	
	Pre	Post	Pre	Post	Pre	Post
1	177	180	181	173	173	170
2	176	179	181	172	171	169
3	178	179	176	175	170	172
4	174	177	175	172	175	171
5	178	180	179	172	172	175
6	177	180	179	173	169	173
7	178	183	180	171	172	171
8	176	182	181	177	175	174
9	180	180	180	172	170	174
10	178	178	179	170	172	174
Average	**177.2**	**179.8**	**179.1**	**172.7**	**171.9**	**172.3**
Standard Deviation	**1.6**	**1.8**	**2.1**	**2.0**	**2.0**	**2.0**
RSD	**0.9%**	**1.0%**	**1.2%**	**1.2%**	**1.2%**	**1.2%**

Table E14 Summary of Daily QC Source Measurements for Yellow Detector

Source Measurement #	8/2/2021		8/3/2021		8/4/2021	
	Yellow		Yellow		Yellow	
	Pre	Post	Pre	Post	Pre	Post
1	174	169	174	175	168	172
2	180	180	171	177	172	175
3	175	170	173	169	174	172
4	172	168	166	175	169	177
5	178	171	176	174	171	169
6	170	173	173	168	174	171
7	173	182	177	171	178	177
8	176	177	176	166	171	167
9	178	167	174	175	170	176
10	170	173	171	170	169	175
Average	**174.6**	**173.0**	**173.1**	**172.0**	**171.6**	**173.1**
Standard Deviation	**3.4**	**5.1**	**3.2**	**3.7**	**3.0**	**3.4**
RSD	**2.0%**	**3.0%**	**1.9%**	**2.1%**	**1.8%**	**2.0%**

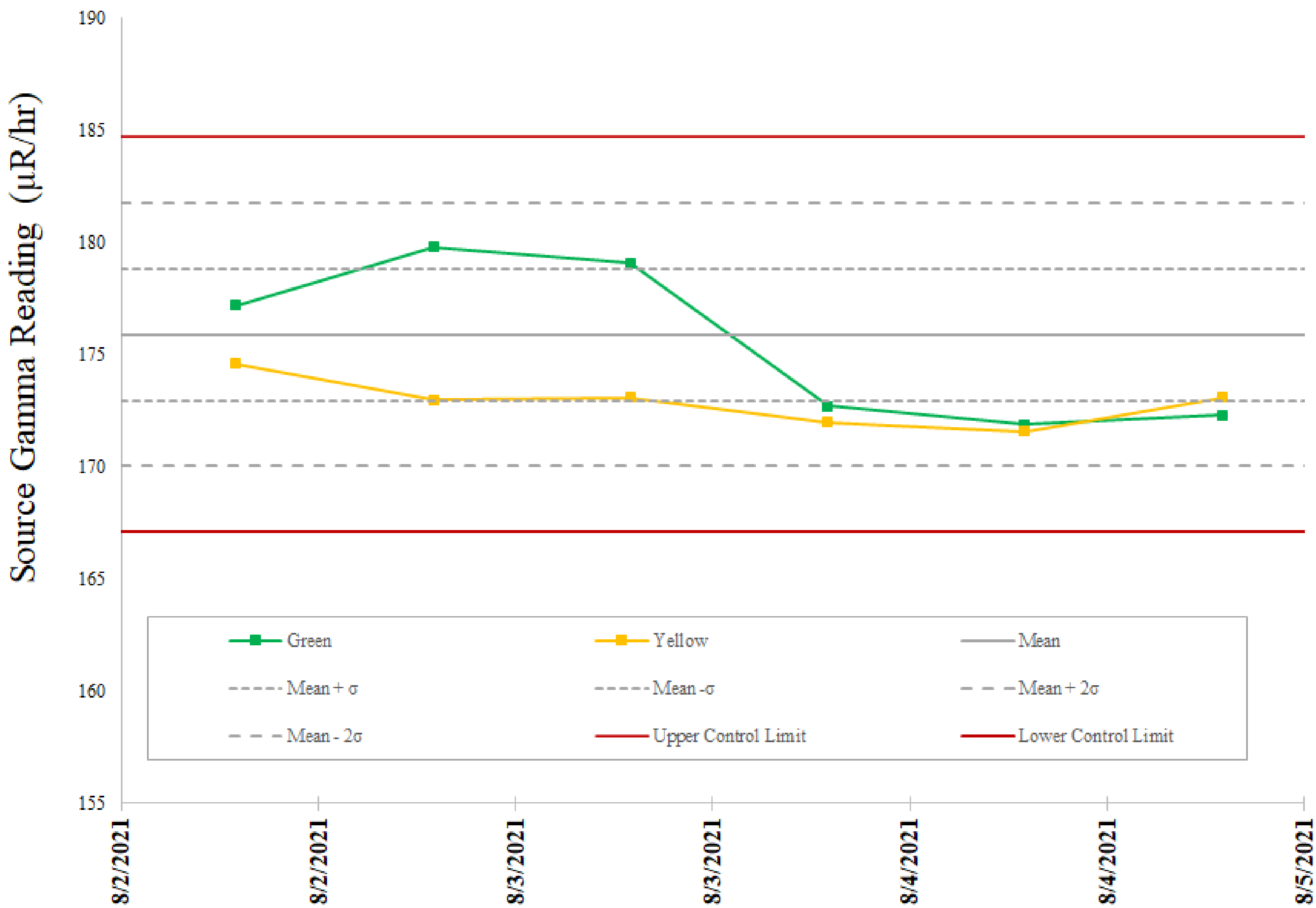


Figure E8 Daily QC Check Control Chart – Source Measurements

4.0 VALIDATION AND VERIFICATION

This section presents the validation and verification of the in-field gamma radiation surveys.

4.1 CACLULATIONS

The following calculations are used to assess precision or comparability. Precision is an indicator of repeatability and reproducibility and can be assessed by evaluating primary and duplicate measurements or datasets. Comparability refers to how well instruments compare to each other so they can be interchanged in the field. The data validation methods used to evaluate the precision or comparability are:

Relative percent difference (RPD). The RPD was used for pre-survey and post-survey gamma exposure rate measurements.

Relative standard deviation (RSD). The RSD was used for evaluation of pre-trip and post-trip survey gamma exposure rate measurements and daily QC checks.

The equation for RPD is:

$$RPD(\%) = \frac{|S - D|}{\frac{(S + D)}{2}} \times 100$$

where:

RPD = relative percent difference
S = value of first measurement
D = value of second measurement

The RSD of the sample mean is used to assess method precision. The equation for calculating RSD is:

$$RSD = \frac{\sigma}{\mu} \times 100$$

where:

RSD = relative standard deviation for the precision measurement for the analyte
σ = standard deviation of the concentration for the analyte
μ = mean concentration for the analyte

4.2 VALIDATION

Validation of in-field data involves a technical review performed to compare the QC data with established quality criteria to ensure that data are adequate for intended use. The primary validation provided here is for the pre-trip and post-trip QC checks performed in the office and the daily QC checks performed in the field.

4.2.1 Pre-Trip and Post-Trip Validation

The methods and results for pre-trip and post-trip QC checks is presented in Section 3.2.1. The data validation project quality criteria for pre-trip and post-trip is as follows:

The project QC acceptance limits for pre-trip and post-trip average background and source measurements between detectors is less than 5 percent, for the instruments to be considered comparable. **This was achieved.**
The comparison of the average background and source measurements between pre-trip and post-trip for a detector is less than 5 percent, for the data to be considered usable during the project. **This was achieved.**
Each individual detector's background and source measurements should be normally distributed. **This was achieved.**
The RSD of an individual detector's background and source measurements should be less than 10 percent. **This was achieved.**

All of the project quality criteria requirements were achieved.

4.2.2 Daily QC Checks

The goal of the daily QC checks was to ensure the instruments were working properly during the field surveys performed. The results of the daily QC calibration checks are presented in Section 3.2.2. The QC charts show the data points for background, field strip, and source checks were all within the project quality criteria limits.

4.3 VERIFICATION

Data verification for in-field gamma radiation survey data is the process for evaluating the completeness, correctness, consistency, and compliance of a data package against the SAP. In this context, "completeness" means all required hard-copy and electronic deliverables are present. For in-field gamma radiation survey compliance verification the primary evaluation involves the completeness of the gamma radiation surveys that were performed during the 2021 field investigation. A number of documents pertaining to the in-field gamma radiation survey compliance verification evaluation are as follows:

A photographic log of the in-field gamma radiation surveys are included as Appendix A to the main report.

A detailed methodology regarding the aerial gamma flyover survey is presented as the UAV summary report in Appendix B of the main report.

A detailed methodology regarding the gamma-radium correlation study is presented as the Gamma Correlation Report in Appendix G of the main report.

The scanned field forms relating to the in-field gamma radiation surveys are included as Appendix F to the main report.

5.0 REFERENCES

American National Standards Institute (ANSI). 1997. *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.*

EPA. 2000b. "Multi-Agency Radiation Survey and Site Investigation Manual." August.

EPA. 2004. Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP). July.

Tetra Tech, Inc. 2015. Final Verification Sampling Plan. Riley Pass Uranium Mines Site (North Cave Hills), Harding County, South Dakota. November 18.

ATTACHMENT E1: INSTRUMENT CALIBRATION DOCUMENTS

Drone Instrument Calibration Forms

Designer and Manufacturer
of
Scientific and Industrial
Instruments

www.ludlums.com

LUDLUM MEASUREMENTS, INC.
501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

Functional Check

Customer MERRICK INDUSTRIES LLC ORDER NO. 20314657

This Certifies that Ludlum Model 441 Serial No. 210023 has been functionally checked.
Refer to applicable instrument manuals for specific operating instructions.

This Detector operates at 900 Volts, 35 mV Sensitivity.

Check performed by mary castillo Mary Castillo Date 19/July/17

www.ludlums.com
Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

Bench Test Data For Detector

Detector 44-10 Serial No. PR 367180

Customer MERRICK INDUSTRIES LLC ORDER NO. 20314657

Counter 2200 Serial No. 177355 Counter Input Sensitivity 10 mV

Count Time 6 seconds Distance Source to Detector Surface

Other Resolution For Cs-137 = 9.4%

High Voltage	Background	Isotope Am 241 Size ≈ 0.76 µCi	Isotope Size	Isotope Size	Isotope Size
550	459	5192			
600	472	10883			
650	590	12132			
700	547	12115			
✓750	499	12351			
800	498	12331			
850	576	12603			
900	922	13252			
950	1544	15407			

Signature LEONOR ORTEGA *Leonor Ortega* Date 11-Jul-17

FORM C4A 12/12/2016 Page 1 of 1

ORDER#: 20314657

SHIP VIA:
FE GROUND

SHIP DATE:
7/20/2017

LMI CUST. #:
40952

20314657

PACKING LIST FROM:
LUDLUM MEASUREMENTS, INC.
501 OAK ST PO BOX 810
SWEETWATER TEXAS USA 79556
TEL: 325-235-5494

CUST PO #: CHRISTOPHER D MERRICH CC

SHIP TO:
MERRICK INDUSTRIES LLC
18785 NORLENE WAY
GRASS VALLEY, CA 95949
USA

CHRIS@GLASS-PLANETS.COM

Ordered By: CHRIS
530-277-2277

PHONE NUMBER: 530-277-2277

BOX# / # OF BOXES:
/

BOX LN	ORD QTY	SHIP QTY	PART NO.	DESCRIPTION	ADDITIONAL INFO
01	1.00 EA	1.00 EA	48-2900	M 441 DET INTERFACE	210023
02	1.00 EA	1.00 EA	47-1540	M 44-10 GAMMA SCIN (2X2)	PR367180

COMMENTS:
MM/VO

(D) Product is export controlled for AT reasons under ECCN 1A 999. As such, these commodities, technology or software are eligible for export from the United States only in accordance with Export Administration regulations. Diversion contrary to U.S. law is prohibited.

LUDLUM MEASUREMENTS, INC.

501 OAK ST. SWEETWATER, TX 79556 • 1.800.622.0828 • 325.235.5497 • 325.235.4672 • www.ludlums.com
MAILING ADDRESS TEL US / CAN PHONE FAX WEBSITE

INSTRUMENT RETURN FORM

Date: ____________ Item(s) returned for: ☐ Calibration ☐ Repair ☐ Other ____________

Company Name: ____

Contact Person: ______________________ Phone: ( ) ____________
(End-User)

E-Mail: ____________________

Bill to Address: ____________________
____
____
____

Ship to Address: ____________________
____
____
____

Ship Via: ☐ UPS ☐ FedEx ☐ Other: ________

Instrument/Probe Model Number	Serial Number	Instrument/Probe Model Number	Serial Number

for Estimate: Call ☐ E-mail ☐

Purchase Order # ____________________ for PO#: Call ☐ E-mail ☐

Credit Card # _____ - _____ - _____ - _____ Expiration: ____ / ____ for CC#: Call ☐ E-m

Contact Person: ____________________ Phone: ( ) ____________
(Purchasing)

Fax: ( ) ____________________ E-mail: ____________________

Malfunctioning Symptoms, Special Instructions, etc: ____________________
____
____

All Other Instrument Calibration Forms

Environmental Restoration Group, Inc.
8809 Washington NE, Suite #150
Albuquerque, NM 87113

office: (505) 298-4224
fax: (505) 797-1404
web: www.ERGOffice.com

EQUIPMENT PACKING SLIP

Company Name: Tetra Tech - Aaron Orechwa
Contact Name: Aaron Orechwa
Contact Telephone: 9704209395

Order Number: 4709
P.O. or Reference Number:

Date Ordered: 6/29/2021
Date Shipped: 7/22/2021
Date of Delivery: 7/22/2021

Shipping Method: n/a
Shipping Number: ERG FedEx Number

Ship To Information:
Aaron Orechwa
Tetra Tech - Aaron Orechwa
405 North Roosevelt Ave.
Fort collins, CO 80521

9704209395

Billing Address:
Tetra Tech - CO
Accounts Payable
3801 Automation Way
Ste 100
Fort Collins, CO 80525

Equipment Enclosed:

Instrument	*Serial Number*	*Tested*
Ludlum 3000	25017006	☑
Ludlum 3000	25018557	☑
Ludlum 3000	25020045	☑
Ludlum 3000	25018596	☑
Ludlum 4260-233	ERG-020	☑
Ludlum 44-10	PR373528	☑
Ludlum 44-10	PR295014	☑
Ludlum 44-10	PR357752	☑
Ludlum 44-10	PR321872	☐
Juniper Geode	213614	☑
Juniper Geode	194576	☑
Juniper Mesa2	228134	☑
Juniper Mesa2	249856	☑

Special Instructions:

Order continued on next page

Environmental Restoration Group, Inc.
8809 Washington NE, Suite #150
Albuquerque, NM 87113

office: (505) 298-4224
fax: (505) 797-1404
web: www.ERGOffice.com

EQUIPMENT PACKING SLIP

Order Number: 4709

None

Note:
(a) By accepting and using ERG rental equipment, the Renter indemnifies and holds harmless ERG against any and all claims, actions, proceedings, costs, expenses, damages, and liabilities (including attorney's fees and costs) arising out of Renter's use of equipment.

Designer and Manufacturer of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED CERT # 4084.01

Customer: ENVIRONMENTAL RESTORATION GRP — ORDER NO. 20402048/510141

Mfg. Ludlum Measurements, Inc. — Model 3000 — Serial No. 25020045

Mfg. Ludlum Measurements, Inc. — Model 44-10 — Serial No. PR357752

Cal. Date 25-Jun-21 — Cal Due Date 25-Jun-22 — Cal. Interval 1 Year — Meterface 44-10 R

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. — T. 71 °F — RH 40 % — Alt 703.8 mm Hg

☐ New Instrument — Instrument Received ☐ Within Toler. +-10% ☑ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☐ Geotropism
☑ Audio ck. ☑ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 4.4 VDC
☑ Calibrated in accordance with LMI SOP 14.8 ☑ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 1000 V Input Sens. 10 mV Det. Oper. 1000 V at 10 mV Threshold Dial Ratio = mV

☑ HV Readout (2 points) Ref./Inst. 500 / 494 V Ref./Inst. 1500 / 1504 V

COMMENTS:

```
         Deadtime: 8.9 µSec Overload checked but not set.
Calibration Constant: 549 e+8 Pulser calibration RATEMETER READOUT performed without deadtime.
    Primary Units: R/hr      Pulser calibration SCALER READOUT reflects 6 second count.
Primary Units Alarm: 7 mR/hr Calibrated using 5' C-cable.
  Secondary Units: cpm
Secondary Units Alarm: 5 kcpm
         Firmware: 49835N34
```

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital	5 mR/hr	4.14 mR/hr	5.05 mR/hr				
Digital	1 mR/hr	988 µR/hr	1.02				
	800 µR/hr	800	813 µR/hr				
	200 µR/hr	194	193				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	Scaler REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
800K cpm	799 kcpm	799 kcpm	800K cpm	79.9K	79.9K
200K cpm	199	199	200K cpm	19.9K	19.9K
80K cpm	79.9	79.9	80K cpm	7.99K	7.99K
20K cpm	20.0	20.0	20K cpm	1.99K	1.99K
8K cpm	7.99	7.99	8K cpm	800	800
2K cpm	2.00	2.00	2K cpm	200	200
800 cpm	800 cpm	800 cpm	800 cpm	80	80
200 cpm	201	201	200 cpm	20	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.
All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.
Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2.
The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☑ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241(0.66µCi)

☑ m 500 S/N 251106 ☐ Oscilloscope S/N ☑ Multimeter S/N 15060230

Calibrator James McBeth *James McBeth* — Title Calibrator — Date 25 JUN 21

QC'd By [signature] — Title Final QC — Date 28 JUN 21

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed

Order #: 20402048/510141

Customer: ENVIRONMENTAL RESTORATION GRP

Detector: 44-10 **Serial No.:** PR357752

Instrument: Model 3000 **Serial No.:** 25020045

BKG Time: 6

Distance: Surface

Selected HV: 1000

Date: Friday, June 25, 2021

Notes: Performed using 5' C-cable.

Signature: James McBeth

Channel(s)

Name	Threshold
Channel 1	10 mV

Source(s)

Name	ID	Activity	Time	Type
Am241		0.66 μCi	6	γ

High Voltage	Background	Am241
	Reading	Reading
750	475	10,444
800	502	11,669
850	502	12,196
900	480	12,173
950	493	12,526
– 1000	516	12,481
1050	552	12,322
1100	523	12,414
1150	582	12,394
1200	625	12,673
1,250	711	12,882
1,300	1,059	13,797

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25020045
6/25/2021 11:05:11 AM

Device

Device Firmware	5LC-N34.3969
Device Model	Model 3000
Device Serial Number	25020045
Device Real Time Clock Day	25
Device Real Time Clock Hour	11
Device Real Time Clock Minutes	5
Device Real Time Clock Month	6
Device Real Time Clock Seconds	4
Device Real Time Clock Year	2021
Device Real Time Clock Day of the Week	6
Device Backlight Threshold	0
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	40
Device Backlight Threshold Low Turn Off	120
Device Backlight Threshold High Turn On	17
Device Backlight Threshold High Turn Off	100
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	5
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0

Device Calibration

Device Calibration High Voltage Slope	42
Device Calibration High Voltage Offset	-55
Device Calibration Channel [1] Pulse Threshold Offset	2

Detector 1

Detector [1] Serial Number	PR357752
Detector [1] Model	44-10
Detector [1] High Voltage	1000
Detector [1] Overload	100
Detector [1] Count Time	60

Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	0
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit 1 Rate Unit Type	9
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	700
Detector [1] Unit 1 Rate Max Range	1
Detector [1] Unit 1 Rate Max Decimal Point	2
Detector [1] Unit 1 Rate Alarm Value	700
Detector [1] Unit 1 Rate Alarm Range	1
Detector [1] Unit 1 Rate Alarm Decimal Point	2
Detector [1] Unit 1 Scaler Unit Type	3
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	0
Detector [1] Unit [2] Rate Min Exponet	0
Detector [1] Unit [2] Rate Max Value	0
Detector [1] Unit [2] Scaler Unit Type	0
Detector [1] Unit [2] Scaler Min Exponet	0
Detector [1] Unit 2 Rate Unit Type	5
Detector [1] Unit 2 Rate Min Range	0
Detector [1] Unit 2 Rate Min Decimal Point	0
Detector [1] Unit 2 Rate Max Value	999
Detector [1] Unit 2 Rate Max Range	1
Detector [1] Unit 2 Rate Max Decimal Point	0
Detector [1] Unit 2 Rate Alarm Value	5
Detector [1] Unit 2 Rate Alarm Range	1
Detector [1] Unit 2 Rate Alarm Decimal Point	0
Detector [1] Unit 2 Scaler Unit Type	1
Detector [1] Unit 2 Scaler Min Range	0
Detector [1] Unit 2 Scaler Min Decimal Point	0
Detector [1] Unit 2 Scaler Alarm Value	0
Detector [1] Unit 2 Scaler Alarm Range	0
Detector [1] Unit 2 Scaler Alarm Decimal Point	0
Detector [1] Unit [3] Rate Unit Type	0
Detector [1] Unit [3] Rate Min Exponet	0
Detector [1] Unit [3] Rate Max Value	0
Detector [1] Unit [3] Scaler Unit Type	0
Detector [1] Unit [3] Scaler Min Exponet	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	8.9
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	549
Detector [1] Channel [1] Calibration Constant Exponent	8
Detector [1] Channel [1] Efficiency 4pi	15

Designer and Manufacturer of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED CERT # 4084.01

Customer: ENVIRONMENTAL RESTORATION GRP — ORDER NO. 20402048/510141

Mfg. Ludlum Measurements, Inc. Model 3000 Serial No. 25017006

Mfg. Ludlum Measurements, Inc. Model 44-10 Serial No. PR295014

Cal. Date 25-Jun-21 Cal Due Date 25-Jun-22 Cal. Interval 1 Year Meterface 44-10 R

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 40 % Alt 703.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☑ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☐ Geotropism
☑ Audio ck. ☑ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 4.4 VDC
☑ Calibrated in accordance with LMI SOP 14.8 ☑ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 1050 V Input Sens. 10 mV Det. Oper. 1050 V at 10 mV Threshold Dial Ratio = mV

☑ HV Readout (2 points) Ref./Inst. 500 / 495 V Ref./Inst. 1500 / 1508 V

COMMENTS:

```
              Deadtime: 5.4 µSec Overload checked but not set.
  Calibration Constant: 538 e+8  Pulser calibration RATEMETER READOUT performed without deadtime.
         Primary Units: R/hr     Pulser calibration SCALER READOUT reflects 6 second count.
   Primary Units Alarm: 5 mR/hr  Calibrated using 30' C-cable.
       Secondary Units: cpm
 Secondary Units Alarm: 999 kcpm
              Firmware: 49835N34
```

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital	5 mR/hr	6.09 mR/hr	5.03 mR/hr				
Digital	1 mR/hr	1.06	1.01				
	800 µR/hr	847 µR/hr	808 µR/hr				
	200 µR/hr	199	197				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	Scaler REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
800K cpm	799 kcpm	799 kcpm	800K cpm	79.9K	79.9K
200K cpm	199	199	200K cpm	19.9K	19.9K
80K cpm	79.9	79.9	80K cpm	7.99K	7.99K
20K cpm	19.9	19.9	20K cpm	2.00K	2.00K
8K cpm	8.00	8.00	8K cpm	800	800
2K cpm	2.00	2.00	2K cpm	200	200
800 cpm	799 cpm	799 cpm	800 cpm	80	80
200 cpm	201	201	200 cpm	20	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques
All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.
Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2.
The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☑ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ☐ Beta S/N ☑ Other Am241(0.66µCi)

☑ m 500 S/N 251106 ☐ Oscilloscope S/N ☑ Multimeter S/N 15060230

Calibrator James McBeth *James McBeth* Title Calibrator Date 25 JUN 21

QC'd By *[signature]* Title Final QC Date 28 Jun 21

FORM C3000 01/22/2020

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Order #: 20402048/510141

Customer: ENVIRONMENTAL RESTORATION GRP

Detector: 44-10 **Serial No.:** PR295014

Instrument: Model 3000 **Serial No.:** 25017006

BKG Time: 6

Distance: Surface

Selected HV: 1050

Date: Friday, June 25, 2021

Notes: Performed using 30' C-cable.

Signature: James McBride

Channel(s)

Name	Threshold
Channel 1	10 mV

Source(s)

Name	ID	Activity	Time	Type
Am241		0.66 µCi	6	γ

High Voltage	Background	Am241
	Reading	Reading
850	510	9,110
900	513	9,693
950	534	11,242
1000	551	11,633
– 1050	531	11,687
1100	534	11,749
1150	549	11,789
1200	600	12,000
1,250	674	12,016
1,300	1,482	13,018

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25017006
6/25/2021 12:44:31 PM

Device

Device Firmware	5LC-N34.3969
Device Model	Model 3000
Device Serial Number	25017006
Device Real Time Clock Day	25
Device Real Time Clock Hour	12
Device Real Time Clock Minutes	44
Device Real Time Clock Month	6
Device Real Time Clock Seconds	25
Device Real Time Clock Year	2021
Device Real Time Clock Day of the Week	6
Device Backlight Threshold	1
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	120
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	100
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	5
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0

Device Calibration

Device Calibration High Voltage Slope	41
Device Calibration High Voltage Offset	-58
Device Calibration Channel [1] Pulse Threshold Offset	-31

Detector 1

Detector [1] Serial Number	PR295014
Detector [1] Model	44-10
Detector [1] High Voltage	1050
Detector [1] Overload	100
Detector [1] Count Time	60

Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	1
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit 1 Rate Unit Type	9
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	7
Detector [1] Unit 1 Rate Max Range	1
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	5
Detector [1] Unit 1 Rate Alarm Range	1
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	3
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	1
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	0
Detector [1] Unit [2] Rate Min Exponet	0
Detector [1] Unit [2] Rate Max Value	0
Detector [1] Unit [2] Scaler Unit Type	0
Detector [1] Unit [2] Scaler Min Exponet	0
Detector [1] Unit 2 Rate Unit Type	5
Detector [1] Unit 2 Rate Min Range	0
Detector [1] Unit 2 Rate Min Decimal Point	0
Detector [1] Unit 2 Rate Max Value	999
Detector [1] Unit 2 Rate Max Range	1
Detector [1] Unit 2 Rate Max Decimal Point	0
Detector [1] Unit 2 Rate Alarm Value	999
Detector [1] Unit 2 Rate Alarm Range	1
Detector [1] Unit 2 Rate Alarm Decimal Point	0
Detector [1] Unit 2 Scaler Unit Type	1
Detector [1] Unit 2 Scaler Min Range	0
Detector [1] Unit 2 Scaler Min Decimal Point	0
Detector [1] Unit 2 Scaler Alarm Value	0
Detector [1] Unit 2 Scaler Alarm Range	0
Detector [1] Unit 2 Scaler Alarm Decimal Point	0
Detector [1] Unit [3] Rate Unit Type	0
Detector [1] Unit [3] Rate Min Exponet	0
Detector [1] Unit [3] Rate Max Value	0
Detector [1] Unit [3] Scaler Unit Type	0
Detector [1] Unit [3] Scaler Min Exponet	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	5.4
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	0
Detector [1] Channel [1] Calibration Constant	538
Detector [1] Channel [1] Calibration Constant Exponent	8
Detector [1] Channel [1] Efficiency 4pi	15

Designer and Manufacturer of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED CERT # 4084.01

Customer: ENVIRONMENTAL RESTORATION GRP — ORDER NO. 20402991/510773

Mfg. Ludlum Measurements, Inc. — Model 3000 — Serial No. 25018596

Mfg. Ludlum Measurements, Inc. — Model 44-10 — Serial No. PR321872

Cal. Date 12-Jul-21 — Cal Due Date 12-Jul-22 — Cal. Interval 1 Year — Meterface 44-10 R

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 74 °F RH 45 % Alt 707.2 mm Hg

☐ New Instrument — Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity

☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☐ Geotropism

☑ Audio ck. ☑ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 4.4 VDC

☑ Calibrated in accordance with LMI SOP 14.8 ☑ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 950 V Input Sens. 10 mV Det. Oper. 950 V at 10 mV Threshold Dial Ratio = mV

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 1500 / 1498 V

COMMENTS:

```
         Deadtime: 8.5 µSec Calibrated using 5' C-cable.
Calibration Constant: 535 e+8  Alarms disabled.
     Primary Units: cpm      Overload checked but not set.
   Secondary Units: R/hr     Pulser calibration RATEMETER READOUT performed without deadtime.
          Firmware: 49835N34 Pulser calibration SCALER READOUT reflects 6 second count.
```

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital	5 mR/hr	5.17 mR/hr	5.17 mR/hr				
Digital	1 mR/hr	1.04	1.04				
	800 µR/hr	829 µR/hr	829 µR/hr				
	200 µR/hr	197	197				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	Scaler REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
800K cpm	799 kcpm	799 kcpm	800K cpm	79.9K	79.9K
200K cpm	200	200	200K cpm	20.0K	20.0K
80K cpm	79.9	79.9	80K cpm	7.99K	7.99K
20K cpm	20.0	20.0	20K cpm	2.00K	2.00K
8K cpm	8.00	8.00	8K cpm	800	800
2K cpm	2.00	2.00	2K cpm	200	200
800 cpm	799 cpm	799 cpm	800 cpm	80	80
200 cpm	201	201	200 cpm	20	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors. Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521 ☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☑ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982 ☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N — ☐ Beta S/N — ☑ Other Am241(0.66µCi)

☑ m 500 S/N 251106 — ☐ Oscilloscope S/N — ☑ Multimeter S/N 15060230

Calibrator James McBeth *James McBeth* — Title Calibrator — Date 12JUL21

QC'd By *[signature]* — Title Final QC — Date 12 JUL 21

FORM C3000 01/22/2020

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed

Order #: 20402994/510773
Customer: ENVIRONMENTAL RESTORATION GRP
Detector: 44-10 **Serial No.:** PR321872
Instrument: Model 3000 **Serial No.:** 25018596
BKG Time: 6
Distance: Surface
Selected HV: 950
Date: Monday, July 12, 2021
Notes: Performed using 5' C-cable.
Signature: James McBett

Channel(s)

Name	Threshold
Channel 1	10 mV

Source(s)

Name	ID	Activity	Time	Type
Am241		0.66 µCi	6	γ

High Voltage	Background	Am241
	Reading	Reading
700	515	10,405
750	552	11,517
800	510	12,369
850	513	12,746
900	511	12,490
– 950	547	12,580
1000	545	12,694
1050	529	12,782
1100	497	12,734
1150	549	12,795
1200	695	13,529
1,250	1,054	14,498

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25018596
7/12/2021 7:34:23 AM

Device

Device Firmware	5LC-N34.3969
Device Model	Model 3000
Device Serial Number	25018596
Device Real Time Clock Day	12
Device Real Time Clock Hour	7
Device Real Time Clock Minutes	34
Device Real Time Clock Month	7
Device Real Time Clock Seconds	17
Device Real Time Clock Year	2021
Device Real Time Clock Day of the Week	4
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	120
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	100
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	5
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0

Device Calibration

Device Calibration High Voltage Slope	35
Device Calibration High Voltage Offset	-45
Device Calibration Channel [1] Pulse Threshold Offset	5

Detector 1

Detector [1] Serial Number	PR321872
Detector [1] Model	44-10
Detector [1] High Voltage	950
Detector [1] Overload	100
Detector [1] Count Time	60

Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	1
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit 1 Rate Unit Type	5
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	999
Detector [1] Unit 1 Rate Max Range	1
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	1
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	1
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	0
Detector [1] Unit [2] Rate Min Exponet	0
Detector [1] Unit [2] Rate Max Value	0
Detector [1] Unit [2] Scaler Unit Type	0
Detector [1] Unit [2] Scaler Min Exponet	0
Detector [1] Unit 2 Rate Unit Type	9
Detector [1] Unit 2 Rate Min Range	0
Detector [1] Unit 2 Rate Min Decimal Point	0
Detector [1] Unit 2 Rate Max Value	7
Detector [1] Unit 2 Rate Max Range	1
Detector [1] Unit 2 Rate Max Decimal Point	0
Detector [1] Unit 2 Rate Alarm Value	0
Detector [1] Unit 2 Rate Alarm Range	1
Detector [1] Unit 2 Rate Alarm Decimal Point	0
Detector [1] Unit 2 Scaler Unit Type	3
Detector [1] Unit 2 Scaler Min Range	0
Detector [1] Unit 2 Scaler Min Decimal Point	0
Detector [1] Unit 2 Scaler Alarm Value	0
Detector [1] Unit 2 Scaler Alarm Range	1
Detector [1] Unit 2 Scaler Alarm Decimal Point	0
Detector [1] Unit [3] Rate Unit Type	0
Detector [1] Unit [3] Rate Min Exponet	0
Detector [1] Unit [3] Rate Max Value	0
Detector [1] Unit [3] Scaler Unit Type	0
Detector [1] Unit [3] Scaler Min Exponet	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	8.5
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	535
Detector [1] Channel [1] Calibration Constant Exponent	8
Detector [1] Channel [1] Efficiency 4pi	15

Designer and Manufacturer of Scientific and Industrial Instruments

www.ludlums.com

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
501 Oak Street
325-235-5494
Sweetwater, TX 79556, U.S.A.

ACCREDITED CERT # 4084.01

Customer ENVIRONMENTAL RESTORATION GRP ORDER NO. 20402048/510141

Mfg. Ludlum Measurements, Inc. Model 3000 Serial No. 25018557

Mfg. Ludlum Measurements, Inc. Model 44-10 Serial No. PR373528

Cal. Date 25-Jun-21 Cal Due Date 25-Jun-22 Cal. Interval 1 Year Meterface 44-10 R

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 40 % Alt 703.8 mm Hg

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☑ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☐ Geotropism
☑ Audio ck. ☑ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 4.4 VDC

☑ Calibrated in accordance with LMI SOP 14.8 ☑ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 1150 V Input Sens. 10 mV Det. Oper. 1150 V at 10 mV Threshold Dial Ratio ___ = ___ mV

☑ HV Readout (2 points) Ref./Inst. 500 / 494 V Ref./Inst. 1500 / 1495 V

COMMENTS:

```
            Deadtime: 4.4 µSec Overload checked but not set.
Calibration Constant: 536 e+8  Pulser calibration RATEMETER READOUT performed without deadtime.
       Primary Units: R/hr     Pulser calibration SCALER READOUT reflects 6 second count.
 Primary Units Alarm: 5 mR/hr  Calibrated using 15' C-cable.
     Secondary Units: cpm
Secondary Units Alarm: 5 kcpm
            Firmware: 49835N34
```

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source

RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	RANGE MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital	5 mR/hr	6.40 mR/hr	4.78 mR/hr				
Digital	1 mR/hr	1.05		982 µR/hr				
	800 µR/hr	838 µR/hr	785				
	200 µR/hr	200		196				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
Digital Readout	800K cpm	799 kcpm	799 kcpm	Scaler	800K cpm	79.9K	79.9K
	200K cpm	200	200		200K cpm	20.0K	20.0K
	80K cpm	79.9	79.9		80K cpm	7.99K	7.99K
	20K cpm	20.0	20.0		20K cpm	2.00K	2.00K
	8K cpm	8.00	8.00		8K cpm	799	799
	2K cpm	2.00	2.00		2K cpm	200	200
	800 cpm	799 cpm	799 cpm		800 cpm	80	80
	200 cpm	201	201		200 cpm	20	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.
All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.
Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2.
The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☑ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ___ ☐ Beta S/N ___ ☑ Other Am241(~0.66µCi)

☑ m 500 S/N 251106 ☐ Oscilloscope S/N ___ ☑ Multimeter S/N 15060230

Calibrator James McBeth *James McBeth* Title Calibrator Date 25 JUN 21

QC'd By *[signature]* Title Final QC Date 28 Jun 21

FORM C3000 01/22/2020

AC Inst Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ___

Order #: 20402048/510141
Customer: ENVIRONMENTAL RESTORATION GRP
Detector: 44-10 **Serial No.:** PR373528
Instrument: Model 3000 **Serial No.:** 25018557
BKG Time: 6
Distance: Surface
Selected HV: 1150
Date: Friday, June 25, 2021
Notes: Performed using 15' C-cable.
Signature: James McKee

Channel(s)

Name	Threshold
Channel 1	10 mV

Source(s)

Name	ID	Activity	Time	Type
Am241		0.66 µCi	6	γ

High Voltage	Background	Am241
	Reading	Reading
850	482	8,788
900	554	10,673
950	627	12,142
1000	577	12,437
1050	558	12,322
1100	552	12,507
– 1150	517	12,680
1200	533	12,720
1,250	541	12,673
1,300	522	12,461
1,350	520	12,790
1,400	609	12,780
1,450	853	13,122
1,500	1,312	13,988

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25018557
6/25/2021 1:45:19 PM

Device

Device Firmware	5LC-N34.3969
Device Model	Model 3000
Device Serial Number	25018557
Device Real Time Clock Day	25
Device Real Time Clock Hour	13
Device Real Time Clock Minutes	45
Device Real Time Clock Month	6
Device Real Time Clock Seconds	13
Device Real Time Clock Year	2021
Device Real Time Clock Day of the Week	6
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	0
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	0
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	5
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0

Device Calibration

Device Calibration High Voltage Slope	30
Device Calibration High Voltage Offset	-52
Device Calibration Channel [1] Pulse Threshold Offset	-16

Detector 1

Detector [1] Serial Number	PR373528
Detector [1] Model	44-10
Detector [1] High Voltage	1150
Detector [1] Overload	100
Detector [1] Count Time	60

Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	1
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit 1 Rate Unit Type	9
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	7
Detector [1] Unit 1 Rate Max Range	1
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	5
Detector [1] Unit 1 Rate Alarm Range	1
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	3
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	0
Detector [1] Unit [2] Rate Min Exponet	0
Detector [1] Unit [2] Rate Max Value	0
Detector [1] Unit [2] Scaler Unit Type	0
Detector [1] Unit [2] Scaler Min Exponet	0
Detector [1] Unit 2 Rate Unit Type	5
Detector [1] Unit 2 Rate Min Range	0
Detector [1] Unit 2 Rate Min Decimal Point	0
Detector [1] Unit 2 Rate Max Value	999
Detector [1] Unit 2 Rate Max Range	1
Detector [1] Unit 2 Rate Max Decimal Point	0
Detector [1] Unit 2 Rate Alarm Value	500
Detector [1] Unit 2 Rate Alarm Range	1
Detector [1] Unit 2 Rate Alarm Decimal Point	2
Detector [1] Unit 2 Scaler Unit Type	1
Detector [1] Unit 2 Scaler Min Range	0
Detector [1] Unit 2 Scaler Min Decimal Point	0
Detector [1] Unit 2 Scaler Alarm Value	0
Detector [1] Unit 2 Scaler Alarm Range	0
Detector [1] Unit 2 Scaler Alarm Decimal Point	0
Detector [1] Unit [3] Rate Unit Type	0
Detector [1] Unit [3] Rate Min Exponet	0
Detector [1] Unit [3] Rate Max Value	0
Detector [1] Unit [3] Scaler Unit Type	0
Detector [1] Unit [3] Scaler Min Exponet	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	4.4
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	536
Detector [1] Channel [1] Calibration Constant Exponent	8
Detector [1] Channel [1] Efficiency 4pi	15

APPENDIX F

SCANNED FIELD LOGBOOK AND FIELD FORMS

F-1 FIELD LOGBOOK

KILEY PASS ABANDONED URANIUM MINES 2021 FIELD WORK LOGBOOK

Rite in the Rain®
ALL-WEATHER
WORKSITE
LEVEL
№ 1515

AARON ORECHWA P.E.
(970) 420 - 9395

Worksite: RILEY PASS Date: 2021

THIS FIELD LOGBOOK IS INTENDED TO COVER THE FIELD EVENTS IN 2021 RELATED TO THE FOLLOWING EVENTS:

> 2021 BLUFF B, FIELD INVESTIGATION (ISA 1032661) SUBSURFACE, SOIL CORRELATION, OPPORTUNISTIC

> BLUFF J VERIFICATION SAMPLING FOR 2021 (ISA 1037688)

THIS BOOK BELONGS TO

AARON ORECHWA
405 NORTH ROOSEVELT AVE
FORT COLLINS, CO 80521
970 - 420 - 9395
aaron.orechwa@tetratech.com

Rite in the Rain.

Worksite: Date: 7/30/21

FRIDAY, JULY 30, 2021

. FIELD PREP + PRE SURVEYS ON THIS DAY IN FT. COLLINS OFFICE

TWO ERG SCAN SYSTEMS RENTED FOR THIS PROJECT.

"GREEN" SYSTEM

44-10 S/N PR 321872
Model 3000 S/N 25018596
Geode S/N 194576
Mesa S/N 249856
CAL CONSTANT 5.35×10^{10}
→ 891.67 cpm /(μR/hr)

"Yellow" system

44-10 S/N PR 357752
Model 3000 S/N 25020045
Geode S/N 213614
Mesa S/N 228134
CAL CONSTANT 5.49×10^{10}
→ 915.0 cpm /(μR/hr)

END OF FIELD ENTRIES FOR PAGE

Worksite: Date: 7/30/21

FRIDAY, JULY 30, 2021

PERFORMED PRE-SURVEY CALIBRATION CHECKS IN CONTROLLED ENVIRONMENT AT FT. COLLINS TETRA TECH OFFICE

0915 PERFORMED 1,000 BACKGROUND MEASUREMENTS WITH GREEN + YELLOW DETECTORS, AND PERFORMED 1,000 MEASUREMENTS W/A 10 μCi SOURCE OF Cs-137.

ADDITIONAL INSTRUMENTS WERE RENTED FROM ERG FOR DOWNHOLE LOGGING

- Model 3000 S/N 25017006
- Model 3000 S/N 25018557
- 44-10 S/N PR 373528
- 44-10 S/N PR 295014

30' cable
15' cable

Green presurvey file name:
Background: 073021-085315-44
10μCi : 073021-092723-44

Yellow pre-survey file names:
Background: 073021-093532-31
10μCi : 073021-101335-31

END OF ENTRIES FOR 7/30/21

Rite in the Rain.

Worksite: Date:

SUNDAY, AUGUST 1, 2021

- TRAVEL FROM FT. COLLINS to BOWMAN, NORTH DAKOTA.

Met w/ Bill Craig, Braden Bellivear, and Shane Matolyak.

2015 MT

Aaron + Braden performed instrument QC calibration checks on Green and Yellow detectors in designated location in Bowman Travel Lodge parking lot.

Static Background (μR/hr)		Static Cs-137 Source 10μCi (μR/hr)		Field Strip (μR/hr)	
GREEN	Yellow	Green	Yellow	Green	Yellow
8	7	177	174	7	7
8	8	176	180	7	8
8	8	178	175	7	7
8	8	174	172	7	7
8	7	178	178	7	8
7	8	177	170	7	7
8	8	178	173	7	7
8	7	176	176	7	7
8	8	180	178	7	7
8	8	178	170	7	7

END OF ENTRIES FOR 8/1/21

Worksite: Date:

MONDAY, AUGUST 2, 2021 85° Sunny

GOAL: PERFORM VERIFICATION SAMPLING AT BLUFF J INCLUDING GAMMA RADIATION SURVEY + CONFIRMATION SOIL SAMPLING AT PRE-DETERMINED RANDOM GRID SYSTEM.

— "10327688" PROJECT NUMBER —

PRE-QC DAILY CHECKS PERFORMED ON 8/1 EVENING

0630 MET W/TEAM IN LOBBY

0800 ARRIVED AT BLUFF J

- HEALTH & SAFETY MEETING AT BASE CAMP LED BY BILL CRAIG

TOPICS: - WILDLIFE - HYDRATION, HEAT
- SLIPS, TRIPS, & FALLS - COVID
- RADIATION ALARA, METALS - SURVEY DESIGN
- ETC. - COMMUNICATION

- BRADEN + SHANE INITIATED GAMMA SURVEY OF BLUFF J ~0830

- AARON/BILL CONDUCTED VERIFICATION GRID SOIL SAMPLING @ 0830

END OF ENTRIES FOR PAGE

Rite in the Rain

Worksite: Date:

MONDAY, AUGUST 2, 2021
SAMPLE ID "J-VS366-080221"

GRID	Date	Time	DUPLICATE
366	8/2/21	0915	J-DUP-01
362	8/2/21	0925	–
354	8/2/21	0935	–
355	8/2/21	0945	–
345	8/2/21	0955	–
303	8/2/21	1005	–
277	8/2/21	1015	–
259	8/2/21	1025	–
226	8/2/21	1035	–
212	8/2/21	1045	–
180	8/2/21	1055	–
126	8/2/21	1125	–
127	8/2/21	1135	–
117	8/2/21	1145	J-DUP-02
116	8/2/21	1155	
101	8/2/21	1245	
85	8/2/21	1300	
83	8/2/21	1310	
67	8/2/21	1320	
49	8/2/21	1330	

END OF ENTRIES FOR PAGE

Worksite: Date:

MONDAY, AUGUST 2, 2021
CONTINUED SOIL SAMPLE TABLE...

GRID	DATE	TIME	DUPLICATE	
25	8/2/21	1340	–	
24	8/2/21	1350	–	
07	8/2/21	1400	–	
311	8/2/21	1415	–	
266	8/2/21	1455	–	
232	8/2/21	1505	–	
217	8/2/21	1515	–	(NO PHOTO)
169	8/2/21	1525	–	
151	8/2/21	1535	–	
140	8/2/21	1545	–	
143	8/2/21	1555	–	
159	8/2/21	1605	–	
254	8/2/21	1615	–	
270	8/2/21	1625	–	
357	8/2/21	1635	–	

LAST SAMPLE COLLECTED AT 1635.
PHOTO TAKEN OF EVERY SAMPLE LOCATION
BY 40
UAV PHOTOS TAKEN AT END OF DAY

END OF ENTRIES FOR PAGE

Rite in the Rain.

Worksite: Date:

MONDAY, AUGUST 2, 2021

* NOTE ELEVATED AREA WAS DOCUMENTED OUTSIDE OF VERIFICATION SURVEY AREA BOUNDARY AFTER GRID VS311 WAS SAMPLED.
* ADDITIONAL SCANNING WAS PERFORMED, PER GUIDANCE BY AARON, AS WELL AS ADDITIONAL PHOTO & VIDEO DOCUMENTATION.

SCAN FILES FROM YELLOW:

Yellow Cal factor 915 cpm/μR/hr

[Operator: Shane]

080221 - 084023-31
080221 - 810355-31
080221 - 122951-31

SCAN FILES FROM GREEN:

green cal factor 891.67 cpm/μR/hr

[Operator: Braden]

080221 - 084852-44

LEFT SITE @ 1700
ARRIVE @ BOWMAN 1800

PERFORMED DAILY QC CHECKS IN SAME LOCATION AS PRE - CHECKS

END OF ENTRIES FOR PAGE

Worksite: Date:

MONDAY, AUGUST 2, 2021

PERFORMED QC CHECKS @ 1900 FOR GREEN & YELLOW SYSTEMS

Static Background (μR/hr)		Static Cs-137 (μR/hr)		FIELD STRIP (μR/hr)	
GREEN	YELLOW	GREEN	YELLOW	GREEN	YELLOW
8	8	180	169	7	8
8	8	179	180	7	7
8	8	179	170	7	8
8	8	177	168	7	8
8	8	180	171	7	7
8	8	180	173	7	7
8	8	183	182	7	7
8	8	182	171	7	7
8	8	180	167	8	8
8	8	178	173	8	8

Completed post-QC daily checks at 1930 MT

AARON

PERFORMED DATA ANALYSIS /POST PROCESSING IN HOTEL AFTER DINNER (~1-2 hours)

END OF FIELD ENTRIES FOR 8/2/21

END OF BLUFF J SAMPLING

Rite in the Rain.

Worksite: Date:

TUESDAY, AUGUST 3, 2021 90° Sunny, windy

GOAL PERFORM SUBSURFACE TEST PIT INVESTIGATION + LATERAL DELINEATION GAMMA SCANNING AT BLUFF B.

0530 PERFORM QC CHECKS (8/3/21 PRE)

Static Background (µR/hr)		Cs-137 Static µR/hr		Field Strip (µR/hr)	
GREEN	YELLOW	GREEN	YELLOW	GREEN	Yellow
8	8	181	174	7	7
8	9	181	171	7	7
8	8	176	173	7	7
8	8	175	166	8	7
8	7	179	176	7	8
8	8	179	173	7	7
8	8	180	177	7	7
8	8	181	176	7	8
7	8	180	174	8	7
8	8	179	171	7	7

LEFT HOTEL 0630 → USFS TRAILER 0730

IN ADDITION, TO QC CHECKS FOR GREEN + YELLOW SYSTEMS A QUALATATIVE CHECK WAS PERFORMED ON DOWNHOLE METER, (STATIC BG + STATIC CS-137 ONLY)

END OF FIELD ENTRIES FOR PAGE

Worksite: Date:

TUESDAY, AUGUST 3, 2021
@ USFS TRAILER TIME: 0730
QC CHECKS (QUALATATIVE ONLY) FOR
MODEL 3000 25017006 } 30' cable
44-10 PR 295014

Static BG (µR/hr)	Cs-137
14	180
14	179
16	179
15	180
15	177
14	181
14	180
14	177
14	179
14	181

ALSO, PERFORMED QUALATATIVE CHECK ON OTHER "BACKUP" DOWNHOLE METER AT SAME LOCATION AT USFS TRAILER

END OF ENTRIES FOR PAGE

Rite in the Rain

Worksite: Date:

TUESDAY, AUGUST 3, 2021

QC CHECKS (QUALITATIVE) FOR

MODEL 3000 | 250 18557 } 15' cable
44-10 | PR 373528

Static BG µR/hr	Static Cs-137 µR/hr
14	189
13	188
14	185
14	188
13	189
13	186
14	185
13	191
14	187
14	186

DETERMINED BOTH INSTRUMENT RESPONSES WERE COMPARABLE WITHIN LIMITS AND CAN BE USED INTERCHANGEABLY FOR DOWN HOLE GAMMA MEASUREMENTS IF NECESSARY.

END OF ENTRIES FOR PAGE

Worksite: Date:

Tuesday, August 3, 2021

- FINISHED QC & HAD H&S meeting led by BILL CRAIG ON H&S FIELD FORM.
- LEFT TRAILER

BRADEN & SHANE PERFORMED SCANNING IN GOBACK AREAS, AARON & BILL MET WITH EXCAVATION UNIT FOR TEST PITS.

ARRIVE @ TP-01 0830 MT (OLD TP-12)

Took photos w/camera & drone.
GPS collected at center of test pit.
DOWN HOLE GAMMA collected; (unshielded)

Depth (bgs)	Gamma (µR/hr)	
SURFACE (1m)	113	TOTAL DEPTH = 11 feet
1	107	(Bedrock @ 11')
2	92	NOTE: Elevated waste
3	87	material at surface
4	77	followed by lower grade
5	73	waste material 0-7.5'.
6	75	LIGNITE 7.5'-11' (native)
7	70	Samples — As
8	68	TP01-SURF-080321 — 1138 ppm
9	72	TP01-(5'-6')-080321 — 220 ppm
10	77	TP01-(7.5'-8')-080321 — 805 ppm

END OF FIELD ENTRIES FOR DAY

Rite in the Rain

Worksite: Date:

TUESDAY, AUGUST 3, 2021

ARRIVED AT TP-02 @ 0930

TP02 (is OLD TP-11) has similar surface material as TP-01.

GPS/Photos/Video collected at TP-02.
Surface Gamma at 1m is 157 µR/hr and 675 ppm arsenic.
→ TP02-SURF-080321

Depth ft (bgs)	Downhole Gamma (µR/hr)	
1	264	
2	275	
3	294	TP02-(3'-4')-080321 561 ppm As
4	225	
5	225	
6	175	
7	166	
8	155	
9	150	
10	125	
11	112	TP02-(10'-11')-080321 117 ppm
12	111	
13	146	
14	123	
15	121	
16	168	* Bedrock at 16 feet *

Waste material 0'-5' loose silty sand;
Waste material 5'-16' consolidated more clayey
Could be same material, check lab results.

END OF FIELD ENTRIES FOR PAGE

Worksite: Date:

TUESDAY, AUGUST 3, 2021

ARRIVED AT TP-03 (old TP-10); GPS/Photo/Video

Surface Gamma at 1m is 43 µR/hr and 232 ppm As

0-4 ft grey silt/clay w/ broken grey mudstone and siltstone fragments

4-14 ft Mixture of lignite and silt/clay spoils waste rock

14-19 ft yellow/tan sandy silt (unconsolidated native?)

Depth ft (bgs)	Downhole Gamma (µR/hr)	
1	47	
2	53	
3	65	
4	70	
5	75	TP03-(5'-6')-080321 262 ppm As
6	82	
7	72	
8	73	
9	55	
10	53	
11	53	
12	50	
13	51	
14	38	TP03-(14'-15')-080321 23 ppm As
15	34	TP-DUP-01 -080321
16	34	

END OF ENTRIES FOR PAGE

Rite in the Rain

Worksite: Date:

TUESDAY, AUGUST 3, 2021

ARRIVE at TP-04 1115 MT

Surface Gamma 28 µR/hr & 147 ppm As

Depth ft bgs	Gamma µR/hr	
1	38	TP04-(SURF)-080321
2	30	
3	45	
4	45	
5	49	TP04-(5'-6')-080321 - 91 ppm As
6	53	
7	58	
8	61	
9	55	
10	65	
11	71	
12	65	
13	59	
14	53	
15	48	TP04-(15'-16')-080321 46 ppm As
16	47	(native?)

0-15 intermixed spoils/waste
15-16 native

This TP shows not all waste on top bluff B is elevated but can be borderline for Ra-226 or As; and native also detectable.

END OF ENTRIES FOR PAGE

Worksite: Date:

TUESDAY, AUGUST 3, 2021

Arrive at TP-05 at 1230 MT (old TP-9 in SAP)

Test pit was moved from TP-9 position to lignite/spoils zone at lower elevation area w/higher gamma.

Surface gamma (1 m) is 108 µR/hr Arsenic = 283 ppm

Depth ft bgs	Gamma µR/hr	
1	168	TP05-(SURF)-080321 (283 ppm As, 108 µR/hr)
2	210	lignite, coal silt — Top sample is assumed to represent entire test pit to 18' bgs.
3	217	
4	194	
5	221	
6	333	
7	500	Lignite mixed w/ silty greyish brown clay
8	256	
9	263	
10	388	
11	285	
12	179	Assumption is 0-18 ft is waste material.
13	138	
14	115	
15	87	
16	78	
17	No Measurement	
18		TP05-(18'-19')-080321 34 ppm
19		

END OF ENTRIES FOR PAGE

Rite in the Rain

Worksite: Date:

TUESDAY, August 3, 2021

Arrive at TP06 at 1330 MT (old TP13)

Surface gamma 69µR/hr @ 1m; 117ppm As

Depth bgs ft	Gamma µR/hr	
1	239	TP06-(SURF)-080321 [69µR/hr 117ppm As]
2	298	
3	280	0-12' mine waste/spoils
4	233	12-16 lignite/spoils mix
5	229	
6	238	16+ yellowish tan sand and sandstone w/clay
7	188	
8	165	
9	155	
10	148	
11	163	TP06-(11'-12')-080321 [36ppm 258µR/hr]
12	258	
13	232	
14	133	
15	92	
16	82	
17	No measurement	TP06-(17'-18')-080321 [17ppm 82µR/hr]
18		

END OF ENTRIES FOR PAGE

Worksite: Date:

TUESDAY, AUGUST 3, 2021

ARRIVE @ TP-07 at 1500 (OLD TP-15)

LOCATED OFF ROAD NEAR POND.

TEST PIT EXCAVATION FOUND Bedrock at 2' bgs and only surface sample was collected.

TP07-(SURF)-080321

Surface Gamma at 1m was 35 µR/hr and Arsenic (XRF) was 264 ppm.

No additional samples were collected at TP-07.

LEFT AT 1510.

END OF ENTRIES FOR PAGE

Rite in the Rain.

Worksite: Date:

TUESDAY, AUGUST 3, 2021

ARRIVE @ TP-08 at 1515 MT

Vegetated at surface on what appears to be spoils

Gray soil w/sparse coverage of orange/tan rocks.

Surface gamma (1m) = 22 μR/hr ; 235 ppm (As)

Depth ft bgs	Gamma μR/hr		
1	↑	TP08-(SURF)-080321	(235 ppm) As
2			
3	No gamma		
4	unsafe		
5			
6			
7			
8			
9		TP08(9'-10')-080321	22 ppm As
10			
11			
12			
13			
14	↓		

Test pit collapsed; possible sediment pond materials (liquefaction occurred) too dangerous to gamma scan. 2 soil Samples collected.

END OF ENTRIES FOR PAGE

Worksite: Date:

TUESDAY, AUGUST 3, 2021

Arrive at TP-09 at 1620 MT.

Vegetated with sparse rabbit brush and sage brush.

Surface gamma (1m) is 26 μR/hr w/ 163 ppm As.

Depth ft bgs	Gamma μR/hr	
1	26	TP09-(SURF)-080321 [26 μR/hr 163 ppm As]
2	24	
3	22	
4	22	
5	24	
6	23	TP09-(6'-7')-080321 [39 ppm As]
7	24	
8	25	
9	25	~~TP09~~
10	24	
11	25	0-2.5 feet dark gray/silt/fill Spoils gravelly silt w/rock fragments
12	25	
13	26	2.5-15 feet yellowish ~~gray~~ brown silty clay w/rock fragments, compact
14	26	
15	26	

END OF ENTRIES FOR PAGE

Rite in the Rain.

Worksite: Date:

TUESDAY, AUGUST 3, 2021

NOTES: ELIMINATED TP-17, TP-18, + TP-19 because we know the surface levels and these were small waste piles w/obvious bedrock setting. We can use DEM to estimate these volumes. We flew drone to document this.

TP-09 was added to the cliff side as it appeared waste materials had been pushed over the side. For TP-09, the uppermost layer was arsenic laden to 2.5 feet either native (unlikely) or fill (TENORM) rest of test pit from 2.5'-15'.

Scan files

Yellow: 080321-081322-31.gsf (Shane)

Green: 080321-072610-44.gsf

LEFT SITE @ 1730

ARRIVE @ HOTEL 1830

END OF ENTRIES FOR PAGE

Worksite: Date:

TUESDAY, AUGUST 3, 2021

PERFORMED 8/3/21 POST QC ON GREEN + Yellow instruments at parking lot @ 1830

Static BG μR/hr		Static Cs-137 μR/hr		Field Strip μR/hr	
Green	Yellow	Green	Yellow	Green	Yellow
8	AO ~~8~~ 7	173	175	7	7
8	8	172	177	7	7
8	AO ~~8~~ 7	175	169	7	7
8	AO ~~8~~ 7	172	175	7	7
8	AO ~~8~~ 7	172	174	7	7
8	8	173	168	7	7
8	8	171	171	7	7
8	8	177	166	8	7
8	8	172	175	8	7
8	9	170	170	8	7

Post data analysis performed by AO in hotel 1900-2100

END OF FIELD ENTRIES FOR 8/3/21

Rite in the Rain.

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021 80°F Sunny

GOAL Continue subsurface investigati[on] + lateral delineation gamma scan + soil sampling.

@0530 Conducted 8/4/21 pre-survey QC measurements:

Static BG μR/hr		Static Cs-137 μR/hr		Field Strip μR/hr	
Green	Yellow	Green	Yellow	Green	Yellow
8	7	173	168	7	7
8	8	171	172	7	6
8	8	170	174	7	7
8	8	175	169	7	7
8	7	172	171	7	7
8	8	169	174	8	7
8	8	172	178	7	7
8	8	175	171	7	7
8	8	170	170	8	8
8	8	172	169	8	7

LEFT HOTEL @ 0600
ARRIVE @ USFS TRAILER @ 0700
H&S meeting; Go over objectives

END OF FIELD ENTRIES FOR PAGE

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021

Arrive @ BENFB B @ 0800 performed Recon at (old TP22); decided against TP21

ARRIVE @ TP-10 @ 0815

Flew drone over region; collected GPS/Photos

Surface gamma 16 μR/hr (1m); 22ppm As

Depth ft bgs	Gamma μR/hr	
		TP10-(SURF)-080421 [16 μR/hr 22 ppm As]
1	26	
2	30	
3	33	
4	37	
5	42	
6	48	TP10-(6'-7')-080421 [19ppm 48μR/hr]
7	51	
8	56	
9	66	* most waste/spoils 0-15 (dryo-2)
10	75	* low level spoils
11	86	* natural lignite at 15' (seam)
12	102	elevated Ra-226 + As suspected
13	125	
14	166	
15	303	TP10-(15'-16')-080421 [303 μR/hr 320 ppm As]
16	120	

END OF ENTRIES FOR PAGE

Rite in the Rain

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021

ARRIVE @ TP11 @ 0930 MT

This pit was selected because it was same material composition as TP10 but at a different elevation (higher up). *Rattlesnake* Lots of vegetation

The area here is suspected to contain intermixed spoils & low level (<AK) waste material highly vegetated; level above TP10.

TP11-(SURF)-080421 [@ 1m 15 μR/hr 49 ppm]

Depth ft bgs	Gamma μR/hr	
1	19	dry material 0-3'
2	20	
3	20	
4	21	TP11-(5'-6')-080421 (represents entire pit) 210 ppm As
5	22	
6	22	3'-10 nasty, wet, liquifaction old pond material?
7	24	
8	27	
9	27	
10	28	
11	26	

END OF ENTRIES FOR PAGE

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021

ARRIVE @ TP12 1045 MT (OLD TP23)

This is a waste pile which is isolated, found hottest spot in area.

Surface gamma 122 μR/hr; 440 ppm As

Orange rock, sparse vegetation

TP12-(SURF)-080421

Depth ft bgs	Gamma μR/hr
1	175
2	142
3	138
4	175
5	107
6	88
7	70
8	58
9	49
10	47
11	47
12	45
13	51
14	51
15	53

END OF ENTRIES FOR PAGE

Rite in the Rain.

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021 [Eliminate TP21]

* ARRIVE @ 1150 to TP13 *

Located on a finger mesa of Bluff B w/spoils material ZAL to see subsurface.

Surface (1m) Gamma 18 µR/hr ; 51 ppm As

Depth ft bgs	Gamma µR/hr	
		TP13-(SURF)-080421
1	43	
2	59	
3	101	
4	95	
5	96	
6	101	TP13-(6'-7')-080421 [115 µR/hr]
7	115	
8	136	
9	157	
10	200	
11	242	
12	300	
13	527	~bedrock~

0-3	spoils
3-12	waste w/lignite
12-14	waste (?)
>14	bedrock

END OF ENTRIES FOR PAGE

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021

ARRIVE @ TP14 @ 1500

GOAL OF THIS PIT WAS TO EVALUATE THE BASE OF THE EASTERN BLUFF WASTE MATERIAL ANGLE OF REPOSE TO EVALUATE SUBSURFACE CONTAMINATION & SURFACE CONTAMINATION, ASWELL.

SURFACE (1m) GAMMA ~28 µR/hr ; 69 ppm As

Depth ft bgs	Gamma µR/hr	
		TP14-(SURF)-080421
1	29	
2	28	
3	27	
4	28	TP14-(4'-5')-080421 (9 ppm As)
5	29	NOTE! ① use slope angle of repose for calcs parallel w/native sandstone
6	29	② use surface sample/gamma for YAV calc.

0'-2.5' OUTWASH FROM CLIFF DUMP lt. brown dry loose silty sand w/loose silty sand

2.5'-6' Native material yellowish tan fine sand w/silt ; slightly moist to moist

*NOTE gamma level in hole is higher than natural background on surface due to geometry of hole and detector

Note: drainage to north of pit has >47 µR/hr when detector dropped down

END OF ENTRIES FOR PAGE

Rite in the Rain.

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021

ARRIVE TO TP15 @ 1550

TP15 is very similar situation to TP14 but slightly south.

SURFACE GAMMA 30μR/hr As = 61 ppm

DEPTH ft bgs	Gamma μR/hr	
		TP15-(SURF)-080421
1	28	
2	25	
3	26	
4	27	TP15(3'-4')-080421 (<9ppm As)
5	25	

0'-2' outwash (same as TP14)

2'-4' e.o.b native (same as TP14)

> Test pit halted once native material was reached.

No other proposed test pits were evaluated on Eastern Bluff B due to cultural concerns, access, and safety.

* Began to rain during last test pit

Left site @ 1700

Arrive @ hotel 1800

END OF ENTRIES FOR PAGE

Worksite: Date:

WEDNESDAY, AUGUST 4, 2021

PERFORMED POST-8/4 QC CHECKS AT BOWMAN LODGE HOTEL @ 1815

Static BG μR/hr		Static Cs-137 μR/hr		Field Strip μR/hr	
Green	Yellow	Green	Yellow	Green	Yellow
8	7	170	172	7	8
8	8	169	175	7	8
8	8	172	172	7	8
7	7	171	177	7	7
8	8	175	169	7	8
8	8	173	171	7	8
8	7	171	177	7	7
8	8	174	167	7	7
8	7	174	176	7	8
8	7	174	175	8	7

FINISHED QC CHECKS FOR 8/4/21 at 1845; FINISHED FOR DAY but met w/Braden & Shane to collect opportunistic soil sampling INFORMATION (ON Next page)

END OF ENTRIES FOR PAGE

Rite in the Rain.

Worksite:
Date:

WEDNESDAY, AUGUST 4, 2021

Scan files for 8/4

Yellow (Shane)

080421 - 073411 - 31

080421 - 113405 - 31

Green (Braden)

080421 - 075408 - 44

080421 - 092106 - 44

080421 - 103737 - 44

DURING THE DAY, BRADEN + SHANE CONDUCTED GAMMA SCANNING OF THE NORTH & SOUTH DATA GAP AREAS, THEY ALSO COLLECTED THE FOLLOWING SOIL SAMPLES:

ID	TIME
OPP-1-080421	1245
OPP-2-080421	1300
OPP-3-080421	1305
OPP-4-080421	1315
OPP-5-080421	1330
OPP-6-080421	1335 > same
OPP-DUP-080421	1335
OPP-7-080421	1340
OPP-8-080421	1350

Note: Shane sent Aaron photos of "OPP" samples.

END OF FIELD ENTRIES FOR 8/4/21

Worksite:
Date:

THURSDAY, AUGUST 5, 2021 85° Sunny

QC CHECKS PERFORMED FOR PRE-8/5 @ 0730, FOR GREEN + YELLOW INSTRUMENTS.

Static BG µR/hr		Static Cs-137 µR/hr		FIELD STRIP µR/hr	
GREEN	YELLOW	GREEN	YELLOW	GREEN	YELLOW
8	8	173	171	8	7
8	7	171	173	7	8
8	8	172	169	8	7
8	8	175	165	8	8
8	8	172	171	8	8
8	8	173	177	8	7
8	8	175	170	8	7
8	8	173	173	8	7
8	7	171	168	7	7
8	7	172	174	8	7

Completed QC checks at 0815

LEFT HOTEL @ 0830

ARRIVE @ USFS ~0930

H&S meeting w/USFS employee

GOAL: PERFORM GAMMA - RADIUM CORRELATION STUDY

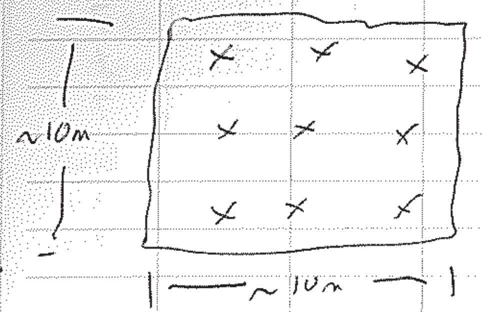
END OF ENTRIES FOR PAGE

Rite in the Rain.

Worksite: Date:

THURSDAY, AUGUST 5, 2021

NOTE: All correlator plots were pre-sel by lead RAD engineer and consisted of 100% gamma scan w/ and w/o shield.
A 9-point composite sample was collected at each plot as follows:



- Ideally photo, GPS, and drone video of each plot is desired.

CORR1-080521 (DUP collected)
@1015

Background Sample - off site

12-13k cpm at plot (2-3k shielded)

LEFT PLOT @ 1030 (11 μR/hr)

END OF ENTRIES FOR PAGE

Worksite: Date:

THURSDAY, AUGUST 5, 2021

CORR 02-080521 ST: 1050

ALSO BACKGROUND SAMPLE BUT WITHIN BOUNDARY OF BLUFF B; NEAR ROAD

12-14k cpm (14 μR/hr)

CORR 03-080521 ST: 1110

LOCATED ON MINE SITE; BACKGROUND LEVEL, BUT POTENTIALLY DISTURBED; SLIGHTLY HIGHER THAN CORR 2 (?)

~19 μR/hr

CORR 04-080521 ST: 1140

LOCATED ON MAN MADE BERM

BROWN, DRY, LOOSE MATERIAL

CORR 05-080521 ST: 1210

ALSO LOCATED ON BERM, NEAR CORR 04

FINE SAND

CORR 06-080521 ST: 1225

(FORGOT GPS!) MINE WASTE, grayish clay above CLIFF ON FLAT AREA (30-40k cpm)
(8-10k cpm) shielded

END OF ENTRIES FOR PAGE

Rite in the Rain

Worksite: Date:

THURSDAY, AUGUST 5, 2021

CORR07-080521 ST: 1240

~SCK LOCATED ON WASTE MATERIAL ON TOP OF BLUFF B

CORR08-080521 ST: 1255

Sandy silt, O.2L1 brwn

Spoils waste

CORR09-080521 ST: 1305

Drone piclure, GPS

TOP OF BLUFF

CORR10-080521 ST: 1315

LOCATED ON TOP OF BLUFF B

SPOILS MATERIAL → Sandy silt

CORR11-080521 ST: 1330

LOCATED IN DRIED POND

POND SEDIMENT MATERIAL; MORE MOIST BUT CRUST WAS DRY silty clay

CORR12-080521 ST: 1350

Clear waste rock/material

dark brown sandy silt w/iron oxide stained pebbles on surface

END OF ENTRIES FOR PAGE

Worksite: Date:

THURSDAY, AUGUST 5, 2021

CORR13-080521 ST: 1410

ON ROAD NEAR TEST PITS THAT WERE ELIMINATED

silty sand, dry, light grey loosely compacted

CORR14-080521 ST: 1430

LOCATED UP ON HILL ABOVE POND; SAME AREA AARON DID DAILY MOISTURE CHECKS DURING JULY 2021 UAV STUDY; LOCATED NEAR TP-68 (CHECK RA-226 VALUES)

sandy silt, dark brown on mine waste pile (low level?)

CORR15-080521 ST: 1445

Adjacent to sediment pond; Sandy silt w/small rock fragments

LEFT SITE TO TRAILER @ 1445

ARRIVE @ TRAILER @ ~1500

END OF ENTRIES FOR PAGE

Rite in the Rain

Worksite: Date:

THURSDAY, AUGUST 5, 2021
LEFT SITE @ 1530
ARRIVE @ HOTEL 1630

PERFORMED POST - 8/5 QC CHECKS
FOR GREEN & YELLOW (FINAL OF PROJ

Static Background µR/hr		Static Cs-137 µR/hr		FIELD STR µR/hr	
GREEN	YELLOW	GREEN	YELLOW	GREEN	YELL
8	8	182	173	8	[illegible]
8	8	180	168	8	[illegible]
8	8	176	173	8	[illegible]
8	8	174	169	8	[illegible]
8	8	173	177	7	8
8	7	176	179	7	8
8	7	180	177	8	7
8	8	179	171	7	7
9	8	180	178	8	8
8	8	182	172	8	7

COMPLETED QC CHECKS @ 1700
AARON/BILL ORGANIZED SOIL SAMPLES
1700 - 1800 MT

END OF FIELD ENTRIES
FOR 8/5/21

Worksite: Date:

FRIDAY, AUGUST 6, 2021

LEFT BOWMAN, ND @ 0700
ARRIVED IN FT COLLINS @ 1345

DROPPED OFF SOIL SAMPLES
FOR BLUFF J & BLUFF B
w/ ALS LABORATORY IN
FT COLLINS, COLORADO.

Scan files from 8/5
Green (shielded) Braden 080521 - 100779-44
080521 - 101349-44
080521 - 113003-44
Yellow unshielded (Aaron) 080521 - 101013-31
080521 - 113138-31

END OF FIELD
ENTRIES FOR
8/6/21 & FIELD PROJECT

AARON ORESCHAK P.E.

Rite in the Rain.

Worksite: Date:

SUNDAY, AUGUST 8, 2021

AARON PERFORMED POST SURVEY QC AT FT COLLINS OFFICE.

THIS WAS SAME AS PRE-SURVEY QC CHECKS, WHICH CONSISTED OF 1,000 STATIC BACKGROUND + 1,000 10 μCi SOURCE FOR GREEN + YELLOW DETECTORS.

SCAN FILES FOR POST-SURVEY ARE AS FOLLOWS:

YELLOW

080821 - 010548-31.gsf Background
080821 - 124750-31.gsf 10μCi

GREEN

080821 - 124248-44.gsf 10μCi
080821 - 013615-44.gsf Background

AARON ORECCHIA pos
END OF ENTRIES FOR 8/8/21 & PROJECT

Worksite: Date:

Rite in the Rain.

F-2 CORRELATION FIELD FORMS

9 pt. Comp.

Gamma Correlation Soil Field Form

Site Type

Site Name Bluff B Subsurfa

Tetra Tech ID

Sampling Team Aaron O. / Bill C.

Pag No.:

Date: 8/5/21

Weather: Cloudy

GPS Color

Example Sample ID:

Example Duplicate ID:

Plot Location	Date (M/D/Y)	Time (MST)	Sample ID	Lab Sample Duplicate Collected (Y or N)	Duplicate ID	HPIC Value (μR/Hr)	Notes
native CORR01	8/5/21	10:15	CORR01-080521	Y	CORR-(DUP1)-080521		~11 μR/hr; silty loam; light tan
native CORR02	8/5/21	10:50	CORR02-080521	N	–		light tan sandy silty loam 14 μR/hr
spoils/waste CORR03	8/5/21	11:10	CORR03-080521	N	–		sandy silty loam 19 μR/hr surface w/ iron oxide coated gravels
Berm ~~S/W~~ CORR04	8/5/21	11:40	CORR04-080521	N	–		Berm Material - Brown, dry, loose fine sand
Berm ~~S/W~~ CORR05	8/5/21	12:10	CORR05-080521	N	–		Berm Material - fine sand
S/W CORR06	8/5/21	12:25	CORR06-080521	N	–		Sandy silt, loose, dry, light brown
S/W CORR07	8/5/21	12:40	CORR07-080521	N	–		Sandy silt, light brown, dry loosely compacted
S/W CORR08	8/5/21	12:55	CORR08-080521	N	–		Sandy silt, light brown
S/W CORR09	8/5/21	13:05	CORR09-080521	N	–		Sandy silt w rock fragments brown, dry, loosely compacted
S/W CORR10	8/5/21	13:15	CORR10-080521	N	–		Sandy silt spoils

Notes to field team:

Record the centroid of each plot on the Trimble GPS Unit

All correlation samples are nine-point composite samples of 0" to 6"

9 point composit

Site Type Bluff B Subsorface

Site Name

Tetra Tech ID

Sampling Team Aaron O. / Bill C

Pag No.:

Gamma Correlation Soil Field Form

Date: 8/5/21

Weather: Clear

GPS Color

Example Sample ID:

Example Duplicate ID:

	Plot Location	Date (M/D/Y)	Time (MST)	Sample ID	Lab Sample Duplicate Collected (Y or N)	Duplicate ID	HPIC Value (µR/Hr)	Notes
Pond Sediment	CORR 11	8/5/21	13:30	CORR11-080521	N			Pond sediment / pond crust Silt/Clay
Mine waste	CORR 12	8/5/21	13:50	CORR12-080521	N		mine waste	Dark brown sandy silt w/ iron oxide stained pebbles on surface
Spoils?	CORR13	8/5/21	14:10	CORR13-080521	N			Silty sand, dry, light grey loosely compacted
m/w	CORR 14	8/5/21	14:30	CORR14-080521	N			on mine waste pile. Sandy silt Dark brown
spoils?	CORR 15	8/5/21	14:45	CORR15-080521	N			Adjacent to sediment pond Sandy Silt w/ small rock fragments

Notes to field team:

Record the centroid of each plot on the Trimble GPS Unit

All correlation samples are nine-point composite samples of 0" to 6"

F-3 TEST PIT FIELD FORMS

TETRA TECH

NE BLUFF B TEST PIT # TP01

(Page 1 of 1)

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started 8/2/21
Date Completed 8/3/21
Test Pit Length 15
Test Pit Width 8

Sampling Method excavator
Northing Coord GPS'd
Easting Coord
Logged By Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Surface Sample TP01-(SURF)-080321 Oxidized Sandstone 0-6" Chocolate brown spoils/waste rock	0"	TP01-(SURF)-080321 1138		~~749~~ 113
2.5						
5			5-6	TP01-(5'-6')-080321		74
7.5		Lignite seam (6" thick) in grey clay (native)	7.5-8	TP01-(7.5'-8.0')-080321		70
10		Sandstone bedrock 11' bgs				
12.5						
15		Contaminated to 11 ft				
17.5						
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTt - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP02

USFS Custer Gallatin National Forest Riley Pass Uranium Mines Site North Cave Hills Area, Harding, SD	Date Started 8/3/21 Date Completed 8/3/21 Test Pit Length 15 Test Pit Width 8	Sampling Method EXCAVATOR Northing Coord GPS Easting Coord Logged By Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		TP02 -(SURF)- 080321 0-6" oxidized sandstone broken rock 6" - waste rock/spoils Mixture of silt, sand, stonestone fragments loose	0"	TP02-(SURF)-080321	575ppm	157 uR
2.5						
			3-4	TP02-(3'-4')-080321	501ppm	294uR
5		waste rock/spoils higher clay content and soil moisture, compact/denser				
7.5						
10			10-11	TP02-(10'-11')-080321	117ppm As	125 uR/hr
12.5						
15		Sandstone bedrock 16' bgs				
17.5						
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTt - Test Pit Log.bor

TETRA TECH	NE BLUFF B TEST PIT # TP03 (Page 1 of 1)	
USFS Custer Gallatin National Forest Riley Pass Uranium Mines Site North Cave Hills Area, Harding, SD	Date Started 8/3/21 Date Completed 8/3/21 Test Pit Length 15 Test Pit Width 8	Sampling Method EXCAV Northing Coord GPS'd Easting Coord Logged By B. Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Grey sandy silt w/ oxidized gravel at surface. Light grey silt/clay/mudstone Spoils. Loose and dry	0"	TP03-(Surf)-080321	232 ppm	47 uR/hr
4'		- - - - - - - - - - - -				
5		Intermixed spoils and lignite. Spoils consist of moist to slightly moist grey clay/silt (compact/dense)	5-6	TP03-(5'-6')-080321	262 ppm	18 uR/hr
14'		- - - - - - - - - - - -				
15		Yellowish tan sand/silt Moist, loosely compacted (Unconsolidated Native)	14-15	TP03-(14'-15')-080321	22 ppm	38 uR/hr
		TD ~16 ft				
20		TP-(DUP)-01 Duplicate of TP03-(14'-15')-080321				

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTt - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP04

(Page 1 of 1)

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started 8/3/21
Date Completed 8/3/21
Test Pit Length 15' x 5'
Test Pit Width

Sampling Method EXCAVATOR
Northing Coord. GPS'd
Easting Coord.
Logged By Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Grey sand silt w oxidized gravel and rock fragments 0-6"	0"	TP04-(SURF)-080321	147ppm	28 uR/hr
		6" - 4' Loosely compact spoils brown sandy silt w/ rock fragments				
2.5						
4		Waste/spoils, compact and moist sandy, silty clay with rock fragments	5-6	TP04-(5'-6')-080321	91ppm	49 uR/hr
5						
7.5						
10						
12.5						
15		Light brown to tan v. fine sand with silt (Native?)	15-16	TP04-(15'-16')-080321	46ppm	48 uR/hr
17.5		TD ~17 ft				
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTt - Test Pit Log.bor

TETRA TECH	NE BLUFF B TEST PIT # TP05 (Page 1 of 1)

USFS Custer Gallatin National Forest Riley Pass Uranium Mines Site North Cave Hills Area, Harding, SD	Date Started 8/3/21 Date Completed 8/3/21 Test Pit Length 15 ft Test Pit Width 5 ft	Sampling Method EXCAVATOR Northing Coord. GPS'd Easting Coord. Logged By Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		0 - 6" Lignite and silt		TP05-(SURF)-080321	283	108
		6"-4' Lignite coal, dry platey / fissile				168
2.5						
5		4'-18' Mixed Lignite and waste soils/spoils Alternating thin bedded mixture of lignite and moist silty greyish brown clay				24
7.5						500
10						
12.5						179
15		Assumption is that it is dirty from GS to ~18 feet bgs				
17.5						78
20		yellow tan sand grading to yellow to reddish tan sandstone (Native) TD 19 ft	18-19	TP05-(18'-19')-080321		78 34ppm As

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aT1 - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP06

(Page 1 of 1)

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started 8/3/21
Date Completed 8/3/21
Test Pit Length 15 ft
Test Pit Width 5 ft

Sampling Method EXCAVATOR
Northing Coord. GPS'd
Easting Coord.
Logged By Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Mine waste / spoils mixture of sand, Silt/Clay and broken ~~sandstone~~ sandstone		TP06-(SURF)-080321	117 ppm As	69 uR/hr
2.5						
5						
7.5						
10						
		Lignite / Clay Spoils mixture	11-12	TP06-(11'-12')-080321	36 ppm	258 uR/hr
12.5						
15						
		Silty Sand / Sandstone mixture (Native)	17-18	TP06-(17'-18')-080321	17 ppm	82 uR/hr
17.5						
20		TD 19 ft				

Assume mine waste to 16 ft bgs

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aT1 - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP07

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USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started	8/3/21	Sampling Method	EXCAVATOR
Date Completed	8/3/21	Northing Coord	GPS'd
Test Pit Length	15 ft	Easting Coord	
Test Pit Width	5 ft	Logged By	Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		0 - 2 ft Brown sandy silt spoils and lignite mixture	0-6"	TP07-(SURF)-080321		
2.5		2 ft + yellowish tan sandstone (Native)				
5						
7.5						
10						
12.5						
15						
17.5						
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTt - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP08

(Page 1 of 1)

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started	8/3/21	Sampling Method	EXCAVATOR
Date Completed	8/3/21	Northing Coord.	GPS'd
Test Pit Length	15 ft	Easting Coord.	
Test Pit Width	5 ft	Logged By	Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		0 - 1.0 Cover! or Mine waste/spoils. Dry/loose	0-6"	TP08-(SURF)-080321	235ppm	22uR/hr
2.5		1.0-14.0ft Pond sediment placed in repository against Cliff face.				
5		Test pit unsafe to gamma scan due to large blocks of sidewall collapsing (No gamma scan)				
7.5						
10			9-10	TP08-(9'-10')-080321		
12.5		Test pit 8A to 3ft bgs XRF'd sidewalls As contaminated Soil at surface to 1.5 ft bgs and clean below				
15						
17.5						
20						

Excavation into suspected pond sediment clean-out material. Pit is caving in & very unstable. No downhole data collected.

10-08-2019 C:\Users\natalie.morrow\Documents\W-Tech\samples_aTt - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP9

(Page 1 of 1)

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started	8/3/21	Sampling Method	Excavator
Date Completed	8/3/21	Northing Coord.	GPS'd
Test Pit Length	15 ft	Easting Coord.	
Test Pit Width	5 ft	Logged By	Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Dark chocolate brown spoils Consisting of Sandy silt w rock fragments	0-6"	TP09-(SURF)-080321	163 ppm	26 uR/hr
2.5		2.5 ft to 18 ft Yellowish brown spoils consisting of Sandy Silty clay w/ Angular rock fragment				
5			6-7'	TP09-(6'-7')-080321	39 ppm As	23 uR/hr
7.5						
10						
12.5		Conclusion - 2 types of fill/ Mine waste. Upper fill to 2.5 ft bgs contains Arsenic over Standard while underlying yellowish Brown mine waste				
15						
17.5		TD = 18.0				
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTI - Test Pit Log.bor

TETRA TECH	NE BLUFF B TEST PIT # TP10 (Page 1 of 1)

USFS Custer Gallatin National Forest Riley Pass Uranium Mines Site North Cave Hills Area, Harding, SD	Date Started 8/4/21 Date Completed 8/4/21 Test Pit Length 15 ft Test Pit Width 5 ft	Sampling Method Excavation Northing Coord. GPS'd Easting Coord. Logged By Bill Grey

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Waste rock/soil spoils Dry and somewhat loosely compacted to 2 ft bgs Moisture content increasing below to 2 ft; more compact	0-6"	TP10-(SURF)-080421	22 ppm As	15 uR/hr
2.5						
5						
			6-7	TP10-(6'-7')-080421		
7.5						
10						
12.5						
15			15-16	TP10-(15'-16')-080421	320 ppm As	
		Lignite (Black coal)				
		Brown moist sand w/ silt TD- 19 ft				
17.5						
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aT1 - Test Pit Log.bor

825 845 830

TETRA TECH

NE BLUFF B TEST PIT # TP 11

(Page 1 of 1)

USFS Custer Gallatin National Forest Riley Pass Uranium Mines Site North Cave Hills Area, Harding, SD	Date Started: 8/4/21 Date Completed: 8/4/21 Test Pit Length: 15 ft Test Pit Width: 5 ft	Sampling Method: EXCAVATOR Northing Coord.: GPS'd Easting Coord. Logged By: Bill Craig	

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Mine waste / Spoils. Brown Somewhat loosely compacted dry to slightly moist	0-6'	TP11-(SURF)-080421	49 ppm As	15 uR/hr
2.5						
	~3-4	UNEVEN CONTACT				
5		Dark gray to black moist to saturated Clay. Possible pond sediment repository	5-6	TP11-(5'-6')-080421	<10 ppm As	22 uR/hr
7.5						
10						
12.5						
15						
		Test pit wall collapsing Maximum depth TD 17				
17.5						
20		∴ Possible future repository location				

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aT1 - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP12

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started	8/4/21	Sampling Method	EXCAVATOR
Date Completed	8/4/21	Northing Coord.	GPS'd
Test Pit Length	15 ft	Easting Coord.	
Test Pit Width	5 ft	Logged By	Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Dark Chocolate brown silt, broken rock, sand ~~Mine~~ mine waste / spoils		TP12-(SURF)-080421	440ppm	122 uR/hr
2.5						
	4ft	contaminate ↑ ↓ clean				
5		Yellowish tan silt/clay w/ embedded angular gravel. (possibly native) Dry to moist w/ depth				
7.5						
10			8-9	TP12-(8'-9')-080421	42 ppm As	49 uR/hr
12.5						
15						
17.5		Light grey clay (Native?)				
		TD 18.5 ft				
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTt - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP13

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started 8/4/
Date Completed
Test Pit Length
Test Pit Width

Sampling Method EXCAVATOR
Northing Coord GPS'd
Easting Coord
Logged By Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Light brown spoils / cover Dry and relatively loosely compacted	0-6"	TP13-(SURF)-080421		15 uR/hr 51 ppm As
2.5						
5		Dark brown mine waste consisting of silty clay w/ sand and broken angular rock				
7.5			6-7	TP13-(6'-7')-080421		115 uR/hr
10						
12.5						300 uR/hr
15		Sandstone bedrock				527 uR/hr
17.5						
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aT1 - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP 14

(Page 1 of 1)

USFS Custer Gallatin National Forest Riley Pass Uranium Mines Site North Cave Hills Area, Harding, SD	Date Started 8/4/21 Date Completed 8/4/21 Test Pit Length 15 ft Test Pit Width 5 ft	Sampling Method EXCAVATOR Northing Coord. GPS'd Easting Coord. Logged By Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Light brown sandy silt w/ rock fragment (outwash) from cliff face dump area Spoils Dry, relatively loosely compacted	0-6"	TP14-(SURF)-080421		28 uR/hr 69 ppm As
2.5		Native				
		Yellowish brown silty sand (Native)	4-5	TP14-(4'-5')-080421		27 uR/hr 9 ppm As
5		Slightly moist to moist				
7.5						
10						
12.5						
15		∴ Extend angle of repose of Native surface from elevation of Spoils/Native contact up-slope to vertical plane intersect between two sandstone bedrock outcrops				
17.5						
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTI - Test Pit Log.bor

TETRA TECH

NE BLUFF B TEST PIT # TP15

(Page 1 of 1)

USFS Custer Gallatin National Forest
Riley Pass Uranium Mines Site
North Cave Hills Area, Harding, SD

Date Started	8/4/21	Sampling Method	EXCAVATOR
Date Completed	8/4/21	Northing Coord	GPS'd
Test Pit Length	15 ft	Easting Coord	
Test Pit Width	5 ft	Logged By	Bill Craig

Depth in Feet	USCS	DESCRIPTION	Sample Interval	Lab Sample #	Arsenic (ppm)	Gamma Count
0		Light brown spoils consisting of Sandy silt and rock fragments (outwash) from cliff dump face	0-1.0	TP15-(SURF)-080421	61 ppm As	30 uR/hr
2.5		Native silty sand Yellowish tan slightly moist to moist				
			3-4	TP15-(3'-4')-080421	<9 ppm As	27 uR/hr
5		TD = 4 ft				
7.5						
10						
12.5						
15						
17.5						
20						

10-08-2019 C:\Users\natalie.morrow\Documents\M-Tech\samples_aTI - Test Pit Log.bor

APPENDIX G
GAMMA CORRELATION STUDY REPORT

TABLE OF CONTENTS

FIGURES

TABLES

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

ags	Above ground surface
ALS	ALS Environmental Laboratories
amsl	Above mean sea level
AUM	Abandoned uranium mine
bgs	Below ground surface
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
ID	Identification
J	Estimated value
K-40	Potassium-40
m^2	Square meter
MARLAP	*Multi-Agency Radiological Laboratory Analytical Protocols Manual*
MARSSIM	*Multi-Agency Radiation Site Survey Investigation Manual*
m/s	Meters per second
MST	Mountain Standard Time
NAD	North American Datum
NaI(TI)	Sodium iodide thallium-laced
pCi/g	Picocuries per gram
ppm	Parts per million
QA	Quality assurance
QC	Quality control
R^2	Statistical measure of how close data come to a fitted regression line (also known as the coefficient of determination)
Ra-226	Radium-226
RPD	Relative percent difference
RSD	Relative standard deviation
TPU	Total propagated uncertainty
TENORM	Technologically enhanced naturally occurring radioactive material
Tetra Tech	Tetra Tech, Inc.
Th-232	Thorium-232
TPU	Total propagated uncertainty
Tronox	Tronox Worldwide, LLC

ACRONYMS AND ABBREVIATIONS (continued)

μR/hr	Microroentgens per hour
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
UPL95	95^{th} upper prediction limit
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

1.0 INTRODUCTION

This Appendix G to the Bluff B Subsurface and Supplemental Surface Investigation Report (hereafter referred to as the main report) presents methodology, results, and data interpretation of the gamma-radium soil correlation study performed at Bluff B (the "Site") within the Riley Pass Uranium Mine complex in South Dakota.

1.1 PURPOSE

A release, or a significant threat of a release, has occurred or is occurring at Riley Pass Bluff B, based on results from numerous previous investigations and as documented in a 2016 Action Memorandum (USDA, USFS 2016) and cleanup levels for the Site have been established as **30 pCi/g** for Ra-226. Elevated gamma radiation is likely to occur in areas around overburden, low-grade ore, or waste rock piles or soils where increased levels of Ra-226 may be present (Daniels and Sylvain 2012). A relationship between gamma exposure rates and gamma emitting radionuclides exists at every site but due to numerous geological and geographic, factors as well as Natural Occurring Radioactive Material (NORM) like thorium and potassium, a generalized relationship does not exist and as such, a site-specific relationship needs to be developed. Once a site-specific correlation has been developed, it allows field staff to easily estimate the concentration of gamma-emitting radionuclides, particularly Ra-226, by using handheld survey meters (i.e., Geiger counters) which is substantially less expensive, quicker, and covers a greater area than alternative soil characterization methods such as laboratory analysis of soil samples. Despite previous gamma-radium correlation studies at Riley Pass (Tetra Tech 2013), no site-specific Bluff B gamma-radium correlation study had occurred that could be referenced to achieve more efficient remedial planning and design, as well as guidance for future cleanup verification efforts at Bluff B. The purpose of the 2021 gamma-radium correlation study on Bluff B was to determine the site-specific relationship between gamma radiation levels and Ra-226 soil concentrations.

1.2 BACKGROUND

Using gamma radiation to estimate soil radionuclide concentrations is a common approach at sites contaminated with windblown uranium tailings (such as at former uranium mills) and at abandoned uranium mines (Abelquist 2013, USEPA 2000, Johnson and others 2006). Attempts have been made to develop relationships between gamma exposure rate and soil Ra-226 concentrations, so that the less expensive gamma data, which is easily collected over large areas, can be used to predict Ra-226 concentrations in soil for remedial action. This has been a common strategy at sites contaminated with windblown contamination near uranium tailings piles. For example, in 1985 at the Edgemont Mill in South Dakota, a linear regression analysis was performed using collimated (lead shielded) gamma scintillometer readings and Ra-226 concentrations measured in soil core samples. While the linear regression resulted in low coefficients of determination, these analyses indicated that collimated readings may ascertain the presence or absence of contamination above average-background in the general vicinity of uranium mill tailings storage piles (Thomas and Kinnison 1985).

The principal method for accurately determining the concentration of Ra-226 present in soil or any given material is by way of gamma spectral analysis, which can be time consuming and costly.

Analytical soil sampling is the only way to measure Ra-226 accurately but is very costly and the results can take over a month to obtain due to sampling requirements for the daughter products (at least for the preferred gamma spectral analysis method). Analytical soil sampling will always be used to identify and confirm the efficacy of cleanup actions at the Site; however, one goal is to be able to utilize gamma radiation survey data as a primary screening or indicator tool for effectively identifying whether the Site has been remediated or needs further remediation. Therefore, it is important to determine if there is a strong relationship of gamma-radium which can used to develop a conversion and/or correlation factor(s) that can be established for the Site.

The correlation factor developed between gamma measurements and Ra-226 may provide an economical and effective method for estimating Ra-226 concentration level over the entire site (Energy Fuels 2014). Currently there lacks any formal guidance on specified methodology for performing gamma-radium correlation studies or specifics on developing correlation factors within the primary U.S. agency guidance documents such as Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM [EPA 2000] or Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) [EPA 2004]. Literature from Johnson and others (2006) and Whicker and other (2007) presented methodology for performing correlations and developing these types of correlation factors, referred here as a "gamma-radium correlation", at uranium mills and uranium mines in the Western U.S.

Tetra Tech has performed gamma-radium correlation studies at different uranium sites using the approaches or variations of the approaches from Johnson and others (2006) and Whicker and others (2008). Some examples include the previous project-wide correlation study performed across Riley Pass in Tetra Tech (2013) or the site-specific correlation performed at Bluff A (Tetra Tech 2019a). Additional correlation studies include the Red Bluff Uranium Mine in the Tonto National Forest (Tetra Tech 2017) or the Northern Agency Tronox Mines in the Navajo Nation (Tetra Tech 2019b), among others.

The gamma-radium correlation study performed during the 2021 field investigation at Bluff B was performed with the intent to determine if there is a strong relationship between gamma exposure rates and soil Ra-226 concentrations at the Site, and if possible, develop statistical correlations which may be used to estimate approximate soil Ra-226 concentrations across the entire site based on the gamma survey results for remediation design, remedial action surveys, and/or for final verification purposes. The study was designed with the intention of incorporating lessons learned from the previous studies mentioned and to improve upon the data collection techniques and data evaluation approaches for this Site. Some of these lessons learned include: (1) how to better identify and address outliers in gamma-radium correlation data pairs and how to prevent those from occurring in the field; (2) how quantifying primordial radionuclides of correlation plots is very important; (3) how utilizing data around the cleanup level and not data that is too much outside of the range is important; (4) and not using a logarithmic regression models for gamma-radium conversion factors.

Quality assurance and quality control (QA/QC) was a priority throughout the data collection and analysis tasks completed in support of the gamma-radium correlation. Specific QA/QC procedures were implemented to both minimize and evaluate potential sources of inaccuracy during sample collection and analysis. QA/QC procedures were designed to consider relevant guidance from USEPA, as well as MARSSIM and MARLAP. Data quality for in field gamma measurements is presented in “In-Field Gamma Validation and Verification” found as Appendix E to the main report. A detailed photographic log of the gamma-radium correlation field activities is presented in Appendix A to the main report.

The following section lays out the methods for performing the gamma-radium correlation study at Bluff B.

2.0 METHODOLOGY

This section presents a discussion of methodology that was followed during the gamma-radium correlation study during the 2021 field investigation of Bluff B.

2.1 PLOT SELECTION

A "plot" refers to a "soil correlaton plot" or "sampling plot" which is an area of land, selected by the lead radiation expert, which will be scanned for radiation and composite soil sampled for analytical testing including metals and radionuclide data. The data from the plots are used in the correlation study typically through linear or non-linear regression or multiple linear regression. Plot selection is crucial for a meaningful and successful correlation. Careful planning during plot selection is likely to be far more beneficial to the quality of the correlation results than other factors. As part of the plot selection process, Tetra Tech conducted a desktop study during the planning stages of the 2021 field investigation. The goal was to identify ideal plot locations. An ideal set of correlation plots have the following characteristics:

- Plots contains a *homogenous* gamma radiation level and soil Ra-226 concentration.
- Plot shape are typically square or rectangular in shape.
- Plots should be located in a relatively flat area and generally be free of dense vegetation.
- Plot size should generally be no smaller than 25 square meters (m^2) and no larger than 200 m^2 in surface area.
- A minimum of 10 plots per correlation is recommended but the higher the number of plots selected the more statistically sound the correlation will become.
- Gamma levels and soil concentrations across the range of plots selected will encompass a wide range ideally bounding the cleanup level for the site with regards to soil Ra-226 concentrations. Gamma levels and soil Ra-226 concentrations should be approximately evenly spaced across this range.

Initial correlation plots were selected by using the 2012 and 2018 gamma radiation survey data at Bluff B as well as site knowledge from previous investigations at Bluff B. Plots were scanned with backpack scan systems by the radiation expert during site visits in June and July of 2021. These visits coincided with the aerial gamma flyover survey field investigations. Plots were then altered, moved, or kept in place, as necessary, for the eventual gamma-radium correlation study performed in August 2021. During the August 2021 field investigation, the final plot locations were all predetermined and were accessed and sampled by the field team. Table G1 below lists sampling information regarding each of the final soil correlation plot locations including field sample identification (ID), laboratory sample number, sample date, sample time, geospatial coordinates, vertical elevation, and surface area of each plot. The plots ranged in size from 27 m^2 to 153 m^2. A map showing the soil correlation plot locations is presented on Figure G1. Once the final plots were selected, gamma scanning was performed following the methods described in the next subsection.

Table G1 Summary Information of Soil Correlation Plots

Sample ID	Laboratory Sample Identification	Date Collected	Sample Type	Northing (US Feet)	Easting (US Feet)	Vertical Elevation (feet amsl)	Surface Area of Correlation Plot (m^2)
CORR01-080521	2108184-1	8/5/2021	Primary	755,688.86	1,079,306.54	-	96
CORR02-080521	2108184-3	8/5/2021	Primary	753,674.55	1,081,723.60	3,376.3	80
CORR03-080521	2108184-4	8/5/2021	Primary	754,133.77	1,081,762.26	3,327.7	83
CORR04-080521	2108184-5	8/5/2021	Primary	753,731.02	1,082,392.24	3,310.4	80
CORR05-080521	2108184-6	8/5/2021	Primary	753,635.53	1,082,506.18	3,309.7	70
CORR06-080521	2108184-7	8/5/2021	Primary	754,172.16	1,082,182.36	3,312.4	111
CORR07-080521	2108184-8	8/5/2021	Primary	753,233.95	1,082,774.92	3,320.4	105
CORR08-080521	2108184-9	8/5/2021	Primary	753,217.21	1,082,871.59	3,323.9	112
CORR09-080521	2108184-10	8/5/2021	Primary	753,154.10	1,082,907.81	3,323.1	147
CORR10-080521	2108184-11	8/5/2021	Primary	753,274.81	1,082,943.00	3,328.1	133
CORR11-080521	2108184-12	8/5/2021	Primary	752,872.85	1,082,392.04	3,322.0	63
CORR12-080521	2108184-13	8/5/2021	Primary	752,798.02	1,082,521.98	3,322.7	27
CORR13-080521	2108184-14	8/5/2021	Primary	752,997.11	1,081,405.20	3,313.9	118
CORR14-080521	2108184-15	8/5/2021	Primary	752,701.04	1,082,018.72	3,326.4	107
CORR15-080521	2108184-16	8/5/2021	Primary	752,774.21	1,082,142.86	3,315.9	153
CORR-(DUP1)-080521	2108184-2	8/5/2021	Duplicate	-	-	-	-

Notes:
Spatial coordinates are in NAD 1983 State Plane South Dakota N FIPS 4001 (US Feet).
No vertical elevation is provided for CORR01-080521 because the location of this plot is outside of the digital elevation model for the Site.

amsl Above mean sea level
"-" Data not available
MST Mountain Standard Time
m^2 Square meter
NAD North American Datum

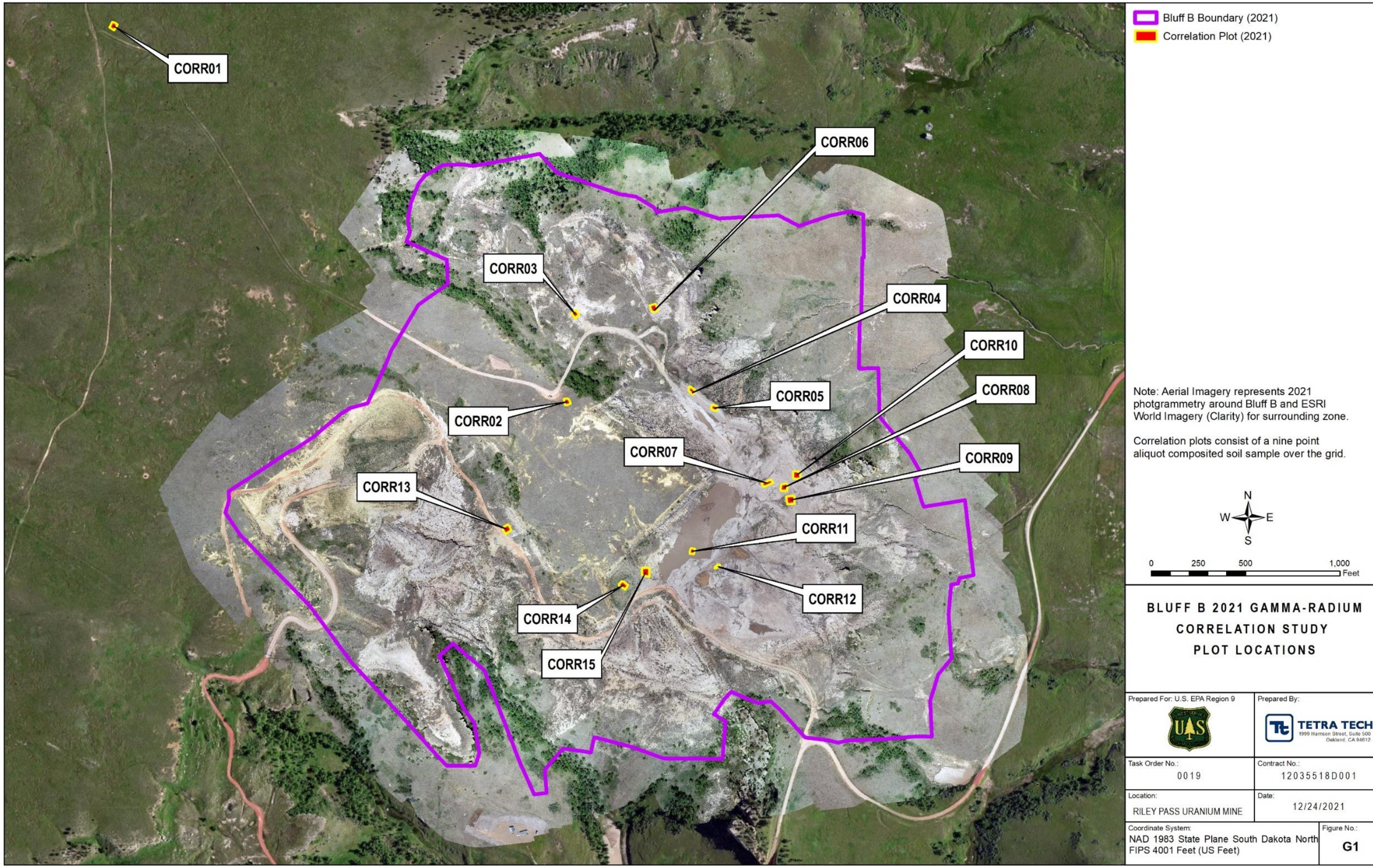

Figure G1 Bluff B 2021 Gamma-Radium Correlation Study Plot Locations

2.2 SCANNING

Gamma radiation scanning was performed at a high density (1-meter transects) within the boundary of the selected correlation plot. Prior to scanning, the field team placed pin flags at the corners of the correlation plot. An initial scan was performed to determine if the boundaries required adjustment based on the measured gamma radiation field. Gamma scanning was performed across the plot in a similar pattern that is shown on Figure G2. On this figure the arrows represent the direction for which scanning occurs (scan lines are shown as blue dashed dots). Scanning was performed on either horizontal or vertical directions at approximately 1-meter transect spacing using the same instruments used for performing ground-based gamma radiation surveys. For this study, field staff used mobile scanning systems with Ludlum Model 44-10 (2- by 2-inch) sodium iodide (NaI) gamma scintillation detectors coupled to Ludlum Model 2221 ratemeters/scalers set in ratemeter mode. The detectors were coupled to ERG Model 105 GPS units. The ERG Model 105 GPS unit consists of a Juniper Mesa 2 field computer and geode GPS receiver.

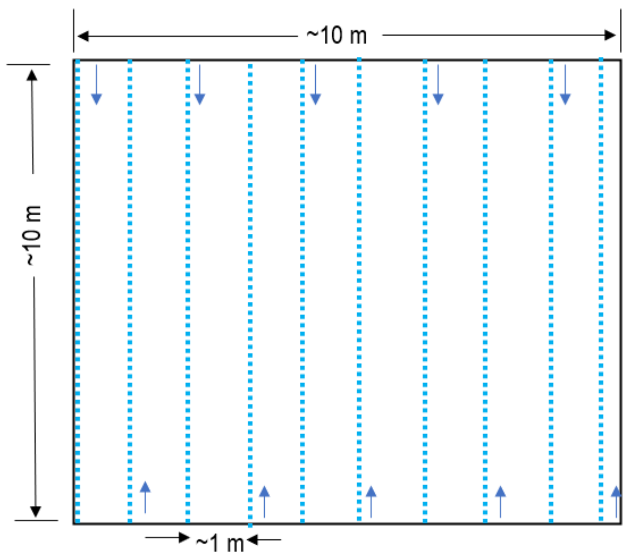

Figure G2 Grid Scanning Pattern for Soil Correlation Plot (Blue Dashed Lines Indicate Scanning Data)

Two gamma scanning techniques were performed in unison at each correlation plot: (1) unshielded 1-meter above the ground surface (ags) survey and (2) shielded 30-cm ags survey unshielded. A lead shield was added to the detector for the shielded survey. The surveys were carried out in unison with the first person using the backpack system at 1-meter ags performing the survey at 1-meter transect spacing. Shortly after the first person began scanning the second person immediately followed the same scan paths using the shielded detector. Figure G3 shows a photograph of the two field engineers performing the radiation scans in unison. Figure G4 presents an example map of the data collected within an example soil correlation plot for both the shielded and unshielded measurements (red dots are unshielded, and blue dots are shielded). The plot location was then marked using a sub-foot handheld Trimble 7XH and the gamma data was saved on the field computer. Soil sampling was performed following the scanning as described in the following subsection.

Figure G3 Photograph of Field Engineers Scanning a Correlation Plot

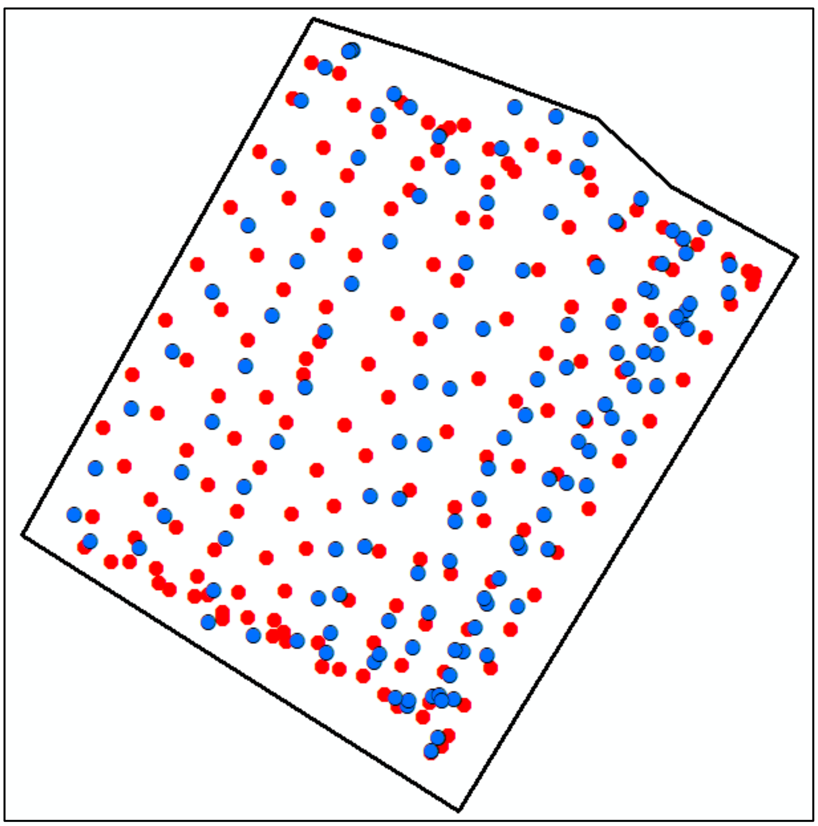

Figure G4 Example Shielded (Blue Dots) and Unshielded (Red Dots) Gamma Measurements Collected within a Correlation Plot

2.3 SOIL SAMPLING

Soil sampling was performed after the gamma scanning was completed within the correlation plot. The soil sampling was performed by collecting nine aliquot samples, each from a depth of 0 to 6-inches below the ground surface(bgs) and compositing them into a stainless-steel bowl, homogenizing, removing organic matter, removing large rocks, removing debris, and placing them into a plastic bag to be submitted for laboratory analysis.

Figure G5 provides a conceptual image of the soil sampling pattern followed at each grid, ideally the nine aliquot samples are equally spaced across the correlation plot and adjusted as necessary to fit the final shape of the correlation plot. Figure G6 presents an aerial photogram of two field engineers collecting soil samples within a correlation plot. Typically, the first team member selects the nine aliquot samples and uses a shovel or pickaxe to loosen the soil while the second team member collects the aliquot using a stainless-steel shovel into a stainless-steel bowl where the soil is then homogenized. The sample is sent to a laboratory and submitted for the analyses listed in Table G2.

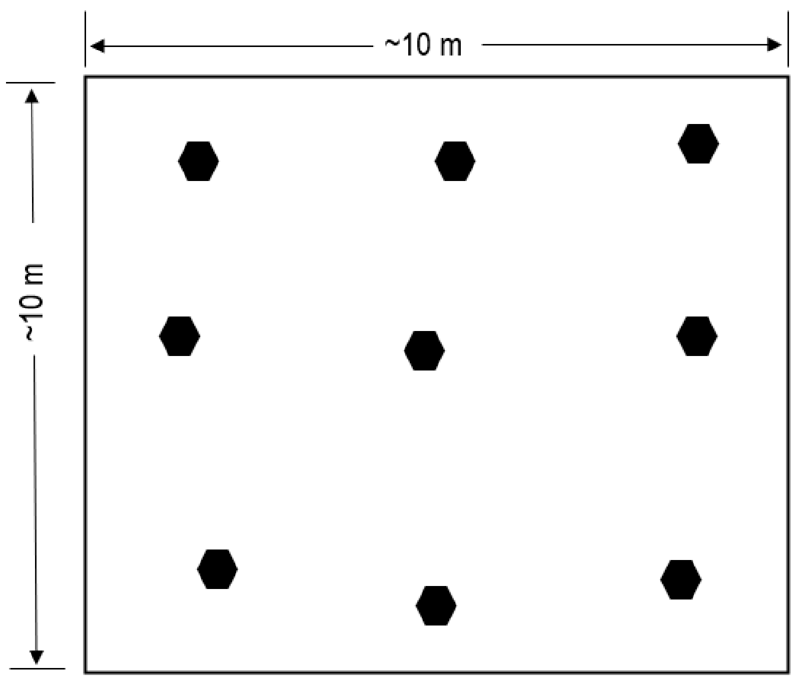

Figure G5 Example Composite Soil Sampling Pattern within Correlation Plot (Black Hexagons represent aliquot 6-inch depth samples)

Figure G6 Aerial View of Field Engineers Collecting Soil Samples from Correlation Plot

Table G2 Summary of Laboratory Analyses of Gamma-Radium Correlation Soil Samples

Analytical Parameter	Abbreviation	CAS Number	Laboratory Method
Actinium-228	Ac-228	14331-83-0	EPA 901.1
Potassium-40	K-40	13966-00-2	EPA 901.1
Radium-226	Ra-226	13982-63-3	EPA 901.1
Thorium-228	Th-228	14274-82-9	ASTM D3972 Modified
Thorium-230	Th-230	14269-63-7	ASTM D3972 Modified
Thorium-232	Th-232	7440-63-7	ASTM D3972 Modified
Uranium-234	U-234	13966-29-5	ASTM D3972 Modified
Uranium-235	U-235	15117-96-1	ASTM D3972 Modified
Uranium-238	U-238	7440-61-1	ASTM D3972 Modified
Arsenic	As	7440-38-2	EPA SW-846 6020B SW3050B
Thorium	Th	7440-29-1	EPA SW-846 6020B SW3050B
Uranium	U	7440-61-1	EPA SW-846 6020B SW3050B

2.4 QUALITY ASSURANCE AND QUALITY CONTROL

The gamma-radium correlation study involved gamma radiation surveys and soil sampling as described in the preceding sections. It is important to ensure the data collected from both these methods are sufficient quantity and quality needed to be able to use the data from the study to make decisions.

The gamma radiation survey required all the instruments used during the gamma-radium correlation study to be calibrated and achieved calibration function check requirements to ensure the instrumentation was working properly and proper validation and verification procedures were followed to ensure the data can be considered high quality and to be usable. Appendix E to the main report describes the procedures and results for the in-field gamma measurements, including the gamma-radium correlation radiation survey data.

Laboratory and field quality assurance and quality control methods were followed for the soil samples collected as part of the gamma-radium correlation study. One field duplicate sample "CORR-(DUP1)-080521" was collected as part of the field quality control (QC) program. The field duplicate sample corresponded to the sample collected at the first correlation plot location "CORR01-080521". A summary of the data validation and field QC statistics for the field duplicate and laboratory data quality analysis is presented in Appendix D to the main report. All the data from both the scanning and analytical sampling was determined to be high quality with respect to in field gamma validation and verification and met the quality assurance and quality control requirements set forth in the project.

The following section presents the data evaluation on the data collected within the correlation plots used to ensure the metrics are achieved that are necessary for a successful correlation.

3.0 RESULTS

This section presents the gamma scanning and analytical results of the data collected within the correlation plots.

3.1 GAMMA SCANNING RESULTS

Two types of gamma scanning techniques were performed at each of the 15 correlation plots: (1) unshielded; and (2) shielded. The results for both of these techniques are presented here.

3.1.1 Unshielded Gamma Scanning Results

On August 5th, 2021, a high-density gamma scan was performed at the 15 correlation plots shown on Figure G1. The first gamma scan technique conducted at each correlation plot was an unshielded 1-meter ags backpack scan performed at a speed of 1 meters per second at 1-meter transect spacing across the correlation plot following a similar pattern to that described in Figure G2. Table G3 presents the descriptive statistics of the “unshielded” gamma radiation survey data collected within the 15 correlation plots. The number of measurements, on average, was 1.1 measurements per 1 square meter (m^2) of correlation plot surface area. The average unshielded gamma measurements per correlation plot ranged from 12.3 μR/hr to 104.9 μR/hr.

The gamma radiation field within the correlation plot should be homogenous and free of gamma shine. Gamma shine refers to gamma radiation originating from sources located outside of the plot that may influence measurements taken within the plot. The gamma radiation data collected within each plot should ideally follow a normal or “gaussian” distribution for this to be true. If there was a heteregenous plot or gamma shine was present, there would be skewed dataset and it would not exhibit a bell curve. However, due to the field conditions and the random nature of radioactive decay, this is not always possible. Therefore, one metric is to compare the mean and the median of the gamma radiation dataset collected within each correlation plot. For a normal distribution, the mean and median are equal which would result in a relative percent difference (RPD) of zero percent (0%). The RPD is calculated by taking the sum of the two measurements and dividing it by the average of the two measurements. A rule of thumb is less than 5 percent RPD between the mean and median of the unshielded gamma measurements within a correlation plot is acceptable. **All of the correlation plots achieved an RPD between the mean and median of unshielded gamma measurements of less than 5 percent.**

Another metric to ensure a usable correlation plot is the relative standard deviation (RSD) of the unshielded gamma radiation survey dataset collected within each correlation plot. The RSD is a special form of the standard deviation and tells you whether the standard deviation is a small or large quantity compared to the mean for that dataset and is used as an indicator for variance. The RSD is calculated by taking the standard deviation of the dataset and dividing it by the mean of the dataset. For the purposes here, the RSD is used to evaluate the precision and homogenous nature of each correlation plot. For a correlation plot considered to contain a homogenous gamma radiation field the RSD should be relatively low, less than 15 percent is a rule of thumb for unshielded gamma measurements. The lower the RSD for a correlation plot the lower the variability of gamma radiation survey measurements within the correlation plot. The RSD of unshielded gamma measurements per correlation plot ranged from 4 percent to 14 percent, with only two plots exceeding 10 percent. **All of the correlation plots achieved an RSD of less than 15 percent for unshielded gamma measurements.**

Table G3 Descriptive Statistics of the Unshielded Gamma Radiation Survey Data within Correlation Plots

Sample ID	# of Unshielded Gamma Measurements Per Plot	Unshielded Minimum Gamma (µR/hr)	Unshielded Maximum Gamma (µR/hr)	Unshielded Average Gamma (µR/hr)	Unshielded Median Gamma (µR/hr)	Unshielded Standard Deviation Gamma (µR/hr)	Unshielded RPD Between Average and Median Gamma	Unshielded RSD of Gamma
CORR01-080521	157	9.8	15.1	12.3	12.3	1.0	0.3%	8%
CORR02-080521	109	12.0	17.5	14.5	14.4	0.9	0.3%	7%
CORR03-080521	97	15.1	20.5	17.3	17.2	1.1	0.6%	6%
CORR04-080521	113	55.7	75.6	62.3	62.0	3.6	0.6%	6%
CORR05-080521	77	58.4	87.0	66.0	64.5	5.5	2.3%	8%
CORR06-080521	113	29.6	45.4	37.5	37.1	3.1	0.9%	8%
CORR07-080521	104	40.0	72.8	49.5	48.0	6.8	3.1%	14%
CORR08-080521	80	29.2	39.6	33.9	33.8	2.2	0.3%	6%
CORR09-080521	143	26.0	37.4	31.3	31.0	2.6	1.2%	8%
CORR10-080521	117	30.8	43.1	37.6	37.6	2.7	0.1%	7%
CORR11-080521	59	38.4	52.1	45.6	45.6	2.6	0.1%	6%
CORR12-080521	58	94.8	113.6	104.9	105.8	4.7	0.9%	4%
CORR13-080521	92	32.8	55.2	43.4	44.3	5.3	2.0%	12%
CORR14-080521	72	17.2	27.0	22.0	22.2	2.0	0.7%	9%
CORR15-080521	96	15.3	24.1	18.6	18.4	1.7	1.4%	9%

Notes:
Unshielded measurements were collected at 1-meter transect spacing with a detector height of 1-meter above the ground surface.
µR/hr Microroentgens per hour
RPD Relative percent difference
RSD Relative standard deviation

3.1.2 Shielded Gamma Scanning Results

On August 5th, 2021 a high-density (1-meter transect) ground-based gamma scan was performed at each of the correlation plot locations shown on Figure G1. The second gamma scan technique conducted at each correlation plot was the shielded 12-inch ags backpack scan performed at a speed of 1 meters per second at 1-meter transect spacing across the correlation plot following a similar pattern to that described in Figure G2. A description of the field used is provided in Attachment G-1.

Table G4 presents the descriptive statistics of the “shielded” gamma radiation survey data collected within the 15 correlation plots. The number of measurements, on average, was 1.1 measurements per 1 m^2 of correlation plot surface area, which is the same as the unshielded scan indicating agreement in number of data points collected per plot. The shielded scan was intended as a means to quantify the gamma shine present in the grids. A shielded detector has a much tighter field of view and is essentially measuring the gamma radiation coming from directly below the detector rather than from a 1- to 2 meter radius. As a consequence of this, the gamma readings resulting from a shielded detector are much lower compared to the unshielded detector for the same location. The average shielded gamma measurements per correlation plot ranged from 3.0 μR/hr to 36.3 μR/hr.

An evaluation was performed, similar to the unshielded detector readings, to compare the mean and the median of the gamma radiation dataset collected within each correlation plot. A rule of thumb is less than 5 percent RPD between the mean and median of the shielded gamma measurements within a correlation plot is acceptable. **All of the correlation plots achieved an RPD between the mean and median of shielded gamma measurements of less than 5 percent.**

An evaluation was performed, similar to the unshielded detector readings, to calculate the RSD of the shielded gamma radiation survey dataset collected within each correlation plot. The RSD is typically higher for shielded measurements compared to unshielded measurements even for relatively homogenous plot locations because the sensitivity is increased with the shielded detector. Therefore, for a correlation plot considered to contain a homogenous gamma radiation field the RSD should be relatively low, less than 20 percent is a rule of thumb for shielded gamma measurements. **All of the correlation plots achieved an RSD of less than 20 percent for shielded gamma measurements.**

The analysis shown for unshielded and shielded correlation plots showed that all the correlation plots achieved the desired metrics required to consider them usable for gamma-radium correlation analysis.

Table G4 Descriptive Statistics of the Shielded Gamma Radiation Survey Data within Correlation Plots

Correlation Plot ID	# of Shielded Gamma Measurements Per Plot	Shielded Minimum Gamma (µR/hr)	Shielded Maximum Gamma (µR/hr)	Shielded Average Gamma (µR/hr)	Shielded Median Gamma (µR/hr)	Shielded Standard Deviation Gamma (µR/hr)	Shielded RPD Between Average and Median Gamma	Shielded RSD of Gamma
CORR01-080521	135	1.7	4.1	3.0	3.1	0.5	2.4%	16%
CORR02-080521	109	2.4	4.6	3.5	3.5	0.5	0.3%	13%
CORR03-080521	94	2.9	6.2	4.5	4.4	0.6	0.7%	13%
CORR04-080521	115	12.8	20.9	16.9	16.9	1.5	0.3%	9%
CORR05-080521	79	15.3	34.5	21.3	20.3	3.7	4.6%	18%
CORR06-080521	112	7.0	13.5	10.0	10.0	1.4	0.2%	13%
CORR07-080521	102	9.2	24.5	14.3	14.3	2.7	0.5%	19%
CORR08-080521	81	6.5	11.8	8.9	8.9	1.0	0.1%	12%
CORR09-080521	119	5.8	11.7	7.8	7.7	1.2	1.9%	15%
CORR10-080521	114	7.2	13.1	10.8	10.9	1.2	1.0%	12%
CORR11-080521	61	10.6	15.9	12.9	12.9	1.2	0.5%	9%
CORR12-080521	56	29.1	42.9	36.3	36.0	3.3	1.0%	9%
CORR13-080521	107	8.7	17.6	12.8	13.1	2.0	2.3%	16%
CORR14-080521	69	3.5	7.1	5.1	5.0	0.7	0.7%	15%
CORR15-080521	96	2.3	5.0	3.8	3.8	0.5	0.7%	14%

Notes:
Shielded measurements were collected at 1-meter transect spacing with a detector height of 12-inches above the ground surface using a lead shield.
µR/hr Microroentgens per hour
RPD Relative percent difference
RSD Relative standard deviation

3.2 ANALYTICAL SOIL SAMPLING RESULTS

Soil samples were collected at each of the 15 correlation plots on August 5th, 2021. The soil collected at each correlation plot was a composite sample containing nine aliquot surface samples 0-inches to 6-inches bgs as described in Section 2.3 following the sampling pattern shown on Figure G5. Each soil sample was submitted the ALS laboratory in Fort Collins, Colorado for the analysis methods presented on Table G2. Table G5 presents the Ra-226 results for the correlation plots. The Ra-226 value for each correlation plot is assumed to represent the average concentration within the plot based on the sampling approach. The soil Ra-226 concentrations ranged between 1.6 pCi/g to 93 pCi/g across the correlation plots. The range of soil Ra-226 concentrations ranges from below the site cleanup level of 30 pCi/g to above the cleanup level; however, there are no samples in the 30 - 40 pCi/g range or 50 – 93 pCi/g range which would have been ideal to fully encapsulate the cleanup level for the Site. However, given the strong linear trend identified, and number of samples within the lower to medium ranges, the gamma-radium correlation is still useful; additionally, a validation was performed to confirm the model works well.

Table G5 Radium-226 Analytical Sampling Results for Correlation Plots

Sample ID	Radium-226 (pCi/g)	TPU (+/-)	Qualifier
CORR01-080521	1.6	0.4	J
CORR02-080521	1.7	0.3	J
CORR03-080521	4.7	0.7	
CORR04-080521	21.9	2.6	J
CORR05-080521	27.7	3.4	J
CORR06-080521	11.6	1.4	
CORR07-080521	23.1	2.9	J
CORR08-080521	10.5	1.4	J
CORR09-080521	11.9	1.5	J
CORR10-080521	12.7	1.6	J
CORR11-080521	18.4	2.2	J
CORR12-080521	93.0	11.0	J
CORR13-080521	30.0	3.6	
CORR14-080521	10.1	1.3	J
CORR15-080521	2.9	0.5	J

Notes:
ID Identification
J Estimated value
pCi/g Picocuries per gram
TPU Total propagated uncertainty

Humans are constantly exposed to gamma emissions from terrestrial primordial radionuclides, (in the earth's crust) there are about 50 of these naturally occurring radionuclides (Gasser and others 2014), which include potassium and three thorium and uranium families (Gasser and others 2014), including potassium-40 (K-40), thorium-232 (Th-232) and decay chain radionuclides, and uranium-238 (U-238) and decay chain radionuclides which are all ubiquitous in the environment. The decay of the three primary radioisotopes that are responsible for the emission from natural materials include: K-40, U-238, and Th-232. While U-238 and Th-232 do not directly emit easily detectable gamma rays, they do decay into a series of daughter isotopes (Haber 2017). The goal of the gamma-radium correlation is to evaluate the direct relationship between gamma emissions and the Ra-226 concentration (which originates from the U-238 decay chain); however, it is important to understand the other sources such as potassium and thorium. These other radionuclides are different around the world and typically are increased with mining and are found naturally throughout the terrestrial environment.

Table G6 presents the analytical results for potassium-40 (K-40) for the correlation plots. K-40 is a primordial radionuclide and gamma emitter that was evaluated to determine if it is a potential influence on the gamma radiation levels across the Site. The soil K-40 concentrations ranged from 11.0 pCi/g to 17.5 pCi/g, with an average of 13.7 pCi/g. The RSD is 15.2 percent, indicating the K-40 is relatively homogenous across the correlation plots. The average K-40 across the other soil samples (opportunistic and test pit) was 14.1 pCi/g and the site wide average of K-40 across all samples was 14.0 pCi/g. This indicates the influence of K-40 on the gamma-radium correlation is likely insignificant. The contribution of K-40 is essentially constant and does not skew the target goal of identifying Ra-226 around 30 pCi/g from gamma emissions.

Table G6 Potassium-40 Analytical Sampling Results for Correlation Plots

Sample ID	Potassium-40 (pCi/g)	TPU (+/-)	Qualifier
CORR01-080521	14.1	3.7	J
CORR02-080521	17.4	3.4	J
CORR03-080521	11.8	3.0	
CORR04-080521	13.0	3.1	J
CORR05-080521	14.3	3.9	J
CORR06-080521	13.1	2.5	
CORR07-080521	15.7	3.9	J
CORR08-080521	14.7	3.0	J
CORR09-080521	11.0	2.9	J
CORR10-080521	14.6	4.0	J
CORR11-080521	17.5	3.7	J
CORR12-080521	11.4	5.3	J
CORR13-080521	11.1	2.4	
CORR14-080521	12.2	3.6	J
CORR15-080521	13.2	3.0	J

Notes:
ID Identification
J Estimated value
pCi/g Picocuries per gram
TPU Total propagated uncertainty

Another primordial radionuclide of interest with gamma emitting properties is the thorium decays series. Thorium-232 (Th-232) was analyzed at each correlation plot as well. Table G7 presents the analytical results for Th-232 for the correlation plots. The soil Th-232 concentrations ranged from 0.8 pCi/g to 1.7 pCi/g, with an average of 1.1 pCi/g. The RSD is 20.7 percent, indicating the Th-232 is relatively homogenous across the correlation plots. This indicates the influence of Th-232 on the gamma-radium correlation is likely insignificant.

Table G7 Thorium-232 Analytical Sampling Results for Correlation Plots

Sample ID	Thorium-232 (pCi/g)	TPU (+/-)	Qualifier
CORR01-080521	0.9	0.2	
CORR02-080521	1.0	0.3	
CORR03-080521	1.1	0.2	
CORR04-080521	1.0	0.2	
CORR05-080521	1.1	0.2	
CORR06-080521	0.9	0.2	
CORR07-080521	1.0	0.2	
CORR08-080521	1.1	0.2	
CORR09-080521	1.0	0.3	J
CORR10-080521	1.2	0.3	
CORR11-080521	1.4	0.3	
CORR12-080521	1.7	0.4	J
CORR13-080521	0.8	0.2	
CORR14-080521	1.1	0.3	
CORR15-080521	1.1	0.3	J

Notes:
ID Identification
J Estimated value
pCi/g Picocuries per gram
TPU Total propagated uncertainty

4.0 MODEL DEVELOPMENT

This section presents the model development for the gamma-radium correlation. This section also presents a linear and nonlinear regression evaluation of the gamma-radium data pairs. In some cases, the possibility of using nonlinear "best fit" models in certain cases could reduce potential prediction error for soil Ra-226 estimation based on the gamma survey data (Whicker and others 2008). This is why model validation is very important to select which model fits the site best and is also discussed below.

4.1 FULL DATASET REGRESSION

Table G8 summarizes the average unshielded gamma exposure rate and soil Ra-226 concentrations for each correlation plot.

Table G8 Gamma-Radium Correlation Analysis Sampling Results

Sample ID	Unshielded Average Gamma Exposure Rate (µR/hr)	Radium-226 (pCi/g)	TPU (+/-)	Qualifier
CORR01-080521	12.3	1.6	0.4	J
CORR02-080521	14.5	1.7	0.3	J
CORR03-080521	17.3	4.7	0.7	
CORR04-080521	62.3	21.9	2.6	J
CORR05-080521	66.0	27.7	3.4	J
CORR06-080521	37.5	11.6	1.4	
CORR07-080521	49.5	23.1	2.9	J
CORR08-080521	33.9	10.5	1.4	J
CORR09-080521	31.3	11.9	1.5	J
CORR10-080521	37.6	12.7	1.6	J
CORR11-080521	45.6	18.4	2.2	J
CORR12-080521	104.9	93.0	11.0	J
CORR13-080521	43.4	30.0	3.6	
CORR14-080521	22.0	10.1	1.3	J
CORR15-080521	18.6	2.9	0.5	J

Notes:
µR/hr Microroentgens per hour
ID Identification
J Estimated value
pCi/g Picocuries per gram
TPU Total propagated uncertainty

A linear regression was performed on the full dataset which includes all 15 data pairs of gamma exposure rate and soil Ra-226 concentrations. Ra-226 is selected as the dependent variable (y-axis) as we want to predict Ra-226 based on the results from the gamma radiation surveys. Figure G7 presents the linear regression results for the full dataset. The R^2 of this model is 0.846, indicating 84.6 percent of the variation of Ra-226 values can be explained by the regression model. The relationship between Ra-226 and unshielded gamma exposure rate is statistically significant (p value is less than 0.05). The p-value for each term tests the null hypothesis that the coefficient is equal to zero (no effect). A low p-value (< 0.05) indicates that you can reject the null hypothesis. In other words, a predictor that has a low p-value is likely to be a meaningful addition to your model because changes in the predictor's value are related to changes in the response variable. Conversely, a larger (insignificant) p-value suggests that changes in the predictor are not associated with changes in the response. Therefore, this model can be used to predict Ra-226 using gamma exposure rate Equation 1 below. Using this relationship, a gamma exposure of 52.7 μR/hr is equivalent to 30 pCi/g of Ra-226 in soil.

Equation 1:

$$Radium - 226 \left(\frac{pCi}{g}\right) = 0.8455 \left(Gamma\ Exposure\ \left[\frac{\mu R}{hour}\right]\right) - 14.851$$

While the linear regression model has a high R^2 value, the quadratic model best fits the data.

R^2 is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination, or the coefficient of multiple determination for multiple regression. The definition of R^2 is the percentage of the response variable variation that is explained by a linear model or R^2 is the ratio of the explained variation to total variation. $R^2$is always between 0 and 1: zero (0 percent) indicates that the model explains none of the variability of the response data around its mean and 1 (100 percent) indicates that the model explains all the variability of the response data around its mean.

The quadratic model is shown in Figure G8. This model has an R^2 of 0.942 and generally appears to fit the dataset the best across higher concentrations (visually it appears smoother across the higher concentrations thus reducing prediction error). This model can be represented by Equation 2 to predict Ra-226 from gamma exposure rate. Using this relationship by solving the quadratic equation, a gamma exposure of 60.6 μR/hr is equivalent to 30 pCi/g of Ra-226 in soil.

Equation 2:

$$Radium - 226 \left(\frac{pCi}{g}\right) = 0.0089 \left(Gamma\ \left[\frac{\mu R}{hour}\right]\right)^2 - 0.1199 \left(Gamma\ \left[\frac{\mu R}{hour}\right]\right) + 4.5224$$

Both linear and quadratic models fit the dataset well and could, individually and/or some combination thereof, be useful predictors of Ra-226 in soil. However, both models are heavily influenced by one single “influential” outlier. An influential point is an outlier that greatly affects the slope of the regression line. One way to test the influence of any outlier is to compute the regression equation with and without the outlier. In this case, correlation sample CORR12-080521 is the influential outlier. This sample has a gamma exposure of 104.9 μR/hr and a soil Ra-226 concentration of 93 pCi/g. Both of these values are significantly higher than the rest of the data pairs within the dataset. As specified in Section 2.1, gamma levels and soil concentrations across the range of plots selected should encompass a wide range ideally bounding the cleanup level for the site with regards to soil Ra-226 concentrations. Gamma levels and soil Ra-226 concentrations should be approximately evenly spaced across this range. Because CORR12-080521 is not evenly spaced across this range, this warrants further investigation with the point removed. The following subsection presents an analysis with the outlier removed.

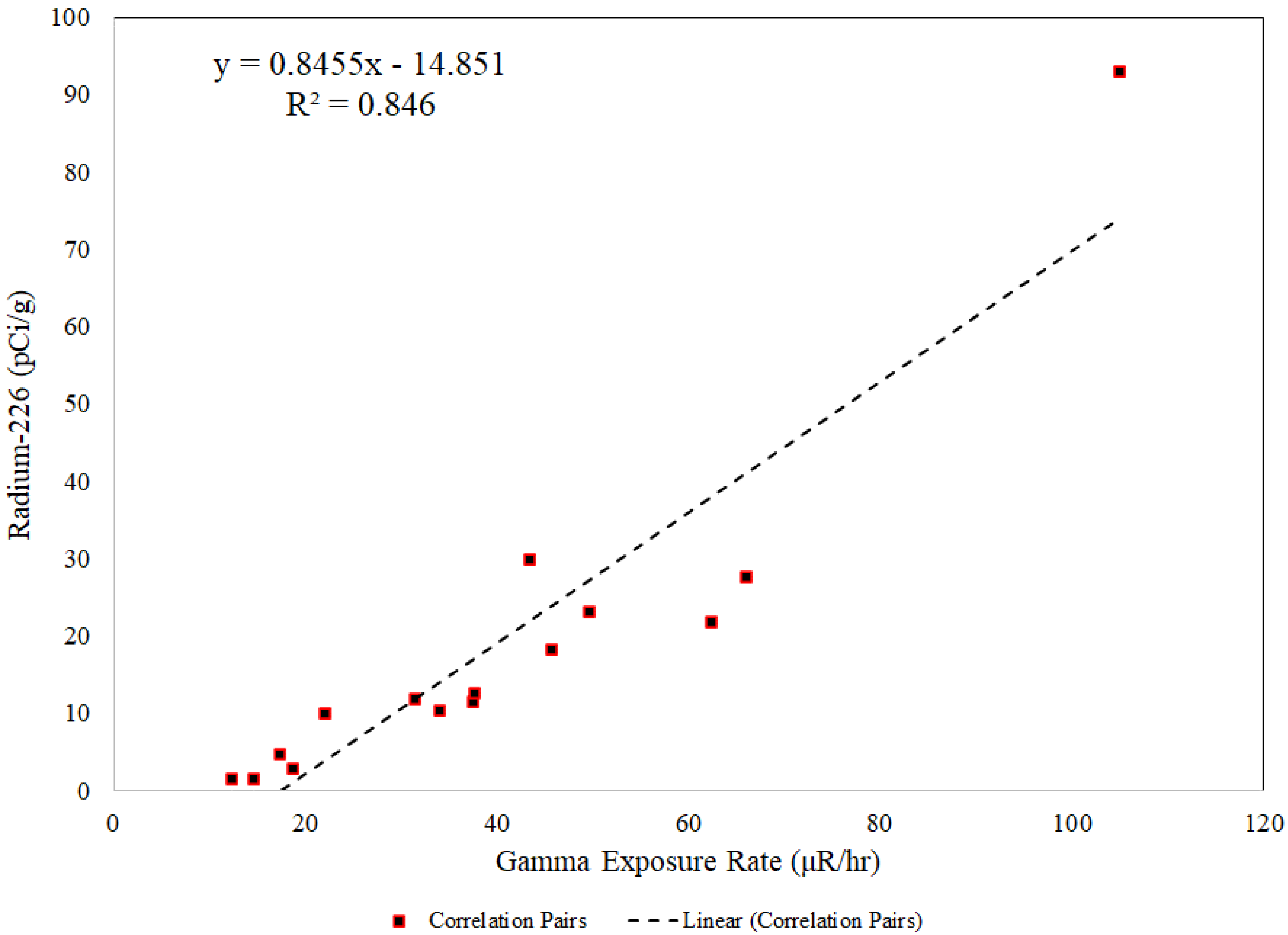

Figure G7 Linear Regression of Gamma Exposure Rate and Ra-226 (Full Dataset)

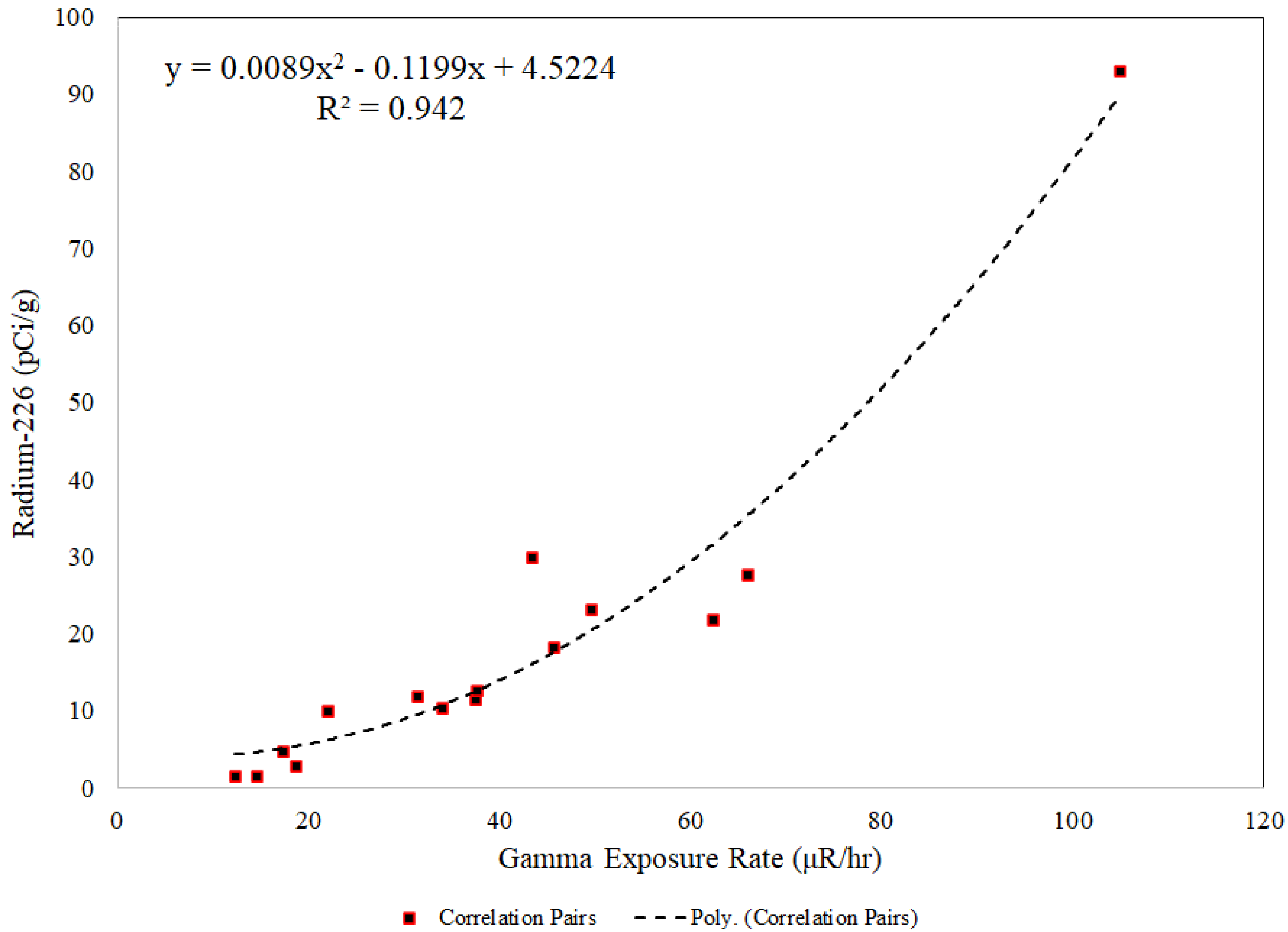

Figure G8 Quadratic Model of Gamma Exposure Rate and Ra-226 (Full Dataset)

4.2 REDUCED DATASET REGRESSION

Correlation plot CORR12-080521 was identified as an influential outlier and further analysis was warranted. A linear regression was performed after removing the data pairs from CORR12-080521. Figure G9 presents the linear regression model less the data pair of Ra-226 and gamma exposure rate from correlation plot CORR12-080521. The resulting linear regression model has an R^2 of 0.8065. While this is less than the R^2 from the full dataset, it is not influenced by any influential outliers and better corresponds to data surrounding the action level of 30 pCi/g. Using this model, the relationship between Ra-226 and unshielded gamma exposure rate is still statistically significant (p value is less than 0.05). Therefore, this model can be used to predict Ra-226 using gamma exposure rate Equation 3 below. Using this relationship, a gamma exposure of 68.4 μR/hr is equivalent to 30 pCi/g of Ra-226 in soil.

Equation 3: $$Radium - 226 \left(\frac{pCi}{g}\right) = 0.4951 \left(Gamma\ Exposure \left[\frac{\mu R}{hour}\right]\right) - 3.903$$

The concentration of Ra-226 in surface soil was well correlated with gamma exposure rate as measured with unshielded detector as shown in Figure G9. However, using Equation 2, this would only predict the Ra-226 concentration successfully 50 percent of the time. Therefore, the 95 percent upper prediction limit (UPL95) was calculated for the model and is displayed as the blue dashed line on Figure G9. The use of the UPL95 or similar is recommended in both Johnson and others (2007) as well as the MARSSIM User's Guide by a lead author of MARSSIM, Abelquist (2014). Using this as the prediction model would provide more assurance the cleanup level of 30 pCi/g is being achieved with a high degree of confidence. The UPL95 prediction model is presented in Equation 4. Using this relationship, a gamma exposure of 48.0 μR/hr is equivalent to 30 pCi/g of Ra-226 in soil.

Equation 4: $$Radium - 226 \left(\frac{pCi}{g}\right) = 0.5011 \left(Gamma\ Exposure \left[\frac{\mu R}{hour}\right]\right) + 5.9464$$

Using the 48 μR/hr as a gamma exposure rate cutoff for remedial engineering design and verification surveys is more conservative and provides a greater level of protectiveness with regards to human health and the environment. This value also nearly matches the value (48.2 μR/hr) determined for what matched the post-reclamation conditions at Bluff G, F, and I as discussed in Tetra Tech (2017). **Therefore, it is recommended that a gamma cutoff of 48 μR/hr derived from Equation 4 be used for estimating areal extent of areas exceeding the soil Ra-226 action level of 30 pCi/g for Bluff B.** A brief discussion on model validation and prediction error is presented in the following subsection.

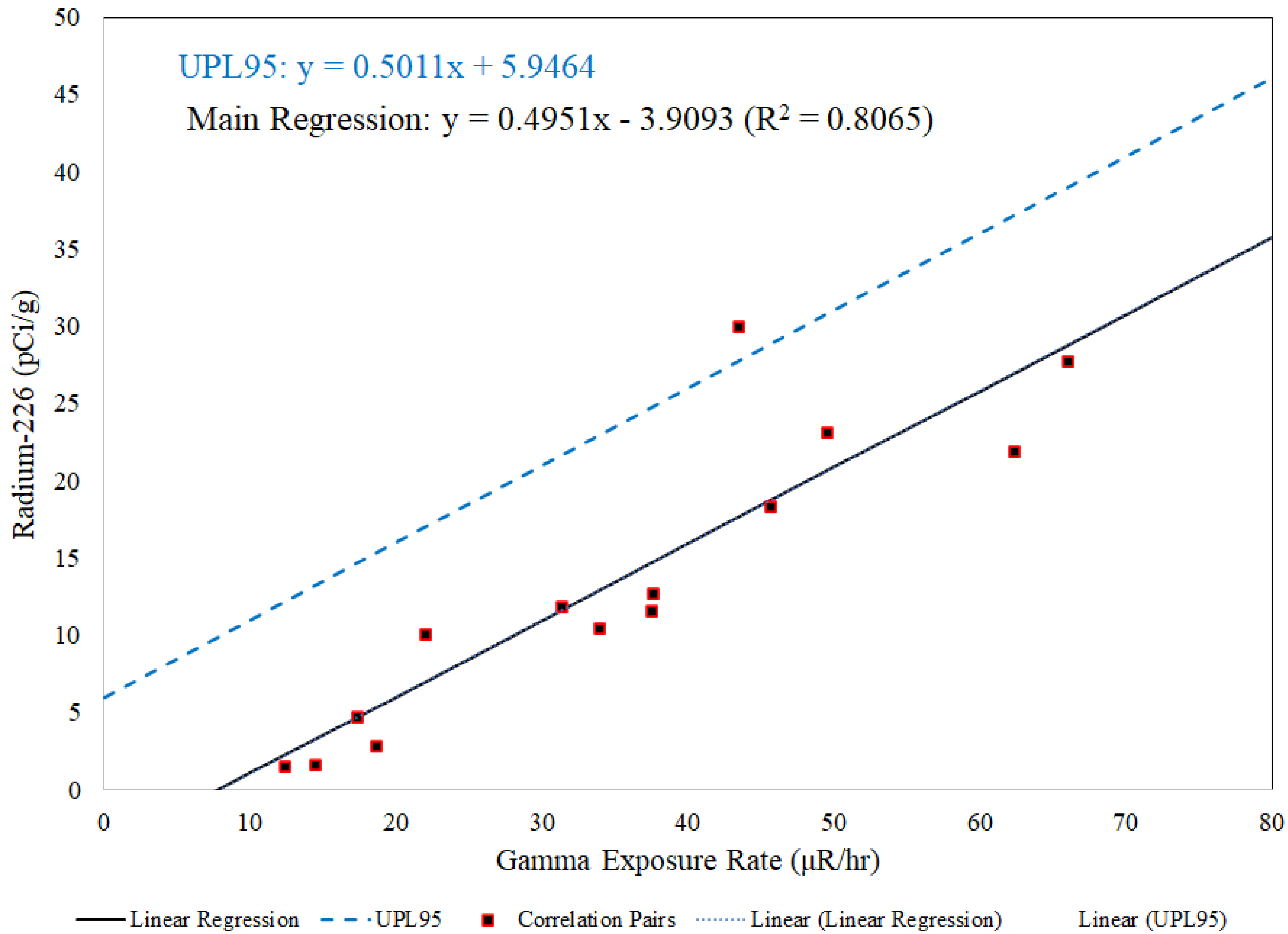

Figure G9 Linear Regression of Gamma Exposure Rate and Ra-226 (Less CORR12-080521)

4.3 MODEL VALIDATION

Model validation was performed to assess the validity of selecting 48 μR/hr from Equation 4 as a gamma cutoff level for future decisions at Bluff B. The model validation is performed by evaluating the surface soil samples collected at each of the test pit locations during the 2021 field investigation. At each surface soil sample location, a static gamma exposure rate measurement was collected at 1-meter ags. Using this information an analysis was performed to quantify the error rate using the gamma exposure measured at the location and the corresponding soil Ra-226 concentration measured in the soil sample. Table G9 presents the test pit surface soil sample data pairs used for the model validation.

Table G9 Model Validation Data Pairs from Surface Soil Samples at Test Pits

Test Pit ID	Sample ID	Unshielded Gamma Exposure Rate (μR/hr)	Radium-226 (pCi/g)
TP-01	TP01-SURF-080321	113	131
TP-02	TP02-SURF-080321	157	130
TP-03	TP03-(SURF)-080321	43	17
TP-04	TP04-(SURF)-080321	28	5.5
TP-05	TP05-(SURF)-080321	108	111
TP-06	TP06-(SURF)-080321	69	11
TP-07	TP07-(SURF)-080321	35	10
TP-08	TP08-(SURF)-080321	22	9.0
TP-09	TP09-(SURF)-080321	26	9.3
TP-10	TP10-(SURF)-080421	16	2.7
TP-11	TP11-(SURF)-080421	15	3.3
TP-12	TP12-(SURF)-080421	122	192
TP-13	TP13-(SURF)-080421	18	4.8
TP-14	TP14-(SURF)-080421	28	10
TP-15	TP15-(SURF)-080421	30	12

To assess an error rate, first a null hypothesis (H_o) must be prescribed. For this analysis the null hypothesis is the value of Ra-226 in soil exceeds the cleanup action level of 30 pCi/g. Therefore, a "Type I error" occurs when the null hypothesis is incorrectly rejected meaning the gamma level is below the cutoff of 48 μR/hr but the Ra-226 is above 30 pCi/g. Alternatively, a "Type II error" is when there is an incorrect failure to reject the null hypothesis meaning the gamma level is above the cutoff of 48 μR/hr but the Ra-226 is below 30 pCi/g.

The implications are that a Type I error would be leaving contaminated material behind leading to greater risk to human health and the environment (more risk) and a Type II error would be cleaning up unnecessary soil that is not actually contaminated (more money and ecological damage). Ideally, a Type I error less 5 percent is desired, and a Type II error less than 10 percent is desired, but these values are typically set by the regulatory agency in charge. Figure G10 presents the Type I and Type II error analysis in a graphic form. The yellow lines represent the gamma cutoff

(48 μR/hr) and the Ra-226 action level (30 pCi/g). The data pairs are from the surface test pit samples and are used for model validation. Any data pairs falling in the upper left region of the graph are considered to be Type I errors and any data pairs falling in the lower right region of the graph are considered to be Type II errors. Out of the 15 soil samples there were no Type I errors (0 percent) and there was one Type II error (20 percent). Therefore, based on the model validation analysis, using a gamma cutoff of 48 μR/hr from Equation 4 would be meet the project data quality guidelines of having a Type I error less than 5 percent.

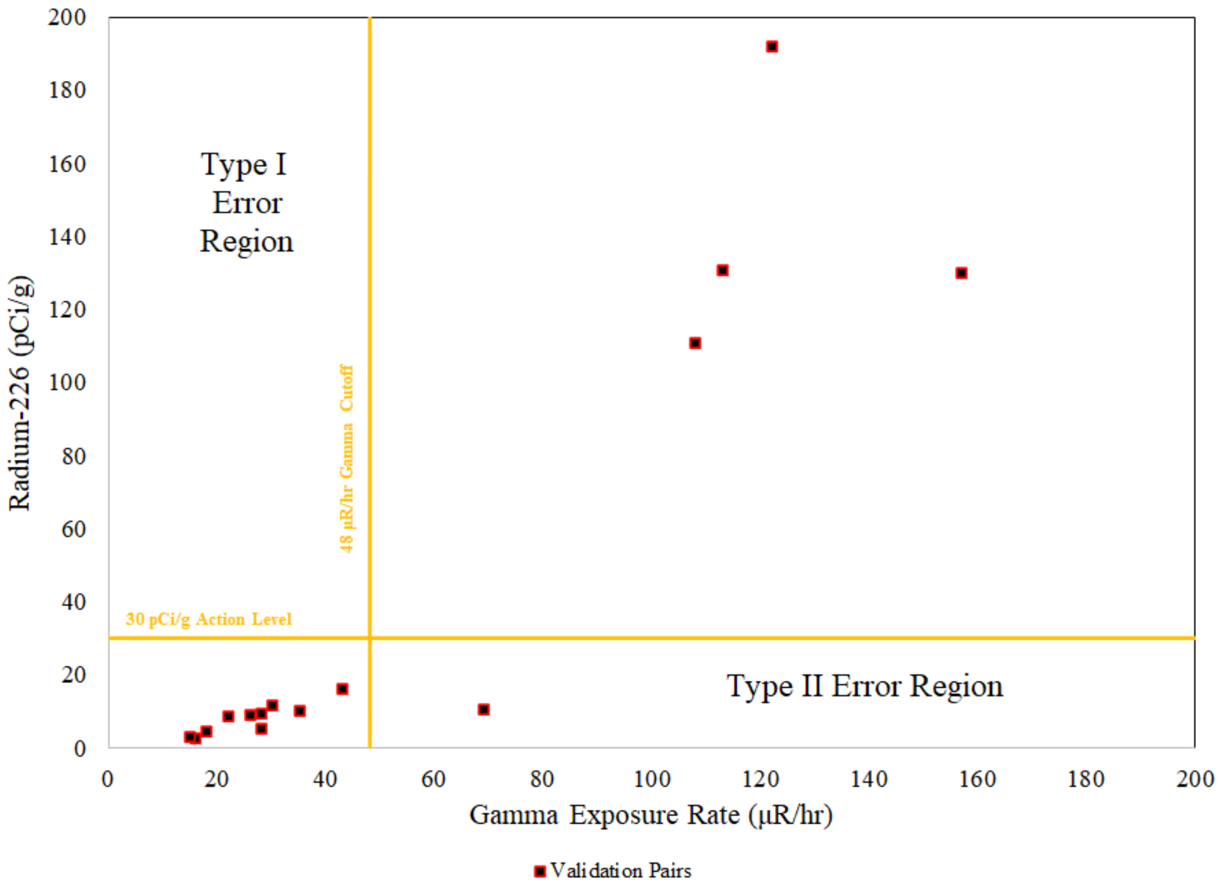

Figure G10 Type I and Type II Error Analysis – Model Validation

5.0 RESULTS

This report presented methodology, results, and data interpretation of the 2021 site-specific Bluff B gamma-radium soil correlation study. Correlation plots selected for the gamma-radium correlation study met the achieved goals for homogeneity meaning the correlation plots consisted of relatively homogenous gamma radiation field and met the project data quality requirements (RPD of mean/median less than 5 percent and RSD less than 15 percent). Additionally, the resulting analytical Ra-226 results were at or around the cleanup levels (30 pCi/g of Ra-226) for the site. An analysis of other naturally occurring gamma emitters such as K-40 and Th-232 showed these radionuclides to be of little influence on the correlation. After performing regression analysis on the full dataset and with an influential outlier removed, it was determined a gamma cutoff of 48 μR/hr corresponding to soil Ra-226 action level of 30 pCi/g is most suitable for making decisions for remediation engineering design and for verification purposes. This was confirmed through model validation resulting in Type I prediction errors suitable for the project objectives.

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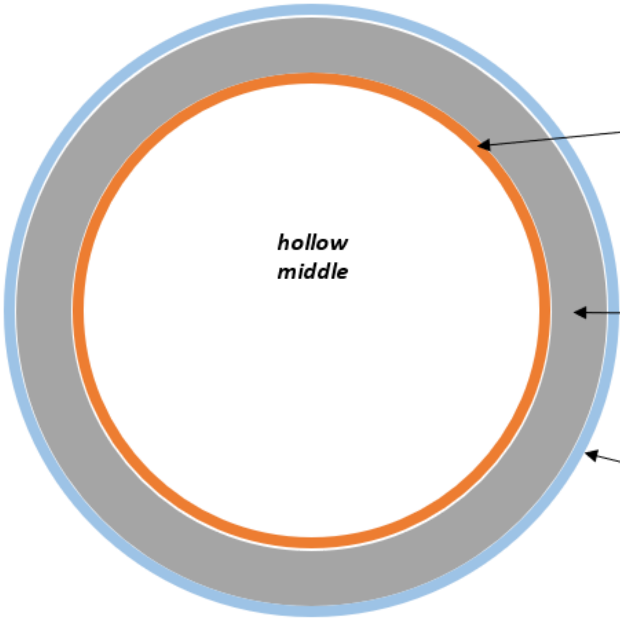
Whicker R, Cartier P, Cain J, Milmine K, Griffin M. (Whicker and others) 2008. Radiological Site Characterizations: Gamma Surveys, Gamma/Radium-226 Correlations, and Related Spatial Analysis Techniques. The Radiation Safety Journal S180. November 2008.

ATTACHMENT G1: OVERVIEW OF DETECTOR SHIELD DESIGN PARAMETERS

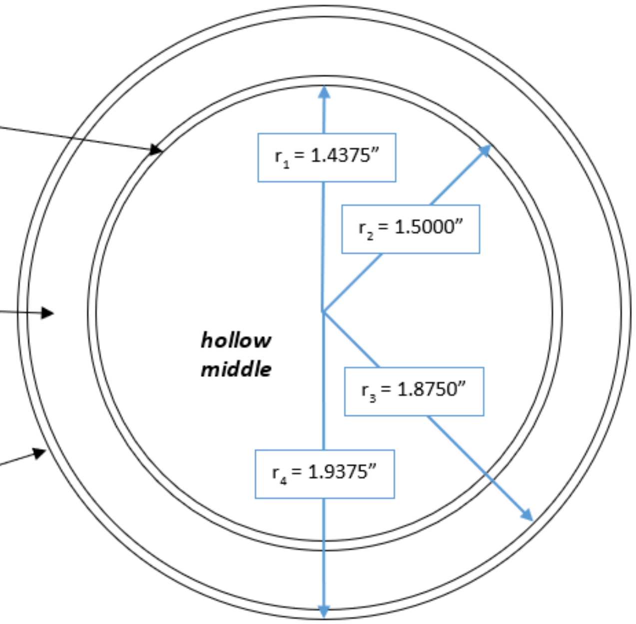


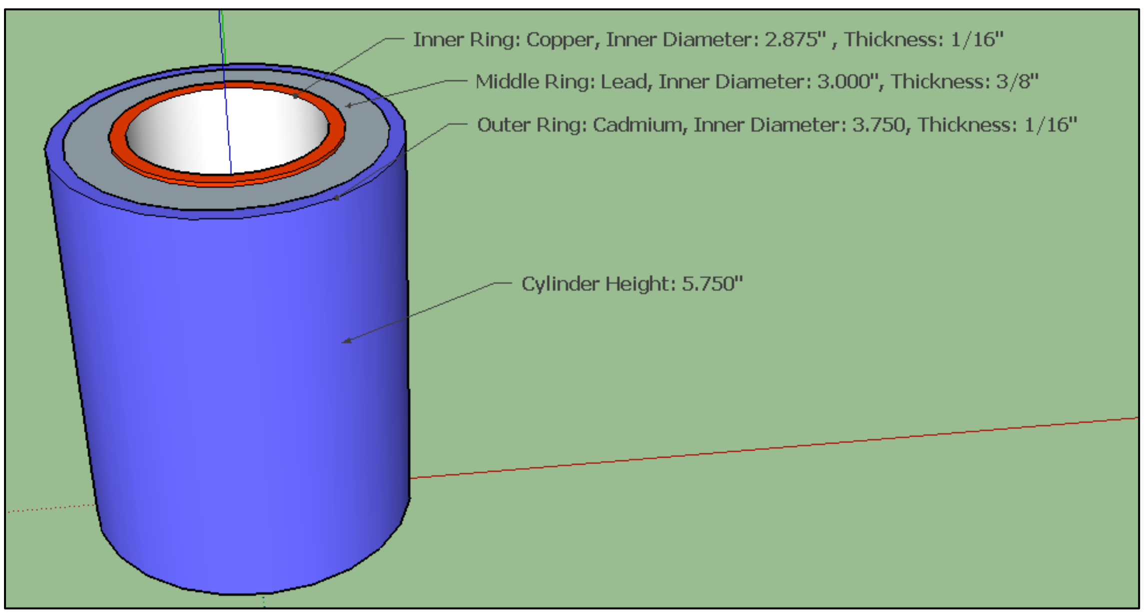
CYLINDER – All Rings
Height: 5.750"

Inner Ring
Copper
Thickness: 1/16"
Inner diameter: 2.875"
Outer diameter: 3.000"

Middle Ring
Lead
Thickness: 3/8"
Inner diameter: 3.000"
Outer diameter: 3.750"

Outer Ring
Cadmium
Thickness: 1/16"
Inner diameter: 3.750"
Outer diameter: 3.875"





APPENDIX H
GAMMA GEODATABASE RECONCILIATION

TABLE OF CONTENTS

Section **Page**

FIGURES

ACRONYMS AND ABBREVIATIONS

AUM	Abandoned uranium mine
BTV	Background threshold value
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NORM	Naturally occurring radioactive material
Ra-226	Radium-226
RSE	Removal site evaluation
Site	Mesa III Complex
TENORM	Technologically enhanced naturally occurring radioactive material
Tetra Tech	Tetra Tech, Inc.
USEPA	U.S. Environmental Protection Agency

1.0 INTRODUCTION

The purpose of this appendix is to present a short summary of how the 2021 Bluff B gamma radiation survey geodatabase was developed from the 2012, 2018, and 2021 aerial and/or ground gamma radiation surveys. Bluff B has been studied since 1990 (see main report for references on Bluff B studies) but it wasn't until 2012 that a comprehensive investigation was performed for gamma radiation to characterize the extent of site contamination. That study was intended to fill in data gaps from the earlier investigations within the initial USFS identified clean-up boundary and didn't focus on expanding the contamination boundary limits; additionally, some of the data gaps were in areas which were considered outside of the scope of work or too steep to scan. In 2018, additional gamma surveys were performed in an area where a sediment pond was proposed further expanding the datset and addressing some data gaps to the northeast. In 2021, the remaining data gaps were completed and the entire Riley Pass CERCLA site is now bound with gamma radiaiton levels less than the expected cleanup level. There may be occurrances of "hot spots" outside this current boundary, but these are limited in extent and isolated from the larger contiguous contaminated areas. These anonmolous occurrences will be inventoried as encountered and addressed at a later date.

2.0 GAMMA SURVEY DATA

2.1 2012 Gamma Survey Data

Tetra Tech conducted back-pack ground gamma radiation surveys at Bluff B in 2012 (Tetra Tech 2013). The data was originally collected in WGS84 and was then projected into NAD 1983 State Plane South Dakota North FIPS 4001 using the projection tool in ArcMap. A total of 67,015 gamma measurements from the 2012 survey are shown as blue dots in Figure H1. This data does not include gamma correlation plot data from 2012. The geodatabase file for the original 2012 gamma survey is titled “Tronox_Bluff_B_2012_Final_Scan_NAD83”. Also shown on Figure H1 is a black boundary 12.3 acres in size representing an area where earthwork has been done since the 2012 survey was conducted. Therefore, the gamma data within this black boundary on Figure H1 was removed from the data set. A total of 3,304 data points was removed from the original file and a new file was generated. A new adjusted 2012 shapefile was generated and titled “Tronox_Bluff_B_2012_Final_Scan_Less_SE_Corner_NAD83”. A visual representation of the new file is presented in Figure H2. This new file was used for combination with the 2018 and 2021 data discussed in subsequent sections. The new adjusted 2012 data contains 63,711 measurements.

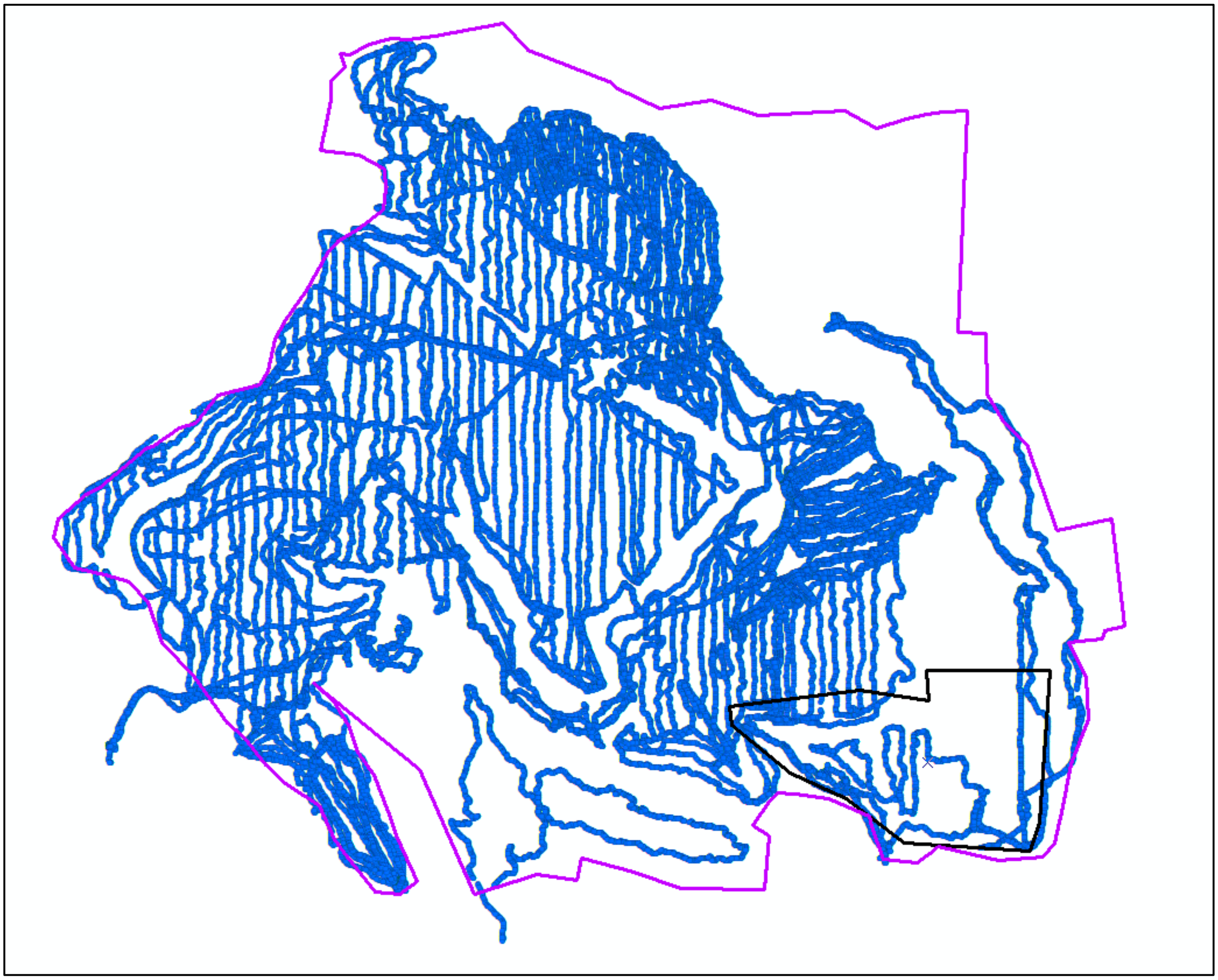


Figure H1 Gamma Radiation Survey Measurements (2012)

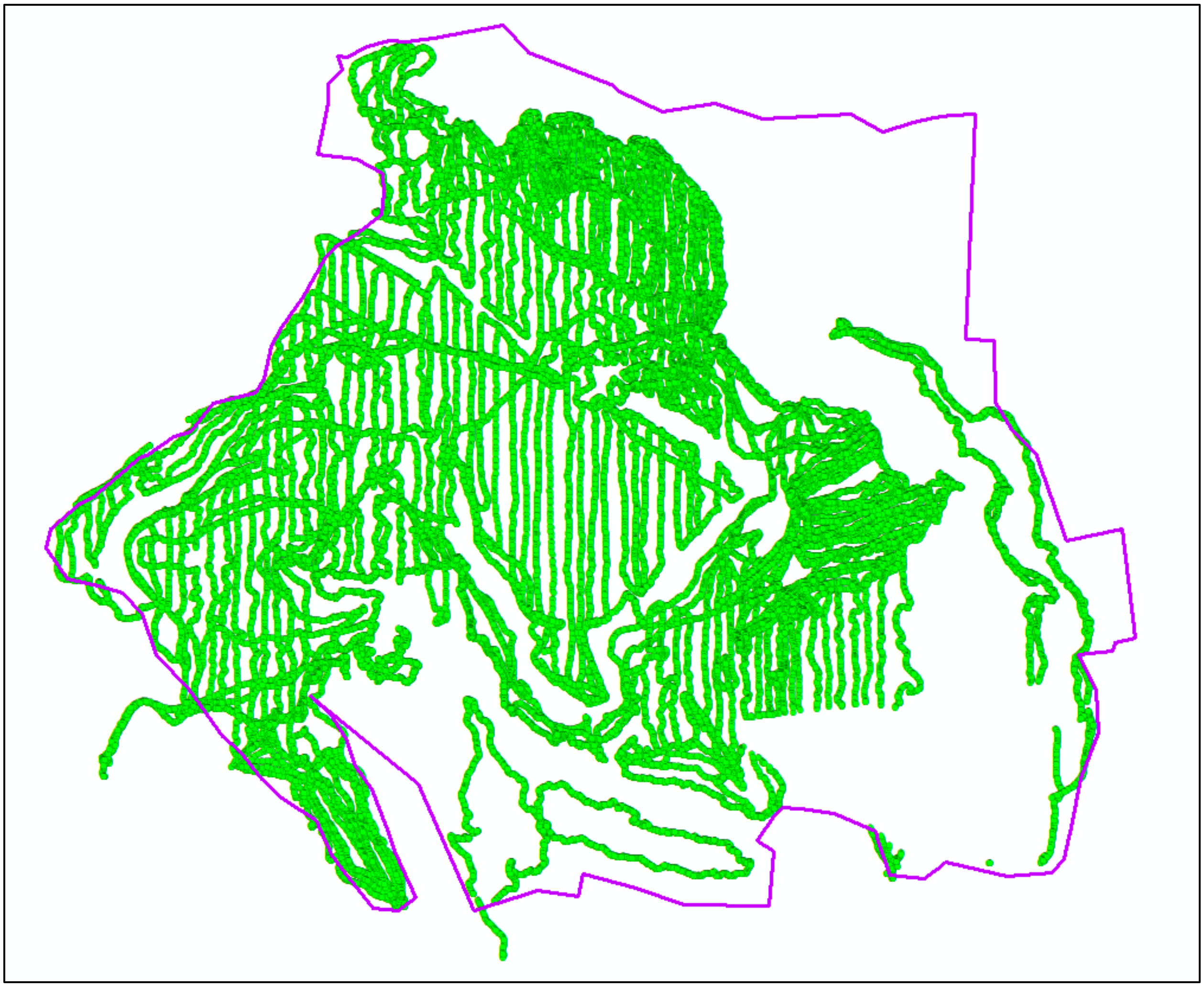


Figure H2 Adjusted Gamma Radiation Survey Measurements (2012)

2.2 2018 Gamma Survey Data

Tetra Tech conducted back-pack ground gamma radiation surveys at Bluff B in 2018 (Tetra Tech 2019). The purpose of the 2018 survey was to fill in data gaps from the 2012 survey in an area where a sediment pond was being proposed. The data was originally collected in WGS84 and was then projected into NAD 1983 State Plane South Dakota North FIPS 4001 using the projection tool in ArcMap. A total of 52,836 gamma measurements from the 2018 survey are shown as red dots in Figure H3. This data includes gamma "verification" plots from the 2018 survey. The geodatabase file for the original 2018 gamma survey is titled "Tronox_Bluff_B_2018_Final_Scan_NAD83". No data was removed from this file and the file was used for combination with the 2012 and 2021 data discussed in subsequent sections.

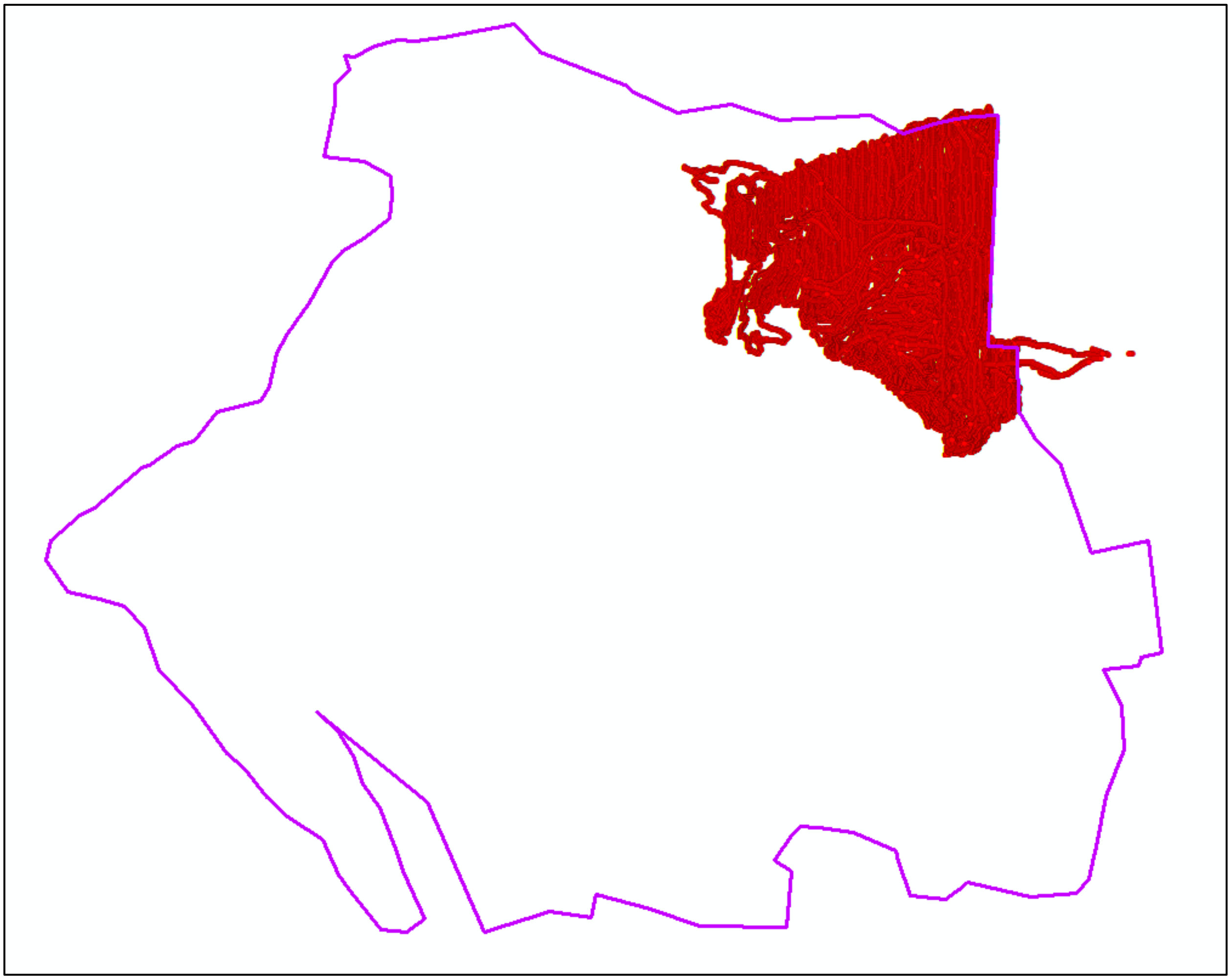


Figure H3 Gamma Radiation Survey Measurements (2018)

2.3 2021 Gamma Survey Data

Tetra Tech conducted a conventional ground-based gamma radiation survey, as had been done in 2012 and 2018, but added an aerial gamma radiation survey at Bluff B in 2021 whose purpose was to evaluate its efficacy as a screening tool to identify areas of contamination in excess of clean-up levels. The ground-based gamma radiation survey involved (1) lateral delineation surveys; (2) and a gamma-radium correlation study, both of these survey methods are described in the main report. The data from aerial gamma radiation survey was converted to 1-meter equivalent using the methods described in Appendix B.

The opportunistic ground-based gamma radiation survey had 35,066 measurements and are shown as orange points on Figure H4. A file was generated representing the 2021 data which is titled "Combined_Green_Yellow_2021_Goback_Scans_NAD83". All of these measurements are used for combination with the other 2021 measurements to develop a main file 2021, described shortly.

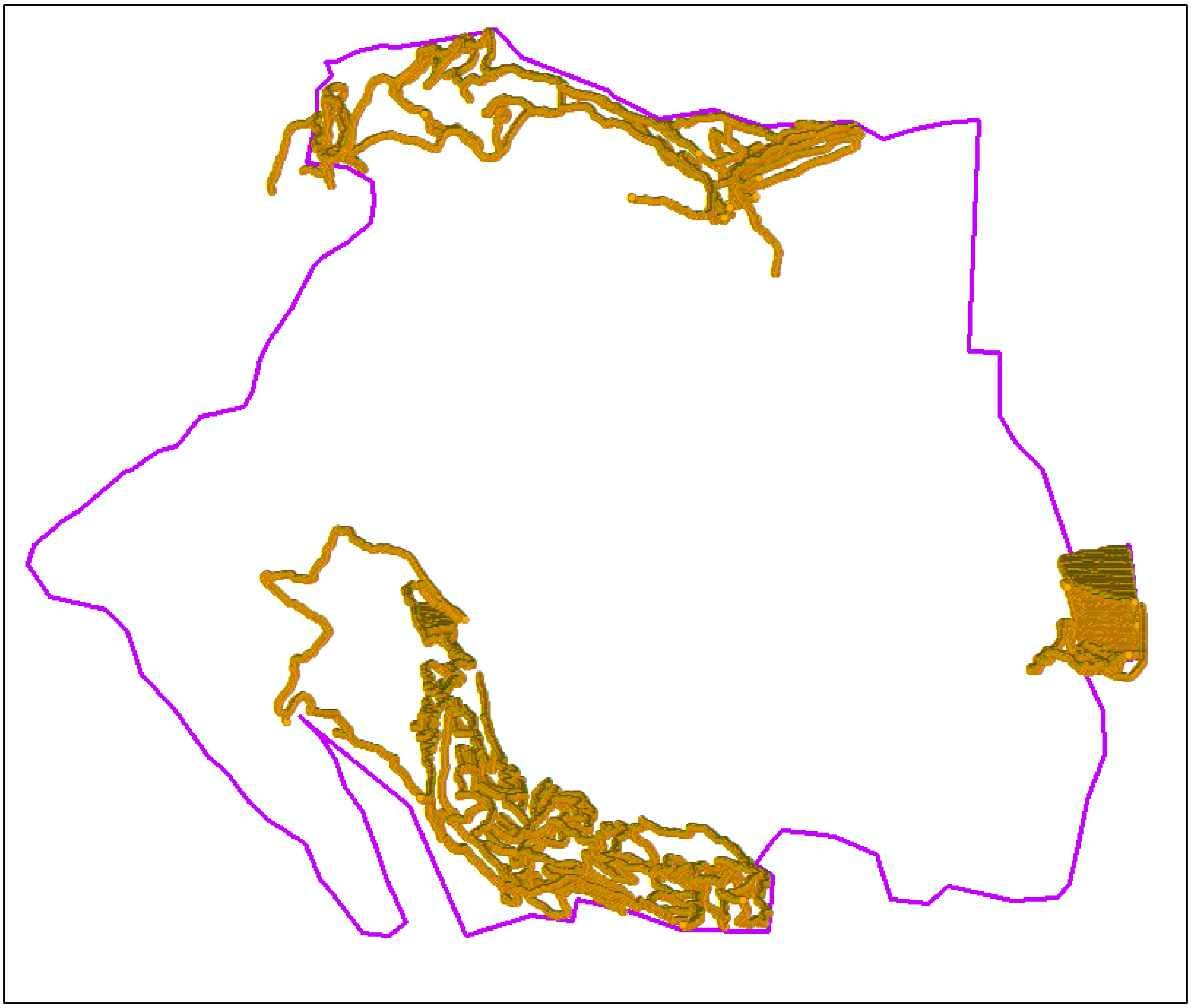


Figure H4 Opportunistic Gamma Radiation Survey Measurements (2021)

The gamma-radium correlation measurements had 1,487 measurements taken from randomly selected correlation plots which are shown as orange points on Figure H5. Note there is a correlation plot not shown on this figure because it is located offsite (outside of the extents shown on this map located in an uncontaminated area- see Appendix G). A file with the of the correlation survey measurements, including the correlation plot offsite, is titled "Unshielded_Gamma_Yellow_Meter_Correlation_Data_NAD83". All of these measurements, with the exception of 157 measurements from offsite, are used for combination with the other 2021 measurements to develop a main file 2021, described shortly. Therefore, only 1,330 measurements from the above mentioned file are used for combination with other 2021 data.

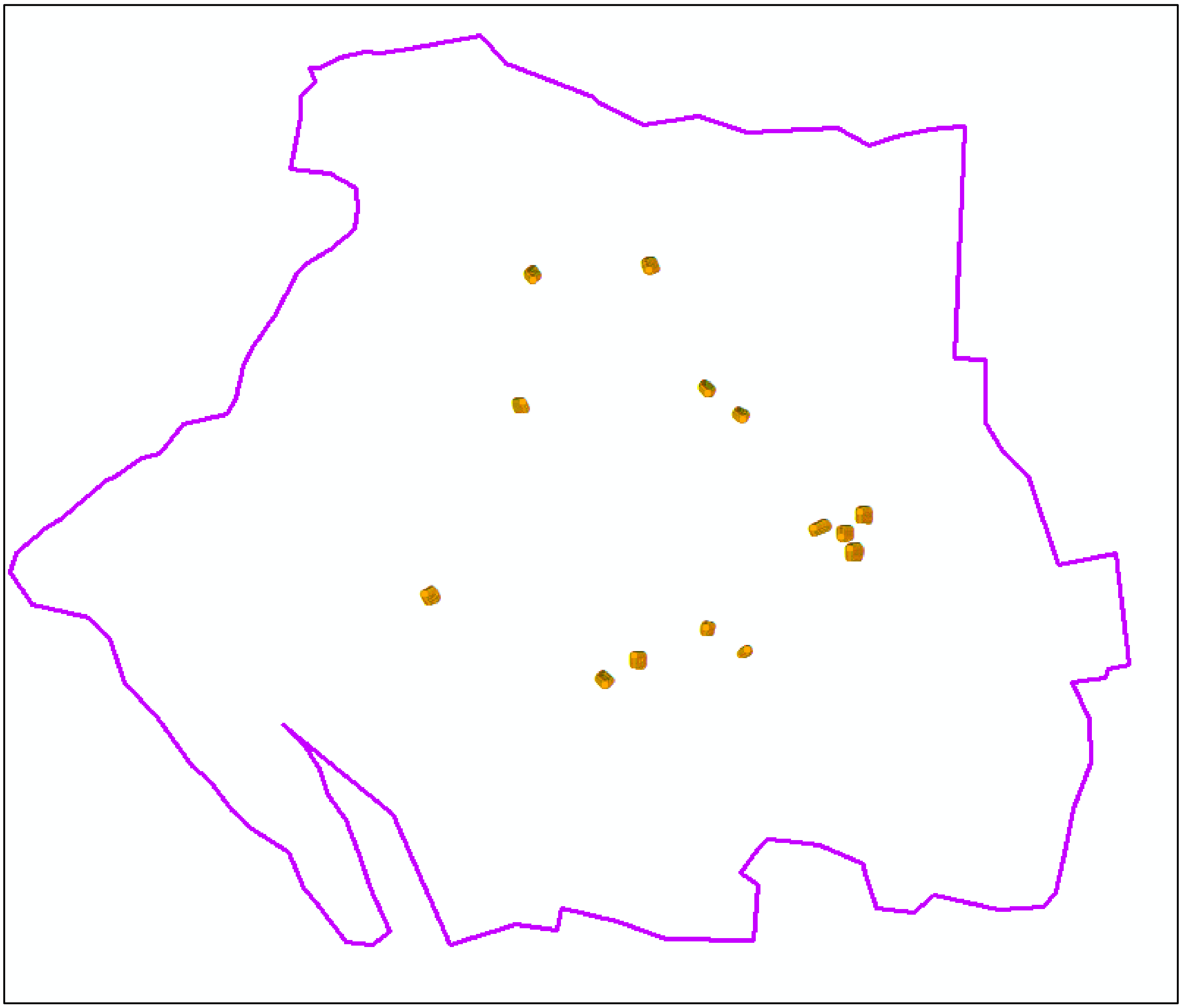


Figure H5 Gamma-Radium Correlation Survey Measurements (2021)

An aerial survey was an experimental approach to collecting gamma survey measurements in areas too steep or unstable for humans to walk (see Appendix B for more explanation). The aerial gamma radiation survey had 11,204 measurements and are shown as orange points on Figure H6. A file was generated representing the 2021 data which is titled "Bluff_B_UAV_1m_2021_Gamma_Final_NAD83". All of these measurements are used for combination with the other 2021 measurements to develop a main file 2021, described shortly.

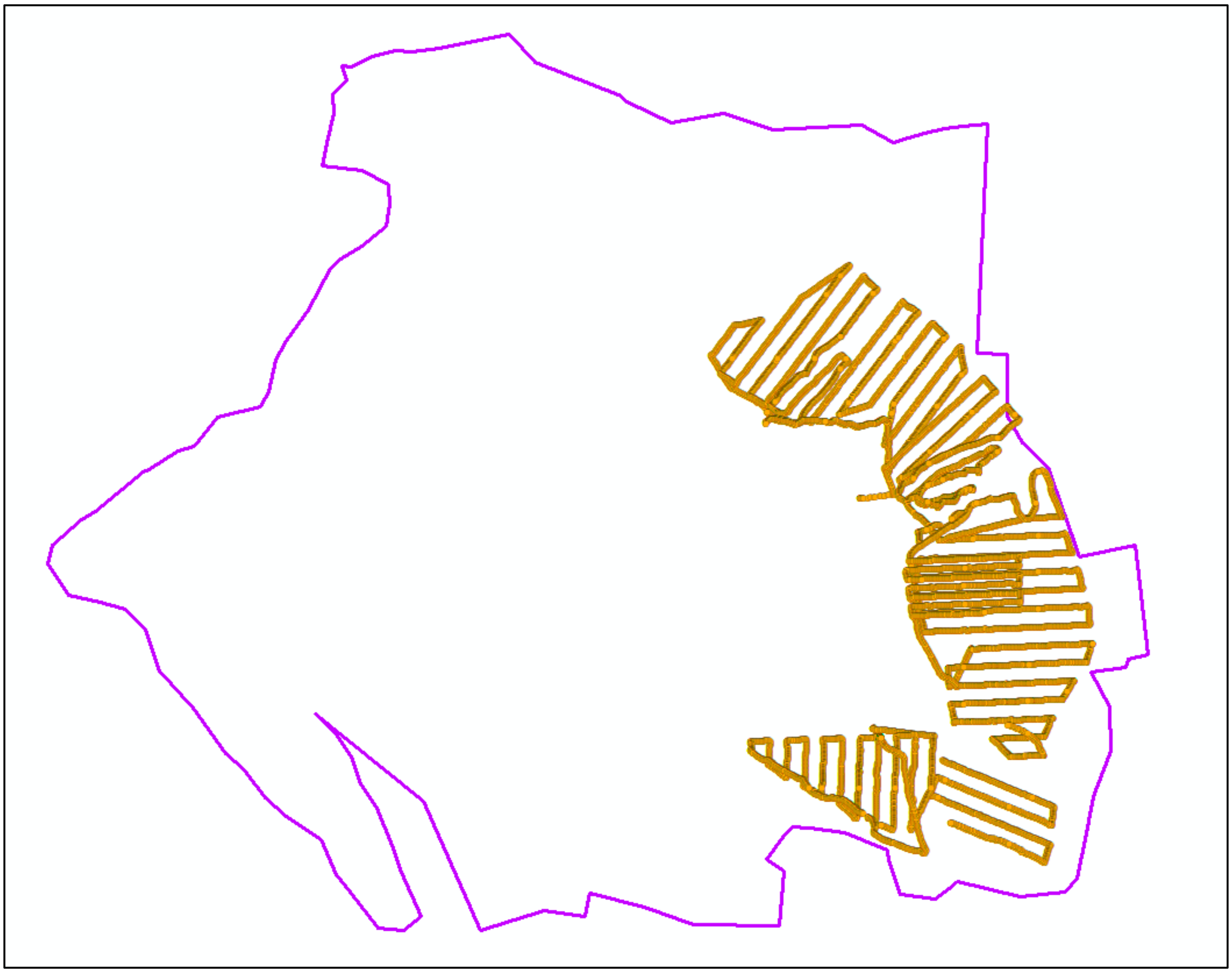


Figure H6 Aerial Gamma Radiation Survey Measurements (2021)

A 2021 file was generated by combining the three different surveys described above and summarized in Figure H7. The following files were used to generate the initial 2021 file:

- Combined_Green_Yellow_2021_Goback_Scans_NAD83 (35,066 points)
- Unshielded_Gamma_Yellow_Meter_Correlation_Data_NAD83 (1,487 points)
- Bluff_B_UAV_1m_2021_Gamma_Final_NAD83 (11,204 points)

These files were initially merged together which totaled 47,757 measurements. However, the 157 measurements from the offsite gamma-radium correlation data were removed because they are outside the Bluff B contamination area and were used merely within the correlation analysis to provide data in the low range (see Appendix G). Therefore, a total of 47,600 measurements remains in the final 2021 data file. The 2021 Bluff B data file is titled "Bluff_B_2021_Status_Update_Gamma_UAV_Ground_Data_NAD83".

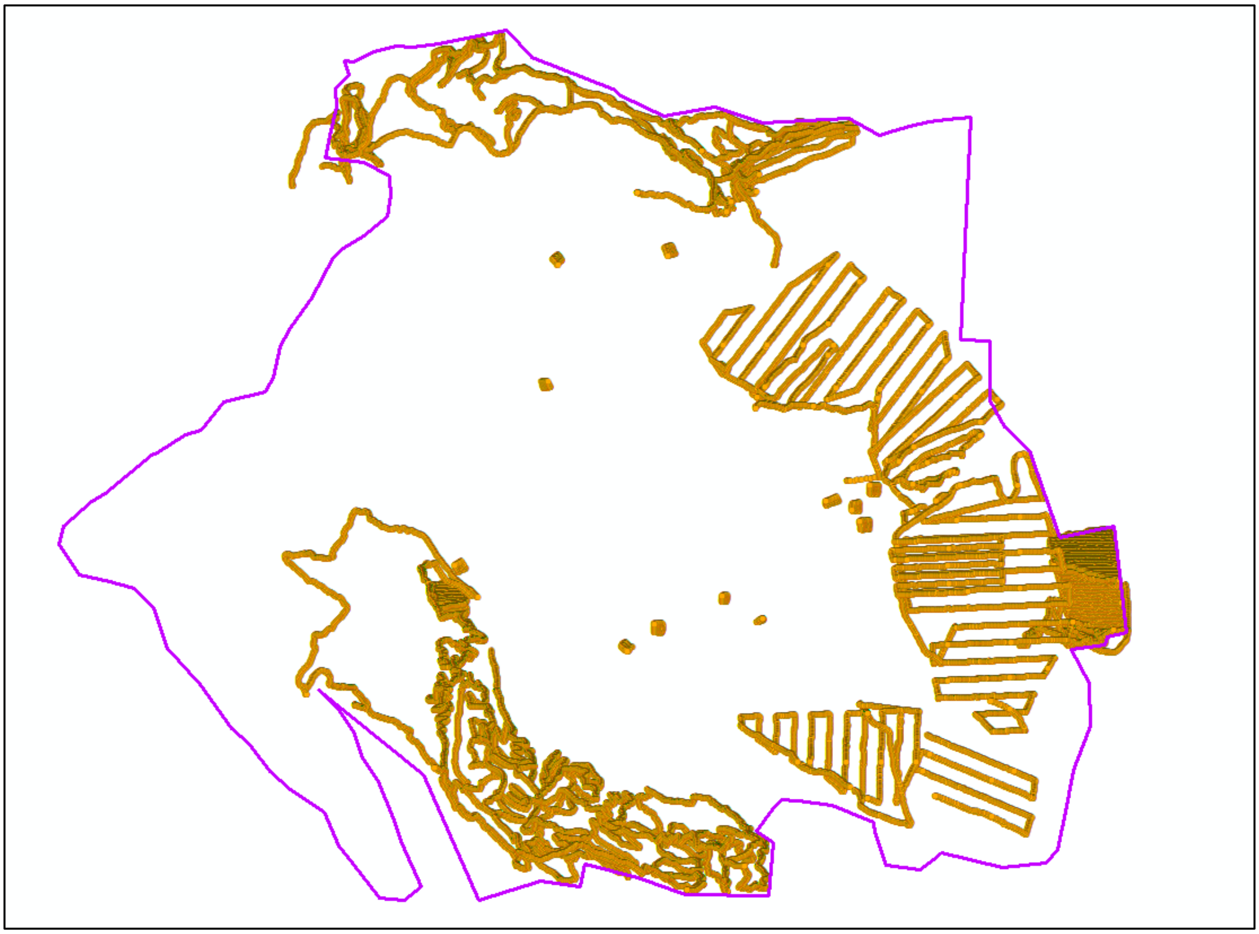


Figure H7 Final Combined 2021 Gamma Radiation Survey Measurements (2021)

3.0 FINAL STATUS UPDATE FILE

A final data file was generated by merging the following data files from 2012, 2018, and 2021 to generate a final status update file for Bluff B:

- Tronox_Bluff_B_2012_Final_Scan_Less_SE_Corner_NAD83 (63,711)
- Tronox_Bluff_B_2018_Final_Scan_NAD83 (52,836)
- Bluff_B_2021_Status_Update_Gamma_UAV_Ground_Data_NAD83 (47,600)

A status update gamma radiation survey measurement file contains 164,147 measurements and is titled "Bluff_B_2021_Status_Update_2012_2018_2021_Gamma_Data_NAD83". A color coordinated map showing the different data sets is presented in

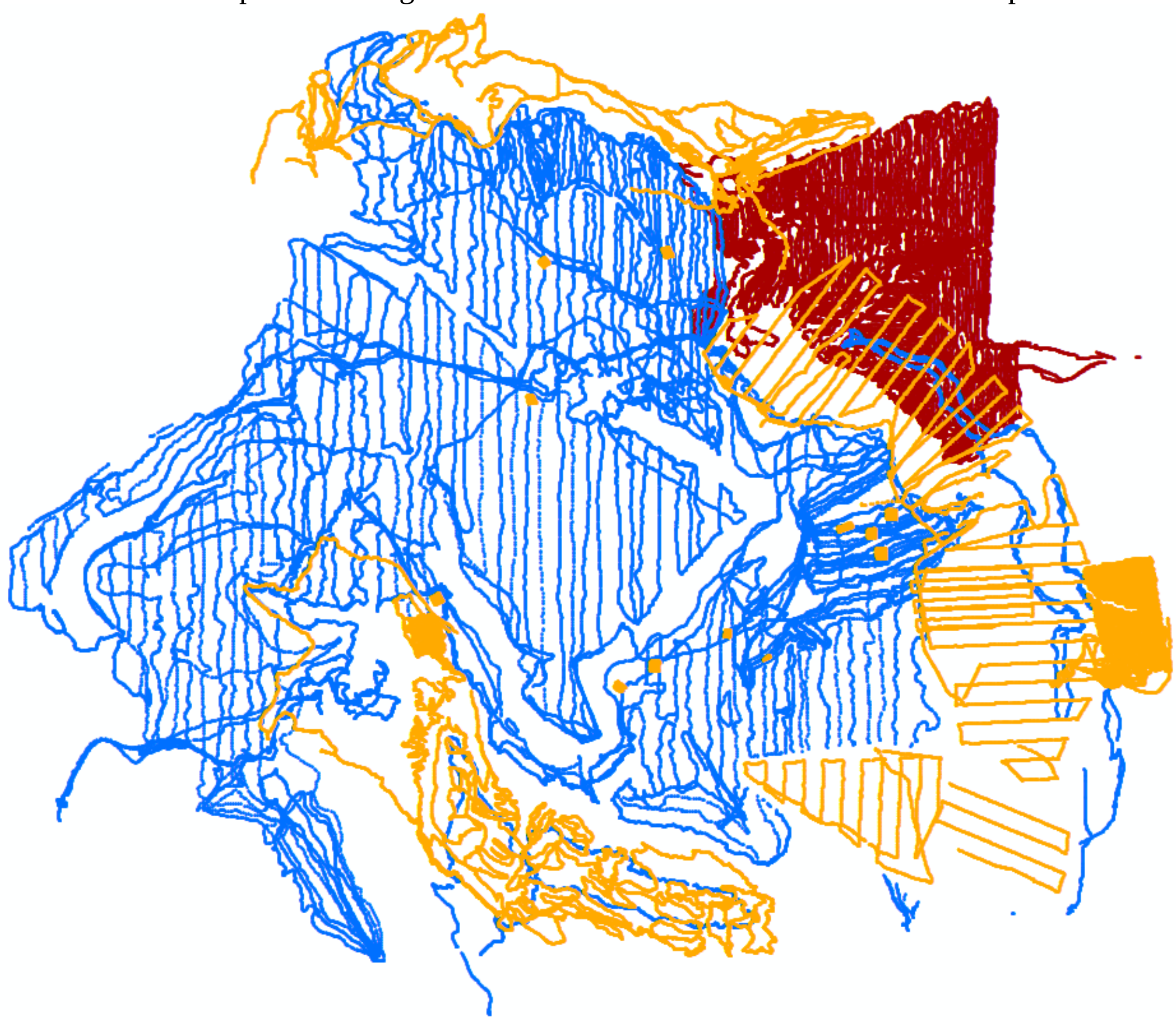


Figure H8.

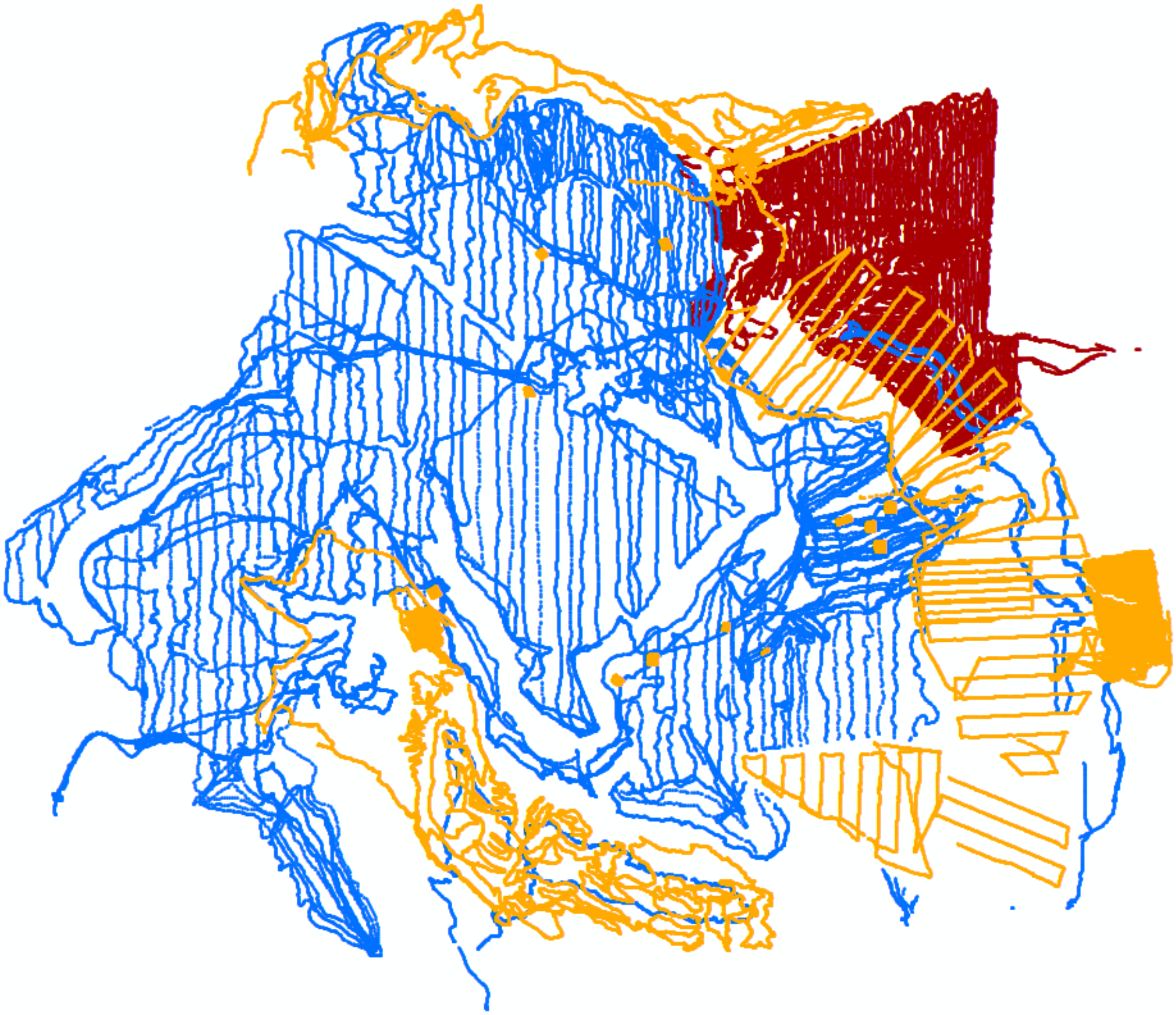


Figure H8 Final Status Update Gamma Survey File – Color Coordinated (2012, 2018, 2021)

Figure H9 shows all of the combined data described earlier as one file. For each data set a data field with “uRhr” and “Year” was added so that the data can be viewed together, and the year of the data may be identified easy. This data file is to be used for future work at Bluff B until more data is collected.

Figure H9 Final Status Update Gamma Survey Measurements (2012, 2018, and 2021)

4.0 REFERENCES

Tetra Tech, 2013. Tronox Bluff Waste Characterization Report, Riley Pass Abandoned Uranium Mines Site, North Cave Hills, Harding County, SD, Prepared for USDA Forest Service, Red Lodge Montana.

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APPENDIX I

FULL ANALYTICAL RESULTS FOR SOIL SAMPLES

I-1 OPPORTUNISTIC SAMPLES

Analyte	Units	Sample ID					
		OPP-1-080421		OPP-2-080421		OPP-3-080421	
		Result	Q	Result	Q	Result	Q
Sampling Event		Opportunistic		Opportunistic		Opportunistic	
Actinium-228	pCi/g	1.07	J	0.86	J	0.93	J
Potassium-40	pCi/g	1.07	J	15.4	J	12.3	J
Radium-226	pCi/g	1.7	J	3.8	J	2.52	J
Arsenic	mg/kg	37		16		44	
Thorium	mg/kg	4.6		3.6		4.7	

Analyte	Units	Sample ID					
		OPP-4-080421		OPP-5-080421		OPP-6-080421	
		Result	Q	Result	Q	Result	Q
Sampling Event		Opportunistic		Opportunistic		Opportunistic	
Actinium-228	pCi/g	0.94	J	0.82	J	1.04	UJ
Potassium-40	pCi/g	12.5	J	16.3	J	7.5	J
Radium-226	pCi/g	5.5	J	7	J	4.5	J
Arsenic	mg/kg	39		39		25	
Thorium	mg/kg	3.4		3.3		2.9	

Analyte	Units	Sample ID					
		OPP-7-080421		OPP-8-080421		OPP-DUP-080421	
		Result	Q	Result	Q	Result	Q
Sampling Event		Opportunistic		Opportunistic		Opportunistic	
Actinium-228	pCi/g	0.79	J	0.86	J	0.76	UJ
Potassium-40	pCi/g	13	J	11.5	J	9.2	J
Radium-226	pCi/g	3.07	J	3.12	J	4.39	J
Arsenic	mg/kg	18		22		25	
Thorium	mg/kg	2.8		2.6		2.9	

I-2 CORRELATION SAMPLES

Analyte	Units	Sample ID					
		CORR01-080521		CORR02-080521		CORR03-080521	
		Result	Q	Result	Q	Result	Q
Sampling Event		Correlation		Correlation		Correlation	
Actinium-228	pCi/g	0.75	UJ	1.27	J	1.2	J
Potassium-40	pCi/g	14.1	J	17.4	J	11.8	
Radium-226	pCi/g	1.57	J	1.68	J	4.7	
Thorium-228	pCi/g	1.01		1.02		1.08	
Thorium-230	pCi/g	1.07		1.42		2.76	
Thorium-232	pCi/g	0.85		1.03		1.08	
Uranium-234	pCi/g	0.67		1.02		3.11	
Uranium-235	pCi/g	0.061		0.05		0.156	
Uranium-238	pCi/g	0.77		1.19		2.75	
Arsenic	mg/kg	67		63		22	
Thorium	mg/kg	3.3		4.9		6	
Uranium	mg/kg	0.87		1.7		7.5	

Analyte	Units	Sample ID					
		CORR04-080521		CORR05-080521		CORR06-080521	
		Result	Q	Result	Q	Result	Q
Sampling Event		Correlation		Correlation		Correlation	
Actinium-228	pCi/g	1.13	J	1.18	UJ	0.53	U
Potassium-40	pCi/g	13	J	14.3	J	13.1	
Radium-226	pCi/g	21.9	J	27.7	J	11.6	
Thorium-228	pCi/g	1.23		1.09		0.79	
Thorium-230	pCi/g	21.7		17.2		9	
Thorium-232	pCi/g	1.02		1.05		0.87	
Uranium-234	pCi/g	21.2		15		8.6	
Uranium-235	pCi/g	0.8		0.7		0.35	
Uranium-238	pCi/g	19.8		14.8		7.9	
Arsenic	mg/kg	120		140		71	
Thorium	mg/kg	5.9		5.5		4.3	
Uranium	mg/kg	49		47		23	

Analyte	Units	Sample ID					
		CORR07-080521		CORR08-080521		CORR09-080521	
		Result	Q	Result	Q	Result	Q
Sampling Event		Correlation		Correlation		Correlation	
Actinium-228	pCi/g	1.15	UJ	1.06	J	1.26	J
Potassium-40	pCi/g	15.7	J	14.7	J	11	J
Radium-226	pCi/g	23.1	J	10.5	J	11.9	J
Thorium-228	pCi/g	1.11		1.11		1.19	J
Thorium-230	pCi/g	20		8.6		8.3	J
Thorium-232	pCi/g	0.95		1.07		1.02	J
Uranium-234	pCi/g	19.1		9.1		9	
Uranium-235	pCi/g	0.9		0.52		0.37	
Uranium-238	pCi/g	19		8.7		9.3	
Arsenic	mg/kg	130		160		110	
Thorium	mg/kg	4.9		6		6.1	
Uranium	mg/kg	71		26		25	

Analyte	Units	Sample ID					
		CORR10-080521		CORR11-080521		CORR12-080521	
		Result	Q	Result	Q	Result	Q
Sampling Event		Correlation		Correlation		Correlation	
Actinium-228	pCi/g	0.97	J	1.53	J	1.3	UJ
Potassium-40	pCi/g	14.6	J	17.5	J	11.4	J
Radium-226	pCi/g	12.7	J	18.4	J	93	J
Thorium-228	pCi/g	1.64		1.81		2.01	J
Thorium-230	pCi/g	12.8		12.8		112	J
Thorium-232	pCi/g	1.21		1.44		1.65	J
Uranium-234	pCi/g	12.8		12.2		97	
Uranium-235	pCi/g	0.63		0.68		4.46	
Uranium-238	pCi/g	13		12.8		97	
Arsenic	mg/kg	180		150		540	
Thorium	mg/kg	6.8		8.7		7.2	
Uranium	mg/kg	33		32		220	

Analyte	Units	Sample ID					
		CORR13-080521		CORR14-080521		CORR15-080521	
		Result	Q	Result	Q	Result	Q
Sampling Event		Correlation		Correlation		Correlation	
Actinium-228	pCi/g	0.72		1.39	J	1.59	J
Potassium-40	pCi/g	11.1		12.2	J	13.2	J
Radium-226	pCi/g	30		10.1	J	2.9	J
Thorium-228	pCi/g	0.75		1.51		1.28	J
Thorium-230	pCi/g	20.5		8.6		2.09	J
Thorium-232	pCi/g	0.75		1.14		1.13	J
Uranium-234	pCi/g	26.2		7.2		1.88	
Uranium-235	pCi/g	1.36		0.303		0.053	
Uranium-238	pCi/g	26.2		7.3		1.71	
Arsenic	mg/kg	72		310		40	
Thorium	mg/kg	4.3		7.1		6.2	
Uranium	mg/kg	72		21		3.3	

Analyte	Units	Sample ID	
		CORR-(DUP1)-080521	
		Result	Q
Sampling Event		Correlation	
Actinium-228	pCi/g	0.89	J
Potassium-40	pCi/g	18.3	J
Radium-226	pCi/g	1.14	J
Thorium-228	pCi/g	0.87	
Thorium-230	pCi/g	0.93	
Thorium-232	pCi/g	0.84	
Uranium-234	pCi/g	0.73	
Uranium-235	pCi/g	0.043	
Uranium-238	pCi/g	0.74	
Arsenic	mg/kg	62	
Thorium	mg/kg	3.4	
Uranium	mg/kg	0.8	

I-3 SUBSURFACE SAMPLES

Analyte	Units	Sample ID					
		TP01-(5'-6')-080321		TP01-(7.5'-8.0')-080321		TP02-(3'-4')-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Subsurface		Subsurface		Subsurface	
Actinium-228	pCi/g	1.59	J	1.31	J	1.4	UJ
Potassium-40	pCi/g	11.4	J	7.6	J	15.9	J
Radium-226	pCi/g	46.8	J	3.7	J	141	J
Arsenic	mg/kg	1500		71		730	
Cadmium	mg/kg	1.1		0.69		0.71	
Copper	mg/kg	21		13		16	
Lead	mg/kg	37		13		23	
Thorium	mg/kg	9.5		6.1		8	
Zinc	mg/kg	59		85		43	

Analyte	Units	Sample ID					
		TP02-(10'-11')-080321		TP03-(5'-6')-080321		TP03-(14'-15')-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Subsurface		Subsurface		Subsurface	
Actinium-228	pCi/g	1.08	J	0.63	UJ	0.75	J
Potassium-40	pCi/g	15.9	J	9.6	J	14.1	J
Radium-226	pCi/g	16.2	J	85	J	0.98	J
Arsenic	mg/kg	140		290		29	
Cadmium	mg/kg	0.33		0.4		0.13	J
Copper	mg/kg	8.9		16		20	
Lead	mg/kg	11		13		7.3	
Thorium	mg/kg	4.9		5.2		5.4	
Zinc	mg/kg	34		36		28	

Analyte	Units	Sample ID					
		TP04-(5'-6')-080321		TP04-(15'-16')-080321		TP05-(18'-19')-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Subsurface		Subsurface		Subsurface	
Actinium-228	pCi/g	0.94	UJ	0.79	J	1.23	J
Potassium-40	pCi/g	13.7	J	14.9	J	11.4	J
Radium-226	pCi/g	8.9	J	3.62	J	14.7	J
Arsenic	mg/kg	180		44		43	
Cadmium	mg/kg	0.52		0.065	J	0.095	J
Copper	mg/kg	11		4.2		14	
Lead	mg/kg	16		6.9		17	
Thorium	mg/kg	6		3.6		7.9	
Zinc	mg/kg	56		21		32	

Analyte	Units	Sample ID					
		TP06-(11'-12')-080321		TP06-(17'-18')-080321		TP08-(9'-10')-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Subsurface		Subsurface		Subsurface	
Actinium-228	pCi/g	1.66	J	1.01		1.62	J
Potassium-40	pCi/g	17.1		14.8		17.5	J
Radium-226	pCi/g	1.83		1.25		4.53	J
Arsenic	mg/kg	15		18		29	
Cadmium	mg/kg	0.18	J	0.053	J	0.34	
Copper	mg/kg	19		11		16	
Lead	mg/kg	16		14		17	
Thorium	mg/kg	9.6		7.6		7.4	
Zinc	mg/kg	43		23		50	

Analyte	Units	Sample ID					
		TP09-(6'-7')-080321		TP10-(6'-7')-080421		TP10-(15'-16')-080421	
		Result	Q	Result	Q	Result	Q
Sampling Event		Subsurface		Subsurface		Subsurface	
Actinium-228	pCi/g	1.56	J	0.85	J	0.1	UJ
Potassium-40	pCi/g	13.2	J	14.5	J	10.2	J
Radium-226	pCi/g	1.82	J	5.04	J	189	J
Arsenic	mg/kg	64		19		280	
Cadmium	mg/kg	0.36		0.22	J	4	
Copper	mg/kg	21		9.4		14	
Lead	mg/kg	16		10		27	
Thorium	mg/kg	9.3		4.8		4.1	
Zinc	mg/kg	72		36		51	

Analyte	Units	Sample ID					
		TP11-(5'-6')-080421		TP13-(6'-7')-080421		TP14-(4'-5')-080421	
		Result	Q	Result	Q	Result	Q
Sampling Event		Subsurface		Subsurface		Subsurface	
Actinium-228	pCi/g	0.99	J	1.25	J	0.56	J
Potassium-40	pCi/g	14.1		17.6	J	15.5	J
Radium-226	pCi/g	1.61		2.73	J	2.21	J
Arsenic	mg/kg	7.5		88		9.1	
Cadmium	mg/kg	0.19	J	0.32		0.083	J
Copper	mg/kg	9.7		15		2.9	
Lead	mg/kg	9.1		15		4.1	
Thorium	mg/kg	4		8.2		2.9	
Zinc	mg/kg	35		77		21	

Analyte	Units	Sample ID					
		TP15-(3'-4')-080421		TP15-(8'-9')-080421		TP-(DUP)-01-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Subsurface		Subsurface		Subsurface	
Actinium-228	pCi/g	0.45	J	0.8	UJ	1.23	J
Potassium-40	pCi/g	14.1	J	14.1	J	16.9	J
Radium-226	pCi/g	1.88	J	7.6	J	1.29	J
Arsenic	mg/kg	14		38		30	
Cadmium	mg/kg	0.23		0.32		0.14	J
Copper	mg/kg	2.4		11		20	
Lead	mg/kg	4.1		11		8	
Thorium	mg/kg	2.7		5.6		5.8	
Zinc	mg/kg	20		38		33	

Analyte	Units	Sample ID	
		TP-(DUP)-02-080421	
		Result	Q
Sampling Event		Subsurface	
Actinium-228	pCi/g	2	J
Potassium-40	pCi/g	12.4	J
Radium-226	pCi/g	178	J
Arsenic	mg/kg	400	
Cadmium	mg/kg	1.5	
Copper	mg/kg	19	
Lead	mg/kg	29	
Thorium	mg/kg	9.3	
Zinc	mg/kg	47	

I-4 SURFACE SAMPLES

Analyte	Units	Sample ID					
		TP01-SURF-080321		TP02-SURF-080321		TP03-(SURF)-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Surface		Surface		Surface	
Actinium-228	pCi/g	1.9	UJ	1.56	UJ	1.48	J
Potassium-40	pCi/g	16.2	J	16.4	J	18.1	J
Radium-226	pCi/g	131	J	130	J	16.5	J
Arsenic	mg/kg	790		520		240	
Cadmium	mg/kg	0.88		0.44		0.19	J
Copper	mg/kg	15		12		15	
Lead	mg/kg	23		23		23	
Thorium	mg/kg	8.3		6.3		8.3	
Zinc	mg/kg	72		41		69	

Analyte	Units	Sample ID					
		TP04-(SURF)-080321		TP05-(SURF)-080321		TP06-(SURF)-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Surface		Surface		Surface	
Actinium-228	pCi/g	1.17	J	1.5	UJ	0.67	UJ
Potassium-40	pCi/g	18.1	J	0.5	UJ	17.9	J
Radium-226	pCi/g	5.53	J	111	J	10.8	J
Arsenic	mg/kg	150		310		100	
Cadmium	mg/kg	0.89		0.41		0.75	
Copper	mg/kg	13		33		14	
Lead	mg/kg	14		21		16	
Thorium	mg/kg	6.8		7.9		7.3	
Zinc	mg/kg	98		72		88	

Analyte	Units	Sample ID					
		TP07-(SURF)-080321		TP08-(SURF)-080321		TP09-(SURF)-080321	
		Result	Q	Result	Q	Result	Q
Sampling Event		Surface		Surface		Surface	
Actinium-228	pCi/g	1.66	J	1.3	J	1.7	J
Potassium-40	pCi/g	15.1	J	15.8	J	14.5	J
Radium-226	pCi/g	10.3	J	9	J	9.3	J
Arsenic	mg/kg	340		350		220	
Cadmium	mg/kg	0.36		0.49		0.56	
Copper	mg/kg	20		14		18	
Lead	mg/kg	20		18		28	
Thorium	mg/kg	8.7		6.8		8.4	
Zinc	mg/kg	50		45		66	

Analyte	Units	Sample ID					
		TP10-(SURF)-080421		TP11-(SURF)-080421		TP12-(SURF)-080421	
		Result	Q	Result	Q	Result	Q
Sampling Event		Surface		Surface		Surface	
Actinium-228	pCi/g	1.15		1.22	J	0.2	UJ
Potassium-40	pCi/g	17.4		15.2	J	11.4	J
Radium-226	pCi/g	2.71		3.34	J	192	J
Arsenic	mg/kg	24		25		470	
Cadmium	mg/kg	0.29		0.28		1.2	
Copper	mg/kg	12		14		17	
Lead	mg/kg	11		14		21	
Thorium	mg/kg	5.1		5.7		8.7	
Zinc	mg/kg	37		46		44	

Analyte	Units	Sample ID					
		TP13-(SURF)-080421		TP14-(SURF)-080421		TP15-(SURF)-080421	
		Result	Q	Result	Q	Result	Q
Sampling Event		Surface		Surface		Surface	
Actinium-228	pCi/g	0.94	J	1.16	J	0.78	
Potassium-40	pCi/g	15.7	J	10.3		10	
Radium-226	pCi/g	4.82	J	9.7		11.8	
Arsenic	mg/kg	53		60		55	
Cadmium	mg/kg	0.49		0.2		0.16	J
Copper	mg/kg	11		10		7.6	
Lead	mg/kg	12		11		8.3	
Thorium	mg/kg	6.3		4.9		4.4	
Zinc	mg/kg	57		30		25	