Charles Keith (#225)

Removal Site Evaluation Report

Final | October 8, 2018

Stantec

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

Stantec

Charles Keith (#225) Removal Site Evaluation Report - Final

October 8, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust
– First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: Charles Keith Removal Site Evaluation Report - Final

Approvals

This Removal Site Evaluation Report is approved for implementation without conditions.

10/15/18

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Navajo Nation Environmental Protection Agency
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10/16/18

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Revision Log

Revision No.	Date	Description
0	February 13, 2018	Submission of Draft RSE report to Agencies for review
1	*October 8, 2018*	*Submission of Final RSE report to Agencies*

Sign-off Sheet

This document entitled *Charles Keith Removal Site Evaluation Report* was prepared by MWH, now part of Stantec Consulting Services Inc. (Stantec) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase (the "Client") for submittal to the Navajo Nation Environmental Protection Agency (NNEPA) and United States Environmental Protection Agency (USEPA) (collectively, the "Agencies"). The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Per the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase*, *Section 5.4.1,* (United States [US], 2015) the following certification must be signed by a person who supervised or directed the preparation of the Removal Site Evaluation report: "Under penalty of law, I certify that to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted herein is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Prepared by Emily Yeager

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Reviewed by Kelly Johnson

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Kelly Johnson, PhD, P.G.

Approved by Toby Leeson

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Toby Leeson, P.G.

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- Tabular database files
- 2017 Cooper aerial survey orthophotographs and data files
- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
    - Chenoweth, 1991 – The Geology and Production History of the Uranium-Vanadium Deposits in Monument Valley San Juan County, Utah
    - Hendricks, 2001 – An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation
    - NAML, 2001 – Monument Valley 4 AML Reclamation Project Proposal Documents
    - NAML, n.d. – Navajo AML Reclamation Program Tuba City AML Reclamation Program GR#807810 – Close Out Report
    - USEPA, 2007a – Abandoned Uranium Mines and the Navajo Nation. Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data
    - Weston Solutions, 2012a – Navajo Abandoned Uranium Mine Site Screen Report – Charles Keith
    - Weston Solutions, 2012b - Navajo Abandoned Uranium Mine Site Screen Report – Skyline Road

Executive Summary

Introduction

The Charles Keith site (the Site) is located within the Navajo Nation, Tuba City Bureau of Indian Affairs (BIA) Agency, Oljato Chapter in southeastern Utah. The Site is one of 46 "priority" abandoned uranium mines (AUMs) within the Navajo Nation selected by the United States Environmental Protection Agency (USEPA) in collaboration with the Navajo Nation Environmental Protection Agency (NNEPA) for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). Mining for uranium occurred prior to, during, and after World War II, when the United States (US) sought a domestic source of uranium located on Navajo lands (USEPA, 2007a).

On April 30, 2015, the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase* (the *Trust Agreement*) became effective. The *Trust Agreement* was made by and among the US, as Settlor and as Beneficiary on behalf of the USEPA, the Navajo Nation, as Beneficiary, and the Trustee, Sadie Hoskie. The *Trust Agreement* was developed in accordance with a settlement on April 8, 2015 between the US and Navajo Nation for the investigation of 16 specified priority AUMs. The priority sites were selected by the US and Navajo Nation, as described in the *Trust Agreement*:

> "based on two primary criteria, specifically, demonstrated levels of Radium-226[1]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)."

The purpose of this report is to summarize the objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between August 2015 and September 2017 at the Site. The primary objectives of the RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data (e.g., the review of relevant information and the collection of data related to historical mining activities) is to determine the volume of technologically enhanced naturally occurring radioactive material (TENORM) at the Site in excess of Investigation Levels (ILs) as a result of historical mining activities. ILs are based on the background gamma measurements (in counts per minute [cpm]), and Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. .

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[1] The Agencies selected the priority mines based on gamma radiation but the *Trust Agreement* erroneously states "levels of Radium -226".

Site History and Physical Characteristics

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. The Site is located in the Monument Valley mining area in the west-central portion of the Colorado Plateau. Bedrock outcrops on or adjacent to the Site consist of Shinarump Member of the Chinle Formation, Moenkopi Formation, and the De Chelly Sandstone Member and Organ Rock Tongue of the Cutler Formation. The Site is also located within the San Juan River watershed, an area of approximately 24,600 square miles spanning Utah, Colorado, New Mexico, and Arizona. Topographically the Site is located downgradient from a mesa top, on the vertical cliffs, colluvium-covered bedrock slopes, and pediment areas of the mesa, at an elevation of approximately 5,150 ft above mean sea level. On-site overland surface water flow, when present, either terminates within the unconsolidated deposits or drains west into an unnamed drainage.

Mine workings on-site consisted of portals and rim stripping. Between 1954 and 1955, the Site produced 58.59 tons of ore that contained 236.57 pounds of 0.27 percent U_3O_8 (uranium oxide) and 178.67 pounds of 0.21 percent V_2O_5 (vanadium oxide).

In 2001 the Site was included in a Navajo Abandoned Mine Lands Reclamation Program (NAML) reclamation bid document (NAML, 2001). The bid document included the reclamation of 24 AUMs, referred to as the Monument Valley 4 Project. The Site was one of the 24 AUMs and was referred to in the bid document as either Keith Mine or NA-0214. NAML submitted a reclamation program closeout report for the Monument Valley 4 Project sometime after December 31, 2002 (NAML, n.d.). The closeout report is not dated but covered the reporting period between April 1, 1999 and December 31, 2002. The closeout report stated that the Monument Valley 4 Project was complete and listed reclamation activity accomplishments by project and not by individual AUM. In addition, in 2007 the USEPA listed the Site as reclaimed (USEPA, 2007a). In 2012 Weston Solutions (Weston) performed site screening on behalf of the USEPA. The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[2] around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey.

Summary of Removal Site Evaluation Activities

The Trust's RSE was performed in accordance with the *Site Clearance Work Plan* (MWH, 2016a) and the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). The *Site Clearance Work Plan* and the *RSE Work Plan* were approved in April and October 2016, respectively, by the NNEPA and the USEPA (collectively, the Agencies). The Trust conducted Site Clearance activities as the initial task for the RSE work to obtain information necessary to develop the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). Following Site Clearance activities, the Trust conducted two sequential tasks to complete the RSE: Baseline Studies activities and Site

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[2] Weston defined sensitive environments as "all sensitive environments located within visible range of the mine site, including: wetlands, endangered species, habitats and approximate locations of sites that may be under protection of the government of the Navajo Nation"

Characterization Activities and Assessment. Details of the Site Clearance activities, Baseline Studies activities, and Site Characterization and Assessment activities are as follows:

- **Site Clearance activities** consisted of a desktop study of historical information, site mapping, potential background reference area evaluation, biological (vegetation and wildlife) surveys, and cultural resource survey. Results of the Site Clearance activities provided historical information, site access information, potential background reference area data, and vegetation, wildlife, and cultural clearance of the Site for the Baseline Studies activities and Site Characterization and Assessment activities to commence.

- **Baseline Studies activities** included a background reference area study, site gamma radiation surveys, and a Gamma Correlation Study. Results of the Baseline Studies were used to plan and prepare the Site Characterization Activities and Assessment. Data collected in the background reference area (soil sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements) were used, along with sampling, to evaluate potential mining-related impacts in areas containing radionuclides. The Gamma Correlation Study objectives were to determine the correlations between: (1) gamma measurements and concentrations of Ra-226 in surface soils; and (2) gamma measurements and exposure rates; to use as screening tools for site assessments.

- **Site Characterization Activities and Assessment** included surface and subsurface soil and sediment sampling, and surface water sampling. The results of the surface and subsurface soil and sediment sampling analyses were used to evaluate mining impacts and define the lateral and vertical extent of TENORM at the Site. The results of the surface water analyses were used to evaluate mining impacts to surface water.

In addition, the Trust discussed with the Agencies the safety risks of performing an interim action at an un-reclaimed prospect portal located on-site that was approximately 10 ft deep and terminated on bedrock. The Trustee determined that an interim action was not feasible due to the safety risks. The Trustee also determined that it was unlikely that people and/or animals could access the portal.

Findings and Discussion

Surface and subsurface soil and sediment sampling results. Three background reference areas were selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, molybdenum, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed constituents of potential concern (COPCs) for the Site. An IL for selenium was not identified because selenium sample results were non-detect in the background areas. However, because selenium was detected in soil/sediment samples from the Survey Area (i.e., the full areal extent of the Site surface gamma survey), it is also confirmed as a COPC for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 42.4 acres, out of the 49.4 acres of the Survey Area (i.e., the full areal of the Site surface gamma survey), were estimated to contain TENORM. Of the 42.4 acres that contain TENORM, 22.3 acres contain TENORM exceeding the surface gamma ILs. The volume of TENORM in excess of ILs was estimated to be 36,640 cubic yards (yd^3) (28,013 cubic meters). Because bedrock devoid of colluvium was excluded from the TENORM volume calculation. The area of TENORM considered for the volume estimate (17.6 acres) is smaller than the area of the Site where TENORM exceeded surface gamma ILs (22.3 acres).

Gamma Correlation Study results. Results of the Gamma Correlation Study indicated that surface gamma survey results do not correlate with Ra-226 concentrations in soil. The model was made of the correlation results predicting the concentrations of Ra-226 in surface soils from the mean of the gamma measurements in five correlation locations. Therefore, users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating Ra-226 concentrations. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

Water sampling results. Surface water samples were collected from one seep and one pond. For the seep surface water sample analytical results indicated that radionuclides, metals, and general chemistry were all below their respective ILs. For the pond surface water sample analytical results indicated that radionuclides and metals were all below their respective ILs and total dissolved solids (TDS), chloride, and sulfate were at or above their respective ILs. Based on these results, there are no confirmed COPCs for the seep, and TDS, chloride, and sulfate are confirmed COPCs for the pond.

Based on the Site Clearance and RSE data collection and analyses for the Site, potential data gaps were identified and are presented in Section 4.9 of this RSE report. These potential data gaps can be taken into consideration for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

Acronyms/Abbreviations

°F	degrees Fahrenheit
e.g.	exempli gratia
etc.	et cetera
ft	feet
ft^2	square feet
i.e.	id est
mg/kg	milligram per kilogram
µR/hr	microRoentgens per hour
pCi/g	picocuries per gram
Adkins	Adkins Consulting Inc.
ags	above ground surface
amsl	above mean sea level
AUM	abandoned uranium mine
bgs	below ground surface
BIA	Bureau of Indian Affairs
CCV	continuing calibration verification
C.F.R	Code of Federal Regulations
COPC	constituent of potential concern
cpm	counts per minute
Dinétahdóó	Dinétahdóó Cultural Resource Management
DMP	Data Management Plan
DQO	Data Quality Objective
ERG	Environmental Restoration Group, Inc.
ESA	Endangered Species Act
FSP	Field Sampling Plan
GIS	geographic information system
GPS	global positioning system
HASP	Health and Safety Plan
ICAL	initial calibration
ICB/CCB	initial/continuing calibration blank
ICV	initial calibration verification
IL	Investigation Level
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
MARSSIM	Multi-agency Radiation Survey and Site Investigation Manual

MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MLR	Multivariate Linear Regression
MS/MSD	matrix spike/matrix spike duplicate
MWH	MWH, now part of Stantec Consulting Services Inc. (formerly MWH Americas, Inc.)

NaI	sodium iodide
NAML	Navajo Abandoned Mine Lands Reclamation Program
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NNDFW	Navajo Nation Department of Fish and Wildlife
NNDOJ	Navajo Nation Department of Justice
NNDNR	Navajo Nation Division of Natural Resources
NNDWR	Navajo Nation Department of Water Resources
NNEPA	Navajo Nation Environmental Protection Agency
NNESL	Navajo Nation Endangered Species List
NNHP	Navajo Natural Heritage Program
NNHPD	Navajo Nation Historic Preservation Department
NNPDWR	Navajo National Primary Drinking Water Regulation
NORM	Naturally Occurring Radioactive Material
NSDWR	National Secondary Drinking Water Regulation
NTUA	Navajo Tribal Utility Authority

QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan

R^2	Pearson's Correlation Coefficient
Ra-226	Radium-226
Ra-228	Radium-228
Redente	Redente Ecological Consultants
RSE	Removal Site Evaluation

Shasta	Shasta Copper and Uranium Company
SOP	standard operating procedure
Stantec	Stantec Consulting Services Inc.

T&E	threatened and endangered
Th-230	thorium-230
Th-232	thorium-232
TDS	total dissolved solids
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material

U-235	uranium-235
U-238	uranium-238
U_3O_8	uranium oxide
UCL	upper confidence limit
US	United States
U.S.C.	United States Code
UTL	upper tolerance limit
USAEC	US Atomic Energy Commission

USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
V_2O_5	vanadium oxide
Weston	Weston Solutions

Glossary

Adit – a nearly horizontal entry leading into a mine.

Alluvium – material deposited by flowing water.

Arroyo – a steep sided gully cut by running water in an arid or semiarid region.

Bin Range – as presented in the RSE report, a range of values to present surface gamma measurement data in relation to: (1) the surface gamma Investigation Level (IL); (2) multiples of the surface gamma IL; or (3) the mean and standard deviation of the predicted Radium-226 (Ra-226) concentrations for the Site based on the correlation equation.

Colluvium – unconsolidated, unsorted, earth material transported under the influence of gravity and deposited on lower slopes (Schaetzl and Thompson, 2015).

Composite sample – "Volumes of material from several of the selected sampling units are physically combined and mixed in an effort to form a single homogeneous sample, which is then analyzed" (USEPA, 2002a).

Constituent of potential concern (COPC) – analytes identified in the *RSE Work Plan* where their levels were confirmed based on the results of the RSE.

Data Validation – "an analyte- and sample-specific process that extends the evaluation of data beyond, method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set" (USEPA, 2002b).

Data Verification – "the process of evaluating the completeness, correctness and conformance/compliance of a specific data set against the method, procedural, or contractual requirements" (USEPA, 2002b).

Earthworks – human-caused disturbance of the land surface related to mining or reclamation.

Eolian – a deposit that forms as a result of the accumulation of wind-driven products from the weathering of solid bedrock or unconsolidated deposits.

Ephemeral – ephemeral streams flow only in direct response to surface runoff precipitation or melting snow, and their channels are at all times above the water table (USGS, 2003). This concept also applies to ephemeral ponds that contain water in response to surface runoff precipitation or melting snow and are at all times above the water table.

Ethnographic – relating to the scientific description of peoples and cultures with their customs, habits, and mutual differences.

Gamma – a type of radiation that occurs as the result of the natural decay of uranium.

Geochemical – the chemistry of the composition and alterations of the solid matter of the earth (American Heritage Dictionary, 2016).

Geomorphology – the physical features of the surface of the earth and their relation to its geologic structures (English Oxford Dictionary, 2018).

Grab sample – a sample collected from a specific location (and depth) at a certain point in time.

Investigation Level (IL) – based on the background gamma measurements (in counts per minute [cpm]) and, Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts.

Isolated Occurrences – in relation to the Site Cultural Resource Survey: Any non-structural remains of a single event: alternately, any non-structural assemblage of approximately 10 or fewer artifacts within an area of approximately 10 square meters or less, especially if it is of questionable human origin or if it appears to be the result of fortuitous causes. The number and/or composition of observed artifact classes are a useful rule of thumb for distinguishing between a site and an isolate (NNHPD, 2016).

Mineralized – economically important metals in the formation of ore bodies that have been geologically deposited. For example, the process of mineralization may introduce metals, such as uranium, into a rock. That rock may then be referred to as possessing uranium mineralization (World Heritage Encyclopedia, 2017).

Naturally occurring radioactive material (NORM) – "materials which may contain any of the primordial radionuclides or radioactive elements as they occur in nature, such as radium, uranium, thorium, potassium, and their radioactive decay products, that are undisturbed as a result of human activities" (USEPA, 2017).

Orthophotograph – an aerial photograph or image geometrically corrected such that the scale is uniform: the photograph has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure distances, because it is an accurate representation of the earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

Pan Evaporation – evaporative water losses from a standardized pan.

Pediment – gently sloping erosional surface of low relief developed on bedrock (Dohrenwend and Parsons, 2009)

Portal – The surface entrance to a drift, tunnel, adit, or entry (US Bureau of Mines, 2017).

Radium-226 (Ra-226) – a radioactive isotope of radium that is produced by the natural decay of uranium.

Radium-228 (Ra-228) – a radioactive isotope of radium that is produced by the natural decay of uranium.

Remedial Action (or remedy) – "those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment…For the purpose of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the term also includes enforcement activities related thereto" (USEPA, 1992).

Remove or removal – "the cleanup or removal of released hazardous substances from the environment; such actions as may be necessary taken in the event of the threat of release of hazardous substances into the environment; such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare of the United States or to the environment, which may otherwise result from a release or threat of release…" (USEPA, 1992).

Respond or response – "remove, removal, remedy, or remedial action, including enforcement activities related thereto" (USEPA, 1992).

Secular equilibrium – a type of radioactive equilibrium in which the half-life of the precursor (parent) radioisotope is so much longer than that of the product (daughter) that the radioactivity of the daughter becomes equal to that of the parent with time; therefore, the quantity of a radioactive isotope remains constant because its production rate is equal to its decay rate. In secular equilibrium the activity remains constant.

Static gamma measurement – stationary gamma measurement collected for a specific period of time (e.g., 60 seconds).

Technologically enhanced naturally occurring radioactive material (TENORM) – "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing", which includes disturbance from mining activities. Where "technologically enhanced means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures" (USEPA, 2017).

Thorium (Th) – "a naturally occurring radioactive metal found at trace levels in soil, rocks, water, plants and animals. Thorium (Th) is solid under normal conditions. There are natural and man-made forms of thorium, all of which are radioactive" (USEPA, 2017).

Th-230 – a radioactive isotope of thorium that is produced by the natural decay of thorium.

Th-232 – a radioactive isotope of thorium that is produced by the natural decay of thorium.

Upper Confidence Limit (UCL) – the upper boundary (or limit) of a confidence interval of a parameter of interest such as the population mean (USEPA, 2015).

Upper Tolerance Limit (UTL) – a confidence limit on a percentile of the population rather than a confidence limit on the mean. For example, a 95 percent one-sided UTL for 95 percent coverage represents the value below which 95 percent of the population values are expected to fall with 95 percent confidence. In other words, a 95 percent UTL with coverage coefficient 95 percent represents a 95 percent UCL for the 95th percentile (USEPA, 2015).

Uranium (U) – a naturally occurring radioactive element that may be present in relatively high concentrations in the geologic materials in the southwest United States.

U-235 – a radioactive isotope of uranium that is produced by the natural decay of uranium.

U-238 – a radioactive isotope of uranium that is produced by the natural decay of uranium.

Walkover gamma radiation survey – referred to as a scanning survey in the Multi-agency Radiation Survey and Site Investigation Manual (*MARSSIM*; USEPA, 2000). A walkover gamma radiation survey is the process by which the operator uses a portable radiation detection instrument to detect the presence of radionuclides on a specific surface (i.e., ground, wall) while continuously moving across the surface at a certain speed and in a certain pattern (USEPA, 2000). Referred to in the RSE report as surface gamma survey after the first mention in the report.

Wind rose – a circular graph depicting average wind speed and direction.

1.0 INTRODUCTION

1.1 BACKGROUND

This report summarizes the purpose and objectives, field investigation activities, findings, and conclusions of Site Clearance and Removal Site Evaluation (RSE) activities conducted between August 2015 and September 2017 at the Charles Keith site (the Site) located in southeastern Utah, as shown in Figure 1-1. The Site is also identified by the United States Environmental Protection Agency (USEPA) as abandoned uranium mine (AUM) identification #225 in the *Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data* (the *2007 AUM Atlas*; USEPA, 2007a). The *2007 AUM Atlas* was prepared for the USEPA in cooperation with the Navajo Nation Environmental Protection Agency (NNEPA) and the Navajo Abandoned Mine Lands Reclamation Program (NAML). The claim boundary polygon (refer to Figure 2-1) used for the RSE encompassed an area of approximately 8.4 acres (365,904 square feet [ft^2]) and was provided as part of the *2007 AUM Atlas*. Per the *2007 AUM Atlas* this polygon and other factors represent the location and surface extent of the AUM.

Stantec Consulting Services Inc. (Stantec; formerly MWH), performed Site Clearance activities in accordance with the *Site Clearance Work Plan* (MWH, 2016a), and performed RSE activities in accordance with the *Removal Site Evaluation Work Plan* ([*RSE Work Plan*] MWH, 2016b). The *Site Clearance Work Plan* and the *RSE Work Plan* were approved in April and October 2016, respectively, by the NNEPA and the USEPA (collectively, the Agencies). Stantec conducted this investigation on behalf of Sadie Hoskie, Trustee pursuant to Section 1.1.21 of the *Navajo Nation AUM Environmental Response Trust Agreement – First Phase* (the *Trust Agreement*), effective April 30, 2015 (United States [US], 2015). The *Trust Agreement* is made by and among the US, as Settlor, and as Beneficiary on behalf of the USEPA, the Navajo Nation, as Beneficiary, and the Trustee. The *Trust Agreement* was developed in accordance with a settlement on April 8, 2015 between the US and Navajo Nation for the investigation of 16 specified "priority" AUMs.

A "Site" is defined in the *Trust Agreement* as:

> "each of the 16 AUMs listed on Appendix A to the Settlement Agreement, including the proximate areas where waste material associated with each such AUM has been deposited, stored, disposed of, placed, or otherwise come to be located." *Trust Agreement*, § 1.1.25.

The Site is one of 46 priority AUMs within the Navajo Nation selected by the USEPA in collaboration with the NNEPA for further evaluation based on radiation levels and potential for water contamination (USEPA, 2013). The 16 priority AUMs included in the *Trust Agreement* are located on Navajo Lands throughout southeastern Utah, northeastern Arizona, and western New Mexico, as shown in Figure 1-1. The 16 priority AUMs were selected by the US and Navajo Nation, as described in the *Trust Agreement*:

> "based on two primary criteria, specifically, demonstrated levels of Radium-226[3]: (a) at or in excess of 10 times the background levels and the existence of a potentially inhabited structure located within 0.25 miles of AUM features; or (b) at or in excess of two times background levels and the existence of a potentially inhabited structure located within 200 feet (ft)." *Trust Agreement*, Recitals.

In addition, the 16 priority AUMs are, for the purposes of this investigation, a subset of priority mines for which a viable private potentially responsible party has not been identified. Mining for uranium occurred prior to, during, and after World War II, when the US sought a domestic source of uranium located on Navajo lands (USEPA, 2007a). *Trust Agreement*, Recitals.

1.2 OBJECTIVES AND PURPOSE OF THE REMOVAL SITE EVALUATION

The primary objectives of the RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data (e.g., the review of relevant information and the collection of data related to historical mining activities) is to determine the volume of technologically enhanced naturally occurring radioactive material (TENORM) at the Site in excess of Investigation Levels (ILs) as a result of historical mining activities. ILs are based on the background gamma measurements (in counts per minute [cpm]), and Radium-226 (Ra-226) and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. The USEPA (2017) defines TENORM as:

> "naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing" (mine waste or other mining-related disturbance).
>
> "Technologically enhanced means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures."

An understanding of the extent and volume of TENORM that exceeds the ILs at the Site is key information for future Removal or Remedial Action evaluations, including whether, and to what extent, a Response Action is warranted under federal and Navajo law. Definitions presented in the glossary for "Removal", "Remedial Action", and "Response" are defined in 40 Code of Federal Regulations (CFR) Section 300.5 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; USEPA, 1992).

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[3] The Agencies selected the priority mines based on gamma radiation but the *Trust Agreement* erroneously states "levels of Radium -226".

The Trust conducted Site Clearance activities to obtain information necessary to develop the *RSE Work Plan*. Site Clearance activities consisted of two separate tasks: a "desktop" study (e.g., literature and historical documentation review) and field activities.

Desktop study – included review of readily available and reasonably ascertainable information including:

- Historical and current aerial photographs to identify any potential historical mining features, and to identify if buildings, homes and/or other structures, and potential haul roads were present within 0.25 miles of the Site
- Topographic and geologic maps
- Available data concerning perennial surface water features and water wells
- Previous studies and reclamation activities
- Meteorological data (e.g., predominant wind direction in the region of the Site)

Site Clearance field activities – included the following:

- Site reconnaissance to evaluate in the field: access routes to the Site, location of site boundaries, and observations presented in the Weston Solutions (Weston)(2012a) report
- Mapping of site features and boundaries
- Evaluation of potential background reference areas
- Biological surveys (wildlife and vegetation)
- Cultural resource surveys

Following Site Clearance activities, two sequential tasks were conducted to complete the RSE: Baseline Studies and Site Characterization and Assessment. Baseline Studies activities were completed to establish the basis for the Site Characterization and Assessment activities.

Baseline Studies activities – included the following:

- Background Reference Area Study – walkover gamma radiation survey (referred to hereafter as surface gamma survey), subsurface static gamma radiation measurements (referred to hereafter as subsurface static gamma measurements), surface and subsurface soil sampling, and laboratory analyses
- Site gamma survey – surface gamma survey
- Gamma Correlation Study – co-located surface static gamma measurements and exposure-rate measurements at fixed points, high-density surface gamma surveys (intended to cover 100 percent of the survey area), surface soil sampling, and laboratory analyses

Site Characterization Activities and Assessment – included the following:

- Characterization of surface soils and sediments – surface soil and sediment sampling and laboratory analyses.
- Characterization of subsurface soils and sediments – static gamma measurements (at surface and subsurface hand auger borehole locations), and subsurface sampling and laboratory analyses. Hand auger borehole locations are referred to hereafter as boreholes.
- Characterization of perennial surface water – surface water sampling and laboratory analyses.

Details regarding the Site Clearance activities are provided in the *Charles Keith Site Clearance Data Report* (*Site Clearance Data Report*; MWH, 2016c) and summarized in Section 3.2 of this report. Details regarding the Baseline Study activities are provided in the *Charles Keith Baseline Studies Field Report* (Stantec, 2017) and summarized in Section 3.3 of this report. Details regarding the Site Characterization Activities and Assessment are provided in Section 3.3 of this report. Findings are presented in Section 4.0 of this report.

1.3 REPORT ORGANIZATION

This report presents a comprehensive discussion of all RSE activities, including applicable aspects of the outline suggested in the *Multi-Agency Radiation Survey and Site Investigation Manual – Appendix A* ([*MARSSIM*] USEPA, 2000), and consists of the following sections:

Executive Summary – Presents a concise description of the principal elements of the RSE report.

Section 1.0 Introduction – Describes the purpose and objectives of the RSE process, and organization of this RSE report.

Section 2.0 Site History and Physical Characteristics – Presents the history, land use, and physical characteristics of the Site.

Section 3.0 Summary of Site Investigation Activities – Summarizes the Site Clearance and RSE activities.

Section 4.0 Findings and Discussion – Presents the results of the Site Clearance and RSE activities, areas that exceed ILs, areas of Naturally Occurring Radioactive Material (NORM) and TENORM, and the volume of TENORM that exceeds the ILs. Potential data gaps are also presented, as applicable.

Section 5.0 Summary and Conclusions – Summarizes data and presents conclusions based on results of the investigations completed to date.

Section 6.0 Estimate of Removal Site Evaluation Costs – A statement of actual or estimated costs incurred in complying with the *Trust Agreement*, as required by the *Trust Agreement*.

Section 7.0 References – Lists the reference documents cited in this RSE report.

Tables Included at the end of this RSE report.

Figures Included at the end of this RSE report.

Appendices – Appendices A through F.1 are included at the end of this RSE report and Appendix F.2 is provided as a separate electronic file due to its file size and length.

- **Appendix A** – Includes the radiological characterization report for the Site
- **Appendix B** – Includes photographs of the Site
- **Appendix C** – Includes copies of RSE field activity forms
- **Appendix D** – Provides the potential background reference areas selection and the methods and results of the statistical data evaluation for the Site
- **Appendix E** – Includes the biological evaluation report and the biological and cultural resources compliance forms
- **Appendix F** – Includes the Data Usability Report, laboratory analytical data, and data validation reports for the RSE analyses

Attachments – Site-specific geodatabase, tabular database files, and available historical documents referenced in this RSE report.

2.0 SITE HISTORY AND PHYSICAL CHARACTERISTICS

2.1 SITE HISTORY AND LAND USE

2.1.1 Mining Practices and Background

The Site is located on the Navajo Nation, in southeastern Utah, and approximately 0.20 miles northeast of Oljato, Utah, as shown in Figure 1-1 inset. The Site is located in the Monument Valley mining area, along the northwestern rim of the Oljeto Mesa, as shown in Figure 2-1. A summary of historical mining on the Site (Chenoweth, 1991) is presented below.

In 1949, the US Atomic Energy Commission (USAEC) began uranium mining in the Monument Valley area. In 1950 an un-numbered mining permit was issued to Charles Keith for 240 acres on the western tip of Oljeto Mesa. In 1951, the USAEC conducted aerial radiometric surveys of the Oljeto Mesa and discovered two areas of anomalous radioactivity. In 1952, the USAEC examined the Charles Keith mining permit area and documented a 25-ft-long adit on-site. In May 1954, Charles Keith was issued a new mining permit (number MP-134) for the same piece of property and in July 1954, the mining rights for MP-134 were assigned to Shasta Copper and Uranium Company (Shasta). Mine workings on-site consisted of two short portals and rim stripping. Between 1954 and 1955, Shasta produced 58.59 tons of ore from the Site that contained 236.57 pounds of 0.27 percent U_3O_8 (uranium oxide) and 178.67 pounds of 0.21 percent V_2O_5 (vanadium oxide). By 1966, mines in the Monument Valley mining area became inactive.

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Tuba City Bureau of Indian Affairs (BIA) Agency in Section 13 of Township 43 South, Range 14 East, Salt Lake Principal Meridian. Land ownership where the Site is located falls under Navajo Trust lands. The Site is located within the Oljato Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 8, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). The Site is currently uninhabited but is located approximately 0.20 miles northeast of the town of Oljato, Utah, as shown in Figure 2-1. Based on the 2010 US Census Bureau; the population of Oljato, Utah was 674 (US Census Bureau, 2017).

2.1.3 Site Access

In 2015, the Navajo Nation Department of Justice (NNDOJ) provided the Trustee with legal access to all Navajo Trust lands to implement work in accordance with the *Trust Agreement*. The Trustee also obtained individual written access agreements from residents living at or near the Site, or with an interest in lands at or near the Site, such as home-site leases and grazing rights, as applicable. In addition, the Trustee consulted with the Oljato Chapter officials and nearby residents and notified them of the work.

2.1.4 Previous Work at the Site

2.1.4.1 1994 through 1999 Aerial Radiological Surveys

Between 1994 and 1999, aerial radiological surveys were conducted at 41 geographical areas within the Navajo Nation, including the Oljato area, which included the location of the Site (Hendricks, 2001). The surveys were done at the request of the USEPA Region 9 and were performed by the Remote Sensing laboratory, a US Department of Energy facility, National Nuclear Security Administration Nevada Operations Office. The intent of the surveys was to characterize the overall radioactivity levels and excess bismuth-214 activity (i.e., a radioisotope that is an indicator of uranium ore deposits and/or uranium mines) within the surveyed areas. Data collected from the surveys was used to assess the risks (i.e., average gross exposure rate) in mined areas and to determine what action, if any, was needed.

The aerial radiological survey for the Oljato area covered approximately 113.59 square miles and included the location of the Site. The aerial radiological survey results for the area within a 0.25 mile radius of the Site indicated a gross exposure rate range of 3 μR/hr to 12 μR/hr and excess bismuth (i.e., bismuth activity greater than approximately 3.5 μR/hr) present in approximately 0.0007 square miles (0.42 acres) of the area (*2007 AUM Atlas*). The aerial radiological survey results for the Oljato area indicated a gross exposure rate range of 1.66 μR/hr to 57.95 μR/hr and excess bismuth (i.e., bismuth activity greater than approximately 3.5 μR/hr) present in approximately 0.40 square miles of the 113.59 square miles of the Oljato flight area (Hendricks, 2001).

2.1.4.2 2001 Monument Valley 4 Project Invitation for Reclamation Bids

In 2001, NAML Reclamation Department issued an invitation for bids for the reclamation of 24 AUMs, referred to as the Monument Valley 4 Project (NAML, 2001). The Site was included in the Monument Valley 4 Project bid document and was referred to in the bid document as either Keith Mine or NA-0214. The bid document stated that the Site contained three portals having the following dimensions: Portal-1 was 6 ft wide and 7 ft high; Portal-2 was 5 ft wide and 6 ft high, and Portal-3 was 20 ft wide and 8 ft high. The depth of the portals was not provided in the bid document. The bid document also included a historical drawing of the Site showing the locations of the three portals. The bid document identified the following reclamation activities needed at the Site:

- Excavation and stabilization of the three portals.
- Closure of the three portals by filling them in with a polyurethane foam plug.
- Backfill the polyurethane foam plug exterior at Portals-1 and -2 with native rock for a hidden seal. Portal-3 was not to be covered with native rock.

2.1.4.3 Monument Valley 4 Project Closeout Report

NAML submitted a reclamation program closeout report for the Monument Valley 4 Project sometime after December 31, 2002 (NAML, n.d.). The report is not dated. The closeout report covered the reporting period between April 1, 1999 and December 31, 2002. The closeout report stated that the Monument Valley 4 Project was complete and listed the following reclamation activity accomplishments at the 24 AUMs (listed in the closeout report as NA-0204, NA-0214 through NA-0226, NA-0228 through NA-0231, and NA-0233 through NA-0238). According to the closeout report, the following reclamation was done:

- 1,935 linear ft of dangerous highwall reclaimed
- 13.61 acres of dangerous piles/embankments reclaimed
- 3.38 acres of pits reclaimed
- 35 portals reclaimed
- Four vertical openings reclaimed

The closeout report provided reclamation activity accomplishments by project and not by AUM. In addition, the *2007 AUM Atlas* lists the Site as reclaimed by NAML.

2.1.4.4 2012 Site Screening

In 2012, Weston performed site screening on behalf of the USEPA (Weston, 2012a). The screening included: (1) recording site observations (i.e., number of homes, water sources, and sensitive environments[4] around the Site); (2) recording the type, number, and reclamation status of mine features; and (3) performing a surface gamma survey. Weston reported the Town of Oljato, Utah was within 0.25 miles of the Site, one reservoir was with a one-mile radius of the Site and located 0.75 miles southwest of the Site, and no sensitive environments were identified. Weston also reported the Site was reclaimed and identified five adits and a scattered waste rock pile extending 200 ft by 300 ft below the Site, consisting mostly of large boulders. Weston mistakenly identified the mining features as adits, when the features were actually portals. The identification of five adits (portals) contradicts the two portals reported in the *2007 AUM Atlas*, as well as the two portals reported by Chenoweth (1991), and three portals reported in the NAML (2001) bid document. Based on Weston's performance of a surface gamma survey, Weston determined that the highest gamma measurements were greater than 101 times the site-specific background level used for its gamma screening.

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[4] Weston defined sensitive environments as "all sensitive environments located within visible range of the mine site, including: wetlands, endangered species, habitats and approximate locations of sites that may be under protection of the government of the Navajo Nation"

2.2 PHYSICAL CHARACTERISTICS

2.2.1 Regional and Site Physiography

The Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. Figure 2-2 presents a current regional aerial photograph (BING® Maps, 2018) of the Site within a portion of the Colorado Plateau. The Colorado Plateau is typically high desert with scattered forests and varying topography having incised drainages, canyons, cliffs, buttes, arroyos, and other features consistent with a regionally uplifted, high-elevation, semi-arid plateau (Encyclopedia Britannica, 2017). The physiographic province landscape includes mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This physiographic province is a large transitional area between the semi-arid grasslands to the east, the drier shrub-lands and woodlands to the north, and the lower, hotter, less-vegetated areas to the west and south.

The Colorado Plateau includes the area drained by the Colorado River and its tributaries: the Green, San Juan, and Little Colorado Rivers (Kiver and Harris, 1999). The physiographic province is composed of six sections: Uinta Basin, High Plateaus, Grand Canyon, Canyon Lands, Navajo, and Datil-Mogollon. The Site is located within the Navajo section.

The Site is located in the Monument Valley mining area in the west-central portion of the Colorado Plateau. Figure 2-3 presents the regional US Geological Survey (USGS) topographic map of a portion of the Colorado Plateau in the vicinity of the Site. The Site is located downgradient from a mesa top, on the vertical cliffs, colluvium-covered bedrock slopes, and pediment areas of the mesa, at an elevation of approximately 5,150 ft above mean sea level (amsl), as shown in Figure 2-4. The vertical cliffs, steep colluvium-covered bedrock slope, and pediment area are shown in Appendix B-1 photograph number 11.

2.2.2 Geologic Conditions

2.2.2.1 Regional Geology

Regionally the Site is located within the Colorado Plateau, which is a massive outcrop of generally flat-lying sedimentary rocks ranging in age from the Paleozoic Era to the Cenozoic Era (USGS, 2017). The plateau has very little regional structural deformation, compared with the mountainous basin-and-range region to the west, and the sedimentary beds range widely in thickness from less than one inch to hundreds of feet. Changes in paleoclimate and elevation produced alternating occurrences of deserts, streams, lakes, and shallow inland seas; and these changes contributed to the type of rock deposited in the region. The rock units of the plateau consist of shallow submarine or sub-aerially deposited rocks including sandstone, shale, limestone, mudstone, siltstone, and various other sedimentary rock subtypes.

The portion of the Monument Valley mining area where the Site is located consists of the Shinarump Member of the Triassic Chinle Formation, the Triassic Moenkopi Formation, and the

Permian De Chelly Sandstone Member of the Cutler Formation and Permian Organ Rock Tongue of the Cutler Formation. Figure 2-5 depicts a regional geology map showing the Site in relation to the regional extent of the Chinle, Moenkopi, and Cutler Formations. Regionally, the Shinarump Member caps most mesas, and uranium ore has been found within channel sediments of the Shinarump Member (Lewis and Trimble, 1959). The Moenkopi Formation ranges from 80 ft to 300 ft thick and forms steep slopes in-between the resistant Shinarump Member and the cliff forming De Chelly Sandstone Member in this region. The De Chelly Sandstone is a massive sandstone unit that ranges from 0 to 450 ft thick, and the Organ Rock Tongue can be up to 700 ft thick across this region.

2.2.2.2 Site Geology

Bedrock outcrops on or adjacent to the Site consist of Shinarump Member of the Chinle Formation, Moenkopi Formation, and the De Chelly Sandstone Member and Organ Rock Tongue of the Cutler Formation, as shown in Figure 2-6a. In addition, a significant portion of the Site is exposed bedrock, as shown in Figure 2-6b, that forms a mesa top, vertical cliffs, colluvium-covered bedrock slopes, and pediment. A geologic profile of the geologic formations forming the mesa top, vertical cliffs, colluvium-covered bedrock slopes, and pediment is shown in Figure 2-6a inset. Site-specific geology consists of the following as provided by Hackman and Wyant (1973):

- Shinarump Member of the Chinle Formation (mesa top and vertical cliffs) – moderate-orange and yellowish-gray sandstone, siltstone, conglomerate, and sandy shale
- Moenkopi Formation (weathered bedrock slopes) – reddish-brown, platy to slabby, ripple-marked siltstone, thin marine limestones, and thick beds of brown, fine-grained calcareous sandstone
- De Chelly Sandstone Member of the Cutler Formation (colluvium-covered bedrock slopes and pediment) – reddish-orange to pale-reddish-brown, fine to medium-grained eolian sandstone that erodes to cliffs and domes
- Organ Rock Tongue of the Cutler Formation (pediment) – reddish brown, evenly thin bedded siltstone and fine-grained sandstone

Unconsolidated deposits on-site are alluvium, colluvium, and eolian deposits consisting of poorly graded sand, well graded sand, sandstone gravel, sandstone cobble, and sandstone boulders. During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger until termination within native material or refusal at either bedrock, large cobbles or gravels, or caving sands (refer to Section 3.3.2.2 and Appendix C.2 for borehole logs). The unconsolidated deposits ranged in depth from 0.5 ft to 1.3 ft below ground surface (bgs).

According to the US Department of Agriculture (USDA) Soil Survey for the Navajo Nation – San Juan County, Utah, soils on-site that have not been disturbed are classified as Moenkopi soils consisting of well drained soils formed from sandstone and shale (USDA, 1980).

2.2.3 Regional Climate

The Colorado Plateau is located in a zone of arid temperate climates characterized by periods of drought and irregular precipitation, relatively warm to hot growing seasons, and winters with sustained periods of freezing temperatures (National Park Service, 2017). The average monthly high temperature at weather station 425812 Monument Valley Mission, Utah (Western Regional Climate Center, 2017) located approximately 6 miles southeast of the Site, ranges between 41.2 degrees Fahrenheit (°F) in January to 92.3°F in July. Daily temperature extremes reach as high as 106°F in summer and as low as -11°F in winter. Monument Valley Mission receives an average annual precipitation of 7.4 inches, with July and August being the wettest months, averaging 0.97 inches, and June being the driest month, averaging 0.25 inches.

Potential evaporation in the area is greater than the area's average annual precipitation. The potential evaporation noted at the Mexican Hat, Utah weather station, located approximately 26 miles northeast of the Site, averages 86 inches of pan evaporation annually (Western Regional Climate Center, 2017). Average wind speeds in the area are generally moderate, although relatively strong winds often accompany occasional frontal activity, especially during late winter and spring months. Blowing dust, soil erosion, and local sand-dune migration/formation are common during dry months. The Page, Arizona airport, located approximately 63 miles to the west of the Site, had the most complete record of wind conditions. A wind rose for the Page airport is presented on Figure 1-1. The wind rose was produced using data contained in the *2007 AUM Atlas* for the years 1996 to 2006. Predominant winds were from the west (refer to the wind rose on Figure 1-1). The Site is surrounded by mesas which may influence wind direction at the Site so that it differs from the available regional wind data.

2.2.4 Surface Water Hydrology

The Site is located within the San Juan River watershed, an area of approximately 24,600 square miles spanning Utah, Colorado, New Mexico, and Arizona, as shown in Figure 1-1. On-site surface water flow is controlled by an elevation decrease to the west (refer to Figures 2-4, 2-7a, and 2-7b). Along the pediment area several trellis-patterned ephemeral drainages join into an unnamed drainage which flows southwest, as shown in Figure 2-7a. Precipitation run-off on-site either terminates within the unconsolidated deposits or drains west into the unnamed drainage. The unnamed drainage drains southwest toward Oljeto Wash (refer to Figure 2-1). Oljeto Wash joins the San Juan River approximately 20 miles north of the Site.

Adkins Consulting Inc. (Adkins), under contract to Stantec, performed a wildlife evaluation as part of the Site Clearance field investigations and did not identify any wetlands, seeps, springs, or riparian areas within the Site that would be attractive to wildlife (refer to Appendix E).

2.2.5 Vegetation and Wildlife

In the spring and summer of 2016, biological surveys were conducted as part of Site Clearance activities. In April 2016, Adkins conducted a wildlife survey. In July 2016, Redente Ecological Consultants (Redente), under contract to Stantec, conducted a summer vegetation survey.

Information about each survey is provided in Appendix E, which includes the Site biological evaluation reports and the *Navajo Nation Department of Fish and Wildlife* (NNDFW) *Biological Resources Compliance Form*. A summary of the survey activities and findings are provided in Section 3.2.2.3.

Vegetation communities found within the physiographic transitional area described in Section 2.2.1 include shrublands with big sagebrush, rabbitbrush, winterfat, shadscale saltbush, and greasewood; and grasslands of blue grama, western wheatgrass, green needlegrass, and needle-and-thread grass. Higher elevations may support pinyon pine and juniper woodlands. The vegetation communities on-site included sporadic shrubs and pinyon-juniper (refer to Appendix E). During the surveys, Stantec and/or its subcontractors observed on-site wildlife including common raven and cottontail rabbit (refer to Appendix E).

2.2.6 Cultural Resources

In April 2016, as part of Site Clearance activities, Dinétahdóó Cultural Resource Management (Dinétahdóó), under contract to Stantec, conducted a cultural resource survey, as well as ethnographic and historical data reviews (Dinétahdóó, 2016). Based on historical and ethnographic data reviews Dinétahdóó did not identify any mining history information for the Site (Dinétahdóó, 2016).

During the cultural resource survey Dinétahdóó identified one archaeological site and two isolated occurrences. Appendix E includes a copy of the *Cultural Resource Compliance Form,* and findings of the cultural resource survey are summarized in Section 3.2.2.4.

2.2.7 Observations of Potential Mining and Potential Exploration

During RSE activities, Stantec field personnel (field personnel) observed the following features indicative of potential mining or exploration activities at the Site: an upper and a lower potential haul road, three reclaimed portals, one un-reclaimed portal, five waste piles, a borehole, rim strip features, a blasted area, and mining disturbed areas. Details regarding these observations are presented in Section 3.2.2.1. These observations were used, along with additional lines of evidence (refer to Section 3.3.3), to identify areas at the Site where TENORM was present (refer to Section 4.6).

3.0 SUMMARY OF SITE INVESTIGATION ACTIVITIES

3.1 INTRODUCTION

This section summarizes Site Clearance and other RSE activities conducted between August 2015 and September 2017. Site Clearance activities were conducted initially to obtain information necessary to develop the *RSE Work Plan*. Site Clearance activities were performed in accordance with the approved *Site Clearance Work Plan*. Resulting RSE activities were performed in accordance with the approved *RSE Work Plan*.

The primary objectives of the RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It is not intended to establish cleanup levels or determine cleanup options or potential remedies.

The *RSE Work Plan* is comprised of a Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), Health and Safety Plan (HASP), and a Data Management Plan (DMP). The FSP guided the fieldwork by defining sampling and data-gathering methods. The QAPP presented quality assurance/quality control (QA/QC) requirements designed to meet Data Quality Objectives (DQOs) for the environmental sampling activities. The HASP listed site hazards, safety procedures and emergency protocols. The DMP described the plan for the generation, management, and distribution of project data deliverables. The FSP, QAPP, HASP, and DMP provided the approved requirements and protocols to be followed for the RSE data collection, data management, and data analyses performed to develop this RSE report. Any deviations or modifications from the *RSE Work Plan* are described in the appropriate RSE report sections.

The RSE process followed applicable aspects of the USEPA DQO Process and *MARSSIM*, to verify that data collected during the RSE activities would be adequate to support reliable decision-making (USEPA, 2006). The USEPA DQO Process is a series of planning steps based on the scientific method for establishing criteria for data quality and developing survey designs. *MARSSIM* provides technical guidance on conducting radiation surveys and site investigations.

The USEPA DQO Process is a seven-step process[5] that was performed as part of the *RSE Work Plan* to identify RSE data objectives. The goal of the USEPA DQO Process is to minimize expenditures related to data collection by eliminating unnecessary, duplicate, or overly precise data and verifies that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. It provides a systematic procedure for defining the criteria that the survey design should satisfy. This approach provides a more effective survey design combined with a basis for judging the usability of the data collected (USEPA, 2006).

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[5] (1) State the problem; (2) Identify the goals of the study; (3) Identify the information inputs; (4) Define the boundaries of the study; (5) Develop the analytical approach; (6) Specify the tolerance on decision errors; and (7) Optimize sampling design (USEPA, 2006).

The USEPA DQO Process performed for the RSE is presented in the *RSE Work Plan*, Section 3, and identifies the purpose of the data collected as follows:

1. Background reference area soil sampling, laboratory analyses, surface gamma surveying, and subsurface static gamma measurements to establish background analyte concentrations and gamma measurements, which will be used as the ILs, for the Site.
2. Site sampling (soil and sediment), laboratory analyses, surface gamma surveying, and subsurface static gamma measurements for comparison with ILs, to define the lateral and vertical extent of contamination at the Site to characterize the Site to support future Removal or Remedial Action evaluations.

The USEPA DQO Process was used in conjunction with *MARSSIM* guidance for RSE planning and data collection. Per *MARSSIM* guidance, "planning radiation surveys, using the USEPA DQO Process, can improve radiation survey effectiveness and efficiency, and thereby the defensibility of decisions" (USEPA, 2000).

The applicable aspects of *MARSSIM* incorporated into the RSE process include:

- Historical site assessment
- Determining RSE DQOs
- Selecting background reference areas
- Selecting radiation survey techniques
- Site preparation
- Quality control
- Health and safety
- Survey planning and design
- Baseline surface gamma surveys and subsurface static gamma measurements
- Field measurement methods and instrumentation
- Media sampling and preparation for laboratory analyses

The RSE process also used applicable aspects of *MARSSIM* for interpretation of the RSE results, including:

- Data quality assessment through statistical analyses
- Evaluation of the analytical results
- Quality assurance and quality control

Sections 3.2 and 3.3 summarize the preparation, field investigation methods, and procedures for data collection during the Site Clearance activities and other RSE activities. Activities subsequent to the Site Clearance are described in detail in the *RSE Work Plan,* Section 4. Appendix A includes the radiological characterization report prepared by Environmental Restoration Group, Inc. (ERG), under contract to Stantec. Appendix B includes photographs of features at the Site and the surrounding area, Appendix C.1 includes soil/sediment sample field forms, Appendix C.2 includes borehole logs, and Appendix C.3 includes water sample field forms.

3.2 SUMMARY OF SITE CLEARANCE ACTIVITIES

The Site Clearance activities consisted of two tasks: a desktop study and field investigations. The desktop study was completed prior to field investigations, and the findings of the desktop study were used to guide field investigations. The Site Clearance activities are detailed in the *Site Clearance Data Report* and are described below.

3.2.1 Desktop Study

The desktop study included:

- Review of historical aerial photographs (USGS, 2016). Photographs were selected based on sufficient scale, quality, resolution, and whether the photograph met one or more of the following criteria:
    - Showed evidence of active mining or grading of the Site, or provided information on how the Site was developed or operated (e.g., haul roads and open pits).
    - Showed evidence of reclamation (e.g., soil covers).
    - Showed significant changes in ground cover compared to current photographs.
- Review of current aerial photographs for identification of buildings, homes and other structures, and potential haul roads within 0.25 miles of the Site.
- Review of topographic and geologic maps.
- Review of information related to surface water features and water wells on the Navajo Nation within a one-mile radius of the Site, provided by: (1) the Navajo Nation Department of Water Resources (NNDWR, 2016); and (2) ESRI Shapefiles data contained in the *2007 AUM Atlas*.
- Review of previous studies, information related to potential past mining/exploration and reclamation activities.
- Identification of the predominant wind direction in the region of the Site.

Based on the list above, the following findings were identified during the desktop study:

- Historical photographs (USGS, 2016) for the Site were selected from 1951, 1953, 1955, 1979, and 1997 for comparison against a current 2017 image (Cooper, 2017). The selected historical photographs are shown in Figure 3-1a. Figure 3-1b presents a historical aerial photograph comparison of the Site showing the aerial photograph from 1979 and the current 2017 image. The 1975 historical photograph is presented because it provided the best resolution of what the Site looked like after mining occurred. The light color features located in the central and northern areas of the Site, visible in the 1979 photograph, are Waste Piles 1 and 2 (refer to Section 3.2.2.1).

- The current aerial photograph review confirmed that the Site was located to the northeast of and within 0.20 miles of the town of Oljato, Utah, as shown in Figure 2-1. Numerous dirt roads were identified within 0.25 miles of the Site, refer to Figure 2-2. The road type (i.e., potential haul road or road unrelated to historical mining) was identified by the current aerial photograph review, historical document review, and visual identification during the Site Clearance field investigations (refer to Section 3.2.2.1).

- Nine potential water features were identified based on the review of information provided by the NNDWR and the *2007 AUM Atlas*, refer to Table 3-1 and Figure 2-1.

- The predominant regional winds were from the west (refer to Section 2.2.3 and Figure 1-1).

Previous studies and information related to past mining/exploration are discussed in Sections 2.1.1 and 2.1.4.

3.2.2 Field Investigations

3.2.2.1 Site Mapping

The *Site Clearance Work Plan* specified that the following features at and near the Site, if present, should be mapped, marked, and/or their presence confirmed:

- Claim boundaries and the 100-ft buffers of the claim boundaries

- Roads, fences/gates, utilities: haul roads to a distance of 0.25 miles or to the intersection with the next major road, whichever is closer

- Structures, homes, buildings, livestock pens, etc.

- Surface water and water well locations: surface water channels that drain the Site to a distance of 0.25 miles away from the Site or to the confluence with a major drainage, whichever is closer; surface water features and water wells identified within a one-mile radius of the Site

- Topographic features

- Potential background reference areas

- Type of ground cover, including rock, soil, waste rock, etc.
- Physical hazards

Based on the list above, the following site features were mapped during field investigations:

- Claim boundaries – 100-ft buffers of the claim boundaries, as shown in Figure 2-7a, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).
- Drainages – Numerous trellis-patterned ephemeral drainages were mapped, as shown in Figure 2-7a. The drainages predominately ran in a westerly direction and joined an unnamed drainage located southwest of the Site.
- Topographic features – The mapped area can be divided into three topographic areas: (1) the mesa top; (2) the mesa sidewall (i.e., the vertical cliffs and steep colluvium-covered bedrock slope); and (3) the pediment area (i.e., the area in-between the base of the steep bedrock slope and the unnamed drainage). The three topographic areas are shown in Figure 2-4. The mesa top is shown in Figure 2-7b and Appendix B-1 photograph number 9. The mesa sidewall vertical cliffs and steep colluvium-covered bedrock slope, and pediment area are shown in Appendix B-1 photograph number 11.
- Portals – Four historical mining portals were mapped, as shown in Figure 2-7a. Portals-1 through -3 align with the three reclaimed portals reported by NAML (2001). Portals-1 through -3 were backfilled with a polyurethane foam plug and the exteriors of Portals-1 and -2 were covered with native rock for a hidden seal (refer to Appendix B-1 photograph number 5). The native rock placed in front of Portal-2 has since been disturbed (refer to Appendix B-1 photograph number 6). Portal-3 was not covered with native rock as shown in Appendix B-1 photograph number 7. Graffiti was present on the bedrock below Portal-3 (refer to Appendix B-1 photograph number 8). Portal-4 was mapped by field personnel as an un-reclaimed prospect portal approximately 10 ft deep that terminated on bedrock (refer to Appendix B-1 photograph number 4). On May 2, 2018 the Trust discussed with the Agencies the safety risks of performing an interim action at Portal-4. The Trustee determined that an interim action was not feasible due to the safety risks. The Trustee also determined that it was unlikely that people and/or animals could access the portal.
- Roads – An upper and a lower potential haul road were mapped, as shown in Figure 2-1.
  - The upper potential haul road ran on the mesa top and ended at the edge of the mesa (refer to Figure 2-7b and Appendix B-1 photograph number 16). Portions of bedrock on the mesa top and along the mesa rim had been excavated to build the upper haul road (refer to Appendix B-1 photograph number 15). The upper potential haul road was potentially built for exploration purposes and terminated above Portal-3.
  - The lower potential haul road ran along the mesa sidewall, as shown in Appendix B-1 photograph number 2, in a north to south direction and followed a northeast direction near Portal-3 (refer to Figure 2-7b, shown as the northern most yellow line). Appendix B-1 photograph number 12 shows where the upper and lower potential haul roads divided, and photograph number 13 shows the topography of the lower road. The lower potential haul road provided access to Portals-1, -2, -3, and -4. The lower potential haul road

appeared to have been blasted away and ended abruptly approximately 375 ft south of Portal-1 (refer to Appendix B-1 photograph number 17). It is unknown if the lower road was blasted away as part of historical mining, historical reclamation, or for other reasons (refer to Figure 2-7a for the location of the blasted area).

- Rim strip features – Field personnel observed evidence of rim stripping near the four identified portals and along the lower potential haul road, south of Portal-1.
- Footpath – A footpath was mapped east of the Site, as shown in Figure 2-7b. The footpath connected the mesa top to the lower potential haul road.
- Waste piles - Five waste piles were mapped, as shown in Figure 2-7a. Waste Pile 1 (refer to Appendix B-1 photograph number 1) was downgradient of and associated with Portals-1 and 2. Waste Pile 2 was downgradient of and associated with Portal-3. Waste Piles 3, 4, and 5 were located on the mesa top (refer to Appendix B-1 photograph number 14 for Waste Pile 3). Field personnel mapped the lateral extent of the waste piles based on the following visual observations: (1) changes in topography (e.g., Waste Pile 3 was a mound of material); (2) differences in color between waste rock material and bedrock (e.g., Waste Piles 1 and 2 contained light gray material where the bedrock and colluvium were red); and (3) variations of grain sizes in the waste piles versus the surrounding colluvium (e.g., Waste Pile 1 contained finer-grained materials than the surrounding colluvium). The waste piles are also shown in Figures 2-6a and 2-6b as earthworks.
- Mining disturbed area – Mining disturbed areas were mapped, as shown in Figures 2-7a and 2-7b. The areas surrounding Waste Piles 3, 4, and 5 were inclusive of mining disturbed areas, where soils appeared to have been cleared or graded.
- Borehole – One borehole approximately 3-inches in diameter was mapped on the mesa top, as shown in Figure 2-7a. The borehole was in line with Portal-3 and was likely drilled for exploration purposes.
- Structures – The Site was located to the northeast of and within 0.20 miles of the town of Oljato, Utah, as shown in Figure 2-1, with a population in 2010 of 674 (US Census Bureau, 2017).
- Water features – Field personnel assessed the nine potential water features identified during the desk top study and findings are summarized in Table 3-1. In addition, during site mapping activities field personnel identified a large pond located approximately 0.75 miles northwest of the Site, refer to Figure 2-1 location 08GS-12-9. Weston (2012a) reported the Oljato Reservoir was located approximately 0.75 miles southwest of the Site, but during site mapping field personnel did not observe a surface water feature in this area. However, in the site screening report for Skyline Road Mine, located approximately 2.75 miles southeast of the Site, Weston (2012b) reported Oljato Reservoir was approximately 3.5 miles northwest of the Skyline Road Mine (or 0.75 miles northwest of the Site). Therefore, the large pond identified by field personnel was assumed to be Oljato Reservoir and Weston apparently incorrectly reported the location of the reservoir in the site screening report for the Site (2012a).
- Ground cover – ground cover and vegetation observed on-site are discussed in Sections 2.2.2.2 and 2.2.5, respectively.

Field personnel attempted to locate the fifth adit (portal) identified by Weston (2012a) but did not observe a portal located where Weston mapped the feature.

In June 2018, the USEPA provided the Trust with a copy of a NNDWR database that was generated in 2018. The USEPA stated that there were discrepancies between the NNDWR water feature locations in the 2018 database and those provided in the 2016 NNDWR database used by the Trust. This information was provided after Site Characterization activities had occurred and was therefore not included in the RSE for the Site. Comparison of the 2018 NNDWR database against the 2016 NNDWR database and the *2007 AUM Atlas* will require additional field work and it is recommended that this be addressed in future studies for the Site.

In addition to the Site mapping activity, the Trust took high-resolution aerial photographs and collected topographic data at the Site. The objective of the high-resolution aerial photography survey was to develop orthophotographs and topographic data of the Site to:

- Assist with identifying ground cover (e.g., soil versus bedrock)
- Assist with delineating historical mine features (e.g., haul roads, portals, and waste piles)
- Allow additional evaluation of areas that were inaccessible due to steep or unsafe terrain
- Provide site base maps (high resolution imagery and elevation data) that could be used to support future Removal or Remedial Action evaluations at the Site

Stantec proposed to perform aerial photography in order to provide an overview of the Site and identify features that could not otherwise be accomplished safely on foot. USEPA is not authorized to allow drones on sites it oversees: therefore, drone use was not an option. Although aerial photography was not included in the approved *Scope of Work* (MWH, 2016d), the Trustee notified the Agencies and obtained approval prior to commencement of the work. The Trust also consulted with Oljato Chapter officials and nearby residents and notified them of the aerial photography survey. On June 16, 2017, Cooper flew over the Site in a piloted fixed-wing aircraft and collected 3.5-centimeter digital color stereo photographs of the Site. Cooper provided the following data:

- Digital, high-resolution color orthophotograph imagery
- AutoCAD files (2-dimensional and 3-dimensional) that included elevation contours (refer to Figure 2-4) and plan features
- Elevation point files
- Triangular Irregular Network surface files

The site orthophotographs and supporting data files were used for data analyses, including estimating volumes of potentially mining-impacted material at the Site. They also were used as the base image for selected figures included in this RSE report, to the extent applicable.

3.2.2.2 Potential Background Reference Area Evaluation

The desktop study findings and field investigation observations were used to identify four potential background reference areas (BG-1 through BG-4) for the Site, as shown in Figure 3-2 and described in Appendix D.1. BG-1, BG-2, and BG-3 were selected as suitable background reference areas for the Site for the following reasons:

- BG-1 encompassed an area approximately 5,100 ft^2 (approximately 0.12 acres), was located 200 ft southeast of the Site, and was cross-gradient from the Site. BG-1 was downwind of the Site, but located on the opposite side of Oljeto Mesa, which sheltered it from potential wind transport from the Site. Geologically, BG-1 represented the Moenkopi Formation areas on-site with a mixture of colluvium-covered slopes and bedrock outcrops at the base of the cliffs.
- BG-2 encompassed an area approximately 2,615 ft^2 (approximately 0.06 acres), was located 400 ft north of the Site, and was crosswind and hydrologically upgradient of the Site. Geologically, BG-2 represented the Cutler Formation areas on-site with valley bottom/alluvial deposits.
- BG-3 encompassed an area approximately 1,974 ft^2 (approximately 0.05 acres), was located 800 ft east of the Site, and was hydrologically upgradient of the Site. BG-3 was downwind of the Site, but located on the mesa top, which sheltered it from potential wind transport from the Site. BG-3 was also crosswind of Waste Piles 3, 4, and 5. Geologically, BG-3 represented the Chinle Formation (Shinarump Member) areas on-site with thin residual soils on bedrock outcrops.

BG-4 was not selected as a background reference area for the Site for the reasons described in Appendix D.1.

Soil in BG-1 was shallow (generally less than 0.25 ft deep) and the ground surface consisted of a mixture of bedrock, colluvium, and thin soils. These conditions were similar to and representative of conditions on-site within the Moenkopi Formation. Photograph number 2 in Appendix B shows the prevalent bedrock outcrops mixed with fine-grained to boulder-sized colluvium.

The potential background reference areas were selected based on *MARSSIM* guidance (i.e., similar geology and ground conditions, upwind of the Site, distance from the Site, etc.) to:

1. Represent undisturbed conditions at the Site (e.g., pre-mining conditions)
2. Provide a basis for establishing the ILs

The approved *RSE Work Plan* did not specify any minimum or maximum size criteria for these areas. Stantec does not view the size of the selected background reference areas as affecting the validity of the background concentrations. The sizes were based on professional judgment that the identified areas were generally representative of the Site.

The background reference areas were selected in areas outside of the Site that were considered to be representative of the general conditions observed at the Site. However, an important consideration is that the background gamma radiation and metals concentrations within soil and bedrock can be variable and often contain a wider range of concentrations than what was measured at the selected background reference areas. The ILs derived from the background reference areas provide a useful reference for comparison to the Site. However, it will be important to consider the variations in concentrations when conducting site assessment work and/or to support future Removal or Remedial Action evaluations at the Site.

3.2.2.3 Biological Surveys

The objective of the biological surveys was to determine if identified species of concern or potential federal or Navajo Nation Threatened and Endangered (T&E) species and/or critical habitat are present on or near the Site. Biological (vegetation and wildlife) clearance was required at the Site before RSE activities could begin, to determine if the RSE activities could affect potential species of concern or federal or Navajo Nation listed T&E species and/or critical habitat. The Site biological evaluation reports, the *NNDFW Biological Resources Compliance Form*, and the US Fish and Wildlife Service (USFWS) consultation email are provided in Appendix E.

The Federal Endangered Species Act (ESA) of 1973, 16 U.S.C. §1531 et seq., requires that each Federal agency confer with the USFWS on any agency action that is likely to jeopardize the continued existence of any proposed T&E species or result in the destruction or adverse modification of critical habitat proposed to be designated for such species 16 U.S.C. §1536(a)(4).An "action area", as defined in the regulations implementing the ESA, includes "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action". 50 C.F.R §402.2.

The vegetation and wildlife surveys were conducted according to guidelines of the ESA and the NNDFW-Navajo Natural Heritage Program (NNHP), including the procedures set forth in the Biological Resource Land Use Clearance Policies and Procedures, RCS-44-08 (NNDFW, 2008), the Species Accounts document (NNHP, 2008), and the USFWS survey protocols and recommendations (USFWS, 1996).

Based on the results of the vegetation and wildlife surveys, the NNDFW's opinion was that the RSE Baseline Studies and Site Characterization Activities,

> "with applicable conditions, [were] in compliance with Tribal and Federal laws protecting biological resources including the Navajo Endangered Species and Environmental Policy Codes, US Endangered Species, Migratory Bird Treaty, Eagle Protection and National Environmental Policy Acts".

A copy of the *NNDFW Biological Resources Compliance Form* is included in Appendix E. In addition, after the Trust submitted the results of the biological survey, USEPA consulted with John Nystedt of the USFWS on August 26, 2016, and received an email response on August 29, 2016 stating:

> "Based on the information you [Stantec] provided [i.e., there is no habitat for any Federally listed species in the action area], we [the USFWS] believe no endangered or threatened species or critical habitat will be affected by the project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat" (Nystedt, 2016).

A copy of the Nystedt email is included in Appendix E. In light of the results of the biological surveys described below, the USFWS recommended no further action from the USFWS for the project unless the project or regulations change, or a new species is listed.

Vegetation Survey - In July 2016, Redente performed a summer vegetation survey as part of the Site Clearance field investigations. Complete details of the vegetation survey, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and summarized below.

In preparation for the vegetation survey, Redente submitted data requests for species of concern to the NNDFW and NNHP, and for Federal T&E species, to the USFWS. The NNDFW-NNHP responded to MWH (now Stantec) by letter dated November 19, 2015. The letter provided a list of species of concern known to occur within the proximity of the Site and included their status as either Navajo Nation Endangered Species List (NNESL), and/or Federally Endangered, Federally Threatened, or Federal Candidate. The NNESL species were further classified as G2, G3, or G4[6]. A copy of this letter is included in Appendix E. A spring vegetation survey was not required for the Site because the species of concern data provided by NNDFW-NNHP did not include listed potential plant species that require a spring survey.

The NNDFW listed one T&E plant species that may occur on-site: Parish's alkali grass (G4). The USFWS also listed one T&E plant species that may occur on-site: Navajo sedge. Parish's alkali grass is a native annual grass that grows in a series of widely disjunct populations ranging from southern California to eastern Arizona and western New Mexico in alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes at elevations from 2,600 ft to 7,200 ft amsl. Navajo sedge is a native perennial grass-like plant that grows in seeps and hanging gardens primarily on sandstone cliffs and alcoves. Known populations occur at elevations from 4,600 ft to 7,200 ft amsl in San Juan County, Utah and northern Arizona. Parish's alkali grass was eliminated from further evaluation because there was no potential for the species to occur on the Site due to lack of suitable habitat. Navajo sedge was the only T&E species evaluated during the Site vegetation survey.

Before beginning the Site vegetation surveys, Redente reviewed the ecologic and taxonomic information for the T&E species to understand ecological characteristics of the species, habitat requirements, and key taxonomic indicators for proper identification (Arizona Native Plant

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[6] G2 classification includes endangered species or subspecies whose prospect of survival or recruitment are in jeopardy, G3 classification includes endangered species or subspecies whose prospect of survival or recruitment are likely to be in jeopardy in the foreseeable future, and G4 classification are "candidates" and includes those species or subspecies which may be endangered but for which sufficient information is lacking to support being listed (refer to Appendix E).

Society, 2000). Redente also reviewed currently accepted resource agency protocols and guidelines for conducting and reporting botanical inventories for special status plant species (USFWS, 1996). An experienced Redente botanist with local flora knowledge conducted the rare plant survey. The botanist walked transect lines on the Site with emphasis on areas with suitable habitat for Navajo sedge, specifically seeps and hanging gardens.

The Redente botanist did not identify Navajo sedge at the Site based on observations he made during the on-site survey. The botanist concluded he did not identify Navajo sedge at the Site because the Site was not a likely habitat for the T&E species. Observed vegetation communities on-site were predominantly sporadic shrubs and pinyon-juniper.

Wildlife Survey - In April 2016, Adkins performed a wildlife evaluation survey as part of the Site Clearance field investigations. The completed wildlife survey, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and are summarized below.

Adkins performed the survey under a permit issued by NNDFW for the purpose of assessing habitat potential for ESA-listed or NNESL animal species. Adkins biologists with experience identifying local wildlife species led the field survey, which consisted of walking transects 10 ft apart throughout the Site, including a 100-ft buffer beyond the claim boundary. The surrounding areas were visually inspected with binoculars for nests, raptors, or signs of raptor use.

The wildlife evaluation was performed for species listed as NNESL, Federally Endangered, Federally Threatened, or Federal Candidate, and species protected under the Migratory Bird Treaty Act (MBTA) that have the potential to occur on-site. Prior to the start of the wildlife survey, Adkins submitted data requests to USFWS and NNDFW for animal species listed under the ESA. The NNESL species were further classified as G2, G3, or G4. The USFWS included eight ESA-species with the potential to occur in the area of the Site; five birds (southwestern willow flycatcher, Mexican spotted owl, western yellow-billed cuckoo, California condor, and Gunnison sage-grouse), and three fish (Colorado pike minnow, greenback cutthroat trout, and razorback sucker). The NNDFW included: four birds (mountain plover [G4], American peregrine falcon [G4], golden eagle [G3], and ferruginous hawk [G3]), one mammal (black footed ferret [USFWS endangered]), and one amphibian (northern leopard frog [G2]). All species on the USFWS list and all species from the NNDFW list, with the exception of the golden eagle and ferruginous hawk, were eliminated from further evaluation because there was no potential for those species to occur on the Site due to lack of suitable habitat. Based on the preparation data, two birds (golden eagle and ferruginous hawk) remained as species of concern warranting further analysis during the Site survey.

In addition, Adkins reviewed species protected under the MBTA that have the potential to occur in the area of the Site. The MBTA review resulted in the potential for identification of 15 bird species in addition to those listed above, known as "Priority Birds of Conservation Concern with the Potential to Occur"[7] in the areas of the Site: black-throated sparrow, Brewer's sparrow, gray

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[7] USFWS, 2008. Birds of Conservation Concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp.

vireo, loggerhead shrike, mountain bluebird, mourning dove, sage sparrow, sage thrasher, scaled quail, Swainson's hawk, vesper sparrow, bald eagle, Bendire's thrasher, pinyon jay, and prairie falcon. These 15 MBTA bird species were added for further analysis during the survey for effects to potential habitat.

The wildlife survey revealed two NNESL species of concern that have the potential to occur within or near the Site based on habitat suitability or actual recorded observation: golden eagle and ferruginous hawk. Based on these findings Adkins recommended the use of best management practices to protect potential habitat during RSE activities, specifically: (1) confining equipment travel to within the boundaries of the Site; (2) minimizing travel corridors as much as possible; (3) limiting truck and equipment travel within the Site when surfaces are wet and soil may become deeply rutted; and (4) using previously disturbed areas for travel when possible. The recommended best management practices were followed to protect potential habitat during RSE activities.

3.2.2.4 Cultural Resource Survey

In April 2016, Dinétahdóó conducted a cultural resource survey as part of the Site Clearance field investigations. Navajo Nation Historic Preservation Department (NNHPD) issued a Class B permit to Dinétahdóó on behalf of the Trust to conduct the cultural resource survey. Following the cultural resource survey, the NNHPD issued a Cultural Resources Compliance Form that included a "Notification to Proceed" with RSE field work. A copy of the Cultural Resources Compliance Form is included in Appendix E. According to NNHPD, this form is the equivalent of a "permit" to conduct the work (NNHPD, 2018[8]).

The survey included the areas within the claim boundary and the 100-ft claim boundary buffer, as shown in Figure 2-7a. Dinétahdóó did not survey areas on steep terrain due to safety concerns. The survey identified one archaeological site and two isolated occurrences. For confidentiality reasons, details regarding the archaeological site and isolated occurrences are not provided herein. NNHPD can be contacted for additional information. NNHPD contact information is located on the *Cultural Resource Compliance Form* included in Appendix E.

Based on the survey findings Dinétahdóó recommended during RSE activities that the boundaries of the archaeological site be flagged and that an archaeologist monitor all ground disturbing activities, including soil sampling, within 50 ft of the archaeological boundaries. Dinétahdóó also stipulated that RSE activities be halted at any time if cultural resources were encountered. Stantec complied with Dinétahdóó's recommendations while conducting RSE activities on–site.

Dinétahdóó also escorted field personnel during: (1) the collection of subsurface soil samples at the background reference areas (refer to Section 3.3.1.1); and (2) during Site Characterization borehole subsurface soil/sediment sample collection in those locations outside the 100-ft buffer (refer to Section 3.3.2.2). The Trust and NNHPD agreed that Dinétahdóó's archeologist would be

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[8] Call with Sadie Hoskie, Tamara Billie of NNHPD, and Linda Reeves, June 8, 2018.

present because the subsurface sample locations were outside of the area originally surveyed during the Site Clearance cultural resource survey.

3.3 SUMMARY OF REMOVAL SITE EVALUATION ACTIVITIES

The RSE activities consisted of two additional tasks following the Site Clearance Activities: Baseline Studies and Site Characterization activities. The Baseline Studies included a Background Reference Area Study, Site gamma survey, and Gamma Correlation Study. The results of the Baseline Studies were used to plan and prepare the Site Characterization field investigations, which included surface and subsurface soil and sediment sampling, and surface water sampling. Results of the RSE activities are presented in Section 4.0. Baseline Studies and Site Characterization activities are summarized in Sections 3.3.1 and 3.3.2, respectively.

3.3.1 Baseline Studies Activities

3.3.1.1 Background Reference Area Study

The Background Reference Area Study activities were completed at the background reference areas selected for the Site. Refer to Section 3.2.2.2 for an explanation of the selection of the background reference areas for the Site. The Background Reference Area Study included a surface gamma survey, static surface and subsurface gamma measurements, surface soil sampling, and subsurface soil sampling. The soil sample locations in the background reference areas were initially selected using a triangular grid, set on a random origin. Where possible, samples were collected at the center points of the triangles. However, in some instances, the actual sample locations had to be moved in the field if sampling was not possible (e.g., the location consisted of exposed bedrock or there was a large bush blocking access). In these cases, the closest accessible location was selected instead.

The background reference areas were selected based on a variety of factors, including *MARSSIM* criteria, which indicated whether the areas were representative of unmined locations, regardless of the sizes of the area. These factors are described in this RSE report and accompanying appendices. The objectives of the background reference area study were to measure gamma radiation levels emitted by naturally occurring, undisturbed uranium-series radionuclides, and concentrations of other naturally occurring constituents. The results were used to establish background gamma levels and concentrations of Ra-226 and specific metals (uranium, arsenic, molybdenum, selenium, and vanadium). The soil sampling locations at the background reference areas are presented in Figure 3-3. Field personnel performed the Background Reference Area Study in accordance with the *RSE Work Plan,* Sections 4.2, 4.4, and 4.5.

The background reference area surface gamma surveys at BG-2, BG-1, and BG-3 were completed in May 2016, March 2017, and June 2017, respectively. BG-1 was initially surveyed in April 2016, but a data collection error was identified during the survey. Field personnel noticed there was a problem with the GPS antenna linking up with the receiver and recording the survey data. Field personnel changed cables after noticing the error, but that did not resolve the issue.

It was later identified that the rental vehicle key utilized Bluetooth technology that was interfering with the GPS signal. Once this was discovered, field personnel stored their car keys in a different manner and the type of error did not occur again. Because of the error during the initial survey, the gamma survey was re-completed for BG-1 in March 2017. ERG performed the surface gamma surveys using Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) high-energy gamma detectors (the detectors). Each detector was coupled to a Ludlum Model 2221 ratemeter/scaler that in turn was coupled to a Trimble ProXRT GPS unit with a NOMAD 900 series datalogger. The detector tagged individual gamma measurements with associated geopositions recorded using the Universal Transverse Mercator Zone 12 North coordinate system. ERG matched and calibrated the detector to a National Institute of Standards and Technology-traceable cesium-137 check source, and function-checked the equipment prior-to and after each workday. ERG performed the surveys by walking the background reference areas with the detector carried by hand, along transects that varied depending on encountered topography. The gamma measurements were collected with the height of the detector varying from 1 ft to 2 ft above ground surface (ags) with an average height of 1.5 ft ags to accommodate vegetation, rocks, or other surface features. If field personnel encountered an immovable obstruction (e.g., a tree) during the surface gamma surveys they went around the obstruction. Subsequent to each workday, ERG downloaded the gamma measurements to a computer and secure server.

The same equipment used for the surface gamma surveys was also used to collect static one-minute gamma measurements at the ground surface and down-hole (subsurface) at borehole locations S225-SCX-001 (BG-2) and S225-BG3-011 (BG-3). Refer to Appendix C.2 for borehole logs. Static gamma measurements were categorized as surface measurements where they were collected at ground surface (0.0 ft) and as subsurface measurements where depths were below ground surface due to the influence of downhole geometric effects on subsurface static gamma measurements (refer to Section 4.1). Gamma measurements were collected according to the methods described in the *RSE Work Plan,* Section 4.2 and Appendix E.

Soil samples collected as part of the background study are detailed in Table 3-2 and sample locations are shown in Figure 3-3. Soil samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Field personnel collected the following samples from the background reference areas:

- BG-1 – In October 2016, 10 surface soil grab samples were collected from 10 locations. The 10 surface soil grab samples were collected from 0 ft to 0.25 ft bgs due to shallow soils. A borehole was not attempted at BG-1 because field personnel observed that BG-1 was primarily bedrock with some soil less than 0.25 ft thick on top of the bedrock. Therefore, no subsurface soil samples were collected from BG-1.

- BG-2 – In October 2016, 11 surface soil grab samples were collected from 11 locations and in November 2016, one subsurface soil grab sample was collected from borehole S225-SCX-001. The reason for terminating the borehole was inadvertently omitted from the boring log.

- BG-3 – In August 2017, 11 surface soil grab samples were collected from 11 locations. No subsurface soil samples were collected from BG-3. Borehole S225-BG3-011 was attempted at BG-3 but the hand auger met refusal on bedrock at 0.5 ft bgs. A grab sample was collected from 0 ft to 0.5 ft bgs at borehole S225-BG3-011 but this was categorized as a surface sample.

The lack of subsurface soil samples from BG-1 and BG-3 will not affect the derivation of Ra-226 or metal ILs because the Ra-226 and metals ILs (i.e., surface and subsurface) were based on surface soil samples (refer to Section 4.1).

Samples were shipped to a USEPA approved laboratory, ALS Environmental Laboratories in Fort Collins, Colorado for analyses. Samples were collected according to the methods described in the *RSE Work Plan,* Section 3.8.1.1. The results of the surface gamma survey, static surface and subsurface gamma measurements, and surface and subsurface soil sample analytical results provided background reference data to guide the Site Characterization surface and subsurface soil/sediment sampling (refer to Section 3.3.2). The Background Reference Area Study results are presented in Section 4.1. The ERG survey report in Appendix A provides further details on the gamma surveys. Field forms, including borehole logs, are provided in Appendix C.1 and C.2.

3.3.1.2 Site Gamma Radiation Surveys

Baseline Studies activities included a surface gamma survey of the Site in accordance with the *RSE Work Plan,* Section 4.2 and Appendix E. The lower potential haul road was not surveyed from Waste Pile 1 to the southern extent where the road ends at the blasted area (refer to Figure 2-7a) due to an oversight by field personnel; and the approximate centerline of the potential haul roads were surveyed, but the shoulders were not due to miscommunication with the field personnel. In addition, approximately 2.9 acres of the mesa sidewall were not surveyed because field personnel were unable to safely access these areas, as shown in Figure 3-4. The areas not surveyed are considered potential data gaps in Section 4.9.

The surface gamma survey was used to evaluate the extent of potential mining-related impacts or areas containing elevated radionuclides associated with uranium mineralization. In addition, surface and subsurface soil and sediment samples and surface water samples were also collected and used to evaluate mining-related impacts (refer to Section 3.3.2).

In November 2016, May 2017, and September 2017, the surface gamma survey was performed using the methods and equipment described in Section 3.3.1.1 with the exception that the detector was carried in a backpack when topographical features did not allow field personnel to carry the detector by hand for safety reasons. Refer to Appendix B-1 photograph numbers 3 and 10 showing topography encountered during the surface gamma survey. The surface gamma survey included the claim area, a 100-ft buffer around the claim area, and roads and drainages out to approximately 0.25 miles from the Site. The *RSE Work Plan* specified that the surface gamma survey would be an iterative process where the surface gamma survey would be extended laterally until gamma measurements appeared to be within background levels. Subsequent to each workday, the gamma measurements were evaluated by ERG and Stantec, and compared to the background reference areas to determine if additional surface gamma surveying was needed.

The full areal extent of the surface gamma survey is referred to as the Survey Area, as shown in Figure 3-4. The Survey Area was 49.4 acres and was subdivided into three separate survey areas, as shown in Figure 3-4, based on *MARSSIM* criteria, including different geologic conditions on-site. Survey Area A is within the Moenkopi Formation (based on BG-1), Survey Area B is within the Cutler Formation (based on BG-2), and Survey Area C is within the Chinle Formation (based on BG-3).

It was necessary to subdivide the Survey Area based on geologic conditions and present the findings in Section 4.0 based on the subdivision, because geologic formations can have different geochemical compositions (i.e., gamma levels and concentrations of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium). The surface gamma survey results are presented in Section 4.2. The ERG survey report in Appendix A provides further detailed information on the surface gamma survey.

3.3.1.3 Gamma Correlation Study

Baseline Studies activities included a Gamma Correlation Study in accordance with the *RSE Work Plan,* Section 4.3. The objectives of the Gamma Correlation Study were to determine correlations between the following constituents to use as screening tools for site assessments:

- Gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (in picocuries per gram [pCi/g])
- Gamma measurements (in cpm) and exposure rates (in microRoentgens per hour [µR/hr])

Two regression analyses were conducted for these correlations. The first regression analysis was performed using co-located high-density surface gamma measurements and laboratory concentrations of Ra-226 in surface soils to develop a correlation equation (refer to Section 4.2.2). The correlation equation allows for Ra-226 concentrations in soil and sediment to be estimated (predicted) based on gamma measurements in the field.

This correlation equation was not used in the field to estimate Ra-226 concentrations or to evaluate the extent of Ra-226 concentrations. The correlation was used to develop a site-specific prediction for Ra-226 concentrations from the actual gamma survey data, as presented in Section 4.2.2. The correlation can be used as a site-specific field screening tool during site assessments, using the same gamma survey methods as in this RSE (e.g., walkover gamma survey) and based on site-specific conditions. The data related to the correlations are provided in Appendices A and C.

The second regression analysis was performed using co-located static one-minute gamma measurements and exposure rates to develop an exposure-rate correlation equation. Exposure rates can be predicted, based on gamma measurements, using the developed exposure-rate correlation equation. The exposure rate correlation also provides a standard by which future gamma measurements can be compared to previous gamma measurements, if those previous gamma measurements were also correlated with exposure. In addition, exposure rates can be used to provide an estimate of gamma radiation levels when an exposure meter is used as a health and safety tool for field personnel working on-site. The exposure rate correlation was not used for Site Characterization. Because the exposure rates are not part of the data analyses for the RSE report, a summary of the exposure rate correlation is not presented in this report. Appendix A provides a discussion of the correlations and the regression equations for both correlations.

In November 2016 field personnel identified five areas for the Gamma Correlation Study, as shown in Figure 3-5, by considering the results of the Site surface gamma survey (described in Section 3.3.1.2), field conditions (e.g., suitable terrain), and feasibility of sampling. To minimize variability when determining a correlation between gamma measurements (in cpm) and concentrations of Ra-226 in soil, the study area soils must: (1) represent a specific gamma measurement within the range of gamma measurements collected at the Survey Area; and (2) be as homogenous as possible with respect to soil type, and gamma measurement within the correlation area. At each area, field personnel completed a high-density surface gamma survey (intended to cover 100 percent of the survey area) and collected one five-point composite surface soil sample per area (refer to Table 3-2). Field personnel made a field modification from the *RSE Work Plan* by adjusting the size of the 900 ft^2 area smaller at the Gamma Correlation Study locations, to minimize the variability of gamma measurements observed. The area used for the Gamma Correlation Study is shown in Figure 3-5, where the box shown at the five study locations represents a 900 ft^2 area in comparison to the actual area covered for the study, as shown by the extent of the gamma measurements within each area.

On initial review of the Ra-226 concentration at correlation location S225-C05-001 (3.5 pCi/g) the concentration appeared to be unusually high given the relatively low gamma measurements observed at S225-C05-001 (refer to Appendix A). Therefore, a second sample was collected at correlation location S225-C05-001 and an additional correlation sample location was added (S225-C06-001) in May 2017. Field personnel also re-surveyed correlation locations S225-C01-001 through -C05-001 and surveyed location -C06-001 in May 2017. Gamma measurements were collected at all six locations on the same day because gamma measurements may vary with soil moisture content, seasons, etc. The sixth location (S225-C06-001) was added in May 2017 to provide an alternative location for the correlation if sample results from S225-C05-001 varied from the November 2016 sampling event. However, the Ra-226 concentration for the May 2017 sample event (3.86 pCi/g) was similar to the concentration measured in November 2016 and the gamma survey measurements were similar as well (refer to Appendix A Table 4). Therefore the data collected from correlation locations S225-C01-001 through -C05-001 in November 2016 were used for the following: (1) develop the correlation equation to predict Ra-226 values from gamma data; (2) develop the correlation of exposure rates to surface gamma measurements; (3) evaluate the potential influence of thorium on the correlation of gamma measurements to concentrations of Ra-226 in surface soils; and (4) evaluate the status of secular equilibrium within the U-238 decay series.

Of note, the gamma data from correlation location S225-C05-001 were reviewed to evaluate if there was any indication of an area in the correlation plot with measurements that were higher than the rest of the plot. If such an area was present, it may have indicated a location where one of the grab samples of the five-point composite sample may have collected more mineralized material, resulting in the higher Ra-226 concentration. However, the standard deviations of the gamma data for both the November 2016 and May 2017 were relatively low at 741 and 934 cpm, respectively (refer to Appendix A, Table 4). Additionally, the maximum of both gamma surveys was less than 10,600 cpm, which is still unusually low compared to the Ra-226 concentration. This information along with the similar Ra-226 concentrations supports the determination that the unusual Ra-226/gamma relationship was the result of variable physical or chemical conditions in the field and was not due to instrument or laboratory error. The ground conditions present in the area of correlation location S225-C05-001 are shown in Appendix B photograph number 9.

Field personnel collected, logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.4, 4.9, 4.11, and Appendix E. Soil samples were collected for analyses of Ra-226 and isotopic thorium, as described in the *RSE Work Plan,* Section 3.4.1.

The objectives of the thorium analyses were for site characterization and evaluation of potential effects of thorium on the correlation. The data can be used to assess the potential effects of thorium-232 (Th-232) series radioisotopes on the correlation of gamma measurements to concentrations of Ra-226 in surface soils (i.e., if gamma-emitting radioisotopes in the Th-232 series, such as actinium-228, lead-212, and thallium-208, are impacting gamma measurements at the Site), as discussed in Section 4.2.2. Uranium, radium, and thorium occur in three natural decay series (uranium-238 [U-238], Th-232, and U-235), each of which include significant gamma emitters (USEPA, 2007b). Therefore, in order to develop a correlation between gamma radiation and Ra-226 concentrations, the gamma radiation from each significant decay series present at the Site, may need to be taken into account. Typically, only U-238, and sometimes Th-232, are present in significant quantities. The contribution from the U-235 decay series to gamma measurements can be excluded because U-235 is only approximately 0.72 percent of the total uranium concentration. If the Th-232 decay series is present in significant quantities, it should be accounted for in the correlation to accurately predict Ra-226 concentrations based on all significant sources of gamma radiation.

3.3.1.4 Secular Equilibrium

The Gamma Correlation Study soil samples (refer to Section 3.3.1.3) were also analyzed for thorium-230 (Th-230), in accordance with the *RSE Work Plan,* Section 3.4.1. The activities of Th-230 and Ra-226 can be compared to evaluate the status of secular equilibrium within the U-238 decay series (USEPA, 2007b). The U-238 decay series is in secular equilibrium when the radioactivity of a parent radionuclide (e.g., U-238) is equal to its decay products (refer to Appendix A). If the U-238 decay series is out of secular equilibrium, the quantities of the daughter products become depleted. This could be considered for potential site assessments (e.g., when evaluating the contribution of the daughter products to the total risk related to U-238 during a human health and/or ecological risk assessment). As part of the RSE, the secular equilibrium evaluation was a general indicator (e.g., screening level assessment) of the status of equilibrium at the sites. It was not used to characterize the extent of constituents of potential concern (COPCs) at the Site. The secular equilibrium evaluation is discussed here only because Th-230 was included in the isotopic thorium analysis.

3.3.2 Site Characterization Activities and Assessment

3.3.2.1 Surface Soil and Sediment Sampling

Site Characterization activities included surface soil and sediment sampling and associated laboratory analyses. The soil and sediment surface sampling locations within the Survey Area were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical mining features and geologic features). Based on the surface gamma survey results and site features, a limited number of samples were collected and analyzed where the gamma survey measurements were within background levels, mining and or exploration-related features were not present, and no ground disturbance was observed. The results were compared to the site-specific ILs and published regional concentrations to support the overall evaluation of potential mining impacts (refer to Section 4.3). Soil/sediment samples were categorized as surface samples where sample depths ranged from 0.0 to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Samples collected in drainages were classified as sediment samples.

In June 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The numbers of surface samples collected within specific mine features are listed in Table 3-3. Twenty-six surface soil/sediment grab samples were collected from 26 locations in the Survey Area (seven from Survey Area A, 16 from Survey Area B, and three from Survey Area C). Field personnel collected, logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.4, 4.9, 4.11, and Appendix E. Samples were shipped to ALS Environmental Laboratories in Fort Collins, Colorado for analyses of: Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The surface soil and sediment analytical results are presented in Section 4.3. Field forms are provided in Appendix C.1 and the laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.2 Subsurface Soil and Sediment Sampling

Site Characterization activities included subsurface soil and sediment sampling and associated laboratory analyses. Similar to the surface soil/sediment sampling discussed in Section 3.3.2.1, subsurface sampling locations were selected based on professional judgment (i.e., non-randomly) to evaluate concentrations of Ra-226 and metals in relation to the surface gamma survey measurements and site features (e.g., historical mining features and geologic features).

Grab samples were collected with the intent to characterize specific intervals of interest (e.g., material within zones with elevated static gamma measurements). Surface and subsurface static gamma measurements were collected in the borehole using the same equipment as described in Section 3.3.1.1. Static gamma measurements were collected by holding the detector in the borehole for a one-minute integrated count and are not comparable to the surface gamma survey measurements, which were collected as a walkover survey. Static gamma measurements were not collected at borehole S225-SCX-008 due to caving sands.

Seventeen boreholes were advanced in the Survey Area (four in Survey Area A and 13 in Survey Area B). The boreholes were advanced through the unconsolidated deposits (from 0.5 ft to 1.3 ft bgs; refer to Table 3-2 and Appendix C.2) until refusal at either bedrock, large cobbles or gravels, or due to caving sands. Field personnel manually advanced the subsurface boreholes to a desired sample depth by using a 3-inch diameter hand auger. The boreholes were advanced through poorly graded sand, well graded sand, sandstone gravel, sandstone cobble, and sandstone boulders (refer to Appendix C.2 for borehole information). Subsurface sampling was limited in some areas on the mesa sidewall due to steep, unsafe terrain. A drill rig was not employed at the Site because only limited areas of the Site (portions of the pediment and the mesa top) would have been accessible with a drill rig due to steep, unstable and unsafe terrain. The primary areas of mining-related impact (e.g., Waste Piles 1 and 2) were in the steep and unstable terrain.

In June 2017, samples were collected from the locations shown in Figure 3-6a and are summarized in Table 3-2. Sample locations and the locations of mining-related features are shown in Figure 3-6b. The numbers of subsurface samples collected within specific mine features are listed in Table 3-3. Ten subsurface soil/sediment samples were collected from 10 borehole locations in the Survey Area. Two subsurface samples were collected from Survey Area A and eight from Survey Area B. No subsurface samples were collected from Survey Area C. At borehole locations S225-SCX-005 and –SCX-006 only static gamma measurements were collected and Ra-226 and metals analyses samples were not collected. Sediment samples were not collected at the boreholes due to sands caving in on the boreholes while augering. The two boreholes were generally co-located and a third borehole in the area (S225-SCX-007) was successful. Field observations (e.g., depth to bedrock, etc.) from boreholes where samples were not collected, were used in Section 4.0 to evaluate the physical conditions of the subsurface.

Subsurface samples were not collected from Waste Piles 3 through 5 due to an oversight. Additional subsurface characterization of the waste piles may be warranted during future studies, and the lack of subsurface samples from Waste Piles 3 through 5 is included as a data gap in Section 4.9. A borehole attempt was made in the potential haul road, but refusal was met on large gravels at 0.5 ft bgs and subsurface samples were not collected from the potential haul road; this may warrant addition characterization of the haul road during future studies.

Field personnel logged, classified, packaged, and shipped the samples in accordance with the *RSE Work Plan,* Sections 4.5, 4.9, 4.11, and Appendix E. Samples were shipped to ALS Environmental Laboratories in Fort Collins, Colorado for analyses of Ra-226, uranium, arsenic, molybdenum, selenium, and vanadium, as described in the *RSE Work Plan,* Section 4.13.1. The subsurface analytical results are presented in Section 4.3. Field forms, including borehole logs showing static gamma measurements and Ra-226 analytical results, are provided in Appendix C.2. The laboratory analytical data, data validation reports, and Data Usability Report for the analyses are provided in Appendix F.

3.3.2.3 Water Sampling

Nine potential water features were identified during the Site Clearance desktop study and one surface water feature was identified during the Site Clearance field investigations, as shown in Figure 2-1 and Table 3-1. Two of the 10 water features were sampled as described below.

On October 18, 2016, a surface water sample (S225-WS-001) was collected from the seep identified as S225-Seep-1. The seep was located 0.62 miles northwest of the Site, as shown in Figure 2-1. The seep sample was collected from the pooled area at the base of the seep, as shown in Appendix B-2 photograph number 19. The pooled area of the seep was approximately 1 ft in diameter and the sample was collected in the approximate center of the seep pool.

On October 18, 2016, a surface water sample (S225-WS-002) was collected from the pond identified as 08GS-12-9 in the NNDWR database and the *2007 AUM Atlas*. The pond was located 0.75 miles northwest of the Site, as shown in Figure 2-1. The pond sample was collected approximately 12 ft from the shore of the pond using a dip sampler pole and approximately 0.5 ft to 1 ft below the surface of the pond water. A photograph of the pond is shown in Appendix B-2 photograph number 18.

The remaining eight features were not sampled for the following reasons:

- Surface water or well water features were not observed by field personnel at three of the potential water features (08GS-12-8, 09-174, and 9609001M00). As a result, water from these locations were not sampled as part of the Site Characterization activities in accordance with the requirements of the *Trust Agreement* and *Scope of Work,* which only require sampling of perennial water features.

- Three of the potential water features (08A-216, 08A-216A, and 09-151) were listed as either private, inactive, domestic, or water wells. Attempts were made to locate these wells, including speaking with local residents; however, no wells or surface water features were observed at these locations.

- Two water well features were identified (08A-216B and 08T-554). Water well 08A-216B is the Navajo Tribal Utility Authority (NTUA) well that provides the town of Oljato with drinking water; it was not sampled because it is part of a general NTUA monitoring program and it was padlocked and surrounded by a fence. NTUA was contacted to request water quality results from 08A-216B, but results were not received. Water well 08T-554 was not observed by field personnel and local residents were not aware of the presence of a water well in the area.

The water samples collected for dissolved metals analyses were sampled and field filtered using a peristaltic pump, Teflon® tubing, and 0.45-micron inline filter at the time of sample collection per the *RSE Work Plan*, Section 4.6.1. All other analyses did not require in-field filtering. The samples were collected, packaged, and shipped in accordance with the *RSE Work Plan,* Sections 4.6, 4.9, 4.11, and Appendix E. ACZ Laboratories, Inc. in Steamboat Springs, Colorado conducted the mercury analysis and ALS Environmental Laboratories in Fort Collins, Colorado conducted all other analyses including Ra-226 and Radium-228 (Ra-228), adjusted gross alpha, and the following total and dissolved metals: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc.

Additional general water quality analyses or field measurements included: total dissolved solids (TDS), anions (carbonate, bicarbonate, chloride, and sulfate), cations (sodium and calcium), and field measurements (pH, salinity, conductivity, turbidity, temperature, and oxidation reduction potential). Table 3-4 provides a summary of the water analyses. Per the *RSE Work Plan*, if surface water sample analyte concentrations are above the established ILs then those sample areas would be considered for additional characterization in the future. Surface water analytical results are presented in Section 4.8. Field forms are provided in Appendix C.3 and the laboratory analytical data and Data Usability Report for the analyses are provided in Appendix F.

3.3.3 Identification of TENORM Areas

Areas at the Site where TENORM is present were identified using multiple lines of evidence including:

1. Historical Data Review
    a. Aerial photographs
    b. USAEC records
    c. Reclamation records
    d. Other documents relevant to the Site, including those in the *2007 AUM Atlas*
    e. Interviews with residents living closest to the Site (for those sites where residents were available for interview)
    f. Consultation and site visits with NAML staff to identify reclamation features (for those sites reclaimed by NAML)
2. Geology/Geomorphology
    a. Hydrology/transport pathways with drainage delineation
    b. Site-specific geologic mapping including areas of mineralization
    c. Topography

3. Disturbance Mapping
    a. Exploration
    b. Mining
    c. Reclamation
4. Site Characterization
    a. Surface gamma surveys and subsurface static gamma measurements
    b. Soil/sediment sampling and analyses

Any areas where TENORM was not observed are considered to contain NORM, because soil and/or rock at the Site contain some amount of natural uranium and its daughter products. This area was mined because of the high levels of naturally occurring uranium ore. The areas containing NORM and/or TENORM are presented in Section 4.6. The volume of TENORM is presented in Section 4.7. The areas containing NORM and/or TENORM, along with additional findings of the RSE report, are identified to support future Removal or Remedial Action evaluations at the Site.

3.4 DATA MANAGEMENT AND DATA QUALITY ASSESSMENT

This section summarizes the data management and data quality assessment activities performed for the RSE.

3.4.1 Data Management

The DMP included in the *RSE Work Plan* describes the plan for the generation, validation, and distribution of project data deliverables. Successful data management comes from coordinating data collection, quality control, storage, access, reduction, evaluation, and reporting. A summary of the data management activities performed as part of the RSE process included:

- **Database** – Field-collected and laboratory analytical RSE data were stored in an Oracle SQL relational database, which increased data handling efficiency by using previously developed data entry, validation, and reporting tools. The Oracle SQL database was also used to export project data to a tabular format that can be used in a spreadsheet (e.g., Excel) and to the USEPA Scribe database format.

- **Scribe** – The Stantec Data Manager/Data Administrator was responsible for meeting the project data transfer requirements from the Oracle SQL database to Scribe, which is a software tool developed by the USEPA's Environmental Response Team to assist in the process of managing environmental data. Stantec maintained an Oracle SQL database and exported data from the Oracle SQL database to a Scribe compatible format following completion of each field investigation phase. Custom data queries and "crosswalk" export routines were built in Oracle SQL, to facilitate data export to the Scribe database format with the required frequency.

- **Geographic Information System (GIS)** – Spatial data collected during the RSE (e.g., sample locations and gamma measurements) were stored in a dedicated File Geodatabase for use in the project GIS. The geodatabase format enforces data integrity, version control, file size compression, and ease of sharing to preserve GIS output quality. Periodic geodatabase backups were performed to identify accidentally deleted or otherwise corrupt information that were then repaired or recovered, if applicable.

3.4.2 Data Quality Assessment

The QAPP, included in the *RSE Work Plan*, Appendix B, was followed for RSE data quality assessment, where the QAPP presents QA/QC requirements designed to meet the RSE DQOs. Data quality refers to the level of reliability associated with a particular data set or data point. The Data Usability Report included in Appendix F.1 provides a summary of the data quality assessment activities and qualified data for the RSE. A summary of findings, from the data quality assessment, are included below.

- **Data Verification** – The data were verified to confirm that standard operating procedures (SOPs) specified in the *RSE Work Plan* and *FSP* were followed and that the measurement systems were performed in accordance with the criteria specified in the QAPP. Any deviations or modifications from the *RSE Work Plan* are described in the appropriate RSE report sections. The USEPA definition (USEPA, 2002b) for data verification is provided in the glossary.

- **Data Validation** – The data were validated to confirm that the results of data collection activities support the objectives of the RSE as documented in the QAPP. The data quality assessment process was then applied using the validated data and determined that the quality of the data satisfies the intended use. The USEPA definition (USEPA, 2002b) for data validation is provided in the glossary. A copy of the Data Usability Report is included in Appendix F.1 and a summary of the validation results is presented below:

    - **Precision** Based on the matrix spike/matrix spike duplicate (MS/MSD) sample, laboratory control sample/laboratory control sample duplicate (LCS/LCSD) sample, laboratory duplicate sample, and field duplicate results, the data are precise as qualified.

    - **Accuracy** Based on the initial calibration (ICAL), initial calibration verification (ICV), continuing calibration verification (CCV), MS/MSD, and LCS, the data are accurate as qualified.

    - **Representativeness** Based on the results of the sample preservation and holding time evaluation, the method and initial/continuing calibration blank (ICB/CCB) sample results, the field duplicate sample evaluation, and the reporting limit evaluation, the data are considered representative of the Site as reported.

    - **Completeness** All media and QC sample results were valid and collected as scheduled (i.e., as planned in the *RSE Work Plan*); therefore, completeness for these is 100 percent.

- **Comparability** Standard methods of sample collection and standard units of measure were used during this project. The analyses performed by the laboratory were in accordance with current USEPA methodology and the QAPP.

Based on the results of the data validation, all data are considered valid as qualified.

4.0 FINDINGS AND DISCUSSION

4.1 BACKGROUND REFERENCE AREA STUDY RESULTS AND CALCULATION OF INVESTIGATION LEVELS

The results of the background reference area surface gamma survey are shown in Figures 4-1a through 4-1d with sample locations in the background reference areas shown for BG-1, BG-2, and BG-3 on Figures 4-1b through 4-1d, respectively. The surface gamma survey in BG-1 did not cover the areal extent of the sample locations. Location S225-BG1-002 was stepped outside of the gamma survey area due to inaccessible steep terrain. BG-1 was also located on a steep slope that potentially affected the satellite signal resulting in a shift in the targeted sample points. Analytical results of the samples collected from BG-1, BG-2, and BG-3 are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-1, BG-2, and BG-3 were evaluated statistically to calculate ILs (refer to Appendix D.2) for each corresponding Survey Area (i.e., Survey Area A, Survey Area B, and Survey Area C, respectively). As previously discussed in Section 3.3.1.2, the Site was subdivided into three separate Survey Areas based on the geologic formations on-site.

Statistical evaluation of the gamma measurements and soil sample analytical results included identifying potential outlier values, interpreting boxplots and probability plots, comparing group means between the background reference areas and the respective Survey Area data, and calculating descriptive statistics for each of the background reference areas. The descriptive statistics included the 95 percent upper confidence limit (UCL) on the mean gamma measurements and Ra-226/metals concentrations, and the 95-95 upper tolerance limits (UTLs). The data were analyzed using R statistical programming packages and ProUCL 5.1 software (USEPA, 2016c).

The DQOs presented in the RSE Work Plan indicate that the ILs would be developed using the 95 percent UCL on the mean of the background sample results. However, the 95-95 UTL was used as the basis for the ILs instead because it better reflects the natural variability in the background data and lends itself to single-point comparisons to the Survey Area data. This was a change from the *RSE Work Plan*, as agreed upon with the Agencies prior to the change. The UTL represents a 95 percent UCL for the 95th percentile of a background dataset whereby Survey Area results above this value are not considered representative of background conditions. The UTL is a statistical parameter for the entire population of the variable, whereas the actual results are from a sample of the population. UTLs were calculated in accordance with USEPA's *ProUCL 5.1 Technical Guidance,* Sections 3.4 and 5.3.3 (USEPA, 2015). Appendix D.2 presents a comprehensive discussion on the derivation of the ILs for the Site, which are presented below. The *RSE Work Plan* also stated that gamma radiation measurements from the background surface and subsurface soil would be combined to develop the IL for surface gamma radiation at the Site. However, the surface gamma radiation ILs were instead developed from the surface gamma survey data only. The Agencies have commented that this should be noted as a deviation from the *RSE Work Plan*. The subsurface static gamma measurements were excluded from the derivation of the surface gamma IL for two reasons: (1) they were collected using a different method (static one-minute measurements versus a walkover gamma survey); and (2) because of the downhole geometric effects that influence subsurface static gamma measurements (refer to the discussion of geometric effects below).

The ILs for Survey Area A (i.e., the Moenkopi Formation; refer to Figures 2-6a, 2-6b, and 3-4) were established using statistical analysis of background data collected from BG-1 (refer to Figures 3-3 and 3-4) and are as follows:

- Arsenic – 5.28 milligrams per kilogram (mg/kg)
- Molybdenum – 3.47 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-1 were all non-detect.
- Uranium – 3.99 mg/kg
- Vanadium – 17.9 mg/kg
- Ra-226 – 2.43 pCi/g
- Surface gamma measurements 15,036 cpm

The ILs for Survey Area B (i.e., the Cutler Formation; refer to Figures 2-6a, 2-6b, and 3-4) were established using statistical analysis of background data collected from BG-2 (refer to Figures 3-3 and 3-4) and are as follows:

- Arsenic – 2.36 mg/kg
- Molybdenum – 0.786 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-2 were all non-detect.
- Uranium – 0.482 mg/kg
- Vanadium – 9.45 mg/kg
- Ra-226 – 0.909 pCi/g
- Surface gamma measurements 11,220 cpm

The ILs for Survey Area C (i.e., the Chinle Formation; refer to Figures 2-6a, 2-6b, and 3-4) were established using statistical analysis of background data collected from BG-3 (refer to Figures 3-3 and 3-4) and are as follows:

- Arsenic – 31.6 mg/kg
- Molybdenum – 2.42 mg/kg
- Selenium – an IL for selenium was not identified because selenium sample results in BG-3 were all non-detect.
- Uranium – 0.744 mg/kg
- Vanadium – 19.9 mg/kg
- Ra-226 – 2.08 pCi/g
- Surface gamma measurements 12,649 cpm

It is important to note that comparisons to the IL (i.e., 1.5 times the IL) are provided for context, and evaluations of: (1) areas of the Site; (2) samples or; (3) TENORM that exceed the ILs, which are based on the statistically derived IL values.

In addition to the surface gamma survey performed in background reference areas, subsurface static gamma measurements were collected in the boreholes completed in the BG-2 and BG-3 to establish subsurface static gamma screening levels for Survey Area B, and Survey Area C, respectively. When possible, the selected subsurface static gamma screening level values met the following criteria: (1) it was the lowest value measured at or below 1 ft bgs and (2) it was not directly measured on bedrock. The subsurface static gamma screening levels from BG-2 and BG-3 provide a comparison and assessment tool for Survey Areas B and C and are included as ILs for the Site.

A borehole was not completed in BG-1 (refer to Section 3.3.1.1), and therefore, a subsurface static gamma IL was not established for Survey Area A. The need for a subsurface borehole and subsurface static gamma data for BG-1 is identified as a potential data gap(refer to Section 4.9).

It is important to consider that the subsurface static gamma IL is based on a single measurement, and it is not statistically derived. For this reason, subsurface static gamma IL exceedances should be considered in conjunction with additional lines of evidence including: (1) down-hole trends of static gamma measurements; (2) changes in lithology within the borehole; and (3) a qualitative comparison of subsurface static gamma measurements to Ra-226 and/or metals concentrations in subsurface samples.

Subsurface static gamma measurements from BG-2 and BG-3 are summarized in Table 4-2 and in Appendix C.2. Three subsurface static gamma measurements of 9,424, 10,849, and 8,623 cpm were collected from BG-2 borehole S225-SCX-001 at down-hole depths of 0.5, 1.0, and 1.5 ft bgs, respectively. The lowest value (8,623 cpm) was measured at the borehole termination depth (1.5 ft bgs); however, the borehole termination was not on bedrock (refer to Appendix C.2), and therefore 8,623 cpm was used as the subsurface static gamma IL for Survey Area B. One subsurface gamma measurement of 21,577 cpm was obtained from BG-3 borehole S225-BG3-011 at the down-hole refusal depth of 0.5 ft bgs, and therefore, 21,577 cpm is considered the subsurface static gamma IL for Survey Area C. Note that refusal in BG3-011 was confirmed to be on bedrock (i.e., the Shinarump member of the Chinle Formation) and therefore, this subsurface static gamma measurement may be elevated as a result of the close proximity to bedrock with naturally elevated concentrations of radionuclides.

It is important to consider that the subsurface static gamma IL measurements may be elevated relative to the surface gamma IL because increases in static gamma measurements with depth can result from the detector being in closer proximity to bedrock that has naturally elevated concentrations of radionuclides, and/or geometric effects. Geometric effects are the result of the detector measuring gamma radiation from all directions, regardless of whether it is in a borehole or suspended in air. Gamma radiation measured with the detector held at the ground surface is primarily from the ground beneath the detector. As the detector is advanced down the borehole it measures gamma radiation from the surrounding material emanating from an increasing number of angles. Therefore, as the detector is lowered in the borehole it will generally measure increasingly higher values to a certain depth given a constant source. At approximately 1 ft to 2 ft bgs, the detector is essentially surrounded by solid ground and further increases related to borehole geometry are not expected. Because downhole geometric effects influence static gamma measurements just below ground surface, static gamma measurements collected at or greater than 0.1 ft bgs are considered subsurface.

Due to the differing geometric effects, surface static gamma measurements at borehole locations may only be qualitatively compared to subsurface static gamma measurements, and the subsurface static gamma IL does not apply to the surface static gamma measurements. Instances where the surface static gamma measurement is greater than subsurface static gamma measurements suggest higher levels of radionuclides and may be indicative of the presence of TENORM at the surface, but additional lines of evidence are generally needed to support that conclusion.

The Site gamma measurements, and soil and sediment sample analytical results were compared to their respective ILs to confirm COPCs (refer to Section 4.4) and to identify areas of the Site where ILs are exceeded (refer to Section 4.5). The calculated ILs provide a line of evidence to evaluate potential mining-related impacts, and to support future Removal or Remedial Action evaluations at the Site.

4.2 SITE GAMMA RADIATION SURVEY RESULTS AND PREDICTED RADIUM-226 CONCENTRATIONS

4.2.1 Site Gamma Radiation Results

4.2.1.1 Surface Gamma Survey

Results of the Site surface gamma survey are shown in Figure 4-1a where the calculated surface gamma ILs for each background reference area are used to set bin ranges with color coding to illustrate the spatial extent and patterns of surface gamma measurements within the entire Survey Area. The bins ranges were based on the minimum site gamma measurement, the background reference area ILs, and the maximum site gamma measurement. The maximum survey measurement was 328,342 cpm, which was greater than 10 times the BG-1, BG-2, and BG-3 ILs, and occurred along the lower potential haul road, in an area approximately coincident with Portal-3 and Waste Pile 2 (refer to Figure 2-7a alongside Figure 4-1a).

Surface gamma measurements were generally highest in two areas: (1) the areas of the vertical cliffs and/or steep colluvium–covered bedrock slope of the mesa sidewall that are coincident with Portals-1, -2, and -3, and downgradient and associated Waste Piles 1 and 2 (refer to Section 3.2.2.1 and Appendix B, photograph numbers 1, 5, 6, 7, and 8); and (2) the area coincident with Waste Pile 3 and the mining disturbed area surrounding Waste Pile 3 (refer to Section 3.2.2.1).

The spatial distribution of surface gamma measurements and IL exceedances are shown in 4-1b, 4-1c, and 4-1d for Survey Areas A, B, and C, respectively, and are described below:

- Survey Area A - (refer to Figure 2-7a alongside Figure 4-1b): Surface gamma IL exceedances greater than 15,036 cpm) were observed primarily in areas associated with mining-related disturbances, including: (1) Portals-1, -2, -3, associated Waste Piles 1 and 2, and areas immediately downgradient of the waste piles, and (2) rock debris located downgradient of the southern portion of the lower potential haul road, and potential rim stripped and/or blasted area.
- Survey Area B - (refer to Figure 2-7a alongside Figure 4-1c): Surface gamma IL exceedances (greater than 11,200 cpm) were observed primarily in colluvium that collected in slope breaks on the bedrock slope or along the transitional area from bedrock slope to pediment. The southwestern portion of Survey Area B contained a sparse, but relatively consistent distribution of minor surface gamma IL exceedances (most measurements were less than 12,400 cpm, or 10 percent higher than the IL). In general, the highest measurements occurred in colluvium located downgradient from the waste piles. With the possible exception of one drainage channel that originated from the north-central claim boundary and discharged into the unnamed drainage to the west (refer to Figure 2-7a and 2-7b), the drainages did not systematically contain elevated surface gamma measurements relative to surrounding areas.
- Survey Area C - (refer to Figure 2-7a alongside Figure 4-1d): Surface gamma IL exceedances (greater than 12,649 cpm) were observed primarily coincident with Waste Piles 3 and 5, and along portions of the upper potential haul road.

Five potential data gaps were identified for the surface gamma survey, as listed below:

1. Approximately 2.9 acres of the mesa sidewall were not surveyed because field personnel were unable to safely access these areas.

2. The lower potential haul road from Waste Pile 1 to the southern extent where the road ends at the blasted area was not included in the surface gamma survey due to field personnel oversight.

3. A borehole was not completed in BG-1; therefore, a subsurface static gamma IL was not established for Survey Area A. However, having an established IL would not have affected the volume estimates because all boreholes completed in Survey Area A contained soils that exceeded the Ra-226 IL, as well as one or more metal IL.

4. The approximate centerlines of the potential haul roads were surveyed, but the shoulders were not due to miscommunication with the field personnel.

5. The gamma survey was not extended laterally out from the potential haul roads where gamma measurements were greater than the IL as the result of an oversight.

4.2.1.2 Subsurface Gamma Survey

Surface and subsurface static gamma measurements were collected at 16 out of 17 borehole locations. Surface and subsurface static gamma measurements were not collected at location S225-SCX-008 in Survey Area B because of caving sands; refer to Appendix C.2. Surface and subsurface static gamma measurement locations are shown in Figures 4-1a through 4-1d. Measurements and corresponding measurement depths are provided in Table 4-2 and are shown on the borehole logs in Appendix C.2. Surface and subsurface static gamma measurements from the boreholes are presented below by Survey Area:

- Survey Area A – A subsurface static gamma IL was not established for Survey Area A (refer to Sections 3.3.1.1 and 4.1). Therefore, findings of the subsurface static gamma survey are not considered with respect to an IL. Four boreholes were completed in Survey Area A (S225-SCX-002, -SCX-003, -SCX-004, and –SCX-018). The maximum subsurface measurement (157,480 cpm) was measured at a depth of 1.0 ft bgs in borehole S225-SCX-004, which was located in Waste Pile 1. Boreholes S225-SCX-002 and -SCX-003, located near mining Portal-3 and Waste Pile 2, respectively, had subsurface static gamma measurements greater than 46,500 cpm. Borehole S225-SCX-018, located along the east-central claim boundary, south of Waste Pile 1, had a lower subsurface static gamma measurement (18,821 cpm) relative to the other three Survey Area A boreholes. In general, static gamma measurements increased with depth, except for borehole S225-SCX-003, which showed an increase from the surface (79,579 cpm) to 0.5 ft bgs (108,876 cpm), but then decreased to 88,201 cpm at the refusal depth of 1.0 ft bgs.

- Survey Area B – Of the 13 boreholes that were completed in Survey Area B (S225-SCX-005, -SCX-006, -SCX-007, -SCX-008, -SCX-009, -SCX-010, -SCX-011, -SCX-012, -SCX-013, -SCX-014, -SCX-015, -SCX-016, and -SCX-017), subsurface static gamma measurements were collected in all but S225-SCX-008. Subsurface static gamma measurements exceeded the Survey Area B IL of 8,623 cpm in all 12 boreholes. The maximum subsurface static gamma measurement

(22,418 cpm) was measured directly above bedrock at a depth of 0.7 ft bgs in borehole S225-SCX-011, which was located in a drainage in the west-central portion of the Survey Area. The remaining boreholes had only minor exceedances that were less than two-times the IL. Six boreholes (S225-SCX-009, -SCX-011, -SCX-013, -SCX-014, -SCX-015, and -SCX-017) had overall increases in static gamma measurements with depth, and the remaining six boreholes (-SCX-005, -SCX-006, -SCX-007, -SCX-010, -SCX-012 and -SCX-016) had overall decreases in static gamma measurements with depth. For two boreholes (S225-SCX-012 and -SCX-014), static gamma measurements initially increased with depth and then decreased further down-hole. There was no clear pattern observed with respect to borehole location and down-hole increases or decreases in static gamma measurements. In general, however, borehole static gamma measurements remained relatively constant with depth. For instance, individual down-hole gamma measurements, taken at discrete depths within a given borehole, only varied by a maximum of 25 percent in eight out of 12 boreholes.

- Survey Area C – No boreholes were completed in Survey Area C; therefore, subsurface static gamma measurements were not measured for this area. Boreholes were not advanced in this area because the ground surface at Survey Area C was mainly comprised of bedrock with minimal to no soil/sediment cover. In a few discrete areas within Survey Area C boreholes could potentially have been advanced: (1) the Waste Piles 3, 4, and 5; (2) the areas adjacent to the waste piles; and (3) portions of the upper potential haul road. However, based on observations by field personnel the depths of the waste piles, the soil/sediment cover in the areas adjacent to the waste piles, and soil/sediment cover along the upper potential haul road, could be estimated.

4.2.2 Gamma Correlation Results

The high-density surface gamma measurements and concentrations of Ra-226 in surface soils obtained from the Gamma Correlation Study for data collected at S225-C01-001 through -C05-001 in November 2016 (refer to Section 3.3.1.3) were used to develop a correlation equation, using regression analysis, between the mean gamma measurements and Ra-226 concentrations measured in the co-located composite surface soil samples. This correlation is meant to be used as a general screening tool, and provides approximate predicted Ra-226 concentrations.

Analytical results of the correlation samples, which were used to develop the correlation equation, are presented in Table 4-3. The mean value of the gamma survey results from the correlation plots, with their corresponding Ra-226 concentrations and a graph showing the linear regression line and adjusted Pearson's Correlation Coefficient (R^2) value for the correlation, are shown in Figure 4-2a. The regression produced an adjusted R^2 value of 0.62 which is not within the acceptance criterion of 0.8 to 1.0 described in the *RSE Work Plan* and indicates that surface gamma results do not correlate well with Ra-226 concentrations in soil. The correlation model may have been influenced by the limited number of correlation sample locations. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating Ra-226 concentrations. The inability to construct a statistically defensible correlation model is identified as a data gap. The correlation equation to convert gamma measurements in cpm to predicted surface soil Ra-226 concentrations in pCi/g for the Site is:

$$\text{Gamma (cpm)} = 5{,}239 \times \text{Surface Soil Ra-226 (pCi/g)} + 4{,}454$$

The predicted Ra-226 concentrations in soil, as calculated from the gamma measurements using the developed correlation equation, are shown in Figure 4-2a. Ra-226 concentrations predicted using gamma measurements lower than the minimum (8,257 cpm) and greater than the maximum (48,333 cpm) mean gamma measurements from the Gamma Correlation Study are extrapolated from the regression model and are therefore uncertain. Using the correlation equation, the predicted Ra-226 concentration associated with the minimum mean gamma measurement is 0.7 pCi/g and the concentration associated with the maximum mean gamma measurement is 8.4 pCi/g. Therefore, predicted Ra-226 concentrations less than 0.7 pCi/g and greater than 8.4 pCi/g should be limited to qualitative use only. The correlation locations were intentionally selected to be focused on the lower range of gamma measurements observed at the Site. Mean gamma measurements for correlation locations ranged from 8,257 to 48,333 cpm. The correlation was focused on the lower range because future Removal or Remedial Action decisions are more critical at lower Ra-226 concentrations where the limits of remediation may be defined.

The predicted Ra-226 concentrations are shown in Figure 4-2a. The elevated predicted Ra-226 concentrations occur in the same areas where the elevated surface gamma measurements occur (refer to Section 4.2.1). This is because the predicted Ra-226 concentrations are based on a correlation with the gamma measurements. Predicted Ra-226 concentrations in the Survey Area range from 0.1 to 61.8 pCi/g, with a mean of 1.8 pCi/g, and a standard deviation of 2.9 pCi/g. Bin ranges in Figure 4-2a are based on these mean and standard deviation values.

The gamma correlation was not used for the Site Characterization, which instead relied on actual gamma radiation measurements and soil analytical results. However, predicted Ra-226 concentrations were compared to the Ra-226 laboratory concentrations measured in surface soil samples collected at surface and borehole locations, as shown in Figure 4-2b. The correlation results were also compared to investigation levels, as shown in Figure 4-2c. Per the Agencies, these comparisons can be used for site characterization and are one of many analyses that can be used to interpret the data (NNEPA, 2018).

When comparing the predicted Ra-226 concentrations to the Ra-226 laboratory concentrations, soil/sediment sample locations are generally not co-located with specific gamma measurement locations (refer to Figure 4-2b). Therefore, the measured Ra-226 laboratory concentrations can only be qualitatively compared to the nearby predicted Ra-226 concentrations. With the exception of eight (out of 28) sample locations, the measured Ra-226 laboratory concentrations were within the applicable predicted Ra-226 bin ranges. For five of the eight sample locations where laboratory Ra-226 concentrations did not fall within the applicable predicted Ra-226 bin range, the predicted Ra-226 concentrations were lower than the Ra-226 laboratory concentrations. At the remaining three locations predicted Ra-226 concentrations were higher than the Ra-226 laboratory concentrations. Most of these sample locations had Ra-226 laboratory concentrations and predicted Ra-226 concentrations that were within approximately one standard deviation (2.9 pCi/g) of each other, however two sample locations (S225-CX-005, and -SCX-003) had notable differences between the predicted and laboratory Ra-226 concentrations; these samples had notably higher laboratory Ra-226 concentrations than the predicted Ra-226 concentrations. Both locations were within or adjacent to waste piles on the mesa sidewall (S225-SCX-003 was collected at the toe of Waste Pile 2 and -CX-005 was collected adjacent to Waste Pile 1), and the disparity between the laboratory Ra-226 concentrations and predicted Ra-226 is likely the result of the surface gamma measurements being offset from the sample location. In general, the differences observed between the predicted and actual Ra-226 values at the Site are likely a function of the natural heterogeneity in Ra-226 concentrations and gamma radiation measurements, which affects the correlation based on the five Gamma Correlation Study areas, and the predicted values, based on the subsequent gamma measurements.

The predicted Ra-226 concentrations were also compared to the Ra-226 ILs from each Survey Area, as shown in Figure 4-2c. The symbols for surface sample locations and boreholes where Ra-226 concentrations in surface soil/sediment samples exceeded the IL are highlighted with yellow halos. The predicted Ra-226 concentrations exceeded the Ra-226 ILs for most of the Site. In addition, every soil/sediment sample location where Ra-226 concentrations in the surface sample exceeded the Ra-226 IL was located in an area that was also predicted to exceed the Ra-226 IL. However, there were five sample locations where the Ra-226 concentration was less than the Ra-226 IL but the predicted Ra-226 concentration in the area exceeded the IL. The area of the Site where predicted Ra-226 values exceeded the ILs is compared to surface gamma IL exceedances in Section 4.5.

The correlation soil samples collected at S225-C01-001 through -C05-001 in November 2016 were also analyzed for thorium isotopes Th-232 and Th-228. The objectives of the thorium analyses were to assess the potential effects of Th-232 series radioisotopes on the correlation of gamma measurements to concentrations of Ra-226 in surface soils (i.e., to evaluate whether gamma-emitting radioisotopes in the Th-232 series are impacting gamma measurements at the Site). The justification for the analysis is provided in Section 3.3.1.3. A multivariate linear regression (MLR) model was performed by ERG to relate the gamma count rate to multiple soil radionuclides simultaneously. The MLR and results are described extensively in Appendix A. ERG identified that the thorium series radionuclides do not affect the prediction of concentrations of Ra-226 from gamma survey measurements at the Site.

4.2.2.1 Secular Equilibrium Results

The activities of Th-230 and Ra-226 in the correlation soil samples collected at S225-C01-001 through -C05-001 in November 2016 were compared to consider whether the uranium series is in secular equilibrium at the Site (refer to Section 3.3.1.4 and Appendix A). A linear regression was performed on the dataset (refer to Appendix A Figure 9). The p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the study DQO (adjusted $R^2 > 0.8$), indicating that Ra-226 and Th-230 exist in equilibrium. However, when compared to a y=x line (this line represents a perfect 1:1 ratio between Th-230 and Ra-226, indicating secular equilibrium), the y=x line falls partially outside of the 95% UCL bands of the Th-230/Ra-226 regression, indicating

Ra-226 and Th-230 are not in secular equilibrium at the Site (refer to figures in Appendix A). This may be a consideration in the future if a human health and/or ecological risk assessment is performed.

4.3 SOIL METALS AND RADIUM-226 ANALYTICAL RESULTS

A total of 26 surface soil/sediment grab samples (14 soil and 12 sediment) from 26 locations, and ten subsurface soil/sediment grab samples (three soil and seven sediment) from ten borehole locations were collected at the Site (refer to Table 3-2). The metals and Ra-226 analytical results for each Survey Area are compared to their respective ILs and presented in Tables 4-4a through 4-4c. Figure 4-3 present the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil/sediment samples.

Ra-226 and/or metals concentrations exceeded their respective ILs in all but two surface soil/sediment samples (S225-CX-004 in Survey Area A, and S225-CX-013 in Survey Area C) and in all ten subsurface samples. As seen in Figures 4-1b, 4-1c, 4-1d, and 4-3, the only sample location that did not exceed any ILs was surface soil sample S225-CX-004. In general, the greatest exceedances of Ra-226 and metals ILs were associated with Waste Piles 1, 2, or 3, or areas immediately downgradient of the waste piles. The maximum concentrations for all analytes were detected in sample S225-CX-012, which was collected from Waste Pile 3 in Survey Area C. Surface and subsurface soil/sediment IL exceedances for each analyte, with respect to each of the three survey areas, are described below:

- Ra-226
  - Survey Area A – the Ra-226 IL (2.43 pCi/g) was exceeded in five out of seven surface soil samples (S225-CX-002, -SCX-002, -SCX-003, -SCX-004, and SCX-018), and both subsurface samples (S225-SCX-003, and -SCX-004). The maximum Ra-226 detection (71.9 pCi/g) was from surface soil sample S225-CX-002 located on the colluvium-covered bedrock slope, near Waste Pile 1.
  - Survey Area B – the Ra-226 IL (0.909 pCi/g) was exceeded in 11 out of 16 surface soil/sediment samples (S225-CX-005, -CX-006, -CX-007, -CX-008, -CX-009, -SCX-007, -SCX-010, -SCX-011, -SCX-012, -SCX-013, and -SCX-014) and three out of eight subsurface samples (S225-SCX-010, -SCX-012 and -SCX-015). The maximum Ra-226 detection (34.8 pCi/g) was from surface soil sample S225-CX-005 located just downgradient of Waste Pile 1.
  - Survey Area C – the Ra-226 IL (2.08 pCi/g) was exceeded in one out of three surface soil samples (S225-CX-012) with a concentration of 110 pCi/g. Sample S225-CX-012 was collected from Waste Pile 3.
- Uranium
  - Survey Area A – The uranium IL (3.99 mg/kg) was exceeded in four surface soil samples (S225-CX-002, -SCX-002, -SCX-003, and -SCX-004), and both subsurface samples

  (S225-SCX-003 and -SCX-004). The maximum detection (120 mg/kg) was from surface soil sample S225-CX-002, collected from Waste Pile 1.

  - Survey Area B – The uranium IL (0.482 mg/kg) was exceeded in all but two (S225-CX-009 and -SCX-008) surface soil/sediment samples, and in all but one (S225-SCX-007) subsurface samples. The maximum detection (78 mg/kg) was from surface soil sample S225-CX-005 located just downgradient of Waste Pile 1.
  - Survey Area C – The uranium IL (0.744 mg/kg) was exceeded in two surface soil samples (S225-CX-011 and -CX-012). The maximum uranium detection (220 mg/kg) was from surface soil sample S225-CX-012, collected from Waste Pile 3.

As a broader point of reference, a regional study of the western US documented uranium concentrations in soil that ranged from 0.68 to 7.9 mg/kg, with a mean value of 2.5 mg/kg (USGS, 1984). Uranium concentrations exceeded the maximum regional value in some soil/sediment samples from all Survey Areas (A, B, and C).

- Arsenic
  - Survey Area A – the arsenic IL (5.28 mg/kg) was exceeded in four surface soil samples (S225-CX-002, -SCX-002, -SCX-003, and -SCX-004), and both subsurface samples (S225-SCX-003 and -SCX-004). The maximum arsenic detection (41 mg/kg) was from the surface soil sample from the S225-SCX-004 borehole located on the mesa sidewall, located in Waste Pile 1.
  - Survey Area B – the arsenic IL (2.36 mg/kg) was exceeded in ten surface soil/sediment samples (S225-CX-005, -CX-006, -CX-007, -CX-008, -CX-009, -CX-010, -SCX-008, -SCX-009, -SCX-011, and -SCX-014) and three subsurface samples (S225-SCX-009, -SCX-012, and -SCX-015). The maximum arsenic detection (19 mg/kg) was from surface soil sample S225-CX-005 located just downgradient of Waste Pile 1.
  - Survey Area C – the arsenic IL (31.6 mg/kg) was exceeded in one surface soil sample (S225-CX-012) with a concentration of 150 mg/kg. Sample S225-CX-012 was collected from Waste Pile 3.

As a broader point of reference, a regional study of the western US documented arsenic concentrations in soil that ranged from less than 0.10 to 97 mg/kg, with a mean value of 5.5 mg/kg [USGS, 1984]. Arsenic concentrations were within the typical range of regional values in soil/sediment samples from Survey Areas A and B, but exceeded the maximum regional value in Survey Area C.

- Molybdenum
  - Survey Area A – the molybdenum IL (3.47 mg/kg) was exceeded in one surface soil sample (S225-SCX-002) with a concentration of 10 mg/kg, and was not exceeded in any of the subsurface samples. Sample S225-SCX-002 was located along the lower potential haul road, between Portal-3 and Portal-4 (refer to Figure 2-7b).

  - Survey Area B – the molybdenum IL (0.786 mg/kg) was exceeded in three surface soil/sediment samples (S225-CX-005, -CX-007 and -CX-008), and was not exceeded in any of the subsurface samples. The maximum detection (5.1 mg/kg) was from surface sediment sample S225-CX-007 located in one of the northern-most drainages in the Survey Area.

  - Survey Area C – the molybdenum IL (2.42 mg/kg) was exceeded in one surface soil samples (S225-CX-012) with a concentration of 11 mg/kg. Sample S225-CX-012 was collected from Waste Pile 3.

As a broader point of reference, a regional study of the western US documented molybdenum concentrations in soil that ranged from less than 3 to 7 mg/kg, with a mean value of 0.85 mg/kg [USGS, 1984]. Molybdenum concentrations were within the typical range of regional values in soil/sediment samples from Survey Areas A, B, and C, except for location S225-SCX-002 in Survey Area A and S225-CX-012 in Survey Area C.

- Selenium – ILs for selenium were not identified because selenium sample results in the background areas were all non-detect

  - Survey Area A – Selenium was not detected in any of the surface samples, and was detected in one subsurface soil sample (S225-SCX-004) with a concentration of 1.1 mg/kg. Sample S225-SCX-004 was collected from Waste Pile 1.

  - Survey Area B – Selenium was not detected in any surface or subsurface soil/sediment samples collected from Survey Area B.

  - Survey Area C – Selenium was detected in one surface soil sample (S225-CX-012) with a concentration of 1.2 mg/kg. Sample S225-CX-012 was collected from Waste Pile 3.

As a broader point of reference, a regional study of the western US documented selenium concentrations in soil that typically ranged from less than 0.10 to 4.3 mg/kg, with a mean value of 0.23 mg/kg [USGS, 1984]. Selenium concentrations were within the typical range of regional values in all Survey Areas (A, B, and C).

- Vanadium

  - Survey Area A – The vanadium IL (17.9) was exceeded in six surface soil samples (S225-CX-001, -CX-002, -SCX-002, -SCX-003, -SCX-004 and -SCX-018), and both subsurface samples (S225-SCX-003 and -SCX-004). The maximum vanadium detection (42 mg/kg) was from surface soil sample S225-CX-002, the sample was collected at Waste Pile 1.

  - Survey Area B – The vanadium IL (9.45) was exceeded in five surface soil/sediment samples (S225-CX-005, -CX-010, -SCX-007, -SCX-008, and -SCX-009,) and four subsurface samples (S225-SCX-009, -SCX-010, -SCX-012, and -SCX-014). The maximum vanadium detection (19 mg/kg) was from surface soil sample S225-CX-005 located just downgradient of Waste Pile 1.

  - Survey Area C – The vanadium IL (19.9) was exceeded in one surface soil sample (S225-CX-012) with a concentration of 83 mg/kg. Sample S225-CX-012 was collected at Waste Pile 3.

As a broader point of reference, a regional study of the western US documented vanadium concentrations in soil that ranged from 7 to 500 mg/kg, with a mean value of 70 mg/kg (USGS, 1984). Vanadium concentrations were within the typical range of regional background values in all Survey Areas (A, B, and C).

4.4 CONSTITUENTS OF POTENTIAL CONCERN

Based on the results presented in Sections 4.2 and 4.3, gamma radiation and concentrations of Ra-226, arsenic, molybdenum, uranium, and vanadium in soil/sediment exceeded their respective ILs in Survey Areas A, B, and C. Therefore, these constituents were confirmed as COPCs for the Site. An IL for selenium was not identified because selenium sample results were non-detect in the background areas. However, because selenium was detected in Survey Areas A and C is it also confirmed as a COPC for the Site.

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil/sediment is 22.7 acres, as shown in Figure 4-4a. To estimate this area, polygons were contoured around portions of the Site that had multiple, contiguous surface gamma IL exceedances and then the total area within the polygons was calculated. Figures 4-4b and 4-4d show larger scale views of each of the three Survey Areas to better display those areas with multiple, contiguous surface gamma IL exceedances. A majority of the soil/sediment sample locations that contained IL exceedances were co-located with areas of surface gamma IL exceedances. Two areas with surface and/or subsurface soil/sediment IL exceedances that were not coincident with surface gamma IL exceedances are described below:

- The main unnamed drainage channel located to the west of the Site (sample locations S225-CX-009, -CX-010, -SCX-008, -SCX-009 and -SCX-015). IL exceedances in the unnamed drainage channel primarily consisted of subsurface static gamma, arsenic, uranium, and vanadium exceedances that were less than two-times their respective ILs (refer to Table 4-4b).

- The northeastern portion of the lower potential haul road (sample locations S225-CX-001 and -CX-011). The soil IL exceedances measured along the northeastern portion of the lower potential haul road included uranium (S225-CX-001) or vanadium (S225-CX-011) IL exceedances (refer to Tables 4-4a and 4-4c).

Figure 4-5 shows the vertical extent of IL exceedances in each borehole by incorporating information from each location, including: (1) depth to bedrock; (2) total borehole depth; and (3) depth range of IL exceedances. Table 4-5 lists the IL exceedances identified at each borehole location and Figure 4-5 also shows the surface gamma IL exceedances for reference.

IL exceedances in metals and Ra-226 concentrations at surface and subsurface sample locations were typically, but not always co-located with surface gamma survey measurements and/or subsurface static gamma measurements that also exceeded their ILs. Variations occur due to natural variability and the different field methods. For example, a small piece of mineralized rock or petrified wood may have been collected in a soil sample but may not have been detected by the gamma meter in the gamma survey due to distance from the meter, the depth below ground surface, or because the gamma meter measures radiation over a larger area than the discrete soil sample location.

The lateral extent of the IL exceedances (for surface gamma data) shown in Figure 4-4a were compared to the predicted Ra-226 concentrations that exceeded ILs in Figure 4-2c. Predicted Ra-226 concentrations exceeded the Ra-226 IL in a larger area of the Site than surface gamma measurements exceeded the surface gamma ILs. Surface gamma IL exceedances covered approximately two-thirds of Survey Area B while predicted Ra-226 exceedances covered approximately three-quarters of the Survey Area. Additionally, the predicted Ra-226 concentrations were less than the Ra-226 IL for the entirety of Survey Area C whereas the surface gamma measurements exceeded the IL for limited areas of Survey Area C associated with observed mining-related disturbances.

4.6 AREAS OF TENORM AND NORM

A multiple lines of evidence approach was used to evaluate the Site and distinguish areas of TENORM from areas of NORM within the Survey Area, as described in Section 3.3.3. Based on this evaluation, 42.4 acres, out of the 49.4 acres of the Survey Area, were estimated to contain TENORM at the Site. This estimate is inclusive of three areas: (1) portions of the mesa top; (2) the mesa sidewall (i.e., the vertical cliffs and steep colluvium-covered bedrock slope); and (3) the pediment area (i.e., the area in-between the base of the steep bedrock slope and the unnamed drainage). The area containing TENORM is shown in relation to the lateral extent of IL exceedances in Figure 4-6 and in relation to the gamma measurements in Figure 4-7. Figure 4-7 also shows the areas of the Site that were mapped as exposed bedrock. Colluvium within areas of exposed bedrock is limited, but is considered in the volume estimate in Section 4.7. The area of TENORM at the Site excluding areas of exposed bedrock is 30.3 acres.

The RSE data that supports the delineation of TENORM at the Site includes:

- Historical Data Review Conclusions
    - Historical document review (Chenoweth, 1991; NAML, 2001; Weston Solutions, 2012a) indicated that there were up to five historical mining portals and that rim stripping occurred at the Site. Stantec field personnel observed three reclaimed portals, one unreclaimed prospect portal, and rim stripping areas along the lower potential haul road. The fifth portal reported by Weston Solutions (2012a) was not observed by Stantec field personnel.
    - Between 1954 and 1955, 58.59 tons of ore that contained 236.57 pounds of 0.27 percent U_3O_8 and 178.67 pounds of 0.21 percent V_2O_5 was produced from the Site.

  - Historical document review indicated NAML reclamation activities have taken place at the Site that included excavation, stabilization, and closure of three portals. Stantec field personnel observed evidence of the reclamation activity at three portals.

- Geology/geomorphology

  - Bedrock at the Site consisted of four geologic units from three geologic Formations: (1) the Shinarump Member of the Triassic Chinle Formation; (2) the Triassic Moenkopi Formation; and (3) the De Chelly Sandstone Member and Organ Rock Tongue of the Permian Cutler Formation. The Shinarump member of the Chinle Formation commonly has natural enrichments of uranium. In addition, a significant portion of the Site consisted of shallow or outcropping bedrock. Therefore, the geology and geomorphology of the Site was conducive to the presence of NORM at or near the ground surface.

  - Several ephemeral drainages join into an unnamed drainage that could transport NORM/TENORM to the southwest. Except for one drainage channel that originated from the vicinity of the north-central claim boundary and discharged into the unnamed drainage to the west, the drainages did not systematically contain elevated surface gamma measurements relative to surrounding areas. The unnamed drainage contained sediment that exceeded metals ILs and the subsurface static gamma IL, however the exceedances were generally minor and not co-located with surface gamma IL exceedances. The drainage is included in the TENORM volume estimate in Section 4.7.

- Disturbance Mapping – Stantec field personnel observed the following features:

  - Four historical mining portals on the Site, three of the identified portals align with the three reclaimed and sealed portals reported by NAML (2001). The fourth portal was actually an un-reclaimed prospect portal that was approximately 10 ft deep.

  - Visual evidence of two potential haul roads present on or within 0.25 miles of the Site. The upper potential haul road runs on the mesa top and the lower potential haul road runs along the mesa sidewall, as an access for the portals and an area south of the portals where rim stripping likely occurred. Portions of bedrock on the mesa top and along the mesa rim appear to have been excavated away to create the upper haul road to access areas for exploration. The lower potential haul road appears to have been blasted away and ends abruptly approximately 375 ft south of Portal-1. It is unknown if the lower road was blasted away as part of historical mining, historical reclamation, or for other reasons.

  - Visual evidence of bedrock disturbances consistent with rim stripping activities. The rim strip features were observed in the area of the portals and south of the portals, in the vicinity of the lower potential haul road.

  - A borehole, approximately 3 inches in diameter was observed on the mesa top, just east of the portals and coincident with a portion of the upper haul road.

  - Five waste piles that consisted of waste rock assumed to be related to historical mining activities were observed at the Site. Waste Piles 1 and 2 are the largest and consisted of unsorted fine-grained to boulder-sized material located primarily on the mesa sidewall, immediately downgradient of Portals-1, -2, and -3. Waste Piles 3, 4, and 5 were smaller and located on the mesa top, primarily along portions of the upper potential haul road. The areas inclusive of Waste Piles 4 and 5 were characterized by a mining disturbed area where soils appeared to have been cleared or graded.

- Site Characterization

  - The mesa top was comprised of the majority of Survey Area C, and was inclusive of the upper potential haul road, Waste Piles 3, 4, and 5, and the mining disturbed areas surrounding Waste Piles 3, 4, and 5. Surface gamma IL exceedances were generally coincident with Waste Piles 3 and 5 and along portions of the upper potential haul road. The highest surface gamma measurements observed on the mesa top were coincident with Waste Pile 3. In addition, with the exception of selenium, the highest Ra-226 and metals concentrations measured in surface or subsurface soil/sediments samples for the entire Survey Area were from a soil sample collected in Waste Pile 3.

  - The mesa sidewall was comprised of Survey Area A, the eastern portion of Survey Area B, and the southeastern portion of Survey Area C, and was inclusive of Portals-1 through -4, Waste Piles 1 and 2, rim strip features, the lower potential haul road, and the footpath. Most surface gamma IL exceedances on the mesa sidewall were coincident with, and downgradient of the portals and associated waste piles. In addition, the greatest surface or subsurface soil/sediment static gamma measurement, Ra-226, or metals ILs exceedances were generally associated with Waste Piles 1 and 2, and the areas immediately downgradient of the waste piles.

  - The pediment was comprised of the western portion of Survey Area B, and was inclusive of the drainages. The TENORM boundary was inclusive of the unnamed drainage and surface gamma IL exceedances west of the drainage are attributed to NORM. The majority of the surface gamma exceedances were located in the eastern half of the pediment area adjacent to the base of the mesa sidewall. Surface gamma measurements in the southwest portion of the pediment were characterized by non-contiguous IL exceedances. The greatest surface gamma IL exceedances occurred adjacent to the base of the mesa sidewall and immediately downgradient of Waste Piles 1 and 2. In addition, one or more ILs were exceeded in every surface or subsurface soil/sediment sample location, with the greatest exceedances located downgradient of Waste Piles 1 and 2.

  - It is important to consider that with the exception of two locations, the subsurface static gamma ILs were not used as the only evidence to delineate the vertical extent of TENORM that exceeded the IL in boreholes at the Site. Other than these two exceptions, the static gamma IL was used as a line of evidence as described in Section 4.1. Metals and Ra-226 concentrations in the subsurface sample collected in location S225-SCX-007 (0.5 to 0.8 ft bgs) were less than their respective ILs. However, the subsurface static gamma measurement collected at 0.8 ft bgs exceeded the IL. TENORM exceeding the IL was assumed to extend to 0.8 ft bgs in the borehole. A subsurface sample was not collected in S225-SCX-011, but the subsurface static gamma measurement exceeded the IL at 0.7 ft bgs. TENORM exceeding the IL was assumed to extend to 0.7 ft bgs.

- Mine waste is observable at the ground surface within Waste Piles 1 and 2 and can be seen on aerial photographs of the Site (e.g., Figure 3-5) and in Appendix B-1 photograph number 1. Scattered mine waste material was also present near the portals. The material is gray compared to the surrounding soils which are browner and redder, and it is fine grained compared to the natural talus that is present on most of the mesa sidewall. Mine waste was also present in Waste Pile 3 on the mesa top. The material was a mix of gray, red, and brown material and also contained rock fragments with green copper oxide coatings, as shown in Appendix B-1 photograph number 14. Potential mine waste material was not observed at Waste Piles 4 and 5.

The area of the Site considered to contain TENORM (i.e., multiple lines of evidence indicated the presence of mining-related impacts) was 42.4 acres, as shown on Figure 4-8a. Portions of the TENORM exceeded one or more IL, where approximately 22.3 acres contained TENORM that exceeded the surface gamma IL and the majority of the sample locations where TENORM exceeded the ILs. TENORM exceeding the ILs was observed at seven sample locations that were not coincident with areas of the Site that exceeded the surface gamma IL. Five of the sample locations were along the unnamed drainage and two sample locations were along the lower potential haul road. TENORM that exceeded the ILs in Survey Areas A, B, and C is shown on Figures 4-8b through 4-8d, respectively, and is compared to mining-related features in Figure 4-8e.

4.7 TENORM VOLUME ESTIMATE

The volume estimate of TENORM that exceeded one or more ILs is approximately 36,640 cubic yards (yd^3), as shown in Figure 4-9a. The volume and area of TENORM associated with specific mine features is listed in Table 3-3. This estimate was calculated using ESRI ArcGIS Desktop 10.3.1 Spatial Analyst Extension cut/fill tool (ESRI, 2017) utilizing the ground surface elevation contours developed from the orthophotographs coupled with hand-derived contours based on field personnel observations, depth to bedrock in boreholes, gamma measurements, sample analytical data, and historical mining documentation. Field observations included observations of disturbance, changes in vegetation, estimating/projecting the slope of underlying bedrock, and estimating the shape and topography of waste material and/or soil deposits.

TENORM exceeding the ILs at the Site was split into groups based on the depth or type of material to aid in analysis and describing the basis of the volumes. The locations, volume, and areas of these groups are shown in Figure 4-9a. The individual waste piles are also shown on Figure 4-9a for reference, and the volume and area of the waste piles are listed in Table 3-3. The assumptions that were used to calculate the volume of TENORM with IL exceedances were as follows:

General Assumptions

- It was assumed that subsurface bedrock encountered in boreholes was not previously modified by human activity and is therefore NORM.
- With the exception of a portion of the mesa sidewall adjacent to the potential haul road , bedrock was not exposed through mining practices. Therefore, exposed bedrock surfaces (excluding those along the potential haul road) that were devoid of unconsolidated material were assumed to be NORM and were excluded from the volume calculation. Because bedrock devoid of colluvium was excluded from the volume calculation, the area of TENORM considered for the volume estimate (refer to Figure 4-9a), 17.6 acres, is smaller than the area of the Site where TENORM exceeded surface gamma ILs (22.3 acres).
- For areas of TENORM at the Site containing large cobbles/boulders at the surface whose heights exceeded the assumed depth of TENORM in that area (e.g., a 5-ft-tall boulder in an area where TENORM was assumed to extend 1 ft bgs), the additional volume of the boulders was assumed to be accounted for by the overall TENORM depth estimates.

Mesa Top

- Group 1 (5 yd^3) – The volume of TENORM present in Waste Pile 3 was estimated based on field observations.
- Group 2 (39 yd^3) – A polygon was best fit around the area of TENORM near Waste Pile 3 that excluded exposed bedrock; TENORM was assumed to extend to 0.5 ft bgs.
- Group 3 (1,223 yd^3) – Polygons were fit around the mining disturbed area associated with Waste Pile 5 and the upper potential haul road; TENORM was assumed to extend to 1 ft bgs based on field personnel observations that bedrock is less predominant in these areas than in the area included in Group 2.

Mesa Sidewall

- Group 4 (5,920 yd^3) – Waste Piles 1 and 2 (as shown in Figure 4-9b) were estimated to contain 5,573 and 347 cubic yards of TENORM, respectively. Contours of the depth of each waste pile were created to support these volume calculations. The contours were based on: (1) dynamic profiles of the waste piles created using GIS (ESRI ArcMap 10.3.1, 3D Analyst Extension); (2) the assumption that bedrock beneath the waste piles was a planar surface; (3) the assumption that all material within the footprint of the waste piles was waste rock; and (4) review of oblique imagery in Google Earth (Google Earth, 2018). The dynamic profiles were created by cutting a series of cross-sections along the topographic contours (Cooper, 2017) of each waste pile. Each cross-section visually depicted the depth of the waste pile relative to the assumed depth of bedrock and/or exposed bedrock adjacent to the waste pile. Depth information from each cross-section, in conjunction with the orthophotographs, were then used to create the depth contours that supported the volume calculations. The depth contours ranged from 0 to 12 ft bgs for Waste Pile 1, and 0 ft to 3 ft bgs for Waste Pile 2 (refer to Figure 4-9b). Note that the surface extents of Waste Piles 1 and 2 depicted on Figures 4-9a and 4-9b differ from what was depicted on Figures 2-7a and 2-7b. This is because the extent of the waste piles in Figures 2-7a and 2-7b were based on field mapping alone, whereas the extent in Figures 4-9a and 4-9b were based on a more comprehensive integration of multiple lines of evidence including field mapping, gamma measurements and critical review of aerial imagery (Cooper, 2017; Google Earth, 2018).

- Group 5 (4,255 yd^3) – Polygons were best-fit around areas where colluvium was present on the minor slope breaks in the De Chelly member of the Cutler Formation, on the steeper slopes of the Moenkopi Formation, and along the majority of the lower potential haul road. Based on field personnel observations, bedrock mapping, and borehole depth along the lower potential haul road (S225-SCX-002), TENORM was assumed to be 0.5 ft deep over these areas.

- Group 6 (824 yd^3) – Colluvium was observed by field personnel in larger volumes on some slope break areas of the mesa side wall than on others (i.e., the 0.5 ft depth assumed for Group 5). Based on field observations and bedrock mapping, TENORM was assumed to be 1 ft deep.

- Group 7 (2,859 yd^3) – Based on field observations and bedrock mapping, TENORM in the area of the large boulders and associated colluvium northwest of Waste Pile 2 was assumed to extend to 2 ft bgs. An archaeological site that pre-dates mining was present in the vicinity of the boulders; therefore, some of the boulders and associated colluvium within Group 7 are assumed to be NORM. This area is downslope from the lower potential haul road, near Portal-3, and was also likely impacted by the construction of the potential haul road and other mining- related activities. TENORM from the mining-related activities could not be differentiated from the NORM based on field personnel observations in this area (i.e., the unconsolidated deposits in the area were visually similar), so this area was included as TENORM.

Pediment

- Group 8 (21,149 yd^3) – Polygons were best-fit around the areas of the pediment where soil/sediment were present, and bedrock was not outcropping. Soil/sediment depth was assumed to extend to 1.5 ft bgs based on bedrock being encountered at depths of 0.5 to 1.3 ft bgs in boreholes in the pediment area.

- Group 9 (366 yd^3) – A polygon was fit along the un-named drainage because IL exceedances were present at all sample locations collected in the drainage (S225-CX-009, -CX-010, -SCX-008, -SCX-009, and -SCX-015). Boreholes in the drainage met refusal on bedrock at 0.6 ft bgs (S225-SCX-015) and 0.8 ft bgs (S225-SCX-009). The amount of sediment in the drainage was variable with large areas of exposed bedrock. Therefore, the depth of TENORM in the drainage was assumed to be 0.5 over 50 percent of the mapped area of the un-named drainage.

The following are additional volume estimates and information that may be of interest:

- The volume of the area in the southwestern portion of Survey Area B where there are limited surface gamma IL exceedances is provided. If a depth of 1.5 ft bgs is assumed due to this area being on the pediment and similar to Group 8 above, the volume would be 7,890 yd^3. Note, this area was not included in the calculations of the areas of IL exceedances at the Site or the volume of TENORM at the Site.

- The volume of Waste Pile 4 was estimated to be 5 yd^3 based on field observations. Waste Pile 4 was excluded from the volume calculation because surface gamma survey measurements did not exceed the IL in the area of the waste pile.

- Bedrock along the potential haul road that was exposed by mining related activities exceeds the ILs. A volume is not provided for this area, but bedrock is assumed to be disturbed along 0.22 miles of the potential haul and disturbances are estimated to extend 20 ft above the potential haul road surface based on observations by field personnel.

4.8 WATER ANALYTICAL RESULTS

The surface water samples collected as part of the Site Characterization activities were analyzed for the constituents listed in Section 3.3.2.3. Two of the 10 potential water features were sampled. The locations of these water features are shown in Figure 2-1 and included the following:

- S225-Seep-1 (sample S225-WS-001) located 0.62 miles northwest of the Site

- Pond 08GS-12-9 (sample S225-WS-002) located 0.75 miles northwest of the Site

The analytical results from the samples were compared to the water ILs, which are defined as the lowest value from the following regulations/standards: the National Secondary Drinking Water Regulations (NSDWR), the Navajo Nation Surface Water Quality Standards, the Navajo Drinking Water maximum contaminant levels (MCLs), and/or the National Primary Drinking Water Regulations. The water ILs are shown in Table 4-6a and the analytical results compared to the water ILs are shown in Table 4-6b.

For seep S225-Seep-1, surface water sample (S225-WS-001) analytical results indicated that radionuclides, metals, and general chemistry were all below their respective ILs. For pond 08GS-12-9, surface water sample (S225-WS-002) analytical results indicated that radionuclides and metals were all below their respective ILs and TDS, chloride, and sulfate were at or above their respective ILs. TDS concentrations were three times the IL, chloride concentrations were equal to the IL, and sulfate concentrations were less than two times the IL. Based on these results, there are no confirmed COPCs for seep S225-Seep-1, and TDS, chloride, and sulfate are confirmed COPCs for pond 08GS-12-9 and additional characterization of pond 08GS-12-9 may be considered in the future. The laboratory analytical data and Data Usability Report are provided in Appendix F.

4.9 POTENTIAL DATA GAPS AND SUPPLEMENTAL STUDIES

4.9.1 Data Gaps

Six potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the. These data gaps can be considered for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

1. Approximately 2.9 acres of the mesa sidewall were not surveyed because field personnel were unable to safely access these areas.

2. The lower potential haul road from Waste Pile 1 to the southern extent where the road ends at the blasted area was not included in the surface gamma survey due to field personnel oversight.

3. A borehole was not completed in BG-1; therefore, a subsurface static gamma IL was not established for Survey Area A. However, having an established IL would not have affected the volume estimates because all boreholes completed in Survey Area A contained soils that exceeded the Ra-226 IL, as well as one or more metal IL.

4. The approximate centerlines of the potential haul roads were surveyed, but the shoulders were not due to miscommunication with the field personnel.

5. The gamma survey was not extended laterally out from the potential haul roads where gamma measurements were greater than the IL as the result of an oversight.

6. Subsurface samples were not collected in Waste Piles 3, 4, and 5 on the mesa top due to an oversight.

4.9.2 Supplemental Studies

Following review of the RSE report data and discussions with the Agencies, a limited number of items were identified for supplemental work to be considered for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site, as follows:

1. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

2. Further characterization of the potential haul road may be warranted as part of future work at the Site.

3. The USEPA identified that there were potential discrepancies between the NNDWR database used for this study (received from NNDWR in 2016) and a 2018 version of the NNDWR database that the USEPA reviewed. It is recommended that the two databases be compared (with additional field work, if necessary) to confirm the locations of water features.

4. Boulders located on the Site were included in the area of the surface gamma survey but were not otherwise evaluated. Additional characterization of boulders may be warranted in the future.

5.0 SUMMARY AND CONCLUSIONS

This report details the purpose and objectives, field investigation activities, findings, and conclusions of the Site Clearance and RSE activities conducted for the Site between August 2015 and September 2017. The Site is known as the Charles Keith site and is also identified by the USEPA as AUM identification #225 in the *2007 AUM Atlas*.

The primary objectives of the RSEs are to provide data required to evaluate relevant site conditions and to support future removal action evaluations at the Sites. It is not intended to establish cleanup levels or determine cleanup options or potential remedies. The purpose of the RSE data (e.g., the review of relevant information and the collection of data related to historical mining activities) is to determine the volume of TENORM at the Site in excess of ILs as a result of historical mining activities. ILs are based on the background gamma measurements (in cpm), and Ra-226 and metals concentrations, determined through statistical analyses, that are used to evaluate potential mining-related impacts. The RSE included historical data review, visual observations, surface gamma surveys, surface and subsurface static gamma measurements, and soil/sediment sampling and analyses. An estimate of areas containing TENORM was made based on an evaluation of the RSE information/data and multiple lines of evidence. Surface water samples were also collected as part of the RSE to evaluate potential mining-related impacts. The correlation between gamma measurements (in cpm) and concentrations of Ra-226 in surface soils (pCi/g) was developed as a potential field screening tool for future Removal or Remedial Action evaluations. The gamma correlation was not used for the Site Characterization, which relied instead on the actual gamma radiation measurements and soil/sediment analytical results. However, predicted Ra-226 concentrations were compared to the actual Ra-226 laboratory results and ILs from the surface soil/sediment samples at the Agencies' request.

The Site is located in the Monument Valley mining area. Mine workings on-site consisted of portals and rim stripping. Between 1954 and 1955 the Site produced 58.59 tons of ore that contained 236.57 pounds of 0.27 percent U_3O_8 and 178.67 pounds of 0.21 percent V_2O_5. By 1966, mines in the Monument Valley mining area were inactive.

Four potential background reference areas were considered. Three background reference areas (BG-1 through BG-3) were selected to develop surface gamma, subsurface gamma, Ra-226, and metals ILs for the three Survey Areas (Survey Areas A through C) at the Site.

Arsenic, molybdenum, uranium, vanadium, and Ra-226 concentrations in soil/sediment and gamma radiation measurements exceed their respective ILs and are confirmed COPCs for the Site. An IL for selenium was not identified because selenium sample results were non-detect in the background areas. However, because selenium was detected in Survey Areas A and C is it also confirmed as a COPC for the Site.

Surface gamma measurements and Ra-226 and metals concentrations were generally highest in areas that were coincident with mining-related features (e.g., Portals-1, -2, and -3 and Waste Piles 1, 2 and 3). The maximum surface gamma measurement (328,342 cpm) was greater than 10 times the highest surface gamma IL, and occurred in an area that was approximately coincident with Portal-3 and Waste Pile 2. The highest Ra-226 and metals concentrations were detected in a surface soil sample collected from Waste Pile 3.

Results of the Gamma Correlation Study indicated that surface gamma survey results do not correlate with Ra-226 concentrations in soil. Therefore, users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating Ra-226 concentrations. Additional correlation studies may be needed to identify the relationship between gamma and Ra-226.

Based on the data analysis performed for this RSE report along with the multiple lines of evidence, approximately 42.4 acres out of the 49.4 acres of the Survey Area were estimated to contain TENORM. This estimate is inclusive of three areas: (1) portions of the mesa top; (2) the mesa sidewall (i.e., the vertical cliffs and steep colluvium-covered bedrock slope); and (3) the pediment area (i.e., the area in-between the base of the steep bedrock slope and the unnamed drainage). The areas outside of the TENORM boundary show no signs of disturbance related to mining and, therefore, are considered NORM. Of the 42.4 acres that contain TENORM, 22.3 acres contain TENORM exceeding the surface gamma ILs and TENORM that exceeded the ILs at most of the soil/sediment sample locations. The volume of TENORM in excess of ILs was estimated to be 36,640 yd^3 (28,013 cubic meters). Because bedrock devoid of colluvium was excluded from the TENORM volume calculation. The area of TENORM considered for the volume estimate (17.6) acres, is smaller than the area of the Site where TENORM exceeded surface gamma ILs (22.3 acres).

Surface water samples were collected from one seep (S225-Seep-1) and one pond (08GS-12-9). For seep S225-Seep-1 surface water sample (S225-WS-001) analytical results indicated that radionuclides, metals, and general chemistry were all below their respective ILs. For pond 08GS-12-9 surface water sample (S225-WS-002) analytical results indicated that radionuclides and metals were all below their respective ILs and TDS, chloride, and sulfate were at or above their respective ILs. Based on these results, there are no confirmed COPCs for seep S225-Seep-1, and TDS, chloride, and sulfate are confirmed COPCs for pond 08GS-12-9 and additional characterization of pond 08GS-12-9 may be considered in the future.

In addition, the Trust discussed with the Agencies the safety risks of performing an interim action at an un-reclaimed prospect portal located on-site that was approximately 10 ft deep and terminated on bedrock. The Trustee determined that an interim action was not feasible due to the safety risks. The Trustee also determined that it was unlikely that people and/or animals could access the portal.

Six potential data gaps were identified based on the Site Clearance and RSE data collection and analyses for the Site, as listed in Section 4.9. These data gaps can be taken into consideration for subsequent evaluations in support of future Removal or Remedial Action evaluations at the Site.

6.0 ESTIMATE OF REMOVAL SITE EVALUATION COSTS

The Charles Keith RSE was performed in accordance with the requirements of the *Trust Agreement* to characterize existing site conditions. Project costs related to the RSE include the planning and implementation of the scope of work stipulated in the *Site Clearance Work Plan* and *RSE Work Plan,* and community outreach. Stantec's costs associated with the Charles Keith RSE were $604,410. Stantec's costs associated with interim actions (sign installation) were $5,500. In addition, Administrative costs provided by the Trust were estimated currently at $191,500[9,10]. Administrative costs will change due to continued community outreach and close out activities.

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[9] This cost is based on an approved budget of May 8, 2018; Administrative work, including community communications, are not yet complete.

[10] Administrative costs were averaged across all Sites.

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TABLES

Table 3-1
Identified Potential Water Features
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Identified Water Feature	Source of Identified Water Feature	Water Feature Identification	Field Sample Identification	Field Personnel Observations
Pond	2007 AUM Atlas[1], NNDWR	08GS-12-9	S225-WS-002	Pond that is approximately 360 ft long and 125 ft wide. This location was sampled as part of the RSE on October 18, 2016, sample location ID S225-WS-002.
Seep	Stantec/Trust	S225-Seep-1[2]	S225-WS-001	A water seep with a small (1 ft by 1 ft) pool was observed at the S225-Seep-1 location. Animal tracks leading to the seep indicate horses and cows drink from it. This location was sampled as part of the RSE on October 18, 2016, sample location ID S225-WS-001.
Seep	2007 AUM Atlas[1], NNDWR	08GS-12-8	NA	No surface water observed in this area. This seep location is on a steep slope and was not flowing during RSE visits.
Building	2007 AUM Atlas[1], NNDWR	08A-216	NA	Location of former Trading Post. NNDWR lists the location as a private, inactive, domestic well. Water feature was not sampled because it could not be found.
Building	2007 AUM Atlas[1], NNDWR	08A-216A	NA	Location of former Trading Post, water samples likely collected in the past from water tap in buildings at this location. NNDWR lists the location as a private, inactive, domestic well. Water feature was not sampled because it could not be found.
Well	2007 AUM Atlas[1], NNDWR	08A-216B	NA	NTUA well location. Well was padlocked and had a fence around it, so no water sample was collected.
No Feature	2007 AUM Atlas[1]	09-174	NA	No surface water or well observed at this location. Location was assumed to be associated with 08A-216B NTUA well.
Building	2007 AUM Atlas[1]	09-151	NA	No surface water or well observed at this location, location adjacent to a residence. AUM Atlas lists that location was added due to listing in Utah Division of Water Rights Database. Water Rights Database includes information that a 200 ft deep, 6 inch diameter well was completed on 7/14/1951. Water feature was not sampled because it could not be found.
Drainage	2007 AUM Atlas[1]	9609001M00	NA	No surface water observed at this location during RSE activities. Water samples likely collected from adjacent drainage in the past.
Well	2007 AUM Atlas[1], NNDWR	08T-554	NA	NNDWR identifies this location as an NTUA well, no well observed at this location. Nearby residents were not aware of the presence of a well in the area.

Notes
ft - feet
NA - Water feature not sampled
NNDWR - Navajo Nation Department of Water Resources
NTUA - Navajo Tribal Utility Authority
RSE - Removal Site Evaluation

[1] USEPA, 2007a

[2] Seep was given identification number S225-Seep-001 for RSE sample collection

Table 3-2
Soil and Sediment Sampling Summary
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									Sample Types		
Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Metals, Total	Ra-226	Thorium
Background Reference Area Study - Background Area 1											
S225-BG1-001	0 - 0.5	soil	SF	grab	NA	10/17/2016	561568.97	4099589.58	N	N	--
S225-BG1-002	0 - 0.5	soil	SF	grab	NA	10/17/2016	561550.27	4099590.38	N	N	--
S225-BG1-003	0 - 0.5	soil	SF	grab	NA	10/17/2016	561560.12	4099588.42	N	N	--
S225-BG1-004	0 - 0.5	soil	SF	grab	NA	10/17/2016	561558.20	4099586.79	N	N	--
S225-BG1-005	0 - 0.5	soil	SF	grab	NA	10/17/2016	561557.59	4099586.84	N;MS;MSD	N	--
S225-BG1-006	0 - 0.5	soil	SF	grab	NA	10/17/2016	561565.20	4099592.89	N;FD	N;FD	--
S225-BG1-007	0 - 0.5	soil	SF	grab	NA	10/17/2016	561568.39	4099587.61	N	N	--
S225-BG1-008	0 - 0.5	soil	SF	grab	NA	10/17/2016	561572.65	4099582.31	N	N	--
S225-BG1-009	0 - 0.5	soil	SF	grab	NA	10/17/2016	561568.75	4099576.58	N	N	--
S225-BG1-010	0 - 0.5	soil	SF	grab	NA	10/17/2016	561568.02	4099581.24	N	N	--
Background Reference Area Study - Background Area 2											
S225-BG2-001	0 - 0.5	soil	SF	grab	NA	10/17/2016	561648.64	4100057.74	N	N	--
S225-BG2-002	0 - 0.5	soil	SF	grab	NA	10/17/2016	561646.64	4100062.02	N	N	--
S225-BG2-003	0 - 0.5	soil	SF	grab	NA	10/17/2016	561641.83	4100060.87	N	N	--
S225-BG2-004	0 - 0.5	soil	SF	grab	NA	10/17/2016	561636.50	4100059.58	N	N	--
S225-BG2-005	0 - 0.5	soil	SF	grab	NA	10/17/2016	561638.48	4100061.41	N	N	--
S225-BG2-006	0 - 0.5	soil	SF	grab	NA	10/17/2016	561638.85	4100066.10	N;FD	N;FD	--
S225-BG2-007	0 - 0.5	soil	SF	grab	NA	10/17/2016	561635.49	4100067.80	N	N	--
S225-BG2-008	0 - 0.5	soil	SF	grab	NA	10/17/2016	561635.82	4100071.36	N	N	--
S225-BG2-009	0 - 0.5	soil	SF	grab	NA	10/17/2016	561632.81	4100064.84	N	N	--
S225-BG2-010	0 - 0.5	soil	SF	grab	NA	10/17/2016	561632.52	4100060.50	N	N	--
S225-SCX-001	0 - 0.5	soil	SF	grab	NA	11/2/2016	561637.32	4100067.76	N	N	--
S225-SCX-001	0.5 - 1.5	soil	SB	grab	NA	11/2/2016	561637.32	4100067.76	N	N	--
Background Reference Area Study - Background Area 3											
S225-BG3-001	0 - 0.5	soil	SF	grab	NA	8/24/2017	561894.08	4099829.54	N	N	--
S225-BG3-002	0 - 0.5	soil	SF	grab	NA	8/24/2017	561897.74	4099831.55	N	N	--
S225-BG3-003	0 - 0.5	soil	SF	grab	NA	8/24/2017	561901.08	4099828.42	N;FD	N;FD	--
S225-BG3-004	0 - 0.5	soil	SF	grab	NA	8/24/2017	561896.94	4099829.10	N	N	--
S225-BG3-005	0 - 0.5	soil	SF	grab	NA	8/24/2017	561897.76	4099827.29	N	N	--
S225-BG3-006	0 - 0.5	soil	SF	grab	NA	8/24/2017	561900.11	4099825.58	N	N	--
S225-BG3-007	0 - 0.5	soil	SF	grab	NA	8/24/2017	561901.52	4099824.03	N	N	--
S225-BG3-008	0 - 0.5	soil	SF	grab	NA	8/24/2017	561894.03	4099825.48	N	N	--
S225-BG3-009	0 - 0.5	soil	SF	grab	NA	8/24/2017	561895.64	4099825.00	N	N	--
S225-BG3-010	0 - 0.5	soil	SF	grab	NA	8/24/2017	561897.09	4099823.33	N;MS;MSD	N	--
S225-BG3-011	0 - 0.5	soil	SF	grab	NA	8/24/2017	561898.50	4099824.67	N	N	--
Correlation											
S225-C01-001	0 - 0.5	soil	SF	5-point composite	NA	11/3/2016	561787.95	4099845.74	--	N	N
S225-C02-001	0 - 0.5	soil	SF	5-point composite	NA	11/3/2016	561641.18	4099805.44	--	N	N
S225-C03-001	0 - 0.5	soil	SF	5-point composite	NA	11/3/2016	561619.59	4099798.07	--	N	N
S225-C04-001	0 - 0.5	soil	SF	5-point composite	NA	11/3/2016	561637.47	4099804.53	--	N	N
S225-C05-001	0 - 0.5	soil	SF	5-point composite	NA	11/3/2016	561722.78	4099771.05	--	N	N
S225-C05-001	0 - 0.5	soil	SF	5-point composite	NA	5/24/2017	561722.78	4099771.05	--	N	N
S225-C06-001	0 - 0.5	soil	SF	5-point composite	NA	5/24/2017	561181.40	4099639.84	--	N	N

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface

¹ Coordinate System: NAD 1983 UTM Zone 12N

Table 3-2
Soil and Sediment Sampling Summary
Charles Keith
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Navajo Nation AUM Environmental Response Trust - First Phase

									Sample Types		
Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting ¹	Northing ¹	Metals, Total	Ra-226	Thorium
Characterization											
S225-CX-001	0 - 0.5	soil	SF	grab	A	6/20/2017	561747.34	4099827.69	N	N	--
S225-CX-002	0 - 0.5	soil	SF	grab	A	6/20/2017	561545.50	4099748.13	N	N	--
S225-CX-003	0 - 0.5	soil	SF	grab	B	6/20/2017	561431.38	4099529.08	N	N	--
S225-CX-004	0 - 0.5	soil	SF	grab	A	6/20/2017	561457.33	4099669.91	N;FD;MS;MSD	N;FD	--
S225-CX-005	0 - 0.5	soil	SF	grab	B	6/20/2017	561473.77	4099733.96	N	N	--
S225-CX-006	0 - 0.5	sediment	SF	grab	B	6/20/2017	561464.92	4099877.43	N	N	--
S225-CX-007	0 - 0.5	sediment	SF	grab	B	6/20/2017	561556.91	4099938.75	N	N	--
S225-CX-008	0 - 0.5	sediment	SF	grab	B	6/20/2017	561312.59	4099789.34	N	N	--
S225-CX-009	0 - 0.5	sediment	SF	grab	B	6/20/2017	561234.09	4099714.02	N	N	--
S225-CX-010	0 - 0.5	sediment	SF	grab	B	6/20/2017	561138.87	4099518.60	N	N	--
S225-CX-011	0 - 0.5	soil	SF	grab	C	6/22/2017	561827.04	4099874.16	N	N	--
S225-CX-012	0 - 0.5	soil	SF	grab	C	6/22/2017	561842.37	4099940.19	N	N	--
S225-CX-013	0 - 0.5	soil	SF	grab	C	9/20/2017	561783.93	4099788.64	N	N	--
S225-SCX-002	0 - 0.5	soil	SF	grab	A	6/20/2017	561624.48	4099802.34	N	N	--
S225-SCX-003	0 - 0.5	soil	SF	grab	A	6/20/2017	561565.81	4099815.63	N	N	--
S225-SCX-003	0.5 - 1.0	soil	SB	grab	A	6/20/2017	561565.81	4099815.63	N	N	--
S225-SCX-004	0 - 0.5	soil	SF	grab	A	6/20/2017	561516.05	4099746.52	N;FD	N;FD	--
S225-SCX-004	0.5 - 1.0	soil	SB	grab	A	6/20/2017	561516.05	4099746.52	N	N	--
S225-SCX-007	0 - 0.5	sediment	SF	grab	B	6/21/2017	561517.88	4099937.30	N	N	--
S225-SCX-007	0.5 - 0.8	sediment	SB	grab	B	6/21/2017	561517.88	4099937.30	N	N	--
S225-SCX-008	0 - 0.5	sediment	SF	grab	B	6/21/2017	561444.22	4099929.26	N	N	--
S225-SCX-009	0 - 0.5	sediment	SF	grab	B	6/21/2017	561450.26	4099928.37	N	N	--
S225-SCX-009	0.5 - 0.8	sediment	SB	grab	B	6/21/2017	561450.26	4099928.37	N	N	--
S225-SCX-010	0 - 0.5	soil	SF	grab	B	6/21/2017	561400.61	4099835.66	N	N	--
S225-SCX-010	0.5 - 1.0	soil	SB	grab	B	6/21/2017	561400.61	4099835.66	N	N	--
S225-SCX-011	0 - 0.5	sediment	SF	grab	B	6/21/2017	561366.87	4099819.51	N	N	--
S225-SCX-012	0 - 0.5	sediment	SF	grab	B	6/21/2017	561326.35	4099748.93	N;MS;MSD	N	--
S225-SCX-012	0.5 - 1.3	sediment	SB	grab	B	6/21/2017	561326.35	4099748.93	N	N	--
S225-SCX-013	0 - 0.5	soil	SF	grab	B	6/21/2017	561316.35	4099683.78	N	N	--
S225-SCX-014	0 - 0.5	sediment	SF	grab	B	6/21/2017	561296.51	4099736.25	N	N	--
S225-SCX-014	0.5 - 1.2	sediment	SB	grab	B	6/21/2017	561296.51	4099736.25	N	N	--
S225-SCX-015	0 - 0.6	sediment	SB	grab	B	6/21/2017	561207.51	4099636.91	N	N	--
S225-SCX-016	0 - 0.7	sediment	SB	grab	B	6/21/2017	561255.82	4099534.75	N	N	--
S225-SCX-017	0 - 0.5	sediment	SF	grab	B	6/21/2017	561297.41	4099575.26	N;FD	N;FD	--
S225-SCX-017	0.5 - 1.25	sediment	SB	grab	B	6/21/2017	561297.41	4099575.26	N	N	--
S225-SCX-018	0 - 0.5	soil	SF	grab	A	6/22/2017	561497.94	4099666.57	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
Ra-226	Radium 226
NA	Not Applicable
SB	Subsurface Sample
SF	Surface Sample
ft bgs	feet below ground surface
¹ Coordinate System:	NAD 1983 UTM Zone 12N

Table 3-3
Mine Feature Samples and Area
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Mine Feature	Surface Samples	Subsurface Samples	Area (sq. ft)	Volume of TENORM exceeding ILs (yd^3)
Waste Pile 1	1	1	34,809	5,574
Waste Pile 2	1	1	7,419	346
Waste Pile 3	1	0	182	5
Waste Pile 4	0	0	108	0
Waste Pile 5	1	0	769	29
Potential Haul Road	3	0	*	--
Drainages	13	6	**	--

Notes

sq.ft - square feet

yd^3 - cubic yards

ILs - investigation levels

TENORM - technologically enhanced naturally occurring radioactive material

* Area not determined because the width of the potential haul road varies throughout the Site

** Area not determined because the width of the drainages vary throughout the Site

-- Discrete volume was not identified for feature

Table 3-4
Water Sampling Summary
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					Sample Types							
Field Sample Identification	Water Feature Identification	Sample Date	Easting ¹	Northing ¹	Ra-226	Ra-228	Gross Alpha	Metals, Dissolved	Metals, Total	TDS	Anions	Cations
Surface Water												
S225-WS-001	S225-Seep-1	10/18/2016	560939.92	4100745.46	N	N	N	N	N	N	N	N
S225-WS-002	08GS-12-9	10/18/2016	560563.01	4100708.03	N	N	N	N	N	N	N	N

Notes

N	Normal
Ra-226	Radium 226
Ra-228	Radium 228
TDS	Total Dissolved Solids

¹ Coordinate System: NAD 1983 UTM Zone 12N

Table 4-1
Background Reference Areas Soil Sample Analytical Results
Charles Keith
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Location Identification	S225-BG1-001	S225-BG1-002	S225-BG1-003	S225-BG1-004	S225-BG1-005	S225-BG1-006	S225-BG1-006 Dup	S225-BG1-007	S225-BG1-008	S225-BG1-009	S225-BG1-010
Date Collected	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)											
Metals[1] (mg/kg)											
Arsenic	3.9	3.2	2.1	2.3	4.6	2.2	2.6	2.5	2.8	3.2	2.5
Molybdenum	1.9	2.5	0.57	0.74	2.4 J	0.96	1.2	1.4	0.83	1.9	1.3
Selenium	<0.96	<0.99	<0.91	<0.99	<0.96	<1	<0.99	<0.88	<1	<0.91	<0.94
Uranium	1.5	2.7	1.3	1.6	3.5 J-	1.3	1.3	1.3	1.6	2.2	1.5
Vanadium	16	14	15	16	14	13	15	13	16	14	14
Radionuclides (pCi/g)											
Radium-226	1.41 ± 0.28	1.26 ± 0.26 J-	1.32 ± 0.28 J-	1.68 ± 0.33 J-	2.15 ± 0.37 J-	1.36 ± 0.3 J-	1.7 ± 0.35	1.29 ± 0.25	1.46 ± 0.3	1.99 ± 0.34 J-	1.39 ± 0.27 J-

Notes

Bold	Bolded result indicates positively identified compound
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data

Table 4-1
Background Reference Areas Soil Sample Analytical Results
Charles Keith
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Location Identification	S225-BG2-001	S225-BG2-002	S225-BG2-003	S225-BG2-004	S225-BG2-005	S225-BG2-006	S225-BG2-006 Dup	S225-BG2-007	S225-BG2-008	S225-BG2-009	S225-BG2-010
Date Collected	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016	10/17/2016
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)											
Metals[1] (mg/kg)											
Arsenic	2.1	0.99	1.1	1.4	0.81	1	1.2	0.71	0.98	0.95	0.75
Molybdenum	0.62	0.47	0.46	0.4	0.29	0.31	0.28	0.17	<0.19	0.24	0.18
Selenium	<0.92	<0.88	<0.89	<0.96	<0.84	<1	<0.91	<0.85	<0.97	<0.92	<0.86
Uranium	0.43	0.26	0.38	0.3	0.24	0.26	0.25	0.22	0.2	0.23	0.22
Vanadium	6.7	7.1	6	6.9	7	6.4	7.2	4.4	7.2	5.6	5.6
Radionuclides (pCi/g)											
Radium-226	0.75 ± 0.21	0.65 ± 0.19	0.6 ± 0.2	0.7 ± 0.25	0.46 ± 0.16	0.67 ± 0.3	0.52 ± 0.17	0.49 ± 0.16	0.47 ± 0.22 J-	0.36 ± 0.21	0.44 ± 0.15

Notes

Bold	Bolded result indicates positively identified compound
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data

Table 4-1
Background Reference Areas Soil Sample Analytical Results
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S225-SCX-001	S225-SCX-001	S225-BG3-001	S225-BG3-002	S225-BG3-003	S225-BG3-003 Dup	S225-BG3-004	S225-BG3-005	S225-BG3-006	S225-BG3-007	S225-BG3-008
Date Collected	11/2/2016	11/2/2016	8/24/2017	8/24/2017	8/24/2017	8/24/2017	8/24/2017	8/24/2017	8/24/2017	8/24/2017	8/24/2017
Depth (feet)	0 - 0.5	0.5 - 1.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)											
Metals[1] (mg/kg)											
Arsenic	0.64	0.69	7.9 D	8.3 D	6.8 D	6.4 D	32 D	8.1 D	7.7 D	6.8 D	15 D
Molybdenum	<0.19	<0.19	0.74 D	0.57 D	0.48 D	0.48 D	1.7 D	0.51 D	0.46 D	0.48 D	1.5 D
Selenium	<0.96	<0.96	<1 D	<1 D	<0.99 D	<0.99 D	<0.98 D	<0.97 D	<0.99 D	<0.98 D	<1 D
Uranium	0.18	0.2	0.47 D	0.5 D	0.49 D	0.46 D	0.71 D	0.51 D	0.53 D	0.58 D	0.52 D
Vanadium	3.4	3.8	11 D	13 D	11 D	11 D	19 D	12 D	13 D	14 D	13 D
Radionuclides (pCi/g)											
Radium-226	0.55 ± 0.19	0.45 ± 0.2	1.24 ± 0.28	1.34 ± 0.32	1.26 ± 0.31	1.31 ± 0.26	1.87 ± 0.35	1.58 ± 0.3	1.46 ± 0.31	1.73 ± 0.35	1.22 ± 0.26

Notes

Bold	Bolded result indicates positively identified compound
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data

Table 4-1
Background Reference Areas Soil Sample Analytical Results
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Location Identification	S225-BG3-009	S225-BG3-010	S225-BG3-011
Date Collected	8/24/2017	8/24/2017	8/24/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)			
Metals[1] (mg/kg)			
Arsenic	7.4 D	5.9 D	8 D
Molybdenum	0.32 D	0.3 D	0.29 D
Selenium	<0.97 D	<0.97 D	<0.98 D
Uranium	0.51 D	0.47 D	0.38 D
Vanadium	12 D	9.9 D	11 D
Radionuclides (pCi/g)			
Radium-226	1.12 ± 0.28	1.35 ± 0.32	1.16 ± 0.29

Notes

Bold	Bolded result indicates positively identified compound
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
<	Result not detected above associated laboratory reporting limit
D	Sample dilution required for analysis; reported values reflect the dilution
J	Data are estimated due to associated quality control data
J-	Data are estimated and are potentially biased low due to associated quality control data

Table 4-2
Static Gamma Measurement Summary
Charles Keith
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Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Survey Area	Subsurface Static Gamma Investigation Level (cpm)	Sample Depth (ft bgs)	Media	Static Gamma Measurement (cpm)
S225-SCX-001	Background Area 2	*	0	soil	8,285
S225-SCX-001	Background Area 2	*	0.5	soil	9,424
S225-SCX-001	Background Area 2	*	1	soil	10,849
S225-SCX-001	Background Area 2	*	1.5	soil	8,623
S225-BG3-011	Background Area 3	*	0	soil	12,400
S225-BG3-011	Background Area 3	*	0.5	soil	21,577**
S225-SCX-002	A	--	0.0	soil	49,147
S225-SCX-002	A	NA	0.5	soil	46,893
S225-SCX-003	A	--	0.0	soil	79,579
S225-SCX-003	A	NA	0.5	soil	108,876
S225-SCX-003	A	NA	1.0	soil	88,201
S225-SCX-004	A	--	0.0	soil	111,496
S225-SCX-004	A	NA	0.5	soil	143,956
S225-SCX-004	A	NA	1.0	soil	157,480
S225-SCX-018	A	--	0.0	soil	16,727
S225-SCX-018	A	NA	0.5	soil	18,821**
S225-SCX-005	B	--	0.0	sediment	19,996
S225-SCX-005	B	8,623	0.5	sediment	**13,744**
S225-SCX-006	B	--	0.0	sediment	17,818
S225-SCX-006	B	8,623	0.5	sediment	**14,599**
S225-SCX-007	B	--	0.0	sediment	17,811
S225-SCX-007	B	8,623	0.8	sediment	**10,234****
S225-SCX-009	B	--	0.0	sediment	12,117
S225-SCX-009	B	8,623	0.5	sediment	**13,089**
S225-SCX-009	B	8,623	0.8	sediment	**14,259****
S225-SCX-010	B	--	0.0	soil	13,539
S225-SCX-010	B	8,623	0.5	soil	**11,127**
S225-SCX-010	B	8,623	1.0	soil	**9,690****
S225-SCX-011	B	--	0.0	sediment	17,519
S225-SCX-011	B	8,623	0.7	sediment	**22,418****
S225-SCX-012	B	--	0.0	sediment	13,938
S225-SCX-012	B	8,623	0.5	sediment	**15,025**
S225-SCX-012	B	8,623	1.0	sediment	**14,410**
S225-SCX-012	B	8,623	1.3	sediment	**12,701****
S225-SCX-013	B	--	0.0	soil	11,596
S225-SCX-013	B	8,623	0.5	soil	**12,674****
S225-SCX-014	B	--	0.0	sediment	12,447
S225-SCX-014	B	8,623	0.5	sediment	**12,946**
S225-SCX-014	B	8,623	1.2	sediment	**12,882****
S225-SCX-015	B	--	0.0	sediment	9,994
S225-SCX-015	B	8,623	0.5	sediment	**12,660****
S225-SCX-016	B	--	0.0	sediment	9,811
S225-SCX-016	B	8,623	0.5	sediment	**12,780****
S225-SCX-017	B	--	0.0	sediment	9,642
S225-SCX-017	B	8,623	0.5	sediment	**10,968**
S225-SCX-017	B	8,623	1.0	sediment	**12,198**
S225-SCX-017	B	8,623	1.2	sediment	**12,684****

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation level is derived from the background area measurements, refer to Section 4.1 of the RSE report
**	Measurement collected at interface of unconsolidated material and refusal material (e.g., bedrock)
--	The subsurface gamma investigation level does not apply to surface static gamma measurements
NA	A borehole in Survey Area A was not completed, therefore a subsurface static gamma investigation level was not established for Survey Area A
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface

Table 4-3
Gamma Correlation Study Soil Sample Analytical Results
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Location Identification	S225-C01-001	S225-C02-001	S225-C03-001	S225-C04-001	S225-C05-001	S225-C05-001	S225-C06-001
Date Collected*	11/3/2016	11/3/2016	11/3/2016	11/3/2016	11/3/2016	5/24/2017	5/24/2017
Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Analyte (Units)							
Radionuclides (pCi/g)							
Radium-226	1.42 ± 0.28	3.39 ± 0.5	8.5 ± 1.1	4.56 ± 0.67	3.5 ± 0.53 J-	3.86 ± 0.56	0.42 ± 0.14
Thorium-228	1.06 ± 0.18	0.7 ± 0.14	0.8 ± 0.14	0.91 ± 0.17	0.59 ± 0.12	0.64 ± 0.13	0.286 ± 0.077
Thorium-230	1.25 ± 0.22	3.13 ± 0.52	6.4 ± 1	3.69 ± 0.6	3.58 ± 0.58	4.17 ± 0.67	0.325 ± 0.082
Thorium-232	0.96 ± 0.17	0.74 ± 0.14	0.69 ± 0.13	0.82 ± 0.15	0.51 ± 0.1	0.62 ± 0.12	0.305 ± 0.068

Notes

Bold	Bolded result indicates positively identified compound
pCi/g	picocuries per gram
J-	Data are estimated and are potentially biased low due to associated quality control data
*	Data collected in November 2016 were used to develop the gamma correlation

Table 4-4a
Site Characterization Soil Sample Analytical Results for Survey Area A
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	Location Identification	S225-CX-001	S225-CX-002	S225-CX-004	S225-CX-004 Dup	S225-SCX-002	S225-SCX-003	S225-SCX-003	S225-SCX-004	S225-SCX-004	S225-SCX-004 Dup	S225-SCX-018
	Date Collected	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/22/2017
	Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.0	0 - 0.5	0.5 - 1.0	0 - 0.5	0 - 0.5
	Sample Category	surface	surface	surface	surface	surface	surface	subsurface	surface	subsurface	surface	surface
	Sample Collection Method	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
	Media	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)												
Metals[1] (mg/kg)	Investigation Level											
Arsenic	5.28	3.6	29	2.2	2.5	16	20	26	41	23	39	2.5
Molybdenum	3.47	0.51	0.78	<0.2	0.24	10	1.7	2.5	1.5	0.99	2.9	0.45
Selenium	NA	<1	<1	<1	<1	<0.98	<1	<1	<1	1.1	<1	<1.2
Uranium	3.99	0.75	120 D	1.1	0.96	25	26	65	67	50	170 D	2.4
Vanadium	17.9	27	42	12 J	11	18	22	28	31	25	31	25
Radionuclides (pCi/g)												
Radium-226	2.43	1.13 ± 0.26	71.9 ± 8.6	1.01 ± 0.26 J-	1.21 ± 0.26 J-	8.3 ± 1.1 J-	46.9 ± 5.6 J-	21.3 ± 2.6 J-	53.6 ± 6.4 J-	32.4 ± 3.9 J-	51.5 ± 6.1 J-	2.51 ± 0.41 J-

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
Shaded	Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because selenium sample results in BG-1 were all non-detect
¹	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Analysis required non-standard dilution; reported values have been converted to non-diluted value
J	Data are estimated due to associated quality control data.
J-	Data are estimated and are potentially biased low due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
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Location Identification		S225-CX-003	S225-CX-005	S225-CX-006	S225-CX-007	S225-CX-008	S225-CX-009	S225-CX-010	S225-SCX-007	S225-SCX-007	S225-SCX-008	S225-SCX-009
Date Collected		6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/20/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017
Depth (feet)		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 0.8	0 - 0.5	0 - 0.5
Sample Category		surface	surface	surface	surface	surface	surface	surface	surface	subsurface	surface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment	sediment
Analyte (Units)												
Metals[1] (mg/kg)	Investigation Level											
Arsenic	2.36	0.92	19	3.1	3.5	3.1	3.2	4.3	2	0.77	3.5	2.8
Molybdenum	0.786	0.36	2.8	0.39	5.1	0.82	0.45	0.74	0.61	<0.2	0.52	0.32
Selenium	NA	<0.99	<1	<0.95	<0.93	<0.98	<0.98	<1	<1	<1	<1	<1
Uranium	0.482	1.1	78	8.5	2.7	1.5	0.4	1	3.1	0.38	0.45	2.3
Vanadium	9.45	4.3	19	9.1	8.3	4.9	9.2	10	11	6.8	10	9.6
Radionuclides (pCi/g)												
Radium-226	0.909	0.64 ± 0.17	34.8 ± 4.2	3.16 ± 0.47	1.77 ± 0.32 J-	1.62 ± 0.28 J-	0.92 ± 0.24	0.87 ± 0.23 J-	1.15 ± 0.24	0.43 ± 0.2 J-	0.69 ± 0.19 J-	0.89 ± 0.2 J-

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because selenium sample results in BG-2 were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Analysis required non-standard dilution; reported values have been converted to non-diluted value
J	Data are estimated due to associated quality control data.
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
Charles Keith
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Location Identification		S225-SCX-009	S225-SCX-010	S225-SCX-010	S225-SCX-011	S225-SCX-012	S225-SCX-012	S225-SCX-013	S225-SCX-014	S225-SCX-014	S225-SCX-015	S225-SCX-016
Date Collected		6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017
Depth (feet)		0.5 - 0.8	0 - 0.5	0.5 - 1	0 - 0.5	0 - 0.5	0.5 - 1.3	0 - 0.5	0 - 0.5	0.5 - 1.2	0 - 0.6	0 - 0.7
Sample Category		subsurface	surface	subsurface	surface	surface	subsurface	surface	surface	subsurface	subsurface	subsurface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		sediment	soil	soil	sediment	sediment	sediment	soil	sediment	sediment	sediment	sediment
Analyte (Units)												
Metals[1] (mg/kg)	Investigation Level											
Arsenic	2.36	3	1.4	1.2	2.6	2.1 J	2.6	2.3	2.7	2	2.6	1.4
Molybdenum	0.786	0.51	0.23	0.27	0.39	0.71	0.33	0.47	0.38	0.21	0.64	0.22
Selenium	NA	<1.1	<0.99	<0.98	<0.96	<0.98	<0.96	<1	<1.1	<1	<1.1	<0.99
Uranium	0.482	0.73	1.5	1.9	3.8	1.2 J+	1.5	1.4	1.1	0.78	1.1	0.8
Vanadium	9.45	11	9.4	10	7.7	8.8	11	6.7	9.3	10	8.5	7.7
Radionuclides (pCi/g)												
Radium-226	0.909	0.78 ± 0.25	1.27 ± 0.25 J-	1.11 ± 0.24	2.68 ± 0.4 J-	1.38 ± 0.28 J-	1.29 ± 0.24 J-	1.27 ± 0.29	1.34 ± 0.26 J-	0.82 ± 0.2 J-	0.93 ± 0.2 J-	0.88 ± 0.23 J-

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because selenium sample results in BG-2 were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Analysis required non-standard dilution; reported values have been converted to non-diluted value
J	Data are estimated due to associated quality control data.
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4b
Site Characterization Soil and Sediment Sample Analytical Results for Survey Area B
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

	Location Identification	S225-SCX-017	S225-SCX-017	S225-SCX-017 Dup
	Date Collected	6/21/2017	6/21/2017	6/21/2017
	Depth (feet)	0 - 0.5	0.5 - 1.25	0 - 0.5
	Sample Category	surface	subsurface	surface
	Sample Collection Method	grab	grab	grab
	Media	sediment	sediment	sediment
Analyte (Units)				
Metals[1] (mg/kg)	Investigation Level			
Arsenic	2.36	0.81	1	0.93
Molybdenum	0.786	<0.2	0.22	<0.2
Selenium	NA	<1	<1	<0.99
Uranium	0.482	0.61	0.83	0.69
Vanadium	9.45	6	6.3	5.9
Radionuclides (pCi/g)				
Radium-226	0.909	0.78 ± 0.26	0.48 ± 0.2 J-	0.65 ± 0.17

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because selenium sample results in BG-2 were all non-detect
1	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Analysis required non-standard dilution; reported values have been converted to non-diluted value
J	Data are estimated due to associated quality control data.
J-	Data are estimated and are potentially biased low due to associated quality control data
J+	Data are estimated and are potentially biased high due to associated quality control data

Table 4-4c
Site Characterization Soil Sample Analytical Results for Survey Area C
Charles Keith
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	Location Identification	S225-CX-011	S225-CX-012	S225-CX-013
	Date Collected	6/22/2017	6/22/2017	9/20/2017
	Depth (feet)	0 - 0.5	0 - 0.5	0 - 0.5
	Sample Category	surface	surface	surface
	Sample Collection Method	grab	grab	grab
	Media	soil	soil	soil
Analyte (Units)				
Metals[1] (mg/kg)	Investigation Level			
Arsenic	31.6	9.5	150	6.6 D
Molybdenum	2.42	0.4	11	<0.19 D
Selenium	NA	<0.98	1.2	<0.93 D
Uranium	0.744	1.9	220 D	0.41 D
Vanadium	19.9	3	83	5 D
Radionuclides (pCi/g)				
Radium-226	2.08	0.83 ± 0.21	110 ± 13	1.07 ± 0.28

Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result greater than or equal to the investigation level
Shaded	Shaded result indicates analyte detected, where that analyte does not have an investigation level
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
NA	An investigation level is not identified because selenium sample results in BG-3 were all non-detect
[1]	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-diluted value
<	Result not detected above associated laboratory reporting limit
D	Analysis required non-standard dilution; reported values have been converted to non-diluted value

Table 4-5
Summary of Investigation Level Exceedances in Soil/Sediment at Borehole Locations
Charles Keith
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Sample Location	Survey Area	Investigation Level Exceedances
S225-SCX-002[2]	A	As, Mo, U, V, Ra-226
S225-SCX-003[1,2]	A	As, U, V, Ra-226
S225-SCX-004[1]	A	As, Se, U, V, Ra-226
S225-SCX-005[3]	B	Static Gamma
S225-SCX-006[3]	B	Static Gamma
S225-SCX-007	B	U, V, Ra-226, Static Gamma
S225-SCX-008	B	As, V
S225-SCX-009	B	As, U, V, Static Gamma
S225-SCX-010	B	U, V, Ra-226, Static Gamma
S225-SCX-011	B	As, U, Ra-226, Static Gamma
S225-SCX-012	B	As, U, V, Ra-226, Static Gamma
S225-SCX-013	B	U, Ra-226, Static Gamma
S225-SCX-014	B	As, U, V, Ra-226, Static Gamma
S225-SCX-015	B	As, U, Ra-226, Static Gamma
S225-SCX-016	B	U, Static Gamma
S225-SCX-017	B	U, Static Gamma
S225-SCX-018[2]	A	V, Ra-226

Notes
1 - Detections of Se included for reference, no IL is established for Se
2 - Static subsurface gamma IL was not evaluated for locations in Survey Area A
3 - No soil sample collected for analysis
IL - investigation level
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se- Selenium
U - Uranium
V - Vanadium

Table 4-6a
Water Sampling Investigation Level Derivation
Charles Keith
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	USEPA		Navajo Nation		
Analyte (Units)	MCL (a)	Secondary Standard (b)	Surface Water Quality Standards (c)	Primary Drinking Water MCL(d)	Investigation Level
Radionuclides (pCi/L)					
Ra-226 (e)	5	*	5	5	5
Ra-228 (e)	5	*	5	5	5
Gross Alpha	15	*	15	15	15
Metals (ng/L)					
Mercury	2000	*	2000	2000	2000
Metals (µg/L)					
Antimony	6	*	5.6	6	5.6
Arsenic	10	*	10	10	10
Barium	2000	*	2000	2000	2000
Beryllium	4	*	4	4	4
Cadmium	5	*	5	5	5
Chromium, Total	100	*	100	100	100
Cobalt	*	*	*	*	*
Copper	1300	*	1300	*	1300
Lead	15	*	15	15	15
Molybdenum	*	*	*	*	*
Nickel	*	*	610	*	610
Selenium	50	*	50	50	50
Silver	*	100	35	*	35
Thallium	2	*	2	2	2
Uranium	30	*	30	30	30
Vanadium	*	*	*	*	*
Zinc	*	5000	2100	*	2100
General Chemistry Parameters (mg/L) (f)					
Bicarbonate	*	*	*	*	*
Calcium	*	*	*	*	*
Carbonate	*	*	*	*	*
Chloride	*	250	*	*	250
Sodium	*	*	*	*	*
Sulfate	*	250	*	*	250
TDS	*	500	*	*	500

Notes

Bold – indicates the most conservative value to be used for comparison.

(a) "Table of Regulated Drinking Water Contaminants", Groundwater and Drinking Water (USEPA, 2016a).

(b) "Table of Secondary Drinking Water Standards", Secondary Drinking Water Standards: Guidance for Nuisance Chemicals (USEPA, 2016b).

(c) Navajo Nation Surface Water Quality Standards (NNEPA, 2015)

(d) Maximum Contaminant Levels Navajo Nation Primary Drinking Water Regulations (NNPDWR, 2015)

(e) The MCL for Ra-226 and Ra-228 have a combined limit of 5 pCi/L, and are not individually 5pCi/L

(f) Collected data will be used for water quality analysis purposes

* USEPA primary (MCL), secondary standard, Navajo Nation Surface Water Quality Standards, or Navajo Drinking Water MCLs are not established for these analytes.

MCL - maximum contaminant level
µg/L - micrograms per liter
mg/L - milligrams per liter
ng/L - nanograms per liter
pCi/L - picocuries per liter
TDS - Total Dissolved Solids
Ra-226 - Radium 226
Ra-228 - Radium 228
USEPA - Unites States Environmental Protection Agency

Table 4-6b
Water Sampling Analytical Results
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase
Page 1 of 1

	Water Feature Identification	S225-Seep-1	S225-Seep-1	08GS-12-9	08GS-12-9
	Field Sample Identification	S225-WS-001	S225-WS-001	S225-WS-002	S225-WS-002
	Date Collected	10/18/2016	10/18/2016	10/18/2016	10/18/2016
	Matrix	Surface Water	Surface Water	Surface Water	Surface Water
	Preparation	Dissolved	Total	Dissolved	Total
Analyte (Units)					
Radionuclides (pCi/L)	Investigation Level				
Ra-226	5 [1]	NS	0 ± 0.11	NS	0.24 ± 0.12
Ra-228	5 [1]	NS	0 ± 0.27	NS	0 ± 0.27
Gross Alpha	--	NS	0 ± 1.4	NS	0 ± 3.7
Adjusted Gross Alpha [2]	15	NS	NA	NS	NA
Gross Beta	--	NS	4.3 ± 1.7	NS	15.1 ± 4.5
Mercury (ng/L)					
Mercury	2000	<0.5	1.6	0.4 F	00.2 F
Metals [3] (µg/L)					
Antimony	5.6	<0.3	<0.3	0.46	<0.3
Arsenic	10	2.2	2.5	3.5	3.6
Barium	2000	170	170	72	72
Beryllium	4	<0.5	<0.5	<0.5	<0.5
Cadmium	5	<0.3	<0.3	<0.3	<0.3
Chromium, Total	100	<10	<10	<10	<10
Cobalt	--	<1	<1	<1	<1
Copper	1300	<10	<10	<10	<10
Lead	15	0.58	0.62	<0.5	<0.5
Molybdenum	--	<1	<1	11	11
Nickel	610	5.3	<5	7.3	<5
Selenium	50	4.7	5.4	9.1	9.2
Silver	35	<0.1	<0.1	<0.1	<0.1
Thallium	2	<0.2	<0.2	<0.2	<0.2
Uranium	30	2.3	2.3	20	20
Vanadium	--	13	13	3.2	3.4
Zinc	2100	<20	<20	<20	<20
General Chemistry Parameters (mg/L)					
TDS	500	NS	240	NS	1500
Carbonate	--	NS	<20	NS	350
Alkalinity, Total (as $CaCO_3$)	--	NS	150	NS	180
Chloride	250	NS	6.7	NS	250 D
Sulfate	250	NS	12	NS	490 D
Calcium	--	17000	17000	9800	9900
Sodium	--	28000	28000	410000	420000
Field Parameters					
Oxidation Reduction Potential(millivolts)	--	NS	83.7	NS	98.1
pH(pH units)	--	NS	7.62	NS	9.9
Salinity(PPTV)	--	NS	0.16	NS	1.22
Specific Conductivity(µS/cm)	--	NS	340.7	NS	2365
Temperature(°C)	--	NS	17.6	NS	19.3
Turbidity(NTU)	--	NS	1.52	NS	2.93
Flow Rate(L/HR)	--	NS	10	NS	NS

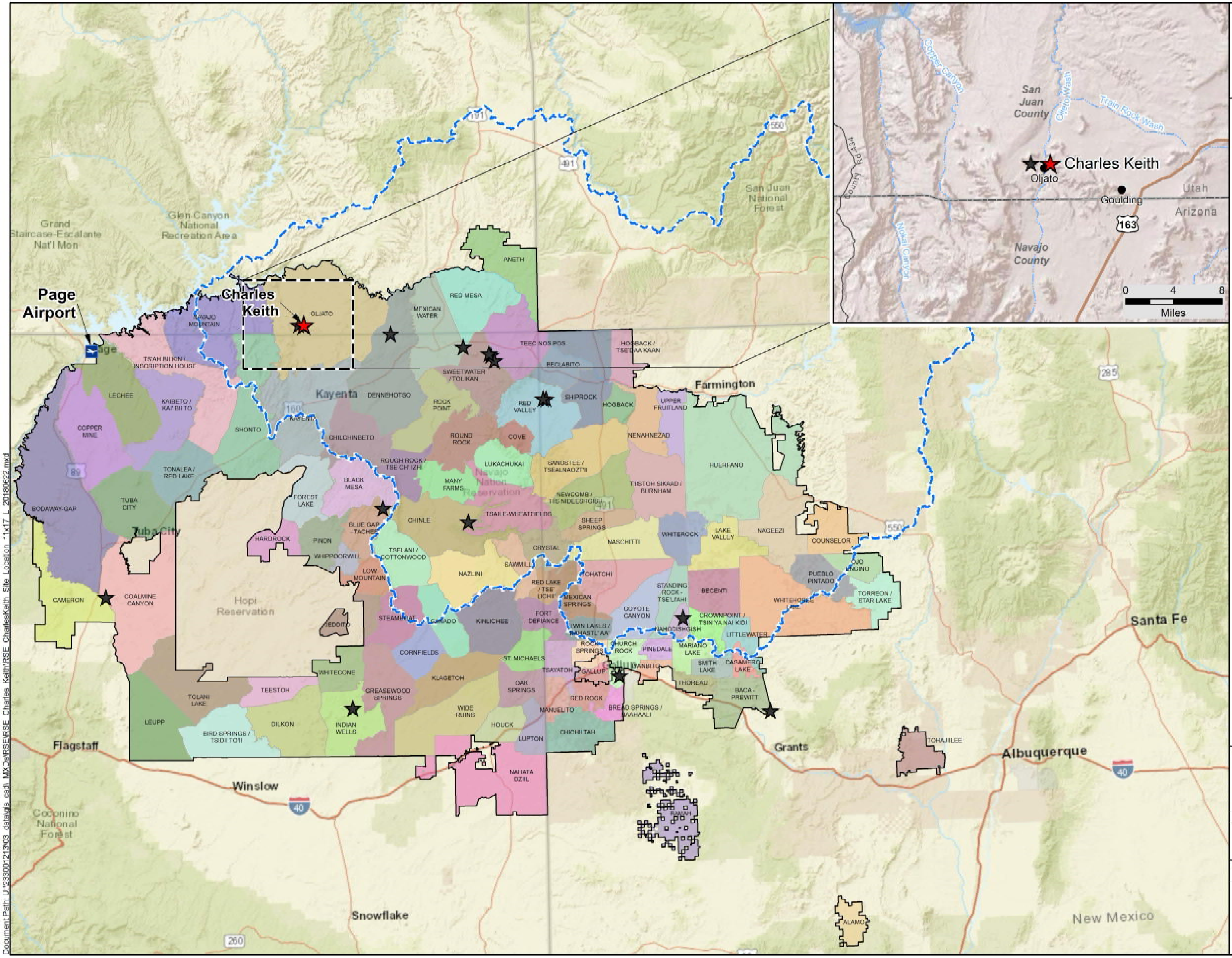
Notes

Bold	Bolded result indicates positively identified compound
Shaded	Shaded result indicates result or reporting limit greater than or equal to the investigation action level
°C	Degrees Celsius
µg/L	micrograms per liter
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
ng/L	nanograms per liter
L/HR	liters per hour
NTU	nephelometric turbidity unit
pCi/L	picocuries per liter
PPTV	parts per trillion volume
--	Not established
NA	Adjusted Gross Alpha result is not applicable because it was negative, refer to note [2]
NS	Not scheduled
Ra-226	Radium 226
Ra-228	Radium 228
TDS	Total Dissolved Solids
<	Result not detected above associated laboratory reporting limit
D	Analysis required a standard sample dilution of 10 times; reported values have been converted to non-dilute value
F	Analyte was positively identified but the reported concentration is estimated; reported concentration is less than the reporting limit, but greater than the method detection limit
1	The Investigation Level for Ra-226 and Ra-228 have a combined limit of 5 pCi/L, and are not individually 5pCi/L
2	Adjusted Gross Alpha = Gross alpha concentration - uranium concentration, using the conversion factor of 0.6757 to convert uranium µg/L to pCi/L (U.S. Department of Energy, 2011)
3	Analysis required sample dilution of 10 times; reported values have been converted to non-diluted value

FIGURES

FIGURE ACRONYMS/ABBREVIATIONS

As	arsenic
BG	potential background reference area
bgs	below ground surface
cpm	counts per minute
ft	feet
IL	investigation level
mg/kg	milligrams per kilogram
Mo	molybdenum
NA	not applicable
NAD	North American Datum
pCi/g	picocuries per gram
Ra	radium-226
Ra-226	radium-226
Se	selenium
TENORM	Technologically Enhanced Naturally Occurring Radioactive Materials
uk	unknown
U	uranium
UTL	upper tolerance limit
UTM	Universal Transverse Mercator
V	vanadium



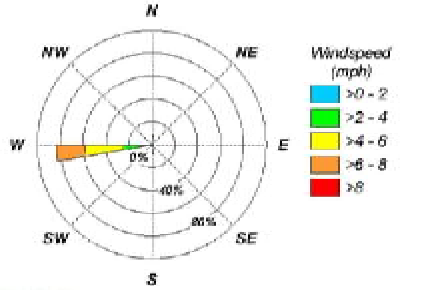
NAVAJO NATION

AUM Environmental Response Trust-First Phase

LEGEND

- 🟥★ Charles Keith Mine Site
- ★ Priority Abandoned Uranium Mine (AUM) Site
- ● Populated Place
- US Highway
- Major Road
- Stream
- Intermittent Stream
- San Juan River Watershed
- Navajo Nation Boundary
- Navajo Nation Chapter

Page Airport, Arizona Wind Rose (KPGA), 1996-2006



REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI World Street Map and World Shaded Relief accessed 06/2018.

Wind Rose: USEPA, 2007a

N
W E
S

0 25 50
Miles

TITLE:

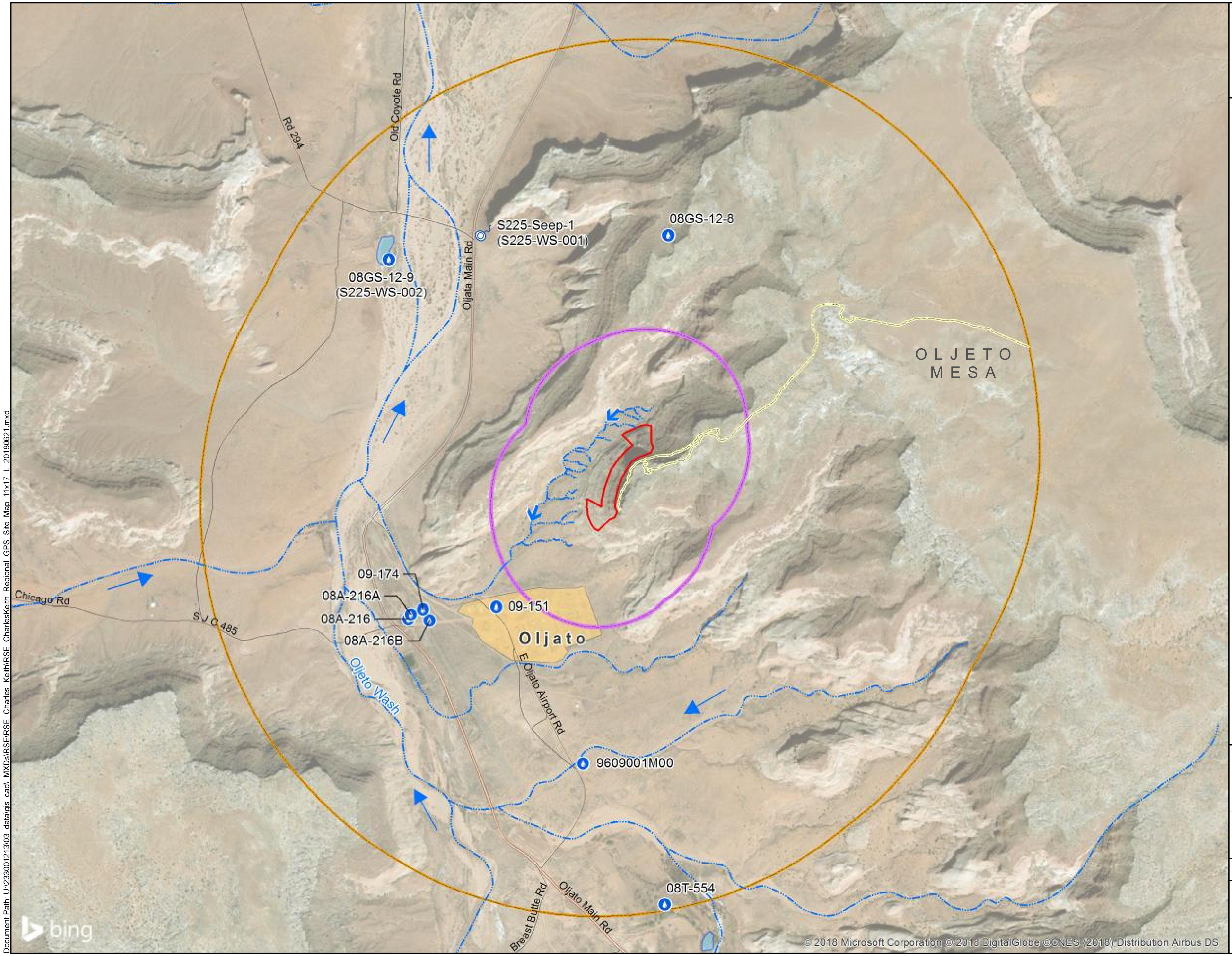
Site Location

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE:	6/29/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec		AUTHOR: CBB	REVIEWER: EDZ
		FIGURE: 1-1	

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_CharlesKeith\RSE_CharlesKeith_Site_Location_11x17_L_20180622.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

●	Site Clearance Identified Water Feature¹
◎	Seep²
↑	Flow Direction
-·-·-	Intermittent Stream/River
- - -	Potential Haul Road
═	Tribal Road
—	Local Road
▭	Pond
▭	Residential Area
▭	Claim Boundary
▭	1/4-Mile Claim Boundary Buffer
▭	1-Mile Claim Boundary Buffer

NOTES:

1. Water features and identification names identified in 2007 AUM Atlas and/or in database provided by the Navajo Nation Department of Water Resources.

2. Seep identified during field mapping by the Trust/Stantec.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

N
W E
S

0 1,300 2,600
Feet

TITLE:

Site Features

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-1

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Regional GPS Site Map 11x17 L 20180621.mxd

NAVAJO
NATION
AUM Environmental
Response Trust-First Phase

LEGEND

🡑	Flow Direction
-·-·-·-	Intermittent Stream/River
═	Tribal Road
—	Local Road
🟥	Claim Boundary
▨	Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 07/2018.

N
W E
S

0 2,000 4,000
Feet

Regional Aerial Photograph

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 7/5/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-2

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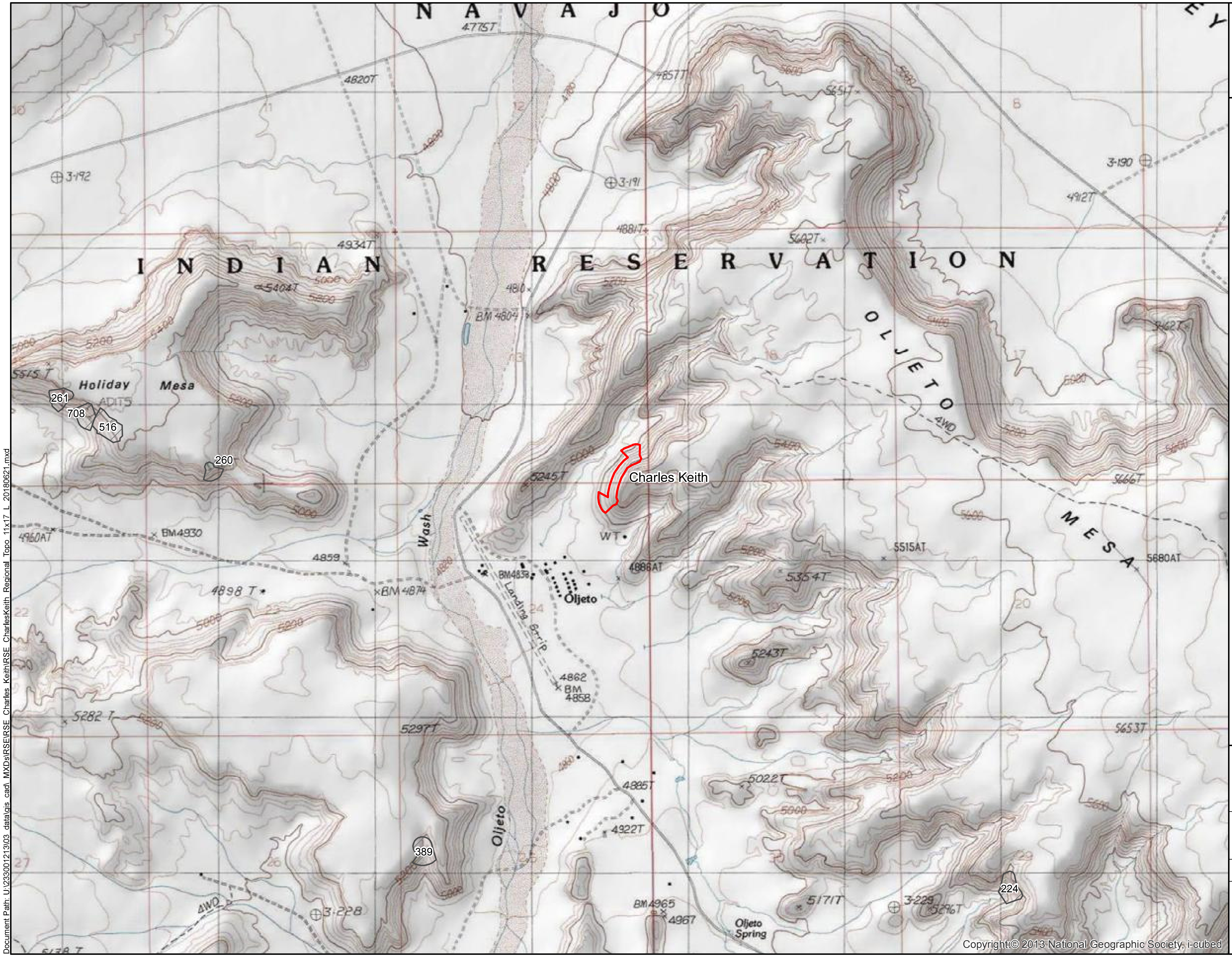


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

🟥 Claim Boundary

▨ Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap: ESRI USA Topo Maps service accessed 06/2018.

N W E S

0 2,000 4,000
Feet

TITLE:
Regional Topographic Map

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

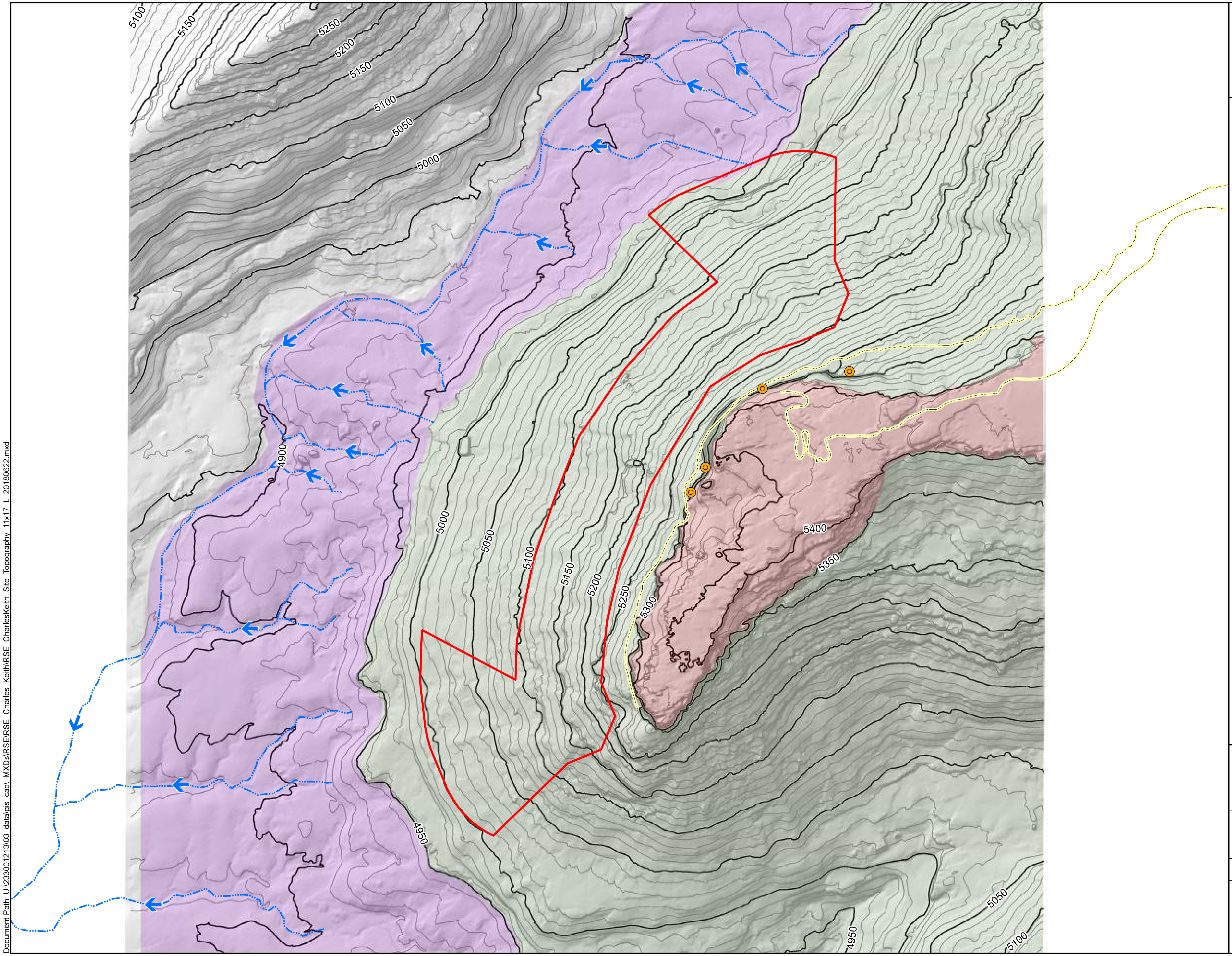
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-3

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles Keith\RSE_CharlesKeith_Regional_Topo_11x17_L_20180621.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

●	Portal
↑	Flow Direction
-·-·-	Drainage
- - -	Potential Haul Road
∼	Index Contour (50 ft Interval)
∼	Intermediate Contour (10 ft Interval)
▭	Claim Boundary

Geomorphology Features

🟥	Mesa Top
🟩	Mesa Sidewall
🟪	Pediment

REFERENCES:
Site-specific contours were generated as part of aerial surveys conducted on June 16, 2017.

Coordinate System: NAD 1983 UTM Zone 12N

N
W E
S

0 200 400
Feet

TITLE:
Site Topography

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-4

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Site Topography 11x17 L 20180622.mxd

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
U.S. ATOMIC ENERGY COMMISSION

MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-744 (SHEET 1 OF 2)

Geology

GEOLOGY, STRUCTURE, AND URANIUM DEPOSITS OF THE ESCALANTE QUADRANGLE, UTAH AND ARIZONA

Compiled By
Robert J. Hackman and Donald G. Wyant
1973

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

TITLE:
Regional Geology

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/29/2018

DOCUMENT NAME:
Removal Site Evaluation Report

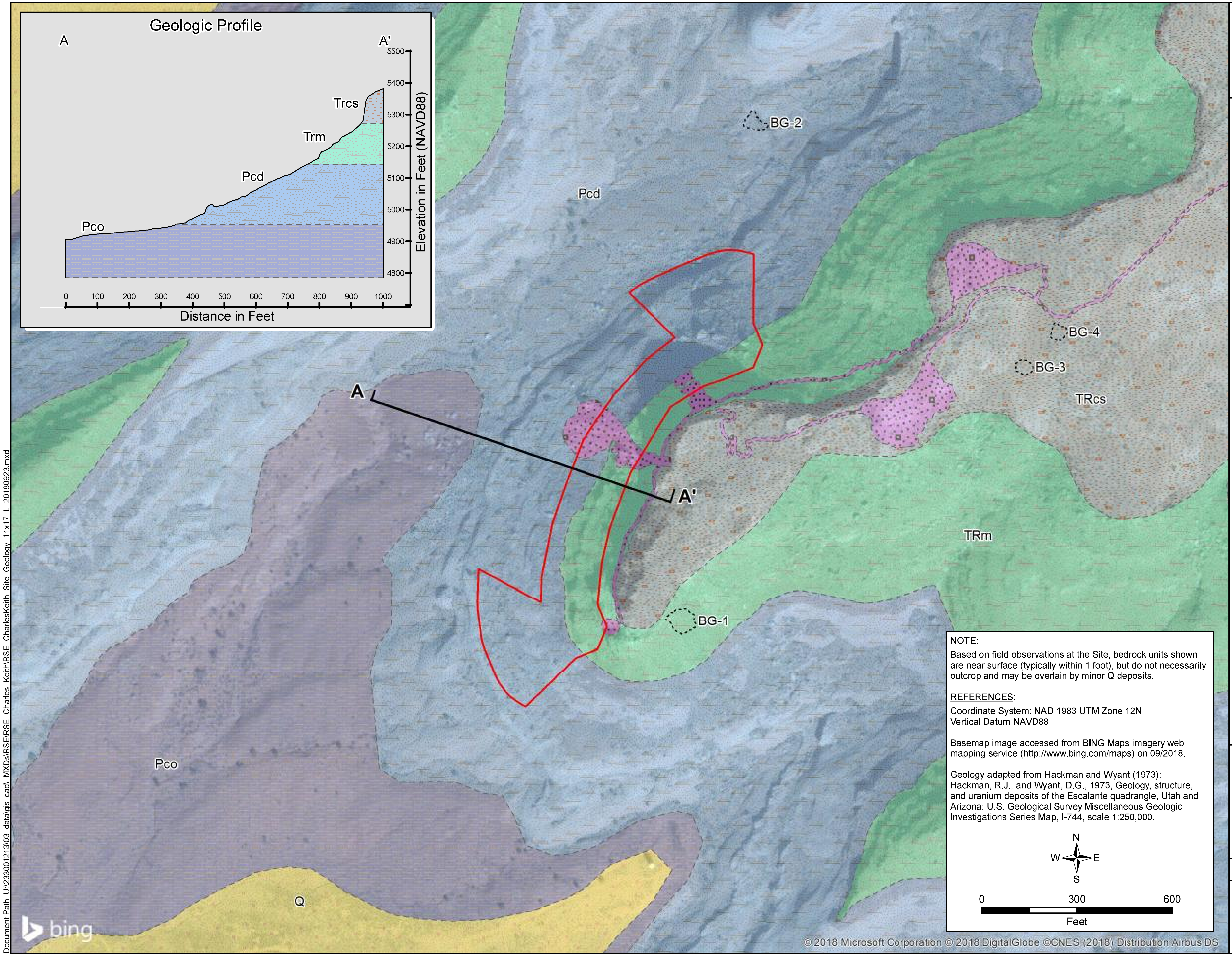
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-5

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Geology_22x34_L_20180621.mxd



NOTE:
Based on field observations at the Site, bedrock units shown are near surface (typically within 1 foot), but do not necessarily outcrop and may be overlain by minor Q deposits.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N
Vertical Datum NAVD88

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Geology adapted from Hackman and Wyant (1973): Hackman, R.J., and Wyant, D.G., 1973, Geology, structure, and uranium deposits of the Escalante quadrangle, Utah and Arizona: U.S. Geological Survey Miscellaneous Geologic Investigations Series Map, I-744, scale 1:250,000.

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

⌐¬	Geologic Profile
🟥	Claim Boundary
╌	Geology Contact (Inferred)
⬚	Potential Background Reference Area

Site Geology

HOLOCENE

▨	Earthworks: Human-caused disturbance of the land surface potentially related to mining.
▨	Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

TRIASSIC

▨	TRcs: Shinarump member of the Chinle Formation (Upper Triassic) – moderate-orange and yellowish-gray sandstone, siltstone, conglomerate and sandy shale.
▨	Trm: Moenkopi Formation (Triassic) – reddish-brown, platy to slabby, ripple-marked siltstone, thin marine limestones, and thick beds of brown, fine-grained calcareous sandstone.

PERMIAN

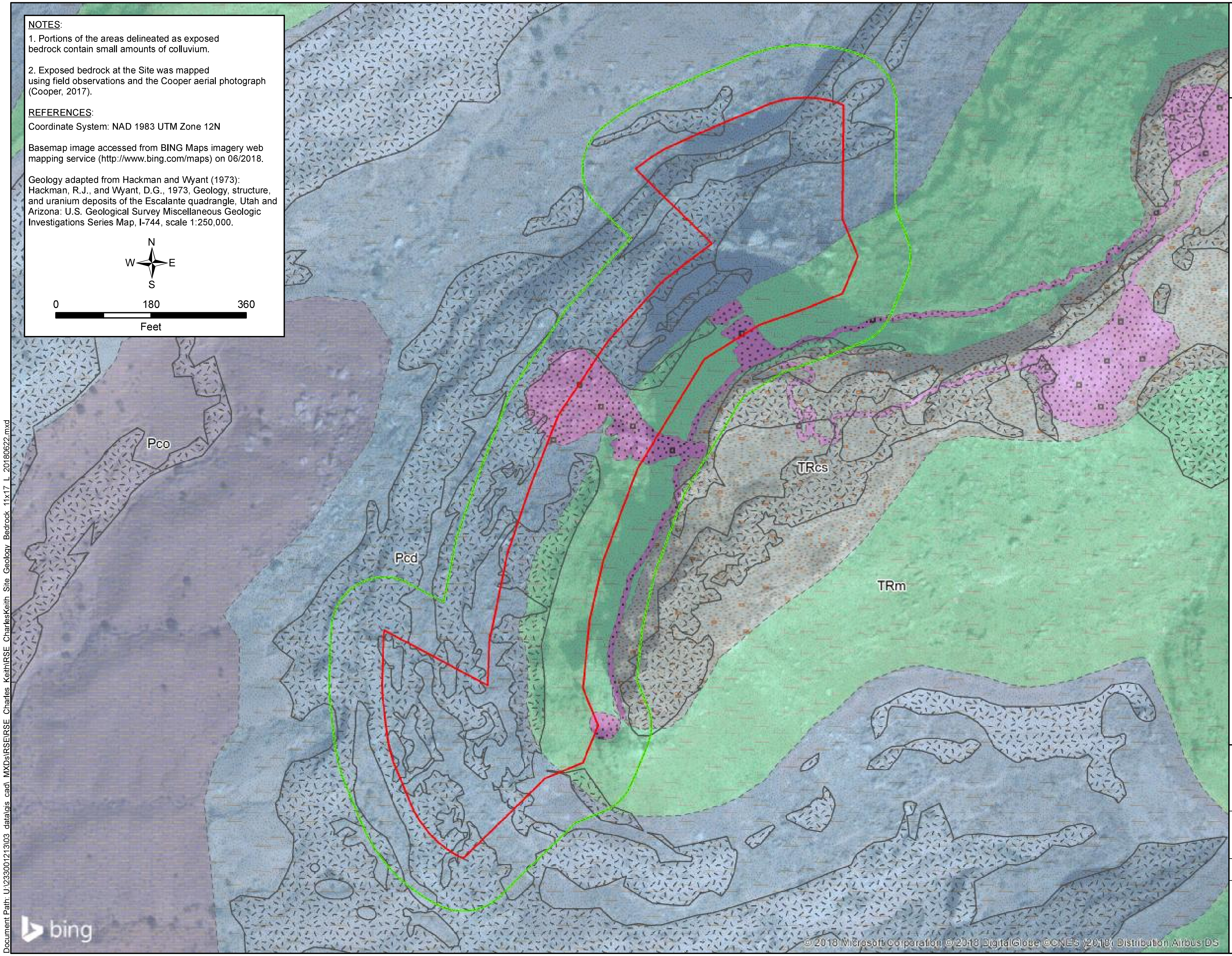
▨	Pcd: De Chelly Sandstone Member of the Cutler Formation (Permian) – reddish-orange to pale-reddish-brown, fine to medium-grained eolian sandstone; erodes to cliffs and domes.
▨	Pco: Organ Rock Tongue of the Cutler Formation (Permian) – reddish brown, evenly thin bedded siltstone and fine-grained sandstone.

TITLE:
Site Geology

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/26/2018
DOCUMENT NAME: Removal Site Evaluation Report
Stantec
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 2-6a

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Site Geology 11x17 L 20180923.mxd



NOTES:

1. Portions of the areas delineated as exposed bedrock contain small amounts of colluvium.

2. Exposed bedrock at the Site was mapped using field observations and the Cooper aerial photograph (Cooper, 2017).

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

Geology adapted from Hackman and Wyant (1973): Hackman, R.J., and Wyant, D.G., 1973, Geology, structure, and uranium deposits of the Escalante quadrangle, Utah and Arizona: U.S. Geological Survey Miscellaneous Geologic Investigations Series Map, I-744, scale 1:250,000.

N
W E
S

0 180 360
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- 🟥 Claim Boundary
- 🟩 100-Foot Claim Buffer
- Geology Contact (Inferred)
- ▨ Exposed Bedrock¹

Site Geology

HOLOCENE

- ▨ Earthworks: Human-caused disturbance of the land surface potentially related to mining.
- ▨ Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

TRIASSIC

- ▨ TRcs: Shinarump member of the Chinle Formation (Upper Triassic) – moderate-orange and yellowish-gray sandstone, siltstone, conglomerate and sandy shale.
- ▨ Trm: Moenkopi Formation (Triassic) – reddish-brown, platy to slabby, ripple-marked siltstone, thin marine limestones, and thick beds of brown, fine-grained calcareous sandstone.

PERMIAN

- ▨ Pcd: De Chelly Sandstone Member of the Cutler Formation (Permian) – reddish-orange to pale-reddish-brown, fine to medium-grained eolian sandstone; erodes to cliffs and domes.
- ▨ Pco: Organ Rock Tongue of the Cutler Formation (Permian) – reddish brown, evenly thin bedded siltstone and fine-grained sandstone.

TITLE:

Site Exposed Bedrock

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

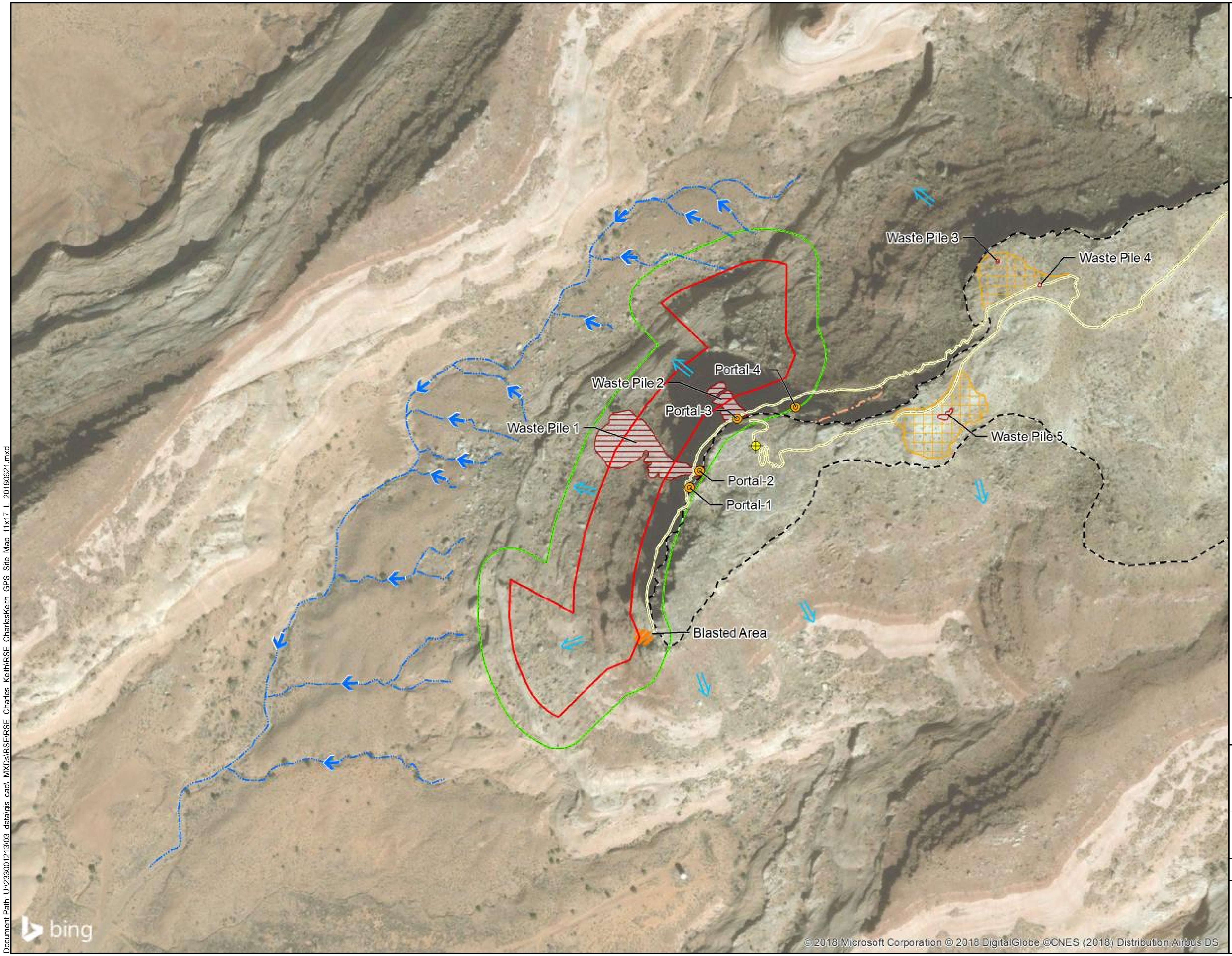
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-6b

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Site Geology Bedrock 11x17 L 20180622.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

⊕	Historical Borehole
◎	Portal
↑	Flow Direction
⇧	Approximate Overland Water Flow Direction
-·-·-	Drainage
-·-·-	Footpath
- - - -	Potential Haul Road
- - - -	Approximate Edge of Mesa
▨	Blasted
▦	Mining Disturbed
▤	Waste Pile
▭	Claim Boundary
▭	100-Foot Claim Buffer

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

N
W E
S

0 300 600
Feet

TITLE:

Site Map

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

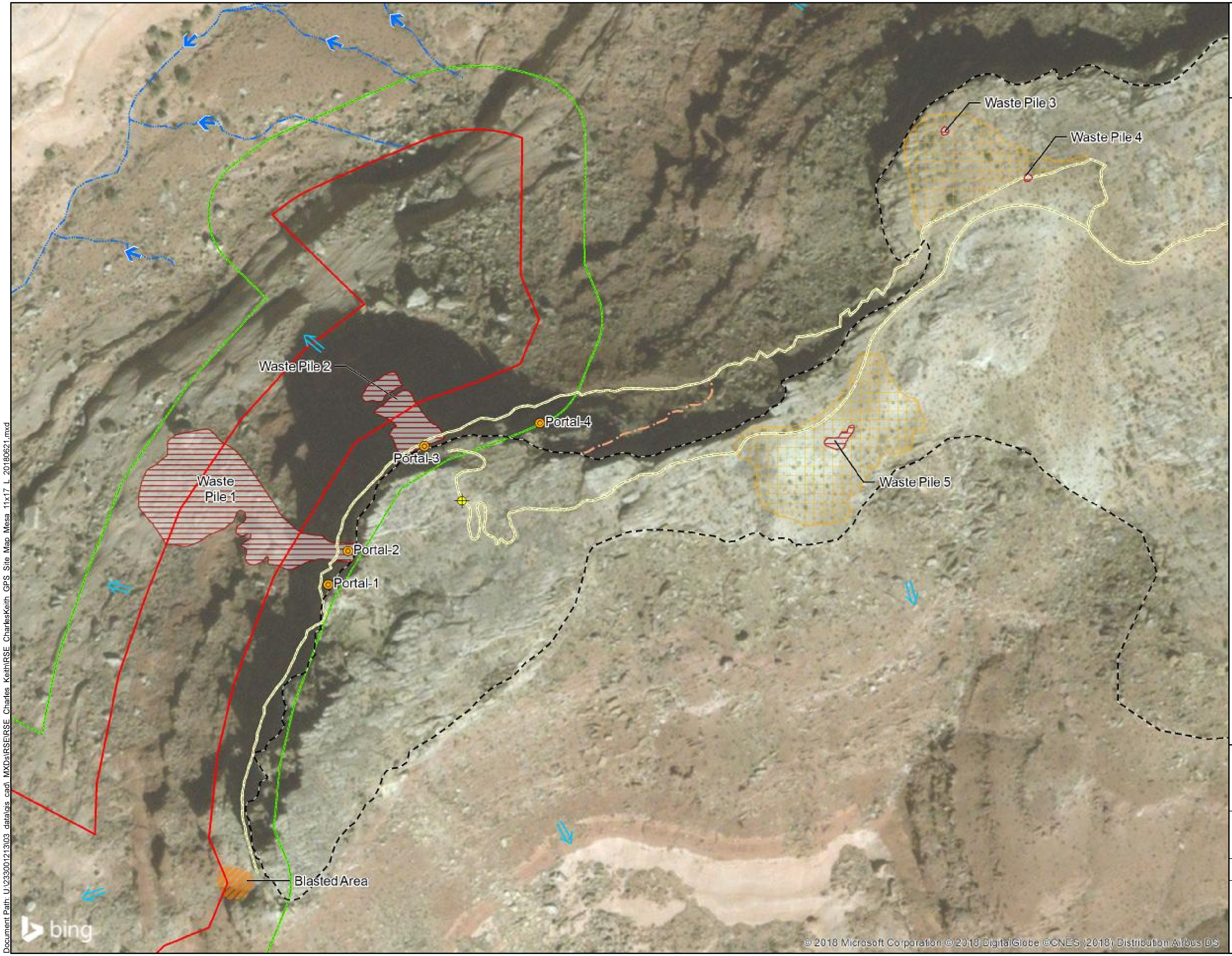
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-7a

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith GPS Site Map 11x17 L 20180621.mxd



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NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- ⊕ Historical Borehole
- ◉ Portal
- ↑ Flow Direction
- ⇑ Approximate Overland Water Flow Direction
- - - - Approximate Edge of Mesa
- -·-·- Drainage
- -·-·- Footpath
- ------ Potential Haul Road
- ▨ Blasted Area
- ▦ Mining Disturbed Area
- ▤ Waste Pile
- ▭ Claim Boundary
- ▭ 100-Foot Claim Buffer

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

N
W E
S

0 150 300
Feet

TITLE:

Top of Mesa
Site Map

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

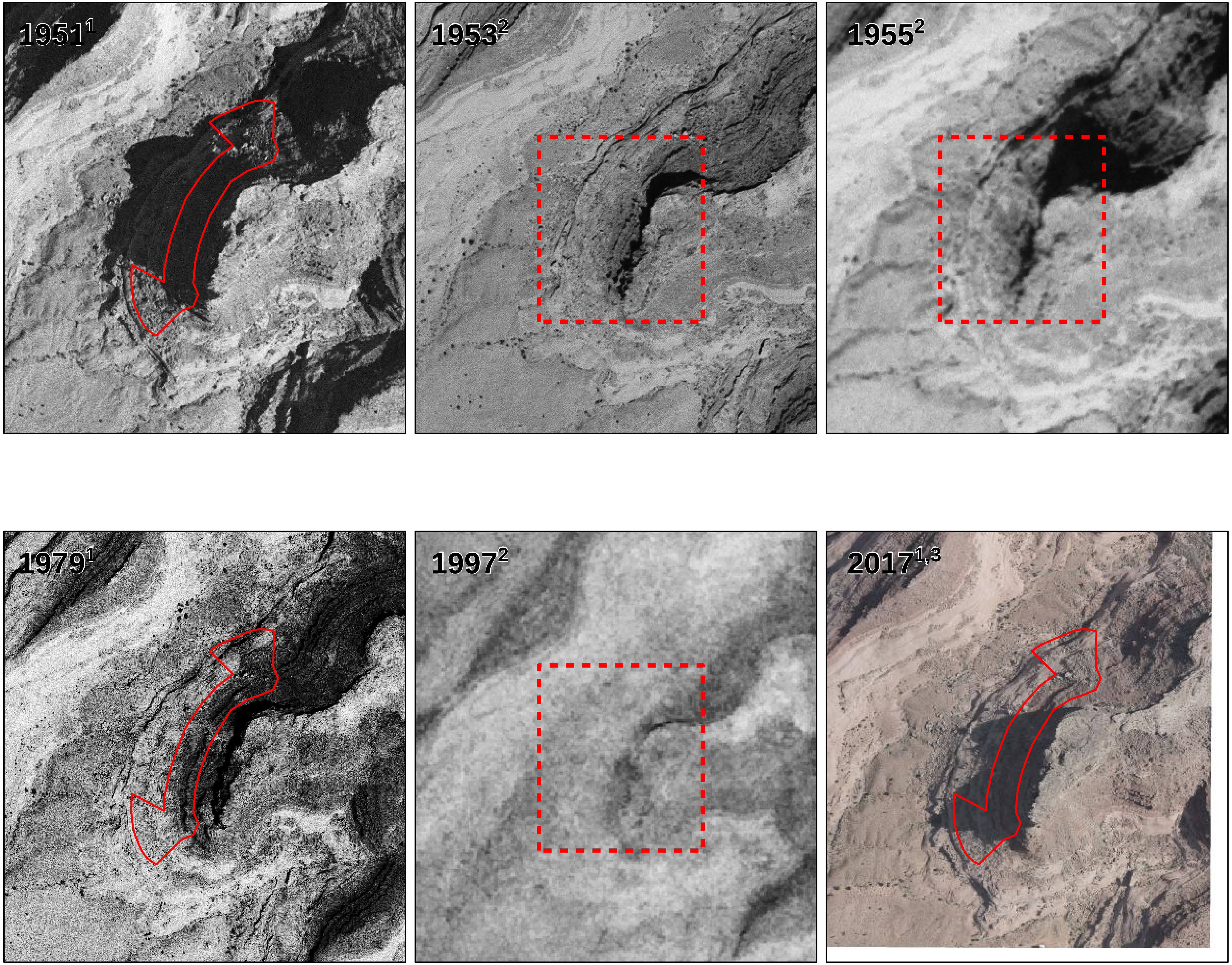
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 2-7b

NAVAJO
NATION
AUM Environmental
Response Trust-First Phase



LEGEND

☐ Charles Keith Claim Boundary

⬚ Approximate Site Location, not georeferenced

NOTES:

1. Image is georeferenced. Scale bar applies to these image frames only.

2. Image is not georeferenced, scale not available.

3. Site specific imagery flown by Cooper Aerial Surveys Co. on June 16, 2017.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Historical Aerial Imagery downloaded from https://earthexplorer.usgs.gov/ (01/2016)

N
W E
S

0 600 1,200
Feet

TITLE:

Historical Aerial Photograph Comparison

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

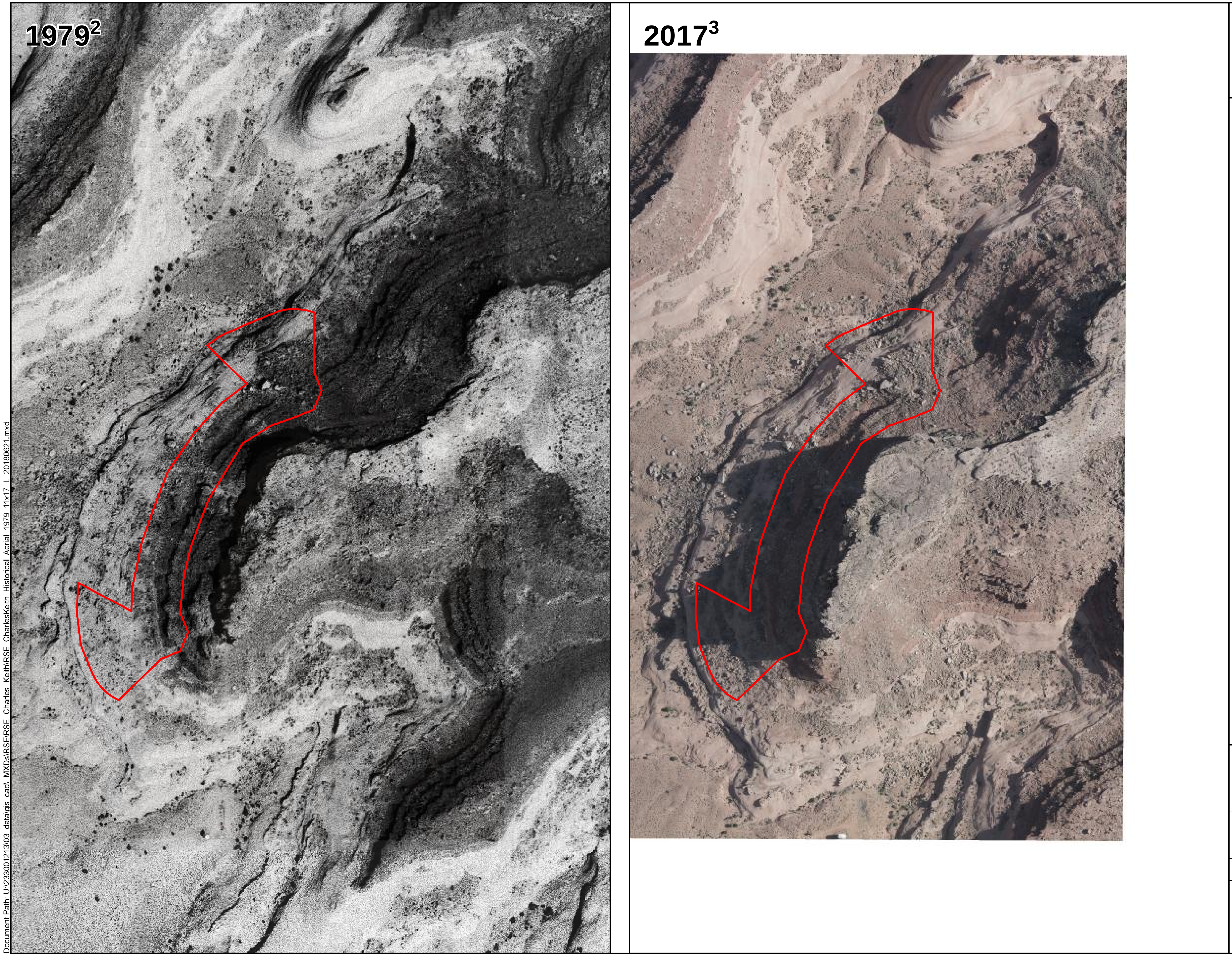
AUTHOR: WDC

REVIEWER: CBB

Stantec

FIGURE: 3-1a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Historical Aerial Compilation 11x17_L_20180622.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

▭ Claim Boundary

REFERENCES:

1. Coordinate System: NAD 1983 UTM Zone 12N
2. 1979 aerial image downloaded from https://earthexplorer.usgs.gov/ (01/2016) and georeferenced using current image from BING (03/2016).
3. Site-specific imagery flown by Cooper Aerial Surveys Co. on June 16, 2017.

N
W E
S

0 350 700
Feet

TITLE:

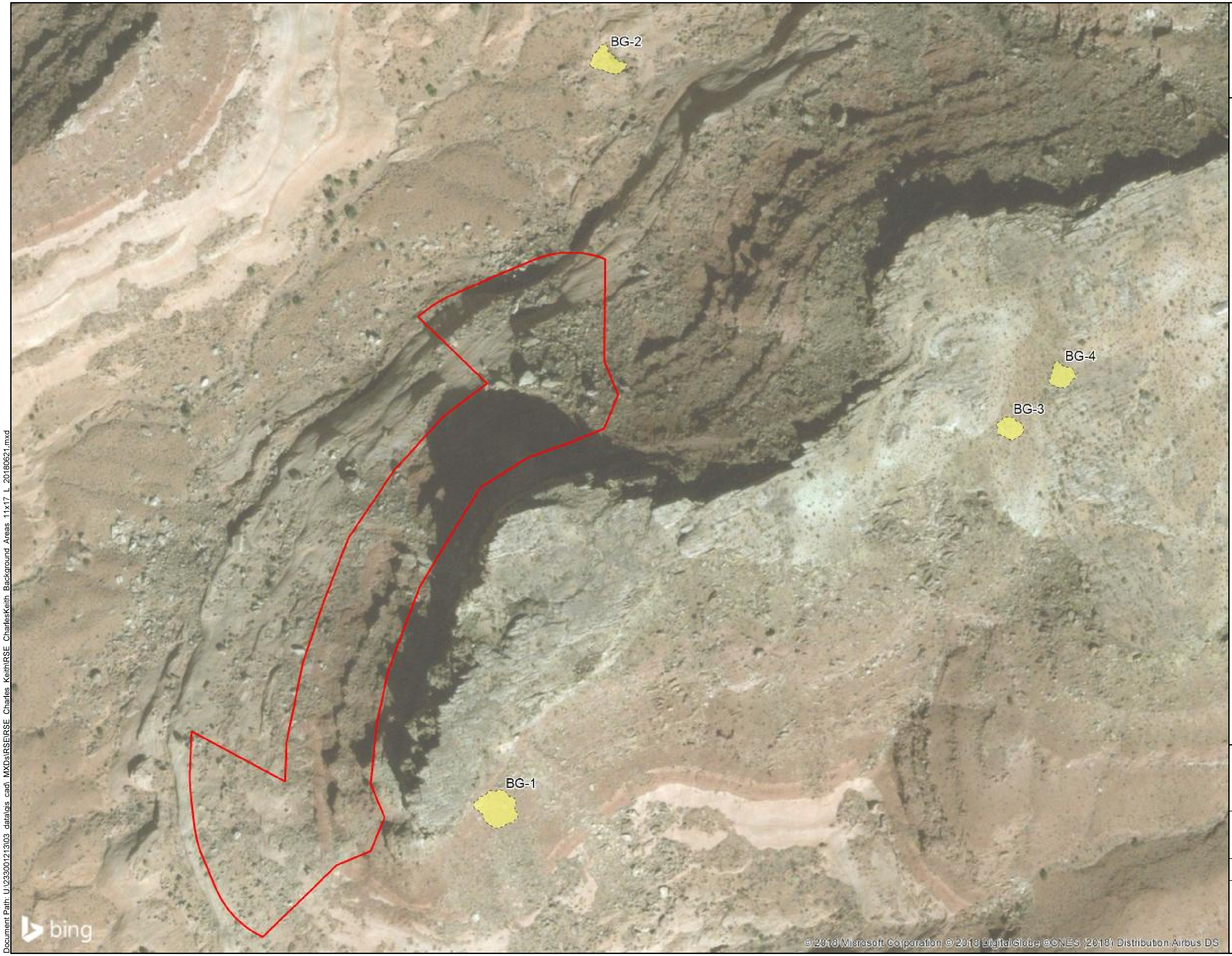
1979 Historical Aerial Photograph Comparison

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/29/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB REVIEWER: EDZ
	FIGURE: 3-1b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Historical_Aerial_1979_11x17_L_20180621.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

🟨 Potential Background Reference Area

☐ Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

N
W E
S

0 200 400
Feet

TITLE:
Potential Background Reference Areas

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

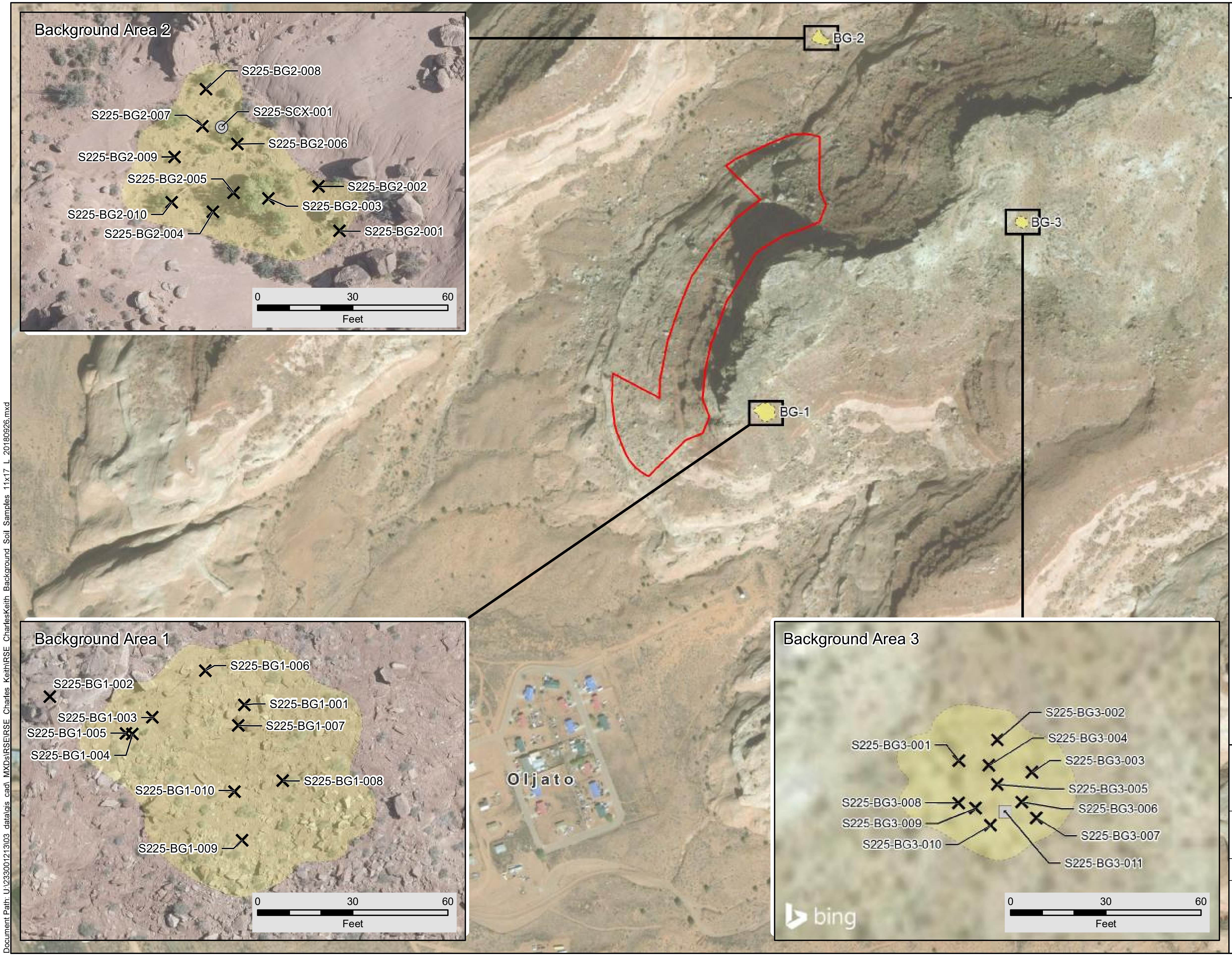
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-2

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Background_Areas_11x17_L_20180621.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▪	Borehole Location - Surface Samples Only
🟨	Background Reference Area
☐	Claim Boundary

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display and background area 3 basemap image inset accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Background area 1 and 2 basemap image insets flown by Cooper Aerial Surveys Co. on June 16, 2017.

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TITLE:

Background Reference Areas - Sample Locations

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

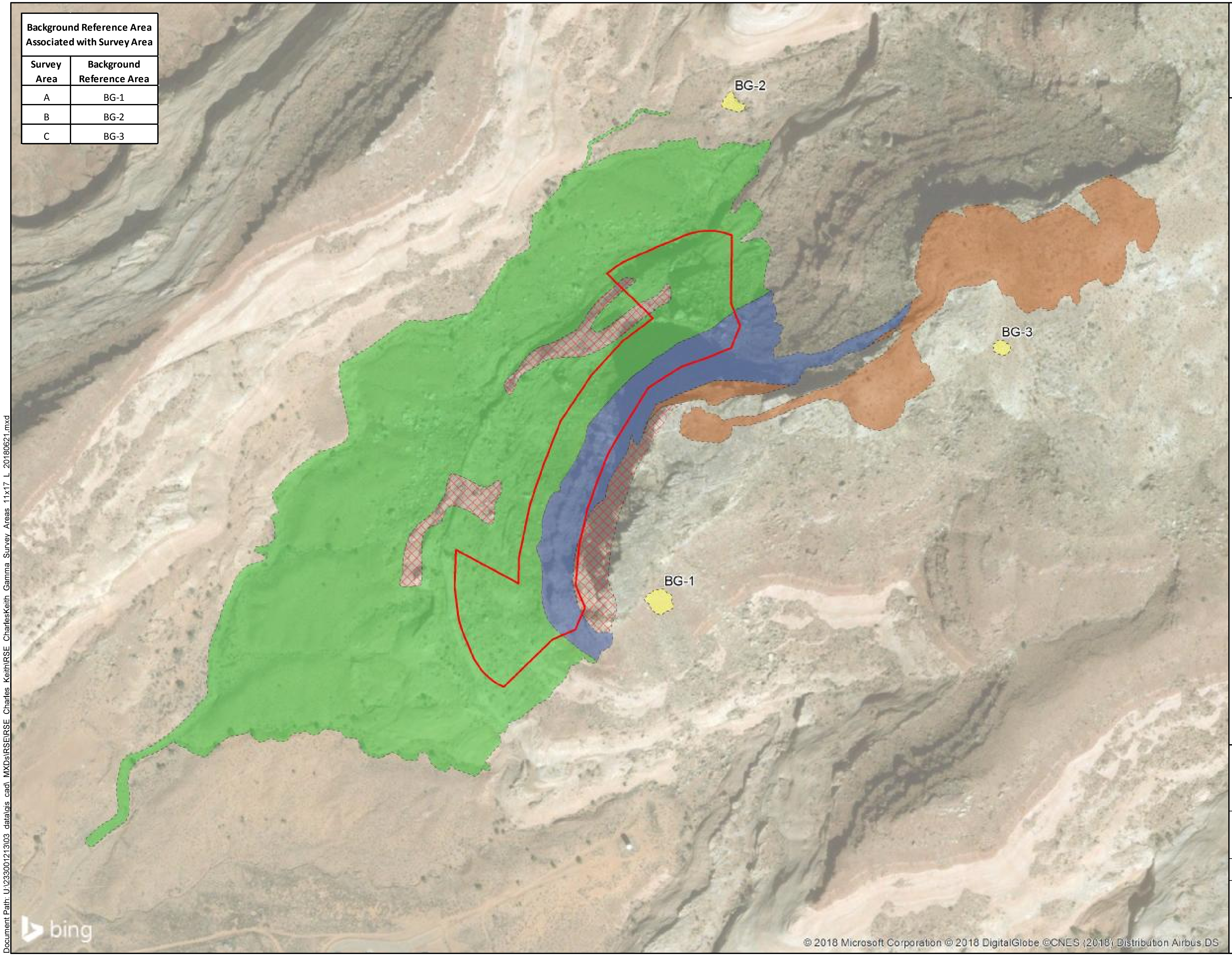
REVIEWER: EDZ

FIGURE: 3-3

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Background_Soil_Samples_11x17_L_20180926.mxd

Background Reference Area Associated with Survey Area

Survey Area	Background Reference Area
A	BG-1
B	BG-2
C	BG-3



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Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Gamma_Survey_Areas_11x17_L_20180621.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

🟨	Background Reference Area
🟦	Survey Area A
🟩	Survey Area B
🟫	Survey Area C
▨	Unsurveyed Area[1]
🟥	Claim Boundary

NOTES:

1. Areas within Survey Areas that were not surveyed (2.9 acres) due to steep/unsafe terrain.

2. Gamma survey area is approximately 49.4 acres.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

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TITLE:

Gamma Radiation Survey Areas

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/26/2018

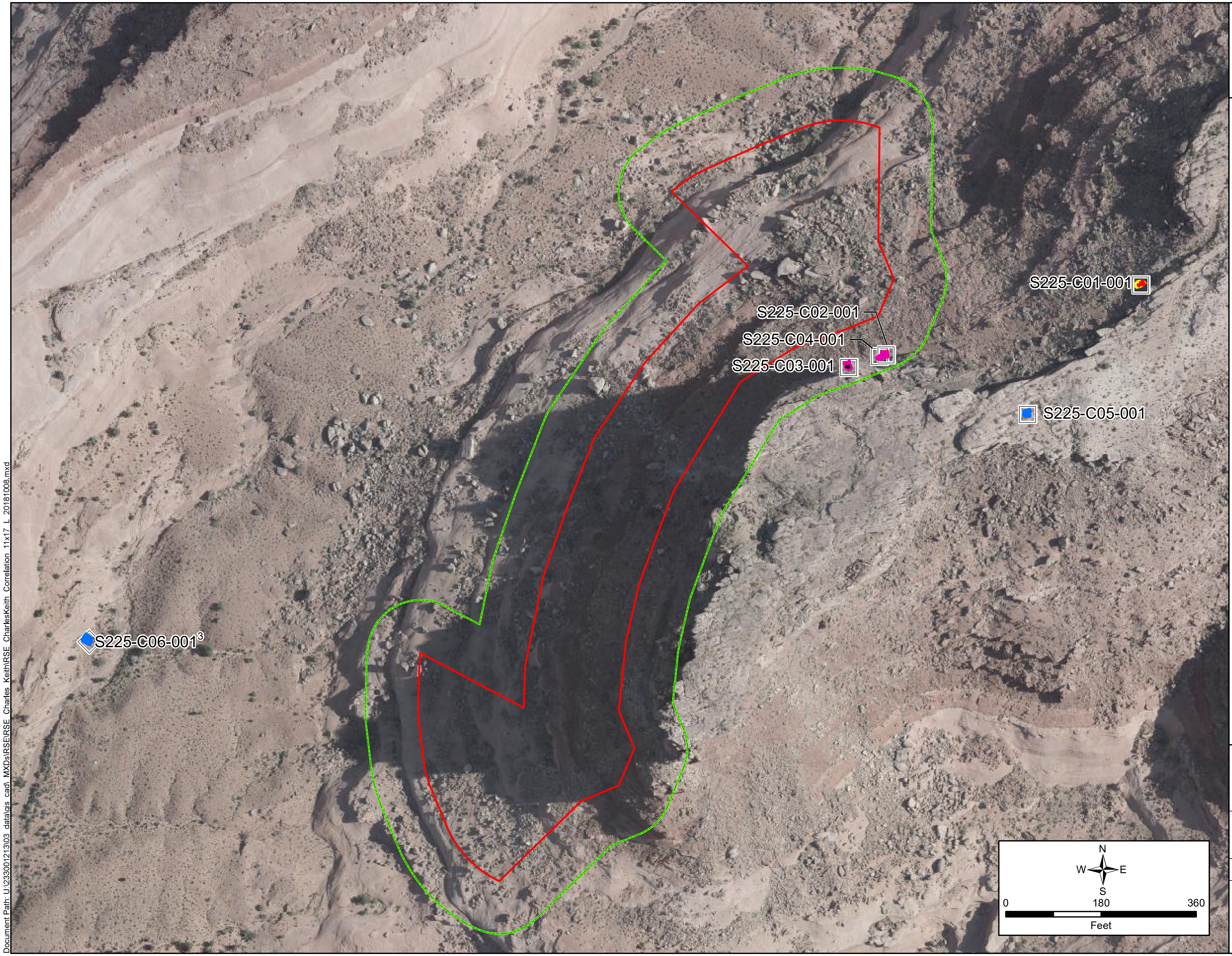
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 3-4



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

☐ S225-C01-001 Correlation Location (30' x 30')

◇ Correlation Location Excluded from Study³

Claim Boundary

100-Foot Claim Buffer

Gamma Survey

Counts per Minute (CPM)

- ● 6,663 - 11,220 (Minimum to BG-2 UTL)
- ● 11,221 - 12,650 (>BG-2 UTL to BG-3 UTL)
- ● 12,651 - 15,040 (>BG-3 UTL to BG-1 UTL)
- ● 15,041 - 22,440 (>BG-1 UTL to 2x BG-2 UTL)
- ● 22,441 - 56,100 (>2x BG-2 UTL to 5x BG-2 UTL)
- ● 56,101 - 58,083 (>5x BG-2 UTL to Maximum)

NOTES:

1. Each correlation sample consists of five grab samples collected from 0.0 - 0.5 feet below ground surface, composited together for laboratory analysis.

2. Correlation study gamma data for locations S225-C01-001 through S225-C05-001 were collected November 3, 2016. Correlation study gamma data for location S225-C06-001 were collected May 24, 2016.

3. Data collected at S225-C06-001 were excluded from the correlation study.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown specifically for the project by Cooper Aerial Surveys Co. on June 16, 2017.

TITLE:

Gamma Correlation Study Locations

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/8/2018

DOCUMENT NAME: Removal Site Evaluation Report

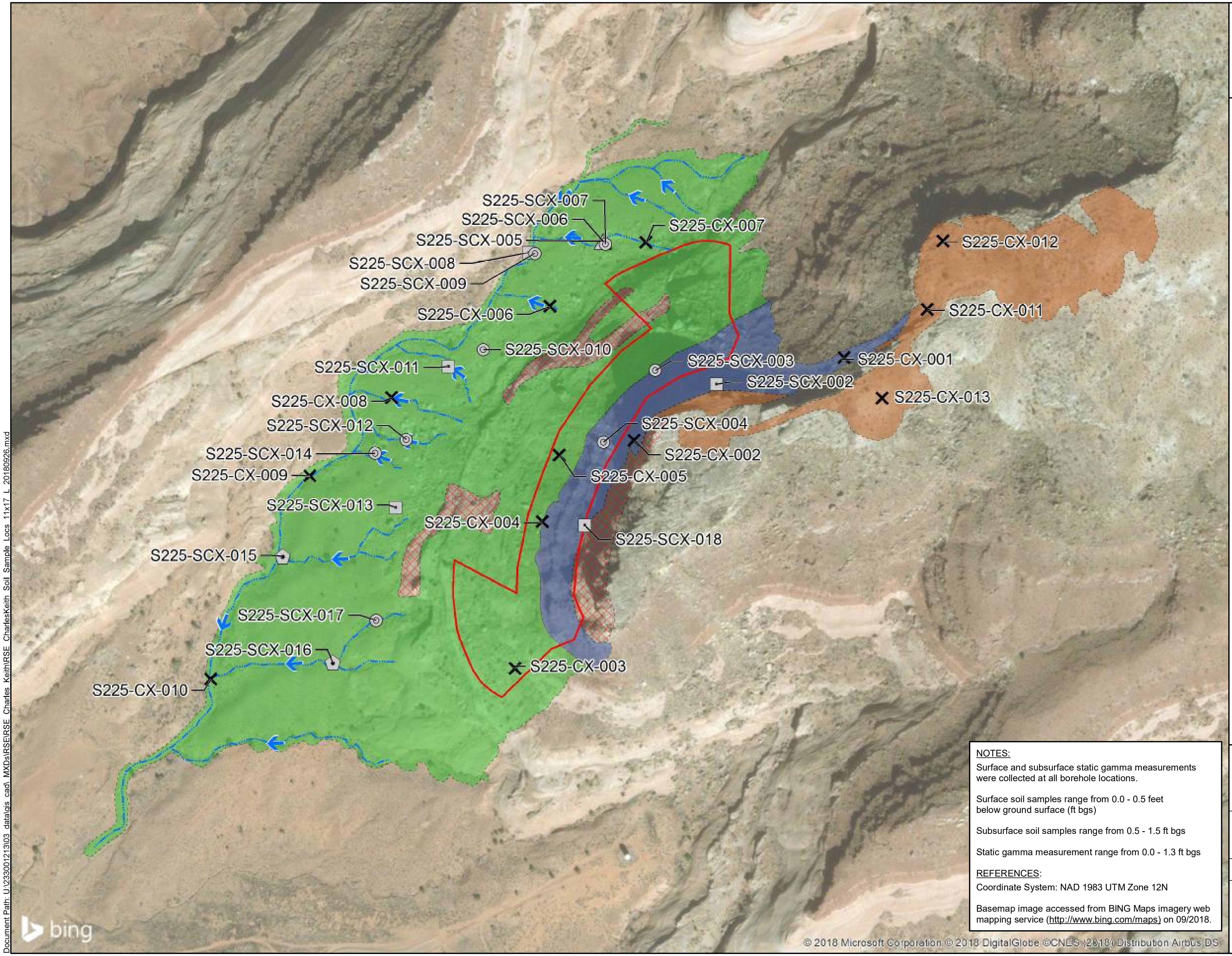
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-5

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Correlation 11x17 L 20181008.mxd



NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.5 - 1.5 ft bgs

Static gamma measurement range from 0.0 - 1.3 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Soil Sample Locs 11x17 L 20180926.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- ⬠ Borehole Location - Subsurface Samples Only
- △ Borehole Location - Static Gamma Data Only
- ↑ Flow Direction
- Drainage
- 🟦 Survey Area A
- 🟩 Survey Area B
- 🟫 Survey Area C
- ▨ Unsurveyed Area
- ☐ Claim Boundary

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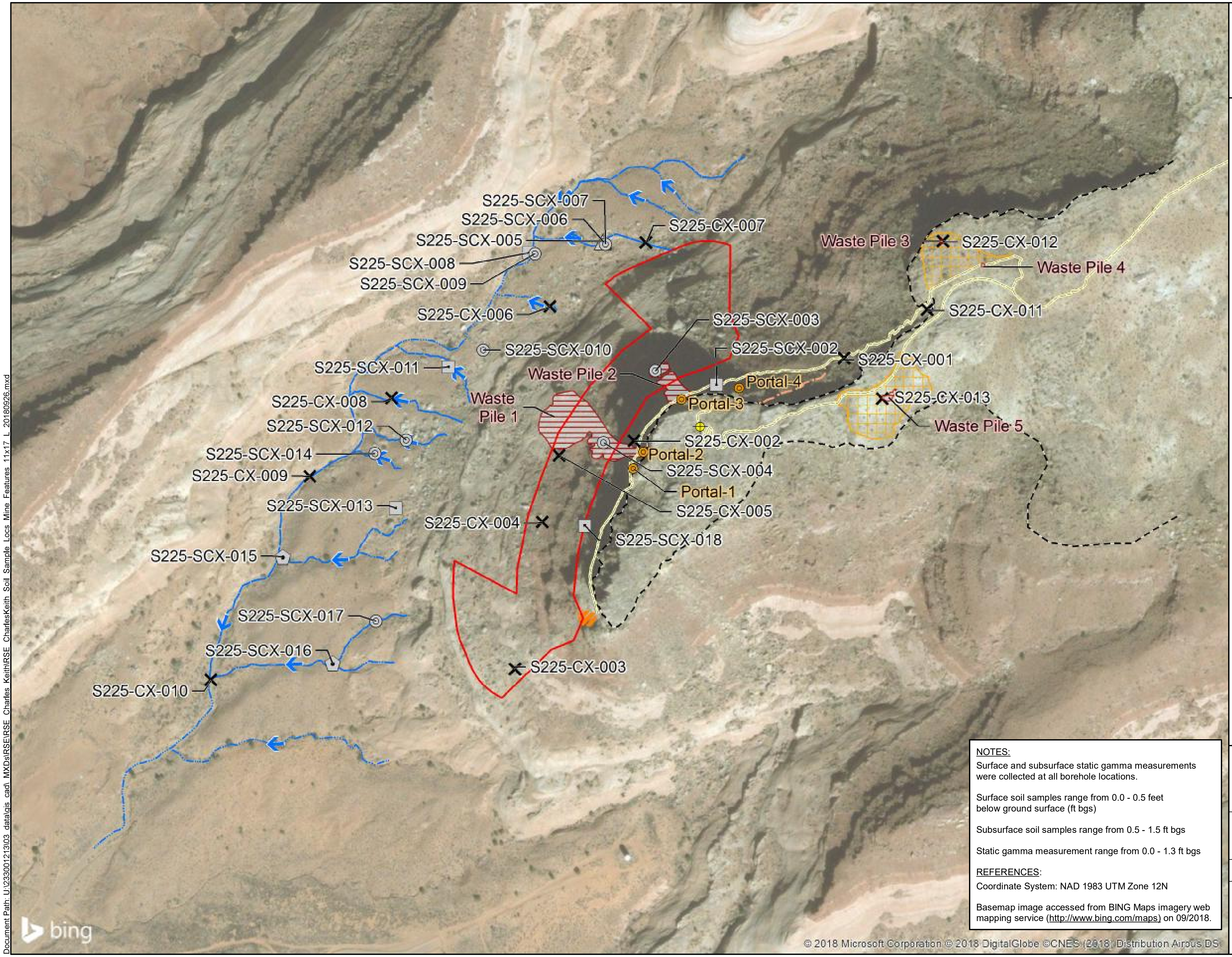
TITLE:

Site Characterization Surface and Subsurface Sample Locations

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/26/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB REVIEWER: EDZ
	FIGURE: 3-6a

NAVAJO NATION
AUM Environmental Response Trust-First Phase



NOTES:

Surface and subsurface static gamma measurements were collected at all borehole locations.

Surface soil samples range from 0.0 - 0.5 feet below ground surface (ft bgs)

Subsurface soil samples range from 0.5 - 1.5 ft bgs

Static gamma measurement range from 0.0 - 1.3 ft bgs

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

LEGEND

- ⊕ Historical Borehole
- ◉ Portal
- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- ⬠ Borehole Location - Subsurface Samples Only
- △ Borehole Location - Static Gamma Data Only
- ↑ Flow Direction
- -·-·- Drainage
- -·-·- Footpath
- ----- Potential Haul Road
- - - - Approximate Edge of Mesa
- ~~~ Drainage
- ▨ Blasted Area
- ▦ Mining Disturbed Area
- ▤ Waste Pile
- ☐ Claim Boundary

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TITLE:
Sample Locations Compared
to Mining-Related Features

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

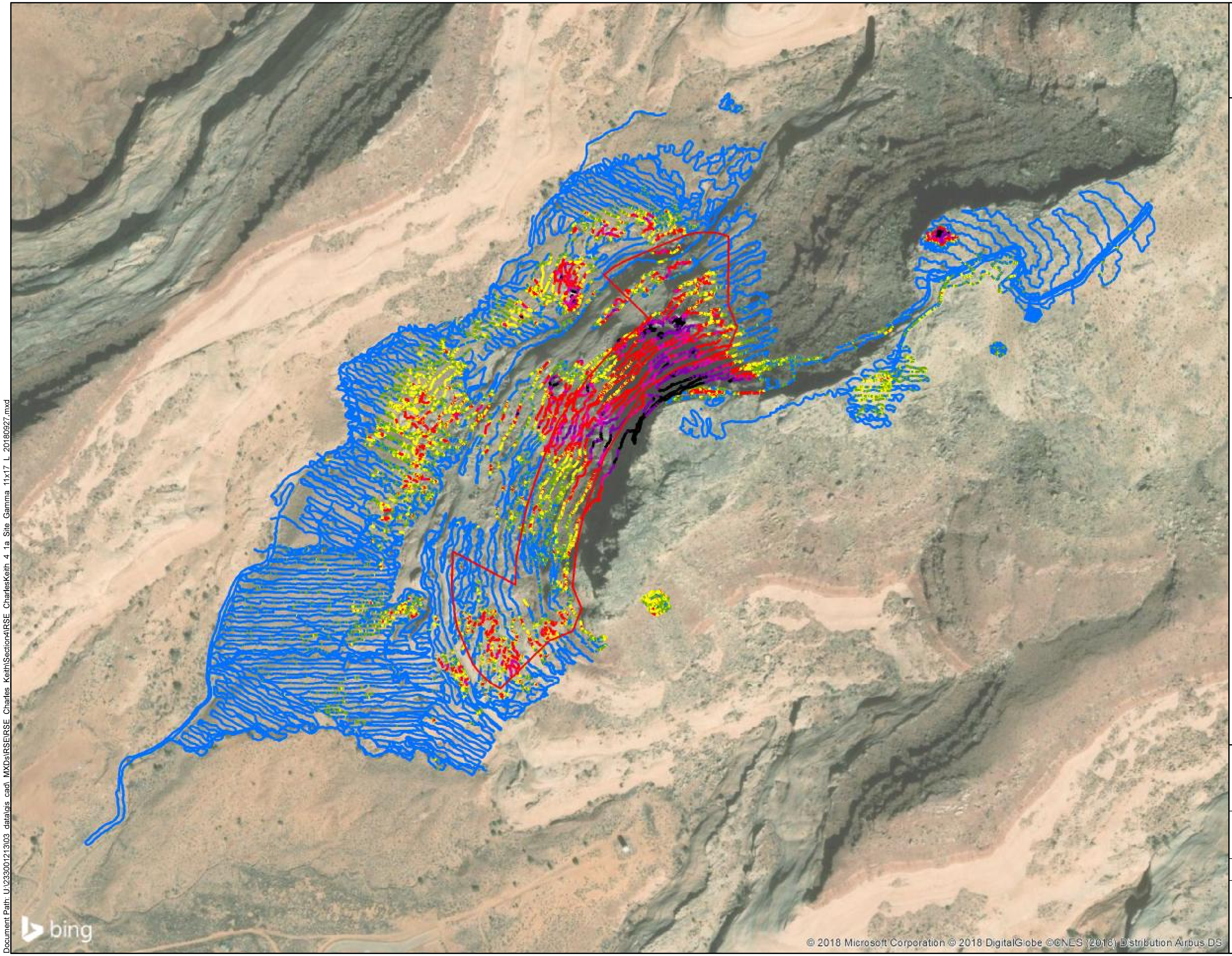
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 3-6b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Soil_Sample_Locs_Mine_Features_11x17_L_20180926.mxd



NAVAJO
NATION
AUM Environmental
Response Trust-First Phase

LEGEND

🟥 Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- ● 4,867 - 11,220 (Minimum to BG-2 IL)
- ● 11,221 - 12,649 (>BG-2 IL to BG-3 IL)
- ● 12,650 - 15,036 (>BG-3 IL to BG-1 IL)
- ● 15,037 - 22,440 (>BG-1 IL to 2x BG-2 IL)
- ● 22,441 - 30,080 (>2x BG-2 IL to 2x BG-1 IL)
- ● 30,081 - 56,100 (>2x BG-1 IL to 5x BG-2 IL)
- ● 56,101 - 328,342 (>5x BG-2 IL to Maximum)

NOTE:
Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

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TITLE:
Gamma Radiation
Survey Results

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/16/2018

DOCUMENT NAME: Removal Site Evaluation Report

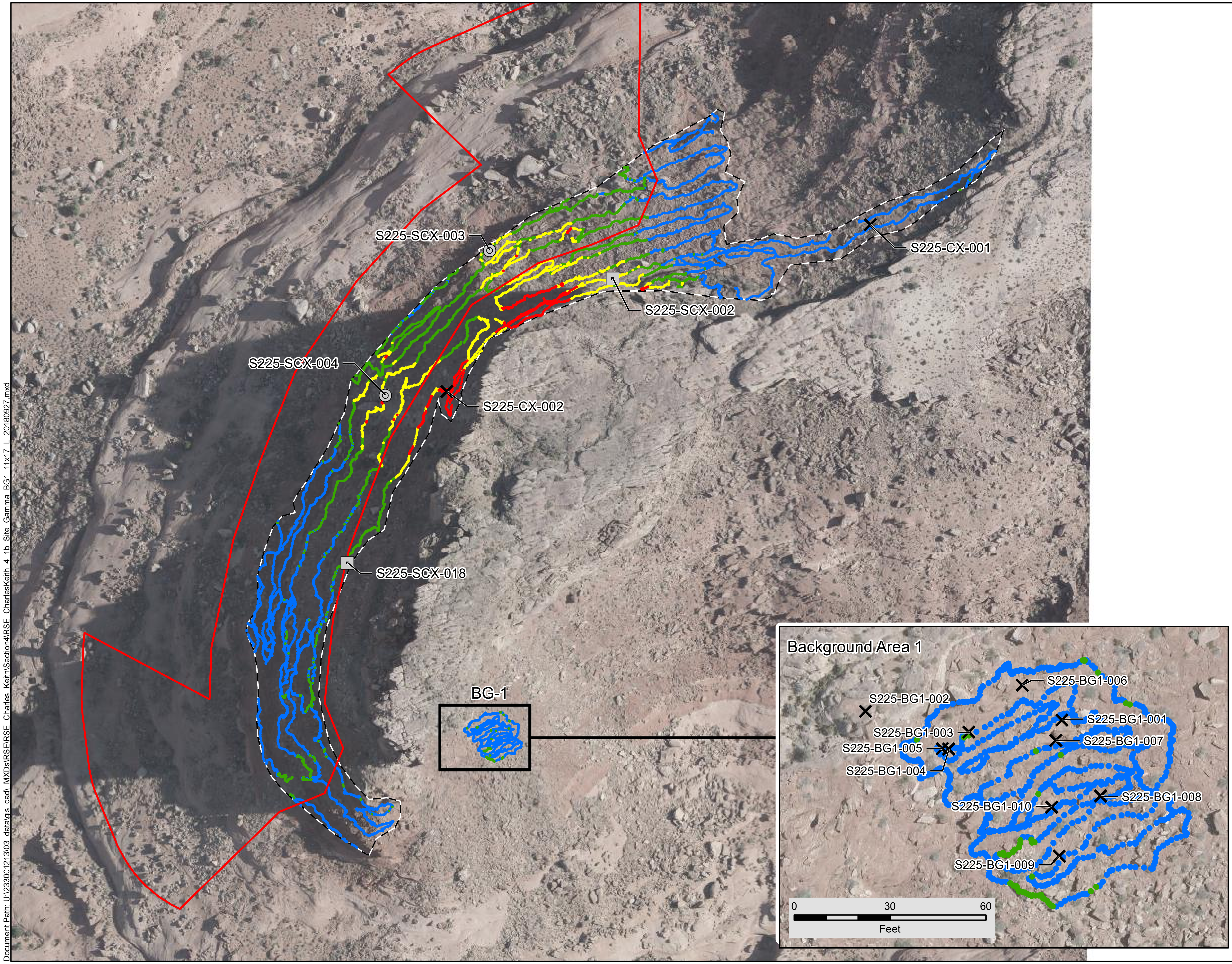
AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-1a

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 1a Site Gamma 11x17 L 20180927.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕ Surface Sample Location

◎ Borehole Location - Surface and Subsurface Samples

▣ Borehole Location - Surface Samples Only

⬚ Survey Area A

🟥 Claim Boundary

Gamma Survey

Counts per Minute (CPM)

● 6,916 - 15,036 (Minimum to BG-1 IL)

● 15,037 - 30,072 (>BG-1 IL to 2x BG-1 IL)

● 30,073 - 75,180 (>2x BG-1 IL to 5x BG-1 IL)

● 75,181 - 328,342 (>5x BG-1 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

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Feet

TITLE:
Gamma Radiation Survey Results
for Survey Area A

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/16/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-1b

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 1b Site Gamma BG1 11x17 L 20180927.mxd

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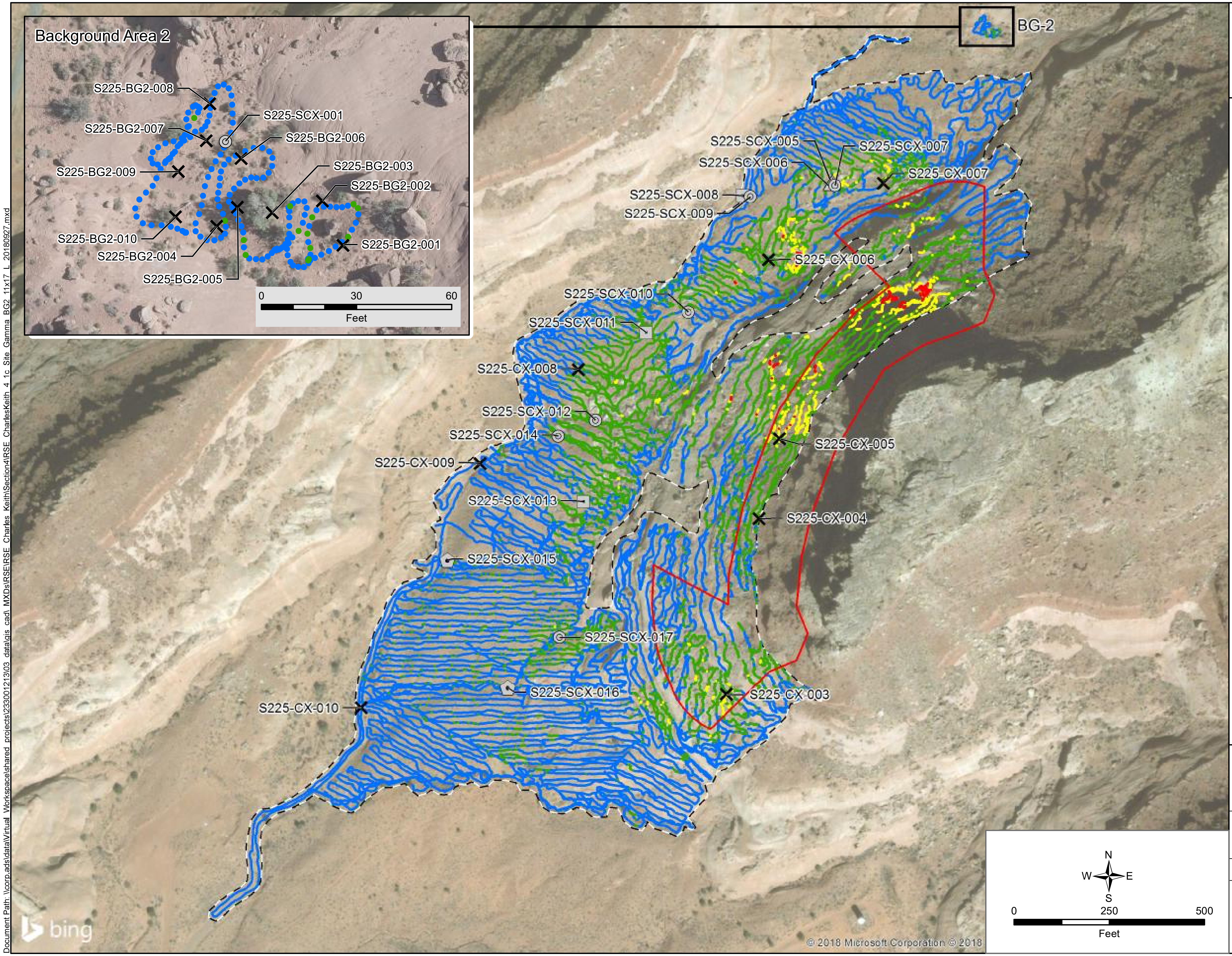


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- ⬠ Borehole Location - Subsurface Samples Only
- △ Borehole Location - Static Gamma Data Only
- ⬚ Survey Area B
- 🟥 Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- ● 4,867 - 11,220 (Minimum to BG-2 IL)
- ● 11,221 - 22,440 (>BG-2 IL to 2x BG-2 IL)
- ● 22,441 - 56,100 (>2x BG-2 IL to 5x BG-2 IL)
- ● 56,101 - 215,310 (>5x BG-2 IL to Maximum)

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

Inset basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

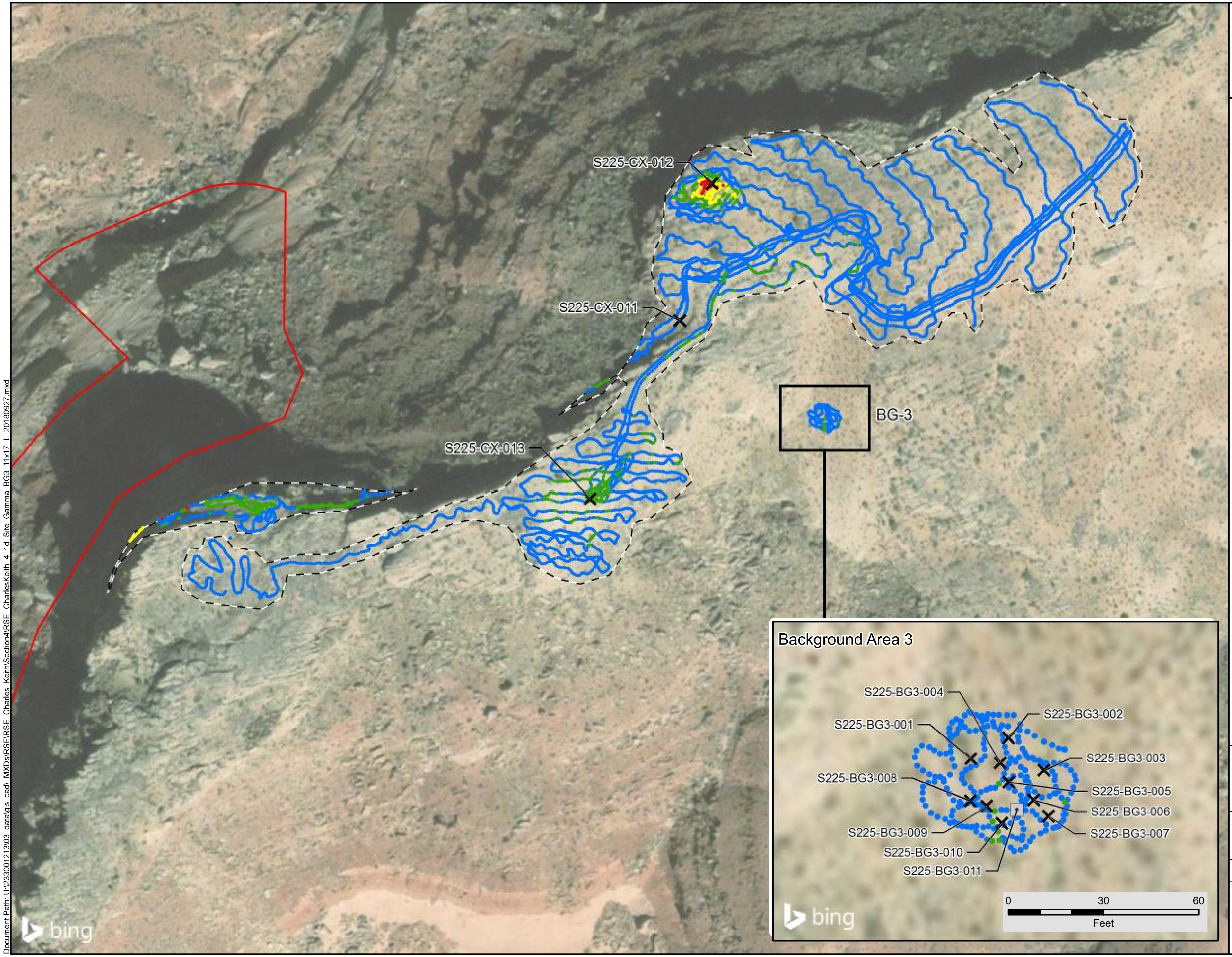
TITLE:
Gamma Radiation Survey Results
for Survey Area B

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/1/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-1c



Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 1d Site Gamma BG3 11x17 L 20180927.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
▪	Borehole Location - Surface Samples Only
⌜ ⌝	Survey Area C
▭	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	4,955 - 12,649 (Minimum to BG-3 IL)
●	12,650 - 25,298 (>BG-3 IL to 2x BG-3 IL)
●	25,299 - 63,245 (>2x BG-3 IL to 5x BG-3 IL)
●	63,246 - 295,008 (>5x BG-3 IL to Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

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TITLE:
Gamma Radiation Survey Results
for Survey Area C

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/16/2018

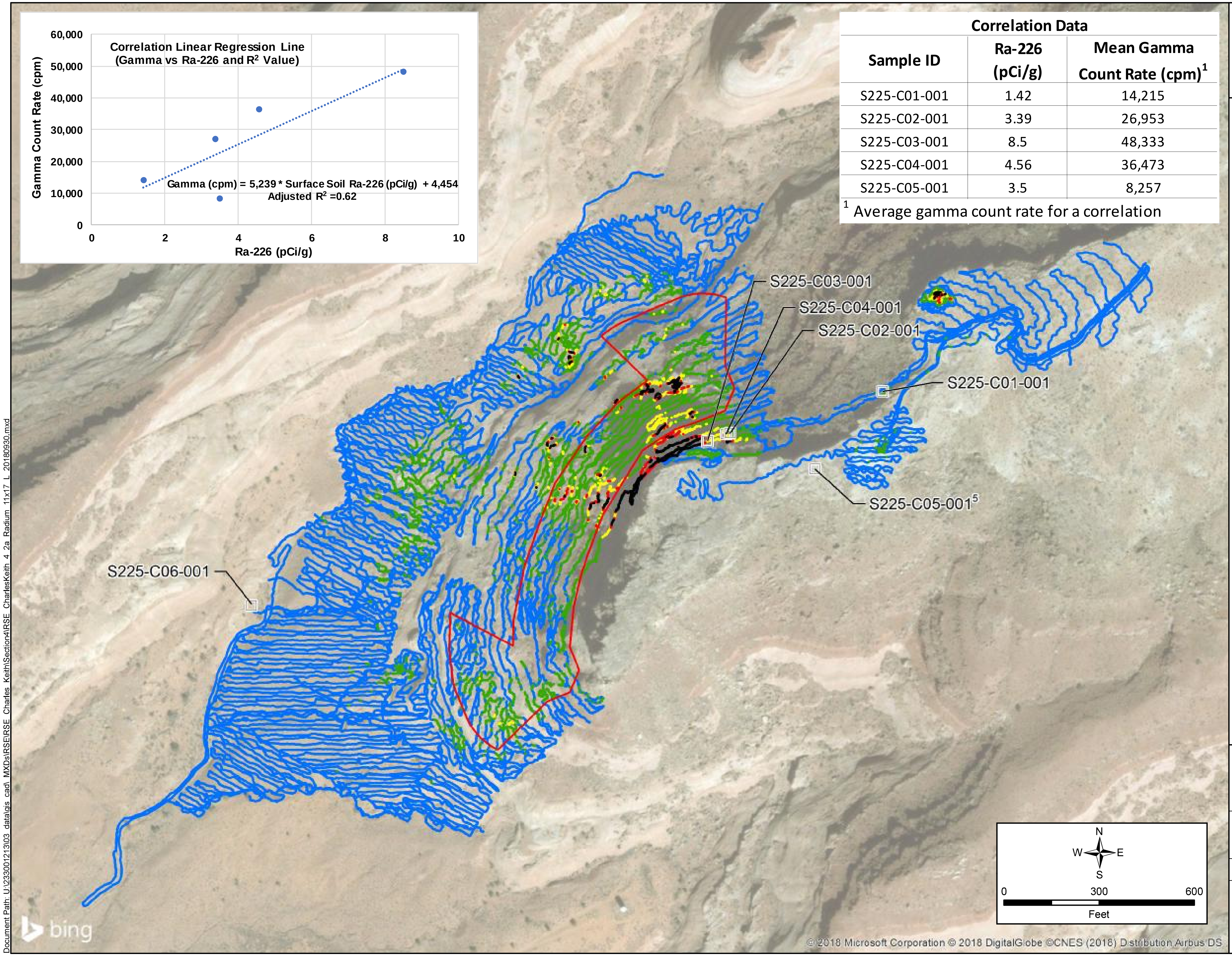
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-1d



Correlation Data

Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (cpm)[1]
S225-C01-001	1.42	14,215
S225-C02-001	3.39	26,953
S225-C03-001	8.5	48,333
S225-C04-001	4.56	36,473
S225-C05-001	3.5	8,257

[1] Average gamma count rate for a correlation

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NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

☐	S225-C01-001 Correlation Location (30' x 30')
🟥	Claim Boundary

Predicted Ra-226 Concentration[1,2] (pCi/g)

●	0.1 - 1.8 (μ)[3]
●	1.9 - 4.7 (μ + 1σ[4])
●	4.8 - 7.6 (μ + 2σ)
●	7.7 - 10.5 (μ + 3σ)
●	10.6 - 61.8

NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (cpm) = 5,239 x Surface Soil Ra-226 (pCi/g) + 4,454

2. The correlation did not meet the Data Quality Objective (R2 > 0.8), users should be cautious when estimating radium-226 concentrations.

3. Mean (μ) of predicted concentrations of Ra-226 in soil (1.8 pCi/g).

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (2.9 pCi/g).

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 48,000 CPM or less than approximately 8,000 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

TITLE:

Predicted Concentrations of Ra-226 in Soil Using the Correlation Equation

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/30/2018

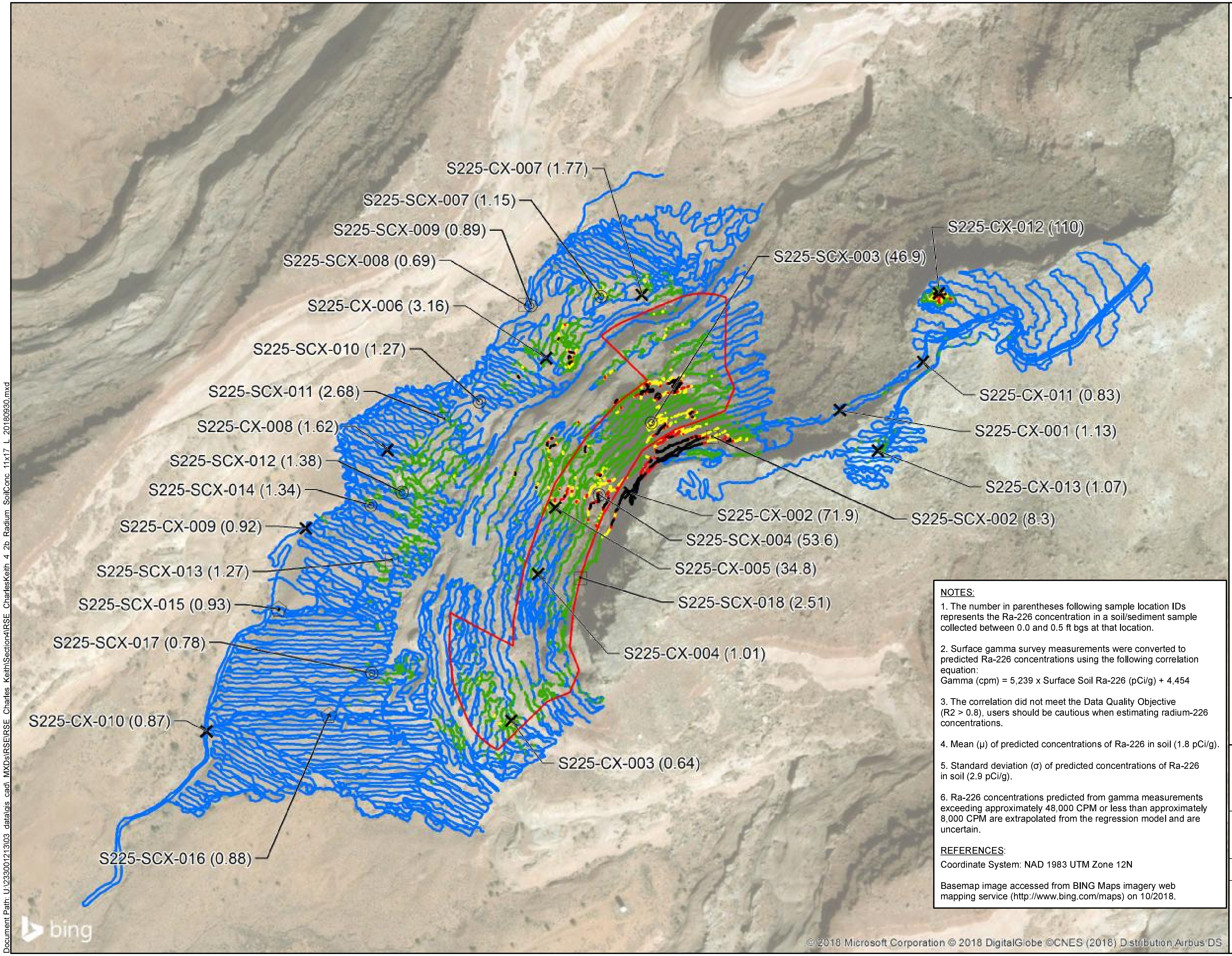
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-2a



NOTES:

1. The number in parentheses following sample location IDs represents the Ra-226 concentration in a soil/sediment sample collected between 0.0 and 0.5 ft bgs at that location.

2. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (cpm) = 5,239 x Surface Soil Ra-226 (pCi/g) + 4,454

3. The correlation did not meet the Data Quality Objective (R2 > 0.8), users should be cautious when estimating radium-226 concentrations.

4. Mean (μ) of predicted concentrations of Ra-226 in soil (1.8 pCi/g).

5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (2.9 pCi/g).

6. Ra-226 concentrations predicted from gamma measurements exceeding approximately 48,000 CPM or less than approximately 8,000 CPM are extrapolated from the regression model and are uncertain.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
⊡	Borehole Location - Surface Samples Only
⬠	Borehole Location - Subsurface Samples Only
🟥	Claim Boundary

Predicted Ra-226 Concentration^{2,3} (pCi/g)

●	0.1 - 1.8 (μ)^4
●	1.9 - 4.7 (μ + 1σ^5)
●	4.8 - 7.6 (μ + 2σ)
●	7.7 - 10.5 (μ + 3σ)
●	10.6 - 61.8

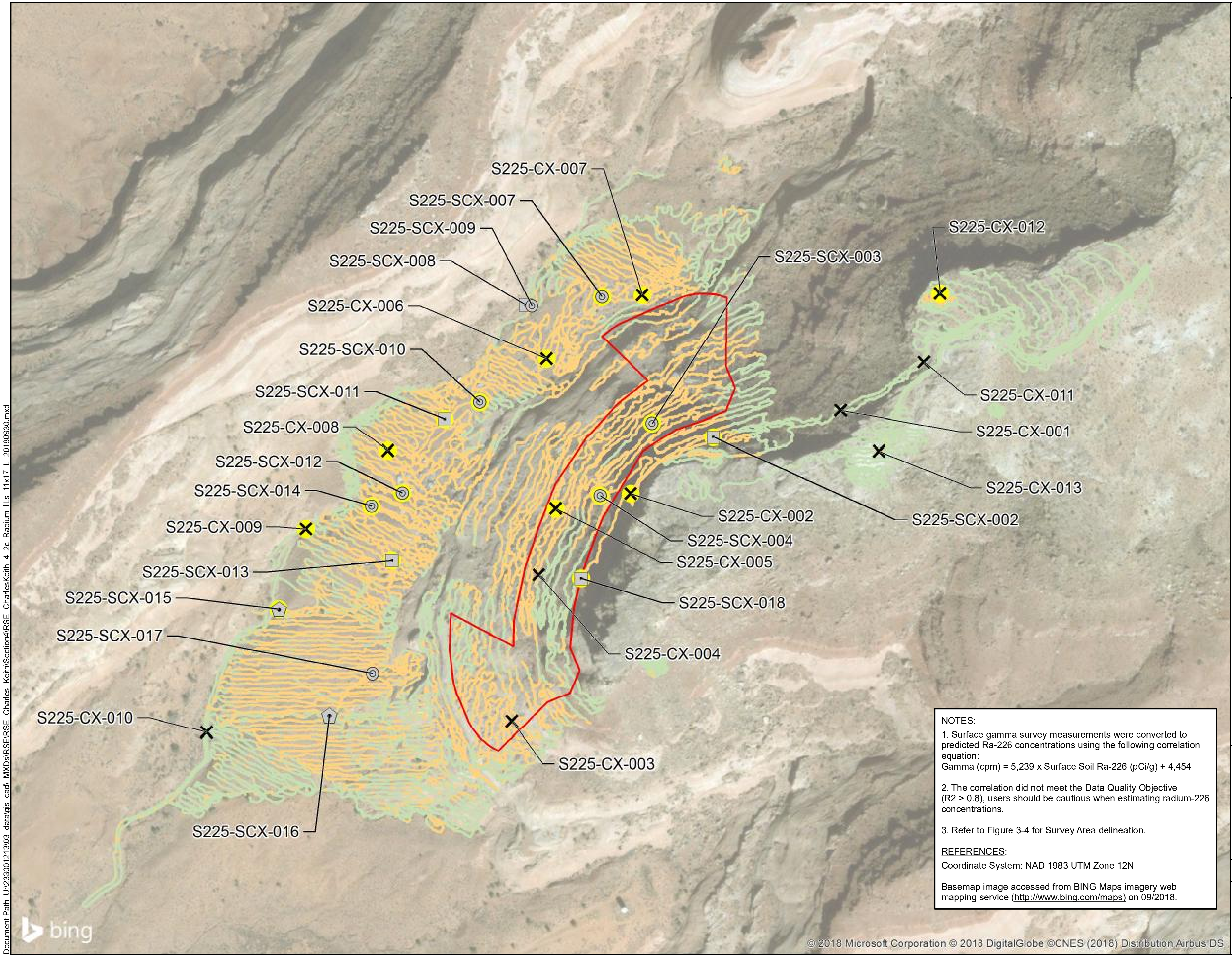
TITLE:
Predicted Ra-226 Concentrations in Soil Compared to Ra-226 Concentrations in Soil/Sediment

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/1/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB
	REVIEWER: EDZ
	FIGURE: 4-2b

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 2b Radium SoilConc 11x17 L 20180930.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase



NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (cpm) = 5,239 x Surface Soil Ra-226 (pCi/g) + 4,454

2. The correlation did not meet the Data Quality Objective (R2 > 0.8), users should be cautious when estimating radium-226 concentrations.

3. Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
●	Ra-226 IL Exceedance in Surface Soil
▭	Claim Boundary

Predicted Ra-226
Concentrations (pCi/g)

● IL Not Exceeded
Survey Area A: 0.5 - 2.43
Survey Area B: 0.1 - 0.909
Survey Area C: 0.1 - 2.08

● IL Exceeded
Survey Area A: 2.44 - 61.8
Survey Area B: 0.910 - 40.2
Survey Area C: 2.09 - 55.5

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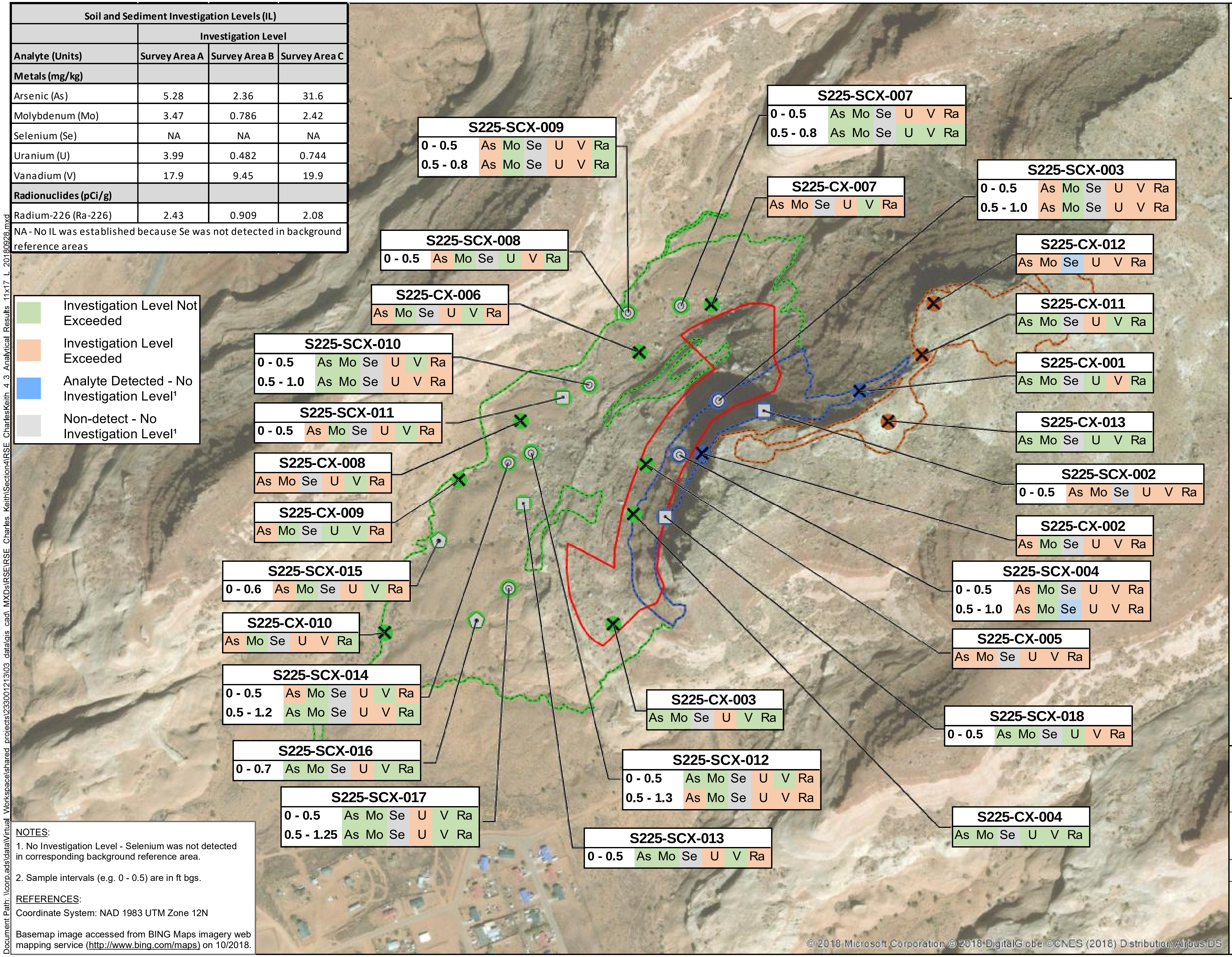
TITLE:
Predicted Ra-226 Concentrations in Soil Compared to Ra-226 ILs

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/30/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-2c

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 2c Radium ILs 11x17 L 20180930.mxd



Soil and Sediment Investigation Levels (IL)

	Investigation Level		
Analyte (Units)	**Survey Area A**	**Survey Area B**	**Survey Area C**
Metals (mg/kg)			
Arsenic (As)	5.28	2.36	31.6
Molybdenum (Mo)	3.47	0.786	2.42
Selenium (Se)	NA	NA	NA
Uranium (U)	3.99	0.482	0.744
Vanadium (V)	17.9	9.45	19.9
Radionuclides (pCi/g)			
Radium-226 (Ra-226)	2.43	0.909	2.08

NA - No IL was established because Se was not detected in background reference areas

🟩	Investigation Level Not Exceeded
🟧	Investigation Level Exceeded
🟦	Analyte Detected - No Investigation Level¹
⬜	Non-detect - No Investigation Level¹

NOTES:

1. No Investigation Level - Selenium was not detected in corresponding background reference area.

2. Sample intervals (e.g. 0 - 0.5) are in ft bgs.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 3 Analytical Results 11x17 L 20180928.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

⊗	Survey Area A - Surface Sample Location
◎	Survey Area A - Borehole Location - Surface and Subsurface Samples
⊡	Survey Area A - Borehole Location - Surface Samples Only
⊗	Survey Area B - Surface Sample Location
◎	Survey Area B - Borehole Location - Surface and Subsurface Samples
⊡	Survey Area B - Borehole Location - Surface Samples Only
⊙	Survey Area B - Borehole Location - Subsurface Samples Only
⊗	Survey Area C - Surface Sample Location
▢	Survey Area A
▢	Survey Area B
▢	Survey Area C
▢	Claim Boundary

TITLE:

Surface and Subsurface Metals and Ra-226 Analytical Results

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/1/2018

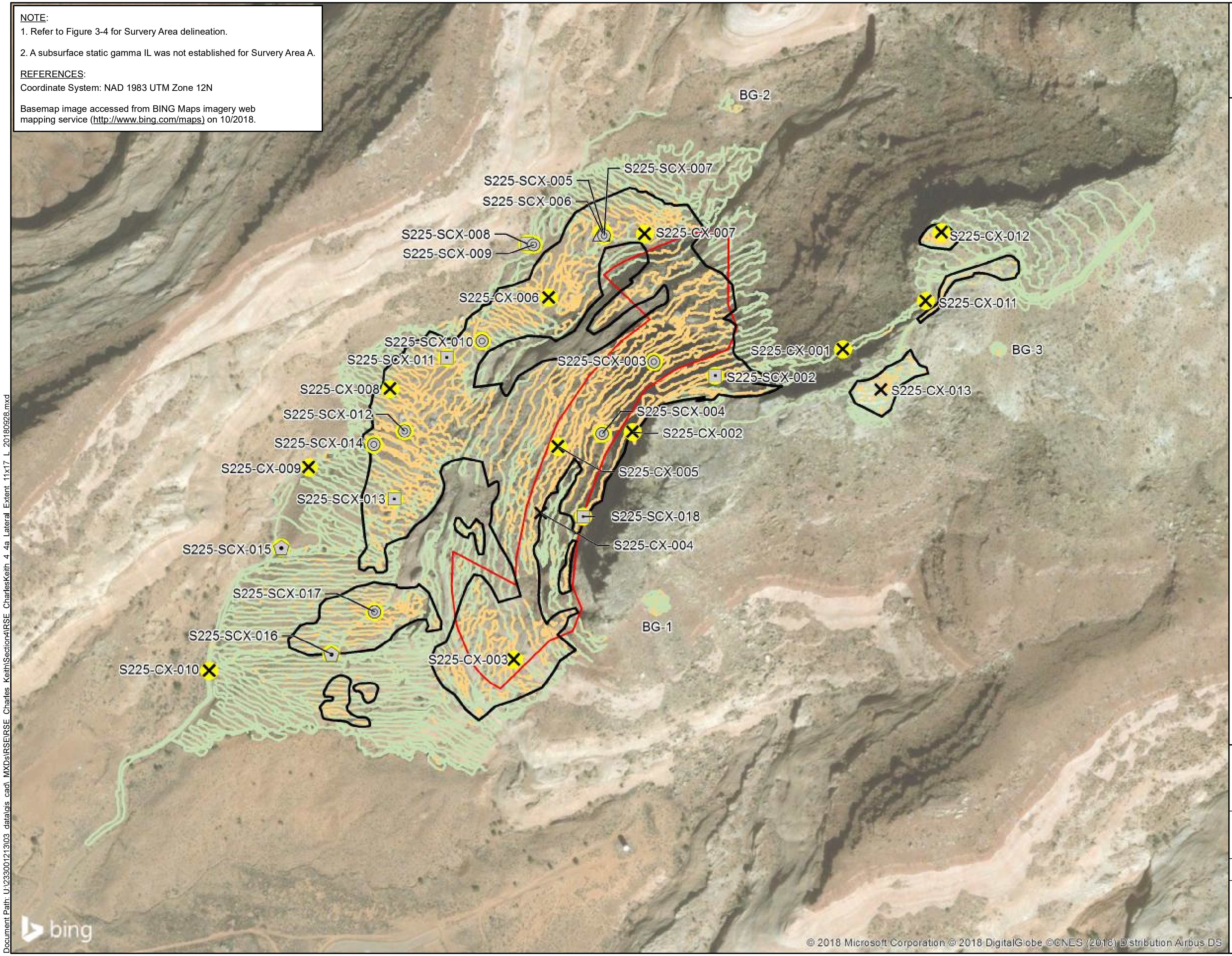
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-3



NOTE:
1. Refer to Figure 3-4 for Survery Area delineation.
2. A subsurface static gamma IL was not established for Survery Area A.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕ Surface Sample Location
◎ Borehole Location - Surface and Subsurface Samples
▣ Borehole Location - Surface Samples Only
⬠ Borehole Location - Subsurface Samples Only
▲ Borehole Location - Static Gamma Data Only
● IL Exceedance in Unconsolidated Material at Location
▭ Approximate Area where Surface Gamma ILs are Exceeded (22.7 acres)
▭ Claim Boundary

Gamma Survey

Counts per Minute (CPM)

● IL Not Exceeded
Survey Area A: 6,916 - 15,036
Survey Area B: 4,867 - 11,220
Survey Area C: 4,955 - 12,649

● IL Exceeded
Survey Area A: 15,037 - 328,342
Survey Area B: 11,221 - 215,310
Survey Area C: 12,650 - 295,008

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0 300 600
Feet

TITLE:
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/3/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ

FIGURE: 4-4a

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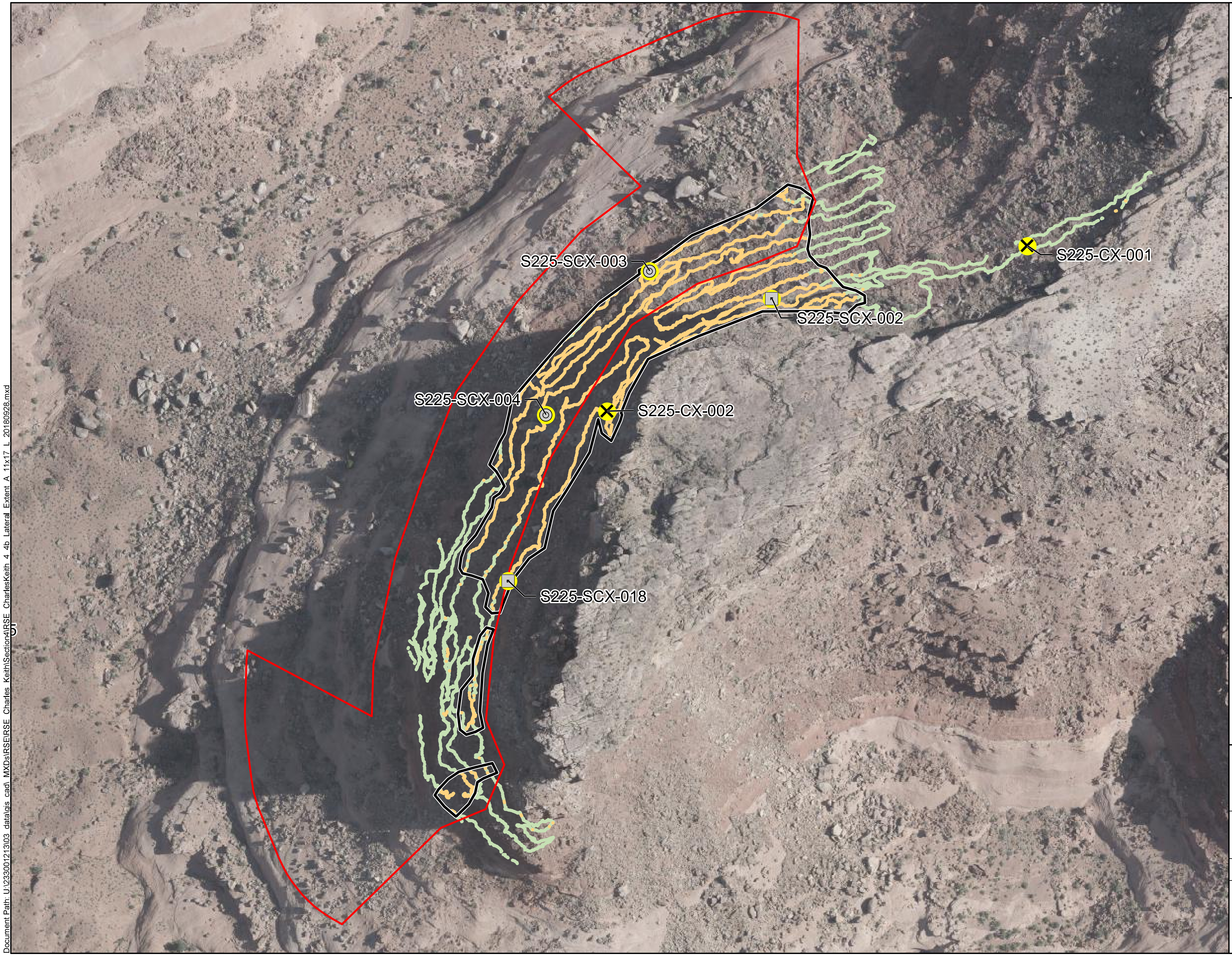


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
●	IL Exceedance in Unconsolidated Material at Location
▭	Approximate Area where Surface Gamma IL is Exceeded (2.7 acres)
▭	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	6,916 - 15,036 (IL Not Exceeded)
●	15,037 - 328,342 (IL Exceeded)

NOTE:
A subsurface static gamma IL was not established for Survery Area A.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

N
W E
S

0 150 300
Feet

TITLE:
Survey Area A
Lateral Extent of Surface and
Subsurface IL Exceedances

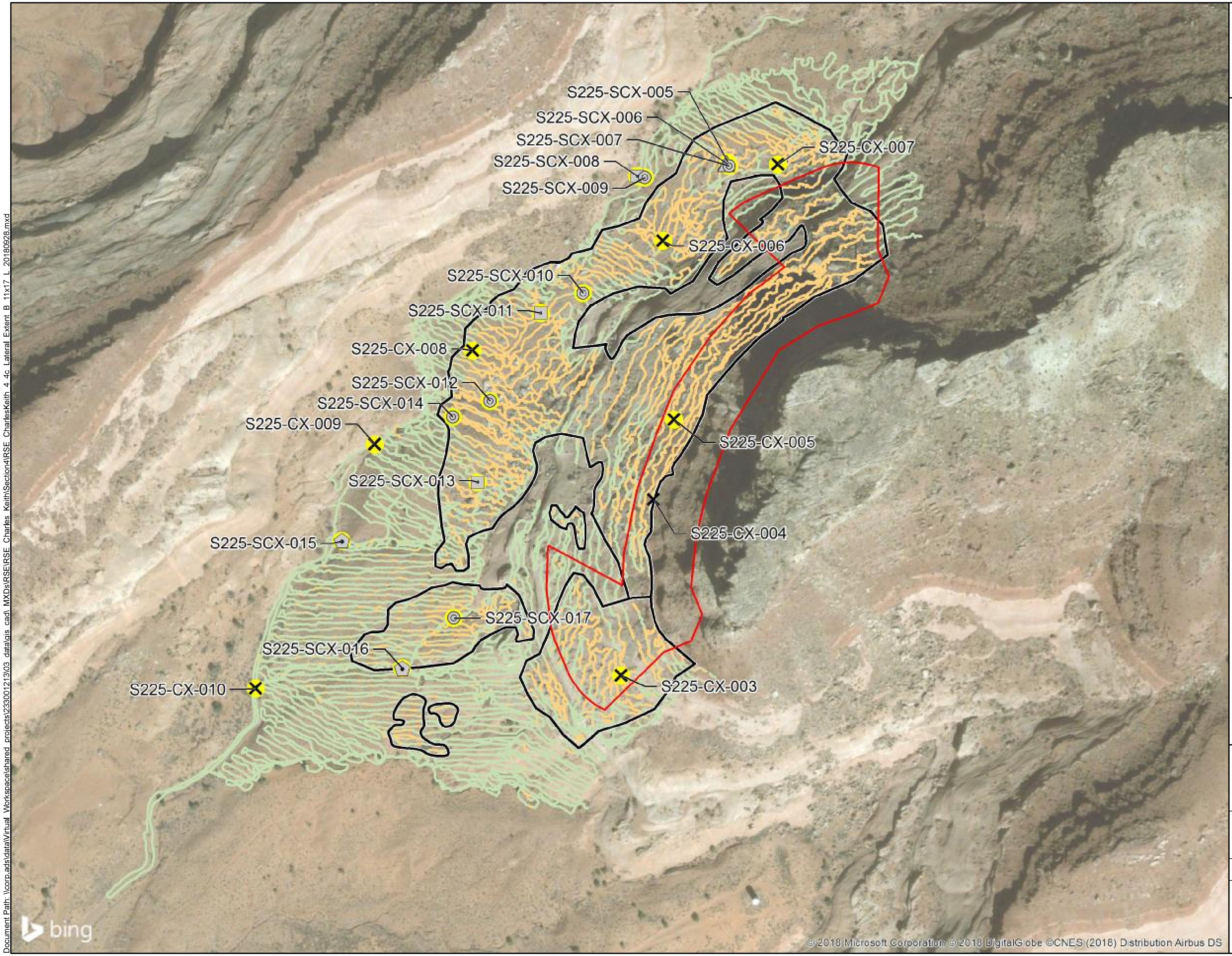
PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/3/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-4b

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 4b Lateral Extent A 11x17 L 20180928.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
⬠	Borehole Location - Subsurface Samples Only
△	Borehole Location - Static Gamma Data Only
●	IL Exceedance in Unconsolidated Material at Location
⌐	Claim Boundary
▢	Approximate Area where Surface Gamma IL is Exceeded (18.6 acres)

Gamma Survey

Counts per Minute (CPM)

●	4,867 - 11,220 (IL Not Exceeded)
●	11,221 - 215,310 (IL Exceeded)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

N
W E
S
0 250 500
Feet

TITLE:
Survey Area B
Lateral Extent of Surface and
Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/1/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-4c

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NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕ Surface Sample Location

● IL Exceedance in Unconsolidated Material at Location

▢ Approximate Area where Surface Gamma IL is Exceeded (1.4 acres)

▢ Claim Boundary

Gamma Survey

Counts per Minute (CPM)

● 4,955 - 12,649 (IL Not Exceeded)

● 12,650 - 295,008 (IL Exceeded)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

N
W E
S
0 150 300
Feet

TITLE:
Survey Area C
Lateral Extent of Surface and
Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/1/2018

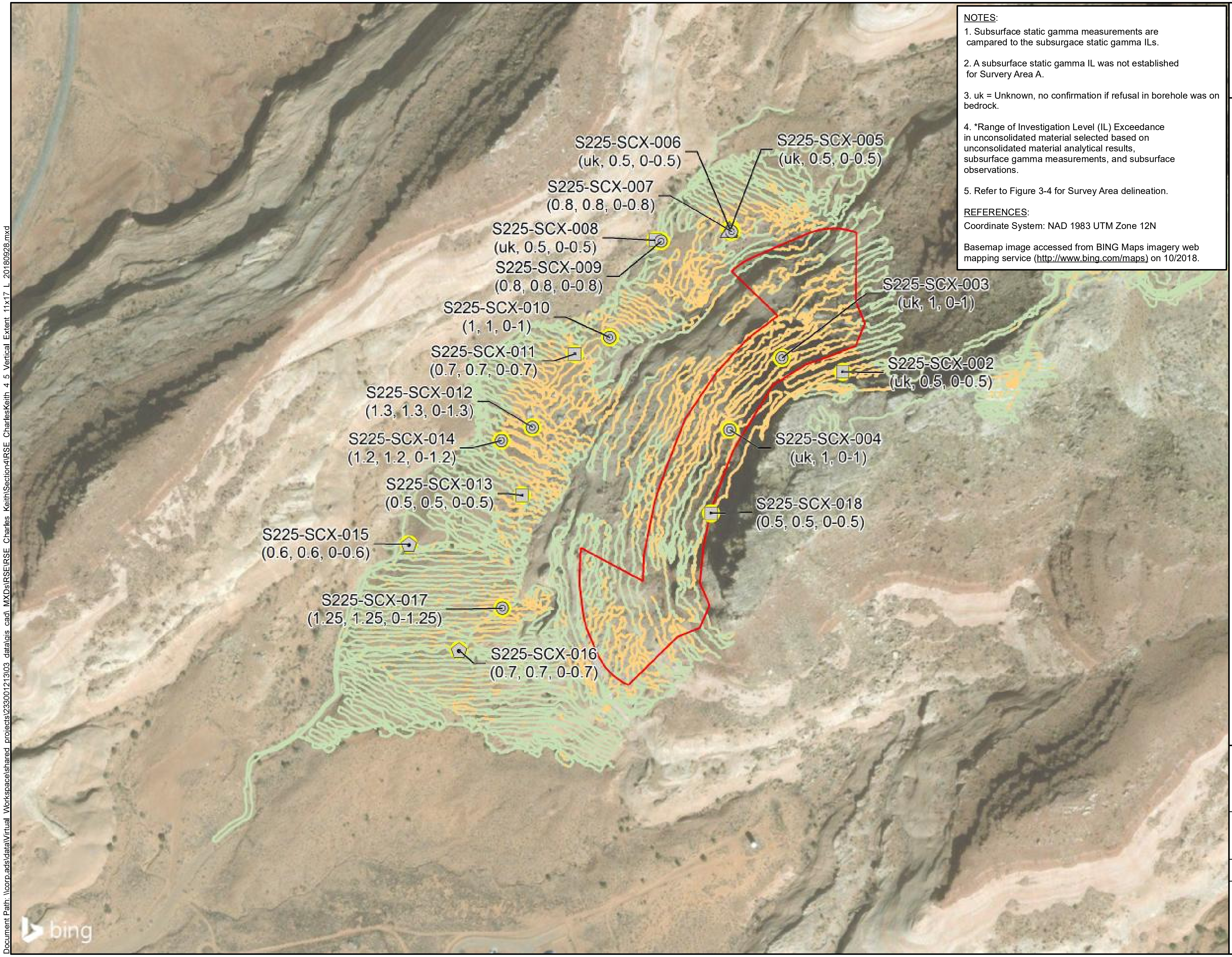
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-4d



NOTES:

1. Subsurface static gamma measurements are compared to the subsurgace static gamma ILs.

2. A subsurface static gamma IL was not established for Survery Area A.

3. uk = Unknown, no confirmation if refusal in borehole was on bedrock.

4. *Range of Investigation Level (IL) Exceedance in unconsolidated material selected based on unconsolidated material analytical results, subsurface gamma measurements, and subsurface observations.

5. Refer to Figure 3-4 for Survey Area delineation.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S225-SCX-018 (0.5, 0.5, 0-0.5) Sample ID (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material or Depth of Gamma IL Exceedance in Unconsolidated Material)

- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- ⬠ Borehole Location - Subsurface Samples Only
- △ Borehole Location - Static Gamma Data Only
- ● IL Exceedance in Unconsolidated Material at Location
- ▭ Claim Boundary

Gamma Survey

Counts per Minute (CPM)

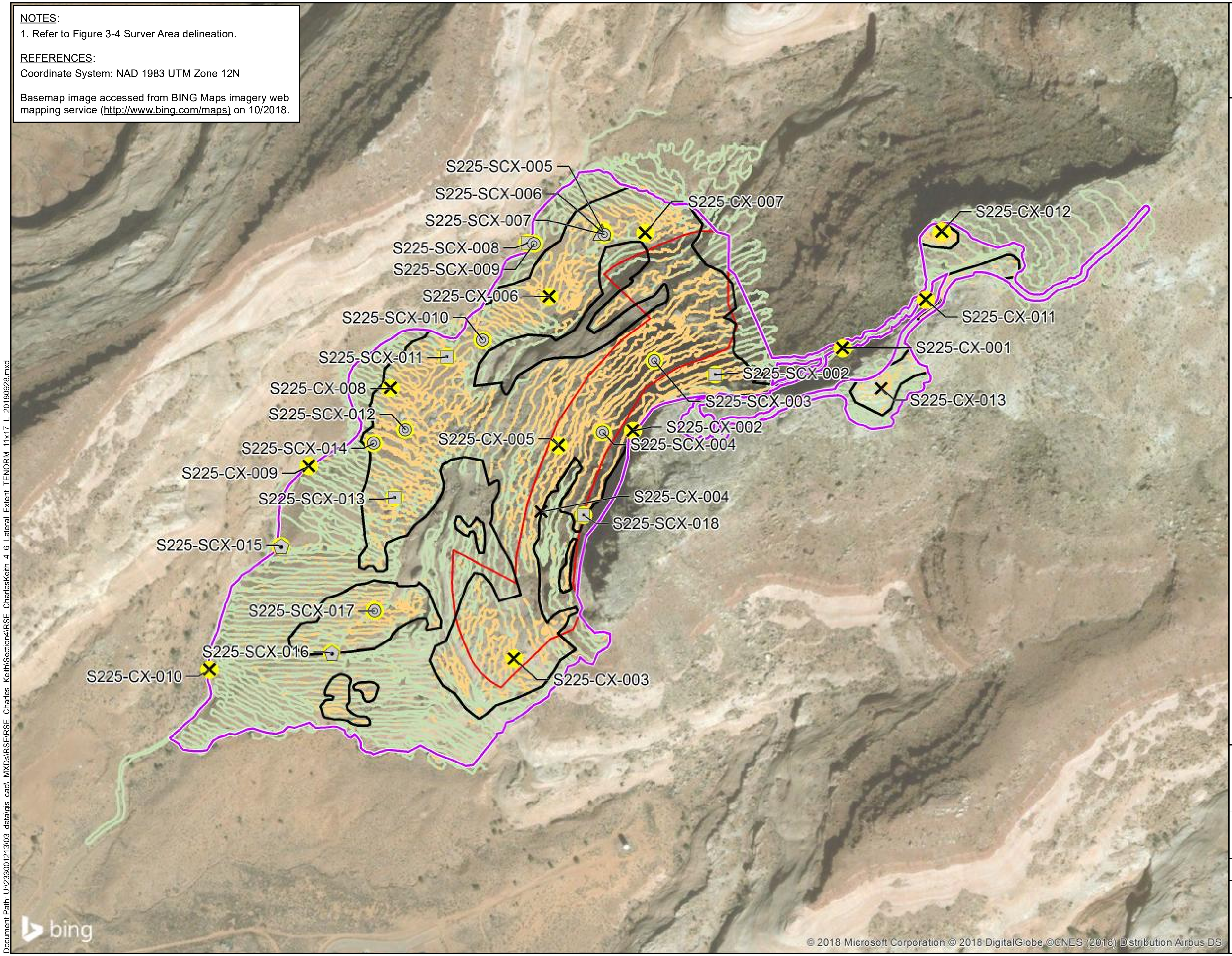
- ● IL Not Exceeded
  - Survey Area A: 6,916 - 15,036
  - Survey Area B: 4,867 - 11,220
  - Survey Area C: 4,955 - 12,649
- ● IL Exceeded
  - Survey Area A: 15,037 - 328,342
  - Survey Area B: 11,221 - 215,310
  - Survey Area C: 12,650 - 295,008

TITLE:
Vertical Extent of IL Exceedances in Unconsolidated Material

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/1/2018
DOCUMENT NAME: Removal Site Evaluation Report
Stantec
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-5

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith\Section4\RSE CharlesKeith 4 5 Vertical Extent 11x17 L 20180928.mxd



NOTES:
1. Refer to Figure 3-4 Surver Area delineation.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
⊡	Borehole Location - Surface Samples Only
⬠	Borehole Location - Subsurface Samples Only
△	Borehole Location - Static Gamma Data Only
●	IL Exceedance in Unconsolidated Material at Location
▭	TENORM (42.4 acres)
▭	Approximate Area where Surface Gamma ILs are Exceeded (22.7 acres)
▭	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	IL Not Exceeded Survey Area A: 6,916 - 15,036 Survey Area B: 4,867 - 11,220 Survey Area C: 4,955 - 12,649
●	IL Exceeded Survey Area A: 15,037 - 328,342 Survey Area B: 11,221 - 215,310 Survey Area C: 12,650 - 295,008

N
W E
S

0 300 600
Feet

TITLE:

TENORM Compared to Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/3/2018

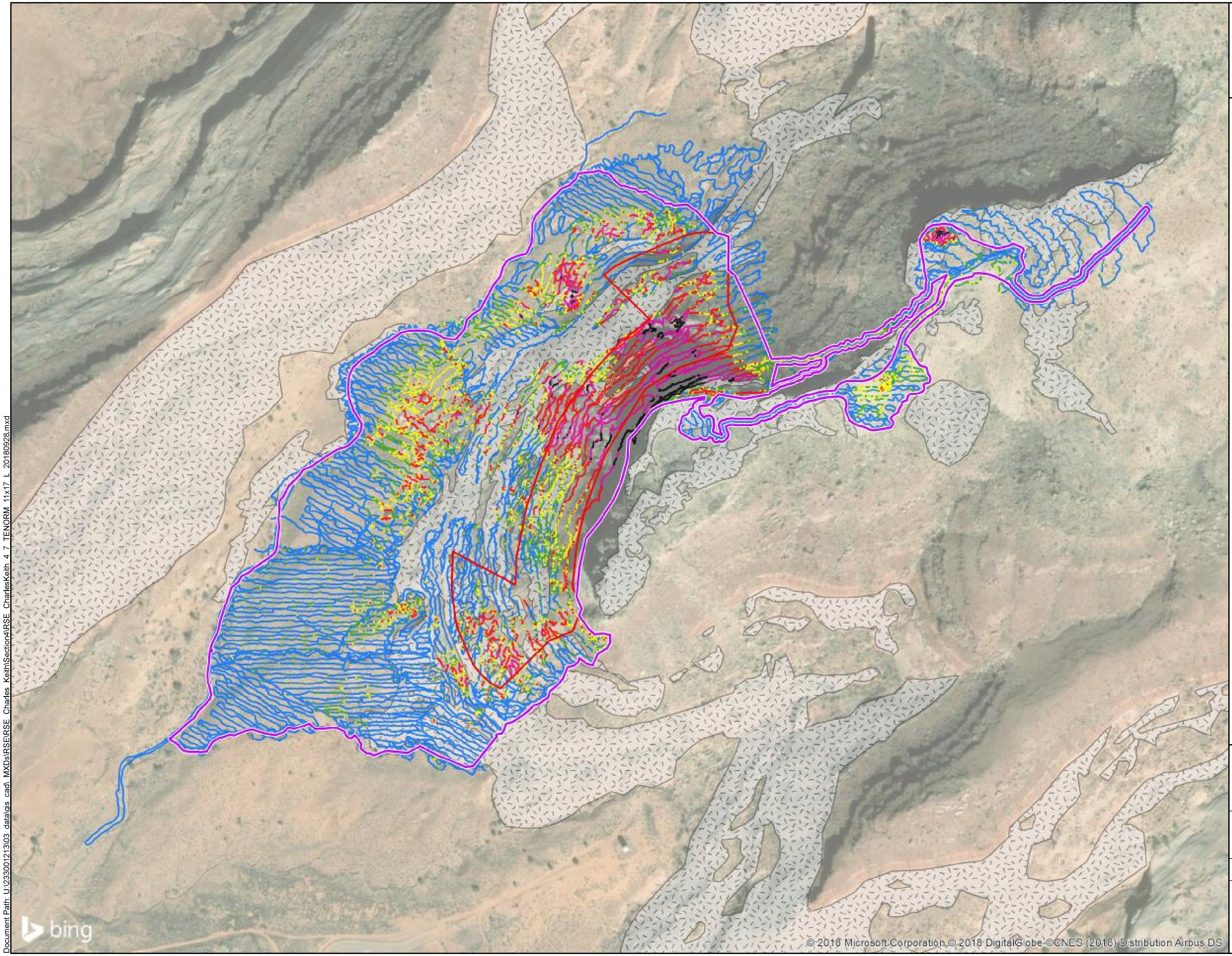
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ

FIGURE: 4-6

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 6 Lateral Extent TENORM 11x17 L 20180928.mxd



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NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

▭	TENORM (42.4 acres)
▨	Exposed Bedrock
▭	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	4,997 - 11,220 (Minimum to BG-2 IL)
●	11,221 - 12,649 (>BG-2 IL to BG-3 IL)
●	12,650 - 15,036 (>BG-3 IL to BG-1 IL)
●	15,037 - 22,440 (>BG-1 IL to 2x BG-2 IL)
●	22,441 - 56,100 (>2x BG-2 IL to 5x BG-2 IL)
●	56,101 - 328,342 (>5x BG-2 IL to Maximum)

NOTES:
TENORM boundary includes areas of exposed bedrock that contain small amounts of colluvium on the surface.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

N
W E
S

0 300 600
Feet

TITLE:
TENORM Compared to Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/16/2018

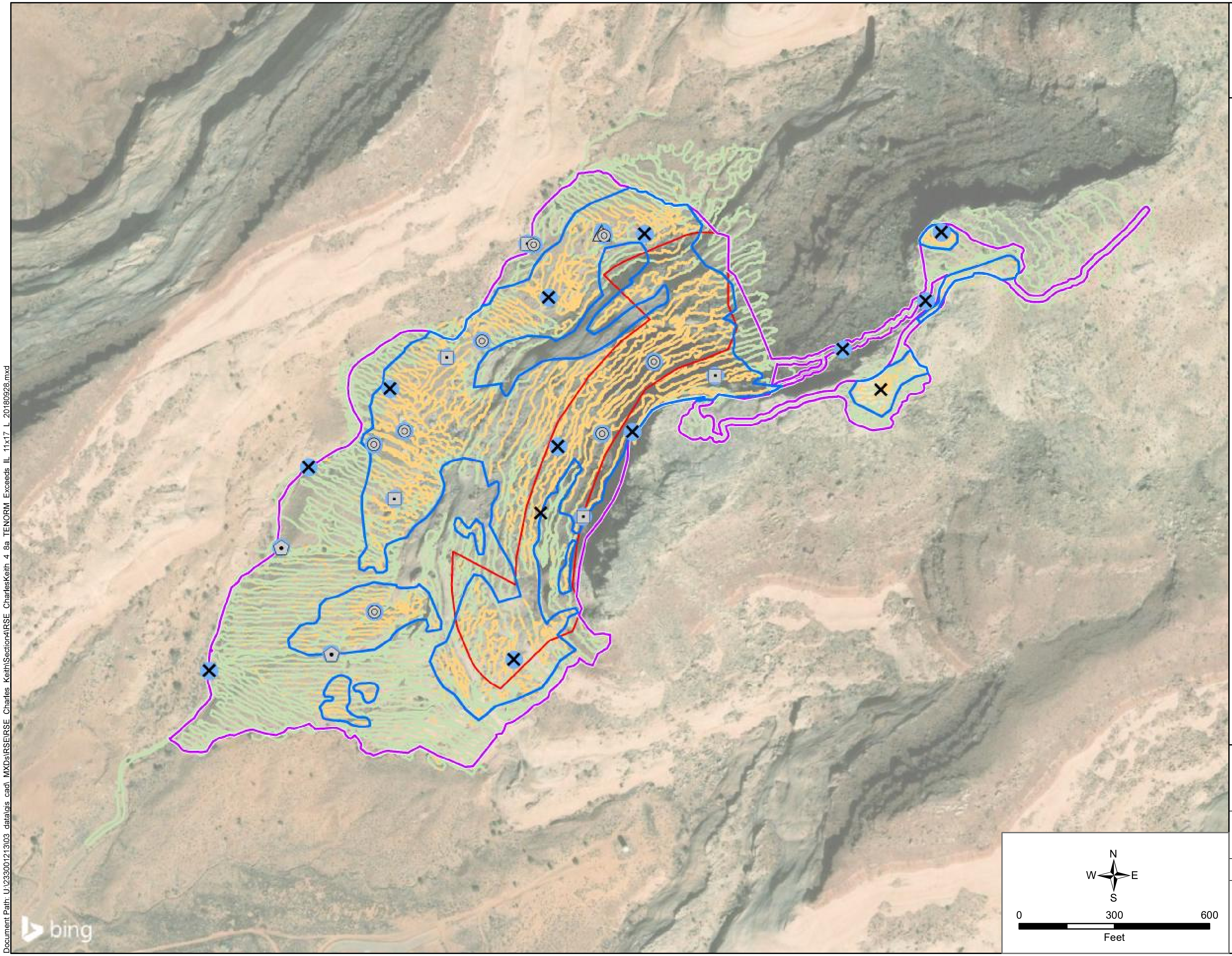
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-7



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
⬠	Borehole Location - Subsurface Samples Only
△	Borehole Location - Static Gamma Data Only
●	TENORM Exceeding IL in Unconsolidated Material at Location
▢	TENORM Area Exceeding Surface Gamma ILs (22.3 acres)
▢	TENORM (42.4 acres)
▢	Claim Boundary

Gamma Survey
Counts per Minute (CPM)

●	IL Not Exceeded Survey Area A: 6,916 - 15,036 Survey Area B: 4,867 - 11,220 Survey Area C: 4,955 - 12,649
●	IL Exceeded Survey Area A: 15,037 - 328,342 Survey Area B: 11,221 - 215,310 Survey Area C: 12,650 - 295,008

NOTE:
Refer to Figure 3-4 for Survery Area delineation.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

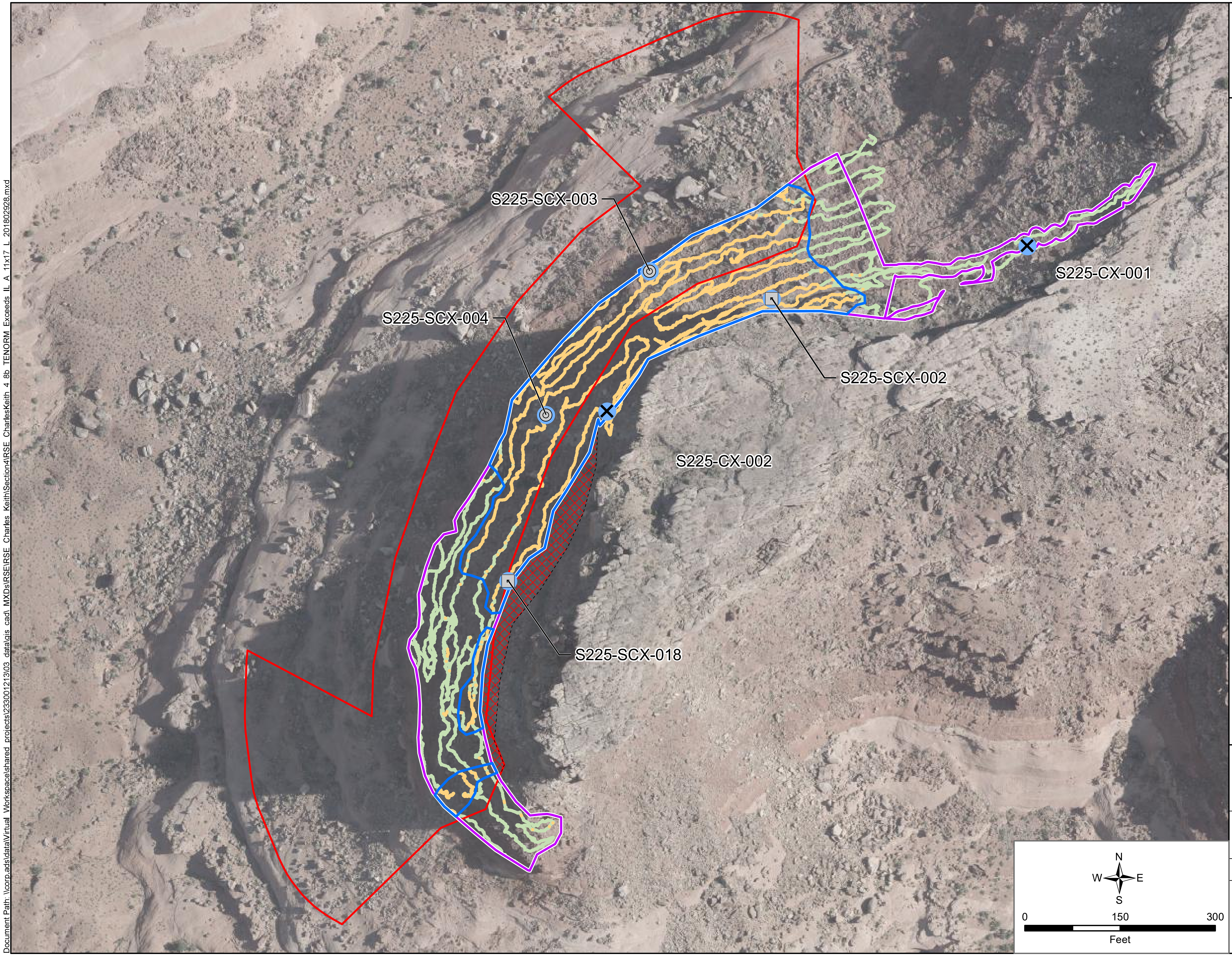
TITLE:
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/8/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-8a

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 8a TENORM Exceeds IL 11x17 L 20180928.mxd



NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
●	TENORM Exceeding IL in Unconsolidated Material at Location
▭	TENORM Area Exceeding Surface Gamma ILs (2.7 acres)
▭	TENORM (4.5 acres)
▨	TENORM Unsurveyed (0.4 acres)
▭	Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

●	6,916 - 15,036 (IL Not Exceeded)
●	15,037 - 328,342 (IL Exceeded)

NOTES:

1. Gamma Survey Area A is approximately 5.0 acres

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

TITLE:

Survey Area A
TENORM that Exceeds ILs

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/1/2018

DOCUMENT NAME: Removal Site Evaluation Report

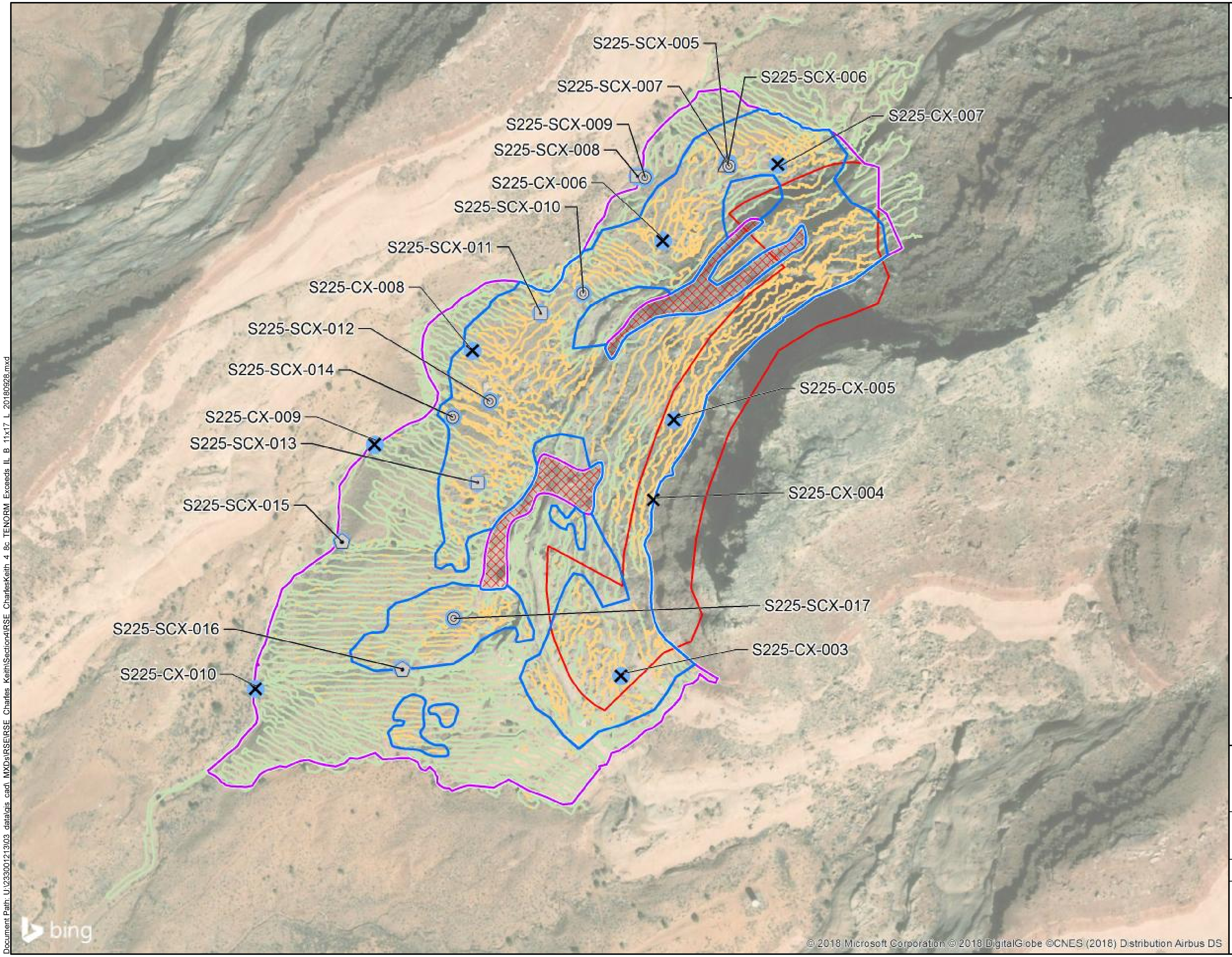
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8b

Document Path: \\corp.ads\data\Virtual Workspace\shared projects\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 8b TENORM Exceeds IL A 11x17 L 2018202928.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Borehole Location - Surface and Subsurface Samples
▣	Borehole Location - Surface Samples Only
⬠	Borehole Location - Subsurface Samples Only
△	Borehole Location - Static Gamma Data Only
●	TENORM Exceeding IL in Unconsolidated Material at Location
▢	TENORM Area Exceeding Surface Gamma ILs (18.4 acres)
▢	TENORM (32.8 acres)
▨	TENORM Unsurveyed (1.5 acres)
▢	Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

●	4,867 - 11,220 (IL Not Exceeded)
●	11,221 - 215,310 (IL Exceeded)

NOTE:
1. Gamma Survey Area B is approximately 37.5 acres

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

TITLE:
Survey Area B
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/8/2018
DOCUMENT NAME: Removal Site Evaluation Report
Stantec
AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 4-8c

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 8c TENORM Exceeds IL B 11x17 L 20180928.mxd

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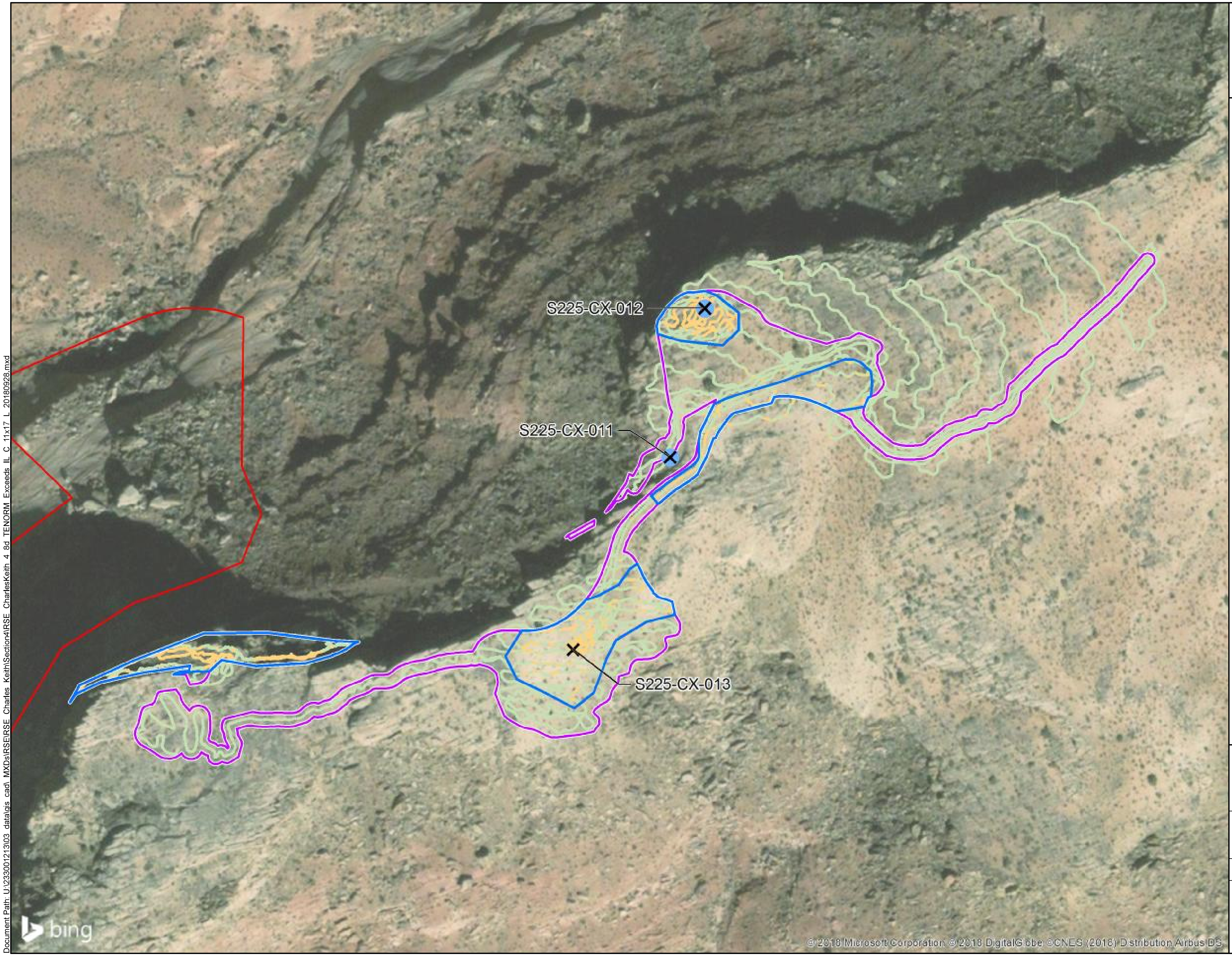


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ● TENORM Exceeding IL in Unconsolidated Material at Location
- ▭ TENORM Area Exceeding Surface Gamma ILs (1.2 acres)
- TENORM (3.0 acres)
- Claim Boundary

Gamma Survey[1]

Counts per Minute (CPM)

- ● 4,955 - 12,649 (IL Not Exceeded)
- ● 12,650 - 295,008 (IL Exceeded)

NOTE:

1. Gamma Survey Area C is approximately 6.8 acres

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/2018.

TITLE:

Survey Area C
TENORM that Exceeds ILs

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/8/2018

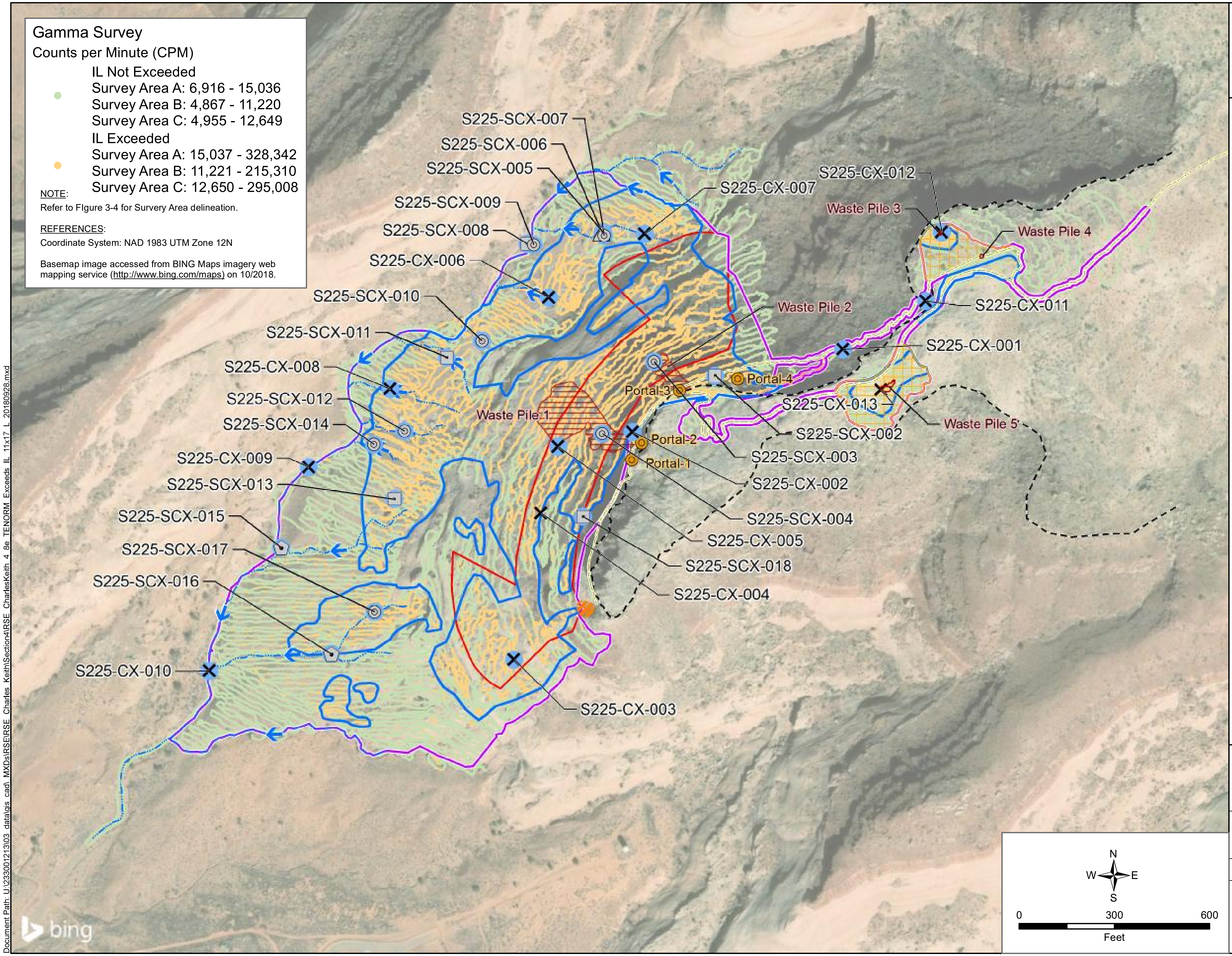
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8d



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- ◎ Borehole Location - Surface and Subsurface Samples
- ▣ Borehole Location - Surface Samples Only
- ⬠ Borehole Location - Subsurface Samples Only
- △ Borehole Location - Static Gamma Data Only
- ● TENORM Exceeding IL in Unconsolidated Material at Location
- ◉ Portal
- ↑ Flow Direction
- Drainage
- Footpath
- Potential Haul Road
- Approximate Edge of Mesa
- ▤ Waste Pile
- ▨ Blasted Area
- ▦ Mining Disturbed Area
- ▢ TENORM Area Exceeding Surface Gamma ILs (22.3 acres)
- ▢ TENORM (42.4 acres)
- ▢ Claim Boundary

TITLE:

TENORM that Exceeds ILs
Compared to Mining-Related Features

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/8/2018

DOCUMENT NAME: Removal Site Evaluation Report

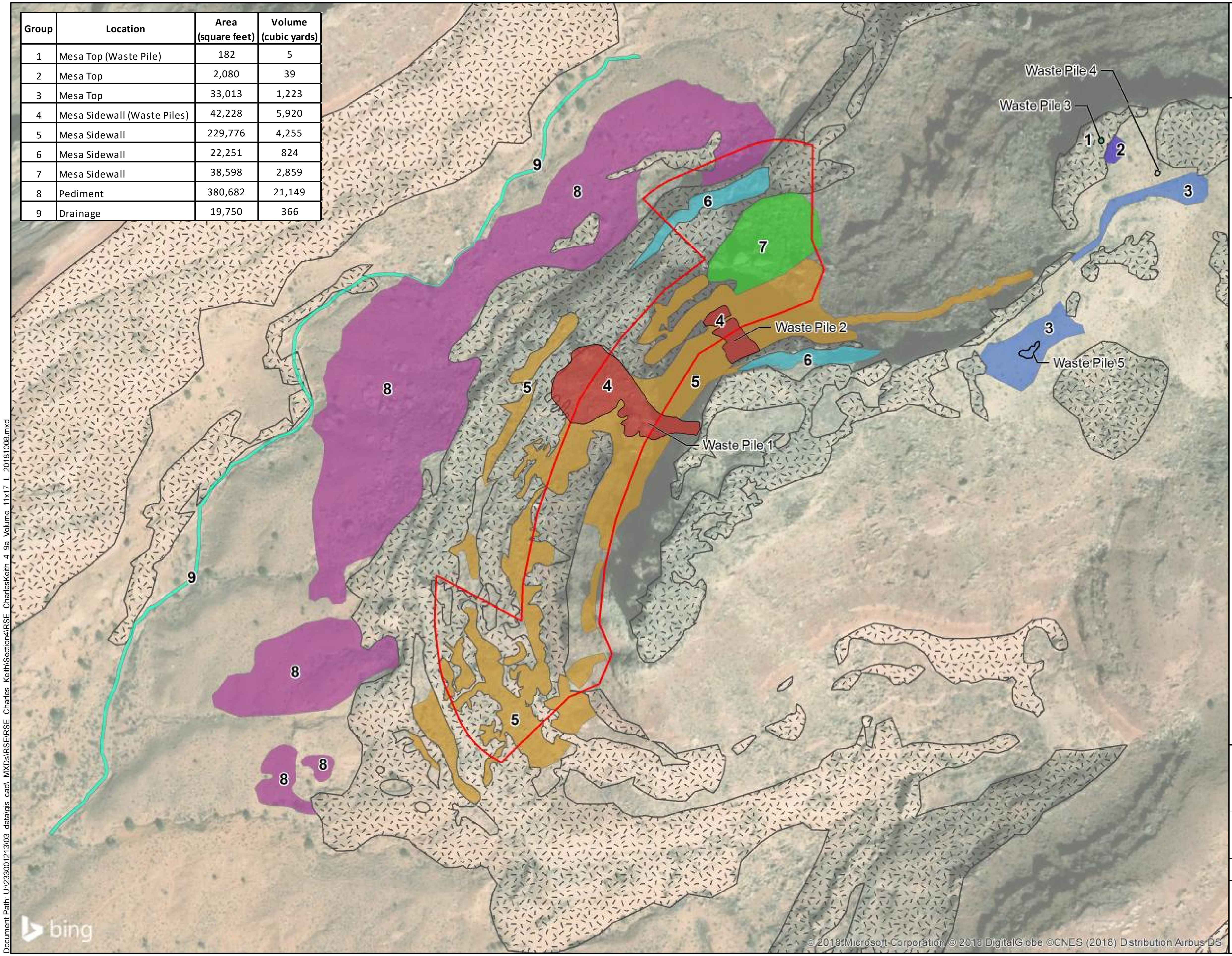
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8e

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\Section4\RSE CharlesKeith 4 8e TENORM Exceeds IL 11x17 L 20180928.mxd



Group	Location	Area (square feet)	Volume (cubic yards)
1	Mesa Top (Waste Pile)	182	5
2	Mesa Top	2,080	39
3	Mesa Top	33,013	1,223
4	Mesa Sidewall (Waste Piles)	42,228	5,920
5	Mesa Sidewall	229,776	4,255
6	Mesa Sidewall	22,251	824
7	Mesa Sidewall	38,598	2,859
8	Pediment	380,682	21,149
9	Drainage	19,750	366

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

▢	Waste Pile
▨	Exposed Bedrock
🟥	Claim Boundary

Average TENORM Depth by Group (feet below ground surface)

🟩	Group 1 - 0.75 ft
🟪	Group 2 - 0.5 ft
🟦	Group 3 - 1.0 ft
🟥	Group 4 - Variable¹
🟧	Group 5 - 0.5 ft
🟦	Group 6 - 1.0 ft
🟩	Group 7 - 2.0 ft
🟪	Group 8 - 1.5 ft
🟦	Group 9 - 0.5 ft

NOTES:

1. See Figure 4-9b.

2. Volume was calculated with the assumption that soil is 0.5 ft deep over 50 percent of the area of the drainage due to the presence of bedrock.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 10/8/2018.

N
W E
S

0 220 440
Feet

TITLE:

Volume Estimate of
TENORM that Exceeds ILs

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 10/8/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-9a

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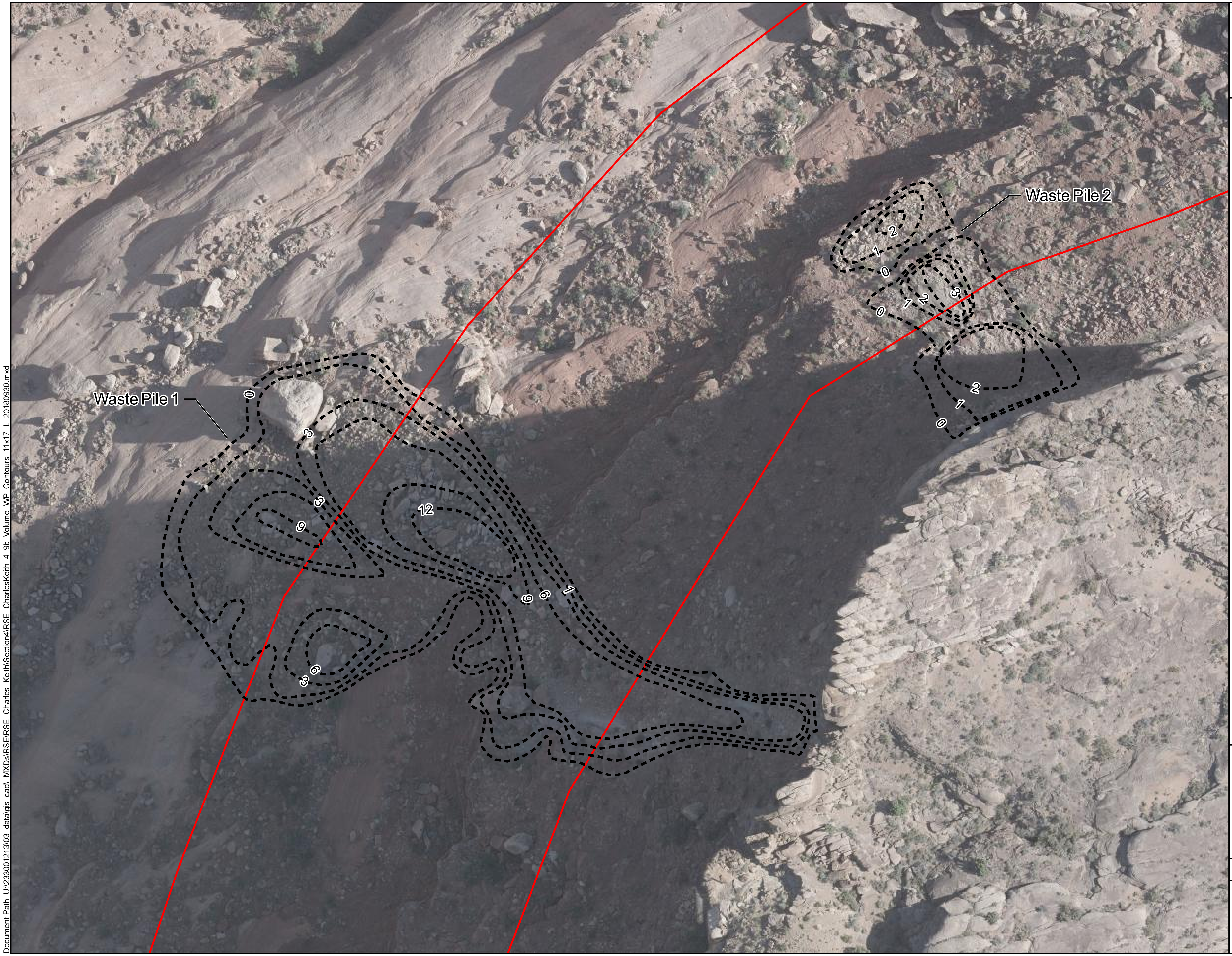


NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

Approximate Waste Pile Contour (thickness in feet)

Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image flown by Cooper Aerial Surveys Co. on June 16, 2017.

TITLE:
Waste Piles 1 and 2
Contours for Volume Estimates

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/30/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-9b

Document Path: U:\123300121\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith\Section4\RSE CharlesKeith 4 9b Volume WP Contours 11x17 L 20180930.mxd

APPENDICES

Appendix A Radiological Characterization of the Charles Keith Abandoned Uranium Mine

Radiological Characterization of the Charles Keith Abandoned Uranium Mine

September 19, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

Contents

Tables

Figures

Appendices

Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
cpm	counts per minute
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
m	meter
MDC	minimum detectable concentration
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Charles Keith abandoned uranium mine (AUM) located in the Oljato Chapter of the Navajo Nation in Monument Valley, Utah. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) in accordance with the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on May 4 and November 1 to 3, 2016; and March 19 and 22, May 24, June 22, and September 20, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the “Charles Keith Removal Site Evaluation Report” (Stantec, 2018).

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.
- Elevated count rates were observed largely on waste piles extending away from portals and on the road and walls near the portals in the mine claim.
- Three potential Background Reference Areas were established.
- The mean relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

$$\text{Gamma Count Rate (cpm)} = 5239 \times [\text{radium-226 (pCi/g)}] + 4454$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model is rightward tailed. The values in the Survey Area range from 0.1 to 61.8 pCi/g, with a central tendency (median) of 1.1 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- There is evidence that thorium-230 and radium-226 are in equilibrium, but not secular equilibrium.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

  Exposure Rate (microRoentgens per hour [μR/h]) = $5\text{x}10^{-4}$ x Gamma Count Rate (cpm) + 5.7462

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 8.2 to 169.9, with a central tendency (median) of 11.0 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Charles Keith abandoned uranium mine (AUM) located in the Oljato Chapter of the Navajo Nation in Monument Valley, Utah. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. (ERG) of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) in accordance with the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series.

The objective of the correlation between field gamma count rate and surface soil concentrations of radium-226 was to use field instrumentation to predict surface soil concentrations of radium-226. The objective of the correlation between field gamma count rate and exposure rate was to use field instrumentation to predict exposure rates.

The field activities addressed in this report were conducted on May 4 and November 1 to 3, 2016; and March 19 and 22, May 24, June 22, and September 20, 2017. They included a GPS-based radiological survey of land surfaces over an approximately 49-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, and areas where the survey was extended; and correlation studies. Section 3.0 of the RSE Work Plan provides the data quality objectives (DQOs) for the project.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in the "Charles Keith Removal Site Evaluation Report" (Stantec, 2018).

Figure 1 shows the location of the AUM. Background information that is pertinent to the characterization of this AUM is presented in the "Charles Keith Removal Site Evaluation Report" (Stantec, 2018).

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in three potential Background Reference Areas and the Survey Area. The survey was extended to bound areas in which elevated count rates were observed. Table 1 lists the detection systems used in the survey. Pursuant to the approved RSE Work Plan, detectors were function checked each day to ensure the instruments were stable to the limits prescribed by the Work Plan. Detector normalization was not performed as it was not addressed by the RSE Work Plan. Appendix A presents the completed function check forms and calibration certificates for the instruments. Standard operating procedures (SOPs) are discussed in Section 4.2 of the RSE Work Plan and are provided in Appendix E therein. ERG followed the quality assurance and control requirements stipulated in the approved Work Plan.

The 2x2 sodium iodide (NaI) detectors used in this investigation are sensitive to sub-surface radium-226 decay products and other gamma emitting radionuclides. The purpose of the gamma correlation was to estimate radium-226 concentrations in the upper 15 cm of soil. ERG selected correlation plots based on the range of gamma radiation levels observed. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

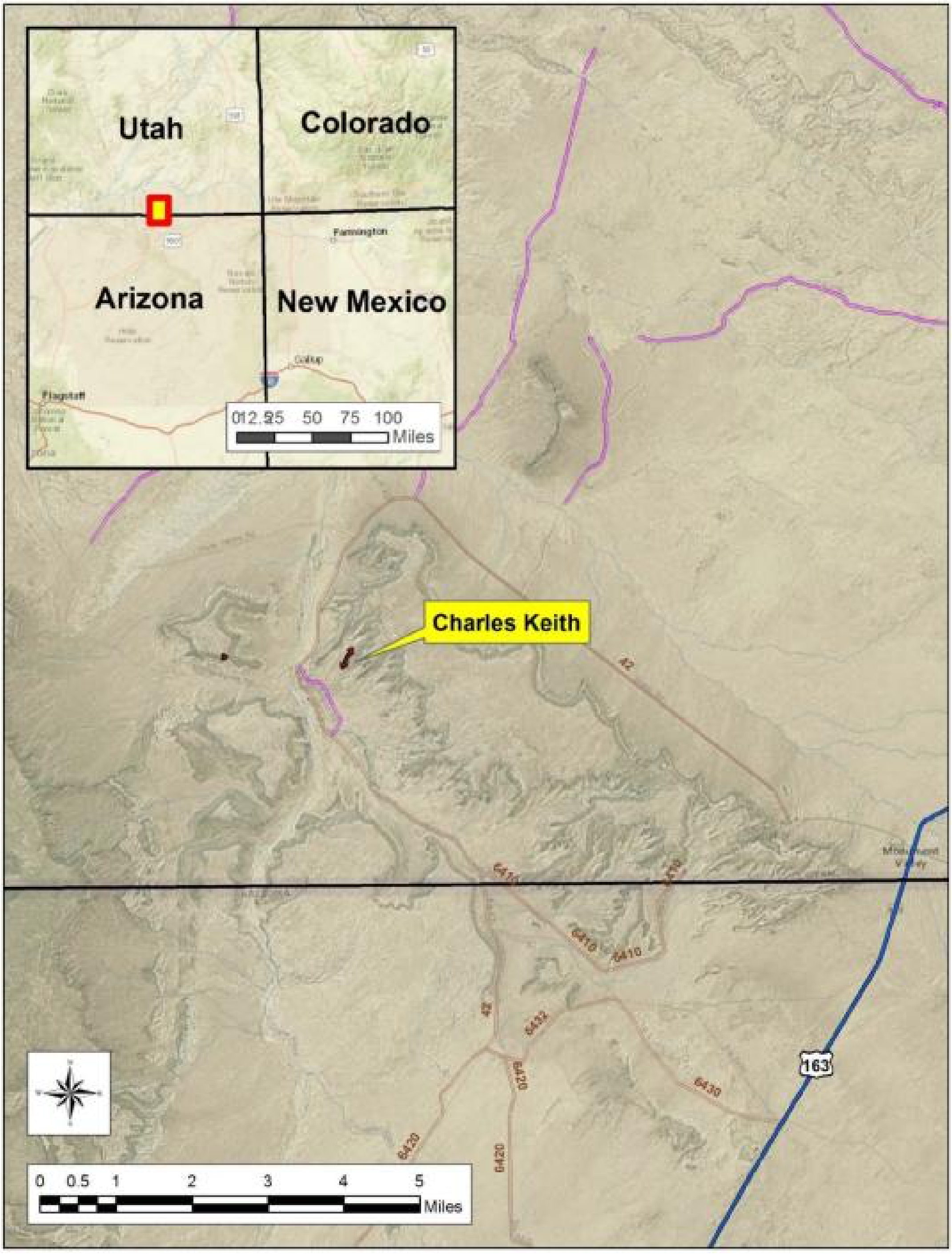


Figure 1. Location of the Charles Keith Abandoned Uranium Mine

Table 1. Detection systems used in the GPS-based gamma surveys.

Survey Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR303727[a]	254772[a]
	PR320678	282971
Survey Area	PR303727[a]	254772[a]
	PR295014	196086
	PR154615	138638
	PR295017	271435
	PR320678	282981
	PR355763	138368

Notes:
[a] Detection system used in the correlation studies described in Section 3.0.
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3

2.1 Potential Background Reference Areas

Three potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, and BG3 in the figure are Background Reference Areas 1, 2, and 3, respectively.

Figure 3 depicts histograms of the gamma count rates in BG1, BG2, and BG3. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

Table 2 lists a summary of the gamma count rates, which in

- BG1 ranged from 10,232 to 19,378 cpm, with a mean and median of 12,942 and 12,790 cpm, respectively.
- BG2 ranged from 6,349 to 12,135 cpm, with a mean and median of 8,898 and 8,726 cpm, respectively.
- BG3 ranged from 7,773 to 13,471 cpm, with a mean and median of 10,630 and 10,514 cpm, respectively.

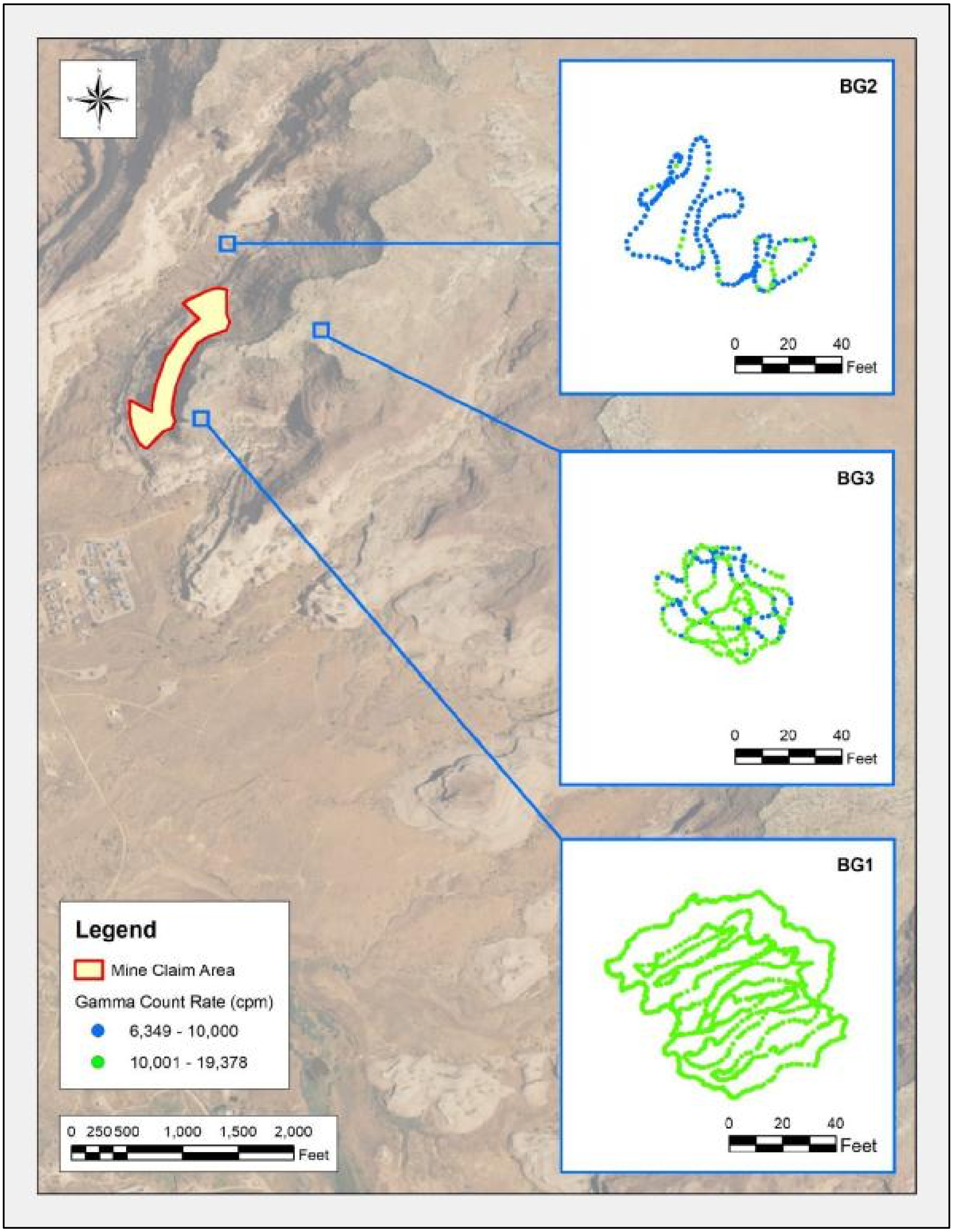
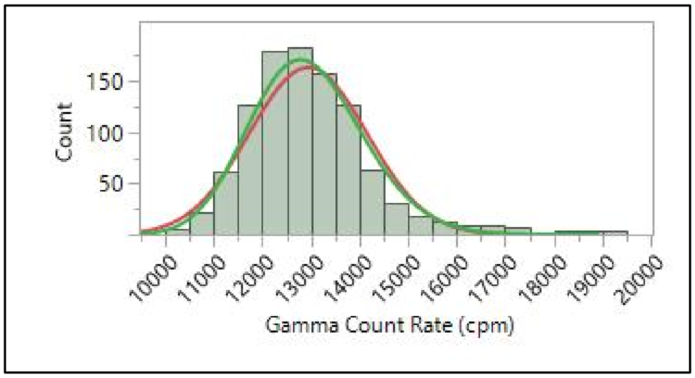
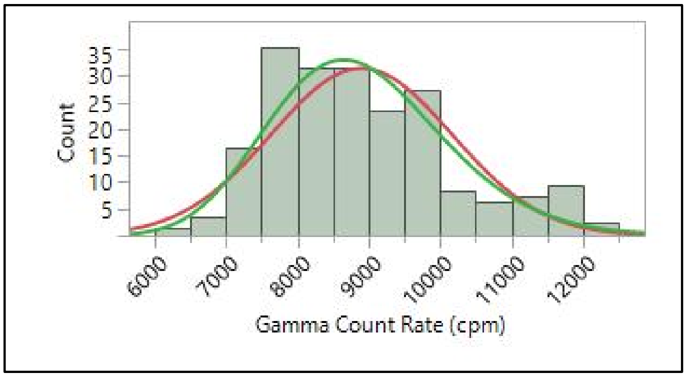


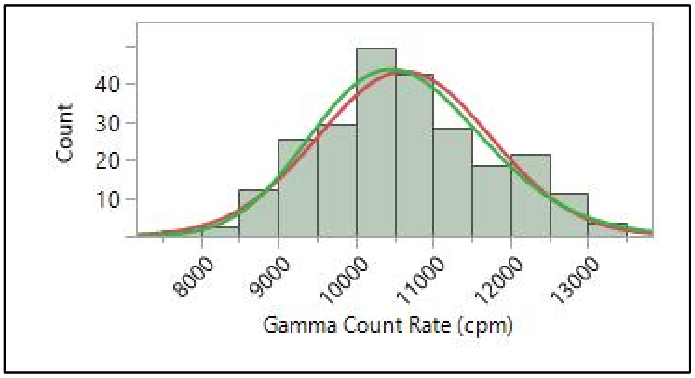
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. Background Reference Area 1



b. Background Reference Area 2



c. Background Reference Area 3

Figure 3. Histograms of gamma count rates in the potential Background Reference Areas.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	991	10,232	19,378	12,942	12,790	1,212
2	199	6,349	12,135	8,898	8,726	1,265
3	241	7,773	13,471	10,630	10,514	1,111

Notes:
cpm = counts per minute

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were observed largely on waste piles extending away from portals and on the road and walls near the portals in the mine claim.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL, is not defined. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 8,482, 10,416, and 13,685 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 4,867 to 328,342 cpm and have a central tendency (median) of 10,416 cpm.

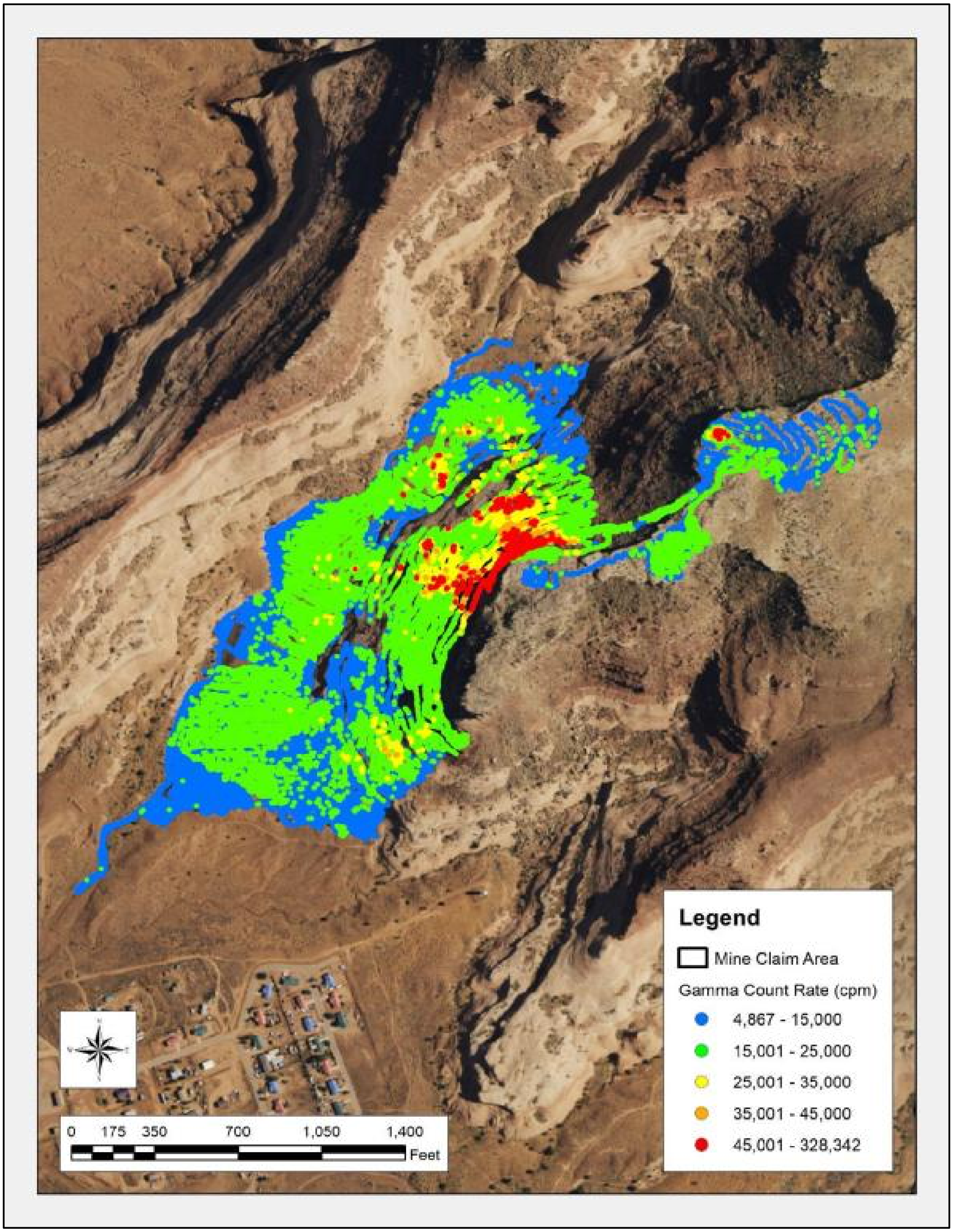


Figure 4. Gamma count rates in the Survey Area.

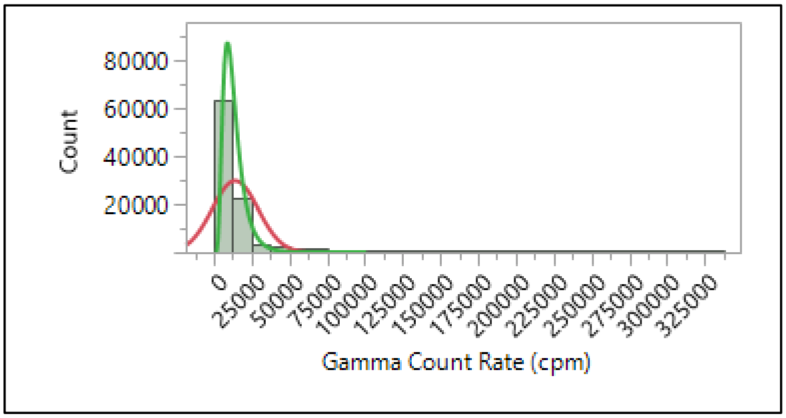


Figure 5. Histogram of gamma count rates in the Survey Area.

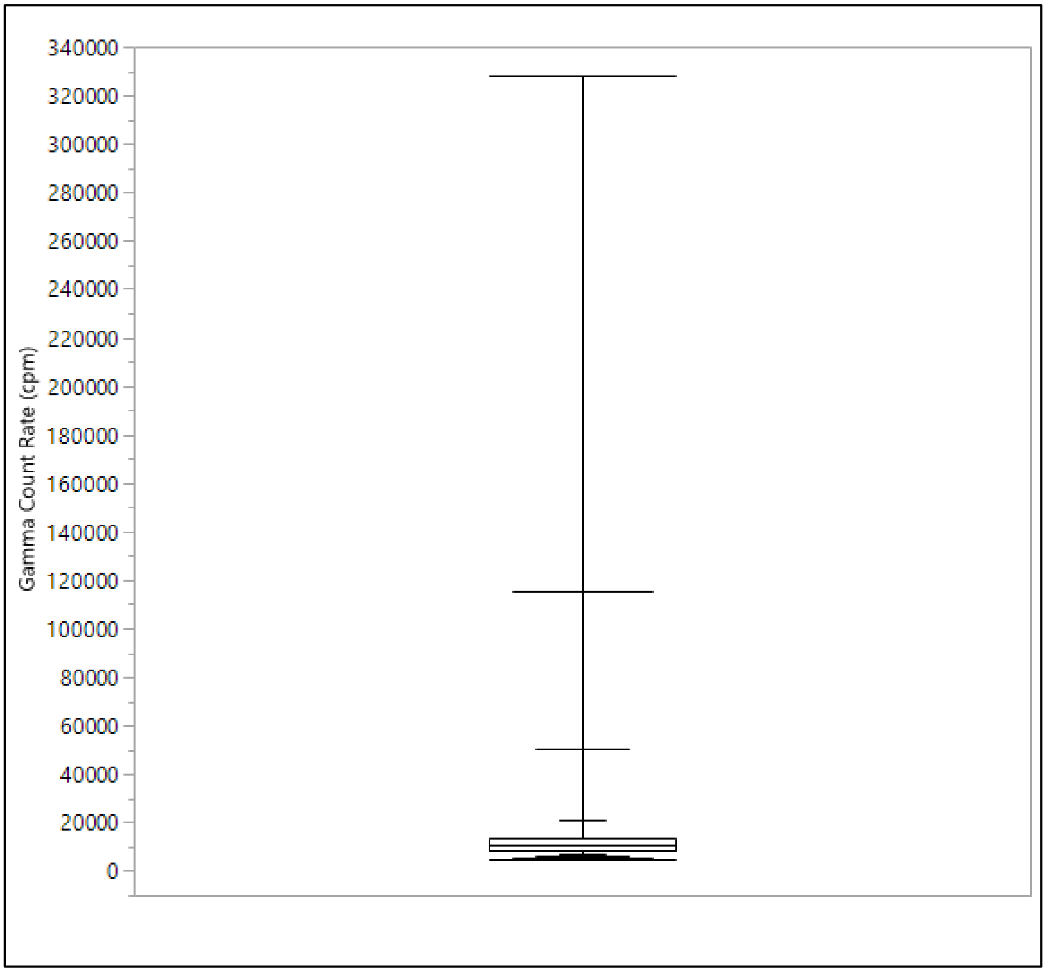


Figure 6. Box plot of gamma count rates in the Survey Area.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	90,885
Minimum	4,867
Maximum	328,342
Mean	14,116
Median	10,416
Standard Deviation	15,244

Notes:
cpm = counts per minute

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work Plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On November 3, 2016 field personnel made GPS-based gamma count rate measurements and collected five-point composite samples of surface soils in each of five areas at the AUM (S225-C01-001, S225-C02-001, S225-C03-001, S225-C04-001, and S225-C05-001). These areas were selected using criteria established in the RSE Work Plan. No DQO was established for homogeneity of the correlation plots and as described in Section 4.3 and Appendix E of the RSE Work Plan, homogeneity of the correlation plots was evaluated qualitatively. Sub-samples were collected from the correlation plot centroid and at each corner of the plot. The activities were performed contemporaneously, by area and all on the same day, such that variations in the gamma count rate measurements could be limited largely to those posed by the soils and rocks at the locations.

On May 24, 2017, the gamma count rate measurements were repeated on the five locations (S225-C01-001, S225-C02-001, S225-C03-001, S225-C04-001, and S225-C05-001), and an additional location (S225-C06-001), because one of the results for radium-226 (3.5 picocuries per gram [pCi/g] at location S225-C05-001), appeared unusual given the relatively low gamma count rates observed there. The gamma data were reviewed to identify if there were any elevated values that potentially corresponded to an area where one of the five grab samples was collected to create the composite. None were observed in the results (i.e., the standard deviation of the gamma data from the plot was relatively small).

Soil samples were collected from S225-C05-001 and S225-C06-001 on May 24, 2017; soil samples were not collected from S225-C01-001, S225-C02-001, S225-C03-001 and S225-C04-001, because the concentrations of radionuclides were not expected to change. Radium-226 results from sample location S225-C05-001 were similar between the two soil sampling events; November 3, 2016 and May 24, 2017. The physical and/or chemical reasons for the results are unknown and future investigation is suggested.

Further discussion is provided in Section 4.2.2 of the "Charles Keith Removal Site Evaluation Report" (Stantec, 2018).

The results of the gamma survey and soil sampling efforts in May 2017 are presented in Tables 4 and 5 but were not used in any regression analysis to predict radium-226 concentrations in soil or evaluate the equilibrium status of uranium series radionuclides.

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

			Gamma Count Rate (cpm)[a]				**Ra-226 (pCi/g)**		
Location	**Area (m^2)**	**Date of Sample Collection**	**Mean**	**Minimum**	**Maximum**	**σ**	**Result**	**Error ±2σ**	**MDC**
S225-C01-001	25.0	11-3-2016	14,215	12,008	16,531	1,015	1.42	0.28	0.34
S225-C01-001	25.0	05-24-2017	14,636	11,629	19,247	1,542	-	-	-
S225-C02-001	15.0	11-3-2016	26,953	19,380	32,365	3118	3.39	0.5	0.42
S225-C02-001	15.0	5-24-2017	26,074	19,681	33,575	2,750	-	-	-
S225-C03-001	39.6	11-3-2016	48,333	40,451	58,083	5,147	8.5	1.1	0.6
S225-C03-001	39.6	5-24-2017	46,957	33,327	63,503	4,928	-	-	-
S225-C04-001	5.6	11-3-2016	36,473	23,902	46,104	7,214	4.56	0.67	0.52
S225-C04-001	5.6	5-24-2017	35,540	24,178	46,285	6,353	-	-	-
S225-C05-001	5.6	11-3-2016	8257	6663	10293	741	3.5	0.53	0.49
S225-C05-001	5.6	5-24-2017	7870	6296	10552	934	3.86	0.56	0.45
S225-C06-001[b]	24.0	5-24-2017	6,572	5,304	9,433	658	0.42	0.14	0.29

Notes:
[a] Gamma count rate data collected on November 3, 2016 were used in radium-226 regression in Figure 8
[b] Results at this location not used to develop the correlation of gamma count rates to radium-226 concentrations in surface soils reported here.
cpm = counts per minute
MDC = minimum detectable concentration
m^2 =square meters
pCi/g = picocuries per gram
σ = standard deviation

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. Table 4 lists the results of the gamma count rate measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements for the November 3, 2016 data, range from 8,257 to 48,333 cpm. The concentrations of radium-226 in the soil samples range from 1.42 to 8.5 pCi/g. Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples. Laboratory analyses are presented in Appendix F.2, Laboratory Analytical Data and Data Validation Report, in the "Charles Keith Removal Site Evaluation Report" (Stantec, 2018).

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

		Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	Date of Sample Collection	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC
S225-C01-001	11-3-2016	1.06	0.18	0.02	1.25	0.22	0.07	0.96	0.17	0.02
S225-C02-001	11-3-2016	0.7	0.14	0.05	3.13	0.52	0.08	0.74	0.14	0.01
S225-C03-001	11-3-2016	0.8	0.14	0.03	6.4	1	0.1	0.69	0.13	0.01
S225-C04-001	11-3-2016	0.91	0.17	0.05	3.69	0.6	0.07	0.82	0.15	0.01
S225-C05-001	11-3-2016	0.59	0.12	0.07	3.58	0.58	0.07	0.51	0.1	0.02
S225-C05-001	5-24-2017[a]	0.64	0.13	0.07	4.17	0.67	0.08	0.62	0.12	0.03
S225-C06-001	5-24-2017[a]	0.286	0.077	0.072	0.325	0.082	0.073	0.305	0.068	0.005

Notes:
[a]Results collected on 5-24-17 are not used in the multivariate regression analysis on gamma count rate or the equilibrium status at the site..
MDC = minimum detectable concentration
pCi/g = picocuries per gram
σ = standard deviation

Figure 7 shows the GPS-based gamma count rate measurements in the six areas (labeled with location identifiers).

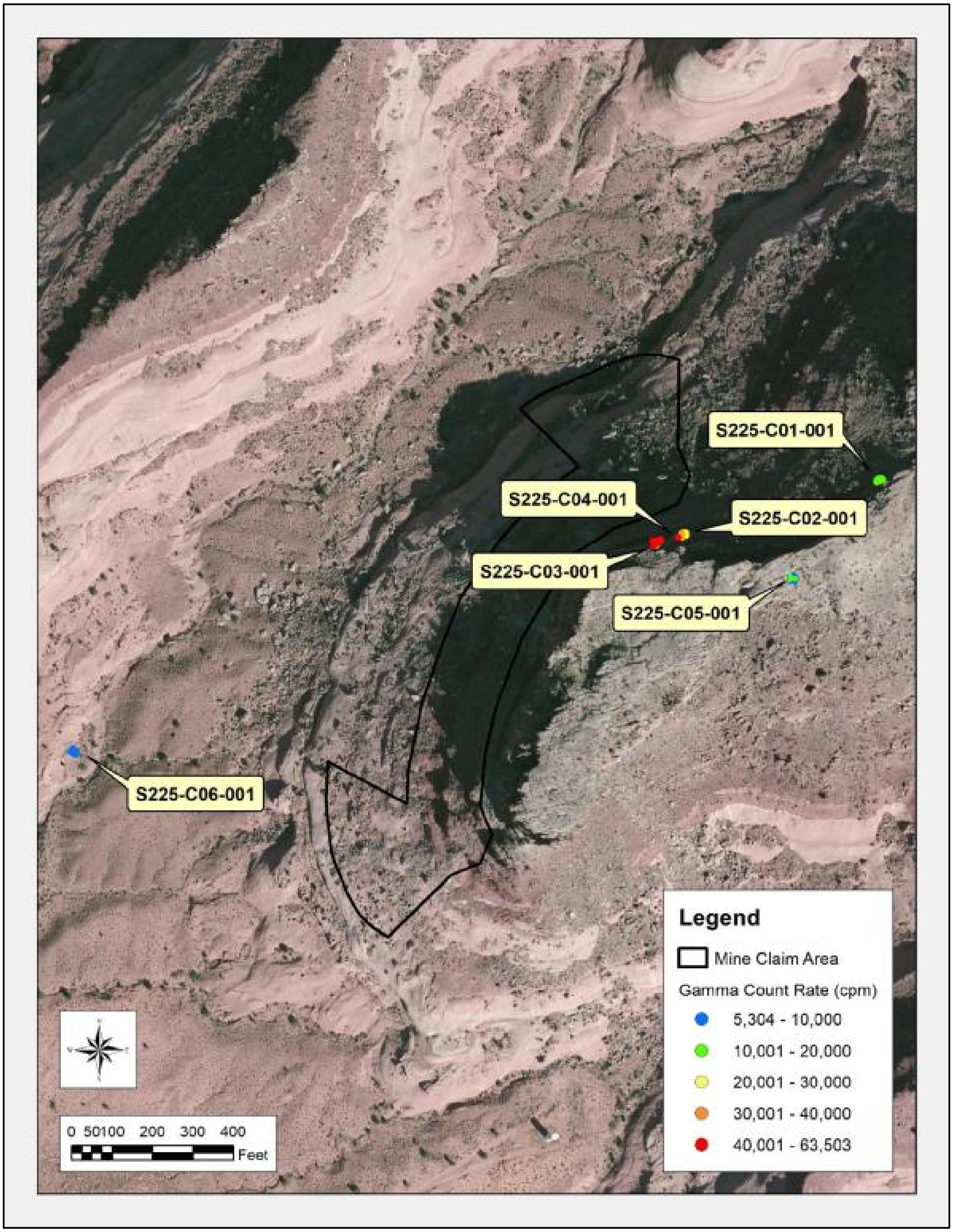


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

A model was made using the November 3, 2016 results presented in Table 4, to predict the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The mean relationship between the measurements, shown in Figure 8, is a linear function with an adjusted Pearson's Correlation Coefficient (adjusted R^2) of 0.62, as expressed in the equation:

$$\text{Gamma Count Rate (cpm)} = 5239 \text{ x } [\text{radium-226 (pCi/g)}] + 4454$$

The root mean square error and p-value for the model are 7.8 x10^3 and 0.07, respectively; these parameters are not data quality objectives (DQOs) and are included only as information. The R^2 value for this model does not meet the project DQO of 0.8. This model could be improved in future investigations with more correlation data points.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area. The range of the predicted concentrations of radium-226 in the Survey Area is 0.1 (0.08) to 61.8 pCi/g, with a mean and median of 1.8 and 1.1 pCi/g, respectively. While the gamma correlation equation can be used to convert gamma count rates to concentrations of Ra-226 in soil, the resulting radium concentrations are highly uncertain estimates, as the wide prediction interval bands illustrated in Figure 8 demonstrate. Users of the regression equation should be aware of the limitations of the dataset and be cautious when estimating radium-226 concentrations.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

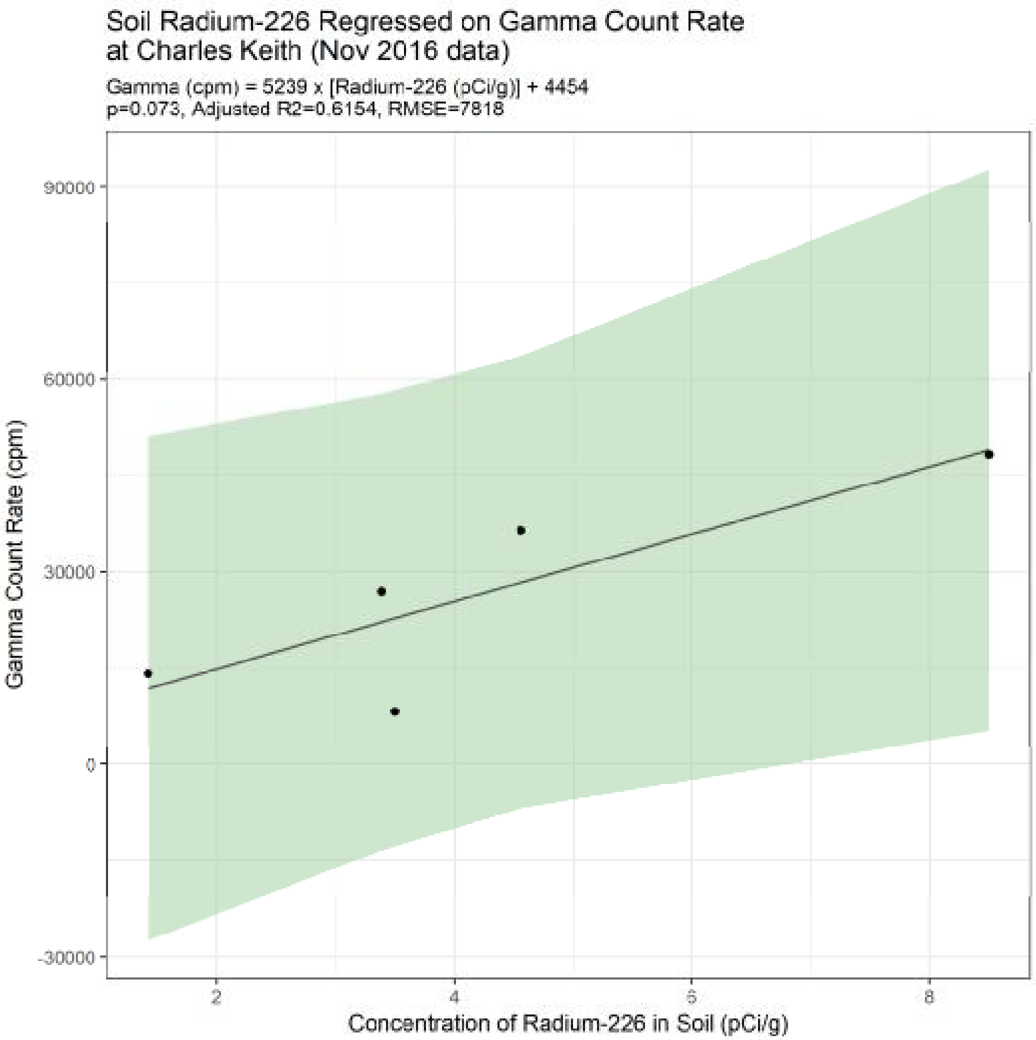


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils (black line) with 95% upper prediction level bands plotted (shaded area).

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	90,885
Minimum	0.08
Maximum	61.8
Mean	1.8
Median	1.1
Standard Deviation	2.9

Notes:
pCi/g = picocuries per gram

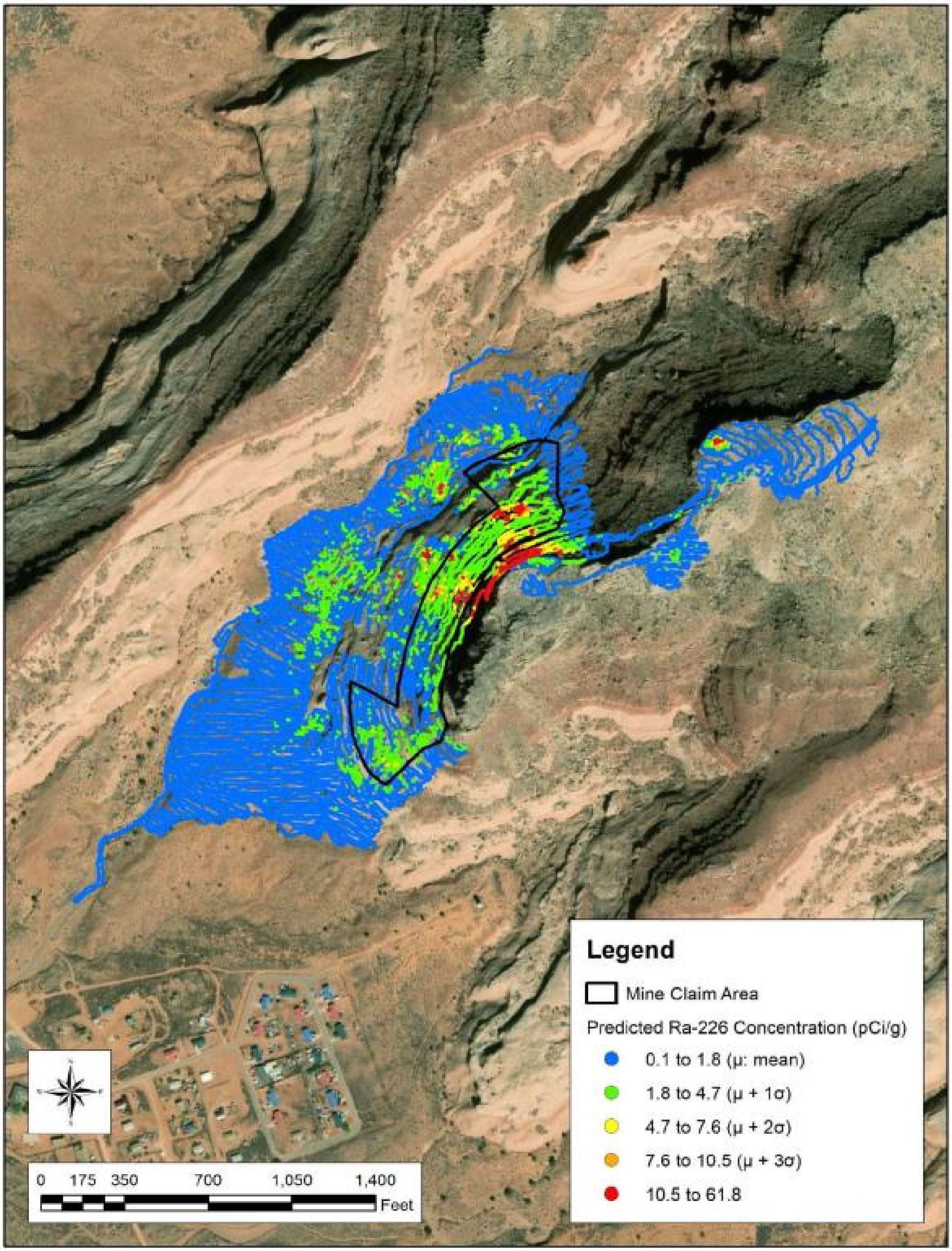


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

Soil concentrations of potassium-40 were not expected to be spatially variable within the site, and therefore this radionuclide was not separately accounted for in the RSE Work Plan. If K-40 concentrations did vary, this variability would be included in the regression model and, if the magnitude of the effect were sufficiently large, would result in failure of DQOs related to the regression analysis.

A multivariate linear regression (MLR) was used to evaluate the influence of thorium-232 and thorium-228, isotopes in the thorium series, on the average gamma count rate in the correlation locations. The MLR model was first run using radium-226, thorium-232, and thorium-228 as predictors of gamma count rate. The model failed to produce results because thorium-232 and thorium-228 are colinear. The MLR model was subsequently run without thorium-228. For the second model, the p-values for radium-226 was significant (p = 0.018), while that for thorium-232 was not (p = 0.51), implying that thorium-232 does not need to be accounted for when predicting concentrations of radium-226 from gamma survey data. Thorium-232 and radium-226 were then each modelled individually as a predictor of gamma count rate. The p-value for thorium-232 coefficient was 0.6 with an adjusted R^2 of -0.19. The thorium-232 coefficient is not significant and the R^2 value does not meet the project DQO. Subsequently we conclude that thorium-232 and thorium-228 concentrations in soil are not significant predictors of gamma count rate. Finally, the p-value for radium-226 as a predictor of gamma count rate was significant (p = 0.03), as described above, and the adjusted R^2 value (0.95) exceeded the applicable project DQO ($R^2 > 0.8$).

The depletion of radon-222 in surface soil due to environmental factors is assumed to be relatively constant across the correlation locations (i.e., the loss is a fixed fraction of the available source). Provided this is the case, any loss of radon-222 in surface soil is unimportant and accounted for within the statistical model. If the loss is not a consistent fraction at each correlation location, it is one of many potential correlation confounders that are all linked to spatial heterogeneity of the environmental conditions, and especially spatial heterogeneity of the soil matrix.

The presence of heterogeneous concentrations of gamma emitting radionuclides in sub-surface soil can affect the gamma correlation model. If subsurface soil concentrations of gamma emitting radionuclides were variable between correlation locations, this variability would be included in the regression model, and if the magnitude of the effect were sufficiently large, it would result in failure of the DQOs related to the regression analysis.

3.2 Equilibrium in the uranium series

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the RSE Work Plan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for thorium-230 and radium-226 was conducted. The RSE Work Plan did not require an evaluation of equilibrium condition of uranium-238 and uranium-234 because the natural activity abundance for these isotopes is expected and therefore assumed. Likewise, thorium-234 and protactinium-234m were not evaluated since their half-lives are sufficiently short that secular equilibrium can be assumed. Uranium-235 is not in the uranium-238 decay therefore it wasn't evaluated. The ratio of thorium-230 to radium-226 can be evaluated even though different analytical methods were used to measure activity concentrations. Radium-226 was measured by EPA method 901.1m, which is a total activity method and thorium-230 was measured by alpha spectroscopy following digestion with hydrofluoric acid, which is also a total-activity method. Thus, it is appropriate to compare the two results.

The evaluation of secular equilibrium for each mine site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of Th-230 plotted against soil concentrations of Ra-226.
2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL bands are plotted on the figure generated in step 1.
3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between Th-230 to Ra-226, indicative of secular equilibrium).
4. An examination of the model and the figure is made sequentially:
    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (Adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that Ra-226 and Th-230 are in equilibrium (secular or otherwise).

b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

    i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in secular equilibrium at the site.

    ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium at the site.

Based on this method, ERG concludes there is evidence that thorium-230 and radium-226 are in equilibrium, but not secular equilibrium (Figure 10).

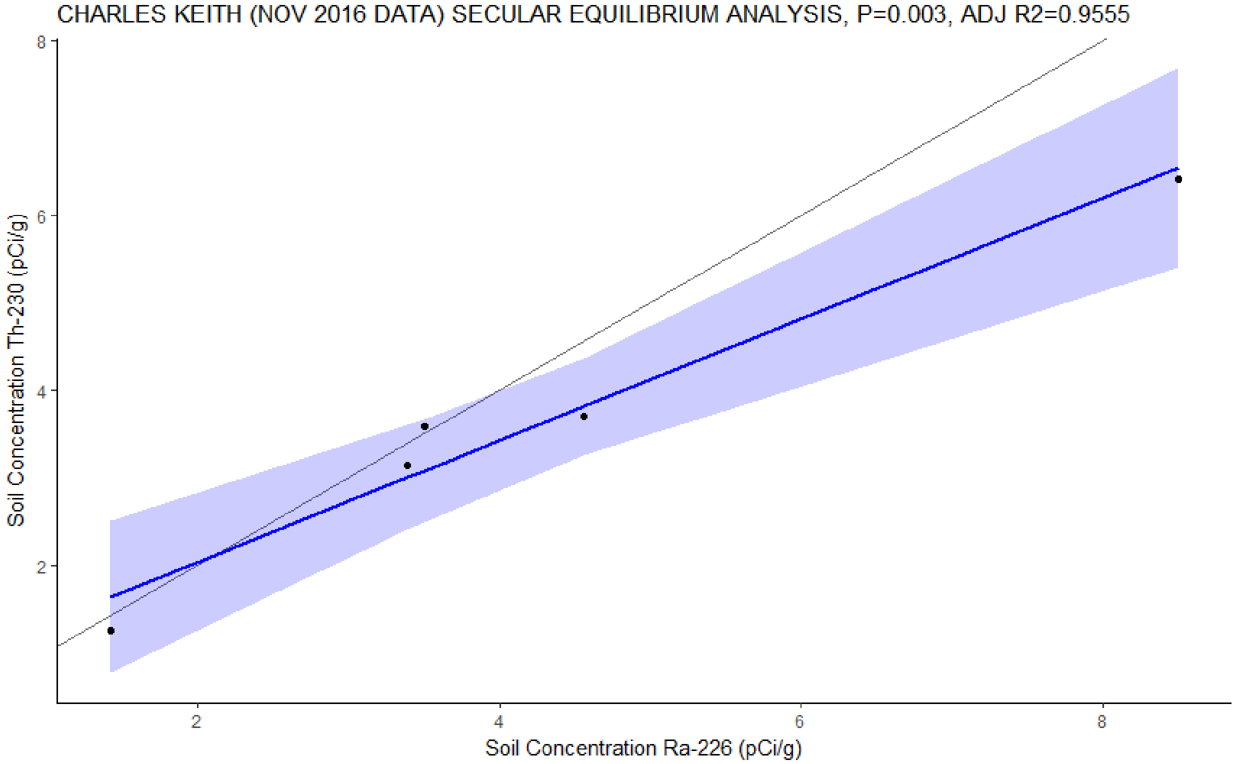


Figure 10. Evaluation of secular equilibrium in the uranium decay series.

3.3 Exposure rates and gamma count rates

On November 3, 2016, field personnel made co-located one-minute static count rate and exposure rate measurements at the same five locations within the Survey Area described in Section 3.1, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 meters (m) and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the sodium iodide detection systems used in the GPS-based gamma survey of the AUM (Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 (Serial Number 07J00KM1) high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rates used in the comparison were the means of each of the 5 measurements, less those occurring in initial instrument spikes. The HPIC was in current calibration and function-checked before and after use. A factor of 1.02 was added to the measured value by the software of the unit. Calibration forms for the HPIC are provided in Appendix A. Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the individual (6-second) exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.994. The root mean square error and p-value for the model are 0.784106 and 0.0002, respectively; these parameters are not DQOs and are included only as information.

The following equation is the linear regression (shown in Figure 11) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

$$\text{Exposure Rate } (\mu R/h) = 5 \times 10^{-4} \text{ x Gamma Count Rate (cpm)} + 5.7462$$

Figure 12 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the potential Background Reference Areas and Survey Area, respectively.

The range of predicted exposure rates at:

- BG1 is 10.9 to 15.4 µR/h, with a mean and median of 12.2 and 12.1 µR/h, respectively.
- BG2 is 8.9 to 11.8 µR/h, with a mean and median of 10.2 and 10.1 µR/h, respectively.
- BG3 is 9.6 to 12.5 µR/h, with a mean and median of 11.1 and 11.0 µR/h, respectively.

The range of predicted exposure rates in the Survey Area is 8.2 to 169.9 µR/h, with a mean and median of 12.8 and 11.0 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S225-C01-001	16,098	14.8
S225-C02-001	27,444	19.2
S225-C03-001	51,721	32.6
S225-C04-001	37,091	23.9
S225-C05-001	8,332	9.8

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour
Data collected on November 3, 2016

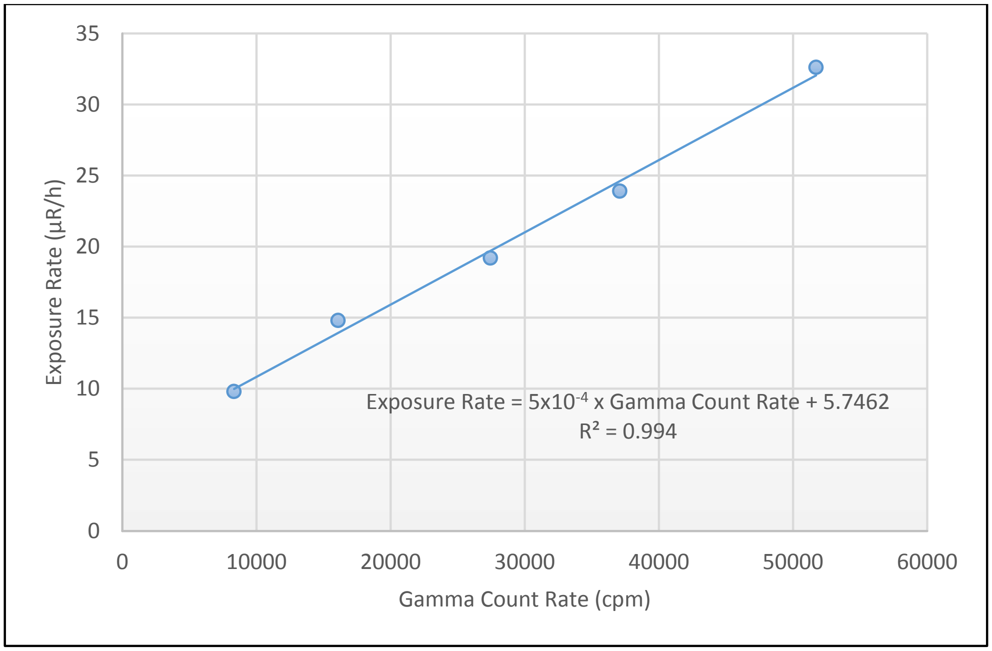


Figure 11. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Areas.

Potential Background Reference Area	**BG1**	**BG2**	**BG3**
Parameter	**Exposure Rate (µR/h)**		
n	991	199	241
Minimum	10.9	8.9	9.6
Maximum	15.4	11.8	12.5
Mean	12.2	10.2	11.1
Median	12.1	10.1	11.0
Standard Deviation	0.6	0.6	0.6

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	**Exposure Rate (µR/h)**
n	90,885
Minimum	8.2
Maximum	169.9
Mean	12.8
Median	11.0
Standard Deviation	7.6

Notes:
µR/h = microRoentgens per hour

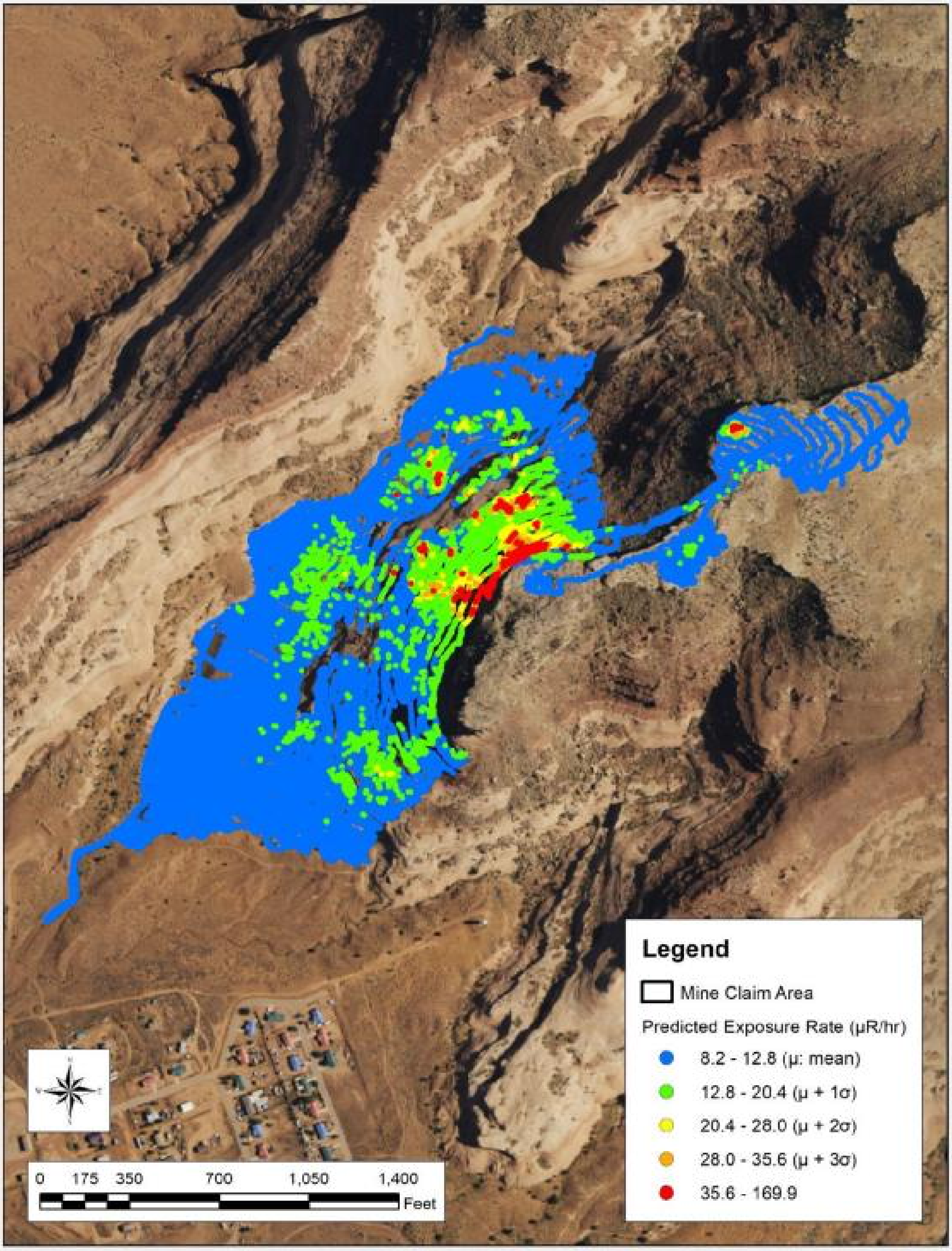


Figure 12. Predicted exposure rates in the Survey Area.

4.0 Deviations to RSE Work Plan

The RSE Work Plan specifies that the comparison of gamma count rates and radium concentrations in surface soils was to occur in 900 square foot areas. Field personnel adjusted the areas as necessary, to minimize the variability of gamma count rates observed, particularly where the spatial distribution of waste rock was heterogeneous.

5.0 Conclusions

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.

- Elevated count rates were observed largely on waste piles extending away from portals and on the road and walls near the portals in the mine claim.

- Three potential Background Reference Areas were established.

- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a linear regression model:

  Gamma Count Rate (cpm) = 5239 x [radium-226 (pCi/g)] + 4454

- The distribution of concentrations of radium-226 in surface soils predicted using this model is rightward tailed. The values in the Survey Area range from 0.1 to 61.8 pCi/g, with a central tendency (median) of 1.1 pCi/g.
- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.
- There is evidence that thorium-230 and radium-226 are in equilibrium, but not secular equilibrium.
- The relationship between gamma count rates and exposure rates is described by a linear regression model:

  Exposure Rate (microRoentgens per hour [μR/h]) = 5x10-4 x Gamma Count Rate (cpm) + 5.7462
- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 8.2 to 169.9, with a central tendency (median) of 11.0 μR/h.
- Further work is recommended to support a robust gamma correlation.

6.0 References

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2018. Charles Keith Removal Site Evaluation Report, (to be finalized in October 2018).

Appendix A Instrument calibration and completed function check forms

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR303727

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

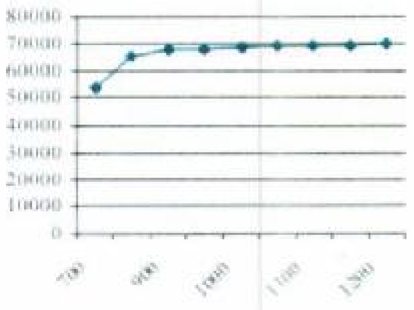
Barometric Pressure: 24.75 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398857	400
x 1000	100	100	100		100
x 100	400	400	400	39913	400
x 100	100	100	100		100
x 10	400	400	400	3992	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	53620	
800	64979	
900	67955	
950	67795	
1000	68536	9542
1050	69153	
1100	69331	
1150	69346	
1200	69492	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source: Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 7-5-16
Calibration Due: 7-5-17

Reviewed By:
Date: 7/20/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A-1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR303727

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

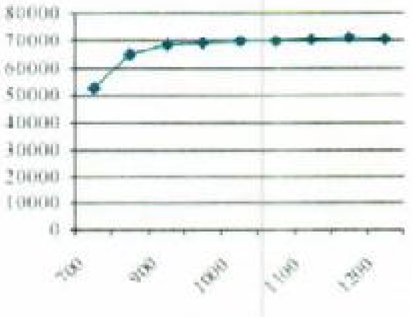
Barometric Pressure: 24.24 inches Hg
Temperature: 78 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399859	400
x 1000	100	100	100		100
x 100	400	400	400	39991	400
x 100	100	100	100		100
x 10	400	400	400	4001	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	52821	
800	65213	
900	68644	
950	69245	
1000	69492	9111
1050	69792	
1100	70472	
1150	71183	
1200	70571	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Reviewed By:

Calibration Date: ~~2 March 17~~ 2/28/17 ASH Calibration Due: ~~2 March~~ 18 2/28/18 ASH

Date: 3-1-17

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

✓ Mechanical Check
✓ F/S Response Check
✓ Geotropism
✓ Meter Zeroed

✓ THR/WIN Operation
✓ Reset Check
✓ Audio Check
✓ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ✓ 500 V ✓ 1000 V ✓ 1500 V
Cable Length: ☐ 39-inch ✓ 72-inch Other:

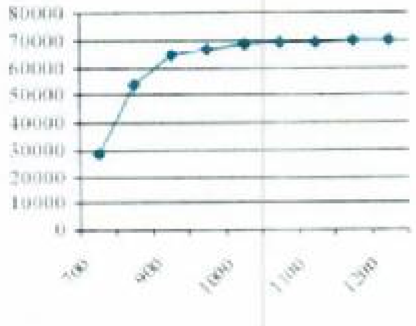
Barometric Pressure: 24.78 inches Hg
Source Distance: ☐ Contact ✓ 6 inches ☐ Other:
Threshold: 10 mV
Temperature: 74 °F
Source Geometry: ✓ Side ☐ Below ☐ Other:
Window:
Relative Humidity: 20 %

Instrument found within tolerance: ✓ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399802	400
x 1000	100	100	100		100
x 100	400	400	400	39989	400
x 100	100	100	100		100
x 10	400	400	400	3999	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	28456	
800	53330	
900	64430	
950	66209	
1000	68333	
1050	69077	
1100	69121	8924
1150	69973	
1200	70155	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:
Ludlum pulser serial number: ☐ 97743 ✓ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✓ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 7 [illegible] 16
Calibration Due: 7/[illegible]/17

Reviewed By:
Date: 7/20/16

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 196086
Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR295014

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed
☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

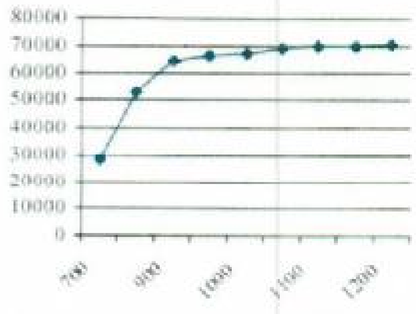
Barometric Pressure: 24.27 inches Hg
Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Threshold: 10 mV
Temperature: 78 °F
Source Geometry: ☑ Side ☐ Below ☐ Other:
Window:
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399386	400
x 1000	100	100	100		100
x 100	400	400	400	39949	400
x 100	100	100	100		100
x 10	400	400	400	3995	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	28235	
800	52834	
900	64481	
950	66468	
1000	67321	
1050	69009	
1100	69981	9079
1150	69564	
1200	70538	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03
☐ Other Source:

Calibrated By:
Calibration Date: 2/28/17 ~~1 March 17~~
Calibration Due: 2/28/18 ~~2 March 18~~
Reviewed By:
Date: 3/1-17

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	138368
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR154615

✓ Mechanical Check
✓ F/S Response Check
✓ Geotropism
✓ Meter Zeroed

✓ THR/WIN Operation
✓ Reset Check
✓ Audio Check
✓ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ✓ 500 V ✓ 1000 V ✓ 1500 V
Cable Length: ☐ 39-inch ✓ 72-inch ☐ Other:

Source Distance: ☐ Contact ✓ 6 inches ☐ Other:
Source Geometry: ✓ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

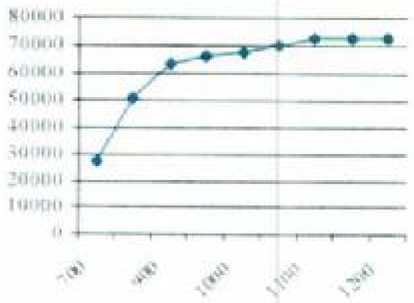
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

Instrument found within tolerance: ✓ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398436	400
x 1000	100	100	100		100
x 100	400	400	400	39845	400
x 100	100	100	100		100
x 10	400	400	400	3984	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	26998	
800	51037	
900	63340	
950	65550	
1000	67410	
1050	70113	
1100	72217	
1150	72561	9216
1200	72337	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1150

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✓ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
✓ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 7-6-16
Calibration Due: 7-6-17

Reviewed By: Cf
Date: 7/20/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A-1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 271435

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR295017

☐ Mechanical Check ☐ THR/WIN Operation
☐ F/S Response Check ☐ Reset Check
☐ Geotropism ☐ Audio Check
☐ Meter Zeroed ☐ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

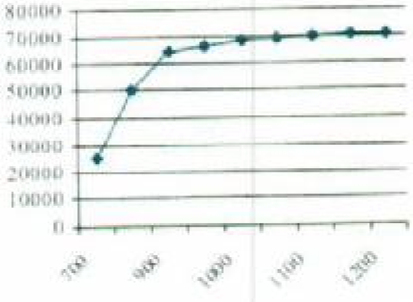
Barometric Pressure: 24.66 inches Hg
Temperature: 76 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	24824	
800	50232	
900	64285	
950	66354	
1000	68179	
1050	69312	9393
1100	69955	
1150	70625	
1200	70633	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1
☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:

Calibration Date: 3 13-17 Calibration Due: 3-13-18

Reviewed By:

Date: 14 March 2017

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	282971
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR320678

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

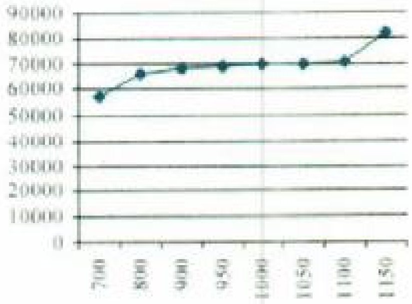
Barometric Pressure: 24.63 inches Hg
Temperature: 75 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399936	400
x 1000	100	100	100		100
x 100	400	400	400	39984	400
x 100	100	100	100		100
x 10	400	400	400	3998	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	57641	
800	65850	
900	68414	
950	68639	
1000	69410	9773
1050	69358	
1100	70301	
1150	81822	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1
☐ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12
☐ Other Source:

Calibrated By:
Calibration Date: 3-13-17
Calibration Due: 3-13-18

Reviewed By:
Date: 14 March 2017

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	138368
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR355763

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

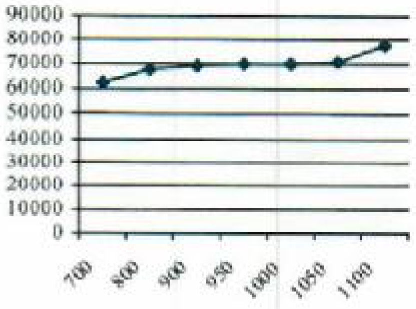
Barometric Pressure: 24.75 inches Hg
Temperature: 76 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398875	400
x 1000	100	100	100		100
x 100	400	400	400	39883	400
x 100	100	100	100		100
x 10	400	400	400	3988	400
x 10	100	100	100		100
x 1	400	400	400	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	62275	
800	68049	
900	69726	
950	70112	9509
1000	70068	
1050	71042	
1100	77619	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
☐ Other Source:

Calibrated By:
Calibration Date: 9/17-17
Calibration Due: 9-17-18

Reviewed By:
Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3718
Phone 800-522-2325   Fax 615-871-0856

ACCREDITED
CALIBRATION CERT #1656.01

CALIBRATION REPORT

SUBMITTED BY: ERG
8809 Washington Street Northeast
Suite 150
Albuquerque, NM 87113

INSTRUMENT: Reuter Stokes RSS-131, #07J00KM1

REPORT NUMBER: 161866
TEST NUMBER(S) M161588
REPORT DATE: June 29, 2016

The CALIBRATION COEFFICIENTS contained in this report were obtained by intercomparison with instruments calibrated by, or directly traceable to, the National Institute of Standards and Technology (NIST). K• S Associates, Inc. is licensed by the State of Tennessee (R-19075-G97, R-19136-B00) to perform calibrations, and is recognized by the Health Physics Society (HPS) as an ACCREDITED INSTRUMENT CALIBRATION LABORATORY. As part of the accreditation K • S participates in a measurement assurance program conducted by the HPS and NIST. K • S also certifies that the calibration was performed using quality policies, methods and procedures that meet or exceed the requirements of ISO/IEC 17025:2005.

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this report have been determined in accordance with the laboratory's terms of accreditation unless stated otherwise in this report

The CALIBRATION COEFFICIENTS stated herein are valid under the conditions specified. It is the instrument user's responsibility to perform the appropriate constancy tests prior to shipment and after return from calibration. It is also the responsibility of the user to assure that the interpretation of the information in this report is consistent with that intended by K • S Associates, Inc.

K&S Associates, Inc
Nashville, Tennessee 37210-3718
ACCREDITED

CALIBRATION CERTIFICATE

Calibration Date: 6/27/2016 Report Number: 161866 Test Number: M161588

K&S certifies that the environmental radiation monitor identified below has been calibrated for radiation measurement using collimated radiation sources whose output has been calibrated with instruments calibrated by or directly traceable to the National Institute of Standards and Technology. K&S is accredited by the American Association for Laboratory Accreditation to perform environmental level calibrations and further certifies that the calibration was performed using accredited policies and procedures (SI 25) that meet or exceed the requirements of ISO/IEC 17025:2005.

Sensor Type: 100 mR/h

Serial Number: 07J00KM1

Average Calibration Coefficient for the range of 0.012 mR/h – 0.220 mR/h*:
1.02 mR/"mR" reading
(Measured at 4 points)

Calibration Coefficient for the 50.0 mR/h point*:
1.12 mR/"mR" reading

Calibration Coefficient for the 80.0 mR/h point*:
1.10 mR/"mR" reading

Found RAC: 2.169e-8

*Multiply the reading in **mR/h** by the Calibration Coefficient to obtain true **mR/h**.

Calibrated By: Richard Harrison Reviewed By: Angela Royer
Richard Hardison Angela Royer
Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED

AS FOUND DATA
Reuter-Stokes Chamber Calibration

June 27, 2016

Test Number *M161588*

CHAMBER:

Mfgr: Reuter Stokes
Model: RSS-131
Serial: 07J00KM1

SUBMITTED BY:

ERG

Albuquerque, NM

ORIENTATION/CONDITIONS:

Serial number away from source

"True" background exposure rate of 6.7 uR/h, instrument reading was 0.0076 mR/h

ATMOSPHERIC COMMUNICATION: SEALED

POLARIZING POTENTIAL 401V

LEAKAGE: negligible

BEAM QUALITY **BEAM**		**EXPOSURE RATE**		**CALIBRATION COEFFICIENT**	**UNCERT**	**LOG**
CsEn220	(11mCi)	0.22mR/h	N_x=	1.00 mR/h/rdg	11%	M-53 73
CsEn80	(11mCi)	0.08mR/h	N_x=	1.03 mR/h/rdg	11%	
CsEnv12	(1mCi)	0.012mR/h	N_x=	1.01 mR/h/rdg	11%	
CsEnv15	(1mCi)	0.015mR/h	N_x=	1.02 mR/h/rdg	11%	
Cs199m	(20 Ci)	50mR/h	N_x=	1.12 mR/h/rdg	8%	
Cs252m	(20 Ci)	80mR/h	N_x=	1.10 mR/h/rdg	8%	

Comments Batt: 6.1V, Temp: 24.6 deg C, K&S Environment: Temp:21 deg C , RH 59%, Press: 752 mmHg;
Report Number: 161866
Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25
RAC Found: 2.169e-8

Calibrated By Richard Hardison

Title: Calibration Technician

Reviewed By:

Title: Calibration Physicist

Checked By:

Prepared By:

Form RSS

①

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7.19.17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7.19.17

Comments:
NNEAT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): PROJECT REFERENCE POINTS
10-26-16	0637	6.1	1008	99	46974	7833	39141	NW	BOYD TISI
10-26-16	1545	6.1	992	98	42850	5959	36891	NW	BOYD TISI
10-27-16	1005	6.0	1004	99	48059	8561	39498	NW	Harvey Blackwater
10-27-16	1555	5.9	999	99	48564	8465	40099	NW	Harvey Blackwater
10-28-16	0808	5.9	1004	99	46814	9142	37672	NW	Harvey Blackwater
10-28-16	1704	5.8	1000	99	43711	5178	38533	NW	Mitten No. 3
10-29-16	0807	5.9	1005	100	43690	5203	38487	NW	Mitten No. 3
10-29-16	1342	5.8	999	99	44561	4801	39760	NW	Mitten No. 3
10-31-16	0840	5.8	1004	99	42426	5084	37342	NW	Mitten No. 3
10-31-16	1507	5.8	999	99	44206	5069	39137	NW	Goulding's back SUV
11-1-16	0748	5.8	1006	100	44441	4842	39599	NW	Charles Keith
11-1-16	1722	5.7	1003	99	44858	5117	39741	NW	Goulding's back of SUV

Reviewed by: MM

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-2-16	0821	5.7	1008	99	45344	6195	39149	NW	Charles, keith
11-2-16	1721	5.6	1002	99	44348	5346	39002	NW	Goulding's in SUV
11-3-16	1037	5.7	1007	100	43600	5834	37766	NW	Charles Keith
11-3-16	1848	5.7	1003	100	46842	7821	39021	NW	Chinle Holiday Inn SUV
11-4-16	0845	5.7	1007	100	48258	8617	39641	NW	Occurrence B
11-4-16	1255	5.5	1003	99	46329	8608	37721	NW	Occurrence B
11-5-16	1108	5.6	1006	99	47858	9264	38594	NW	Claim 28
11-5-16	1527	5.6	1006	99	45039	7398	37641	NW	Chinle lot in SUV
11-7-16	0805	5.7	1008	100	48193	9249	38944	NW	Claim 28
11-7-16	1836	5.6	1003	99	46783	6986	39797	NW	Chinle lot in SUV
11-8-16	0800	5.6	1009	99	47951	9183	38768	NW	Claim 28
11-8-16	1637	5.5	1003	100	45094	6916	38178	NW	Chinle lot

Reviewed by:

Review Date: 11/29/16

ERG Form ITC.201.A

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ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:

NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: 6 Inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-1-16	0744	5.3	1107	100	43406	4729	38677	NW	Charles Keith
11-1-16	1718	5.2	1102	99	44319	5332	38987	NW	Goulding's in SUV
11-2-16	0818	5.2	1108	100	43456	5555	37901	NW	Charles Keith
11-2-16	1703	5.1	1101	100	43874	5111	38763	NW	Gouldings in SUV
a 11-3-16	1050	6.2	1107	100	45017	5399	39618	NW	Charles Keith
a 11-3-16	1845	6.2	1104	99	47896	7562	40334	NW	Chinle Holiday Inn SUV
11-4-16	0856	6.2	1109	100	47119	8187	38732	NW	Occurrence B
11-4-16	1147	6.1	1105	100	46025	7972	38053	NW	Occurrence B
11-5-16	1112	6.1	1107	100	47483	8555	38928	NW	Claim 28
11-5-16	1524	6.1	1107	99	46828	7017	39811	NW	Chinle lot in SUV
11-7-16	0822	6.1	1108	100	46734	8744	37990	NW	Claim 28
11-7-16	1829	5.9	1104	99	46382	6448	39934	NW	Chinle lot

a. Charged batteries

Reviewed by:

Review Date: 11/29/16

③

ERG

Single-Channel Function Check Log

Environmental Restoration Group Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.	138368
Cal. Due Date	7-19-17 NW

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.	PR154615
Cal. Due Date:	7-19-17 NW

Comments:

NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-16-94

Distance to Source: 6 in.

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
10-28-16	0813	5.6	1162	144	50583	9051	41532	NW	Harvey Blackwater
10-29-16	0815	5.6	1222	199	44566	5053	39513	NW	Mitten No. 3
10-29-16	1338	5.5	1141	125	44503	4794	39709	NW	Mitten No. 3
10-31-16	0846	5.5	1133	111	44824	4753	40071	NW	Mitten No. 3
10-31-16	1502	5.5	1132	114	44994	4883	40111	NW	Goulding's in SUV
11-1-16	0758	5.5	1133	110	45344	4771	40573	NW	Charles Keith
11-1-16	1712	5.3	1120	100	44220	4928	39292	NW	Goulding's in SUV
11-2-16	0826	5.3	1127	103	44389	5834	38555	NW	Charles Keith
11-2-16	1715	5.3	1125	106	43737	5179	38558	NW	Goulding's in SUV
11-3-16	1055	5.3	1125	105	44443	5368	39075	NW	Charles Keith
11-3-16	1842	5.3	1123	104	47047	7583	39464	NW	Chinle Holiday Inn SUV
11-4-16	0900	5.4	1128	104	46230	8402	37828	NW	Occurrence B

Reviewed by:

Review Date: 11/29/16

ERG Form ITC.201.A

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Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254992
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 303727
Cal. Due Date:	2-28-18

Comments:
NNERT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: N/A cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-16-17	1322	6.2	947	100	40116	7260	32856	NW	Cameron Trading Post lot
3-16-17	1555	6.1	942	99	38642	5986	32657	NW	Boyd Tisi
3-17-17	0812	6.2	951	100	40027	7965	32122	NW	Cameron Trading Post lot
3-17-17	1328	6.1	943	100	42203	10206	31997	NW	Boyd Tisi ~200 ft from BG4
3-18-17	0730	6.1	949	100	38598	6950	31648	NW	Harvey Blackwater
3-18-17	1505	6.0	941	100	35954	5035	30919	NW	Mitten No. 3
3-19-17	0651	6.1	949	99	36982	4952	32030	NW	Goulding's lot
3-19-17	1217	5.9	945	99	36802	5103	31699	NW	Charles Keith south of claim
3-20-17	0855	6.0	950	100	40829	8989	31840	NW	Claim 28
3-20-17	1555	5.9	943	100	37489	5569	32280	NW	Chinle parking lot
3-21-17	0635	5.9	950	100	38433	5735	32698	NW	Chinle lot
3-21-17	1657	5.9	946	100	36797	4997	31800	NW	Goulding's lot

Reviewed by:

Review Date: 10/17/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-18

Comments:
NNGAT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: N/a cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 Inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0658	5.9	948	100	37553	5150	32403	NW	Goulding's lot
3-22-17	1432	5.7	944	100	35555	4865	30690	NW	Charles Keith shooting range
3-23-17	0903	5.8	949	100	35647	5062	30585	NW	NA-0928
3-23-17	1918	5.7	950	101	41998	10371	31627	NW	Gallup lot
3-24-17	0812	5.7	953	100	36633	4660	31973	NW	Eunice Becenti
3-24-17	1740	5.6	947	100	42350	11142	31208	NW	Gallup lot
3-27-17	0830	5.6	952	100	36518	4677	31841	NW	Eunice Becenti
3-27-17	1230	5.5	949	100	36189	4090	32099	NW	Eunice Becenti
						4-2-17			

Reviewed by:

Review Date: 11/06/17

ERG Form ITC.201.A

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

ERG

Single-Channel Function Check Log

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	2-28-18

Comments: NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-20-17	0905	5.7	1003	101	40471	8507	31964	NW	Claim 28
3-20-17	1547	5.6	996	101	36470	5494	30976	NW	Chinle lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chinle lot
3-21-17	1654	5.6	999	101	36212	4929	31283	NW	Goulding's lot
3-22-17	0702	5.6	1001	101	35714	5119	30595	NW	Goulding's lot
3-22-17	1437	5.4	995	101	35087	4539	30548	NW	Charles Keith shooting range
3-23-17	0907	5.6	1004	101	36031	4879	31152	NW	NA-0928
3-23-17	1922	5.5	1004	101	41793	9955	31838	NW	Gallup lot
3-24-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-24-17	1735	5.5	1000	101	41923	10785	31138	NW	Gallup lot
3-27-17	0833	5.5	1005	101	36943	4282	32661	NW	Eunice Becenti
3-27-17	1235	5.4	1000	101	35141	4013	31128	NW	Eunice Becenti

Reviewed by:

Review Date: 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295017
Cal. Due Date:	3-13-18

Comments:
NNEAT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: NA cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0705	5.6	1050	100	35820	5210	30610	NW	Goulding's lot
3-22-17	1425	5.5	1049	101	36169	4648	31521	NW	Charles Keith shooting range
3-23-17	0908	5.6	1056	102	35972	4828	31144	NW	NA-0928
3-23-17	1915	5.5	1055	102	41686	10757	30929	NW	Gallup lot
3-24-17	0805	5.5	1060	102	36151	4442	31709	NW	Eunice Becenti
3-24-17	1744	5.4	1051	101	41975	10973	31002	NW	Gallup lot
3-25-17	0908	5.5	1057	102	37581	5827	31754		Section 26
3-25-17					DID NOT USE				
					4-2-17				

Reviewed by:

Review Date: ~~9~~ 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-18

Comments:

NNMRT

Source: Cs-137

Activity: 4 uCi

Source Date: 4-18-96

Distance to Source: 6 inches

Serial No.: 544-96

Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
5-18-17	1032	5.5	1001	100	38206	6536	31670	NW	Alongo upper
5-18-17	1206	5.5	1001	100	39193	6515	32678	NW	Alongo upper
5-19-17	0643	5.6	1003	101	36123	4837	31286	NW	Oak 124/125
5-19-17	1456	5.5	999	101	38056	6003	32053	NW	Alongo lower
5-22-17	0729	5.5	1000	100	36624	4799	31825	NW	Mitten
5-22-17	1542	5.4	992	100	35431	4841	30590	NW	Mitten
5-23-17	0733	5.5	995	100	36519	5067	31452	NW	Mitten
5-23-17	1426	5.4	994	100	35848	4830	31018	NW	Goulding's lodge
5-24-17	0757	5.4	997	106	36605	5123	31482	NW	Charles Keith
5-24-17	1143	5.3	993	106	36113	4844	31269	NW	Charles Keith
					NW 5-25-17				

Reviewed by:

Review Date: 11/06/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR320678
Cal. Due Date:	3-13-18

Comments:
NNERT

Source: Cs-137 Activity: 4 uCi Source Date: 4-18-96 Distance to Source: 6 inches

Serial No.: 544-96 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
5-16-17	0747	5.6	1051	100	37255	5170	32085	NW	Eunice Becenti
5-16-17	1332	5.6	1052	100	36609	5251	31358	NW	Eunice Becenti
5-17-17	0808	5.6	1053	101	37256	5821	31435	NW	Eunice Becenti
5-17-17	1417	5.6	1049	100	36737	5441	31296	NW	Eunice Becenti
5-18-17	1029	5.5	1052	100	38435	7070	31365	NW	Alonzo upper
5-18-17	1202	5.5	1052	101	38935	6986	31949	NW	Alonzo upper
5-20-17	0924	5.6	1051	101	38316	7201	31115	NW	Alonzo lower
5-20-17	1352	5.5	1047	99	39498	6654	32844	NW	Alonzo lower
5-23-17	0737	5.6	1050	100	36693	5557	31136	NW	Mitten
5-23-17	1430	5.5	1046	100	37575	5371	32204	NW	Fouldings lodge
5-24-17	0803	5.6	1048	100	37282	5725	31557	NW	Charles Keith
5-24-17	1143	5.5	1044	100	36054	5552	30502	NW	Charles Keith

Reviewed by: **Review Date:** 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR320678
Cal. Due Date:	3-13-18

Comments:
NNE2T - Soils Characterization

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-20-17	1334	5.7	1046	100	37108	6411	30697	NW	Charles Keith
6-20-17	1651	5.6	1038	98	36894	5907	30987	NW	Charles Keith
6-21-17	0720	5.7	1045	100	38258	6568	31690	NW	Charles Keith
6-21-17	1400	5.5	1035	99	36426	5473	30953	NW	Charles Keith
6-22-17	0732	5.6	1044	100	37058	5300	31758	NW	Charles Keith
6-22-17	1710	5.5	1042	99	37441	6708	30733	NW	Tsosie 1
6-24-17	0901	5.6	1047	100	38218	7111	31107	NW	Tsosie 1
6-24-17	1655	5.5	1041	99	36728	6080	30648	NW	Tsosie 1
6-26-17	0852	5.6	1048	100	38982	7442	31540	NW	Tsosie 1
6-26-17	1632	5.4	1040	99	38932	7627	31305	NW	Tsosie 1
6-27-17	1238	5.5	1047	100	36268	5913	30355	NW	Eunice Becenti
6-27-17	1403	5.5	1044	100	36016	5567	30449	NW	Eunice Becenti

Reviewed by:

Review Date: 6/29/17

ERG Form ITC.201.A

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	138368
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR355763
Cal. Due Date:	9-7-18

Comments:
NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 Inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-12-17	0914	5.4	950	101	36935	6331	30604	NW	Barton 3
9-12-17	1432	5.3	944	99	38043	6468	31575	NW	Tsosie 1
9-13-17	0906	5.4	951	99	37146	6538	30608	NW	Alonzo
9-13-17	1600	5.3	944	99	35587	5991	29596	NW	Barton 3
9-14-17	0909	5.4	950	100	36080	6176	29904	NW	NA-0904
9-14-17	1255	5.3	948	100	36099	5764	30335	NW	NA-0904
9-15-17	0920	5.4	954	101	35208	5551	29657	NW	Eunice Becenti
9-15-17	1729	5.3	957	109	35937	5261	30676	NW	Eunice Becenti
9-19-17	0831	5.4	958	105	36467	6034	30433	NW	Section 26 @ trailer
9-19-17	1453	5.3	946	99	44454	14748	29706	NW	Section 26 @ corral
9-20-17	0736	5.3	953	102	37676	6987	30689	NW	Mexican Hat
9-20-17	1611	5.2	947	100	36842	6252	30590	NW	Mexican Hat

Reviewed by:

Review Date: 10/9/17

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Single-Channel Function Check Log

METER	
Manufacturer:	GE
Model:	RS3-131
Serial No.:	07J0UKM1
Cal. Due Date:	6-29-17

DETECTOR	
Manufacturer:	SAME AS METER
Model:	
Serial No.:	
Cal. Due Date:	

Comments:

NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: Contact -housing

Date	Time	Battery	High Voltage	Threshhold	Source Counts μR/h	BKG Counts μR/h	Net Counts	Initials	Note(s): Project reference points
10-26-16	0525	~6.4	~400	NA	~27.8	~10.5	~17.3	NW	Best Western room - Flagstaff
10-26-16	2010	~6.3	~400	NA	~26	~9.5	~16.5	NW	Gouldings room ~~Best Western room - Flagstaff~~ NW
10-27-16	0720	~6.2	~400	NA	~26.7	~10.0	~16.7	NW	Gouldings room
10-27-16	1710	~6.2	~400	NA	~27.0	~10.8	~16.2	NW	Gouldings room
10-31-16	0609	~6.3	~400	NA	~27.0	~10	~16	NW	Gouldings room
10-31-16	1520	~6.3	~400	NA	~26	~10	~16	NW	Gouldings room
11-3-16	0700	~6.2	~400	NA	~26.5	~10.5	~16	NW	Gouldings room
11-3-16	1924	~6.1	~400	NA	~28.8	~12.5	~16.3	NW	Holiday Inn Chinle-room
11-9-16	0615	~6.3	~400	NA	~30	~12.8	~17.2	NW	Holiday Inn-Chinle room
11-9-16	1430	~6.2	~400	NA	~29.5	~12.5	~17	NW	Holiday Inn Chinle - room
11-11-16	0610	~6.4	~400	NA	~31.5	~13.5	~18	NW	Holiday Inn Chinle - room
11-11-16	1825	~6.2	~400	NA	~28	~11	~17	NW	Holiday Inn Chinle - room

Reviewed by:

Review Date: 11-29-16

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
11/03/2016 11:46	0.0544	Correlation Location 1
11/03/2016 11:46	0.0953	Correlation Location 1
11/03/2016 11:46	0.084	Correlation Location 1
11/03/2016 11:47	0.0586	Correlation Location 1
11/03/2016 11:47	0.0394	Correlation Location 1
11/03/2016 11:47	0.0278	Correlation Location 1
11/03/2016 11:47	0.0216	Correlation Location 1
11/03/2016 11:47	0.0182	Correlation Location 1
11/03/2016 11:47	0.0167	Correlation Location 1
11/03/2016 11:47	0.0156	Correlation Location 1
11/03/2016 11:47	0.0145	Correlation Location 1
11/03/2016 11:47	0.0144	Correlation Location 1
11/03/2016 11:47	0.0147	Correlation Location 1
11/03/2016 11:48	0.0148	Correlation Location 1
11/03/2016 11:48	0.0145	Correlation Location 1
11/03/2016 11:48	0.0144	Correlation Location 1
11/03/2016 11:48	0.0144	Correlation Location 1
11/03/2016 11:48	0.0142	Correlation Location 1
11/03/2016 11:48	0.0142	Correlation Location 1
11/03/2016 11:48	0.0148	Correlation Location 1
11/03/2016 11:48	0.0151	Correlation Location 1
11/03/2016 11:48	0.015	Correlation Location 1
11/03/2016 11:48	0.0147	Correlation Location 1
11/03/2016 11:49	0.0144	Correlation Location 1
11/03/2016 11:49	0.0142	Correlation Location 1
11/03/2016 11:49	0.0143	Correlation Location 1
11/03/2016 11:49	0.0145	Correlation Location 1
11/03/2016 11:49	0.0147	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:49	0.0148	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:50	0.0147	Correlation Location 1
11/03/2016 11:50	0.0145	Correlation Location 1
11/03/2016 11:50	0.0142	Correlation Location 1
11/03/2016 11:50	0.0141	Correlation Location 1
11/03/2016 11:50	0.0144	Correlation Location 1
11/03/2016 11:50	0.0146	Correlation Location 1
11/03/2016 11:50	0.015	Correlation Location 1
11/03/2016 11:50	0.0152	Correlation Location 1
11/03/2016 11:50	0.0153	Correlation Location 1
11/03/2016 11:50	0.0154	Correlation Location 1
11/03/2016 11:51	0.0153	Correlation Location 1
11/03/2016 11:51	0.0148	Correlation Location 1
11/03/2016 11:51	0.0149	Correlation Location 1
11/03/2016 11:51	0.015	Correlation Location 1
11/03/2016 11:51	0.015	Correlation Location 1
11/03/2016 11:51	0.0153	Correlation Location 1
11/03/2016 11:51	0.0156	Correlation Location 1
11/03/2016 11:51	0.0152	Correlation Location 1
11/03/2016 11:51	0.0146	Correlation Location 1
11/03/2016 11:51	0.0145	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0143	Correlation Location 1
11/03/2016 11:52	0.0148	Correlation Location 1
11/03/2016 11:52	0.0149	Correlation Location 1
11/03/2016 11:52	0.0148	Correlation Location 1
11/03/2016 11:52	0.0147	Correlation Location 1
11/03/2016 11:52	0.0151	Correlation Location 1
11/03/2016 11:53	0.0155	Correlation Location 1
11/03/2016 11:53	0.0153	Correlation Location 1
11/03/2016 11:53	0.0151	Correlation Location 1
11/03/2016 11:53	0.0151	Correlation Location 1
11/03/2016 11:53	0.0148	Correlation Location 1
11/03/2016 11:53	0.0143	Correlation Location 1
11/03/2016 11:53	0.014	Correlation Location 1
11/03/2016 11:53	0.0142	Correlation Location 1
11/03/2016 11:53	0.0149	Correlation Location 1
11/03/2016 11:53	0.015	Correlation Location 1
11/03/2016 11:54	0.0152	Correlation Location 1
11/03/2016 11:54	0.0151	Correlation Location 1
11/03/2016 11:54	0.0148	Correlation Location 1
11/03/2016 11:54	0.0145	Correlation Location 1
11/03/2016 11:54	0.0147	Correlation Location 1
11/03/2016 11:54	0.0149	Correlation Location 1
11/03/2016 11:54	0.0147	Correlation Location 1
11/03/2016 11:54	0.0145	Correlation Location 1
11/03/2016 11:54	0.0146	Correlation Location 1
11/03/2016 11:54	0.0144	Correlation Location 1
11/03/2016 11:55	0.0144	Correlation Location 1
11/03/2016 11:55	0.0141	Correlation Location 1
11/03/2016 11:55	0.0137	Correlation Location 1
11/03/2016 11:55	0.0136	Correlation Location 1
11/03/2016 11:55	0.0143	Correlation Location 1
11/03/2016 11:55	0.0149	Correlation Location 1
11/03/2016 11:55	0.0153	Correlation Location 1
11/03/2016 11:55	0.0154	Correlation Location 1
11/03/2016 11:55	0.0151	Correlation Location 1
11/03/2016 11:55	0.0149	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0155	Correlation Location 1
11/03/2016 11:56	0.0155	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0152	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.015	Correlation Location 1
11/03/2016 11:56	0.0149	Correlation Location 1
11/03/2016 11:57	0.015	Correlation Location 1
11/03/2016 11:57	0.015	Correlation Location 1
11/03/2016 11:57	0.0152	Correlation Location 1
11/03/2016 11:57	0.0151	Correlation Location 1
11/03/2016 12:16	0.0552	Correlation Location 2
11/03/2016 12:16	0.0978	Correlation Location 2
11/03/2016 12:16	0.0874	Correlation Location 2
11/03/2016 12:16	0.0622	Correlation Location 2
11/03/2016 12:17	0.0429	Correlation Location 2

Charles Keith Exposure Rate Measurments for Correlation

Date and Time	Exposure Rate (mR/h)	Location
11/03/2016 12:17	0.0316	Correlation Location 2
11/03/2016 12:17	0.0251	Correlation Location 2
11/03/2016 12:17	0.0221	Correlation Location 2
11/03/2016 12:17	0.0207	Correlation Location 2
11/03/2016 12:17	0.0199	Correlation Location 2
11/03/2016 12:17	0.0192	Correlation Location 2
11/03/2016 12:17	0.0192	Correlation Location 2
11/03/2016 12:17	0.0194	Correlation Location 2
11/03/2016 12:17	0.0192	Correlation Location 2
11/03/2016 12:18	0.0189	Correlation Location 2
11/03/2016 12:18	0.0186	Correlation Location 2
11/03/2016 12:18	0.019	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.0192	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.019	Correlation Location 2
11/03/2016 12:18	0.019	Correlation Location 2
11/03/2016 12:19	0.0189	Correlation Location 2
11/03/2016 12:19	0.0188	Correlation Location 2
11/03/2016 12:19	0.0187	Correlation Location 2
11/03/2016 12:19	0.0186	Correlation Location 2
11/03/2016 12:19	0.0184	Correlation Location 2
11/03/2016 12:19	0.0186	Correlation Location 2
11/03/2016 12:19	0.0189	Correlation Location 2
11/03/2016 12:19	0.019	Correlation Location 2
11/03/2016 12:19	0.0192	Correlation Location 2
11/03/2016 12:19	0.0196	Correlation Location 2
11/03/2016 12:20	0.0198	Correlation Location 2
11/03/2016 12:20	0.02	Correlation Location 2
11/03/2016 12:20	0.0198	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0189	Correlation Location 2
11/03/2016 12:20	0.019	Correlation Location 2
11/03/2016 12:21	0.0189	Correlation Location 2
11/03/2016 12:21	0.0186	Correlation Location 2
11/03/2016 12:21	0.0189	Correlation Location 2
11/03/2016 12:21	0.0192	Correlation Location 2
11/03/2016 12:21	0.0194	Correlation Location 2
11/03/2016 12:21	0.019	Correlation Location 2
11/03/2016 12:21	0.0189	Correlation Location 2
11/03/2016 12:21	0.019	Correlation Location 2
11/03/2016 12:21	0.0194	Correlation Location 2
11/03/2016 12:21	0.0194	Correlation Location 2
11/03/2016 12:22	0.0197	Correlation Location 2
11/03/2016 12:22	0.0194	Correlation Location 2
11/03/2016 12:22	0.0192	Correlation Location 2
11/03/2016 12:22	0.019	Correlation Location 2
11/03/2016 12:22	0.019	Correlation Location 2
11/03/2016 12:22	0.0189	Correlation Location 2
11/03/2016 12:22	0.0189	Correlation Location 2
11/03/2016 12:22	0.0189	Correlation Location 2
11/03/2016 12:22	0.0192	Correlation Location 2
11/03/2016 12:22	0.0192	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0194	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0189	Correlation Location 2
11/03/2016 12:23	0.0186	Correlation Location 2
11/03/2016 12:23	0.019	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0194	Correlation Location 2
11/03/2016 12:23	0.0194	Correlation Location 2
11/03/2016 12:24	0.0192	Correlation Location 2
11/03/2016 12:24	0.0194	Correlation Location 2
11/03/2016 12:24	0.0194	Correlation Location 2
11/03/2016 12:24	0.0198	Correlation Location 2
11/03/2016 12:24	0.02	Correlation Location 2
11/03/2016 12:24	0.0199	Correlation Location 2
11/03/2016 12:24	0.0194	Correlation Location 2
11/03/2016 12:24	0.0197	Correlation Location 2
11/03/2016 12:24	0.02	Correlation Location 2
11/03/2016 12:24	0.0197	Correlation Location 2
11/03/2016 12:25	0.0196	Correlation Location 2
11/03/2016 12:25	0.0196	Correlation Location 2
11/03/2016 12:25	0.0196	Correlation Location 2
11/03/2016 12:25	0.0194	Correlation Location 2
11/03/2016 12:25	0.0194	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.019	Correlation Location 2
11/03/2016 12:26	0.0189	Correlation Location 2
11/03/2016 12:26	0.0187	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:26	0.0192	Correlation Location 2
11/03/2016 12:26	0.0194	Correlation Location 2
11/03/2016 12:26	0.0192	Correlation Location 2
11/03/2016 12:26	0.0187	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:27	0.019	Correlation Location 2
11/03/2016 12:27	0.0187	Correlation Location 2
11/03/2016 12:27	0.0185	Correlation Location 2
11/03/2016 12:27	0.0188	Correlation Location 2
11/03/2016 12:27	0.0186	Correlation Location 2
11/03/2016 12:43	0.0581	Correlation Location 3
11/03/2016 12:43	0.1047	Correlation Location 3
11/03/2016 12:43	0.098	Correlation Location 3
11/03/2016 12:43	0.0745	Correlation Location 3
11/03/2016 12:44	0.056	Correlation Location 3
11/03/2016 12:44	0.045	Correlation Location 3
11/03/2016 12:44	0.0389	Correlation Location 3
11/03/2016 12:44	0.0355	Correlation Location 3
11/03/2016 12:44	0.0336	Correlation Location 3
11/03/2016 12:44	0.0328	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
11/03/2016 12:44	0.0327	Correlation Location 3
11/03/2016 12:44	0.0327	Correlation Location 3
11/03/2016 12:44	0.0322	Correlation Location 3
11/03/2016 12:44	0.0322	Correlation Location 3
11/03/2016 12:45	0.0324	Correlation Location 3
11/03/2016 12:45	0.0328	Correlation Location 3
11/03/2016 12:45	0.033	Correlation Location 3
11/03/2016 12:45	0.0332	Correlation Location 3
11/03/2016 12:45	0.0332	Correlation Location 3
11/03/2016 12:45	0.033	Correlation Location 3
11/03/2016 12:45	0.0328	Correlation Location 3
11/03/2016 12:45	0.0324	Correlation Location 3
11/03/2016 12:45	0.0321	Correlation Location 3
11/03/2016 12:45	0.0321	Correlation Location 3
11/03/2016 12:46	0.0322	Correlation Location 3
11/03/2016 12:46	0.0324	Correlation Location 3
11/03/2016 12:46	0.0319	Correlation Location 3
11/03/2016 12:46	0.032	Correlation Location 3
11/03/2016 12:46	0.0322	Correlation Location 3
11/03/2016 12:46	0.0327	Correlation Location 3
11/03/2016 12:46	0.0326	Correlation Location 3
11/03/2016 12:46	0.0328	Correlation Location 3
11/03/2016 12:46	0.0328	Correlation Location 3
11/03/2016 12:46	0.0332	Correlation Location 3
11/03/2016 12:47	0.0335	Correlation Location 3
11/03/2016 12:47	0.0336	Correlation Location 3
11/03/2016 12:47	0.0336	Correlation Location 3
11/03/2016 12:47	0.0335	Correlation Location 3
11/03/2016 12:47	0.0332	Correlation Location 3
11/03/2016 12:47	0.0336	Correlation Location 3
11/03/2016 12:47	0.0337	Correlation Location 3
11/03/2016 12:47	0.0332	Correlation Location 3
11/03/2016 12:47	0.0328	Correlation Location 3
11/03/2016 12:47	0.0328	Correlation Location 3
11/03/2016 12:48	0.033	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0331	Correlation Location 3
11/03/2016 12:48	0.0334	Correlation Location 3
11/03/2016 12:48	0.0332	Correlation Location 3
11/03/2016 12:48	0.0331	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0331	Correlation Location 3
11/03/2016 12:49	0.033	Correlation Location 3
11/03/2016 12:49	0.033	Correlation Location 3
11/03/2016 12:50	0.0328	Correlation Location 3
11/03/2016 12:50	0.0328	Correlation Location 3
11/03/2016 12:50	0.0324	Correlation Location 3
11/03/2016 12:50	0.0327	Correlation Location 3
11/03/2016 12:50	0.0326	Correlation Location 3
11/03/2016 12:50	0.0324	Correlation Location 3
11/03/2016 12:50	0.0324	Correlation Location 3
11/03/2016 12:50	0.0327	Correlation Location 3
11/03/2016 12:50	0.0322	Correlation Location 3
11/03/2016 12:50	0.0322	Correlation Location 3
11/03/2016 12:51	0.0324	Correlation Location 3
11/03/2016 12:51	0.0326	Correlation Location 3
11/03/2016 12:51	0.0326	Correlation Location 3
11/03/2016 12:51	0.0328	Correlation Location 3
11/03/2016 12:51	0.0332	Correlation Location 3
11/03/2016 12:51	0.0332	Correlation Location 3
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11/03/2016 13:21	0.0247	Correlation Location 4
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11/03/2016 13:21	0.0245	Correlation Location 4
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11/03/2016 13:24	0.0239	Correlation Location 4
11/03/2016 13:24	0.0235	Correlation Location 4
11/03/2016 13:24	0.0233	Correlation Location 4
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Date and Time	Exposure Rate (mR/h)	Location
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Appendix C Technical Memo from ERG to Stantec. "Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230".

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Memo

To: Kirsty Woods, Program Director, Stantec

From: Liz Ruedig, PhD, CHP, and Mike Schierman, CHP, Environmental Restoration Group

Date: 7/31/2018

Re: Statistical Analysis of the Navajo Trustee Mines Dataset: Multivariate Linear Regression for Evaluation of Gamma Correlation with Ra-226 and Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Multivariate Linear Regression for Evaluation of Gamma Count Rate with Ra-226 Concentrations in Surface Soil

Due to a large number of reviewer comments at the sixteen Navajo Trust Abandoned Uranium Mines (AUMs) concerning the influence of gamma-emitting radionuclides not within the uranium-238 decay series on the correlation between dynamic gamma count rate and soil concentration of radium-226, Environmental Restoration Group has performed multivariate linear regression (MLR), relating gamma count rate to multiple soil radionuclides simultaneously. MLR models the influence of a set of predictor variables (in this case, soil concentrations of several gamma-emitting radionuclides, or surrogates for these radionuclides) on a single response variable (in this case, dynamic gamma count rate), accounting for the influence of each predictor variable upon the response variable independently of the other predictor variables within the set.

In a MLR, it is possible to distinguish from a large set of variables the subset that significantly predicts a response variable. This is done by evaluating potential models on a number of criteria:

1. **The multi-collinearity of predictor variables.**

   Predictor variables that are linearly related to each other (i.e., variables y and x, where y may also be mathematically expressed as some multiple of x) produce a condition known as multicollinearity, where the matrix math used to solve the multivariate linear regression becomes irreducible. A physical example of multicollinearity occurs when modelling the influence of two radionuclides in equilibrium with each other (e.g., Th-230 and Ra-226) on a single response variable (e.g., gamma count rate). In order to compute a mathematical solution to the regression model, one of the multicollinear variables must be removed from the regression matrix. The multicollinear variables are identifiable by a large variance inflation factor (VIF), typically greater than 7, but in cases of near-perfect multicollinearity, often much greater than this value (e.g., > 100).

   It is also possible to identify multicollinear predictor variables by regressing two suspect variables upon each other. A high degree of correlation (i.e., $p < 0.05$ and high adjusted R^2) between the two variables suggests that the predictor variables are multicollinear, and that one variable should be eliminated from the multivariate regression prior to analysis.

2. **The p-value of predictor variables**

   For a variable to be considered a significant predictor of the response variable, the p-value of its slope (as calculated in an ANOVA table) must be significant (i.e., $p < 0.05$). In a MLR, the adjusted R^2 value for individual predictor variables is not indicative of overall model quality.

For the Navajo Trust AUMs there are three potential gamma-contributing radionuclides (defined as radionuclides that emit gamma radiation, or whose short-lived decay products emit gamma radiation) present in soil: thorium-232, radium-226 and, thorium-228. Thorium-230, which does not emit gamma radiation, was excluded as a potentially significant gamma-contributing radionuclide.

A MLR model: gamma = radium-226 + thorium-228 + thorium-232 was run for each AUM. For 15 of the 16 mines, thorium-232 and thorium-228 were multicollinear. On this basis, thorium-228 was excluded from the MLR. No multicollinearity was detected at Barton 3. However, none of the predictor variables was a significant predictor of gamma count rate ($p > 0.05$) for the complete model. As such, analysis for all 16 AUMs proceeded by removing thorium-228 from the set of predictor variables and running a new MLR model: gamma = radium-226 + thorium-232. None of the 16 models exhibited multicollinearity with the reduced model. After accounting for the effect of radium-226, thorium-232 was not a significant predictor of gamma count rate at any of the 16 AUMs. Radium-226 was a significant predictor ($p < 0.05$) of gamma count rate (after accounting for the influence of thorium-232 and thorium-228) at some of the AUMs (six of 16 AUMs).

Since neither predictor variable (thorium-232 or radium-226) was unambiguously a predictor in the MLR, two univariate regression models were performed as a final step: gamma = radium-226 and gamma = thorium-232. Thorium-232 was a significant predictor of gamma count rate ($p < 0.05$) only at Standing Rock, which is not unexpected given the geological conditions at this AUM. At all other sites, thorium-232 (and thorium-228 by association) were not significant predictors of gamma count rate ($p > 0.05$). By way of contrast, radium-226 was a significant predictor of the gamma count rate ($p < 0.05$) at 13 of the 16 AUMs. At three AUMs (Mitten, NA-0928, and Tsosie 1) none of the measured radionuclides significantly predicted the gamma count rate. Additionally, the adjusted R^2 values for the correlation models at the three AUMs, plus Claim 28, fail to meet the specified data quality objective (DQO) of greater than 0.8.

The failure to construct statistically defensible correlation models at four AUMs has been identified as a data gap in the relevant AUM report. The unsatisfactory correlation result at these locations is likely due to the small number of correlation locations, or environmental conditions at the AUMs (e.g., spatial heterogeneity in radionuclide concentration in soil, topographic features influencing gamma count rate, etc.), or some combination thereof.

Note that while the statistical measures (i.e., conformance with the study DQO of $R^2 > 0.8$) associated with these regressions can be improved by fitting a power curve to the data, and reporting unadjusted R^2 values, with only five data points at each AUM, ERG does not believe that any statistical correlation model is sufficiently robust to make meaningful inferences concerning soil radium-226 concentration from the gamma scanning data. ERG believes that linear functions – not power curves – best mimic the conceptual model for the physical processes governing the observed data. Fitting any other function in an effort to achieve the study DQO for R^2 is not a statistically rigorous approach, and improving R^2 does not commensurately improve a statistical model's predictive ability. Figure *1* compares the result of fitting a linear versus a power function to the available correlation data for one AUM (Hoskie Tso); the other AUM results are similar.

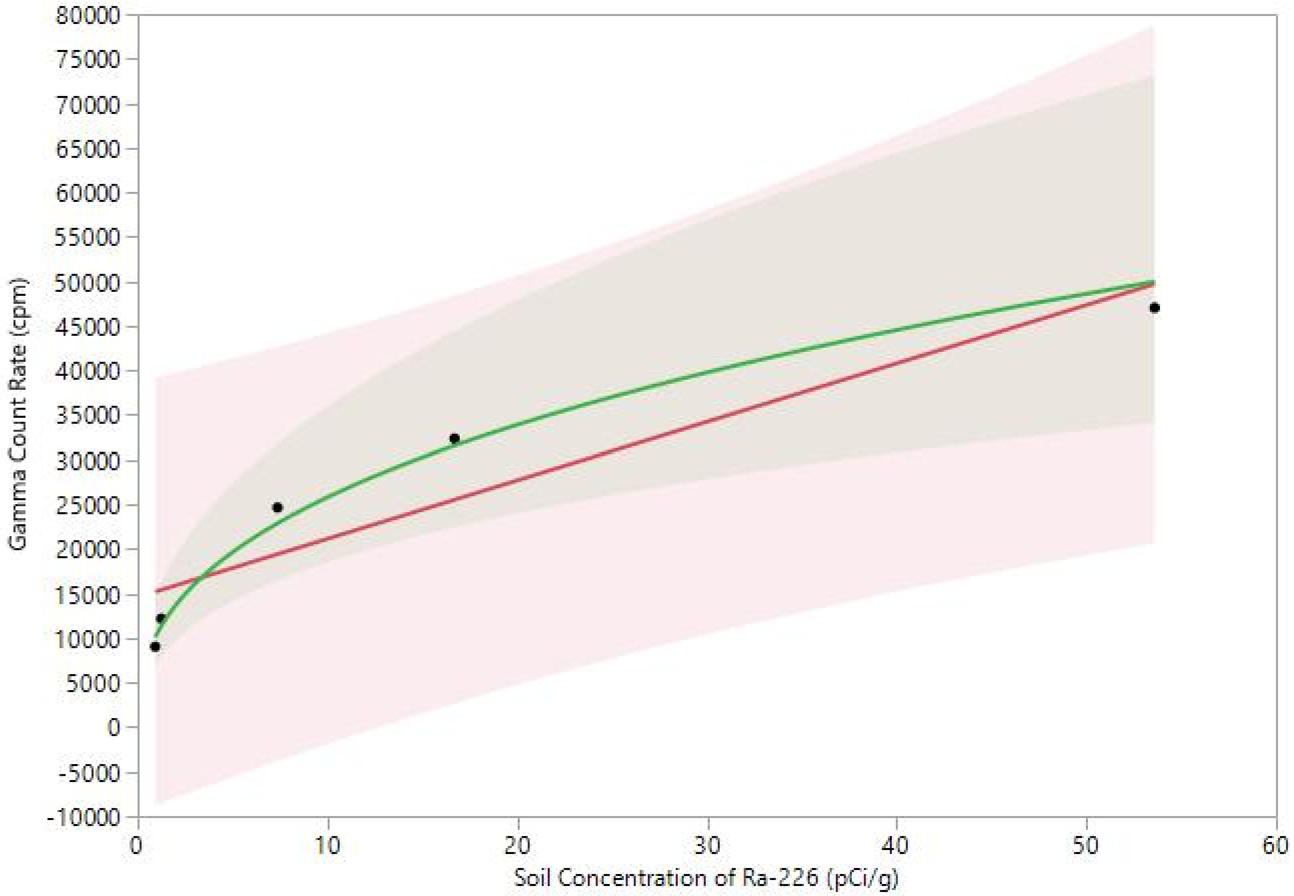

Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226 for either function.

ERG has updated the individual AUM reports with linear correlation functions and reported the more robust measures of statistical performance described in this memo.

Evaluation of Secular Equilibrium Between Ra-226 and Th-230

Secular equilibrium is a condition that occurs when the half-life of a decay-product nuclide is significantly shorter than that of its parent nuclide. After a period of ingrowth equal to approximately seven times the half-life of the decay product, the two nuclides effectively decay with the half-life of the parent. When two radionuclides are in secular equilibrium, their activities are equal.

Equilibrium, for the purpose of this report, is defined as a condition whereby a parent nuclide and its decay product are present in the environment at a fixed ratio, but this ratio – for whatever reason – is not a one-to-one relationship indicative of secular equilibrium. Most commonly, an equilibrium condition results from an environmental process which chemically selects for and transports one nuclide (parent or decay product) away from the other nuclide. Because a consistent fraction of one nuclide has been removed, the two nuclides are present at a fixed ratio other than one-to-one.

Determination of secular equilibrium for an AUM can be an important part of the risk assessment process, as the assumed fraction of radium-226 decay products present in the environment greatly influences a hypothetical receptor's radiation dose and mortality risk. However, it is also acceptable and conservative to assume secular equilibrium between radium-226 and its decay products for the purpose of risk assessment, and therefore to avoid the need to conclusively determine the secular equilibrium status of an AUM. Thus, an inconclusive result regarding secular equilibrium is not a study data gap, as the risk assessment phase may still proceed, provided that conservative assumptions are included regarding equilibrium concentrations of radium-226 decay products.

Regardless, the Navajo Nation AUM Environmental Response Trust RSE workplan specified that an evaluation of secular equilibrium would be made at each of the 16 Trust AUMs, and so a robust statistical examination of secular equilibrium status for radium-226 and its decay products at each AUM was conducted. One method of evaluating equilibrium between Ra-226 and Th-230 is to calculate the ratio (φ) between the two nuclides for each soil sample location, i.e.,

$$\varphi = \frac{[^{226}Ra]}{[^{230}Th]}$$

When φ is unity, the two nuclides may be said to be in secular equilibrium. Sometimes, φ is averaged over a number of locations, and if the average is unity, the population of measurement locations is said to be in secular equilibrium. Similarly, if φ is consistently some number other than one, it may be concluded that the measured population is in equilibrium. This approach does not account for the statistical uncertainty associated with making inferences across a population, nor the bias introduced into the measurement by averaging a potentially large number of ratios. It is also difficult to establish defensible cutoffs for whether Ra-226 and Th-230 are in secular equilibrium at a particular site using a ratio approach, as there is no objective basis for concluding, e.g., that φ must be between 0.8 and 1.2 (versus any other range of values for φ) for secular equilibrium to occur.

Due to a large number of reviewer comments concerning secular equilibrium within the RSE reports, Environmental Restoration Group opted to re-evaluate equilibrium at each mine site using a more robust statistical method: simple linear regression. This was done after confirming the methods to analyze Ra-226 (EPA Method 901.1) and Th-230 (alpha spectroscopy following sample digestion with hydrofluoric acid) are both total-activity methods with comparable results (L. Steere, ALS personal email communication, July 25, 2018). Evaluation of secular equilibrium for each mine site proceeded as follows:

1. Construction of a figure that depicts soil concentrations of Th-230 plotted against soil concentrations of Ra-226.

2. Simple linear regression is performed on the dataset; the p-value and the adjusted R^2 are recorded. The resulting linear model and the 95% UCL (upper confidence limit) bands are plotted on the figure generated in step 1.

3. The line y=x is added to the figure generated in step 2 (this line represents a perfect 1:1 ratio between Th-230 to Ra-226, indicative of secular equilibrium).

4. An examination of the model and the figure is made sequentially:

    a. If the p-value for the regression slope is insignificant (i.e., $p > 0.05$) or the adjusted R^2 does not meet the study's data quality objective (Adjusted $R^2 > 0.8$), ERG concludes that there is insufficient evidence to conclude that Ra-226 and Th-230 are in equilibrium (secular or otherwise) therefore, it is listed as inconclusive (no equilibrium). Figure *2* depicts the regression result for an AUM (Mitten) that failed to meet the p-value and adjusted R^2 criteria.

    b. If the p-value for the regression slope is significant (i.e., $p < 0.05$) and the adjusted R^2 meets the DQO (Adjusted $R^2 > 0.8$) there are two possible conditions, which are evaluated via visual examination of the figure generated in step 3.

        i. If the y=x line falls fully within the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in secular equilibrium at the site. Figure *3* depicts the regression result for an AUM (Harvey Blackwater) where there is evidence that Ra-226 and Th-230 are in secular equilibrium.

        ii. If the y=x line falls partially or completely outside the bounds of the 95% UCL bands on the regression, ERG concludes that there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium at the site. Figure *4* depicts the regression result for an AUM (Alongo Mines) where there is evidence that Ra-226 and Th-230 are in equilibrium, but not secular equilibrium.

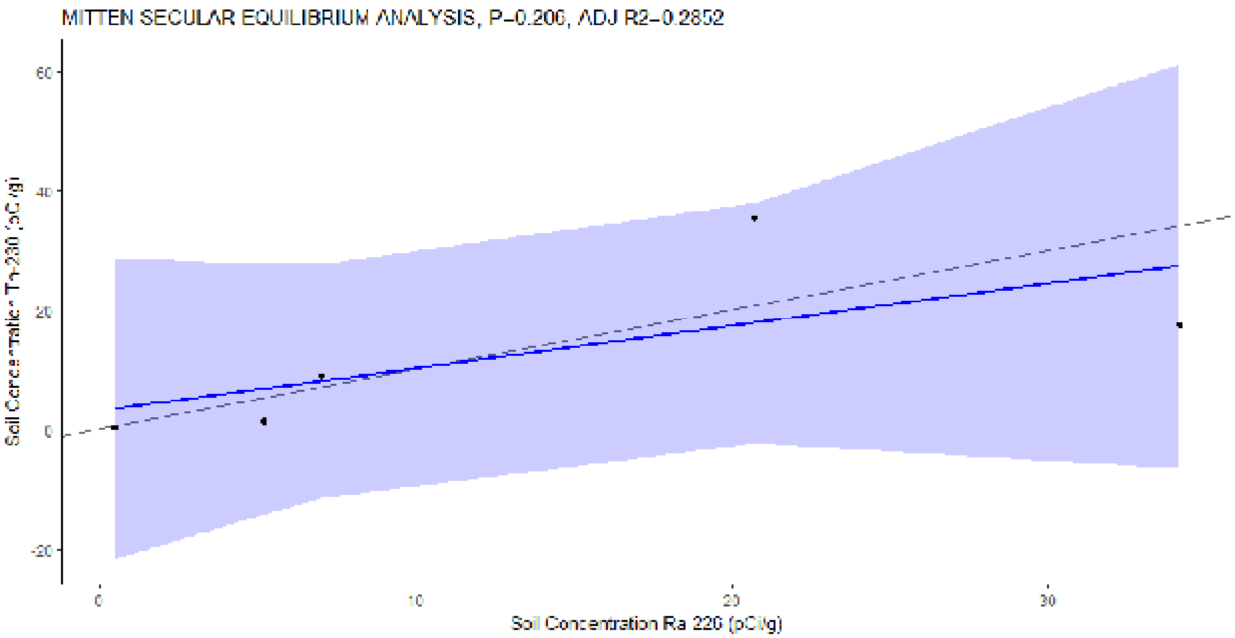

Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

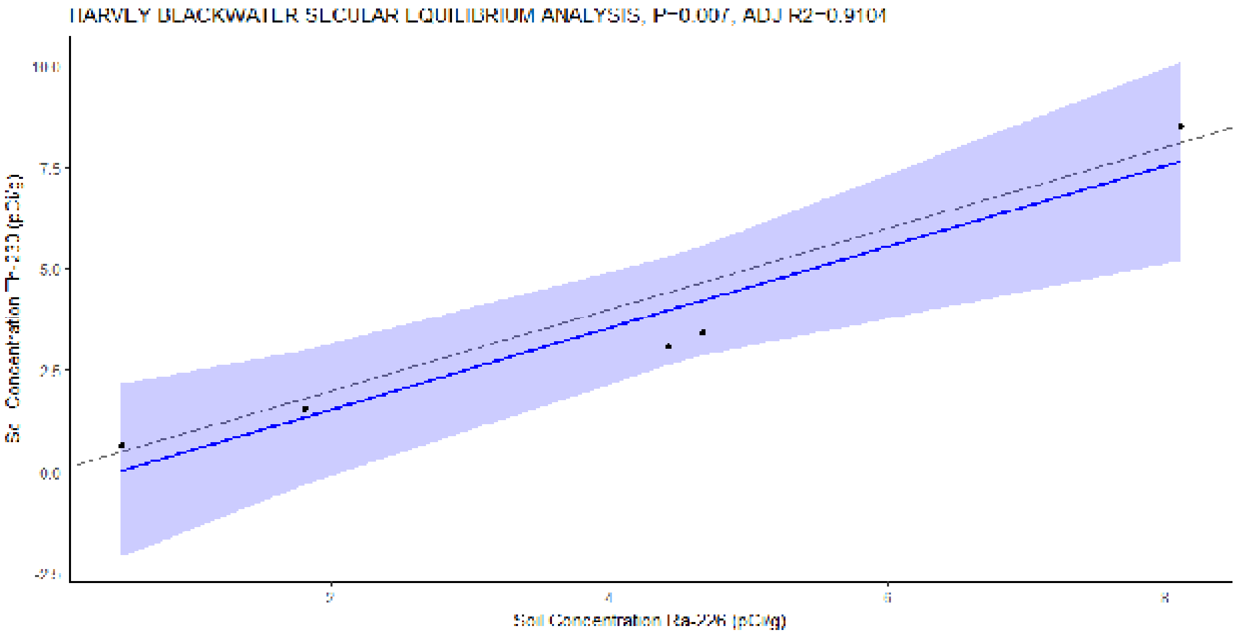

Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

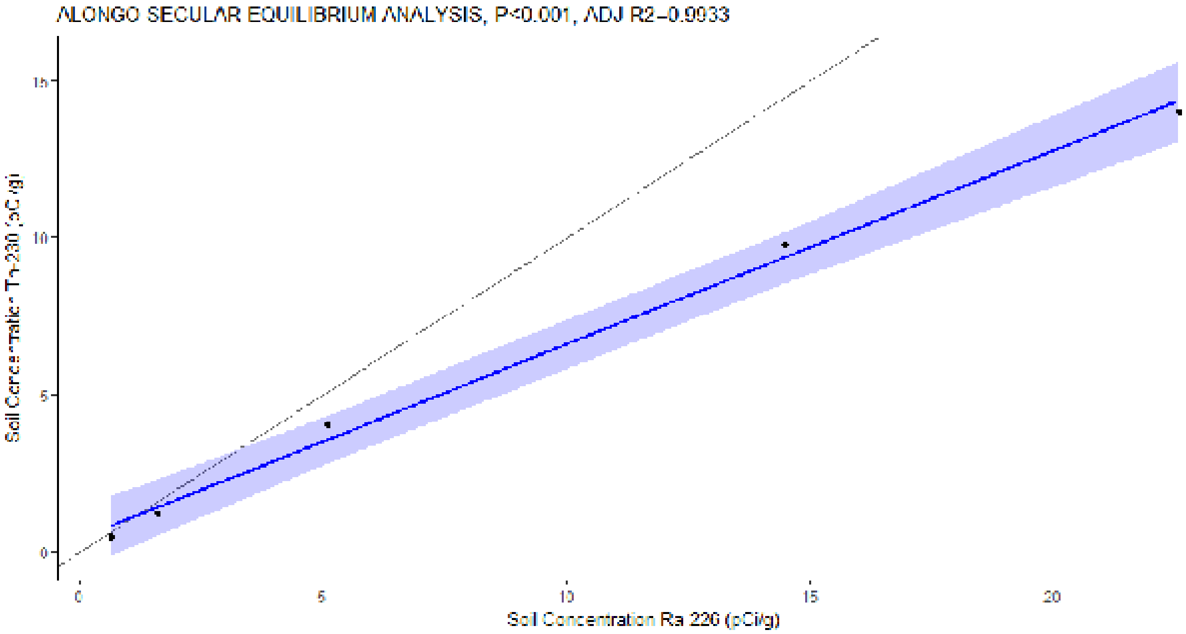

Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

ERG tested for secular equilibrium at each of the 16 Navajo AUMs using the process described above. The results are summarized in Table 1 and in the RSE report for each AUM, respectively. ERG concluded that the data provide evidence that that Ra-226 and Th-230 are in secular equilibrium in soils at two mines (Harvey Blackwater and NA-0928). At one mine (Mitten) there was insufficient evidence to draw any conclusions regarding equilibrium. At the remaining sites, there is evidence that Ra-226 and Th-230 are in equilibrium.

Table 1. Results of secular equilibrium analysis for each of the 16 Navajo Trust AUMs.

Mine	**p-value**	**Adjusted R^2**	**Conclusion**
Alongo Mine	<0.001	0.99	Equilibrium
Barton 3	<0.001	0.98	Equilibrium
Boyd Tisi	<0.001	0.99	Equilibrium
Charles Keith	<0.001	0.99	Equilibrium
Claim 28	<0.001	0.99	Equilibrium
Eunice Becenti	<0.001	0.99	Equilibrium
Harvey Blackwater	0.008	0.91	Secular Equilibrium
Hoskie Tso	<0.001	0.99	Equilibrium
Mitten	0.2	0.29	No Equilibrium
NA-0904	0.001	0.98	Equilibrium
NA-0928	0.002	0.97	Secular Equilibrium
Oak 124-125	<0.001	0.99	Equilibrium
Occurrence B	<0.001	0.98	Equilibrium
Section 26	0.002	0.96	Equilibrium
Standing Rock	0.008	0.91	Equilibrium
Tsosie 1	0.02	0.86	Equilibrium

Appendix D Preliminary Report "Radiological Characterization of the Charles Keith Abandoned Uranium Mine".

Disclaimer: Data and analytical methods used in this Preliminary Report are superseded by the Final Report.

Radiological Characterization of the Charles Keith Abandoned Uranium Mine

Preliminary

February 7, 2018

prepared for:

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prepared by:

ERG

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Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
BG2	Background Reference Area 2
BG3	Background Reference Area 3
cpm	counts per minute
DQOs	data quality objectives
EPA	U.S. Environmental Protection Agency
ERG	Environmental Restoration Group, Inc.
ft	foot
GPS	global positioning system
m	meter
MDL	method detection limit
µR/h	microRoentgens per hour
pCi/g	picocuries per gram
R^2	Pearson's Correlation Coefficient
RSE	removal site evaluation
σ	standard deviation
Stantec	Stantec Consulting Services Inc.

Executive Summary

This report addresses the radiological characterization of the Charles Keith abandoned uranium mine (AUM) located in the Oljato Chapter of the Navajo Nation in Monument Valley, Utah. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) in accordance with the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on May 4 and November 1 to 3, 2016; and March 19 and 22, May 24, June 22, and September 20, 2017. They included a GPS-based radiological survey of land surfaces over a Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in “Charles Keith Removal Site Evaluation Report” (Stantec, 2018).

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.
- Elevated count rates were observed largely on waste piles extending away from portals and on the road and walls near the portals in the mine claim.
- Three potential Background Reference Areas were established.
- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a power regression model:

$$\text{Radium-226 concentration (picocuries per gram [pCi/g])} = \\ 9 \times 10^{-7} \times \text{Gamma Count Rate (in counts per minute [cpm])}^{1.4869}$$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.3 to 143, with a central tendency (median) of 0.8 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- The uranium series radionuclides appear not to be in secular equilibrium.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

  Exposure Rate (microRoentgens per hour [μR/h]) = 5×10^{-4} x Gamma Count Rate (cpm) + 5.7462

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 8.2 to 169.9, with a central tendency (median) of 11.0 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Charles Keith abandoned uranium mine (AUM) located in the Oljato Chapter of the Navajo Nation in Monument Valley, Utah. It documents part of the implementation of the Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan (RSE Work Plan: MWH, 2016). The work was performed by Environmental Restoration Group, Inc. of Albuquerque, New Mexico and Stantec Consulting Services Inc. (Stantec) in accordance with the Navajo Nation AUM Environmental Response Trust – First Phase.

This report provides 1) the results of a Global Positioning System (GPS)-based gamma radiation (gamma) survey, 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils, and 3) an assessment of equilibrium in the uranium series. The field activities addressed in this report were conducted on May 4 and November 1 to 3, 2016; and March 19 and 22, May 24, June 22, and September 20, 2017. They included a GPS-based radiological survey of land surfaces over an approximately 52-acre Survey Area consisting of the mine claim area out to a 100-foot (ft) buffer, roads and drainages within a 0.25-mile radius of the 100-ft buffer, and areas where the survey was extended; and correlation studies.

The discussion of the results of soil sampling in this report is limited to concentrations of radium-226 and isotopes of thorium in samples taken from surface soils, as part of correlation studies. The objective of the analysis of thorium isotopes was to 1) assess the potential effects of thorium-232 and thorium-228 on the correlation of gamma count rates to concentrations of radium-226 in surface soils; and 2) evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. These and additional results for the RSE are addressed in “Charles Keith Removal Site Evaluation Report” (Stantec, 2018).

Figure 1 shows the location of the AUM. Background information that is pertinent to the characterization of this AUM is presented in the “Charles Keith Removal Site Evaluation Report” (Stantec, 2018).

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in three potential Background Reference Areas and the Survey Area. Table 1 lists the detection systems used in the survey, which were function-checked before and after each day of use and within calibration, in accordance with American National Standards Institute (ANSI) Standard N232A (ANSI, 1997). Appendix A presents the completed function check forms and calibration certificates for the instruments.

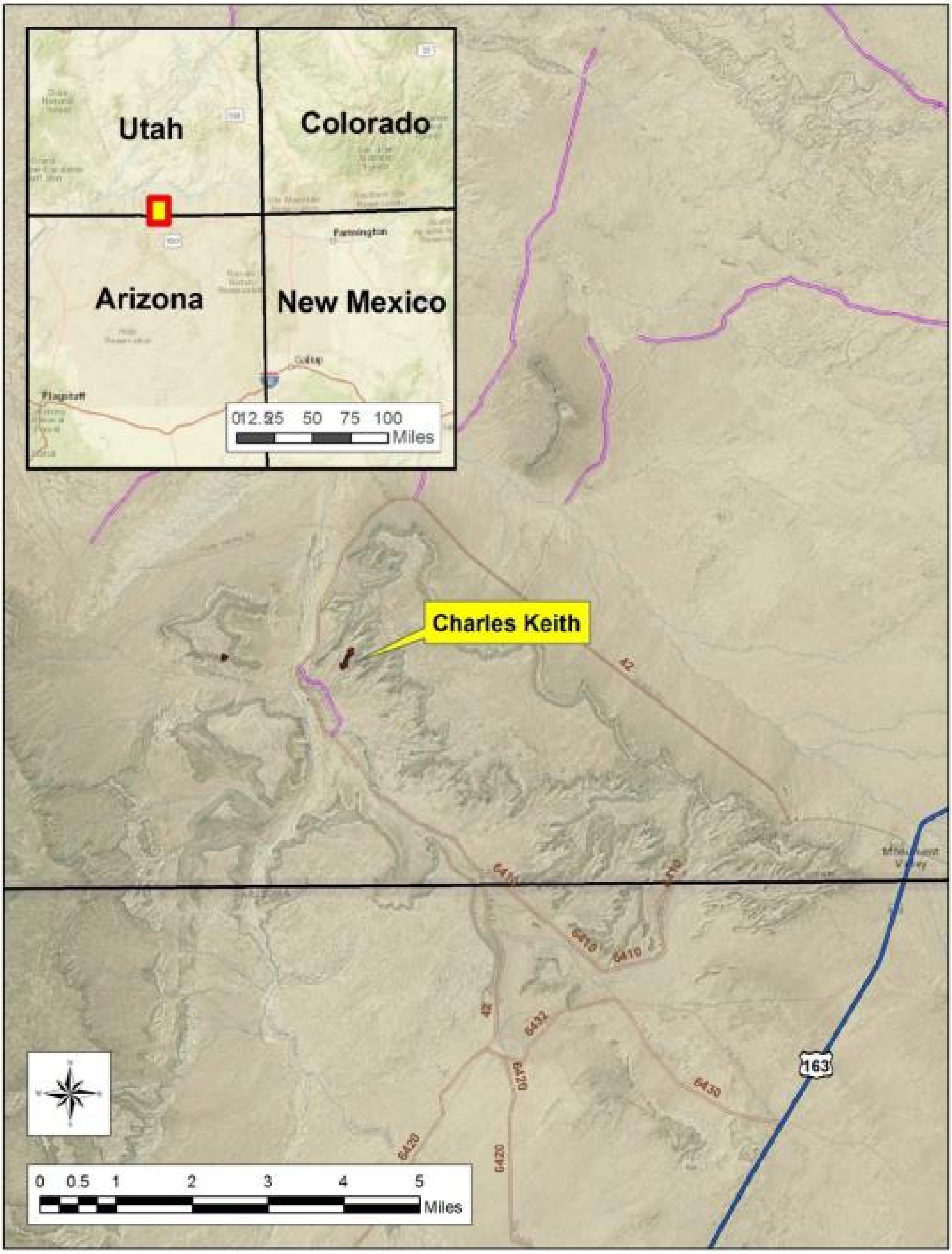


Figure 1. Location of the Charles Keith Abandoned Uranium Mine

Table 1. Detection systems used in the GPS-based gamma surveys.

Survey Area	Ludlum Model 44-10	Ludlum Model 2221 Ratemeter/Scaler
Potential Background Reference Areas	PR303727[a]	254772[a]
	PR320678	282971
Survey Area	PR303727[a]	254772[a]
	PR295014	196086
	PR154615	138638
	PR295017	271435
	PR320678	282981
	PR355763	138368

Notes:
[a] Detection system used in the correlation studies described in Section 3.0.
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3

2.1 Potential Background Reference Areas

Three potential Background Reference Areas were surveyed, the locations and results of which are depicted on Figure 2. BG1, BG2, and BG3 in the figure are Background Reference Areas 1, 2, and 3, respectively.

Figure 3 depicts histograms of the gamma count rates in BG1, BG2, and BG3. The red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal.

Table 2 lists a summary of the gamma count rates, which in

- BG1 ranged from 10,232 to 19,378 cpm, with a mean and median of 12,942 and 12,790 cpm, respectively.
- BG2 ranged from 6,349 to 12,135 cpm, with a mean and median of 8,898 and 8,726 cpm, respectively.
- BG3 ranged from 7,773 to 13,471 cpm, with a mean and median of 10,630 and 10,514 cpm, respectively.

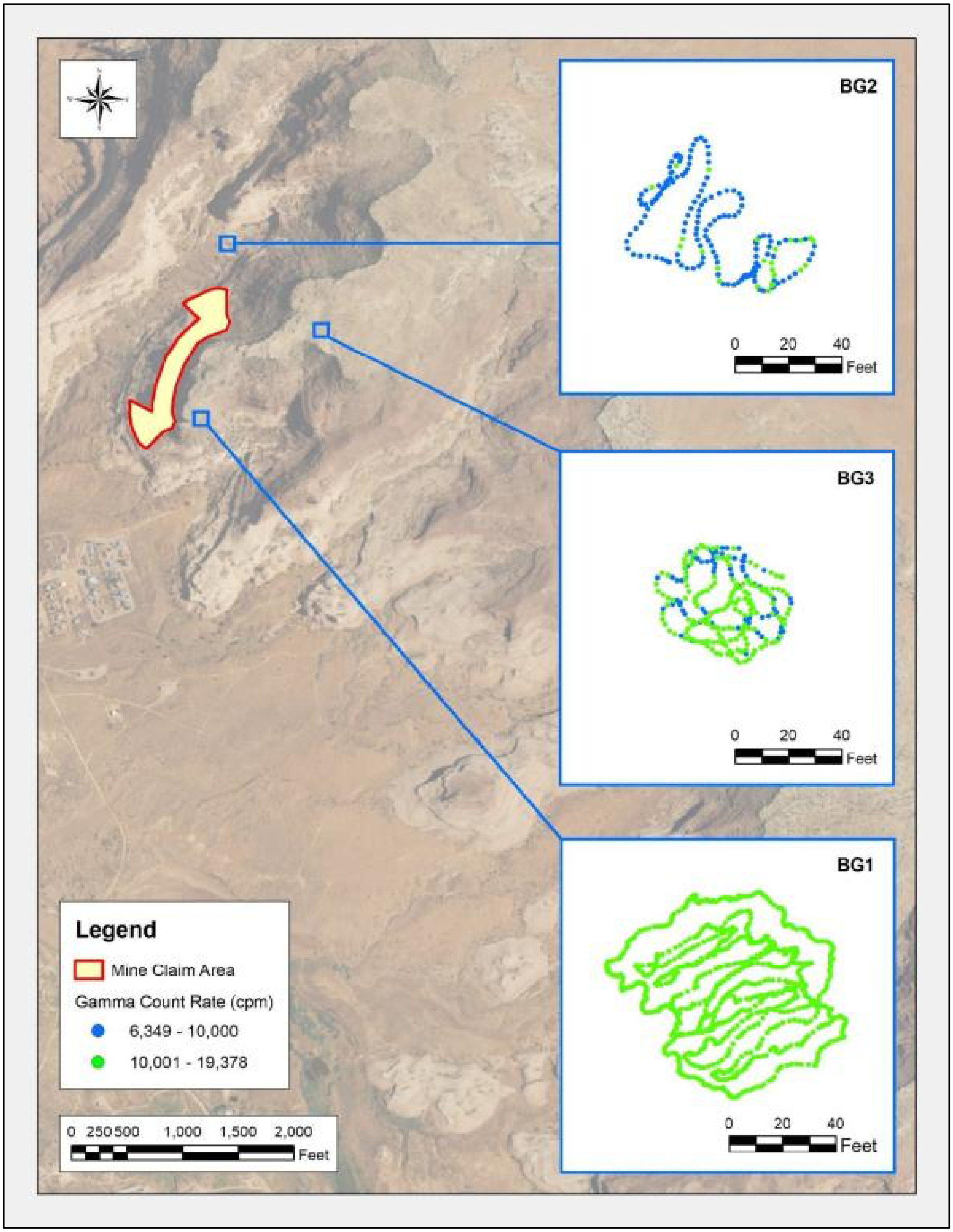
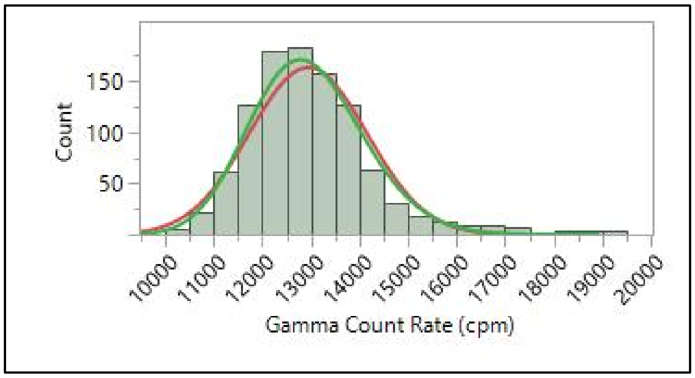
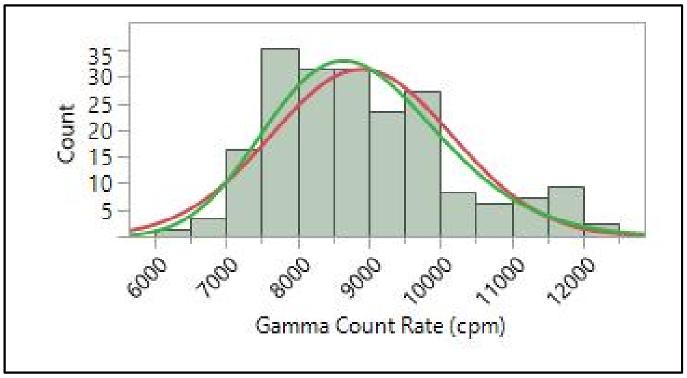


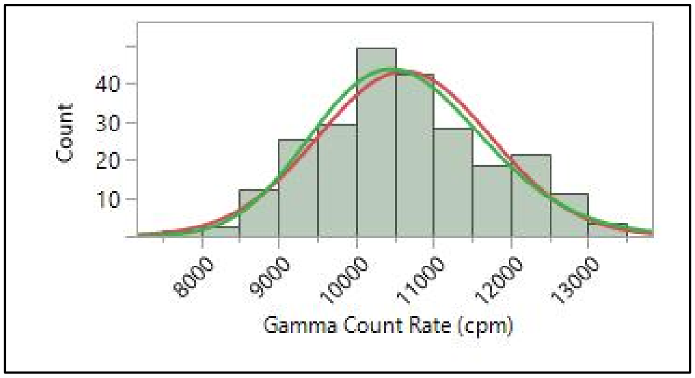
Figure 2. Gamma count rates in the potential Background Reference Areas.



a. **Background Reference Area 1**



b. **Background Reference Area 2**



c. **Background Reference Area 3**

Figure 3. Histograms of gamma count rates in the potential Background Reference Areas.

Table 2. Summary statistics for gamma count rates in the potential Background Reference Areas.

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	991	10,232	19,378	12,942	12,790	1,212
2	199	6,349	12,135	8,898	8,726	1,265
3	241	7,773	13,471	10,630	10,514	1,111

Notes:
cpm = counts per minute

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. Elevated count rates were observed largely on waste piles extending away from portals and on the road and walls near the portals in the mine claim.

Figure 5 is a histogram of the gamma count rate measurements made in the Survey Area, including the area surveyed outside the 100-ft buffer. As stated in Section 2.1, the red and green lines on the figure are theoretical normal and lognormal distributions, respectively. They are presented to show what could be expected if the distributions were normal or lognormal. The distribution of the right-tailed set of measurements, evaluated using U.S. Environmental Protection Agency software ProUCL, is not discernible; i.e., neither normal or logarithmic. The box plot in Figure 6 depicts cutoffs as horizontal bars, from bottom to top, for the following values or percentiles: minimum, 0.5, 2.5, 10, 25, 50, 75, 90, 97.5, 99.5, and maximum. The 25th, 50th, and 75th percentiles (the three horizontal lines of the box inside the box plot) are 8,482, 10,416, and 13,685 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 4,867 to 328,342 cpm and have a central tendency (median) of 10,416 cpm.

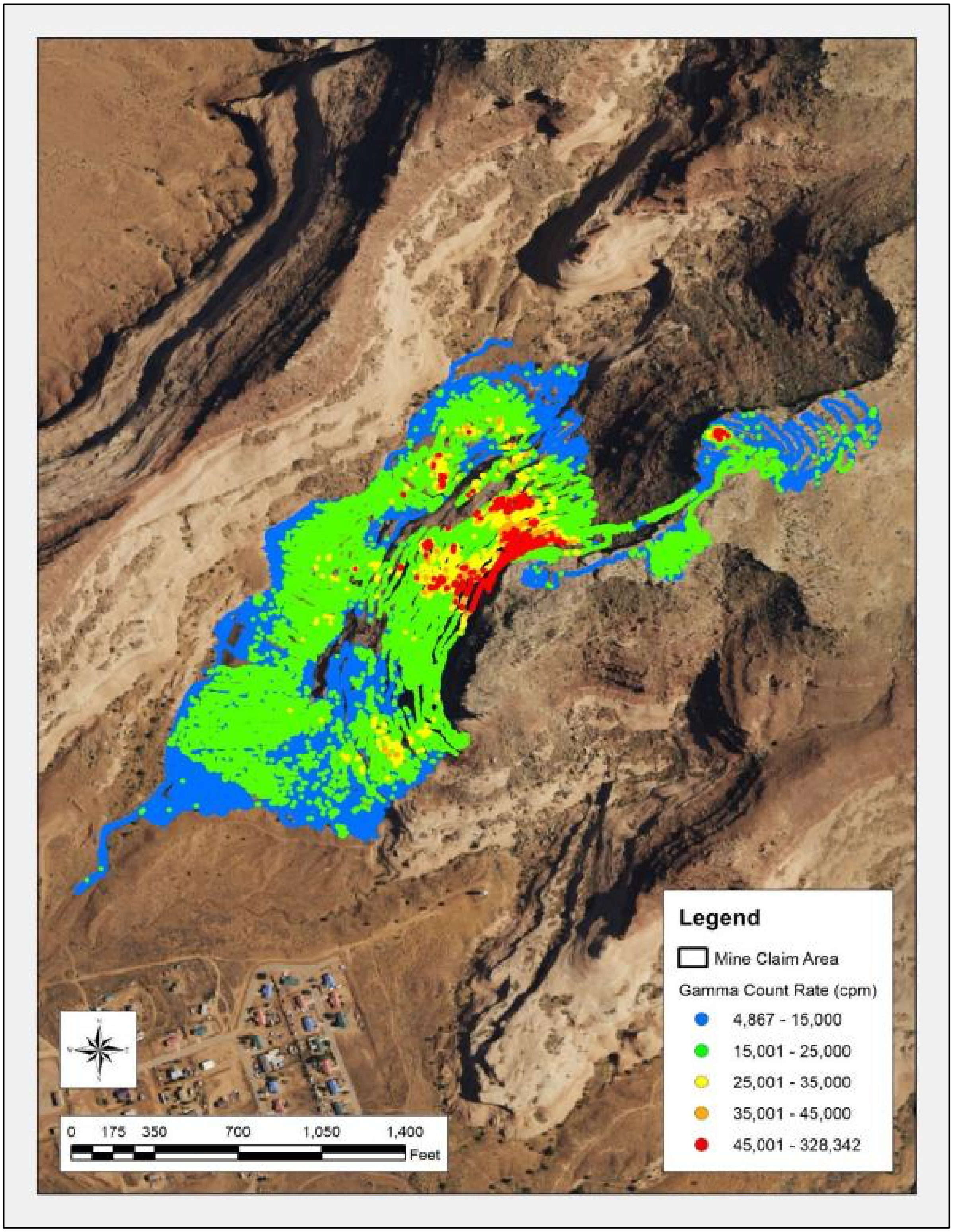


Figure 4. Gamma count rates in the Survey Area.

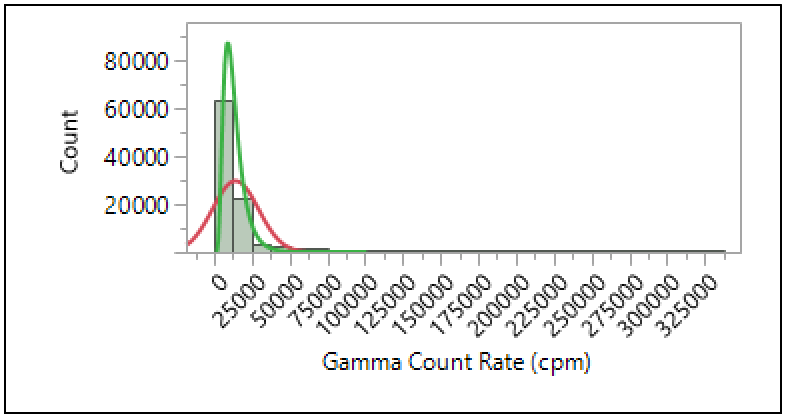


Figure 5. Histogram of gamma count rates in the Survey Area.

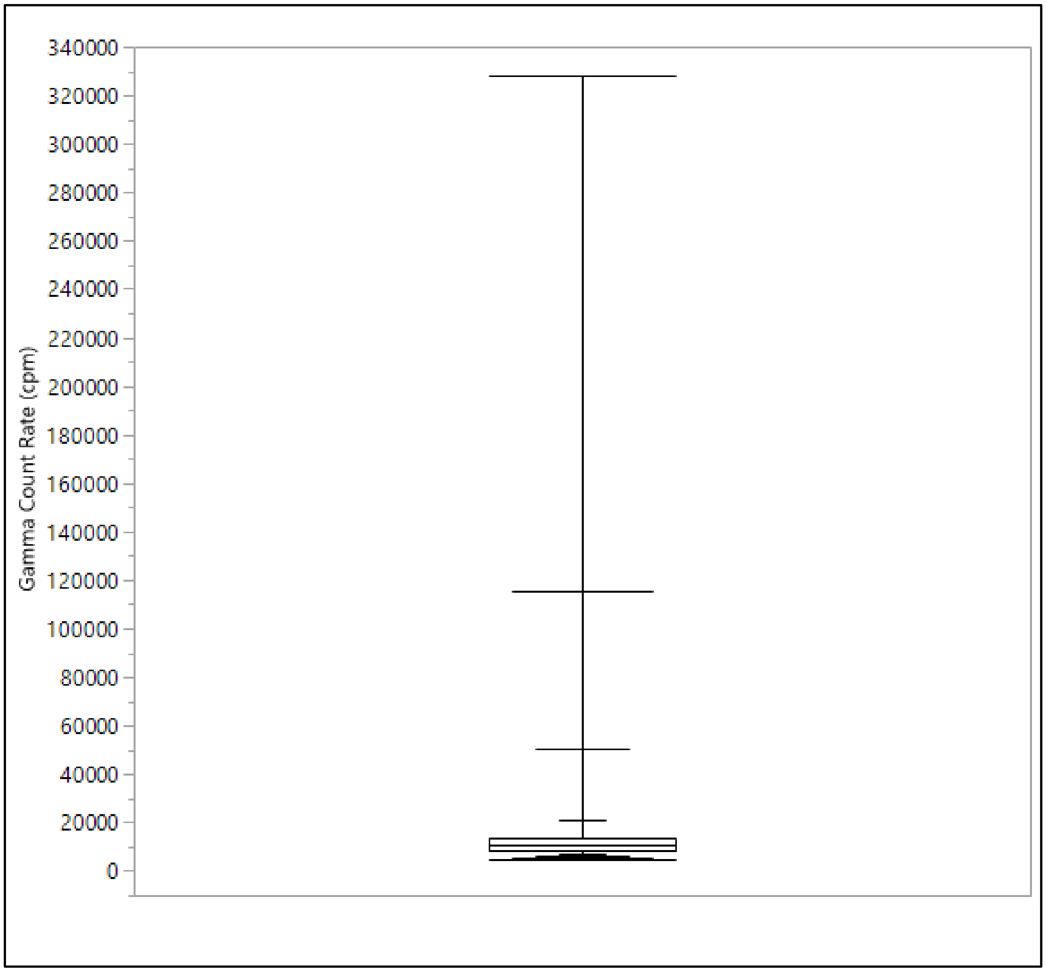


Figure 6. Box plot of gamma count rates in the Survey Area.

Table 3. Summary statistics for gamma count rates in the Survey Area.

Parameter	Gamma Count Rate (cpm)
n	90,885
Minimum	4,867
Maximum	328,342
Mean	14,116
Median	10,416
Standard Deviation	15,244

Notes:
cpm = counts per minute

3.0 Correlation Studies

The following sections address the activities under two types of correlation studies outlined in the RSE Work Plan: comparisons of 1) radium-226 concentrations in surface soils and gamma count rates and 2) exposure rates and gamma count rates. GPS-based gamma count rate measurements were made over small areas for the former study. The means of the measurements were used in this case. Static gamma count rate measurements, co-located with exposure rate measurements, were used in the latter study.

3.1 Radium-226 concentrations in surface soils and gamma count rates

On November 3, 2016 field personnel made GPS-based gamma count rates measurements and collected five-point composite samples of surface soils in each of five areas at the AUM. The activities were performed contemporaneously, by area and all on the same day, such that variations in the gamma count rate measurements could be limited largely to those posed by the soils and rocks at the locations. On May 24, 2017, the gamma count rate measurements were repeated on the five locations (S225-C01-001, S225-C02-001, S225-C03-001, S225-C04-001, and S225-C05-001), and an additional location (S225-C06-001), because one of the results for radium-226 (4.56 picocuries per gram [pCi/g] at Location S225-C05-001), appeared to be an anomaly given the relatively low gamma count rates observed there. The soil samples needed not to be recollected at the original five locations, because the concentrations of radionuclides were not expected to change.

The soil samples were analyzed by ALS Laboratories in Ft Collins, CO for radium-226 and isotopic thorium. The latter analysis was included to assess the potential effects of thorium series isotopes on the correlation and evaluate thorium-230 and radium-226 activities to indicate the status of equilibrium in the uranium decay series. Table 4 lists the results of the gamma count rate measurements made only on May 24, 2017 and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 6,569 to 47,450 cpm. The concentrations of radium-226 in the soil samples range from 0.42 to 8.5 pCi/g.

Table 5 lists the concentrations of isotopes of thorium (thorium-228, -230, and -232) in the same soil samples.

Laboratory analyses are presented in Appendix D, Laboratory Analytical Data and Data Usability Report, in "Charles Keith Removal Site Evaluation Report" (Stantec, 2018).

Figure 7 shows the GPS-based gamma count rate measurements in the six areas (labeled with location identifiers).

Table 4. Gamma count rates and associated concentrations of radium-226 in samples of surface soils obtained in the correlation study.

		Gamma Count Rate (cpm)[a]				Ra-226 (pCi/g)		
Location	**Date of Sample Collection**	**Mean**	**Minimum**	**Maximum**	**σ**	**Result**	**Error ±1σ**	**MDL**
S225-C01-001	11-3-2016	14,636	11,629	19,247	1,542	1.42	0.28	0.34
S225-C02-001	11-3-2016	26,074	19,681	33,575	2,750	3.39	0.5	0.42
S225-C03-001	11-3-2016	46,957	33,327	63,503	4,928	8.5	1.1	0.6
S225-C04-001	11-3-2016	35,540	24,178	46,285	6,353	4.56	0.67	0.52
S225-C05-001[b]	11-3-2016	7,870	6,296	10,552	934	3.5	0.53	0.49
S225-C06-001	05-24-17	6,572	5,304	9,433	658	0.42	0.14	0.29

Notes:
[a]Gamma count rate measurements made on May 24, 2017.
[b]Results at this location not used to develop the correlation of gamma count rates to radium-226 concentrations in surface soils reported here.
cpm = counts per minute
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

Table 5. Concentrations of isotopes of thorium in samples of surface soils obtained in the correlation study.

		Thorium-228 (pCi/g)			Thorium-230 (pCi/g)			Thorium-232 (pCi/g)		
Sample ID	**Date of Sample Collection**	**Result**	**Error ± 1 σ**	**MDL**	**Result**	**Error ± 1 σ**	**MDL**	**Result**	**Error ± 1 σ**	**MDL**
S225-C01-001	11-3-16	1.06	0.18	0.02	1.25	0.22	0.07	0.96	0.17	0.02
S225-C02-001	11-3-16	0.7	0.14	0.05	3.13	0.52	0.08	0.74	0.14	0.01
S225-C03-001	11-3-16	0.8	0.14	0.03	6.4	1	0.1	0.69	0.13	0.01
S225-C04-001	11-3-16	0.91	0.17	0.05	3.69	0.6	0.07	0.82	0.15	0.01
S225-C05-001[a]	11-3-16	0.59	0.12	0.07	3.58	0.58	0.07	0.51	0.1	0.02
S225-C06-001	5-24-17	0.286	0.077	0.072	0.325	0.082	0.073	0.305	0.068	0.005

Notes:
[a]Results at this location not used to develop the correlation of gamma count rates to radium-226 concentrations in surface soils reported here.
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

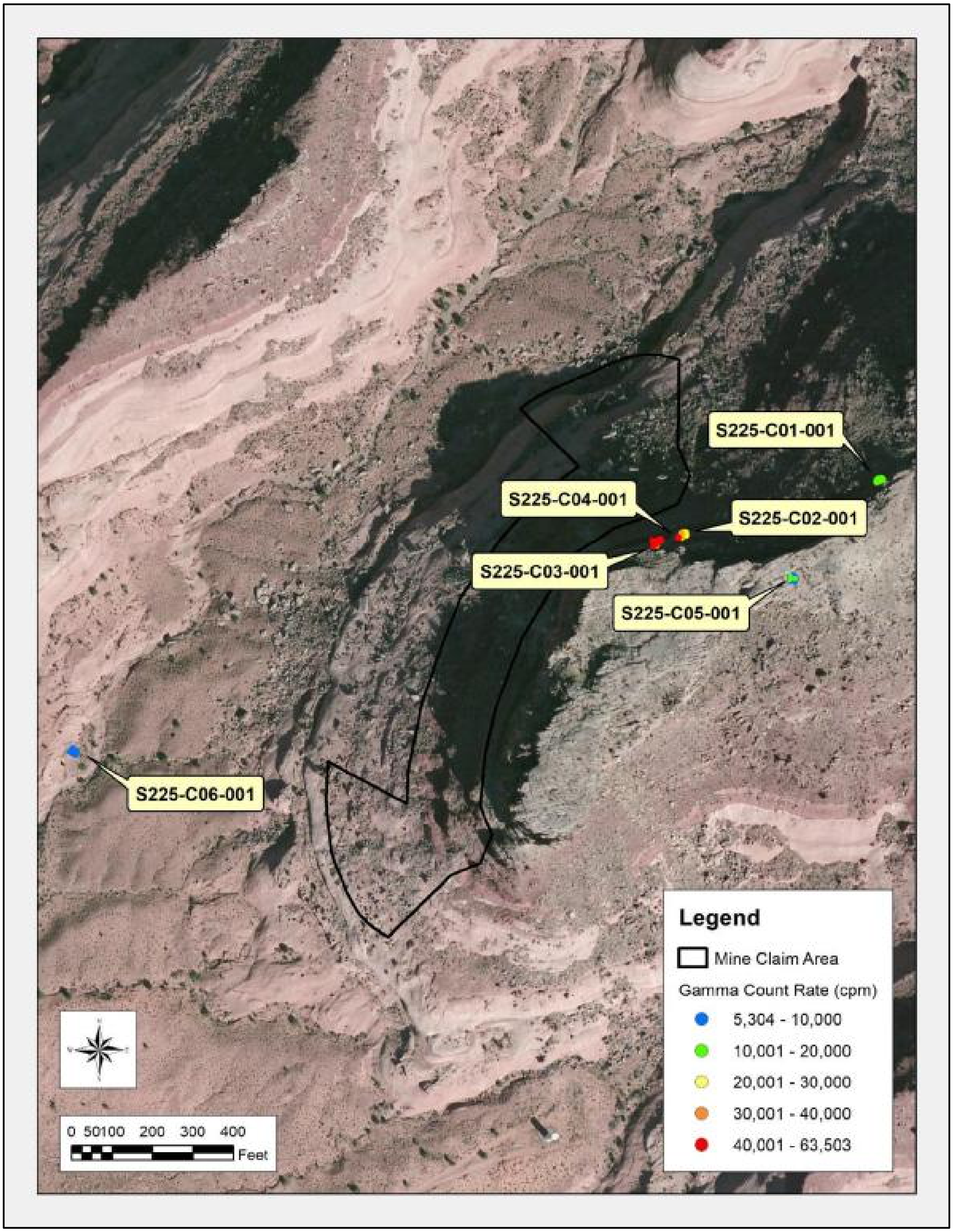


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

A model was made of the results in Table 4 (excluding those at Location S225-C05-001), predicting the concentrations of radium-226 in surface soils from the mean gamma count rate in each area. The best predictive relationship between the measurements, shown in Figure 8, is a strong, power function with a Pearson's Correlation Coefficient (R^2) of 0.9955, as expressed in the equation:

$$\text{Radium-226 concentration (pCi/g)} = 9 \times 10^{-7} \times \text{Gamma Count Rate (cpm)}^{1.4869}$$

R^2 is a measure of the dependence between two variables and is expressed as a value between -1 and +1 where +1 is a positive correlation, 0 is no correlation, and -1 is a negative correlation. The root mean square error and p-value for the model are 0.090843 and 0.0001, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

The concentrations of thorium-232 and thorium-228, isotopes in the thorium series, in the correlation samples are similar and at most 1.1 pCi/g. Given these low concentrations and the high R^2 of the power function, the thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226, using gamma count rates.

This equation was used to convert the gamma count rate measurements observed in the gamma surveys to predicted concentrations of radium-226. Table 6 presents summary statistics for the predicted concentrations of radium-226 in the Survey Area, the range of which is 0.3 to 143 pCi/g, with a mean and median of 1.7 and 0.8 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 47,000 cpm are extrapolated from the regression model and are uncertain.

Figure 9 shows the predicted concentrations of radium-226, the spatial and numerical distribution of which mirror those depicted in Figure 4.

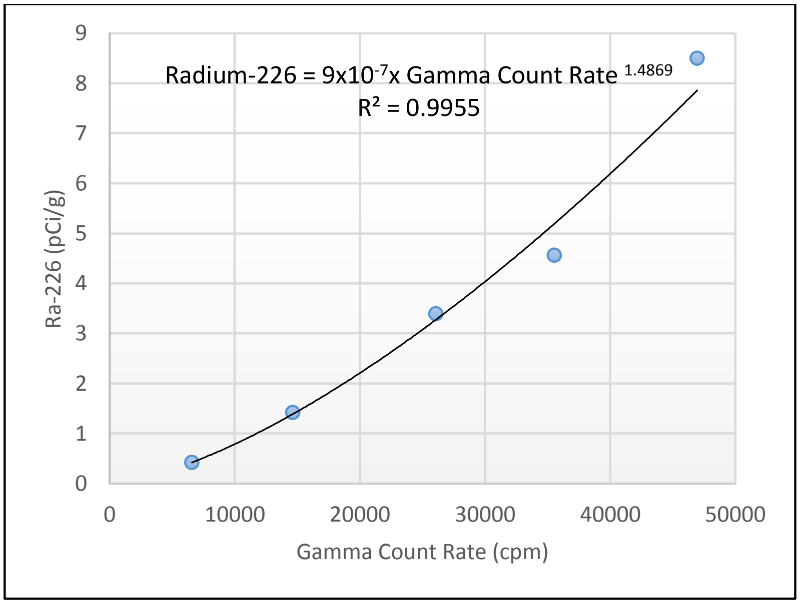


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

Table 6. Predicted concentrations of radium-226 in the Survey Area.

Parameter	Radium-226 (pCi/g)
n	90,885
Minimum	0.3
Maximum	143.4
Mean	1.7
Median	0.8
Standard Deviation	4.4

Notes:
pCi/g = picocuries per gram

3.2 Equilibrium in the uranium series

Secular equilibrium occurs when the activities of a parent radionuclide and its decay product are equal. This can occur in a closed system, when the half-life of the parent radionuclide is much larger than that of the decay product.

The ratio of the concentrations of radium-226 to thorium-230 can be used as an indicator of the status of equilibrium in the uranium series. The half-lives of thorium-230 and radium-226 are 77,000 and 1,600 years, respectively. The ratios in the six correlation samples are 1.1 (Sample S225-C01-001), 1.1 (Sample S225-C02-001), 1.3 (Sample S225-C03-001), 1.2 (Sample S225-C04-001), 1.0 (Sample S225-C05-001), and 1.3 (S225-C06-001) indicating that thorium-230 is depleted in relation to radium-226 and, by extrapolation, the uranium series itself is not in secular equilibrium.

Note this observation is based on the results of six samples, subject to differing analytical methods. Gamma spectroscopy, the method used to determine the concentration of radium-226, assesses an intact portion of the whole sample as it was collected. The concentration of thorium-230 was determined by alpha spectroscopy of an acid-leached aliquot of the sample.

This evaluation is not related to the correlation of radium-226 concentrations in surface soils and gamma count rates. It may be used for a future risk assessment.

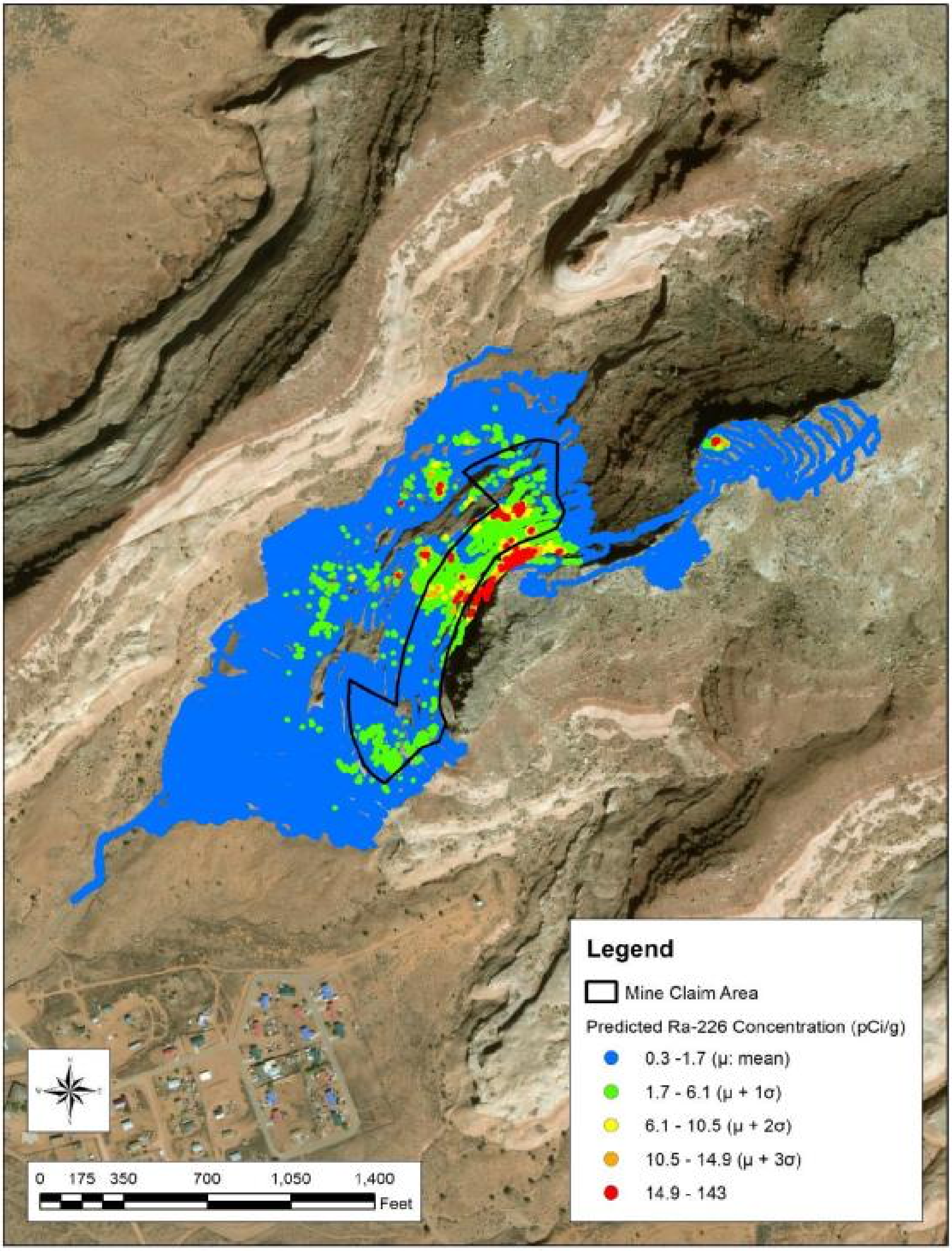


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.3 Exposure rates and gamma count rates

On November 3, 2016, field personnel made co-located one-minute static count rate and exposure rate measurements at the same five locations within the Survey Area described in Section 3.1, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 7 shows the locations of the co-located measurements, which were made in the centers of the areas.

The gamma count rate and exposure rate measurements were made at 0.5 meters (m) and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the sodium iodide detection systems used in the GPS-based gamma survey of the AUM (Serial Number PR303727/254772). The exposure rate measurements were made using a Reuter Stokes Model RSS-131 (Serial Number 07J00KM1) high pressure ionization chamber (HPIC) at six-second intervals for about 10 minutes. The exposure rates used in the comparison were the means of each of the 5 measurements, less those occurring in initial instrument spikes. The HPIC was in current calibration and function-checked before and after use. Calibration forms for the HPIC are provided in Appendix A. Table 7 presents the results for the two types of measurements made at each of the five locations. Appendix B presents the individual (6-second) exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.994, indicating a strong, positive correlation. The root mean square error and p-value for the model are 0.784106 and 0.0002, respectively; these parameters are not DQOs and are included only as information.

The following equation is the linear regression (shown in Figure 10) between the mean exposure rate and gamma count rate results in Table 7 that was generated using MS Excel:

$$\text{Exposure Rate } (\mu R/h) = 5\text{x}10^{-4} \text{ x Gamma Count Rate (cpm)} + 5.7462$$

Figure 11 presents the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Tables 8 and 9 present summary statistics for the predicted exposure rates in the potential Background Reference Areas and Survey Area, respectively.

The range of predicted exposure rates at:

- BG1 is 10.9 to 15.4 µR/h, with a mean and median of 12.2 and 12.1 µR/h, respectively.
- BG2 is 8.9 to 11.8 µR/h, with a mean and median of 10.2 and 10.1 µR/h, respectively.
- BG3 is 9.6 to 12.5 µR/h, with a mean and median of 11.1 and 11.0 µR/h, respectively.

The range of predicted exposure rates in the Survey Area is 8.2 to 169.9 µR/h, with a mean and median of 12.8 and 11.0 µR/h, respectively.

Table 7. Co-located gamma count rate and exposure rate measurements.

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S225-C01-001	16,098	14.8
S225-C02-001	27,444	19.2
S225-C03-001	51,721	32.6
S225-C04-001	37,091	23.9
S225-C05-001	8,332	9.8

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

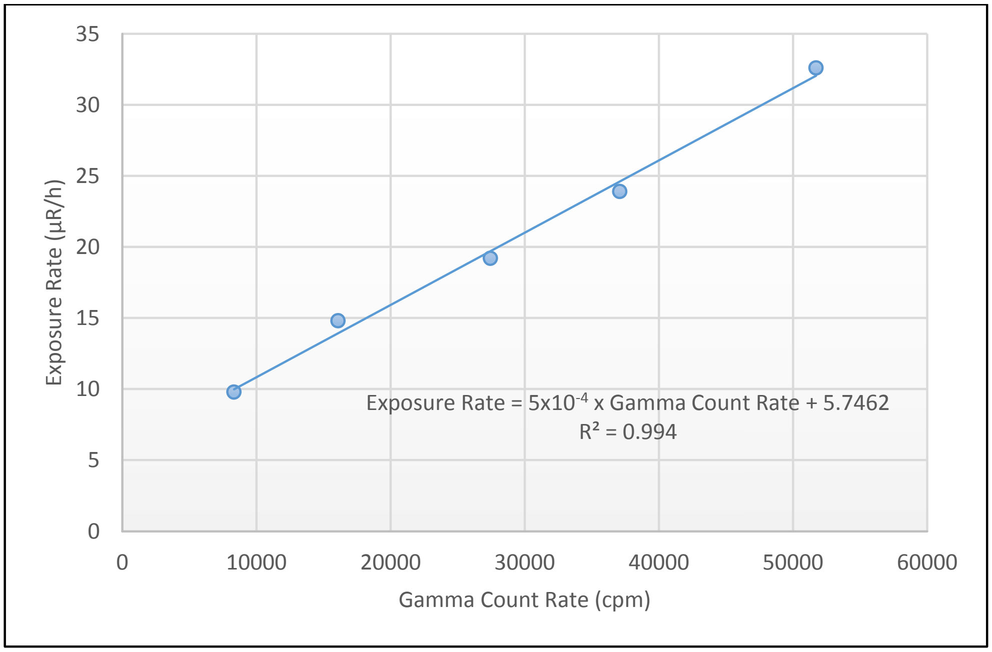


Figure 10. Correlation of gamma count rates and exposure rates.

Table 8. Predicted exposure rates in the potential Background Reference Areas.

Potential Background Reference Area	BG1	BG2	BG3
Parameter	**Exposure Rate (µR/h)**		
n	991	199	241
Minimum	10.9	8.9	9.6
Maximum	15.4	11.8	12.5
Mean	12.2	10.2	11.1
Median	12.1	10.1	11.0
Standard Deviation	0.6	0.6	0.6

Notes:
BG1 = Background Reference Area 1
BG2 = Background Reference Area 2
BG3 = Background Reference Area 3
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	90,885
Minimum	8.2
Maximum	169.9
Mean	12.8
Median	11.0
Standard Deviation	7.6

Notes:
µR/h = microRoentgens per hour

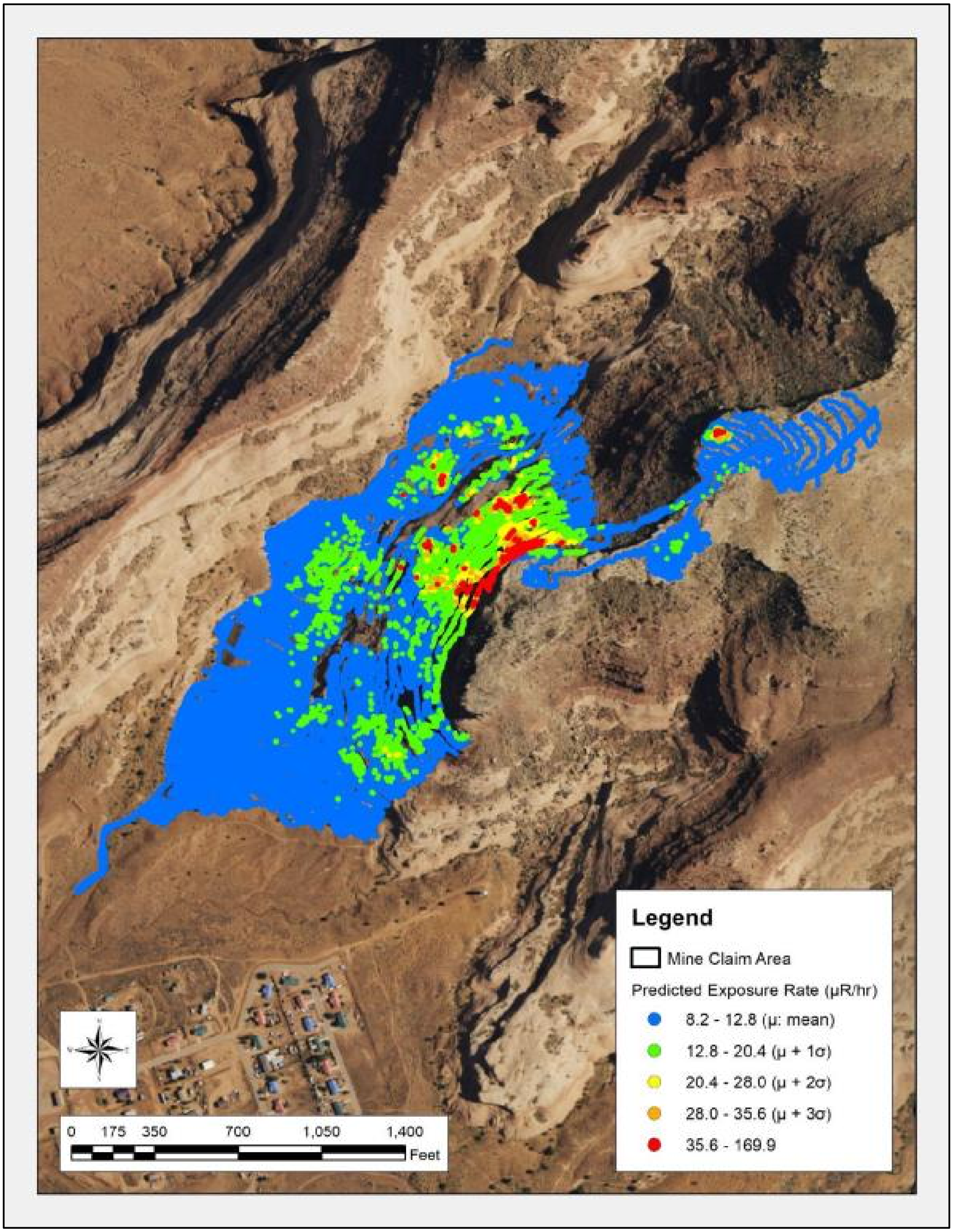


Figure 11. Predicted exposure rates in the Survey Area.

4.0 Deviations to RSE Work Plan

The RSE Work Plan specifies that the comparison of gamma count rates and radium concentrations in surface soils was to occur in 900 square foot areas. Field personnel adjusted the areas as necessary, to minimize the variability of gamma count rates observed, particularly where the spatial distribution of waste rock was heterogeneous.

5.0 Conclusions

The findings of the RSE pertaining to these activities are:

- The horizontal extent and magnitude of mining-related materials were delineated sufficiently to support additional characterization of the subsurface.

- Elevated count rates were observed largely on waste piles extending away from portals and on the road and walls near the portals in the mine claim.

- Three potential Background Reference Areas were established.

- The relationship between gamma count rates and concentrations of radium-226 in surface soils (0 to 0.5 ft below ground surface) is described by a power regression model:

  Radium-226 concentration (pCi/g) = 9×10^{-7} x Gamma Count Rate $(\text{cpm})^{1.4869}$

- The distribution of concentrations of radium-226 in surface soils predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 0.3 to 143, with a central tendency (median) of 1.7 pCi/g.

- The thorium series radionuclides do not appear to affect the prediction of concentrations of radium-226 from gamma count rates.

- The uranium series radionuclides appear not to be in secular equilibrium.

- The relationship between gamma count rates and exposure rates is described by a linear regression model:

  Exposure Rate (µR/h) = 5×10^{-4} x Gamma Count Rate (cpm) + 5.7462

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 8.2 to 169.9, with a central tendency (median) of 11.0 µR/h.

6.0 References

ANSI, 1997. Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments, American National Standards Institute (ANSI) Standard N232A. June 20, 2014.

MWH, 2016. Navajo Nation AUM Environmental Response Trust, First Phase, Removal Site Evaluation Work Plan, October 24, 2016.

Stantec, 2018. Charles Keith Removal Site Evaluation Report, January 2018.

Appendix A Instrument calibration and completed function check forms

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254772
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR303727

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

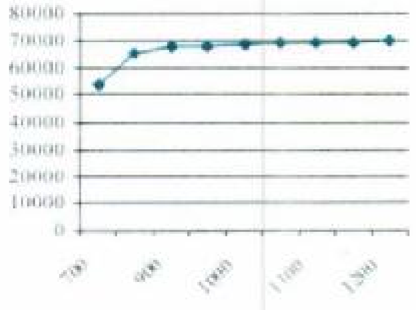
Barometric Pressure: 24.75 inches Hg
Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Threshold: 10 mV
Temperature: 74 °F
Source Geometry: ☑ Side ☐ Below ☐ Other:
Window:
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398857	400
x 1000	100	100	100		100
x 100	400	400	400	39913	400
x 100	100	100	100		100
x 10	400	400	400	3992	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	53620	
800	64979	
900	67955	
950	67795	
1000	68536	9542
1050	69153	
1100	69331	
1150	69346	
1200	69492	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source: Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 7-6-16
Calibration Due: 7-6-17

Reviewed By:
Date: 7/20/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A-1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 254772

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR303727

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

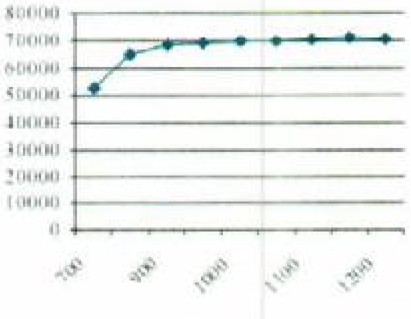
Barometric Pressure: 24.24 inches Hg
Source Distance: ☐ Contact ☑ 6 inches ☐ Other: Threshold: 10 mV Temperature: 78 °F
Source Geometry: ☑ Side ☐ Below ☐ Other: Window: Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399859	400
x 1000	100	100	100		100
x 100	400	400	400	39991	400
x 100	100	100	100		100
x 10	400	400	400	4001	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	52821	
800	65213	
900	68644	
950	69245	
1000	69492	9111
1050	69792	
1100	70472	
1150	71183	
1200	70571	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV =1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibration Date: 2/28/17 ~~2 March 17~~ ASH Calibration Due: 2/28/18 ~~2 March~~ 18 ASH

Calibrated By:

Reviewed By: Date: 3-1-17

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

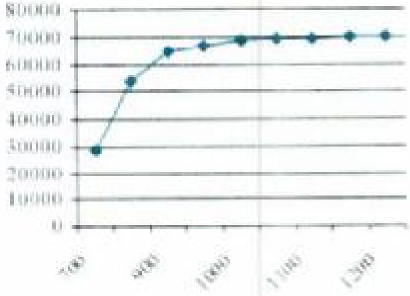
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399802	400
x 1000	100	100	100		100
x 100	400	400	400	39989	400
x 100	100	100	100		100
x 10	400	400	400	3999	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	28456	
800	53330	
900	64430	
950	66209	
1000	68333	
1050	69077	
1100	69121	8924
1150	69973	
1200	70155	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 7/6/16
Calibration Due: 7/6/17

Reviewed By:
Date: 7/20/16

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 196086
Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR295014

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed
☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

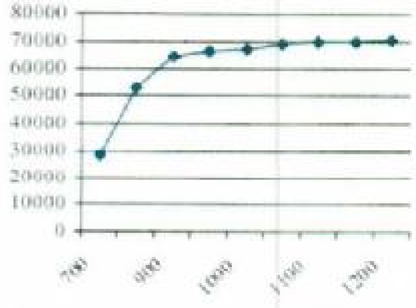
Barometric Pressure: 24.27 inches Hg
Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Threshold: 10 mV
Temperature: 78 °F
Source Geometry: ☑ Side ☐ Below ☐ Other:
Window:
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399386	400
x 1000	100	100	100		100
x 100	400	400	400	39949	400
x 100	100	100	100		100
x 10	400	400	400	3995	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	28235	
800	52834	
900	64481	
950	66468	
1000	67321	
1050	69009	
1100	69981	9079
1150	69564	
1200	70538	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1100

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03
☐ Other Source:

Calibrated By:
Reviewed By:
Calibration Date: 2/28/17 ~~1 March 17~~ Calibration Due: 2/28/18 ~~1 March 18~~
Date: 3/1-17

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Calibration and Voltage Plateau

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8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	138368
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR154615

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed

☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

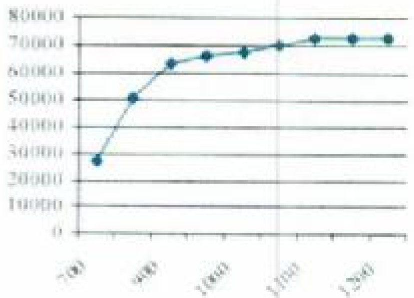
Barometric Pressure: 24.78 inches Hg
Temperature: 74 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398436	400
x 1000	100	100	100		100
x 100	400	400	400	39845	400
x 100	100	100	100		100
x 10	400	400	400	3984	400
x 10	100	100	100		100
x 1	400	400	400	399	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	26998	
800	51037	
900	63340	
950	65550	
1000	67410	
1050	70113	
1100	72217	
1150	72561	9216
1200	72337	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1150

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 @ 12,800 dpm (1/4/12) sn: 4098-03
☐ Beta Source: Tc-99 @ 17,700 dpm (1/4/12) sn: 4099-03

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 7-6-16
Calibration Due: 7-6-17

Reviewed By: Cd
Date: 7/20/16

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

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Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	271435
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295017

☐ Mechanical Check
☐ F/S Response Check
☐ Geotropism
☐ Meter Zeroed
☐ THR/WIN Operation
☐ Reset Check
☐ Audio Check
☐ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☐ 500 V ☐ 1000 V ☐ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

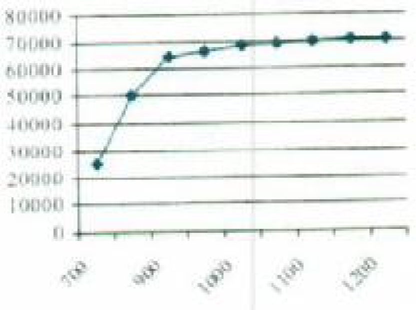
Barometric Pressure: 24.66 inches Hg
Temperature: 76 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400				
x 1000	100				
x 100	400				
x 100	100				
x 10	400				
x 10	100				
x 1	400				
x 1	100				

High Voltage	Source Counts	Background
700	24824	
800	50232	
900	64285	
950	66354	
1000	68179	
1050	69312	0303
1100	69955	
1150	70625	
1200	70633	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1050

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1
☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12

Fluke multimeter serial number: ☐ 87490128
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Other Source:

Calibrated By:
Calibration Date: 3 13-17
Calibration Due: 3-13-18

Reviewed By:
Date: 14 March 2017

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter: Manufacturer: Ludlum Model Number: 2221r Serial Number: 282971

Detector: Manufacturer: Ludlum Model Number: 44-10 Serial Number: PR320678

✓ Mechanical Check
✓ F/S Response Check
✓ Geotropism
✓ Meter Zeroed
✓ THR/WIN Operation
✓ Reset Check
✓ Audio Check
✓ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ✓ 500 V ✓ 1000 V ✓ 1500 V

Cable Length: ☐ 39-inch ✓ 72-inch ☐ Other:

Barometric Pressure: 24.63 inches Hg

Source Distance: ☐ Contact ✓ 6 inches ☐ Other:

Threshold: 10 mV

Temperature: 75 °F

Source Geometry: ✓ Side ☐ Below ☐ Other:

Window:

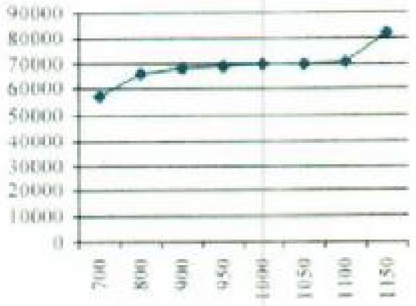
Relative Humidity: 20 %

Instrument found within tolerance: ✓ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	399936	400
x 1000	100	100	100		100
x 100	400	400	400	39984	400
x 100	100	100	100		100
x 10	400	400	400	3998	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	57641	
800	65850	
900	68414	
950	68639	
1000	69410	9773
1050	69358	
1100	70301	
1150	81822	

Voltage Plateau



Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 1000

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ✓ 201932

Fluke multimeter serial number: ☐ 87490128

☐ Alpha Source: Th-230 sn: 4098-03 @ 12,800dpm/6,520 cpm (1/4/1

☐ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03

☐ Beta Source: Tc-99 sn: 4099-03 @ 17,700dpm/11,100cpm (1/4/12

☐ Other Source:

Calibrated By:

Calibration Date: 3-13-17

Calibration Due: 3-13-18

Reviewed By:

Date: 14 March 2017

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	138368
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR355763

☑ Mechanical Check
☑ F/S Response Check
☑ Geotropism
☑ Meter Zeroed
☑ THR/WIN Operation
☑ Reset Check
☑ Audio Check
☑ Battery Check (Min 4.4 VDC)

HV Check (+/- 2.5%): ☑ 500 V ☑ 1000 V ☑ 1500 V
Cable Length: ☐ 39-inch ☑ 72-inch ☐ Other:

Source Distance: ☐ Contact ☑ 6 inches ☐ Other:
Source Geometry: ☑ Side ☐ Below ☐ Other:

Threshold: 10 mV
Window:

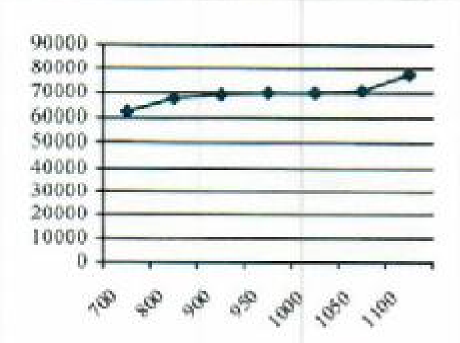
Barometric Pressure: 24.75 inches Hg
Temperature: 76 °F
Relative Humidity: 20 %

Instrument found within tolerance: ☑ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	398875	400
x 1000	100	100	100		100
x 100	400	400	400	39883	400
x 100	100	100	100		100
x 10	400	400	400	3988	400
x 10	100	100	100		100
x 1	400	400	400	398	400
x 1	100	100	100		100

High Voltage	Source Counts	Background
700	62275	
800	68049	
900	69726	
950	70112	9509
1000	70068	
1050	71042	
1100	77619	

Voltage Plateau



Comments: Comments: HV Plateau Scaler Count Time = 1-min. Recommended HV = 950

Reference Instruments and/or Sources:

Ludlum pulser serial number: ☐ 97743 ☑ 201932
Fluke multimeter serial number: ☐ 87490128
☐ Alpha Source: Th-230 sn: 4098-03@12,800dpm/6,520 cpm (1/4/12)
☑ Gamma Source Cs-137 @ 5.2 uCi (1/4/12) sn: 4097-03
☐ Beta Source: Tc-99 sn: 4099-03@17,700dpm/11,100cpm(1/4/12)
☐ Other Source:

Calibrated By:
Calibration Date: 9-17-17
Calibration Due: 9-17-18

Reviewed By:
Date: 09/08/17

ERG Form ITC. 101.A

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3718
Phone 800-522-2325 Fax 615-871-0856

ACCREDITED
CALIBRATION CERT #1656.01

CALIBRATION REPORT

SUBMITTED BY:
ERG
8809 Washington Street Northeast
Suite 150
Albuquerque, NM 87113

INSTRUMENT: Reuter Stokes RSS-131, #07J00KM1

REPORT NUMBER: 161866
TEST NUMBER(S) M161588
REPORT DATE: June 29, 2016

The CALIBRATION COEFFICIENTS contained in this report were obtained by intercomparison with instruments calibrated by, or directly traceable to, the National Institute of Standards and Technology (NIST). K• S Associates, Inc. is licensed by the State of Tennessee (R-19075-G97, R-19136-B00) to perform calibrations, and is recognized by the Health Physics Society (HPS) as an ACCREDITED INSTRUMENT CALIBRATION LABORATORY. As part of the accreditation K • S participates in a measurement assurance program conducted by the HPS and NIST. K • S also certifies that the calibration was performed using quality policies, methods and procedures that meet or exceed the requirements of ISO/IEC 17025:2005.

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this report have been determined in accordance with the laboratory's terms of accreditation unless stated otherwise in this report

The CALIBRATION COEFFICIENTS stated herein are valid under the conditions specified. It is the instrument user's responsibility to perform the appropriate constancy tests prior to shipment and after return from calibration. It is also the responsibility of the user to assure that the interpretation of the information in this report is consistent with that intended by K • S Associates, Inc.

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K&S Associates, Inc
Nashville, Tennessee 37210-3718
ACCREDITED

CALIBRATION CERTIFICATE

Calibration Date: 6/27/2016 Report Number: 161866 Test Number: M161588

K&S certifies that the environmental radiation monitor identified below has been calibrated for radiation measurement using collimated radiation sources whose output has been calibrated with instruments calibrated by or directly traceable to the National Institute of Standards and Technology. K&S is accredited by the American Association for Laboratory Accreditation to perform environmental level calibrations and further certifies that the calibration was performed using accredited policies and procedures (SI 25) that meet or exceed the requirements of ISO/IEC 17025:2005.

Sensor Type: 100 mR/h

Serial Number: 07J00KM1

Average Calibration Coefficient for the range of 0.012 mR/h – 0.220 mR/h*:
1.02 mR/"mR" reading
(Measured at 4 points)

Calibration Coefficient for the 50.0 mR/h point*:
1.12 mR/"mR" reading

Calibration Coefficient for the 80.0 mR/h point*:
1.10 mR/"mR" reading

Found RAC: 2.169e-8

*Multiply the reading in **mR/h** by the Calibration Coefficient to obtain true **mR/h**.

Calibrated By: Richard Hardison Reviewed By: Angela Royer

Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED

AS FOUND DATA
Reuter-Stokes Chamber Calibration

June 27, 2016 ***Test Number*** *M161588*

CHAMBER:

Mfgr: Reuter Stokes
Model: RSS-131
Serial: 07J00KM1

SUBMITTED BY:

ERG

Albuquerque, NM

ORIENTATION/CONDITIONS:

Serial number away from source
"True" background exposure rate of 6.7 uR/h, instrument reading was 0.0076 mR/h

ATMOSPHERIC COMMUNICATION: SEALED

POLARIZING POTENTIAL 401V

LEAKAGE: negligible

BEAM QUALITY BEAM		EXPOSURE RATE		CALIBRATION COEFFICIENT	UNCERT	LOG
CsEn220	(11mCi)	0.22mR/h	N_x=	1.00 mR/h/rdg	11%	M-53 73
CsEn80	(11mCi)	0.08mR/h	N_x=	1.03 mR/h/rdg	11%	
CsEnv12	(1mCi)	0.012mR/h	N_x=	1.01 mR/h/rdg	11%	
CsEnv15	(1mCi)	0.015mR/h	N_x=	1.02 mR/h/rdg	11%	
Cs199m	(20 Ci)	50mR/h	N_x=	1.12 mR/h/rdg	8%	
Cs252m	(20 Ci)	80mR/h	N_x=	1.10 mR/h/rdg	8%	

Comments Batt: 6.1V, Temp: 24.6 deg C, K&S Environment: Temp:21 deg C , RH 59%, Press: 752 mmHg:
Report Number: 161866
Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25
RAC Found: 2.169e-8

Calibrated By Richard Hardison **Reviewed By:**
Title: Calibration Technician **Title:** Calibration Physicist
Checked By: **Prepared By:**

Form RSS

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7.19.17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7.19.17

Comments:
NNEAT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): PROJECT REFERENCE POINTS
10-26-16	0637	6.1	1008	99	46974	7833	39141	NW	BOYD TISI
10-26-16	1545	6.1	992	98	42850	5959	36891	NW	BOYD TISI
10-27-16	1005	6.0	1004	99	48059	8561	39498	NW	Harvey Blackwater
10-27-16	1555	5.9	999	99	48564	8465	40099	NW	Harvey Blackwater
10-28-16	0808	5.9	1004	99	46814	9142	37672	NW	Harvey Blackwater
10-28-16	1704	5.8	1000	99	43711	5178	38533	NW	Mitten No. 3
10-29-16	0807	5.9	1005	100	43690	5203	38487	NW	Mitten No. 3
10-29-16	1342	5.8	999	99	44561	4801	39760	NW	Mitten No. 3
10-31-16	0840	5.8	1004	99	42426	5084	37342	NW	Mitten No. 3
10-31-16	1507	5.8	999	99	44206	5069	39137	NW	Goulding's back SUV
11-1-16	0748	5.8	1006	100	44441	4842	39599	NW	Charles Keith
11-1-16	1722	5.7	1003	99	44858	5117	39741	NW	Goulding's back of SUV

Reviewed by: MA

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-2-16	0821	5.7	1008	99	45344	6195	39149	NW	Charles, keith
11-2-16	1721	5.6	1002	99	44348	5346	39002	NW	Goulding's in SUV
11-3-16	1037	5.7	1007	100	43600	5834	37766	NW	Charles keith
11-3-16	1848	5.7	1003	100	46842	7821	39021	NW	Chinle Holiday Inn SUV
11-4-16	0845	5.7	1007	100	48258	8617	39641	NW	Occurrence B
11-4-16	1255	5.5	1003	99	46329	8608	37721	NW	Occurrence B
11-5-16	1108	5.6	1006	99	47858	9264	38594	NW	Claim 28
11-5-16	1527	5.6	1006	99	45039	7398	37641	NW	Chinle lot in SUV
11-7-16	0805	5.7	1008	100	48193	9249	38944	NW	Claim 28
11-7-16	1836	5.6	1003	99	46785	6986	39797	NW	Chinle lot in SUV
11-8-16	0800	5.6	1009	99	47951	9183	38768	NW	Claim 28
11-8-16	1637	5.5	1003	100	45094	6916	38178	NW	Chinle lot

Reviewed by: MM

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-6-94
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
11-1-16	0744	5.3	1107	100	43406	4729	38677	NW	Charles Keith
11-1-16	1718	5.2	1102	99	44319	5332	38987	NW	Goulding's in SUV
11-2-16	0818	5.2	1108	100	43456	5555	37901	NW	Charles Keith
11-2-16	1703	5.1	1101	100	43874	5111	38763	NW	Gouldings in SUV
a 11-3-16	1050	6.2	1107	100	45017	5399	39618	NW	Charles Keith
a 11-3-16	1845	6.2	1104	99	47896	7562	40334	NW	Chinle Holiday Inn SUV
11-4-16	0856	6.2	1109	100	47119	8387	38732	NW	Occurrence B
11-4-16	1147	6.1	1105	100	46025	7972	38053	NW	Occurrence B
11-5-16	1112	6.1	1107	100	47483	8555	38928	NW	Claim 28
11-5-16	1524	6.1	1107	99	46828	7017	39811	NW	Chinle lot in SUV
11-7-16	0822	6.1	1108	100	46734	8744	37990	NW	Claim 28
11-7-16	1829	5.9	1104	99	46382	6448	39934	NW	Chinle lot

a. Changed batteries

Reviewed by: MR

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

Environmental Restoration Group Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.	138368
Cal. Due Date:	7-19-~~16~~17 NW

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.	PR154615
Cal. Due Date:	7-19-~~16~~17 NW

Comments:
NNERT

Source: Cs-137
Serial No.: 333-94
Activity: 5.12 uCi
Emission Rate: NA cpm/emissions
Source Date: 6-16-94
Distance to Source: 6 in.

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
10-28-16	0813	5.6	1162	144	50583	9051	41532	NW	Harvey Blackwater
10-29-16	0815	5.6	1222	199	44566	5053	39513	NW	Mitten No.3
10-29-16	1338	5.5	1141	125	44503	4794	39709	NW	Mitten No. 3
10-31-16	0846	5.5	1133	111	44824	4753	40071	NW	Mitten No. 3
10-31-16	1502	5.5	1132	114	44994	4883	40111	NW	Goulding's in SUV
11-1-16	0758	5.5	1133	110	45344	4771	40573	NW	Charles Keith
11-1-16	1712	5.3	1120	100	44220	4928	39292	NW	Goulding's in SUV
11-2-16	0826	5.3	1127	103	44389	5834	38555	NW	Charles Keith
11-2-16	1715	5.3	1125	106	43737	5179	38558	NW	Goulding's in SUV
11-3-16	1055	5.3	1125	105	44443	5368	39075	NW	Charles Keith
11-3-16	1842	5.3	1123	104	47047	7583	39464	NW	Chinle Holiday Inn SUV
11-4-16	0900	5.4	1128	104	46230	8402	37828	NW	Occurrence B

Reviewed by: MN

Review Date: 11/29/16

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254792
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 303727
Cal. Due Date:	2-28-18

Comments:
NNERT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: N/A cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-16-17	1322	6.2	947	100	40116	7260	32856	NW	Cameron Trading Post lot
3-16-17	1555	6.1	942	99	38692	5986	32657	NW	Boyd Tisi
3-17-17	0812	6.2	951	100	40027	7965	32122	NW	Cameron Trading Post lot
3-17-17	1328	6.1	943	100	42203	10206	31997	NW	Boyd Tisi ~200 ft from BG4
3-18-17	0730	6.1	949	100	38598	6950	31648	NW	Harvey Blackwater
3-18-17	1505	6.0	941	100	35954	5035	30919	NW	Mitten No. 3
3-19-17	0651	6.1	949	99	36982	4952	32030	NW	Goulding's lot
3-19-17	1217	5.9	945	99	36802	5103	31699	NW	Charles Keith south of claim
3-20-17	0855	6.0	950	100	40829	8989	31840	NW	Claim 28
3-20-17	1555	5.9	943	100	37489	5569	32280	NW	Chinle parking lot
3-21-17	0635	5.9	950	100	38433	5735	32698	NW	Chinle lot
3-21-17	1657	5.9	946	100	36797	4997	31800	NW	Goulding's lot

Reviewed by:

Review Date: 10/17/17

ERG Form ITC.201.A

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

ERG

Single-Channel Function Check Log

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-18

Comments:
NNGRT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: N/a cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 Inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0658	5.9	948	100	37553	5150	32403	NW	Goulding's lot
3-22-17	1432	5.7	944	100	35555	4865	30690	NW	Charles Keith shooting range
3-23-17	0903	5.8	949	100	35647	5062	30585	NW	NA-0928
3-23-17	1918	5.7	950	101	41998	10371	31627	NW	Gallup lot
3-24-17	0812	5.7	953	100	36633	4660	31973	NW	Eunice Becenti
3-24-17	1740	5.6	947	100	42350	11142	31208	NW	Gallup lot
3-27-17	0830	5.6	952	100	36518	4677	31841	NW	Eunice Becenti
3-27-17	1230	5.5	949	100	36189	4090	32099	NW	Eunice Becenti
					NW 4-2-17				

Reviewed by:

Review Date: 11/06/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	196086
Cal. Due Date:	2-28-19

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 295014
Cal. Due Date:	2-28-18

Comments:
NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-20-17	0905	5.7	1003	101	40471	8507	31964	NW	Claim 28
3-20-17	1547	5.6	996	101	36470	5494	30976	NW	Chinle lot
3-21-17	0641	5.7	1004	101	37904	5597	32307	NW	Chinle lot
3-21-17	1654	5.6	999	101	36212	4929	31283	NW	Goulding's lot
3-22-17	0702	5.6	1001	101	35714	5119	30595	NW	Goulding's lot
3-22-17	1937	5.4	995	101	35087	4539	30548	NW	Charles Keith shooting range
3-23-17	0907	5.6	1004	101	36031	4879	31152	NW	NA-0928
3-23-17	1922	5.5	1004	101	41793	9955	31838	NW	Gallup lot
3-24-17	0810	5.5	1007	101	35608	4282	31326	NW	Eunice Becenti
3-24-17	1735	5.5	1000	101	41923	10785	31138	NW	Gallup lot
3-27-17	0833	5.5	1005	101	36943	4282	32661	NW	Eunice Becenti
3-27-17	1235	5.4	1000	101	35141	4013	31128	NW	Eunice Becenti

Reviewed by:

Review Date: 10/9/17

(4)

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	271435
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR295017
Cal. Due Date:	3-13-18

Comments: NNEAT

Source: Cs-137
Activity: 4 uCi
Source Date: 4-18-96
Distance to Source: 6 inches
Serial No.: 544-96
Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
3-22-17	0705	5.6	1050	100	35820	5210	30610	NW	Goulding's lot
3-22-17	1425	5.5	1049	101	36169	4648	31521	NW	Charles Keith shooting range
3-23-17	0908	5.6	1056	102	35972	4828	31144	NW	NA-0928
3-23-17	1915	5.5	1055	102	41686	10757	30929	NW	Gallup lot
3-24-17	0805	5.5	1060	102	36151	4442	31709	NW	Eunice Becenti
3-24-17	1744	5.4	1051	101	41975	10973	31002	NW	Gallup lot
3-25-17	0908	5.5	1057	102	37581	5827	31754		Section 26
3-25-17					DID NOT USE				
					4-2-17				

Reviewed by:
Review Date: ~~9~~ 10/9/17

ERG Form ITC.201.A

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254772
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-18

Comments:

NNMZRT

Source: Cs-137

Serial No.: 544-96

Activity: 4 uCi

Emission Rate: NA cpm/emissions

Source Date: 4-18-96

Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
5-18-17	1032	5.5	1001	100	38206	6536	31670	NW	Alongo upper
5-18-17	1206	5.5	1001	100	39193	6515	32678	NW	Alongo upper
5-19-17	0643	5.6	1003	101	36123	4837	31286	NW	Oak 124/125
5-19-17	1456	5.5	999	101	38056	6003	32053	NW	Alongo lower
5-22-17	0729	5.5	1000	100	36624	4799	31825	NW	Mitten
5-22-17	1542	5.4	992	100	35431	4841	30590	NW	Mitten
5-23-17	0733	5.5	995	100	36519	5067	31452	NW	Mitten
5-23-17	1426	5.4	994	100	35848	4830	31018	NW	Goulding's lodge
5-24-17	0757	5.4	997	106	36605	5123	31482	NW	Charles keith
5-24-17	1143	5.3	993	100	36113	4844	31269	NW	Charles keith
					NW 5-25-17				

Reviewed by: Michael

Review Date: 11/08/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR320678
Cal. Due Date:	3-13-18

Comments:

NNERT

Source: Cs-137
Activity: 4 uCi
Source Date: 4-18-96
Distance to Source: 6 inches
Serial No.: 544-96
Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
5-16-17	0747	5.6	1051	100	37255	5170	32085	NW	Eunice Brent.
5-16-17	1332	5.6	1052	100	36609	5251	31358	NW	Eunice Becenti
5-17-17	0808	5.6	1053	101	37256	5821	31435	NW	Eunice Becenti
5-17-17	1417	5.6	1049	100	36737	5441	31296	NW	Eunice Becenti
5-18-17	1029	5.5	1052	100	38435	7070	31365	NW	Alonzo upper
5-18-17	1202	5.5	1052	101	38935	6986	31949	NW	Alonzo upper
5-20-17	0924	5.6	1051	101	38316	7201	31115	NW	Alonzo lower
5-20-17	1352	5.5	1047	99	39498	6654	32844	NW	Alonzo lower
5-23-17	0737	5.6	1050	100	36693	5557	31136	NW	Mitten
5-23-17	1430	5.5	1046	100	37575	5371	32204	NW	Gouldings lodge
5-24-17	0803	5.6	1048	100	37282	5725	31557	NW	Charles keith
5-24-17	1143	5.5	1044	100	36054	5552	30502	NW	Charles keith

Reviewed by:

Review Date: 10/9/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	282971
Cal. Due Date:	3-13-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	RR320678
Cal. Due Date:	3-13-18

Comments:
NNERT - Soils Characterization

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
6-20-17	1334	5.7	1046	100	37108	6411	30697	NW	Charles Keith
6-20-17	1651	5.6	1038	98	36894	5907	30987	NW	Charles Keith
6-21-17	0720	5.7	1045	100	38258	6568	31690	NW	Charles Keith
6-21-17	1400	5.5	1035	99	36426	5473	30953	NW	Charles Keith
6-22-17	0732	5.6	1044	100	37058	5300	31758	NW	Charles Keith
6-22-17	1710	5.5	1042	99	37441	6708	30733	NW	Tsosie 1
6-24-17	0901	5.6	1047	100	38218	7111	31107	NW	Tsosie 1
6-24-17	1655	5.5	1041	99	36728	6080	30648	NW	Tsosie 1
6-26-17	0852	5.6	1048	100	38982	7442	31540	NW	Tsosie 1
6-26-17	1632	5.4	1040	99	38932	7627	31305	NW	Tsosie 1
6-27-17	1238	5.5	1047	100	36268	5913	30355	NW	Eunice Becenti
6-27-17	1403	5.5	1044	100	36016	5567	30449	NW	Eunice Becenti

Reviewed by:

Review Date: 6/29/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	138368
Cal. Due Date:	9-7-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR355763
Cal. Due Date:	9-7-18

Comments:

NNERT

Source: Cs-137
Serial No.: 544-96
Activity: 4 uCi
Emission Rate: NA cpm/emissions
Source Date: 4-18-96
Distance to Source: 6 Inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
9-12-17	0914	5.4	950	101	36935	6331	30604	NW	Barton 3
9-12-17	1432	5.3	944	99	38043	6468	31575	NW	Tsosie 1
9-13-17	0906	5.4	951	99	37146	6538	30608	NW	Alonzo
9-13-17	1600	5.3	944	99	35587	5991	29596	NW	Barton 3
9-14-17	0909	5.4	950	100	36080	6176	29904	NW	NA-0904
9-14-17	1255	5.3	948	100	36099	5764	30335	NW	NA-0904
9-15-17	0920	5.4	954	101	35208	5551	29657	NW	Eunice Becenti
9-15-17	1729	5.3	957	109	35937	5261	30676	NW	Eunice Becenti
9-14-17	0831	5.4	958	105	36467	6034	30433	NW	Section 26 @ trailer
9-16-17	1453	5.3	946	98	44454	14748	29706	NW	Section 26 @ corral
9-20-17	0736	5.3	953	102	37676	6987	30689	NW	Mexican Hat
9-20-17	1611	5.2	947	100	36842	6252	30590	NW	Mexican Hat

Reviewed by:

Review Date: 10/19/17

ERG

Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	GE
Model:	RSS-131
Serial No.:	07J0UKM1
Cal. Due Date:	6-29-17

DETECTOR	
Manufacturer:	SAME AS METER
Model:	
Serial No.:	
Cal. Due Date:	

Comments:
NNERT

Source: Cs-137

Serial No.: 333-94

Activity: 5.12 uCi

Emission Rate: NA cpm/emissions

Source Date: 6-6-94

Distance to Source: Contact housing

Date	Time	Battery	High Voltage	Threshhold	Source Counts mR/h	BKG Counts µR/h	Net Counts	Initials	Note(s): Project reference points
10-26-16	0525	~6.4	~400	NA	~27.8	~10.5	~17.3	NW	Best Western room - Flagstaff
10-26-16	2010	~6.3	~400	NA	~26	~9.5	~16.5	NW	Gouldings room ~~Best Western room - Flagstaff~~ NW
10-27-16	0720	~6.2	~400	NA	~26.7	~10.0	~16.7	NW	Gouldings room
10-27-16	1710	~6.2	~400	NA	~27.0	~10.8	~16.2	NW	Gouldings room
10-31-16	0609	~6.3	~400	NA	~27.0	~10	~16	NW	Gouldings room
10-31-16	1520	~6.3	~400	NA	~26	~10	~16	NW	Gouldings room
11-3-16	0700	~6.2	~400	NA	~26.5	~10.5	~16	NW	Gouldings room
11-3-16	1924	~6.1	~400	NA	~28.8	~12.5	~16.3	NW	Holiday Inn Chinle-room
11-9-16	0615	~6.3	~400	NA	~30	~12.8	~17.2	NW	Holiday Inn-Chinle room
11-9-16	1430	~6.2	~400	NA	~29.5	~12.5	~17	NW	Holiday Inn Chinle-room
11-11-16	0610	~6.4	~400	NA	~31.5	~13.5	~18	NW	Holiday Inn Chinle-room
11-11-16	1825	~6.2	~400	NA	~28	~11	~17	NW	Holiday Inn Chinle-room

Reviewed by:

Review Date: 11-29-16

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
11/03/2016 11:46	0.0544	Correlation Location 1
11/03/2016 11:46	0.0953	Correlation Location 1
11/03/2016 11:46	0.084	Correlation Location 1
11/03/2016 11:47	0.0586	Correlation Location 1
11/03/2016 11:47	0.0394	Correlation Location 1
11/03/2016 11:47	0.0278	Correlation Location 1
11/03/2016 11:47	0.0216	Correlation Location 1
11/03/2016 11:47	0.0182	Correlation Location 1
11/03/2016 11:47	0.0167	Correlation Location 1
11/03/2016 11:47	0.0156	Correlation Location 1
11/03/2016 11:47	0.0145	Correlation Location 1
11/03/2016 11:47	0.0144	Correlation Location 1
11/03/2016 11:47	0.0147	Correlation Location 1
11/03/2016 11:48	0.0148	Correlation Location 1
11/03/2016 11:48	0.0145	Correlation Location 1
11/03/2016 11:48	0.0144	Correlation Location 1
11/03/2016 11:48	0.0144	Correlation Location 1
11/03/2016 11:48	0.0142	Correlation Location 1
11/03/2016 11:48	0.0142	Correlation Location 1
11/03/2016 11:48	0.0148	Correlation Location 1
11/03/2016 11:48	0.0151	Correlation Location 1
11/03/2016 11:48	0.015	Correlation Location 1
11/03/2016 11:48	0.0147	Correlation Location 1
11/03/2016 11:49	0.0144	Correlation Location 1
11/03/2016 11:49	0.0142	Correlation Location 1
11/03/2016 11:49	0.0143	Correlation Location 1
11/03/2016 11:49	0.0145	Correlation Location 1
11/03/2016 11:49	0.0147	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:49	0.0148	Correlation Location 1
11/03/2016 11:49	0.0149	Correlation Location 1
11/03/2016 11:50	0.0147	Correlation Location 1
11/03/2016 11:50	0.0145	Correlation Location 1
11/03/2016 11:50	0.0142	Correlation Location 1
11/03/2016 11:50	0.0141	Correlation Location 1
11/03/2016 11:50	0.0144	Correlation Location 1
11/03/2016 11:50	0.0146	Correlation Location 1
11/03/2016 11:50	0.015	Correlation Location 1
11/03/2016 11:50	0.0152	Correlation Location 1
11/03/2016 11:50	0.0153	Correlation Location 1
11/03/2016 11:50	0.0154	Correlation Location 1
11/03/2016 11:51	0.0153	Correlation Location 1
11/03/2016 11:51	0.0148	Correlation Location 1
11/03/2016 11:51	0.0149	Correlation Location 1
11/03/2016 11:51	0.015	Correlation Location 1
11/03/2016 11:51	0.015	Correlation Location 1
11/03/2016 11:51	0.0153	Correlation Location 1
11/03/2016 11:51	0.0156	Correlation Location 1
11/03/2016 11:51	0.0152	Correlation Location 1
11/03/2016 11:51	0.0146	Correlation Location 1
11/03/2016 11:51	0.0145	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0144	Correlation Location 1
11/03/2016 11:52	0.0143	Correlation Location 1
11/03/2016 11:52	0.0148	Correlation Location 1
11/03/2016 11:52	0.0149	Correlation Location 1
11/03/2016 11:52	0.0148	Correlation Location 1
11/03/2016 11:52	0.0147	Correlation Location 1
11/03/2016 11:52	0.0151	Correlation Location 1
11/03/2016 11:53	0.0155	Correlation Location 1
11/03/2016 11:53	0.0153	Correlation Location 1
11/03/2016 11:53	0.0151	Correlation Location 1
11/03/2016 11:53	0.0151	Correlation Location 1
11/03/2016 11:53	0.0148	Correlation Location 1
11/03/2016 11:53	0.0143	Correlation Location 1
11/03/2016 11:53	0.014	Correlation Location 1
11/03/2016 11:53	0.0142	Correlation Location 1
11/03/2016 11:53	0.0149	Correlation Location 1
11/03/2016 11:53	0.015	Correlation Location 1
11/03/2016 11:54	0.0152	Correlation Location 1
11/03/2016 11:54	0.0151	Correlation Location 1
11/03/2016 11:54	0.0148	Correlation Location 1
11/03/2016 11:54	0.0145	Correlation Location 1
11/03/2016 11:54	0.0147	Correlation Location 1
11/03/2016 11:54	0.0149	Correlation Location 1
11/03/2016 11:54	0.0147	Correlation Location 1
11/03/2016 11:54	0.0145	Correlation Location 1
11/03/2016 11:54	0.0146	Correlation Location 1
11/03/2016 11:54	0.0144	Correlation Location 1
11/03/2016 11:55	0.0144	Correlation Location 1
11/03/2016 11:55	0.0141	Correlation Location 1
11/03/2016 11:55	0.0137	Correlation Location 1
11/03/2016 11:55	0.0136	Correlation Location 1
11/03/2016 11:55	0.0143	Correlation Location 1
11/03/2016 11:55	0.0149	Correlation Location 1
11/03/2016 11:55	0.0153	Correlation Location 1
11/03/2016 11:55	0.0154	Correlation Location 1
11/03/2016 11:55	0.0151	Correlation Location 1
11/03/2016 11:55	0.0149	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0155	Correlation Location 1
11/03/2016 11:56	0.0155	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0152	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.0153	Correlation Location 1
11/03/2016 11:56	0.015	Correlation Location 1
11/03/2016 11:56	0.0149	Correlation Location 1
11/03/2016 11:57	0.015	Correlation Location 1
11/03/2016 11:57	0.015	Correlation Location 1
11/03/2016 11:57	0.0152	Correlation Location 1
11/03/2016 11:57	0.0151	Correlation Location 1
11/03/2016 12:16	0.0552	Correlation Location 2
11/03/2016 12:16	0.0978	Correlation Location 2
11/03/2016 12:16	0.0874	Correlation Location 2
11/03/2016 12:16	0.0622	Correlation Location 2
11/03/2016 12:17	0.0429	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
11/03/2016 12:17	0.0316	Correlation Location 2
11/03/2016 12:17	0.0251	Correlation Location 2
11/03/2016 12:17	0.0221	Correlation Location 2
11/03/2016 12:17	0.0207	Correlation Location 2
11/03/2016 12:17	0.0199	Correlation Location 2
11/03/2016 12:17	0.0192	Correlation Location 2
11/03/2016 12:17	0.0192	Correlation Location 2
11/03/2016 12:17	0.0194	Correlation Location 2
11/03/2016 12:17	0.0192	Correlation Location 2
11/03/2016 12:18	0.0189	Correlation Location 2
11/03/2016 12:18	0.0186	Correlation Location 2
11/03/2016 12:18	0.019	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.0192	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.0194	Correlation Location 2
11/03/2016 12:18	0.019	Correlation Location 2
11/03/2016 12:18	0.019	Correlation Location 2
11/03/2016 12:19	0.0189	Correlation Location 2
11/03/2016 12:19	0.0188	Correlation Location 2
11/03/2016 12:19	0.0187	Correlation Location 2
11/03/2016 12:19	0.0186	Correlation Location 2
11/03/2016 12:19	0.0184	Correlation Location 2
11/03/2016 12:19	0.0186	Correlation Location 2
11/03/2016 12:19	0.0189	Correlation Location 2
11/03/2016 12:19	0.019	Correlation Location 2
11/03/2016 12:19	0.0192	Correlation Location 2
11/03/2016 12:19	0.0196	Correlation Location 2
11/03/2016 12:20	0.0198	Correlation Location 2
11/03/2016 12:20	0.02	Correlation Location 2
11/03/2016 12:20	0.0198	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0194	Correlation Location 2
11/03/2016 12:20	0.0189	Correlation Location 2
11/03/2016 12:20	0.019	Correlation Location 2
11/03/2016 12:21	0.0189	Correlation Location 2
11/03/2016 12:21	0.0186	Correlation Location 2
11/03/2016 12:21	0.0189	Correlation Location 2
11/03/2016 12:21	0.0192	Correlation Location 2
11/03/2016 12:21	0.0194	Correlation Location 2
11/03/2016 12:21	0.019	Correlation Location 2
11/03/2016 12:21	0.0189	Correlation Location 2
11/03/2016 12:21	0.019	Correlation Location 2
11/03/2016 12:21	0.0194	Correlation Location 2
11/03/2016 12:21	0.0194	Correlation Location 2
11/03/2016 12:22	0.0197	Correlation Location 2
11/03/2016 12:22	0.0194	Correlation Location 2
11/03/2016 12:22	0.0192	Correlation Location 2
11/03/2016 12:22	0.019	Correlation Location 2
11/03/2016 12:22	0.019	Correlation Location 2
11/03/2016 12:22	0.0189	Correlation Location 2
11/03/2016 12:22	0.0189	Correlation Location 2
11/03/2016 12:22	0.0189	Correlation Location 2
11/03/2016 12:22	0.0192	Correlation Location 2
11/03/2016 12:22	0.0192	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0194	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0189	Correlation Location 2
11/03/2016 12:23	0.0186	Correlation Location 2
11/03/2016 12:23	0.019	Correlation Location 2
11/03/2016 12:23	0.0192	Correlation Location 2
11/03/2016 12:23	0.0194	Correlation Location 2
11/03/2016 12:23	0.0194	Correlation Location 2
11/03/2016 12:24	0.0192	Correlation Location 2
11/03/2016 12:24	0.0194	Correlation Location 2
11/03/2016 12:24	0.0194	Correlation Location 2
11/03/2016 12:24	0.0198	Correlation Location 2
11/03/2016 12:24	0.02	Correlation Location 2
11/03/2016 12:24	0.0199	Correlation Location 2
11/03/2016 12:24	0.0194	Correlation Location 2
11/03/2016 12:24	0.0197	Correlation Location 2
11/03/2016 12:24	0.02	Correlation Location 2
11/03/2016 12:24	0.0197	Correlation Location 2
11/03/2016 12:25	0.0196	Correlation Location 2
11/03/2016 12:25	0.0196	Correlation Location 2
11/03/2016 12:25	0.0196	Correlation Location 2
11/03/2016 12:25	0.0194	Correlation Location 2
11/03/2016 12:25	0.0194	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.0192	Correlation Location 2
11/03/2016 12:25	0.019	Correlation Location 2
11/03/2016 12:26	0.0189	Correlation Location 2
11/03/2016 12:26	0.0187	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:26	0.0192	Correlation Location 2
11/03/2016 12:26	0.0194	Correlation Location 2
11/03/2016 12:26	0.0192	Correlation Location 2
11/03/2016 12:26	0.0187	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:26	0.019	Correlation Location 2
11/03/2016 12:27	0.019	Correlation Location 2
11/03/2016 12:27	0.0187	Correlation Location 2
11/03/2016 12:27	0.0185	Correlation Location 2
11/03/2016 12:27	0.0188	Correlation Location 2
11/03/2016 12:27	0.0186	Correlation Location 2
11/03/2016 12:43	0.0581	Correlation Location 3
11/03/2016 12:43	0.1047	Correlation Location 3
11/03/2016 12:43	0.098	Correlation Location 3
11/03/2016 12:43	0.0745	Correlation Location 3
11/03/2016 12:44	0.056	Correlation Location 3
11/03/2016 12:44	0.045	Correlation Location 3
11/03/2016 12:44	0.0389	Correlation Location 3
11/03/2016 12:44	0.0355	Correlation Location 3
11/03/2016 12:44	0.0336	Correlation Location 3
11/03/2016 12:44	0.0328	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
11/03/2016 12:44	0.0327	Correlation Location 3
11/03/2016 12:44	0.0327	Correlation Location 3
11/03/2016 12:44	0.0322	Correlation Location 3
11/03/2016 12:44	0.0322	Correlation Location 3
11/03/2016 12:45	0.0324	Correlation Location 3
11/03/2016 12:45	0.0328	Correlation Location 3
11/03/2016 12:45	0.033	Correlation Location 3
11/03/2016 12:45	0.0332	Correlation Location 3
11/03/2016 12:45	0.0332	Correlation Location 3
11/03/2016 12:45	0.033	Correlation Location 3
11/03/2016 12:45	0.0328	Correlation Location 3
11/03/2016 12:45	0.0324	Correlation Location 3
11/03/2016 12:45	0.0321	Correlation Location 3
11/03/2016 12:45	0.0321	Correlation Location 3
11/03/2016 12:46	0.0322	Correlation Location 3
11/03/2016 12:46	0.0324	Correlation Location 3
11/03/2016 12:46	0.0319	Correlation Location 3
11/03/2016 12:46	0.032	Correlation Location 3
11/03/2016 12:46	0.0322	Correlation Location 3
11/03/2016 12:46	0.0327	Correlation Location 3
11/03/2016 12:46	0.0326	Correlation Location 3
11/03/2016 12:46	0.0328	Correlation Location 3
11/03/2016 12:46	0.0328	Correlation Location 3
11/03/2016 12:46	0.0332	Correlation Location 3
11/03/2016 12:47	0.0335	Correlation Location 3
11/03/2016 12:47	0.0336	Correlation Location 3
11/03/2016 12:47	0.0336	Correlation Location 3
11/03/2016 12:47	0.0335	Correlation Location 3
11/03/2016 12:47	0.0332	Correlation Location 3
11/03/2016 12:47	0.0336	Correlation Location 3
11/03/2016 12:47	0.0337	Correlation Location 3
11/03/2016 12:47	0.0332	Correlation Location 3
11/03/2016 12:47	0.0328	Correlation Location 3
11/03/2016 12:47	0.0328	Correlation Location 3
11/03/2016 12:48	0.033	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0328	Correlation Location 3
11/03/2016 12:48	0.0331	Correlation Location 3
11/03/2016 12:48	0.0334	Correlation Location 3
11/03/2016 12:48	0.0332	Correlation Location 3
11/03/2016 12:48	0.0331	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0332	Correlation Location 3
11/03/2016 12:49	0.0331	Correlation Location 3
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11/03/2016 12:49	0.033	Correlation Location 3
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11/03/2016 12:50	0.0328	Correlation Location 3
11/03/2016 12:50	0.0324	Correlation Location 3
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11/03/2016 12:50	0.0326	Correlation Location 3
11/03/2016 12:50	0.0324	Correlation Location 3
11/03/2016 12:50	0.0324	Correlation Location 3
11/03/2016 12:50	0.0327	Correlation Location 3
11/03/2016 12:50	0.0322	Correlation Location 3
11/03/2016 12:50	0.0322	Correlation Location 3
11/03/2016 12:51	0.0324	Correlation Location 3
11/03/2016 12:51	0.0326	Correlation Location 3
11/03/2016 12:51	0.0326	Correlation Location 3
11/03/2016 12:51	0.0328	Correlation Location 3
11/03/2016 12:51	0.0332	Correlation Location 3
11/03/2016 12:51	0.0332	Correlation Location 3
11/03/2016 12:51	0.033	Correlation Location 3
11/03/2016 12:51	0.033	Correlation Location 3
11/03/2016 12:51	0.0328	Correlation Location 3
11/03/2016 12:51	0.0324	Correlation Location 3
11/03/2016 12:52	0.0324	Correlation Location 3
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11/03/2016 12:52	0.0322	Correlation Location 3
11/03/2016 12:52	0.0311	Correlation Location 3
11/03/2016 12:52	0.0306	Correlation Location 3
11/03/2016 12:52	0.0308	Correlation Location 3
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11/03/2016 12:53	0.0319	Correlation Location 3
11/03/2016 12:53	0.0328	Correlation Location 3
11/03/2016 12:53	0.0326	Correlation Location 3
11/03/2016 12:53	0.0319	Correlation Location 3
11/03/2016 12:53	0.0319	Correlation Location 3
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11/03/2016 12:53	0.0324	Correlation Location 3
11/03/2016 12:53	0.0322	Correlation Location 3
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11/03/2016 12:54	0.0324	Correlation Location 3
11/03/2016 12:54	0.0324	Correlation Location 3
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11/03/2016 12:54	0.0328	Correlation Location 3
11/03/2016 12:54	0.0332	Correlation Location 3
11/03/2016 12:54	0.0335	Correlation Location 3
11/03/2016 12:54	0.0332	Correlation Location 3
11/03/2016 12:54	0.0327	Correlation Location 3
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11/03/2016 12:55	0.0324	Correlation Location 3
11/03/2016 12:55	0.0322	Correlation Location 3
11/03/2016 12:55	0.0322	Correlation Location 3
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Date and Time	Exposure Rate (mR/h)	Location
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11/03/2016 13:15	0.0302	Correlation Location 4
11/03/2016 13:15	0.0274	Correlation Location 4
11/03/2016 13:15	0.0253	Correlation Location 4
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11/03/2016 13:16	0.0235	Correlation Location 4
11/03/2016 13:16	0.0237	Correlation Location 4
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11/03/2016 13:16	0.0241	Correlation Location 4
11/03/2016 13:17	0.024	Correlation Location 4
11/03/2016 13:17	0.0237	Correlation Location 4
11/03/2016 13:17	0.0235	Correlation Location 4
11/03/2016 13:17	0.0235	Correlation Location 4
11/03/2016 13:17	0.0235	Correlation Location 4
11/03/2016 13:17	0.0235	Correlation Location 4
11/03/2016 13:17	0.0237	Correlation Location 4
11/03/2016 13:17	0.0239	Correlation Location 4
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11/03/2016 13:18	0.0237	Correlation Location 4
11/03/2016 13:18	0.0234	Correlation Location 4
11/03/2016 13:18	0.0237	Correlation Location 4
11/03/2016 13:18	0.0241	Correlation Location 4
11/03/2016 13:18	0.0242	Correlation Location 4
11/03/2016 13:18	0.0241	Correlation Location 4
11/03/2016 13:18	0.0237	Correlation Location 4
11/03/2016 13:18	0.0229	Correlation Location 4
11/03/2016 13:18	0.0225	Correlation Location 4
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11/03/2016 13:19	0.0227	Correlation Location 4
11/03/2016 13:19	0.023	Correlation Location 4
11/03/2016 13:19	0.0235	Correlation Location 4
11/03/2016 13:19	0.0241	Correlation Location 4
11/03/2016 13:19	0.0247	Correlation Location 4
11/03/2016 13:19	0.0247	Correlation Location 4
11/03/2016 13:19	0.0247	Correlation Location 4
11/03/2016 13:19	0.0245	Correlation Location 4
11/03/2016 13:19	0.0245	Correlation Location 4
11/03/2016 13:19	0.0244	Correlation Location 4
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11/03/2016 13:20	0.0242	Correlation Location 4
11/03/2016 13:20	0.0247	Correlation Location 4
11/03/2016 13:20	0.0247	Correlation Location 4
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11/03/2016 13:20	0.0242	Correlation Location 4
11/03/2016 13:20	0.0241	Correlation Location 4
11/03/2016 13:20	0.024	Correlation Location 4
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11/03/2016 13:21	0.0247	Correlation Location 4
11/03/2016 13:21	0.0249	Correlation Location 4
11/03/2016 13:21	0.0247	Correlation Location 4
11/03/2016 13:21	0.0245	Correlation Location 4
11/03/2016 13:21	0.0245	Correlation Location 4
11/03/2016 13:21	0.0242	Correlation Location 4
11/03/2016 13:21	0.0239	Correlation Location 4
11/03/2016 13:21	0.0241	Correlation Location 4
11/03/2016 13:21	0.0244	Correlation Location 4
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11/03/2016 13:22	0.0235	Correlation Location 4
11/03/2016 13:22	0.0232	Correlation Location 4
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11/03/2016 13:23	0.0243	Correlation Location 4
11/03/2016 13:23	0.0241	Correlation Location 4
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11/03/2016 13:23	0.0241	Correlation Location 4
11/03/2016 13:23	0.024	Correlation Location 4
11/03/2016 13:23	0.0237	Correlation Location 4
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11/03/2016 13:24	0.0235	Correlation Location 4
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11/03/2016 13:24	0.024	Correlation Location 4
11/03/2016 13:24	0.0237	Correlation Location 4
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11/03/2016 13:25	0.0237	Correlation Location 4
11/03/2016 13:25	0.0242	Correlation Location 4
11/03/2016 13:25	0.0237	Correlation Location 4
11/03/2016 13:25	0.0234	Correlation Location 4
11/03/2016 13:25	0.0231	Correlation Location 4
11/03/2016 13:25	0.0234	Correlation Location 4
11/03/2016 13:25	0.0237	Correlation Location 4
11/03/2016 13:25	0.0243	Correlation Location 4
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Date and Time	Exposure Rate (mR/h)	Location
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11/03/2016 14:02	0.0096	Correlation Location 5
11/03/2016 14:02	0.0096	Correlation Location 5
11/03/2016 14:02	0.0097	Correlation Location 5
11/03/2016 14:02	0.0096	Correlation Location 5
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11/03/2016 14:02	0.0095	Correlation Location 5
11/03/2016 14:03	0.0097	Correlation Location 5
11/03/2016 14:03	0.01	Correlation Location 5
11/03/2016 14:03	0.0099	Correlation Location 5
11/03/2016 14:03	0.0097	Correlation Location 5
11/03/2016 14:03	0.01	Correlation Location 5
11/03/2016 14:03	0.0098	Correlation Location 5
11/03/2016 14:03	0.0097	Correlation Location 5
11/03/2016 14:03	0.0095	Correlation Location 5
11/03/2016 14:03	0.0093	Correlation Location 5
11/03/2016 14:03	0.0093	Correlation Location 5
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11/03/2016 14:04	0.0096	Correlation Location 5
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11/03/2016 14:04	0.0099	Correlation Location 5
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11/03/2016 14:08	0.0091	Correlation Location 5
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11/03/2016 14:08	0.01	Correlation Location 5
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11/03/2016 14:08	0.01	Correlation Location 5
11/03/2016 14:09	0.0098	Correlation Location 5
11/03/2016 14:09	0.0098	Correlation Location 5
11/03/2016 14:09	0.0097	Correlation Location 5
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11/03/2016 14:09	0.01	Correlation Location 5
11/03/2016 14:09	0.0096	Correlation Location 5
11/03/2016 14:09	0.0093	Correlation Location 5
11/03/2016 14:09	0.0093	Correlation Location 5
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11/03/2016 14:10	0.0093	Correlation Location 5
11/03/2016 14:10	0.0095	Correlation Location 5
11/03/2016 14:10	0.0099	Correlation Location 5
11/03/2016 14:10	0.0104	Correlation Location 5
11/03/2016 14:10	0.0104	Correlation Location 5
11/03/2016 14:10	0.0102	Correlation Location 5
11/03/2016 14:10	0.0103	Correlation Location 5
11/03/2016 14:10	0.0104	Correlation Location 5
11/03/2016 14:10	0.0102	Correlation Location 5
11/03/2016 14:11	0.0096	Correlation Location 5
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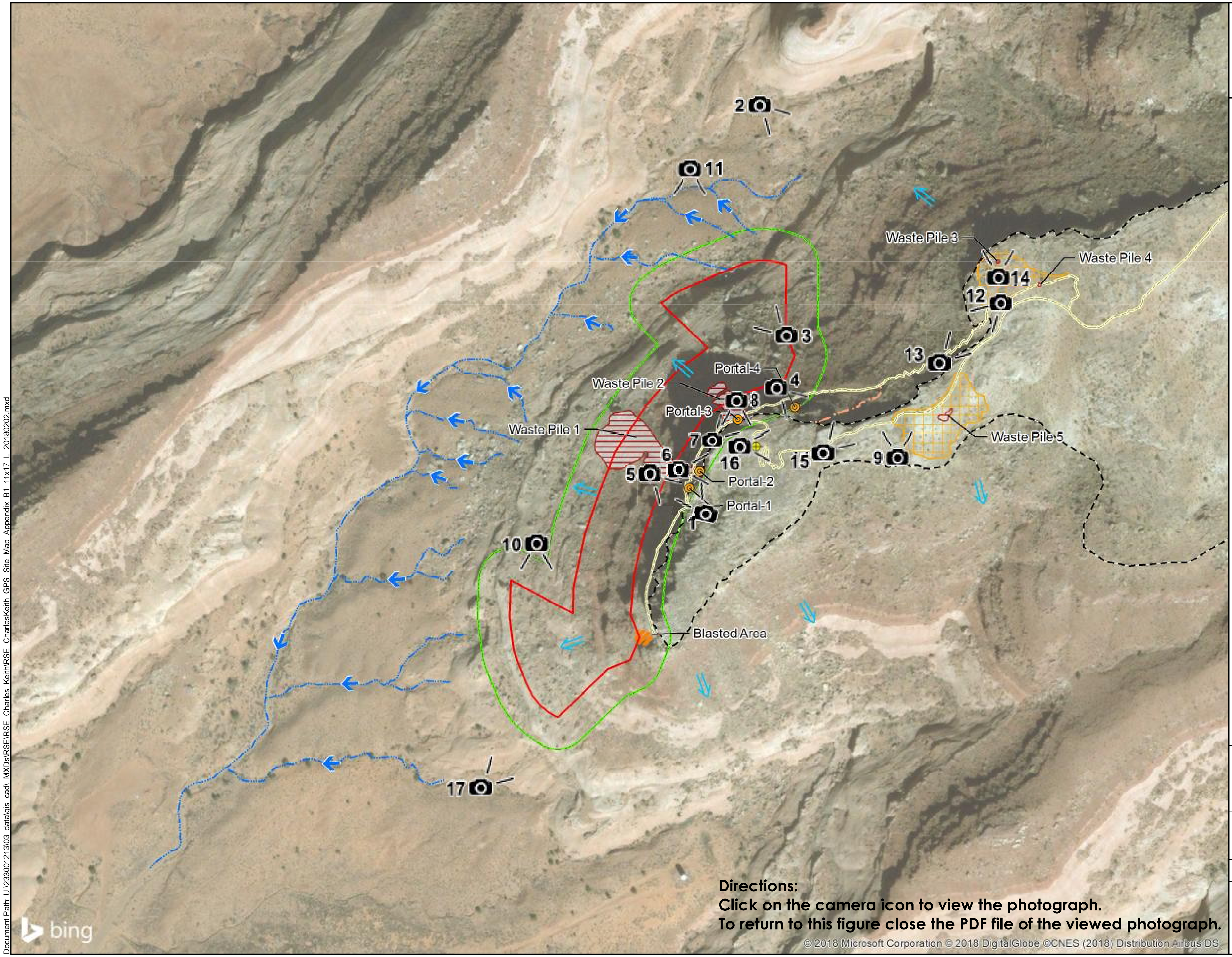
11/03/2016 14:11	0.0095	Correlation Location 5
11/03/2016 14:11	0.0091	Correlation Location 5
11/03/2016 14:11	0.0094	Correlation Location 5
11/03/2016 14:11	0.0097	Correlation Location 5
11/03/2016 14:11	0.01	Correlation Location 5
11/03/2016 14:11	0.0103	Correlation Location 5
11/03/2016 14:11	0.0103	Correlation Location 5
11/03/2016 14:12	0.0098	Correlation Location 5
11/03/2016 14:12	0.0094	Correlation Location 5
11/03/2016 14:12	0.0096	Correlation Location 5
11/03/2016 14:12	0.0098	Correlation Location 5
11/03/2016 14:12	0.0099	Correlation Location 5
11/03/2016 14:12	0.0099	Correlation Location 5
11/03/2016 14:12	0.01	Correlation Location 5

Appendix B Photographs

B.1 Site Photographs

B.2 Regional Site Photographs



Directions:
Click on the camera icon to view the photograph.
To return to this figure close the PDF file of the viewed photograph.

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NAVAJO NATION
AUM Environmental
Response Trust-First Phase

LEGEND

📷	Photograph Indicating Direction Taken
⌖	Borehole
◉	Portal
↑	Flow Direction
⇑	Approximate Overland Water Flow Direction
-·-·-	Drainage
-·-·-	Footpath
------	Potential Haul Road
- - - -	Approximate Edge of Mesa
▨	Blasted Area
▦	Mining Disturbed Area
▤	Waste Pile
☐	Claim Boundary
☐	100-Foot Claim Buffer

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagey web mapping service (http://www.bing.com/maps) on 06/2018.

N
W E
S

0 300 600
Feet

TITLE:

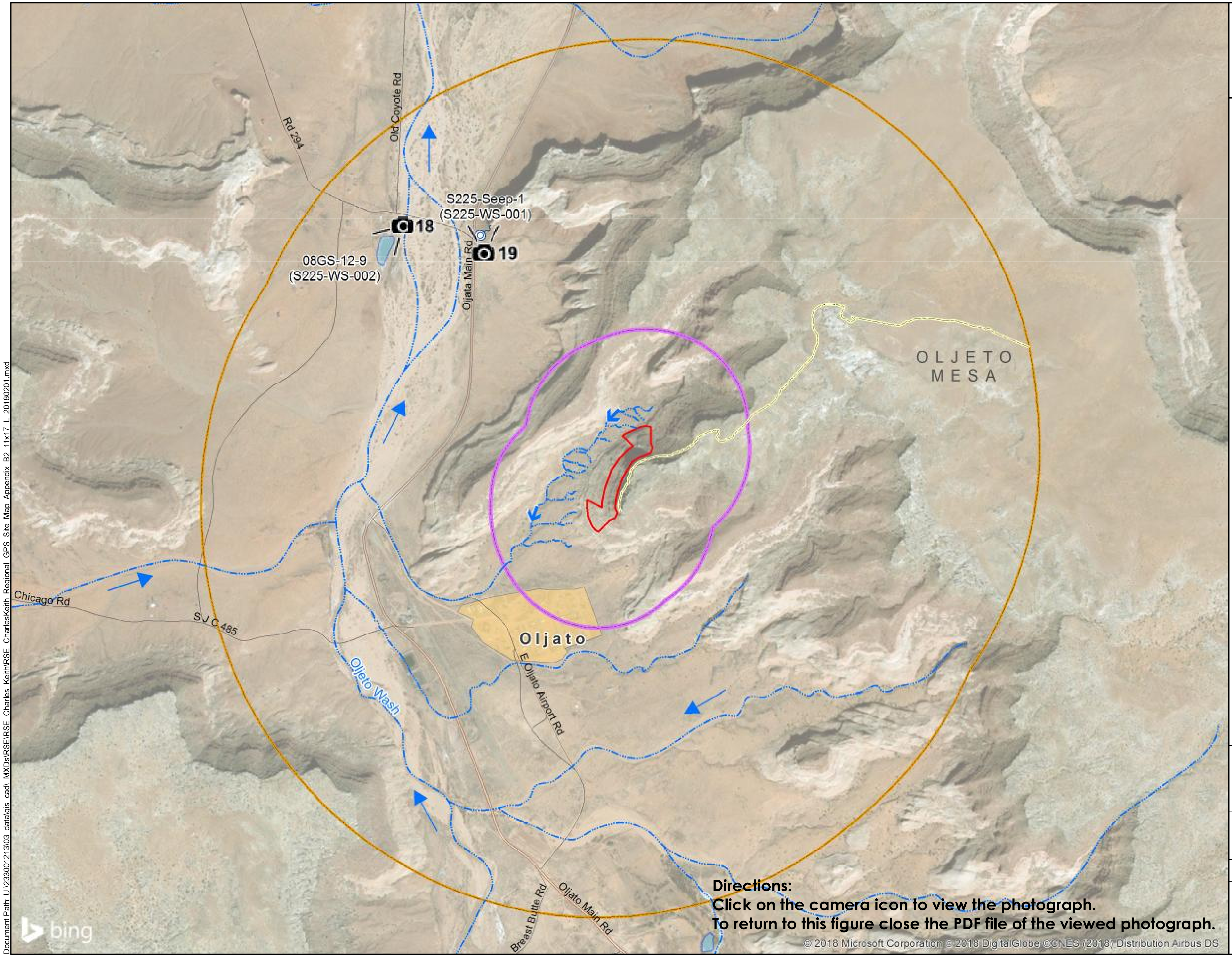
Site Photographs

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/21/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB REVIEWER: EDZ
	FIGURE: B-1

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith GPS Site Map Appendix B1 11x17 L 20180202.mxd



Directions:
Click on the camera icon to view the photograph.
To return to this figure close the PDF file of the viewed photograph.

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Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Charles_Keith\RSE_CharlesKeith_Regional_GPS_Site_Map_Appendix_B2_11x17_L_20180201.mxd

NAVAJO
NATION
AUM Environmental
Response Trust-First Phase

LEGEND

📷	Photograph Indicating Direction Taken
○	Seep[1]
↑	Flow Direction
-·-·-	Intermittent Stream/River
- - -	Potential Haul Road
═	Tribal Road
—	Local Road
▭	Pond
▭	Residential Area
▭	Claim Boundary
▭	1/4-Mile Claim Boundary Buffer
▭	1-Mile Claim Boundary Buffer

NOTES:

1. Seep identified during field mapping by the Trust/Stantec.

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

N
W E
S

0 1,300 2,600
Feet

TITLE:

Regional Site Photographs

PROJECT:

Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/21/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: B-2

Appendix C Field Activity Forms

C.1 Soil Sample Field Forms

C.2 Hand Auger Borehole Logs

C.3 Water Sample Field Forms

C.1 Soil Sample Field Forms

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-BG1-001

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 0959

SAMPLE COLLECTED BY J. Kester, K. Johnson

WEATHER CONDITIONS Sunny ~ 60°/70° - Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand with 5-10% gravel

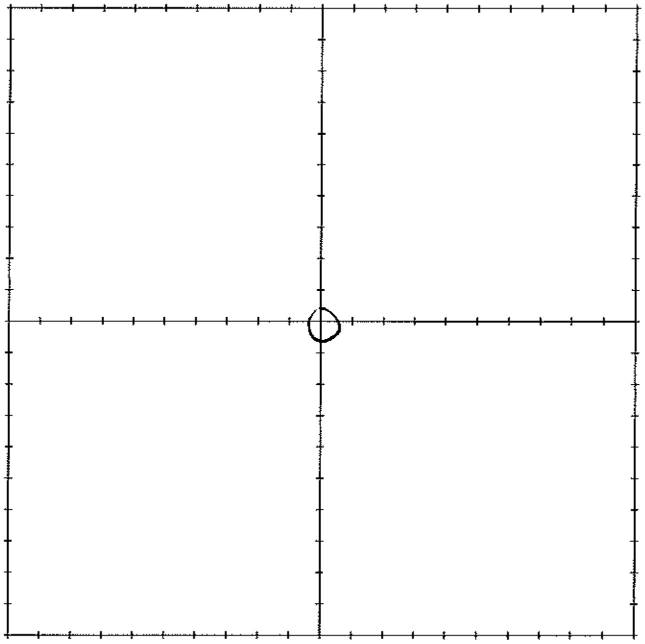
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☑ FINE ☐ MEDIUM ☐ COARSE GRAVEL

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / Zip lock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225 - BG1 - 002

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1017

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 60-70° Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand w/ 5-10% gravels

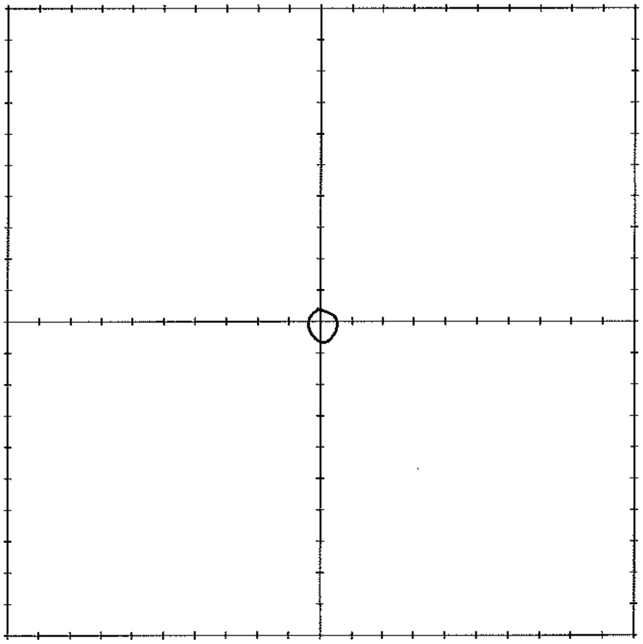
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ Zip lock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. 5225- BG1-003

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1027

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 60-70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand ~ 5-10% gravel

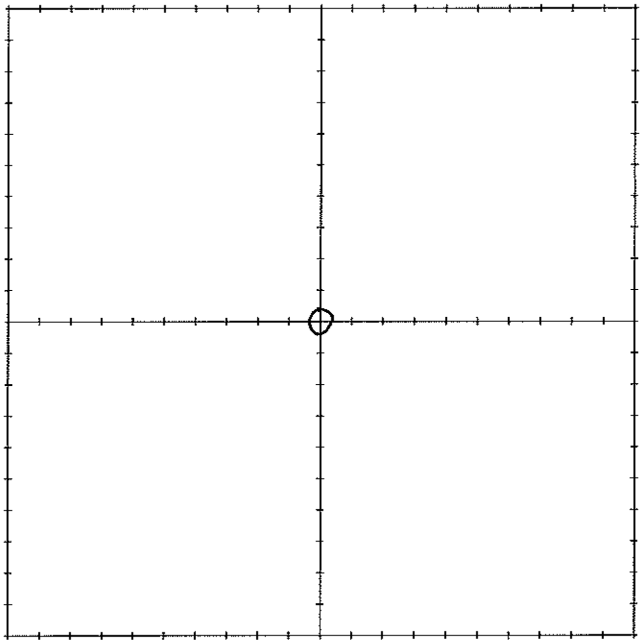
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ Zip lock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keth

SAMPLE I.D. S225 - BG1 - 004

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1035

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 60-70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand ~ 30% Gravels

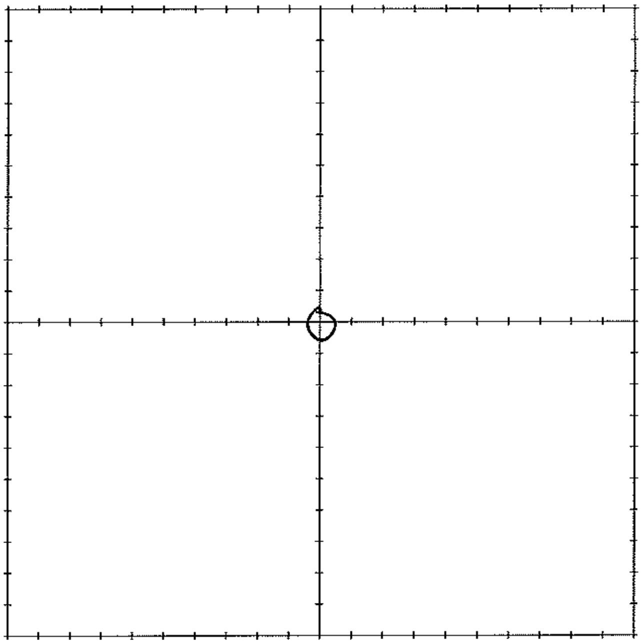
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / Zip lock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225 - BG1 - 005 / MS / MSD

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1053

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 60-70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand 10-20% gravel

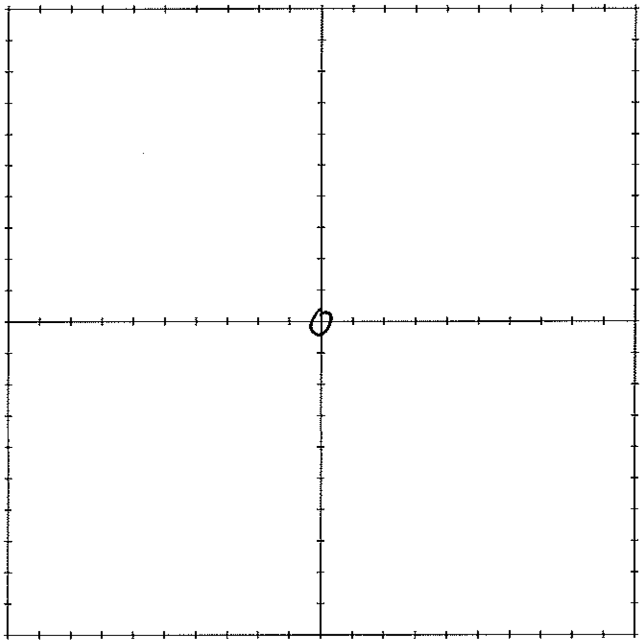
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☑ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☑ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) ~~1~~ 3 10-17-16 / Zip Lock / GRAB ; MS/MSD

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-BG1-006 / Dup - 206

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1108

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 60-70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand ~10% gravel

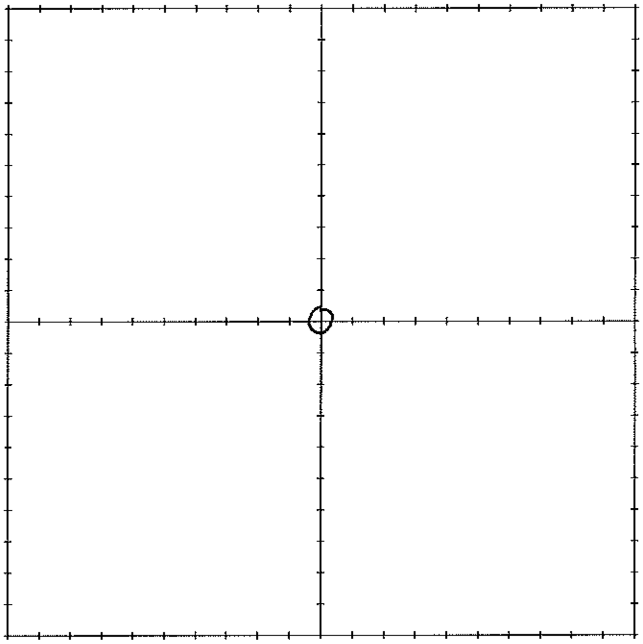
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) ~~1~~ 2 10-17-16 / Zip lock / GRAB ; Dup

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-BG1-007

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1115

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Breezy, Sunny 60-70's

FIELD USCS DESCRIPTIONS Silty fine Sand ~10% gravel

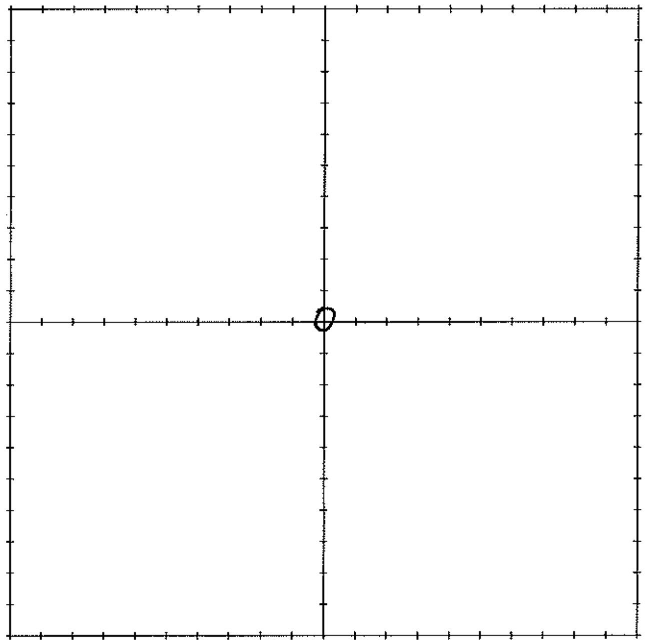
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ Zip lock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225 - B61 - 008

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1127

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Breezy, Sunny 60-70's

FIELD USCS DESCRIPTIONS Silty fine Sand, less silt - coarser Sand

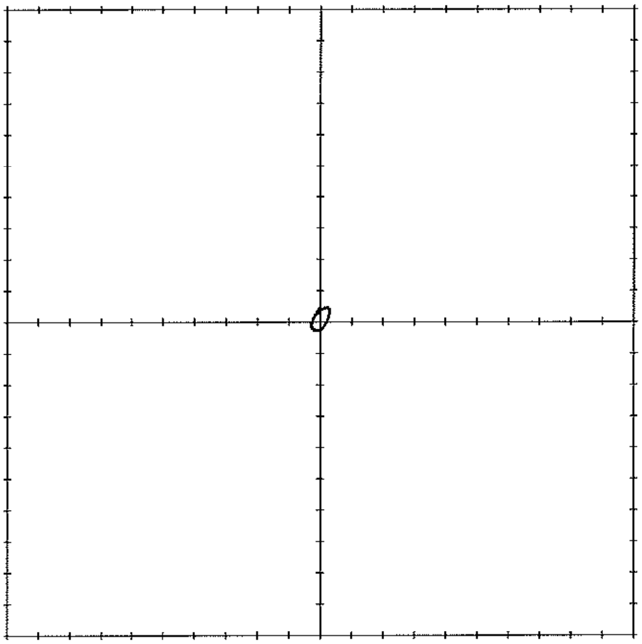
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / ziplock / GRAB

ANALYSES: Ra -226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225 - B61 - 009

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1134

SAMPLE COLLECTED BY JCK, KJS

WEATHER CONDITIONS Sunny 60-70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand 10-15% gravels

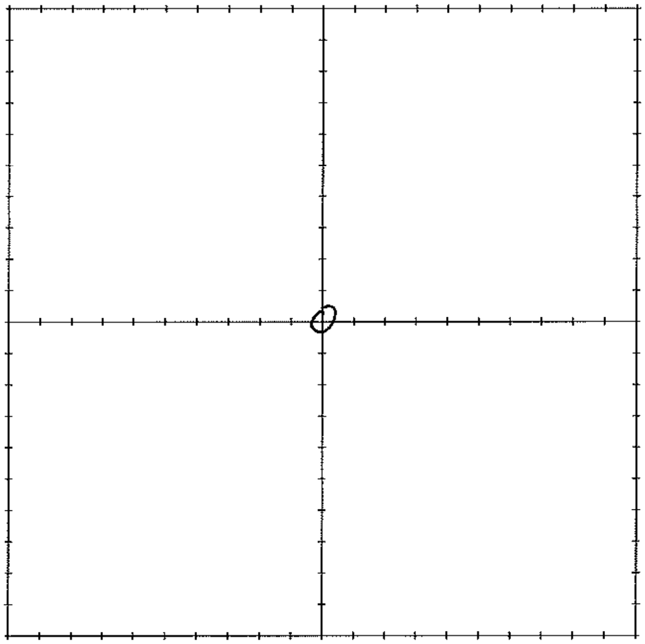
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) Ra-226, Metals

ANALYSES: 1 / Zip lock / GRAB



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-BG1-010

SAMPLE COLLECTION DATE 10-17-24

SAMPLE COLLECTION TIME 1142

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand 10-15% gravels

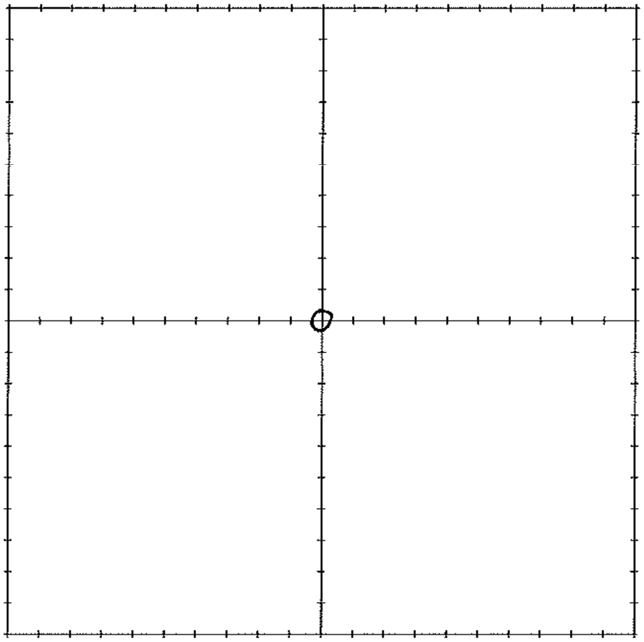
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ziplock/GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-~~B2~~ JCK B62-001

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1408

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand

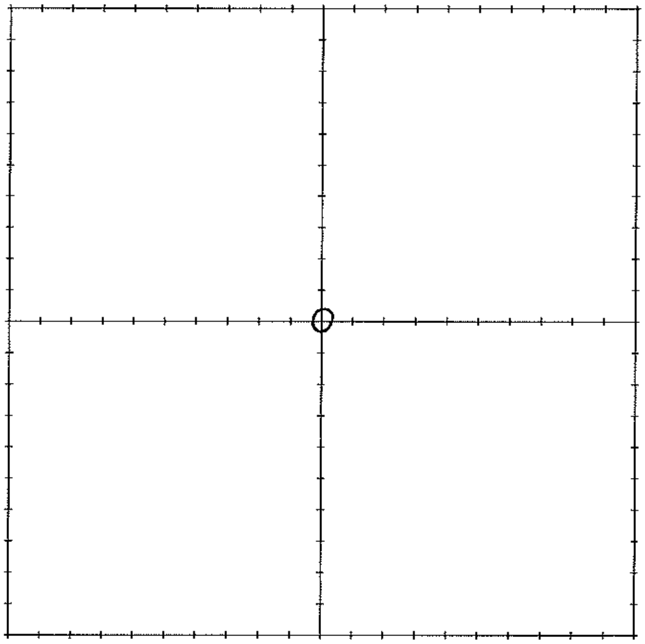
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / ziplock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S22S - BG2 - 002

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1418

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Breezy Sunny 70's

FIELD USCS DESCRIPTIONS Silty fine Sand ~ 10% gravel - dry

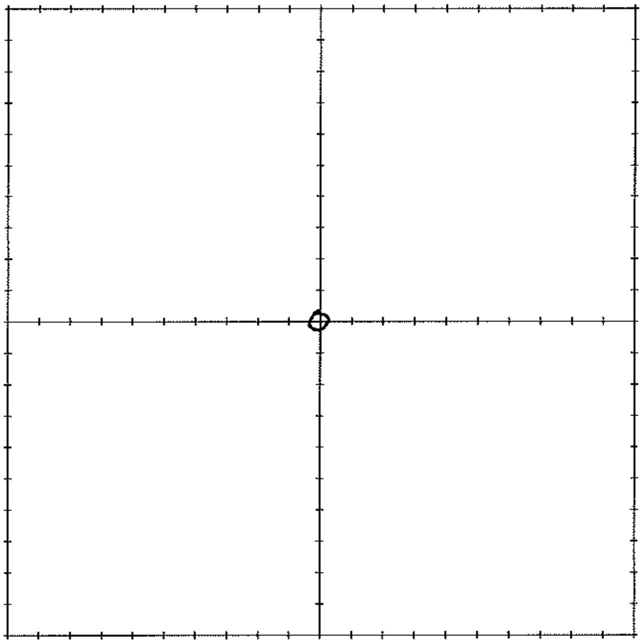
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR Gravel ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / zip lock / GRAB

ANALYSES: Ra-226-Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-BG2-003

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1425

SAMPLE COLLECTED BY JCK, KJS

WEATHER CONDITIONS Breezy 70's Sunny

FIELD USCS DESCRIPTIONS Silty fine Sand ~ 40% gravel

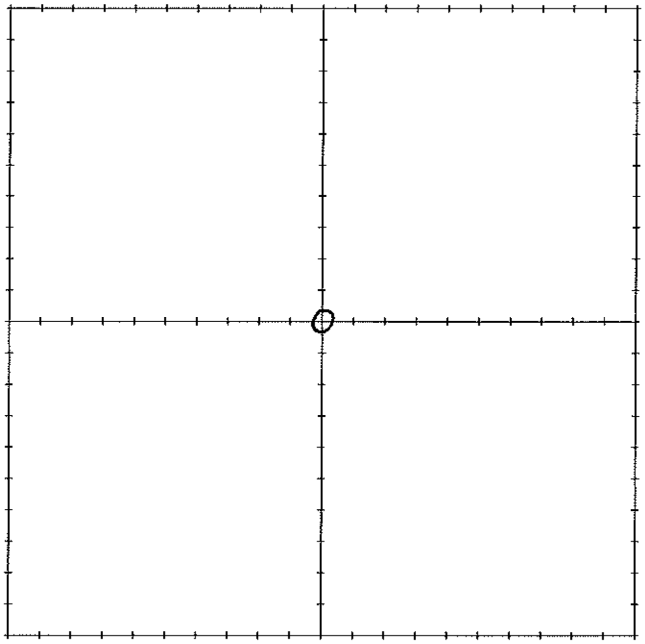
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / Ziplock / GRAB

ANALYSES: Ra-226-Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-B62-004

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1432

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand ~ 5-10% gravel

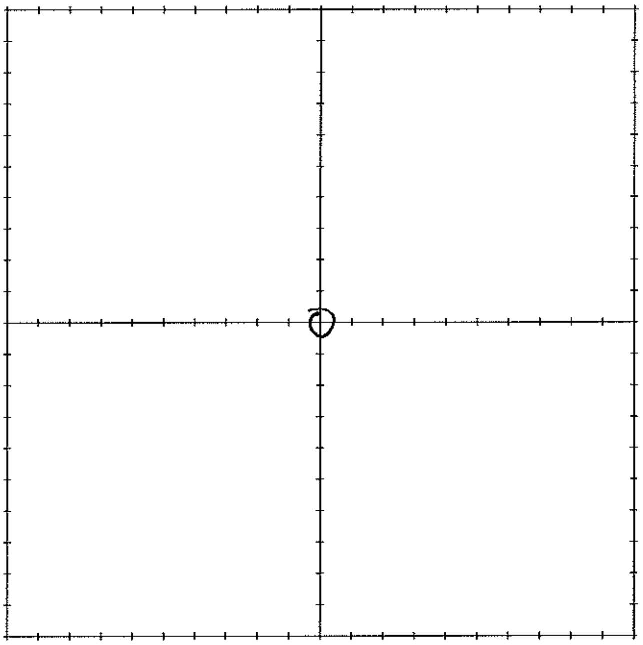
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ziplock/GRAB

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-B62-0045 J 10-17-16

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1439

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand - No gravel

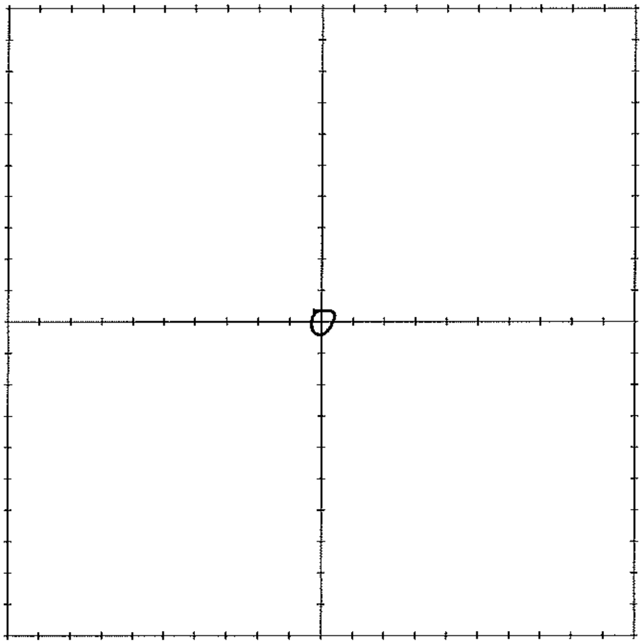
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / zip lock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. 8225-B62-006 / -206 Duplicate

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1449

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand ~10% gravel

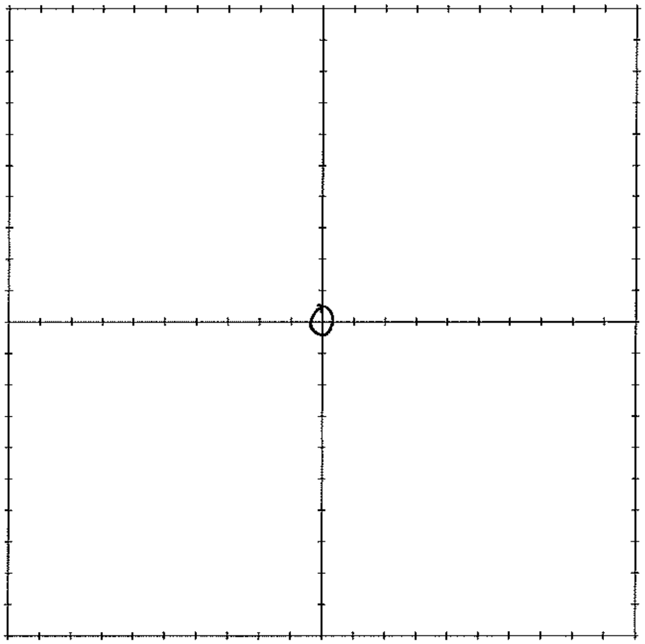
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 / ziplock / GRAB & Duplicate

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225 - BG2-007

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1458

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand < 5% granules

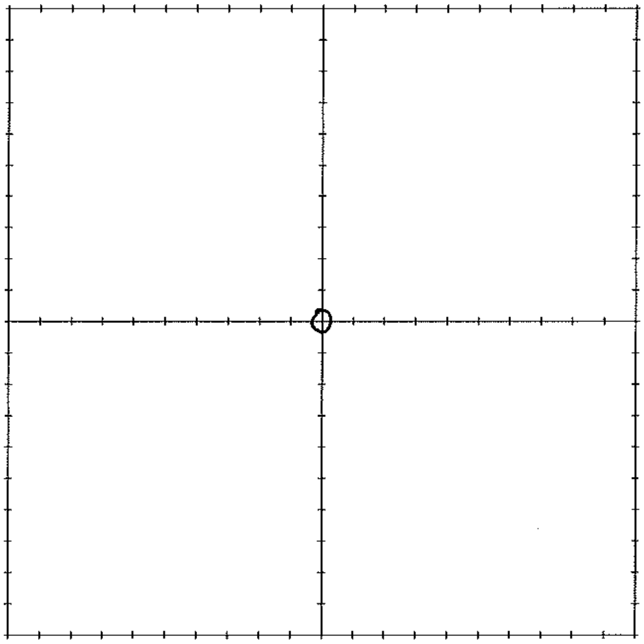
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☒ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 / ziplock / GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-B62-008

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1508

SAMPLE COLLECTED BY SCK, KJJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand ~ 20% gravel

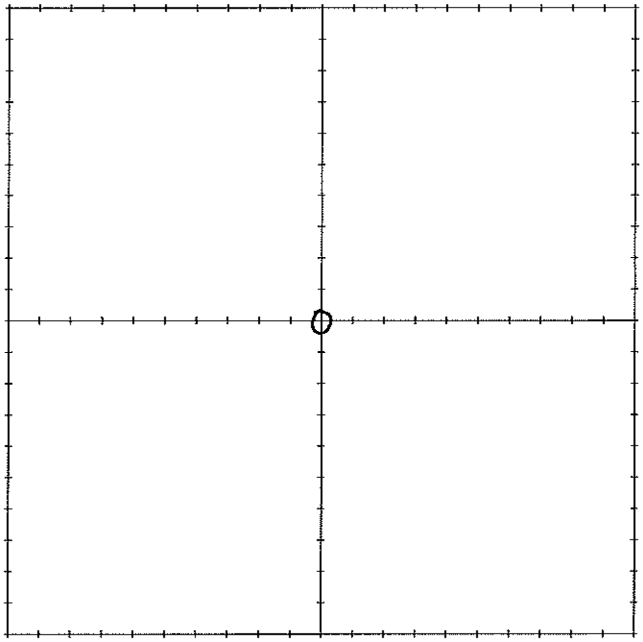
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ziplock/GRAB

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-B62-009

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1514

SAMPLE COLLECTED BY JCK, KJJ

WEATHER CONDITIONS Sunny, 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand ~5%

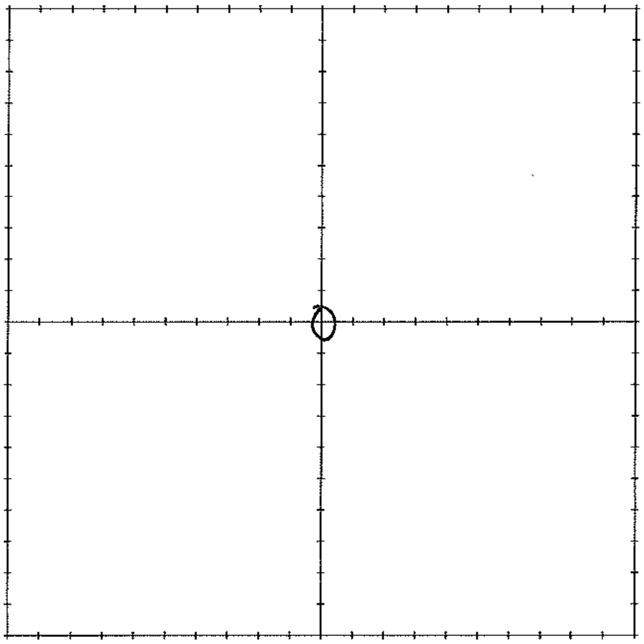
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☒ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ziplock/GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-B62-010

SAMPLE COLLECTION DATE 10-17-16

SAMPLE COLLECTION TIME 1520

SAMPLE COLLECTED BY JCK, KVJ

WEATHER CONDITIONS Sunny 70's Breezy

FIELD USCS DESCRIPTIONS Silty fine Sand Trace gravel

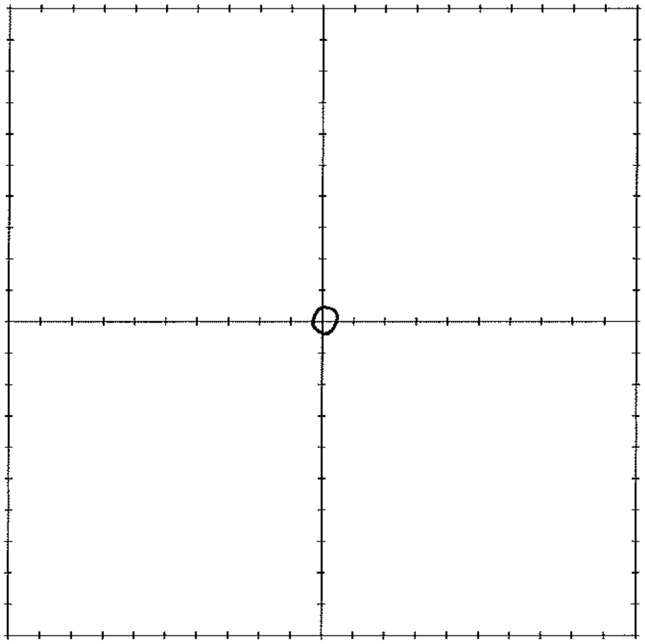
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☑ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1/ziplock/GRAB

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S225-BG3-001 Charles Keith

SAMPLE I.D. S225-BG3-001

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 10:20

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny ~85° F

FIELD USCS DESCRIPTIONS Well gradd sand with gravel (SW) Red, loose, Dry mostly fine sand (60%) grading to corse (20%) with Angular gravels (½" - 3") 20% gravels are predominant petrified wood Fragments

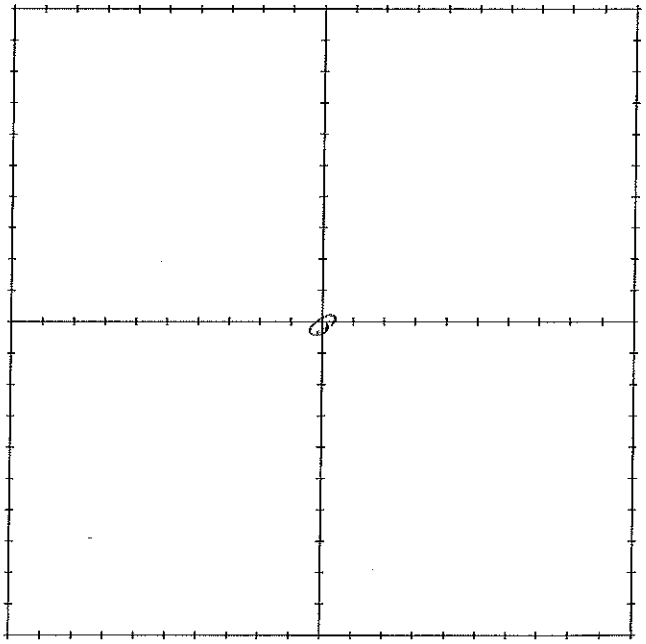
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles. Kieth

SAMPLE I.D. S225-BG3-002

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 10:30

SAMPLE COLLECTED BY Ch

WEATHER CONDITIONS Sunny 90'F

FIELD USCS DESCRIPTIONS (SW) Well graded sand with gravel, RED, loose, Dry mostly Fine sand (60%) grading to coarse (20%) with Angular gravels (20%) (1/2"-3") gravels are predominantly petrified wood

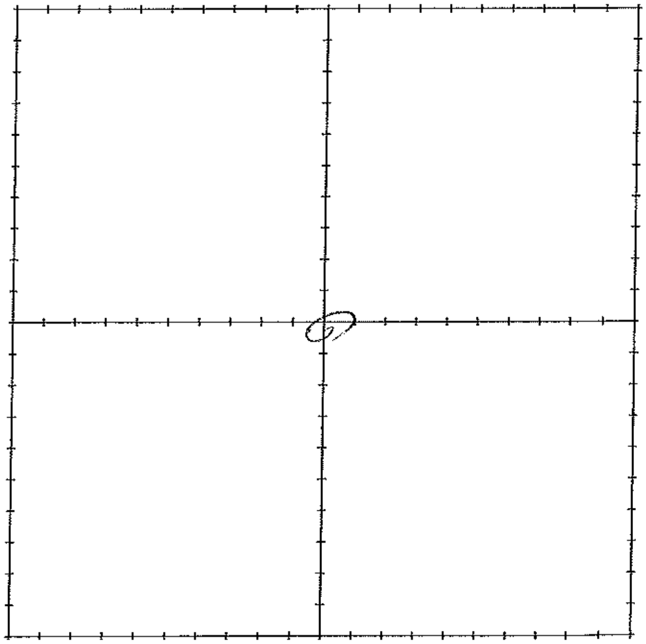
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226 Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kieth

SAMPLE I.D. S225-B63-003 + S225-B63-203

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 10:35

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 90°

FIELD USCS DESCRIPTIONS (SW) Well graded sand with gravel, Red loose Dry mostly fine sand (60%) grading to coarse (20%) with Angular gravels ½"-3" (20%). gravels are predominantly rock; fresh wood fragments

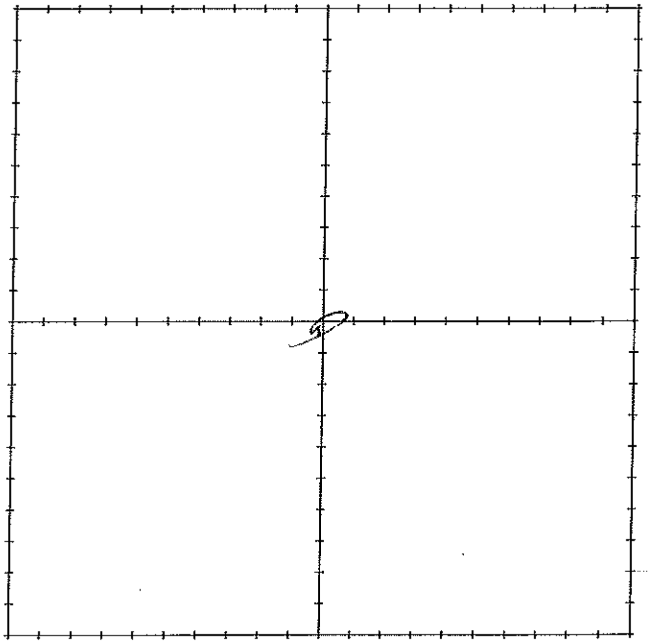
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☑ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kieth

SAMPLE I.D. S225-BG3-004

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 10:40

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS SUNNY 90°F

FIELD USCS DESCRIPTIONS (SW) Well graded sand with gravel, Red, loose, D mostly coarse sand' (6 with fine and medium sand gravels are angular (15%) fragmen of petrified wood.

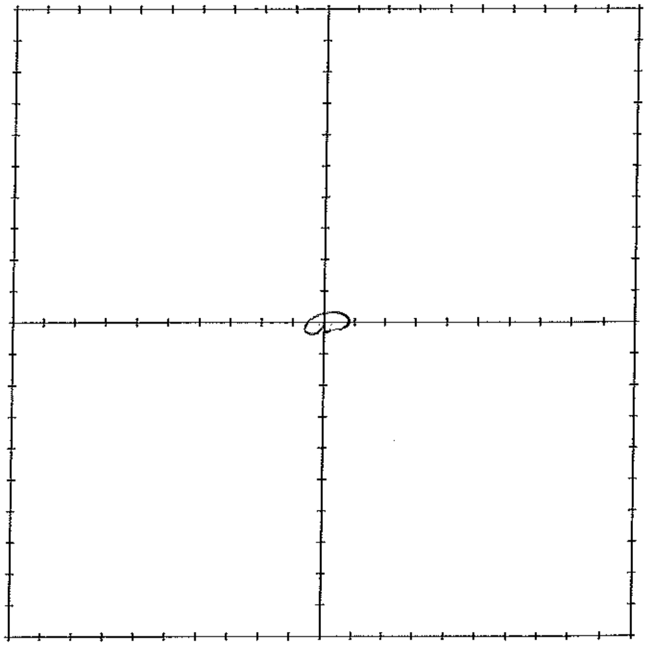
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-BG-3-005

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 10:50

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 90°F

FIELD USCS DESCRIPTIONS Well graded sand with gravels Red, loose, Dry Mostly (SW) Coarse Sand (60%) with (25%) Fine to medium sand gravels are angular (15%) 1/2-3" petrified wood frag

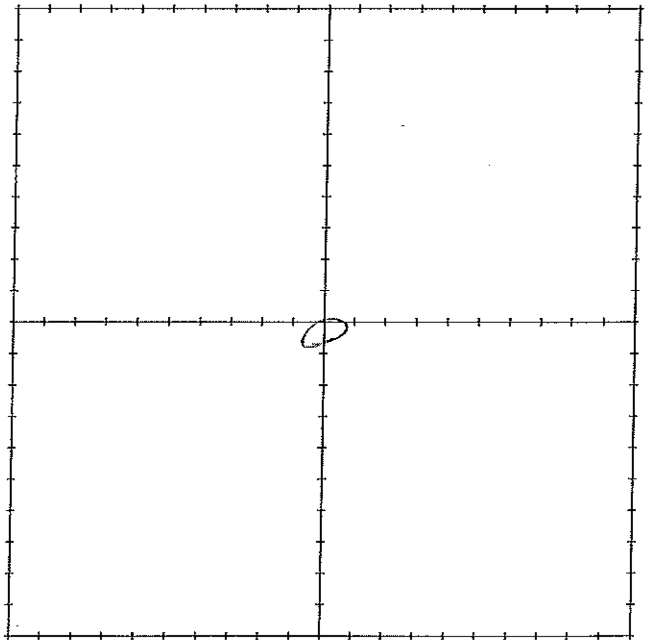
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-BG3-006

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 11:00

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 90° F

FIELD USCS DESCRIPTIONS Well graded sand with gravel, Red, loose, Dry mostly Fine (SW) Sand (60%) grading to coarse (20%) with Angular gr (20%) 1/2"-3" of predominately petrified wood fragments

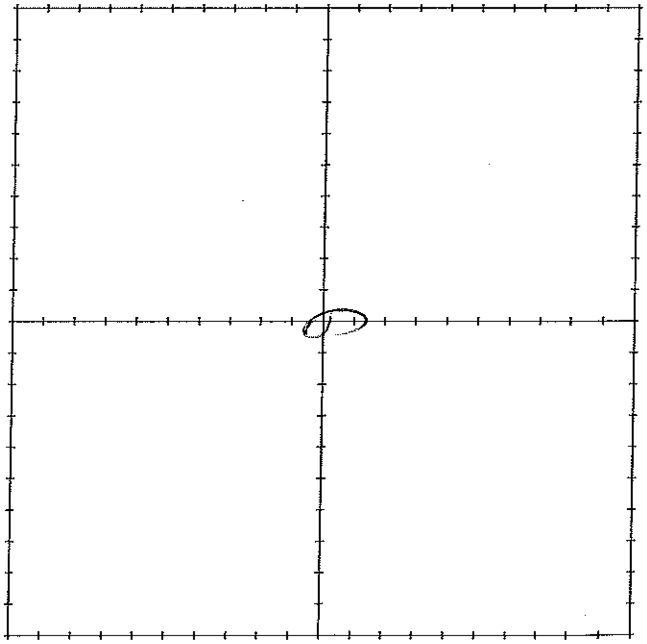
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kieth

SAMPLE I.D. S225-B63-007

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 11:10

SAMPLE COLLECTED BY cL

WEATHER CONDITIONS SUNNY 90°F

FIELD USCS DESCRIPTIONS Well graded sand with gravel, Red, loose, Dry (SW) Mostly fine sand (60%) grading to coarse (20%) with Angular gravels (½"-3") (20%) of petrified wood fragments

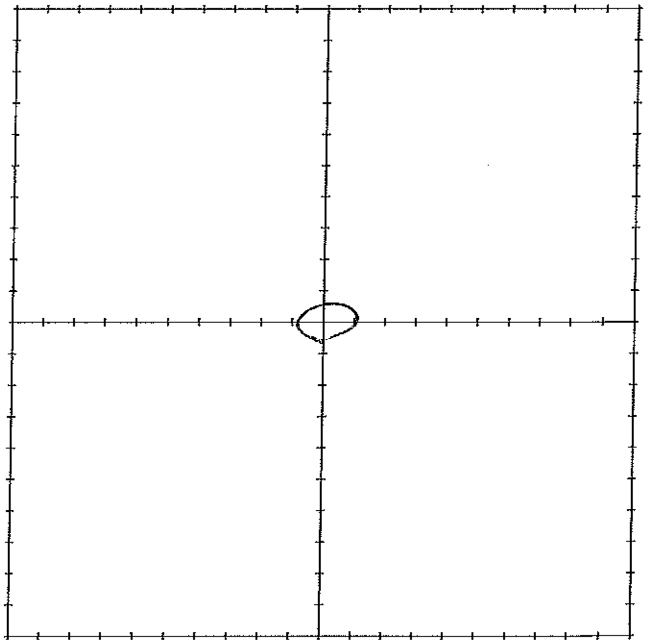
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

- 002

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kistler

SAMPLE I.D. S225-BG3-008

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 11:15

SAMPLE COLLECTED BY ck

WEATHER CONDITIONS Sunny 90° F

FIELD USCS DESCRIPTIONS (SW) Well graded sand with gravel, Red loose, Dry mostly coarse sand (60%) with fine and medium sand (25%) gravels are angular ½"-3" (15%) fragments of petrified wood.

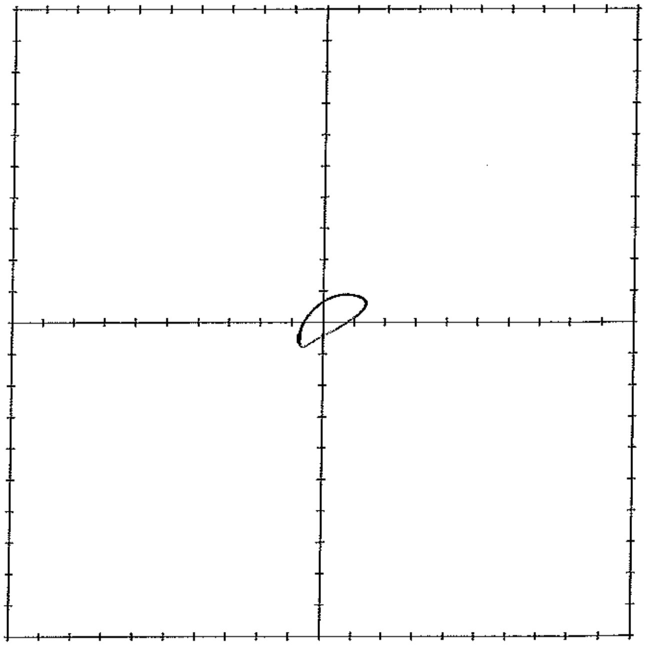
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocks

ANALYSES: Ra-226, metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-B63-009

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 11:20

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS Sunny 90° F

FIELD USCS DESCRIPTIONS (SW) Well graded sand with gravel, Red loose Dry mostly coarse sand (60%) with Fine and medium sand (25%) gravels are angular (15%) petrified wood fragments

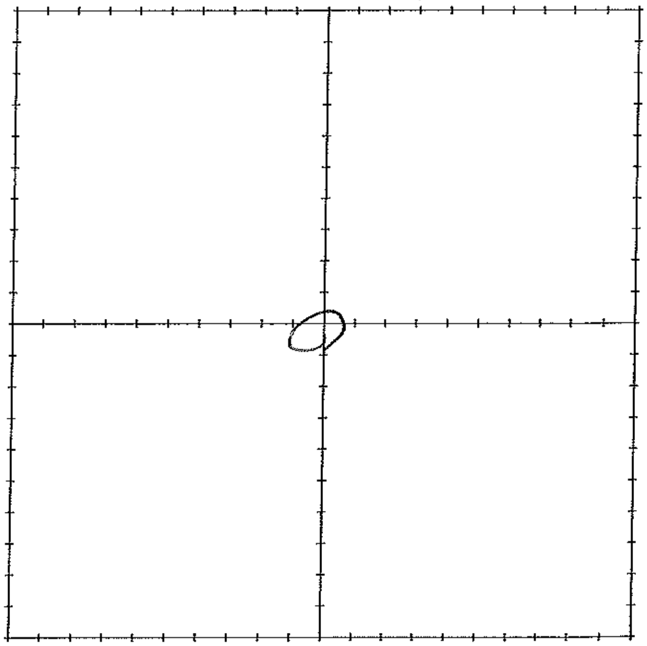
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kleth

SAMPLE I.D. S225-B63-010 MS + MSD

SAMPLE COLLECTION DATE 8/24/17

SAMPLE COLLECTION TIME 11:30

SAMPLE COLLECTED BY CL

WEATHER CONDITIONS SUNNY 90° F

FIELD USCS DESCRIPTIONS (SW) Well graded sand with gravel, Red, loose, Dry mostly fine sand (60%) grading to coarse (20%) gravels are angular (¼"-3" (20%) and predominantly petrified wood fragments

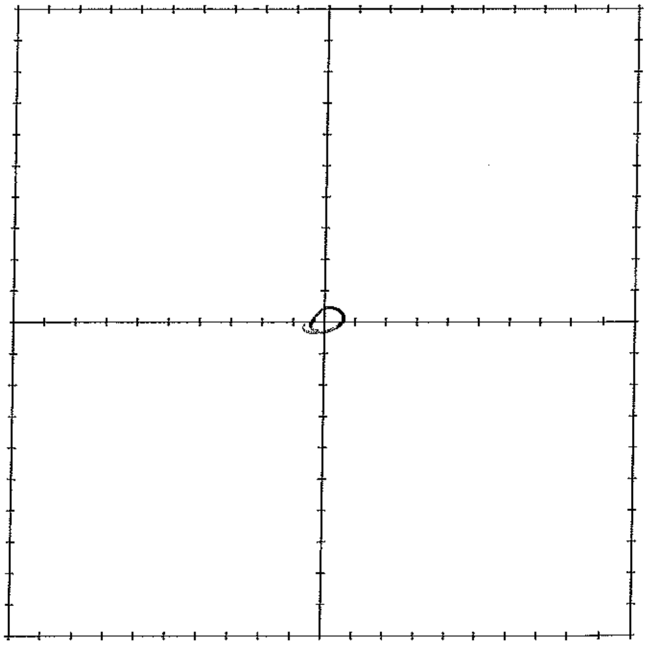
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplocks

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

_002

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S225-C01-001 (Charley Keith)

SAMPLE I.D. S225-C01-001

SAMPLE COLLECTION DATE 11/3/16

SAMPLE COLLECTION TIME 1140

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60s, clear

FIELD USCS DESCRIPTIONS Red fine sand, minor coarse sand, trace silt

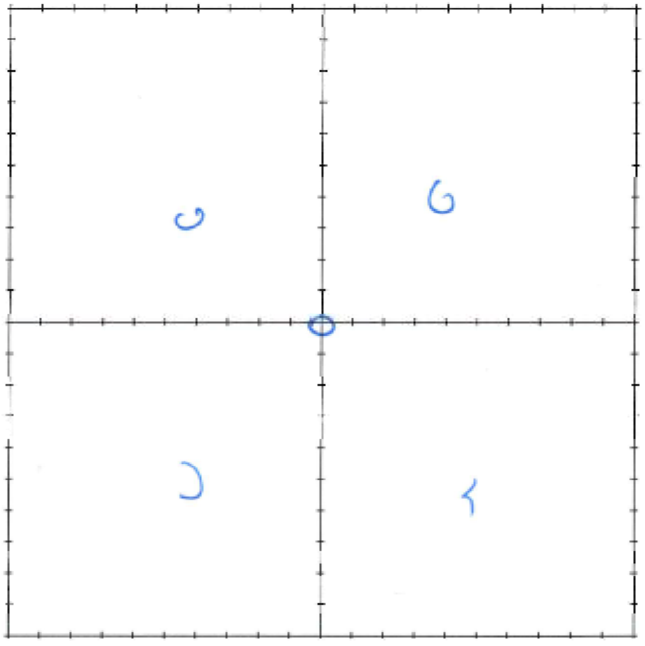
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S225-C02-001 (Charles Knight)

SAMPLE I.D. S225-C02-001

SAMPLE COLLECTION DATE ~~11/2/16~~

Actual sample date was 11/3/16

SAMPLE COLLECTION TIME 1215

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60's, clear

FIELD USCS DESCRIPTIONS Fine med sand, minor coarse sand, trace silt

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

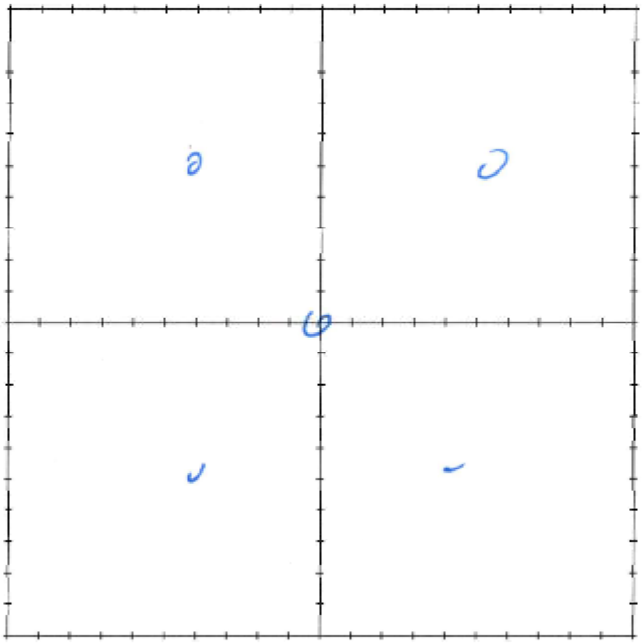
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S225-C03-001 (Charles Kuster)

SAMPLE I.D. S225-C03-001

SAMPLE COLLECTION DATE 11/3/16

SAMPLE COLLECTION TIME 1245

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60's clear

FIELD USCS DESCRIPTIONS Fine tan/red sand, trace coarse sand

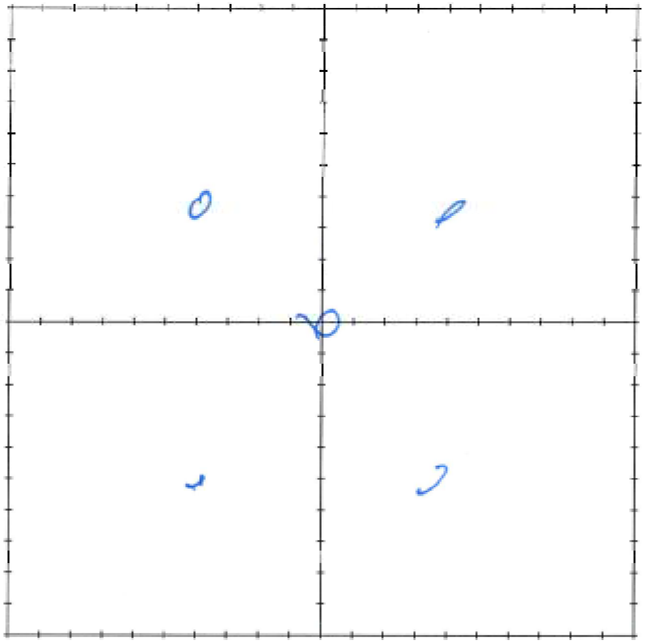
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5225-C04-001 (Charles Knight)

SAMPLE I.D. 5225-C04-001

SAMPLE COLLECTION DATE 11/3/16

SAMPLE COLLECTION TIME 1310

SAMPLE COLLECTED BY C Lee

WEATHER CONDITIONS 60's clear

FIELD USCS DESCRIPTIONS Fine med sand, minor coarse sand

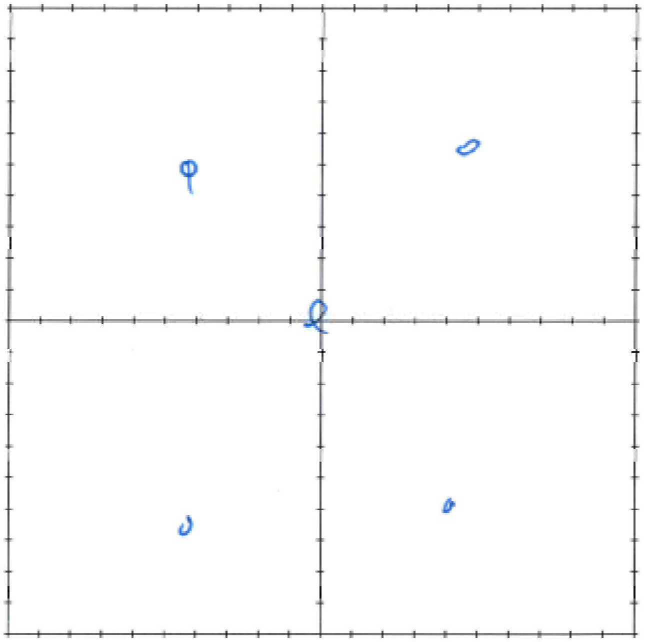
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 Ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S225-COS-001 (Charles Knight)

SAMPLE I.D. S225-COS-001

SAMPLE COLLECTION DATE 11/3/16

SAMPLE COLLECTION TIME 1400

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60's clear

FIELD USCS DESCRIPTIONS Fine med sand, minor coarse sand

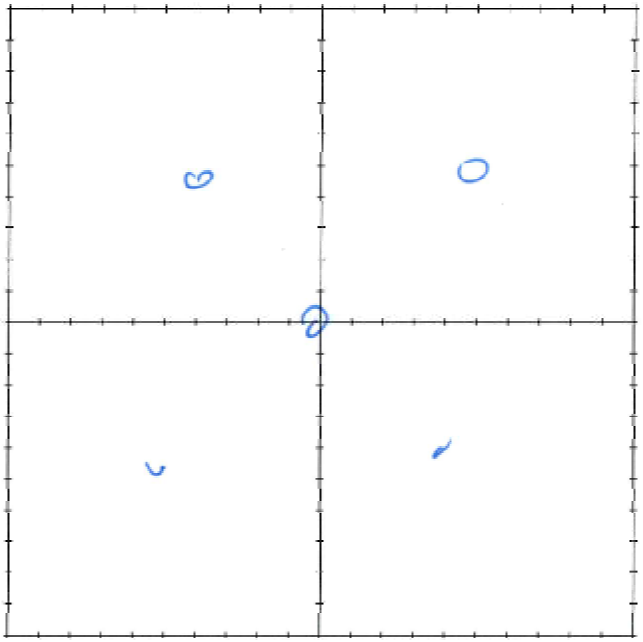
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☒ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1 ziploc

ANALYSES: Ra-226, Isotopic Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-C05-002

Loc. ID
S225-C05-001

SAMPLE COLLECTION DATE 5/24/2017

SAMPLE COLLECTION TIME 0947

SAMPLE COLLECTED BY Chris Lee

WEATHER CONDITIONS Sunny Hot

FIELD USCS DESCRIPTIONS Fine red sand, minor coarse sands

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

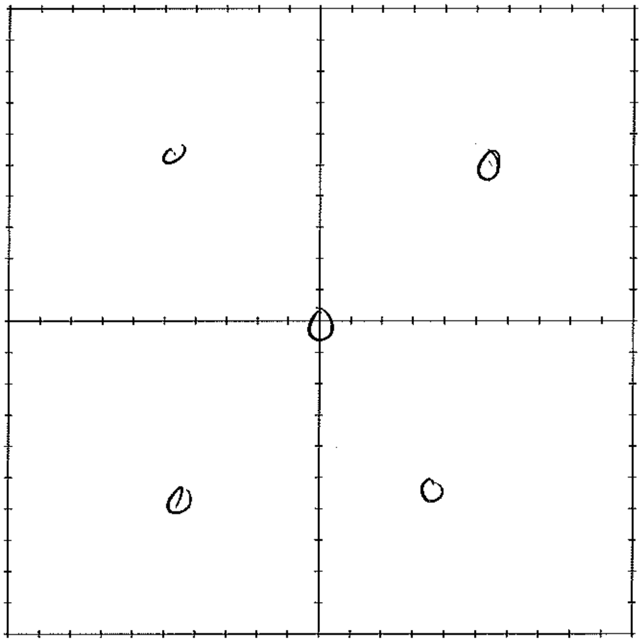
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225 - C06 - 001

SAMPLE COLLECTION DATE 5/24/2017

SAMPLE COLLECTION TIME 1119

SAMPLE COLLECTED BY Chris Lee

WEATHER CONDITIONS Sunny, Hot

FIELD USCS DESCRIPTIONS Well sorted fine-grained sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

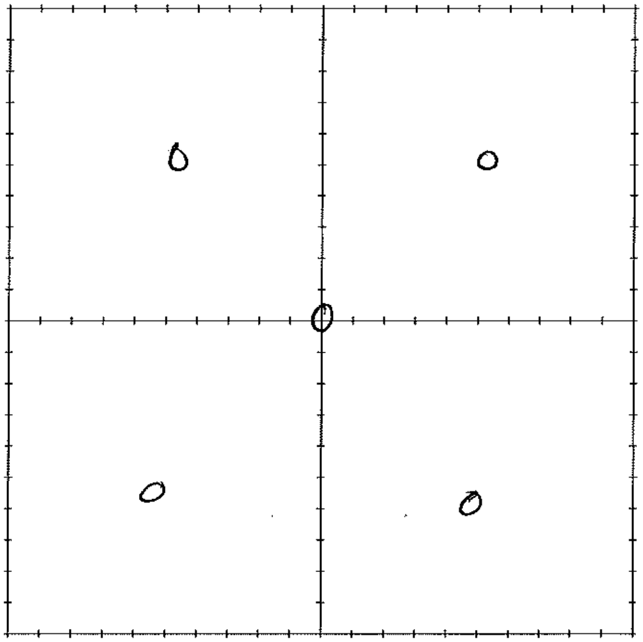
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

MUNSELL COLOR

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziplocs

ANALYSES: Ra-226, thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Chambers Kent (S225)

SAMPLE I.D. S225-CX-001

SAMPLE COLLECTION DATE 6/20/19

SAMPLE COLLECTION TIME 0824

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°, calm, sunny

FIELD USCS DESCRIPTIONS Fine brown sand, ~20% shiny grains, 1/8" in size, SP

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

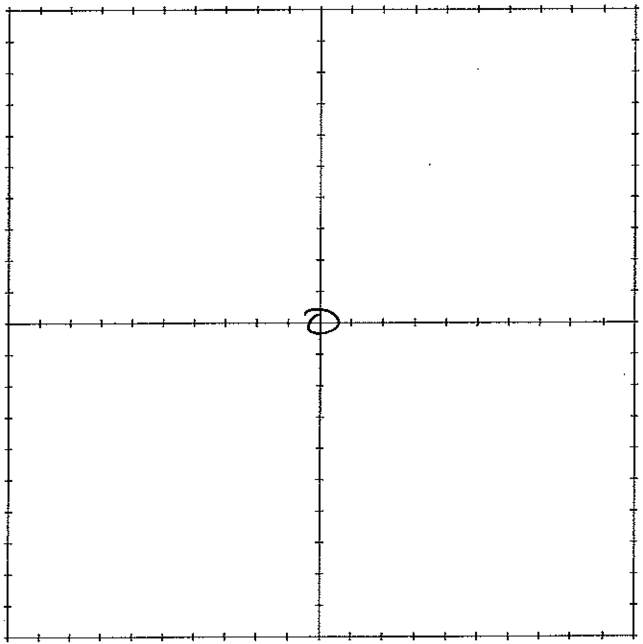
QUALIFIERS: ☒ TRACE ☑ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S225 Chews Ridge

SAMPLE I.D. S225-CR-002

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1017

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, sunny calm

FIELD USCS DESCRIPTIONS Fine med to ~~coarse~~ fine sand, trace coarse, SP

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

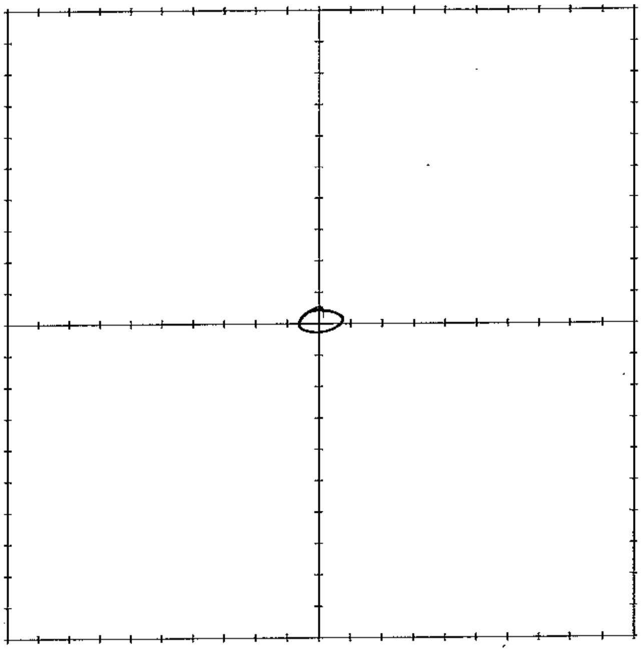
QUALIFIERS: ☒ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☑ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 zips

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith (S225)

SAMPLE I.D. S225-CX-003

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1057

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, sunny, calm

FIELD USCS DESCRIPTIONS Fine Brown/red sand, SP

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

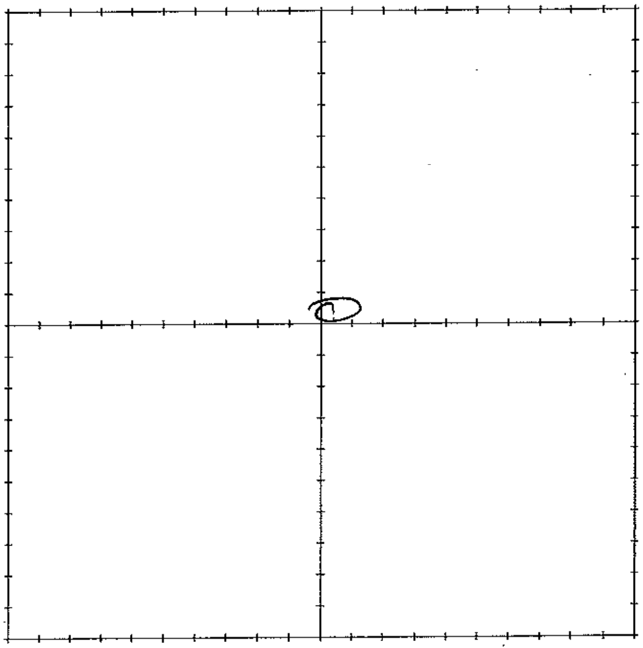
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR

SAMPLE CONTAINERS (NUMBER AND TYPE) ~~Baggie~~, 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kaiser (S225)

SAMPLE I.D. S225-CK-004

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1115

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, sunny, calm

FIELD USCS DESCRIPTIONS Fine med sand, SP

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

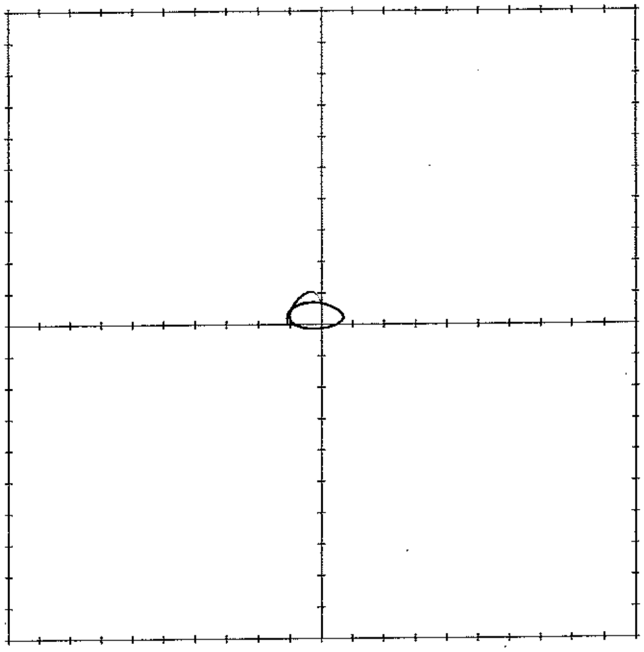
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charlie Keith (S225)

SAMPLE I.D. S225-CK-005

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1130

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, calm, clouds

FIELD USCS DESCRIPTIONS Coarse sands (~40%), 30% fine sand, 30% fine gravels

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC

☐ SM ☐ SP ☒ SW ☐ GC ☐ GM ☐ GP ☐ GW

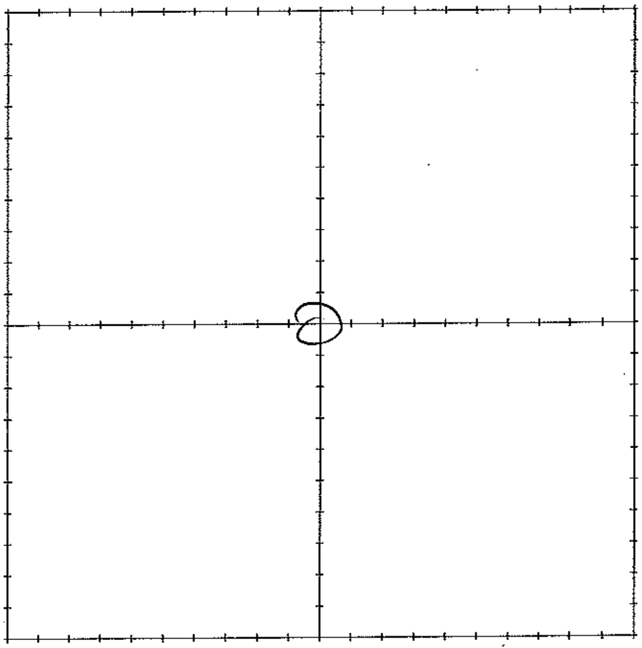
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith (8225)

SAMPLE I.D. S225 - cx-006

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1217

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, calm, cloudy

FIELD USCS DESCRIPTIONS Fine light brown sand, med-coarse black grains

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

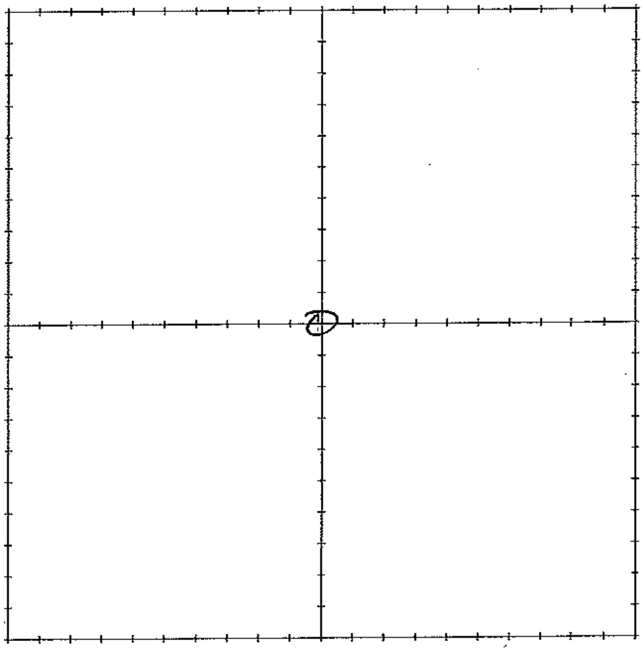
QUALIFIERS: ☐ TRACE ☒ MINOR ☐ SOME; SAND SIZE ☐ FINE ☒ MEDIUM ☒ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith (S225)

SAMPLE I.D. S225-CX-007

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1225

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, ~~Sunny~~ Clouds, calm

FIELD USCS DESCRIPTIONS Fine tan/light brown sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

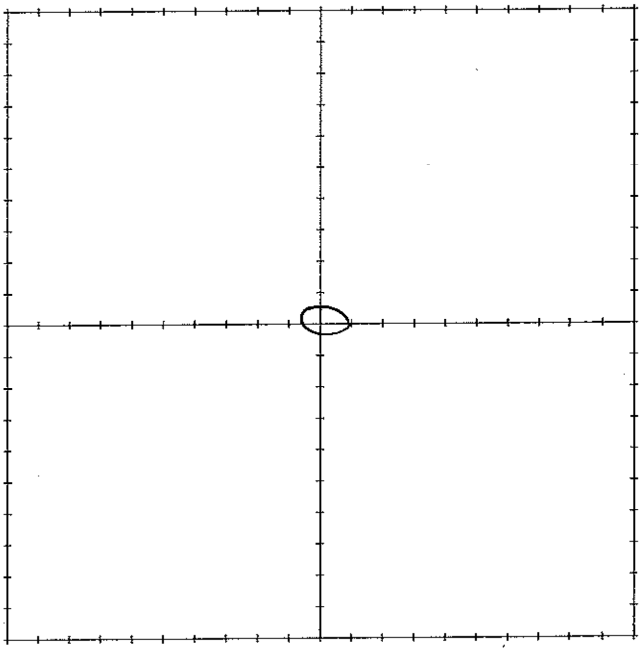
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kiefer (S225)

SAMPLE I.D. S226-CX-008

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1236

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, clouds, calm

FIELD USCS DESCRIPTIONS Fine light brn sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

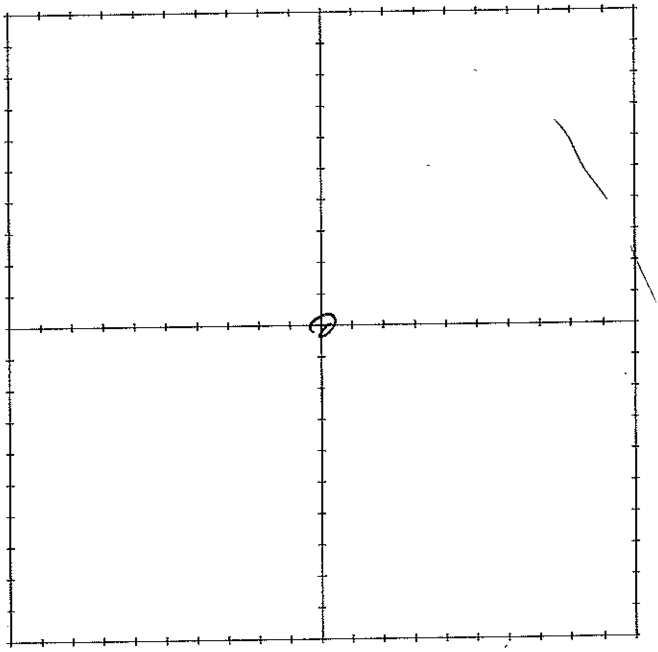
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Chuck Keiser (S225)

SAMPLE I.D. S225-CX-009

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1245

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, clouds, calm

FIELD USCS DESCRIPTIONS Fine light brown sand,

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

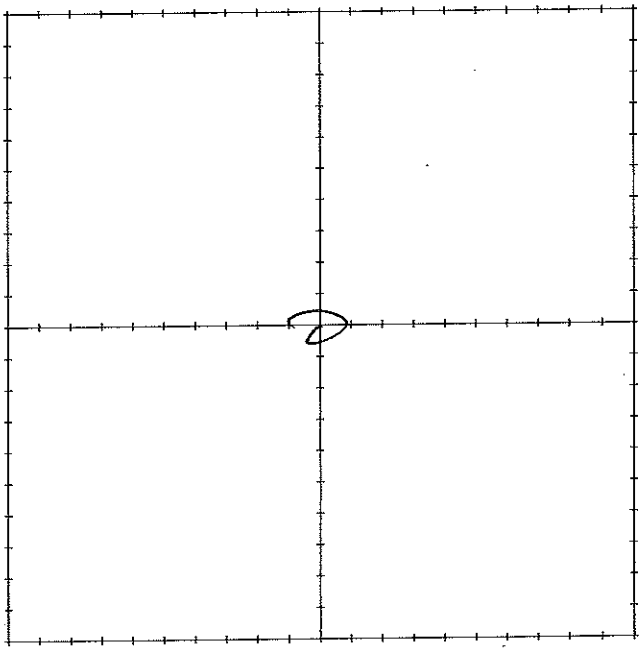
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith (S225)

SAMPLE I.D. S225-CX-010

SAMPLE COLLECTION DATE 6/20/17

SAMPLE COLLECTION TIME 1300

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 104°F, clouds, calm

FIELD USCS DESCRIPTIONS Fine red sand in drainage

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

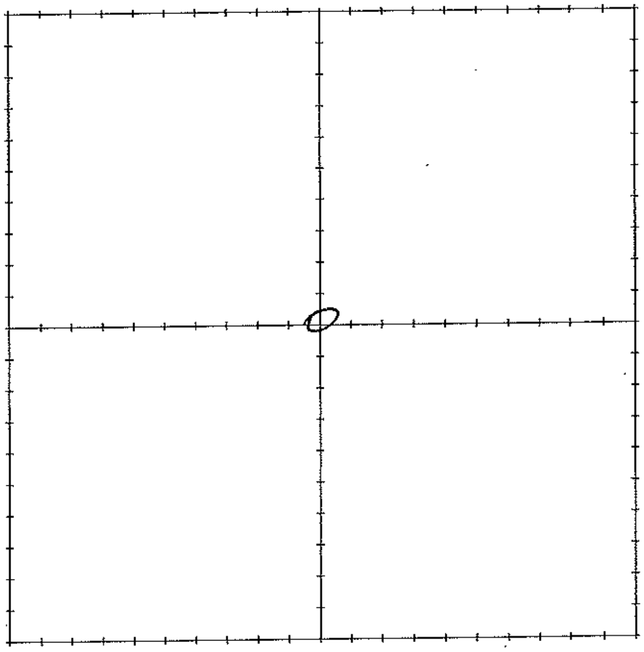
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith (S225)

SAMPLE I.D. S225-CX-011

SAMPLE COLLECTION DATE 6/22/17

SAMPLE COLLECTION TIME 0900

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 100°F, windy, clouds

FIELD USCS DESCRIPTIONS Coarse sand, tan

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

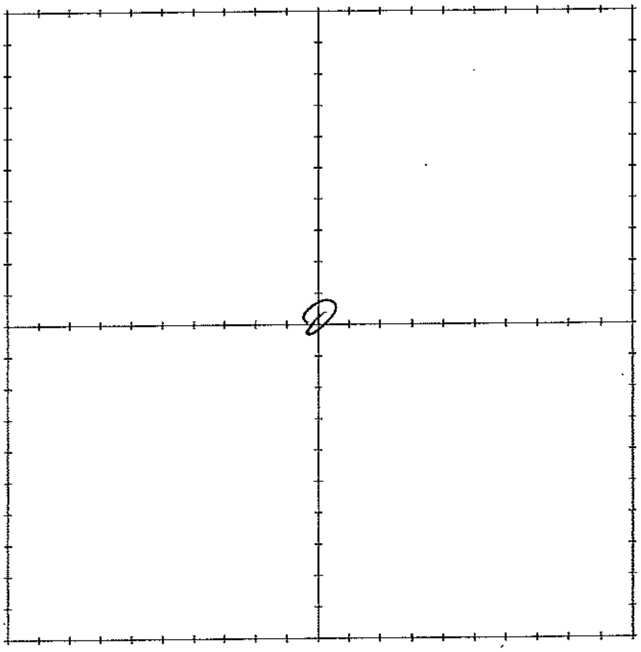
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Kate (S225)

SAMPLE I.D. S225-CX-012

SAMPLE COLLECTION DATE 6/22/17

SAMPLE COLLECTION TIME 0930

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS 100°F, cloudy, windy

FIELD USCS DESCRIPTIONS Fine tan sand, minor fine gravels

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☒ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

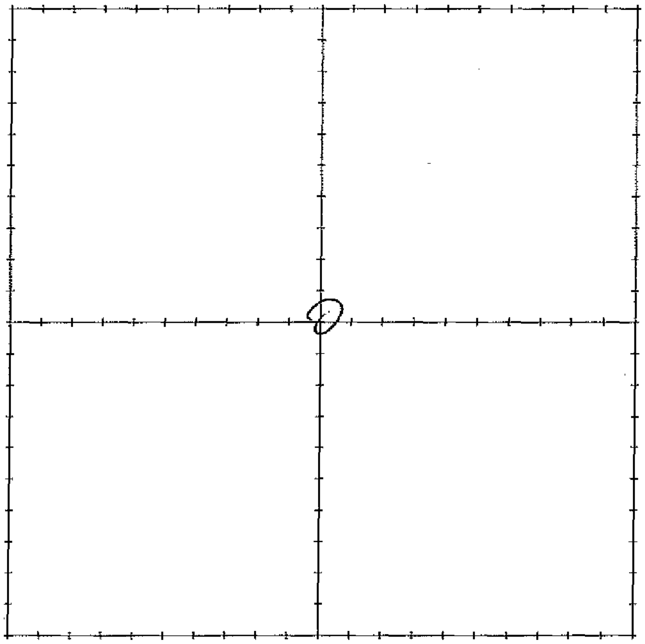
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

MUNSELL COLOR —

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME Charles Keith

SAMPLE I.D. S225-CX-013

SAMPLE COLLECTION DATE 9/20/17

SAMPLE COLLECTION TIME 1027

SAMPLE COLLECTED BY MW

WEATHER CONDITIONS Sunny and Warm

FIELD USCS DESCRIPTIONS Poorly graded gravel with Sand

MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☑ SP ☐ SW ☐ GC ☐ GM ☑ GP ☐ GW

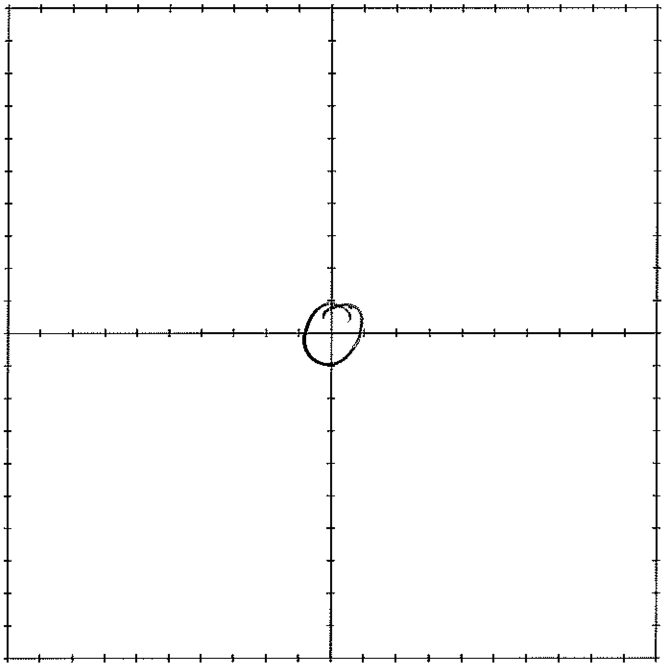
QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☑ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

MUNSELL COLOR brown, white and trace red

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 Ziplock bags / grab

ANALYSES: RA-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

C.2 Hand Auger Borehole Logs

Stantec

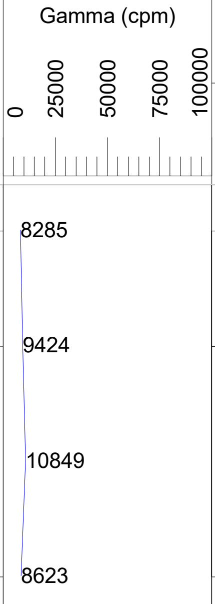
NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-001 (BG-2)**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561637.31
NORTHING: 4100067.76
DATE STARTED: 11/2/2016
DATE STARTED: 11/2/2016
TOTAL DEPTH (ft.): 1.5
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Chris Lee

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SUBSURFACE SAMPLE INFORMATION			
				SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): red, fine grained sand, trace gravel and coarse sand, gravel are 0.25 inches diameter.	8285	S225-SCX-001-1	0-0.5	grab	0.55
		SILTY SAND (SM): red, fine grained sand, minor fine silts.	9424	S225-SCX-001-2	0.5-1.5	grab	0.45
1			10849				
		Terminated hand auger borehole at 1.5 ft. below ground surface. Reason for borehole termination is unknown.	8623				
2							
3							
4							
5							



Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

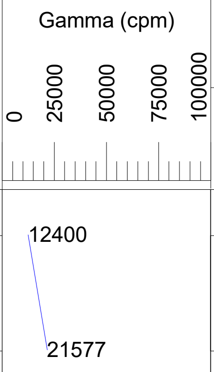
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-BG3-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561697.33
NORTHING: 4099825.11
DATE STARTED: 8/24/2017
DATE STARTED: 8/24/2017
TOTAL DEPTH (ft.): 0.5
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Tom Osborn



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	⁙	WELL GRADED SAND (SW): red, fine to coarse sand, dry, loose.	S225-BG3-011	0-0.5	grab	1.16
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on rock.				
1						
2						
3						
4						
5						

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

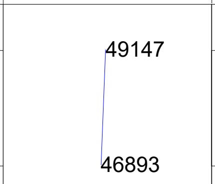
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-002**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561624.48 NORTHING: 4099802.34
DATE STARTED: 6/20/2017 DATE STARTED: 6/20/2017
TOTAL DEPTH (ft.): 0.5 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): dark brown, fine grained sand, dry, loose.		S225-SCX-002-01	0-0.5	grab	8.30
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on large gravels.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

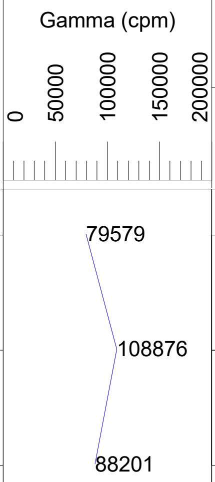
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-003**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561565.81
NORTHING: 4099815.63
DATE STARTED: 6/20/2017
DATE STARTED: 6/20/2017
TOTAL DEPTH (ft.): 1
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL DESCRIPTION	SUBSURFACE SAMPLE INFORMATION			
		SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): red, fine grained sand, dry, loose.	S225-SCX-003-01	0-0.5	grab	46.90
	WELL GRADED SAND (SW): red, fine to coarse sand.	S225-SCX-003-02	0.5-1	grab	21.30
1	Terminated hand auger borehole at 1 ft. below ground surface. Refusal on large cobbles.				
2					
3					
4					
5					

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

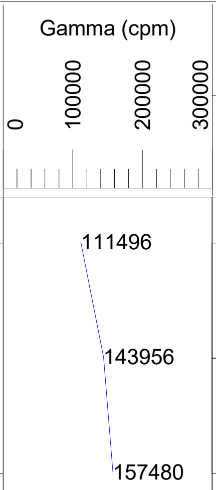
NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-004**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561516.05
NORTHING: 4099746.52
DATE STARTED: 6/20/2017
DATE STARTED: 6/20/2017
TOTAL DEPTH (ft.): 1
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): red, brown, fine grained sand, dry, loose.
1	Terminated hand auger borehole at 1 ft. below ground surface. Refusal on large rocks.
2	
3	
4	
5	



SUBSURFACE SAMPLE INFORMATION

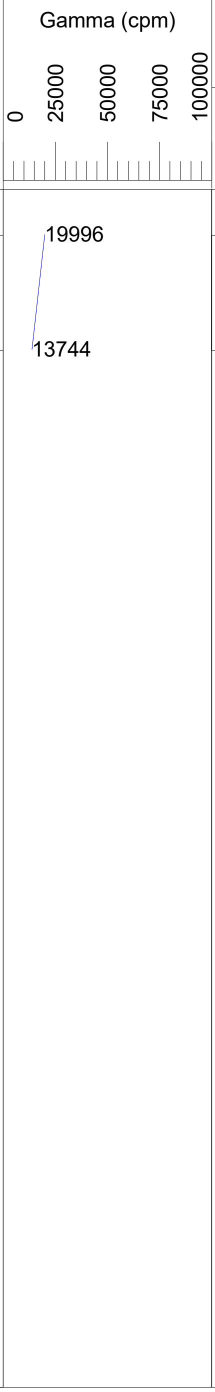
SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S225-SCX-004-01 S225-SCX-204-01	0-0.5	grab	53.60 51.50
S225-SCX-004-02	0.5-1	grab	32.40

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID: **S225-SCX-005**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561516.75
NORTHING: 4099940.48
DATE STARTED: 6/21/2017
DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 0.5
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	POORLY GRADED SAND (SP): red, brown, fine grained sand, dry.	No Sample			No sample collected. No results available.
		Terminated hand auger borehole at 0.5 ft. below ground surface. Terminated due to caving sands.				
1						
2						
3						
4						
5						

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

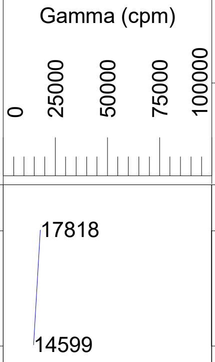
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-006**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561516.43
NORTHING: 4099939.06
DATE STARTED: 6/21/2017
DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 0.5
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SUBSURFACE SAMPLE INFORMATION: SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	POORLY GRADED SAND (SP): red, brown, fine grained sand, dry, trace gravel.	17818 14599	No Sample			No sample collected. No results available.
		Terminated hand auger borehole at 0.5 ft. below ground surface. Terminated due to caving sands.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

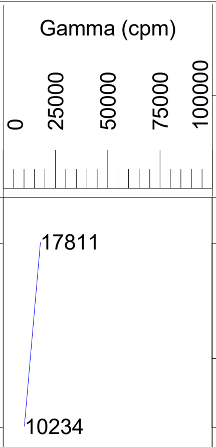
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-007**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561517.88 NORTHING: 4099937.3
DATE STARTED: 6/21/2017 DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 0.8 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	POORLY GRADED SAND (SP): red, brown, fine grained sand, dry, loose.	S225-SCX-007-01	0-0.5	grab	1.15
	▨		S225-SCX-007-02	0.5-0.8	grab	0.43
1		Terminated hand auger borehole at 0.8 ft. below ground surface. Refusal on hard rock.				
2						
3						
4						
5						

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust - First Phase

BOREHOLE ID:	**S225-SCX-008**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Charles Keith

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	561444.22	NORTHING:	4099929.25
DATE STARTED:	6/21/2017	DATE STARTED:	6/21/2017
TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE: 90 degrees	
LOGGED BY:	Luis Rodriguez		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION			
				SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	POORLY GRADED SAND (SP): red, brown, fine grained sand, dry, loose.	No gamma collected due to caving sands.	S225-SCX-008-01	0-0.5	grab 🟨	0.69
		Terminated hand auger borehole at 0.5 ft. below ground surface. Terminated due to caving sands.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

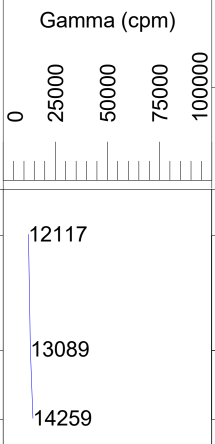
NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-009**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561450.26
NORTHING: 4099928.37
DATE STARTED: 6/21/2017
DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 0.8
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION
0	▦	WELL GRADED SAND (SW): red, brown, fine to coarse sand, trace fine gravel.
	▨	POORLY GRADED SAND (SP): red, brown, fine to medium grained sand.
		Terminated hand auger borehole at 0.8 ft. below ground surface. Refusal on rock.
1		
2		
3		
4		
5		



SUBSURFACE SAMPLE INFORMATION

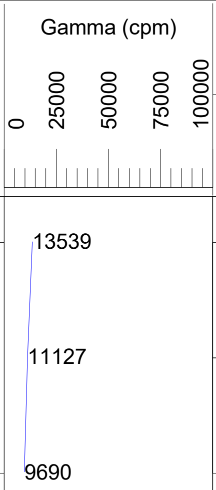
SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S225-SCX-009-01	0-0.5	grab	0.89
S225-SCX-009-02	0.5-0.8	grab	0.78

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

BOREHOLE ID:	**S225-SCX-010**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Charles Keith

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 561400.6	NORTHING: 4099835.66
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 6/21/2017	DATE STARTED: 6/21/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 1	BOREHOLE ANGLE: 90 degrees
		LOGGED BY:	Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	POORLY GRADED SAND (SP): red, brown, fine grained sand, minor medium grained sand.	S225-SCX-010-01	0-0.5	grab	1.27
		S225-SCX-010-02	0.5-1	grab	1.11
1	Terminated hand auger borehole at 1 ft. below ground surface. Refusal on rock.				
2					
3					
4					
5					



Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

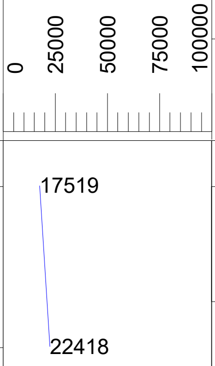
BOREHOLE ID: **S225-SCX-011**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561366.87 NORTHING: 4099819.51
DATE STARTED: 6/21/2017 DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 0.7 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION
0	⁘	POORLY GRADED SAND (SP): tan, red, fine grained sand.
0.7		Terminated hand auger borehole at 0.7 ft. below ground surface. Refusal on rock.
1		
2		
3		
4		
5		

Gamma (cpm)



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S225-SCX-011-01	0-0.5	grab	2.68

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

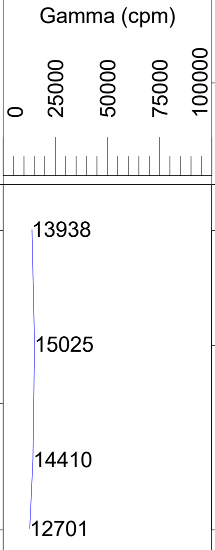
NAVAJO NATION
AUM Environmental
Response Trust-First Phase

BOREHOLE ID: **S225-SCX-012**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561326.34
NORTHING: 4099748.93
DATE STARTED: 6/21/2017
DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 1.3
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	SUBSURFACE SAMPLE INFORMATION SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): fine grained sand, minor coarse gravels, dry, loose.	S225-SCX-012-01	0-0.5	grab	1.38
		trace coarse gravel.	S225-SCX-012-02	0.5-1.3	grab	1.29
1		Terminated hand auger borehole at 1.3 ft. below ground surface. Refusal on rock.				
2						
3						
4						
5						



Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

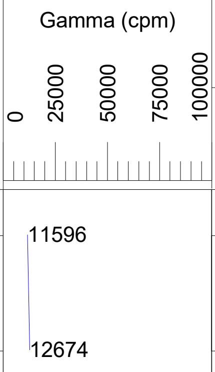
- - - - = approximate contact

BOREHOLE ID:	**S225-SCX-013**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Charles Keith

DRILLING CONTRACTOR:	Stantec
DRILLING METHOD:	Hand auger
DRILLING EQUIPMENT:	Hand auger
SAMPLING METHOD:	Regular hand auger, 3 inch diameter

COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
EASTING:	561316.35	NORTHING:	4099683.78
DATE STARTED:	6/21/2017	DATE STARTED:	6/21/2017
TOTAL DEPTH (ft.):	0.5	BOREHOLE ANGLE:	90 degrees
LOGGED BY:	Luis Rodriguez		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION
0	▨	POORLY GRADED SAND (SP): tan, fine grained sand, trace coarse gravels, dry, loose.
0.5		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on rock.
1		
2		
3		
4		
5		



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S225-SCX-013-01	0-0.5	grab	1.27

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

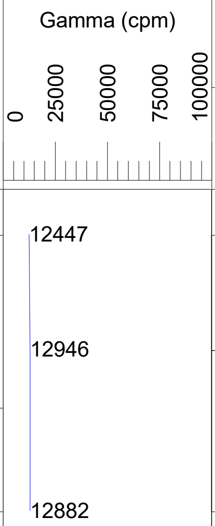
BOREHOLE ID: **S225-SCX-014**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561296.51
NORTHING: 4099736.25
DATE STARTED: 6/21/2017
DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 1.2
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL DESCRIPTION
0	POORLY GRADED SAND (SP): light brown, red, fine grained sand, minor coarse gravels, dry, loose.
0.75	minor medium to coarse gravel.
1.2	Terminated hand auger borehole at 1.2 ft. below ground surface. Refusal on rock.

Depth scale: 0, 1, 2, 3, 4, 5



SUBSURFACE SAMPLE INFORMATION

SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
S225-SCX-014-01	0-0.5	grab	1.34
S225-SCX-014-02	0.5-1.2	grab	0.82

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-015**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561207.51 NORTHING: 4099636.91
DATE STARTED: 6/21/2017 DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 0.6 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SUBSURFACE SAMPLE INFORMATION SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	∴	WELL GRADED SAND (SW): light brown, red, fine grained sand, few medium to coarse gravels, dry, loose.	9994 12660	S225-SCX-015-01	0-0.6	grab	0.93
		Terminated hand auger borehole at 0.6 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

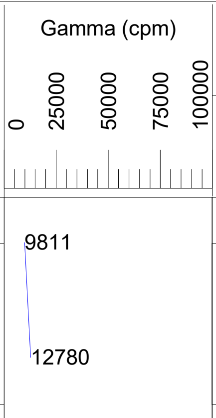
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-016**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561255.82
NORTHING: 4099534.75
DATE STARTED: 6/21/2017
DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 0.7
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	POORLY GRADED SAND (SP): light brown, red, fine grained sand, dry, loose.	9811 12780	S225-SCX-016-01	0-0.7	grab	0.88
		Terminated hand auger borehole at 0.7 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

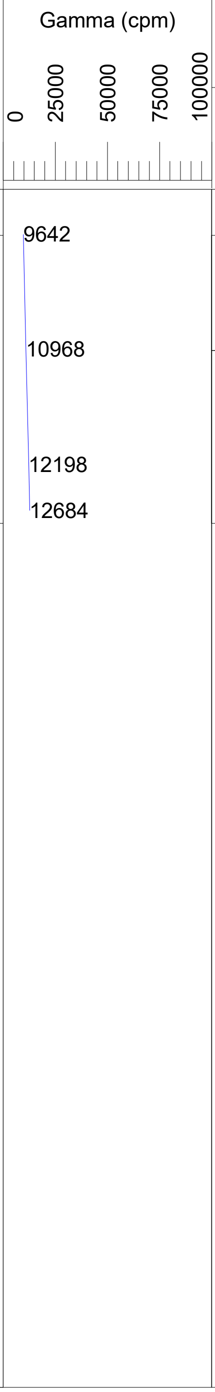
Stantec

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-017**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561297.41 NORTHING: 4099575.26
DATE STARTED: 6/21/2017 DATE STARTED: 6/21/2017
TOTAL DEPTH (ft.): 1.25 BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	⁘	POORLY GRADED SAND (SP): light brown, fine grained sand, dry, loose.	S225-SCX-017-01 S225-SCX-217-01	0-0.5	grab	0.78 0.65
1	⁘		S225-SCX-017-02	0.5-1.25	grab	0.48
		Terminated hand auger borehole at 1.25 ft. below ground surface. Refusal on rock.				
2						
3						
4						
5						

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

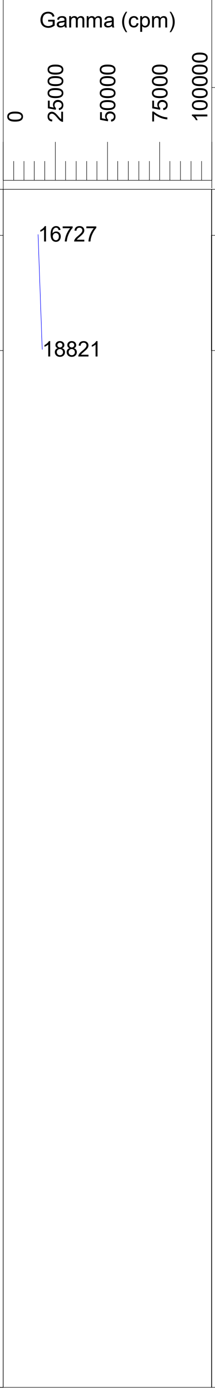
- - - - = approximate contact

NAVAJO NATION
AUM Environmental Response Trust-First Phase

BOREHOLE ID: **S225-SCX-018**
CLIENT: NNAUMERT
PROJECT: Removal Site Evaluation
SITE LOCATION: Charles Keith

DRILLING CONTRACTOR: Stantec
DRILLING METHOD: Hand auger
DRILLING EQUIPMENT: Hand auger
SAMPLING METHOD: Regular hand auger, 3 inch diameter

COORDINATE SYSTEM: NAD 1983 UTM Zone 12N
EASTING: 561497.94
NORTHING: 4099666.57
DATE STARTED: 6/22/2017
DATE STARTED: 6/22/2017
TOTAL DEPTH (ft.): 0.5
BOREHOLE ANGLE: 90 degrees
LOGGED BY: Luis Rodriguez



DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm)	SUBSURFACE SAMPLE INFORMATION			
				SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0	▨	POORLY GRADED SAND (SP): light brown, red, fine grained sand, minor medium grained gravels, moist, loose.	16727 18821	S225-SCX-018-01	0-0.5	grab 🟨	2.51
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on rock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

C.3 Water Sample Field Forms

WATER SAMPLE COLLECTION FORM

Project: Removal Site Evaluation Navajo Nation AUM Environmental Response Trust – First Phase

Date 10 / 18 / 16 **Arrival Time** 1503

Field Personnel

J. Keotea K. Johnson

SITE DESCRIPTION

Entered 12/20/2016

Surface Water ☒ **Well Water** ☐

Station Name Charles Keith Pond **Station Number** 0865-12-9 LOC ID

Site Description Pond ... Birds around..

Water Characteristics (color, odor, appearance): Clear, no odor, (some to moderate algae growing on bottom) white staining around edges

SAMPLE COLLECTION

Collection Method: 1L bottle, Horizontal-bottle, Swing-sampler, Other(Dip). Up-stream / Across-stream

Sample ID: 5225-WS-002 **Sample Time:** 1525

Field Measurements			
Parameter	**Sample 1 (normal sample)**	**Sample 2 (field dup or MS)**	**Sample 3 (MSD)**
Time	~~1535~~ 1525		
pH	9.9		
Conductivity (µS/cm) FLAG	2365	10/18/16	
Turbidity (NTU)	2.93		
Water Temperature (°C)	19.3		
Salinity ppt	1.22		
Oxidation Reduction Potential (mV)	98.1		

- NO FlOW (POND)

SURFACE WATER FLOW MEASUREMENT FORM

Project: Removal Site Evaluation Navajo Nation AUM Environmental Response Trust – First Phase

Date 10 / 18 / 16 **Time** 1503 **Station Number** 08-GS-12-9

Field Personnel: J Koster K. Johnson

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)
NA - POND		

WATER SAMPLE COLLECTION FORM

Project: Removal Site Evaluation Navajo Nation AUM Environmental Response Trust – First Phase

Date 10/18/2016 **Arrival Time** 0810

Field Personnel

J. Kester, K. Johnson

SITE DESCRIPTION

Entered 12/20/2016

Surface Water ☑ **Well Water** ☐

Station Name S225-WS 001 **Station Number** S225-WS-001

Site Description Seep near Charles Keith. Small 12" x 12" x 6" deep pool

Water Characteristics (color, odor, appearance): Clear, some bugs, No odor

SAMPLE COLLECTION

Collection Method: 1L bottle, Horizontal-bottle, Swing-sampler, Other(pump), Up-stream / Across-stream

Sample ID: S225-WS-001 **Sample Time:** 0900

Field Measurements

Parameter	Sample 1 (normal sample)	Sample 2 (field dup or MS)	Sample 3 (MSD)
Time	~~0900~~ JK 10-18-16 0930		
pH	7.62		
FLAG → Conductivity (µS/cm)	340.7		
Turbidity (NTU)	1.52	JK 10-18-16	
Water Temperature (°C)	17.6		
Salinity ppt	0.16		
Oxidation Reduction Potential (mV)	83.7		

SURFACE WATER FLOW MEASUREMENT FORM

Project: Removal Site Evaluation Navajo Nation AUM Environmental Response Trust – First Phase

Date 10 / 18 / 2016 **Time** 0930 **Station Number** Charles Keith Seep

Field Personnel: JCK, KJJ

Entered 12/20/2016

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)
(1)		

Approximat 10 liters per Hour
do not want to breech pond to get better flow
at site, for ~ 1 hour took out ~ 10 liters ~ nad Refilled

Appendix D Evaluation of RSE Data

D.1 Background Reference Area Selection

D.2 Statistical Evaluation

BACKGROUND REFERENCE AREAS SELECTION

1.0 INTRODUCTION

This appendix presents the rationale for selection of the background reference areas for the Charles Keith Site (Site). To select the background reference areas for the Site, personnel considered geology, predominant wind direction, hydrologic influence, similarities of vegetation and ground cover, distance from the Site, and visual evidence of impacts due to mining (or other anthropogenic sources) in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual – Appendix A* ([MARSSIM] USEPA, 2000).

2.0 POTENTIAL BACKGROUND REFERENCE AREAS

The potential background reference area study was initiated during the Site Clearance desktop study and field investigations. The desktop study helped identify the following mining-related features at the Site: four portals along a haul road east of the claim boundary and two waste piles (Waste Pile 1 and Waste Pile 2) located on the slope below the portals. Mining waste is located on the Moenkopi Formation and the Cutler Formation below the portals. In April 2016, two potential background reference areas (BG-1 and BG-2) were identified to represent these geologic formations: BG-1 to represent the Moenkopi Formation and BG-2 to represent the Cutler Formations. The potential background reference areas are shown along with the site geology, predominant wind direction, and mine features in Figure D.1-1. The gamma survey at BG-2 was completed in April 2016 and, due to a data collection error while surveying BG-1 in April 2016, the gamma survey at BG-1 was completed in March 2017. Soil samples were collected at BG-1 and BG-2 in October 2016.

During the Site Characterization program, it was discovered that three small waste rock piles were located on top of the mesa along with an extension of the potential haul road and an exploration borehole (refer to Waste Piles 3, 4, and 5 shown in Figure D.1-1). The geologic unit on the mesa top is the Chinle Formation. While the mesa top is outside of the Site and the 100 ft buffer, the waste piles are likely related to waste rock or ore that was hauled up the lower potential haul road from the four portals (Figure D.1-1). In June 2017, field personnel identified and gamma surveyed two additional potential background reference areas (BG-3 and BG-4) to represent the geologic conditions (Chinle Formation) on the mesa top. Following review of site mapping and gamma survey data, it was determined that BG-3 would be used to represent the geology on the mesa top, as described in Section 3.0 below. Soil samples were collected at BG-3 in August 2017.

The potential background reference areas are described below.

- BG-1 encompasses an area of 5,100 ft^2 (approximately 0.12 acres), is located 200 ft southeast of the Site, and hydrologically cross-gradient from the Site. BG-1 is downwind of the Site, but located on the opposite side of Oljeto Mesa, which shelters it from potential wind transport from the Site. Geologically, BG-1 represents the Moenkopi Formation areas on-site with a mixture of colluvium-covered slopes and bedrock outcrops at the base of the cliffs, and has similar vegetation.

- BG-2 encompasses an area of 2,615 ft^2 (approximately 0.06 acres), is located 400 ft north of the Site, and is crosswind and hydrologically up-gradient of the Site. Geologically, BG-2 represents the Cutler Formation areas on-site with valley bottom/alluvial deposits, and has similar vegetation.

- BG-3 encompasses an area of 1,974 ft^2 (approximately 0.05 acres), is located 800 ft east of the Site, and hydrologically up-gradient of the Site. BG-3 is downwind of the Site, but is located on the mesa top, which shelters it from potential wind transport from the Site. BG-3 is also crosswind of the Waste Piles 3, 4, and 5. Geologically, BG-3 represents the Chinle Formation (Shinarump Member) areas on-site with thin residual soils on bedrock outcrops, and has similar vegetation.

- BG-4 encompasses an area of 2,077 ft^2 (approximately 0.05 acres), is located 950 ft east of the Site, and hydrologically up-gradient of the Site. BG-4 is downwind of the Site, but is located on the mesa top, which shelters it from potential wind transport from the Site. BG-4 is located crosswind of Waste Piles 3, 4, and 5. Geologically, BG-4 represents the Chinle Formation (Shinarump Member) areas on-site with thin residual soils on bedrock outcrops, and has similar vegetation.

The potential background reference area evaluation included walkover gamma surveys, static surface and subsurface gamma measurements (at borehole locations in BG-2 and BG-3), surface soil samples at BG-1, BG-2, and BG-3, and subsurface soil samples at BG-2. Static subsurface gamma measurements were not collected at BG-1 due to shallow soil (<0.25 ft of soil) on bedrock throughout the potential background reference area. Subsurface soil samples were not collected at BG-1 and BG-3 because the soil was too shallow: <0.25 ft and <0.5 ft, respectively. The inability to collect subsurface static gamma measurements in BG-1 is considered a data gap for the Site and is discussed further in Section 4.9 of the RSE Report.

Field personnel collected the following samples from the background reference areas:

- BG-1 – In October 2016, 10 surface soil grab samples were collected from 10 locations. The 10 surface soil grab samples were collected from 0 ft to 0.25 ft bgs due to shallow soils. A borehole was not attempted at BG-1 because field personnel observed that BG-1 was primarily bedrock with some soil less than 0.25 ft thick on top of the bedrock. Therefore, no subsurface soil samples were collected from BG-1.

- BG-2 – In October 2016, 11 surface soil grab samples were collected from 11 locations and in November 2016, one subsurface soil grab sample was collected from borehole S225-SCX-001. The reason for terminating the borehole was inadvertently omitted from the boring log.

- BG-3 – In August 2017, 11 surface soil grab samples were collected from 11 locations. No subsurface soil samples were collected from BG-3. Borehole S225-BG3-011 was attempted at BG-3 but the hand auger met refusal on bedrock at 0.5 ft bgs. A grab sample was collected from 0 ft to 0.5 ft bgs at borehole S225-BG3-011 but this was categorized as a surface sample.

Samples were categorized as surface soil samples where sample depths were up to 0.5 ft bgs and as subsurface samples where sample depths were greater than 0.5 ft bgs. Table 4-1 in the RSE Report provides the results of the sample analyses, and Tables D.1-1 and D.1-2 provide descriptive statistics for the metals/Ra-226 concentrations and the surface gamma measurements, respectively. Field forms, including hand auger borehole logs, are provided in Appendix C of the RSE Report.

The equipment used for the surface gamma survey were also used for static one-minute gamma measurements at the ground surface and for subsurface measurements at borehole locations. Soil samples, sediment samples, and gamma measurements were collected according to the methods described in the *Removal Site Evaluation Work Plan* (MWH, 2016).

3.0 SELECTION OF BACKGROUND REFERENCE AREAS

Background reference areas were needed to represent the three geologic formations present at or near the Site where mining-related disturbance occurred: BG-1 was representative of the Moenkopi Formation, BG-2 was representative of the Cutler Formation, and BG-3 and BG-4 were representative of the Chinle Formation. Subsequent to performing the gamma survey at BG-4, it was not selected as a background reference area due to it being redundant with BG-3, and because it was closer than BG-3 to the potential haul road and, therefore, is more susceptible to potential wind transport of mining impacted materials. Gamma survey measurements and soil sample results collected from BG-1, BG-2, and BG-3 were used for the remainder of the Removal Site Evaluation of the Site.

4.0 REFERENCES

MWH, 2016. *Navajo Nation AUM Environmental Response Trust – First Phase Removal Site Evaluation Work Plan*. October.

USEPA, 2000. *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), EPA 402-R-97-016, Rev. 1.

Table D.1-1
Soil and Sediment Sampling Summary
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase
Page 1 of 2

Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area Study - Background Area 1 - Moenkopi Formation						
Total Number of Observations	10	10	10	10	10	10
Percent Non-Detects	--	--	1	--	--	--
Minimum¹	2.1	0.57	--	1.3	13	1.26
Minimum Detect²	--	--	N/A	--	--	--
Mean¹	2.93	1.45	--	1.85	14.5	1.531
Mean Detects²	--	--	N/A	--	--	--
Median¹	2.65	1.35	--	1.55	14	1.4
Maximum¹	4.6	2.5	--	3.5	16	2.15
Maximum Detect²	--	--	N/A	--	--	--
Distribution	Normal	Normal	No Calculation	Normal	Normal	Normal
Coefficient of Variation¹	0.276	0.479	--	0.397	0.0813	0.202
UCL Type	95% Student's-t UCL	95% Student's-t UCL	No Calculation	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	3.399	1.852	No Calculation	2.275	15.18	1.71
UTL Type	UTL Normal	UTL Normal	No Calculation	UTL Normal	UTL Normal	UTL Normal
UTL Result	5.283	3.471	No Calculation	3.986	17.93	2.431
Background Reference Area Study - Background Area 2 - Cutler Formation						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	0.1818	1	--	--	--
Minimum¹	0.64	--	--	0.18	3.4	0.36
Minimum Detect²	--	0.17	N/A	--	--	--
Mean¹	1.039	--	--	0.265	6.027	0.558
Mean Detects²	--	0.349	N/A	--	--	--
Median¹	0.98	--	--	0.24	6.4	0.55
Maximum¹	2.1	--	--	0.43	7.2	0.75
Maximum Detect²	--	0.62	N/A	--	--	--
Distribution	Gamma	Normal	No Calculation	Normal	Normal	Normal
Coefficient of Variation¹	0.394	--	--	0.29	0.201	0.223
UCL Type	95% Adjusted Gamma UCL	95% KM (t) UCL	No Calculation	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	1.317	0.394	No Calculation	0.307	6.691	0.626
UTL Type	UTL Gamma WH	UTL KM Normal	No Calculation	UTL Normal	UTL Normal	UTL Normal
UTL Result	2.355	0.786	No Calculation	0.482	9.445	0.909

Table D.1-1
Soil and Sediment Sampling Summary
Charles Keith
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Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Study Reference Area 3 - Chinle Formation						
Total Number of Observations	11	11	11	11	11	11
Percent Non-Detects	--	--	1	--	--	--
Minimum[1]	5.9	0.29	--	0.38	9.9	1.12
Minimum Detect[2]	--	--	N/A	--	--	--
Mean[1]	10.35	0.668	--	0.515	12.63	1.394
Mean Detects[2]	--	--	N/A	--	--	--
Median[1]	7.9	0.48	--	0.51	12	1.34
Maximum[1]	32	1.7	--	0.71	19	1.87
Maximum Detect[2]	--	--	N/A	--	--	--
Distribution	Normal	Gamma	No Calculation	Normal	Gamma	Normal
Coefficient of Variation[1]	0.73	0.719	--	0.157	0.192	0.174
UCL Type	95% Student's-t UCL	95% Adjusted Gamma UCL	No Calculation	95% Student's-t UCL	95% Adjusted Gamma UCL	95% Student's-t UCL
UCL Result	14.49	1.031	No Calculation	0.56	14.22	1.526
UTL Type	UTL Normal	UTL Gamma WH	No Calculation	UTL Normal	UTL Gamma WH	UTL Normal
UTL Result	31.64	2.418	No Calculation	0.744	19.92	2.075

Notes

[1] This statistic is reported by ProUCL when the dataset contains 100 percent detections.

[2] This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.

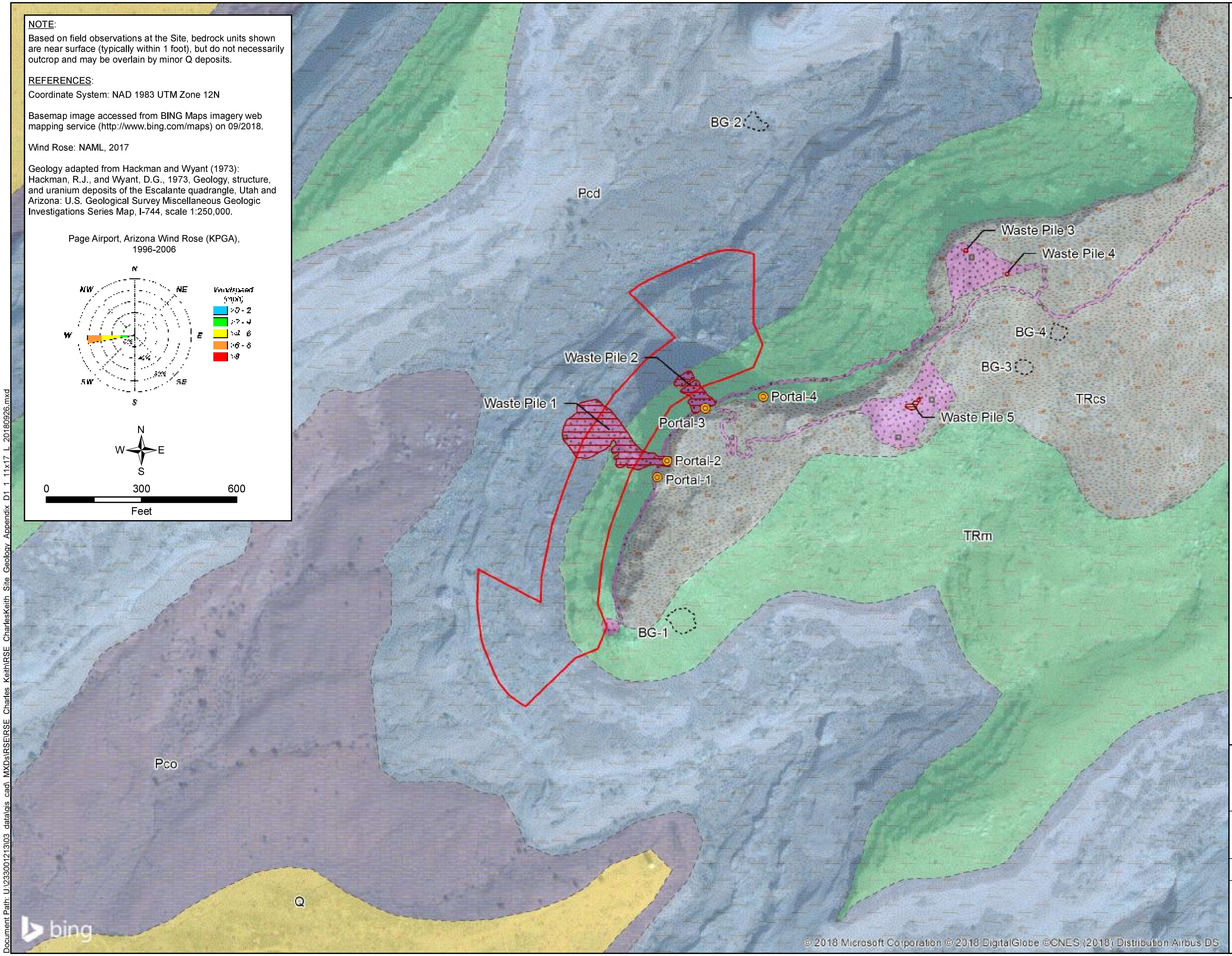
KM	Kaplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty

Table D.1-2
Surface Gamma Survey Summary
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase
Page 1 of 1

Geologic Formation Statistic	Background Reference Area 1 (BG-1) Moenkopi Formation	Background Reference Area 2 (BG-2) Cutler Formation	Background Reference Area 3 (BG-3) Chinle Formation	Background Reference Area 4 (BG-4) Chinle Formation
Total Number of Observations	991	199	241	227
Minimum	10232	6349	7773	5446
Mean	12942	8898	10630	6919
Median	12790	8726	10514	6825
Maximum	19378	12135	13471	9937
Distribution	Normal	Normal	Normal	Normal
Coefficient of Variation	0.0937	0.142	0.105	0.124
UCL Type	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
UCL Result	13006	9046	10748	7013
UTL Type	UTL Normal	UTL Normal	UTL Normal	UTL Normal
UTL Result	15036	11220	12649	8481

Notes

cpm	Counts per minute
UCL	Upper confidence limit
UTL	Upper tolerance limit



NOTE:
Based on field observations at the Site, bedrock units shown are near surface (typically within 1 foot), but do not necessarily outcrop and may be overlain by minor Q deposits.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

Basemap image accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 09/2018.

Wind Rose: NAML, 2017

Geology adapted from Hackman and Wyant (1973): Hackman, R.J., and Wyant, D.G., 1973, Geology, structure, and uranium deposits of the Escalante quadrangle, Utah and Arizona: U.S. Geological Survey Miscellaneous Geologic Investigations Series Map, I-744, scale 1:250,000.

Page Airport, Arizona Wind Rose (KPGA), 1996-2006

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

●	Portal
▤	Waste Pile
⬚	Potential Background Reference
☐	Claim Boundary
╌	Geology Contact (Inferred)

Site Geology

HOLOCENE

▨	Earthworks: Human-caused disturbance of the land surface potentially related to mining.
▨	Q: Quaternary Deposits – Undifferentiated (Pleistocene and Holocene) – includes sandy to gravelly colluvial and alluvial deposits, and eolian sand deposits.

TRIASSIC

▨	TRcs: Shinarump member of the Chinle Formation (Upper Triassic) – moderate-orange and yellowish-gray sandstone, siltstone, conglomerate and sandy shale.
▨	TRm: Moenkopi Formation (Triassic) – reddish-brown, platy to slabby, ripple-marked siltstone, thin marine limestones, and thick beds of brown, fine-grained calcareous sandstone.

PERMIAN

▨	Pcd: De Chelly Sandstone Member of the Cutler Formation (Permian) – reddish-orange to pale-reddish-brown, fine to medium-grained eolian sandstone; erodes to cliffs and domes.
▨	Pco: Organ Rock Tongue of the Cutler Formation (Permian) – reddish brown, evenly thin bedded siltstone and fine-grained sandstone.

TITLE:
Geologic Map and Potential Background Reference Areas

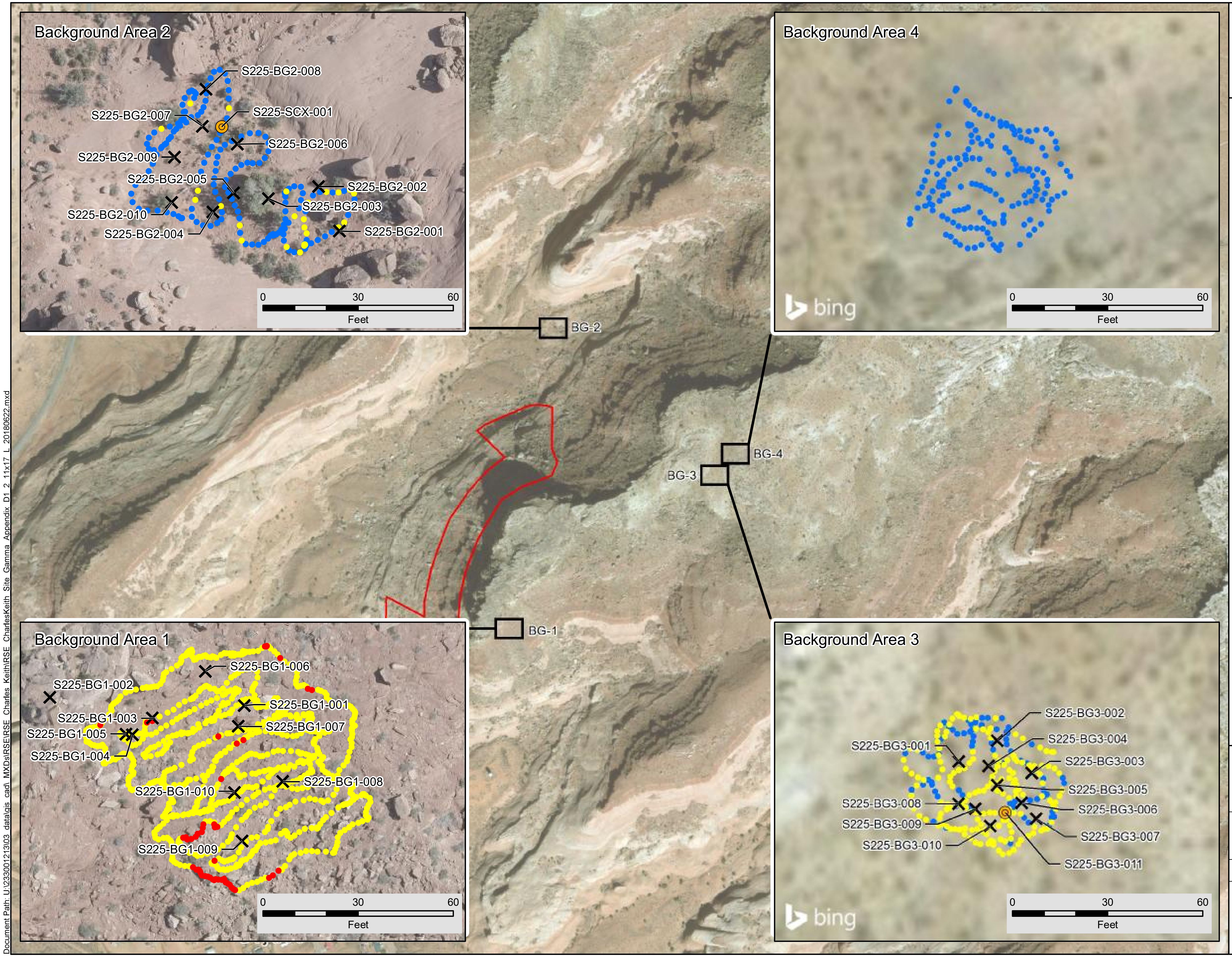
PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 9/26/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ
FIGURE: D.1-1

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Site Geology Appendix D1 1 11x17 L 20180926.mxd



NAVAJO
NATION
AUM Environmental
Response Trust-First Phase

LEGEND

✕	Surface Sample Location
◎	Subsurface Borehole Location for Background Reference
▭	Claim Boundary

Gamma Survey

Counts per Minute (CPM)

●	6,349 - 10,000
●	10,001 - 15,000
●	15,001 - 19,378

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

Main display and background area 3 and 4 basemap image insets accessed from BING Maps imagery web mapping service (http://www.bing.com/maps) on 06/2018.

Background area 1 and 2 basemap image insets flown by Cooper Aerial Surveys Co. on June 16, 2017.

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TITLE:
Potential Background Reference Area Gamma Radiation Survey Results and Soil Sample Locations

PROJECT:
Removal Site Evaluation
Charles Keith Mine Site

DATE: 6/22/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: D.1-2

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Charles Keith\RSE CharlesKeith Site Gamma Appendix D1 2 11x17 L 20180622.mxd

STATISTICAL EVALUATION

1.0 INTRODUCTION

This statistical evaluation presents the methods used in, and results of, statistical analyses performed on gamma radiation survey results and soil sample analytical results collected from the Charles Keith AUM (abandoned uranium mine) site (Site). The statistical evaluation includes comparing background reference area data and Survey Area data distributions, and documents the decision process followed to select site-specific investigation levels (ILs). The ILs are used to confirm contaminants of potential concern (COPCs) listed in the *RSE Work Plan*, and to support identification of technologically enhanced naturally occurring radioactive materials (TENORM) at the Site.

2.0 EVALUATIONS

The evaluation process included compiling the results for gamma radiation surveys and soil sample analytical results from three background reference areas and three Survey Areas. These areas are designated Background Reference Area 1 (BG-1), Background Reference Area 2 (BG-2), Background Reference Area 3 (BG-3), Survey Area A, Survey Area B and Survey Area C. The Background Reference Areas BG-1, BG-2, and BG-3 were selected to represent the Site's natural conditions as described in Appendix D.1. The gamma radiation survey data and soil sample analytical results for the background reference areas and Survey Areas were evaluated to determine the appropriate ILs for the Site as follows:

1. Identify and examine potential outlier values. Potential outlier values were identified statistically and, if justified upon further examination, removed from a dataset prior to further evaluation and calculations. No data were removed from the dataset for the calculations presented in this appendix.

2. Compare data populations between BG-1 and Survey Area A, BG-2 and Survey Area B, and BG-3 and Survey Area C (boxplots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between BG-1 and Survey Area A, BG-2 and Survey Area B, and BG-3 and Survey Area C qualitatively and quantitatively to evaluate similarity or difference in data distributions between the areas, and as a component of evaluating background reference area adequacy and representativeness.

3. Develop descriptive statistics. Descriptive statistics for gamma survey results and soil sample analytical results (e.g., number of observations, mean, maximum, median, etc.) were generated to facilitate qualitative comparisons of soil sample and gamma radiation survey results from one area to another.

4. Select ILs for the Site based on the results of the statistical evaluations.

3.0 RESULTS

The following sections present the evaluation of potential outlier values in the dataset, calculated descriptive statistics, and comparison of data populations between groups in support of determining ILs for use at the Site.

3.1 POTENTIAL OUTLIER VALUES

A potential outlier is a data point within a random sample of a population that is different enough from the majority of other values in the sample as to be considered potentially unrepresentative of the population, and therefore requires further inspection and evaluation. Unrepresentative values in a dataset have potential to yield distorted estimates of population parameters of interest (e.g., means, upper confidence limits, upper percentiles). Therefore, potential outliers in the Site data were evaluated further prior to performing data comparisons (Section 3.2) and developing the descriptive statistics (Section 3.3). In the context of this statistical evaluation, extreme values and statistical outliers are referred to as potential outliers.

A potential outlier value in a sample may be a true representative value in the test population (not a “discrepant” value), simply representing a degree of inherent variation present in the population. Furthermore, a statistical determination of one or more potential outliers does not indicate that the measurements are actually discrepant from the rest of the data set. Therefore, general statistical guidance does not recommend that extreme values (potential outliers) be removed from an analysis solely on a statistical basis. Statistical outlier tests can provide supportive information, but a reasonable scientific rationale needs to be identified for the removal of any potential outlier values (e.g., sampling error, records error, or the potential outlier is determined to violate underlying assumptions of the sampling design, such as the targeted geology).

At BG-1, BG-2, and BG-3, soil samples were collected randomly. Potential outliers in the BG-1, BG-2, and BG-3 datasets were examined using boxplots, probability plots and statistical testing. Descriptive statistics were then calculated with and without the potential outliers, as applicable. Finally, the potential outlier values were evaluated to determine if a reason could be found to remove the data points before calculating the final statistics. The results of these evaluations are described in the following sections.

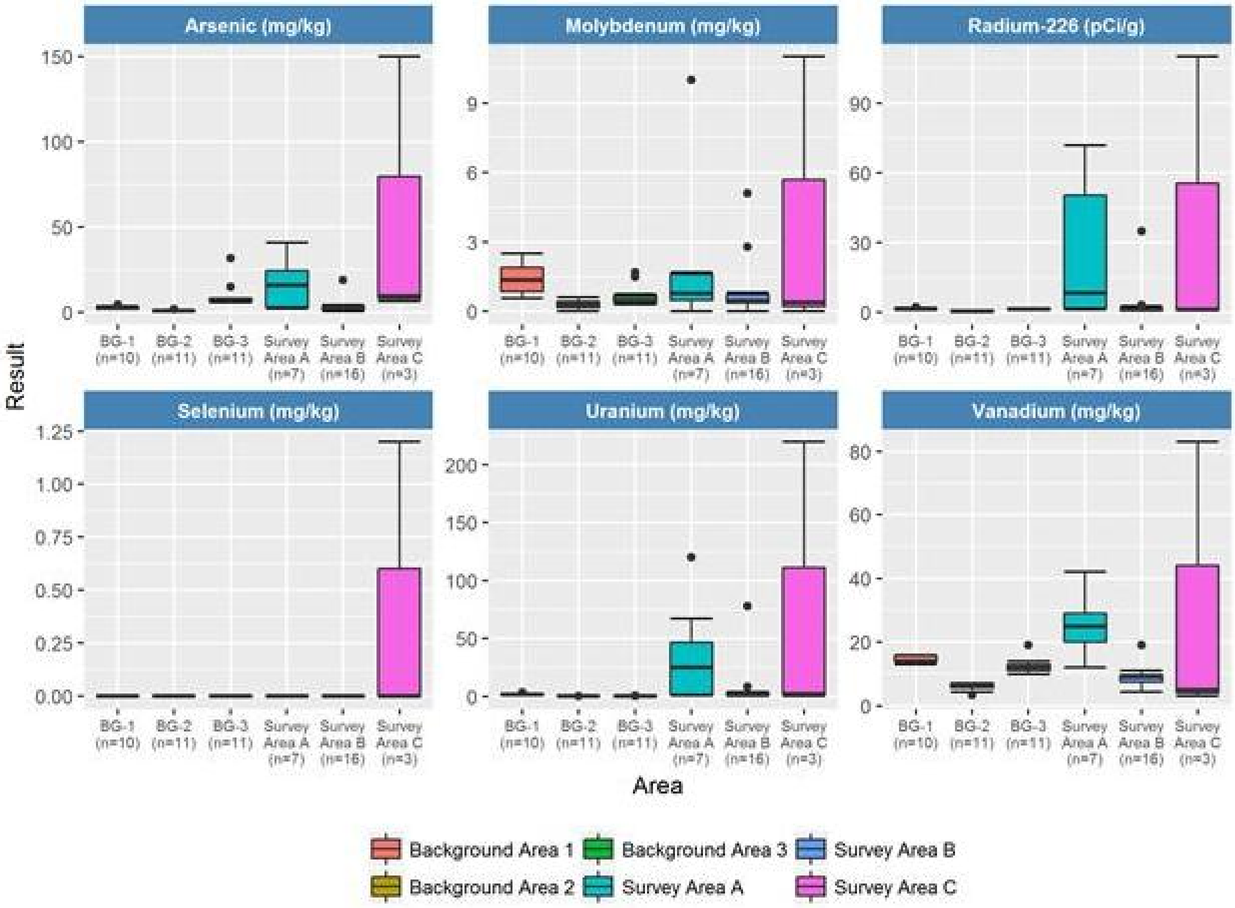
In Survey Areas A, B, and C, soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation and, as a result, potential outlier values are not unexpected. Potential outliers in this context mean values that are well-separated from the majority of the data set coming from the far/extreme tails of the data distribution (USEPA, 2016a). Descriptive statistics and comparisons of the Survey Areas to BG-1, BG-2, and BG-3 are still presented for qualitative assessment. However, potential outlier values in the Survey Areas are not evaluated further nor removed from the dataset.

3.1.1 Boxplots

Box plots depict descriptive statistics from a group of data (Figure 1A). The interquartile range is represented by the bounds of the box, the minimum and maximum values, not including potential outlier values (extreme values), are depicted by the whiskers (vertical lines), and any potential outliers are identified as singular dots. Potential outliers in this context are defined as values outside 1.5 times the interquartile range above or below the box.

3.1.1.1 Soil Sample Results Boxplots

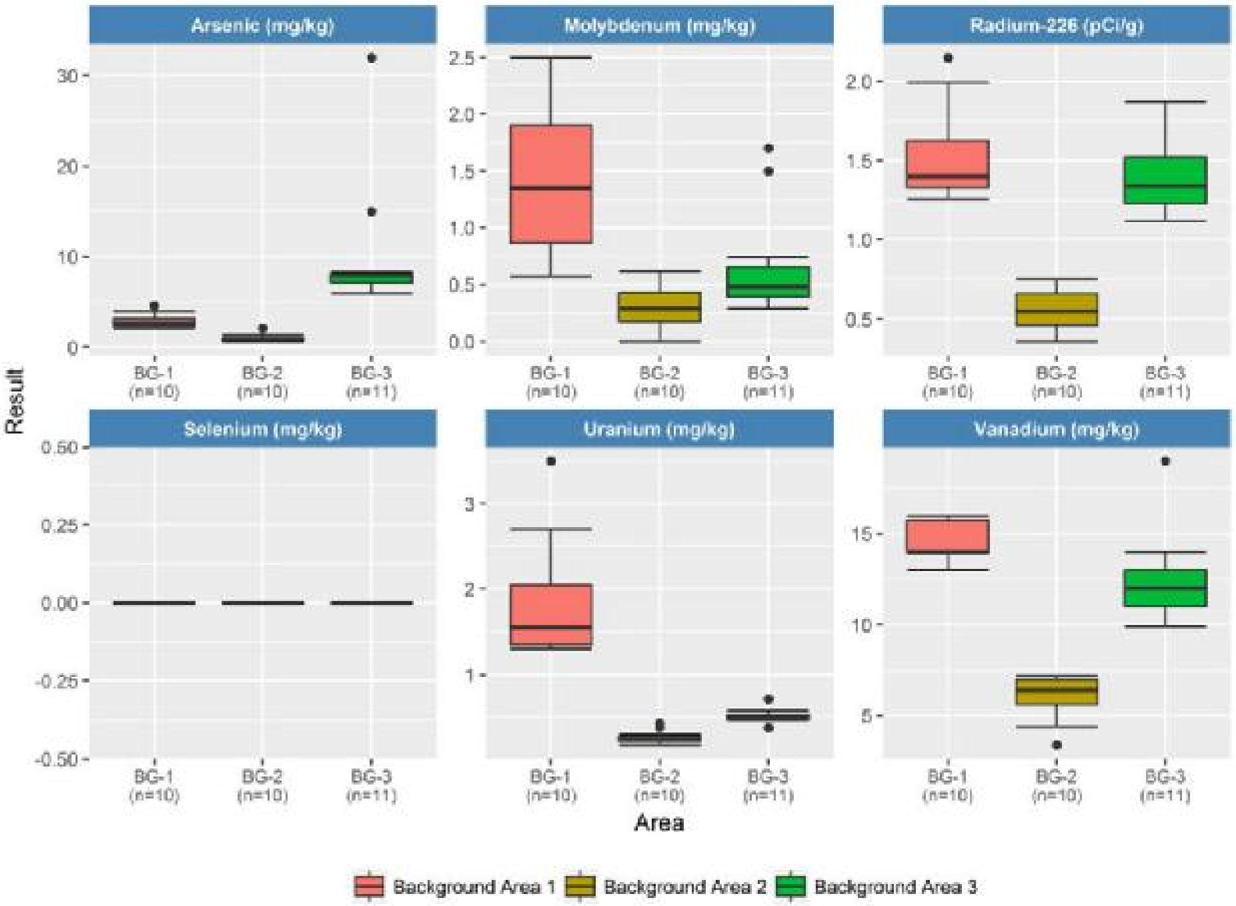
Figure 1A. Survey Areas A, B and C, and Background Reference Areas 1 (BG-1), 2 (BG-2) and 3 (BG-3) Soil Sample Boxplots



The soil sample boxplots shown on Figure 1A depict differences in the data distributions for analytical constituent concentrations between background reference areas and Survey Areas. Some potential outlier values are shown for both background reference areas and the Survey Areas at the Site.

Potential outlier values are of greatest concern in the background reference area datasets as the data from the background reference areas are used to determine the ILs. Background reference area data are presented alone in Figure 1B.

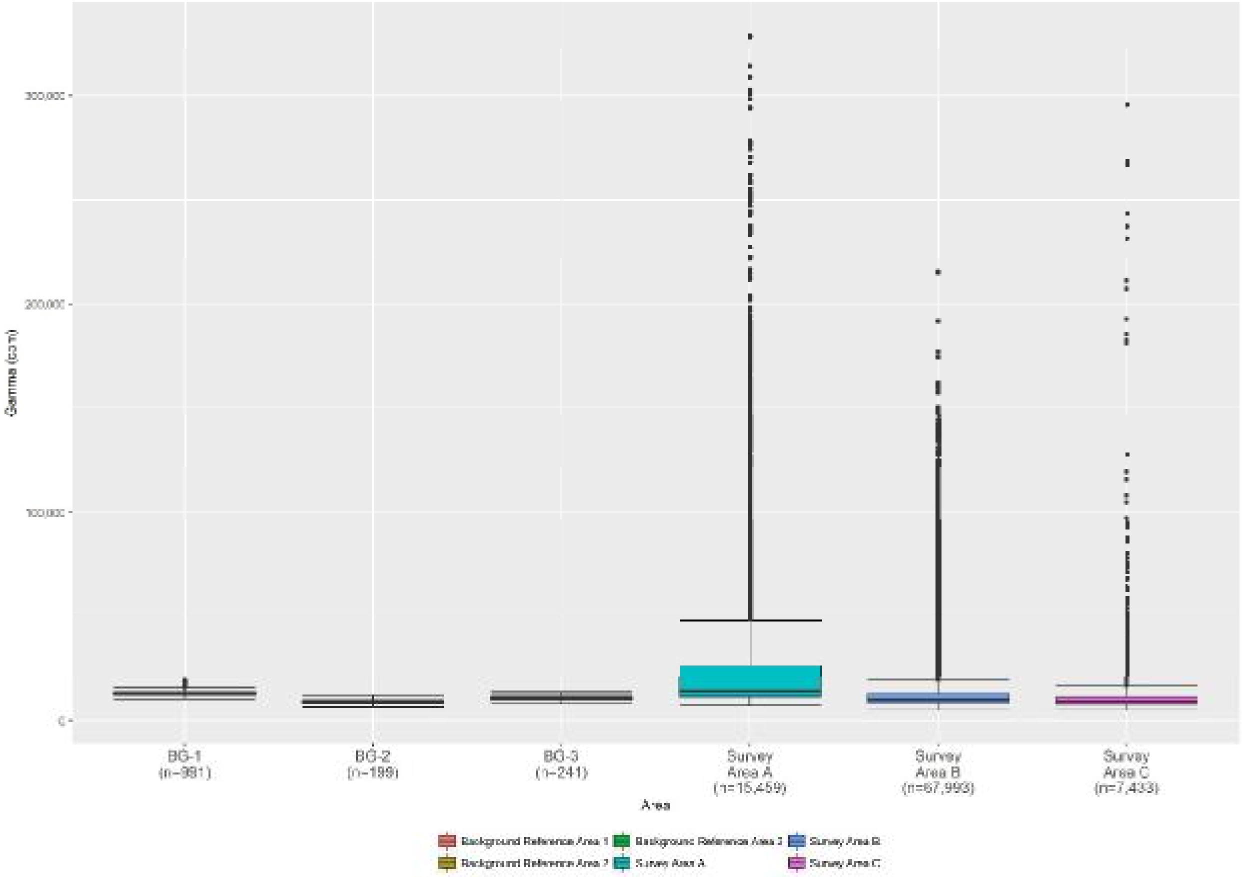
Figure 1B. Background Reference Areas 1 (BG-1), 2 (BG-2) and 3 (BG-3) Soil Sample Boxplots



In Figure 1B several values were identified as potential outliers (i.e., outside 1.5 times the interquartile range) in the boxplots for five analytical constituents: arsenic (one high value each at BG-1 and BG-2, and two high values at BG-3), molybdenum (two high values at BG-3), radium-226 (one high value at BG-1), uranium (one high value each at BG-1 and BG-3, two high values at BG-2, and one low value at BG-3), and vanadium (one high potential outlier value at BG-3, as well as one low potential outlier value at BG-2).

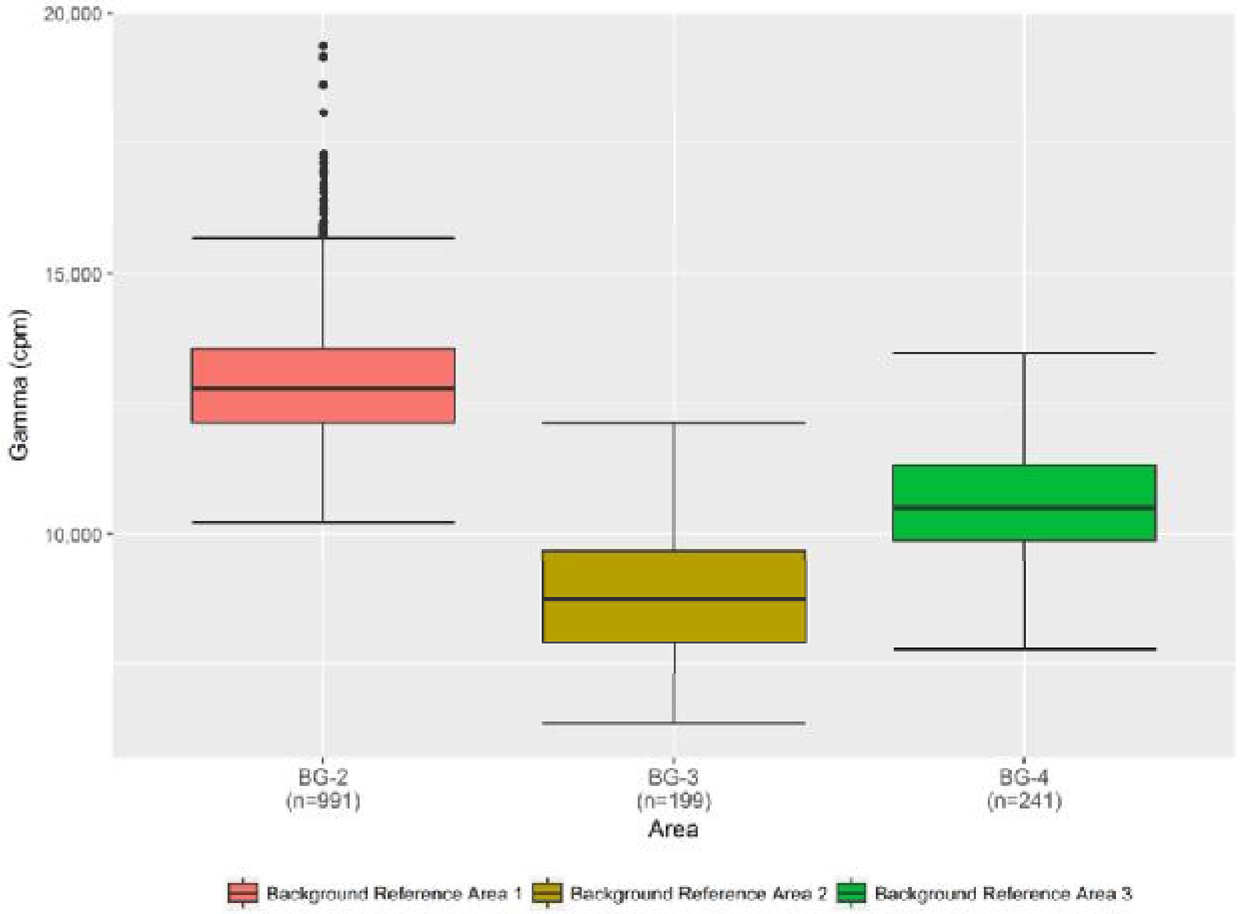
3.1.1.2 Gamma Radiation Results Boxplots

Figure 2A. Survey Area and Background Reference Area Gamma Radiation Boxplots



The gamma radiation survey results boxplots shown on Figure 2A depict differences in the data distribution for gamma measurements between background reference areas and Survey Areas. The large number of potential outlier values in the boxplots for the Survey Areas indicate high skewness or possibly non-normally distributed data, instead of outlier values. This has been further evaluated with the use of probability plots in Section 3.1.2 and statistical testing of potential outlier values in Section 3.1.4. Based on a review of the Site geology, the gamma radiation potential outlier values observed for the Survey Area data on Figure 2A represent localized areas of higher gamma radiation with respect to other parts of the Survey Areas, as would be expected in areas with varying levels of mineralization, naturally occurring radioactive material (NORM), and potential TENORM. Background reference area data are presented alone in Figure 2B.

Figure 2B. Background Reference Area Gamma Radiation Boxplots



There are potential outlier values shown for gamma data in the BG-1 dataset; however, they are not very high, represent a very small proportion of the total BG-1 gamma data values, and there is no other compelling rationale to reject these data based on the boxplot evaluation alone.

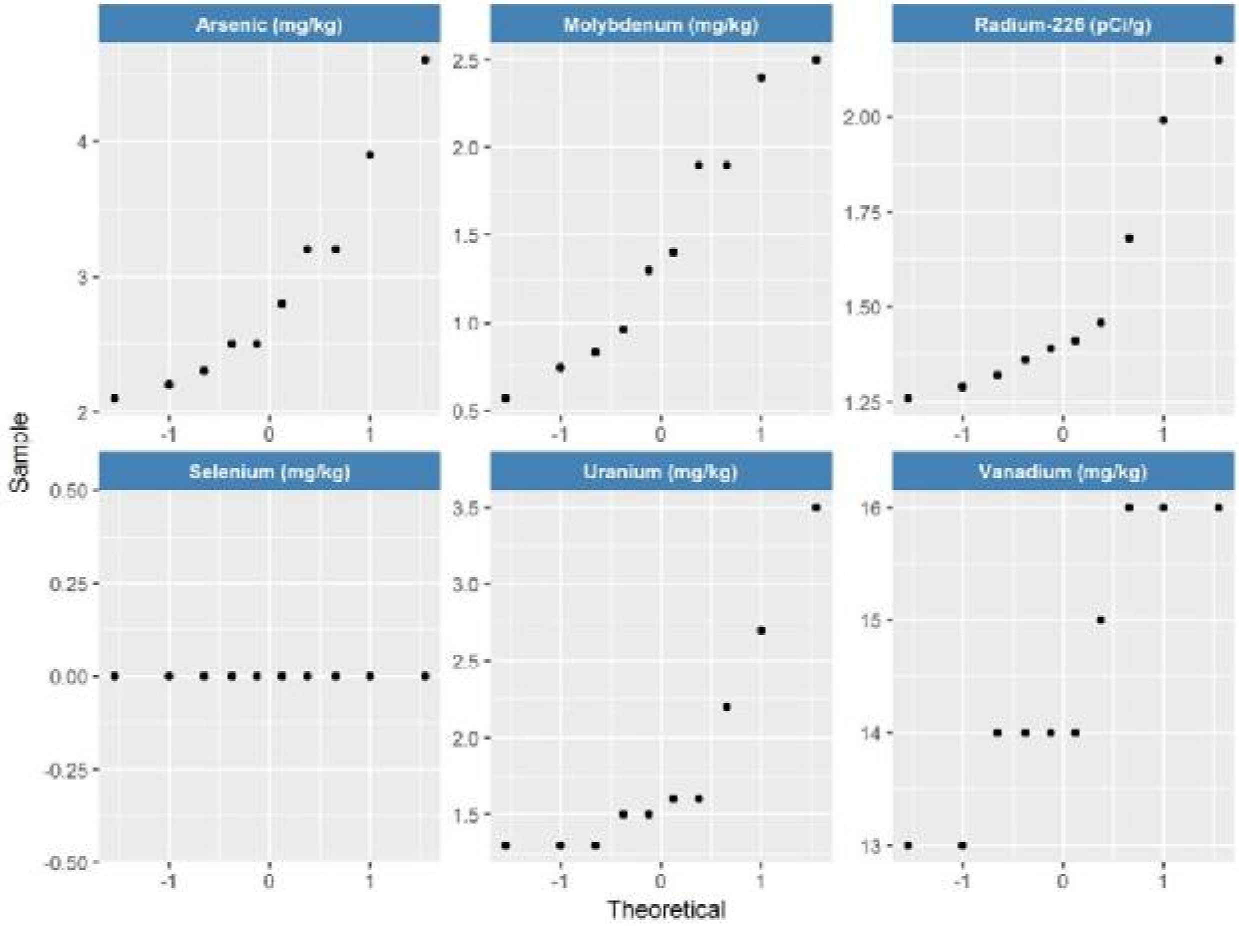
3.1.2 Probability Plots

The normal probability plot is a graphical technique for assessing whether a dataset is approximately normally distributed, and where there may be potential outlier values. The data are plotted against a theoretical normal distribution in such a way that the points, if normally distributed, should form an approximate straight line. Curved lines may indicate non-normally or log-normally distributed data, and "S"-shaped lines may indicate two distinct groups within the dataset.

3.1.2.1 Soil Sample Results Probability Plots

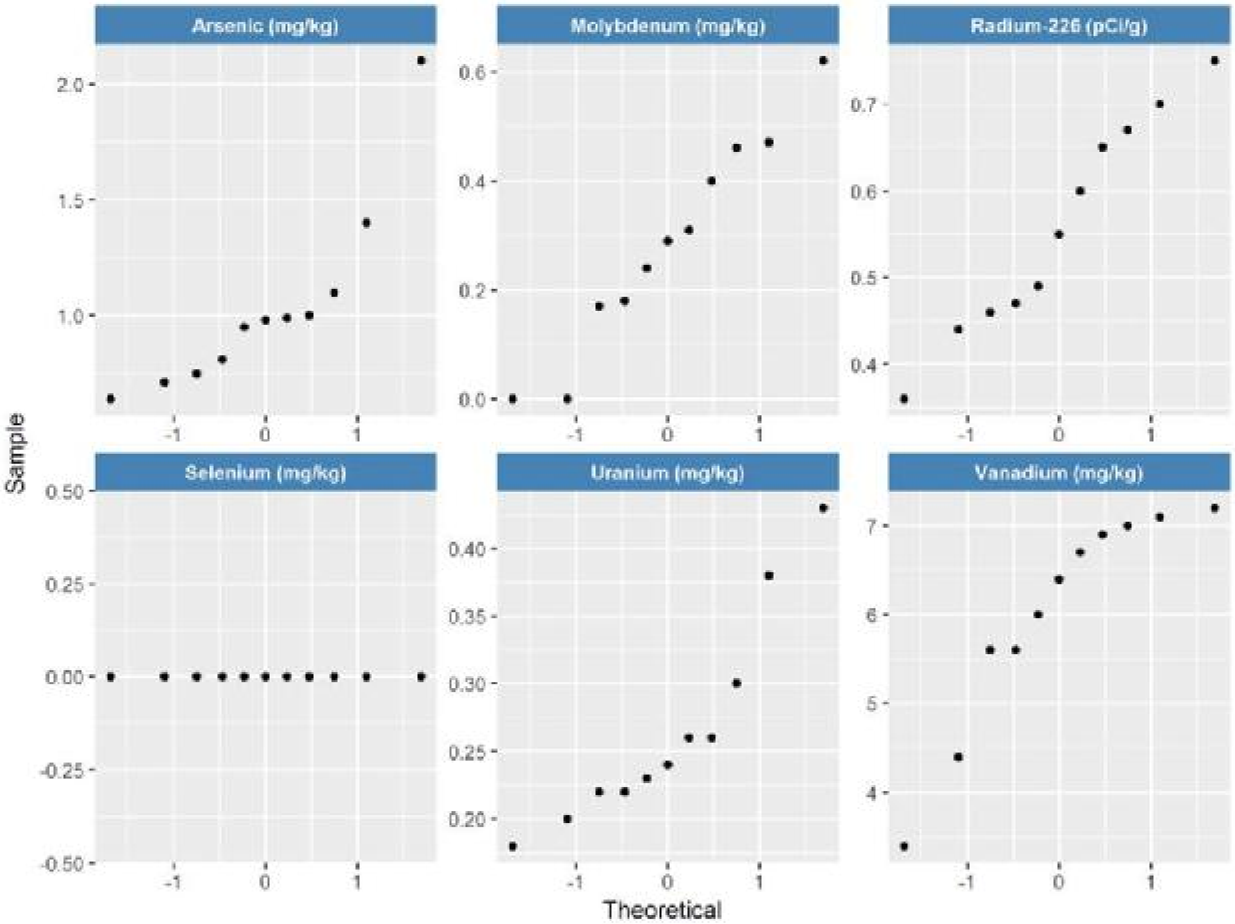
Figures 3 through 5 depict the probability plots for metals and Ra-226 results at BG-1, BG-2, and BG-3.

Figure 3. Background Reference Area 1 (BG-1) Soil Sample Probability Plots



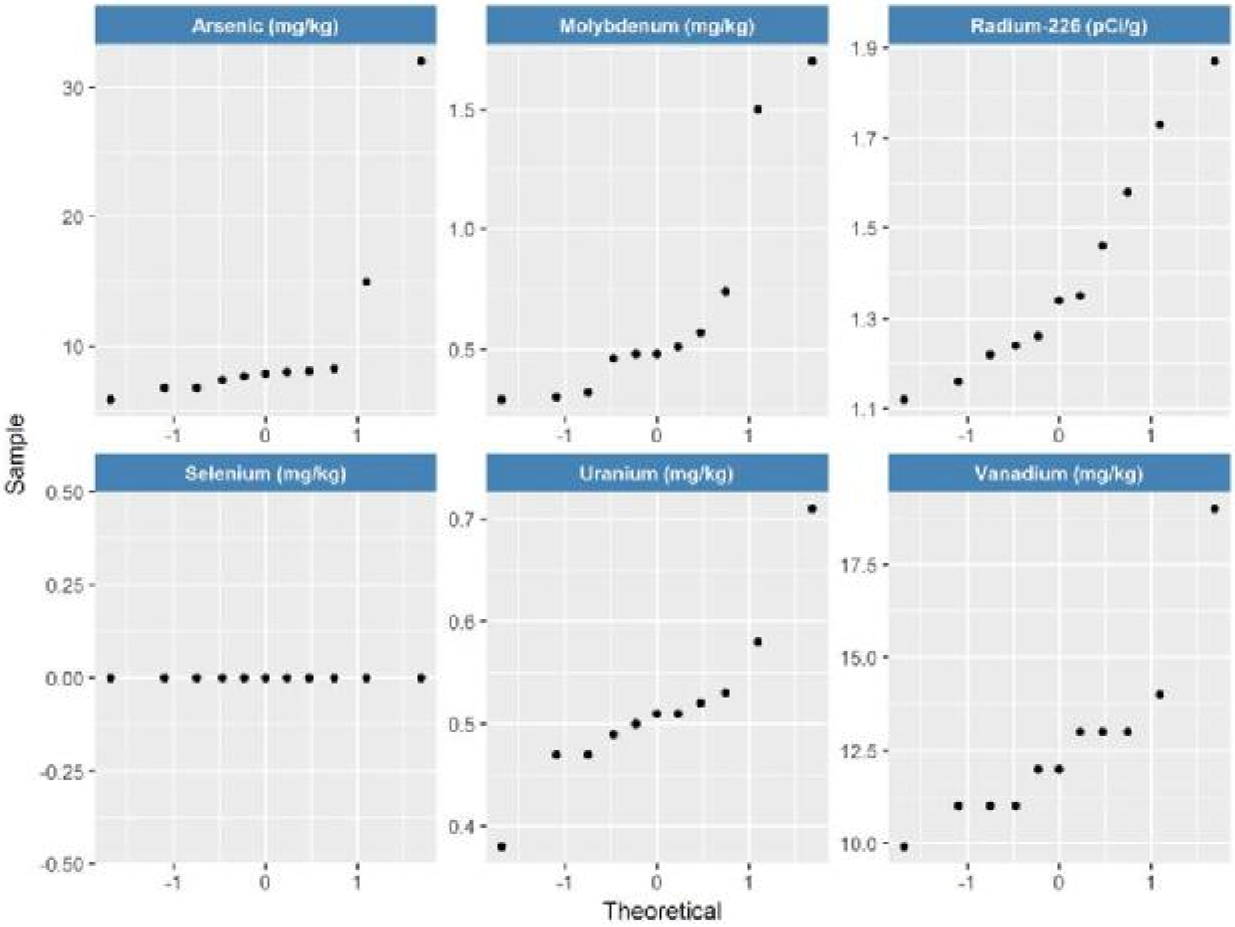
One value each for arsenic, Ra-226, and uranium were identified as potential outliers in the boxplots in Figure 1B. When viewed in the probability plots in Figure 3, these values do appear to be higher than the rest of their respective datasets, but they also fit the general distribution of the dataset. These three values were tested for statistical significance as potential outliers in Section 3.1.3. All 10 soil samples at BG-1 were non-detect for selenium (Se).

Figure 4. Background Reference Area 2 (BG-2) Soil Sample Probability Plots



One high value in the arsenic dataset, one low value in the vanadium dataset, and two high values in the uranium dataset were identified as potential outliers in the boxplots in Figure 1B. When viewed in the probability plots in Figure 4, the highest arsenic value does appear to be substantially higher than the rest of the arsenic dataset, while the highest uranium values conform to the general shape of the dataset. The lowest vanadium value does appear to be substantially lower than the rest of the vanadium values, but conforms to the general shape of the dataset. These four values were tested for statistical significance as potential outliers in Section 3.1.3. All 11 soil samples at BG-2 were non-detect for selenium (Se).

Figure 5. Background Reference Area 3 (BG-3) Soil Sample Probability Plots

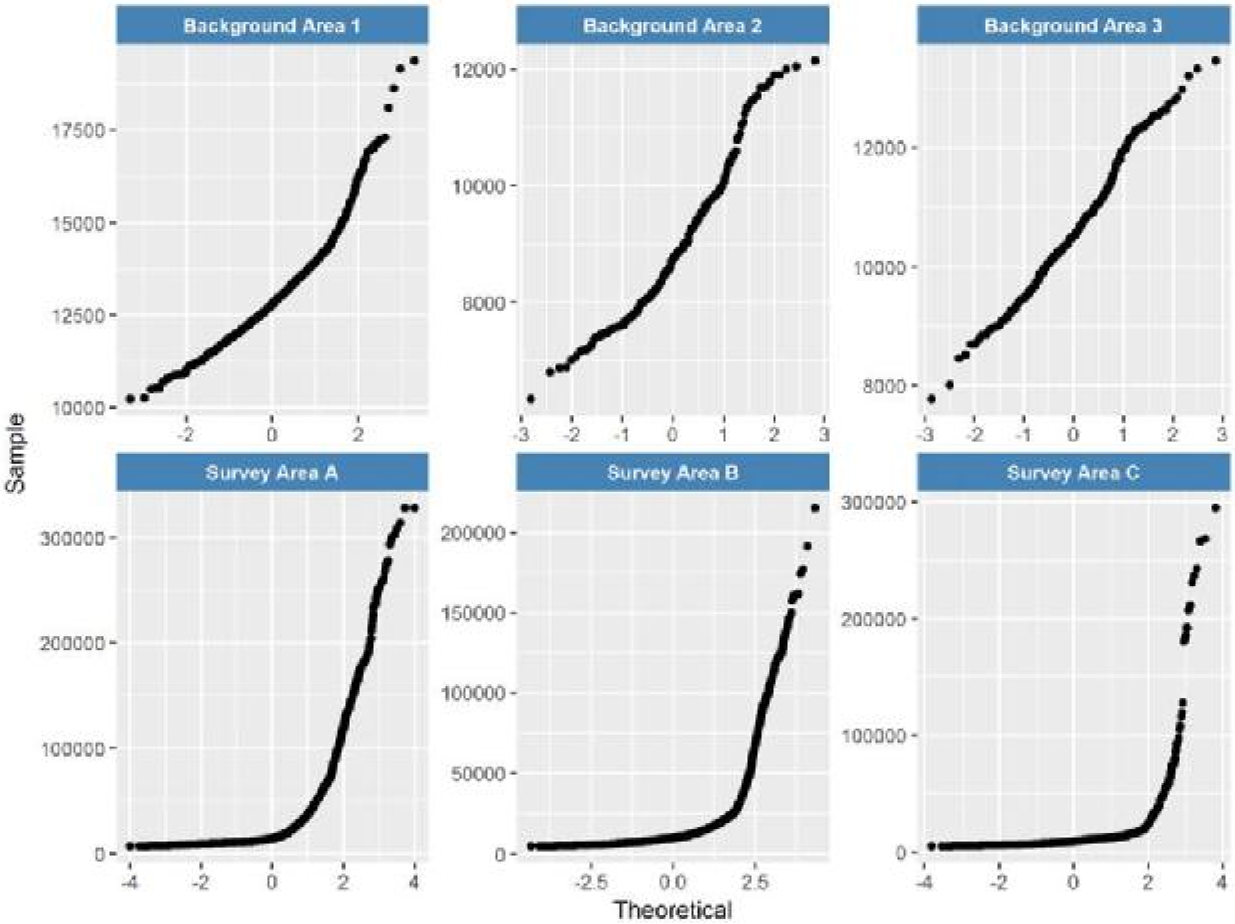


Two values each for arsenic and molybdenum, and one value each for uranium and vanadium, were identified as potential outliers in the boxplots in Figure 1B; one additional low value for uranium was identified as a potential outlier. When viewed in the probability plots in Figure 5, these values do appear to be substantially different than the rest of their respective datasets. These seven values were tested for statistical significance as potential outliers in Section 3.1.3. All 11 soil samples at BG-3 were non-detect for selenium (Se).

3.1.2.2 Gamma Survey Results Probability Plots

Figure 6 depicts the probability plots for gamma radiation results at the background reference areas and Survey Areas.

Figure 6. Survey Area and Background Reference Area Gamma Probability Plots



Gamma survey results indicate generally normal distributions in the background reference area datasets, and likely non-normal distributions in the Survey Area data sets (Figure 6). When viewed in the probability plot, the values identified as potential outliers in the BG-1 gamma dataset in the boxplot in Figure 2B conform to the general distribution of the rest of the dataset, suggesting they are representative of BG-1.

The shape and smoothness of the probability plots for the Survey Area gamma results confirms that the gamma radiation data are more log-normally distributed than the background reference area gamma results. This suggests that these higher values are not outliers but rather are representative of the spatial variability of gamma radiation in the Survey Areas.

3.1.3 Potential Soil Sample Data Outliers

Twelve high results and two low results are identified as potential outlier values in the background reference area datasets in the boxplots in Figure 1B and probability plots in Figures 3 through 5.

These values are:

Background Reference Area 1 (BG-1)

- Arsenic: 4.60 mg/kg
- Ra-226: 2.15 pCi/g
- Uranium: 3.50 mg/kg

Background Reference Area 2 (BG-2)

- Arsenic: 2.10 mg/kg
- Uranium: 0.430 mg/kg, 0.380 mg/kg
- Vanadium: 3.40 mg/kg

Background Reference Area 3 (BG-3)

- Arsenic: 32.0 mg/kg, 15.0 mg/kg
- Molybdenum: 1.70 mg/kg, 1.59 mg/kg
- Uranium: 0.710 mg/kg, 0.380 mg/kg
- Vanadium: 19.0 mg/kg

Dixon's Test (Dixon, 1953) is designed to be used for datasets containing only one or two potential outlier values. Therefore, Dixon's Test was performed to the 95% confidence level on each of the potential soil sample outlier values. The results of Dixon's Test are summarized in Table 1.

Table 1. Summary of Dixon's Test on Maximum Values

Area	Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
Background Reference Area 1 (BG-1)	As	S225-BG1-005	Dixon test for potential outliers	high value 4.60 is a potential outlier	> 0.05	Hypothesis rejected
	Ra-226	S225-BG1-005	Dixon test for potential outliers	high value 2.15 is a potential outlier	> 0.05	Hypothesis rejected
	U	S225-BG1-005	Dixon test for potential outliers	high value 3.50 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 2 (BG-2)	As	S225-BG2-001	Dixon test for potential outliers	high value 2.10 is a potential outlier	< 0.05	Hypothesis accepted
	U	S225-BG2-003	Dixon test for potential outliers	high value 0.380 is a potential outlier	> 0.05	Hypothesis rejected
	U	S225-BG2-001	Dixon test for potential outliers	high value 0.430 is a potential outlier	> 0.05	Hypothesis rejected
	V	S225-BG2-008	Dixon test for potential outliers	low value 3.40 is a potential outlier	> 0.05	Hypothesis rejected
Background Reference Area 3 (BG-3)	As	S225-BG3-008	Dixon test for potential outliers	high value 15.0 is a potential outlier	< 0.05	Hypothesis accepted
	As	S225-BG3-004	Dixon test for potential outliers	high value 32.0 is a potential outlier	< 0.05	Hypothesis accepted
	Mo	S225-BG3-008	Dixon test for potential outliers	high value 1.50 is a potential outlier	< 0.05	Hypothesis accepted
	Mo	S225-BG3-004	Dixon test for potential outliers	high value 1.70 is a potential outlier	< 0.05	Hypothesis accepted
	U	S225-BG3-007	Dixon test for potential outliers	low value 0.380 is a potential outlier	< 0.05	Hypothesis accepted
	U	S225-BG3-004	Dixon test for potential outliers	high value 0.710 is a potential outlier	< 0.05	Hypothesis accepted
	V	S225-BG3-004	Dixon test for potential outliers	high value 19.0 is a potential outlier	< 0.05	Hypothesis accepted

As = Arsenic Ra-226 = Radium 226 Mo = Molybdenum V = Vanadium U = Uranium

The test confirms that 8 of the 14 potential outlier values tested are statistically significant (p value <0.05). The statistically significant potential outlier values for arsenic in BG-2 and arsenic, molybdenum, uranium, and vanadium in BG-3 were further investigated by reviewing sample forms, field notes and laboratory reports. Field staff and field notes indicate nothing abnormal about the locations where these samples were collected, and the laboratory dataset shows no data quality flags were applied to these values that would call their accuracy into question. Therefore, while these values are: 1) outside the interquartile range of their respective datasets (Figure 1B), 2) they might not conform with their respective dataset distributions in the probability plots (Figure 4 and Figure 5), and 3) are deemed potential statistical outliers by Dixon's Test, they were not removed from the BG-2 or BG-3 datasets because no scientific reason was found to justify removing them from their respective datasets. The values are considered representative of the natural variation at these background reference areas. However, descriptive statistics were calculated with and without these values for comparison (Section 3.3.1).

3.1.4 Potential Gamma Data Outliers

The BG-1 gamma dataset shown in the Figure 2B boxplot, shows some potential high gamma survey outlier values. When viewed in the probability plot in Figure 6, the highest values do not appear to conform to the general distribution of the BG-1 gamma dataset. Because the number of values in the BG-1 gamma dataset is >30, Dixon's Test was not appropriate for testing these potential outlier values. Instead, because the values appear to be generally normally distributed, it was appropriate to identify potential outliers using Z, t and chi squared scoring methods at the 95% confidence level. These tests were performed in the 'Outliers' package in R (Lukasz Komsta, 2011), and the results are summarized in Table 2. The R programming language complements ProUCL in its ability to provide more meaningful and useful graphics and summarizes the results equivalent to ProUCL. Because ProUCL and R packages follow similar statistical procedures, the results are comparable. The interquartile range evaluation (values outside 1.5 times the interquartile range) results are also provided in Table 2.

The values shown in Table 2 are deemed potential outliers and represent 31 out of 991 data points (3 percent). One possible reason for the potential outliers in the gamma radiation dataset may be the presence of a localized source of radiation within the BG-1 area. This was evaluated by viewing the relative position of the potential outlier values relative to each other. Most of the potential outlier values occur within an approximately 500 square foot area in the southern portion of BG-1; however, potential outlier values occur throughout the BG-1 area. The cluster of the values supports a localized source of radiation at BG-1, while the scattered potential outlier values indicate that such results are likely part of the natural variation at BG-1. While this observation may explain the presence of these values in the dataset, nothing in the field notes or the gamma data records indicates a scientific reason for these values to be excluded from the dataset (e.g., data handling error, equipment malfunction), and there is no record of anomalous soil or other material at BG-1. Therefore, the values are considered representative of the natural variation present at the BG-1 area, and there is no basis to remove them from the BG-1 gamma dataset. However, descriptive statistics were calculated with and without these values for comparison (Section 3.3.2).

Potential outlier values in the gamma dataset for the Survey Areas appear in the Figure 2A boxplots. However, because of the non-linear shape and continuous distribution of gamma results shown in the probability plot in Figure 6, these values are thought to be representative of the heterogeneous nature of radioactive materials within the Survey Areas and are not outlier values. Indeed, Figure 4-1 of the RSE Report shows that while gamma results for the majority of each of the Survey Areas are within the range of background, localized areas of elevated gamma results associated with mineralized areas are also present.

Table 2. Potential Gamma Outlier Interquartile Range, Z Score, t Score and Chi Squared Score Results

Area	Value (cpm)	Interquartile Range Result	Z Score Result	t Score Result	Chi Sq Score Result
Background Reference Area 1 (BG-1)	19,378	High	Potential Outlier	Potential Outlier	Potential Outlier
	19,173	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,637	High	Potential Outlier	Potential Outlier	Potential Outlier
	18,093	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,295	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,232	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,227	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,133	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,102	High	Potential Outlier	Potential Outlier	Potential Outlier
	17,002	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,992	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,957	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,950	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,888	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,734	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,731	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,650	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,560	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,423	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,400	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,314	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,312	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,263	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,235	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,156	High	Potential Outlier	Potential Outlier	Potential Outlier
	16,011	High	Potential Outlier	Potential Outlier	Potential Outlier
	15,988	High	Potential Outlier	Potential Outlier	Potential Outlier
	15,921	High	Potential Outlier	Potential Outlier	Potential Outlier
	15,845	High	Potential Outlier	Potential Outlier	Potential Outlier
	15,778	High	Potential Outlier	Potential Outlier	Potential Outlier
	15,739	High	Potential Outlier	Potential Outlier	Potential Outlier

3.2 COMPARE DATA POPULATIONS

Group comparison analyses provide insight into the relative concentrations of constituents between background reference areas and Survey Areas. Observations made during these analyses may indicate the need for further evaluation or discussion regarding the influence of potential outlier values, and the use of background data. For instance, if two or more background reference areas were determined to be statistically similar to each other, these data could be combined to calculate more robust statistics (not a factor in this evaluation, as one background reference area was selected to represent each Survey Area). Alternatively, testing of this kind may reveal background concentrations statistically higher than corresponding Survey Area concentrations, requiring additional interpretation or modifications in the use of background reference area datasets. Finally, results of these evaluations are a component of determining background reference area representativeness, though statistical comparisons are not the only factors to be considered in judging representativeness. Factors such as geologic materials, predominant wind direction, distance from the Site, visual evidence of impacts due to mining (or other anthropogenic sources) and soil depth are all important to the selection of background reference areas.

Group comparisons, therefore, are considered instructive as a component of the overall evaluation of soil sample and gamma radiation survey results collected from background reference areas and Survey Areas. Relative data distributions were investigated by evaluating the boxplots and probability plots in Figures 1A through 6, and by hypothesis testing with the non-parametric Mann-Whitney test, as applicable.

3.2.1 Evaluation of Boxplots

3.2.1.1 Soil Sample Boxplots

When interpreting the soil sample boxplots in Figures 1A and 1B, it is important to note that samples at background reference areas were collected randomly, while samples in the Survey Areas were collected judgmentally from areas of suspected contamination. Analytic constituent results from background reference areas tend to be lower than, or similar to, analytical results from the Survey Areas. Arsenic, uranium, vanadium and Ra-226 concentrations are lower at BG-1 than at Survey Area A, while molybdenum concentrations are similar between BG-1 and Survey Area A, and selenium is non-detect at both. All analytical constituent results are similar between BG-2 and Survey Area B, and lower at BG-3 than at Survey Area C. Analytical constituent-specific observations from the boxplots in Figures 1A and 1B indicate:

- Arsenic. Arsenic results appear slightly elevated at BG-3 relative to BG-1, BG-2, and Survey Area B. Arsenic results at Survey Area A and Survey Area C are much higher than arsenic results at Survey Area B and the background reference areas.

- Molybdenum. Molybdenum results appear similar in BG-1 and Survey Area A; these molybdenum results are slightly elevated relative to BG-2, BG-3, and Survey Area B, and much lower than results at Survey Area C.

- Ra-226. Ra-226 results appear similar between BG-1, BG-2, BG-3, and Survey Area B; Ra-226 results at these areas are much lower than Ra-226 results at Survey Area A and Survey Area C.
- Selenium. Selenium was detected at Survey Area C only.
- Uranium. Uranium results appear similar between BG-1, BG-2, BG-3, and Survey Area B; uranium results at these areas are much lower than uranium results at Survey Area A and Survey Area C.
- Vanadium. Vanadium results appear similar between BG-1 and BG-3, and similar between BG-2 and Survey Area B; vanadium results at these areas are much lower than vanadium results at Survey Area A and Survey Area C.

3.2.1.2 Gamma Radiation Boxplots and Probability Plots

The boxplot comparison in Figures 2A and 2B suggests that median values are similar between background reference areas and Survey Areas. Gamma radiation data distributions between background reference areas and Survey Areas shown on Figure 6 are not similar (normal vs. non-normal, respectively). These observations are further evaluated in Section 3.2.2 using the non-parametric Mann-Whitney test.

3.2.2 Mann-Whitney Testing

The Mann-Whitney test (Bain and Engelhardt, 1992) is a nonparametric test used for determining whether a difference exists between two or more population distributions. This test is also known as the Wilcoxon Rank Sum (WRS) test. This test evaluates whether measurements from one population consistently tend to be larger (or smaller) than those from another population. This test was selected over other comparative tests such as the Student’s t test and analysis of variance (ANOVA) because it remains robust in the absence of required assumptions that these two tests require such as normally distributed data and equality of variances.

Soil samples at background reference areas were collected randomly, while soil samples in the Survey Areas were collected judgmentally (see Section 3.1). Mann-Whitney testing is not appropriate for comparative analysis if one or both groups contain data collected using a judgmental approach. Therefore, the Mann-Whitney test was not performed for soil sample data between background reference areas and Survey Areas. Gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between background reference areas and Survey Areas (Table 3). Therefore, the test was performed 2-sided on the background reference area and Survey Area gamma radiation data. The two-sided test accounts for results from one group being lower or higher than any other group (i.e., the hypothesis tested whether the two groups differ, independent of which group is higher). A test result p-value of 0.05 or smaller indicates that a significant difference exists between any two groups that are compared. Results of Mann-Whitney testing are presented in Table 3.

Table 3. Summary of Gamma Survey Mann-Whitney Test Results

Comparison	p_Value	Description
Background Reference Area 1 (BG-1) vs Survey Area A	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 1 (BG-1) Potential Outliers Excluded	0.232	No Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Survey Area A	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Survey Area B	<0.05	Significant Difference
Background Reference Area 3 (BG-3) vs Survey Area C	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 2 (BG-2)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Background Area 2 (BG-2)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 1 (BG-1) Potential Outliers Excluded vs Background Area 3 (BG-3)	<0.05	Significant Difference
Background Reference Area 2 (BG-2) vs Background Reference Area 3 (BG-3)	<0.05	Significant Difference
Survey Area A vs Survey Area B	<0.05	Significant Difference
Survey Area A vs Survey Area C	<0.05	Significant Difference
Survey Area B vs Survey Area C	<0.05	Significant Difference

The results of the Mann-Whitney testing on gamma radiation survey results in Table 3 indicate the following:

- Gamma results are statistically elevated in each of the Survey Areas with respect to their respective background reference areas; this observation is valid for Survey Area A and BG-1 both with and without inclusion of potential outliers in the BG-1 dataset.

- Additionally, gamma results are statistically elevated at Survey Area A relative to Survey Area B, and at both Survey Area A and Survey Area B relative to Survey Area C. Gamma results at BG-1 are statistically elevated relative to BG-3 and BG-2 (with and without consideration of potential outliers at BG-1), and gamma results at BG-3 are statistically elevated relative to BG-2.

- The observation that gamma results are statistically elevated at Survey Area A relative to Survey Areas B and C is likely due to the presence of radiation coincident with historic waste piles in the central and northwest portions of the Survey Area.

- The observation that gamma results at all three survey areas are statistically elevated relative to their respective background reference areas is likely attributable to the fact that background reference areas may not fully represent the degree of natural mineralization present at Survey Areas (see RSE Report Section 3.2.2.2). This latter point does not prohibit use of the gamma ILs calculated from these background reference areas, but this observation should be considered, as Site conditions are further evaluated for remediation.

- The inclusion or removal of potential outlier values has no effect on the results of the Mann-Whitney test between BG-1 and Survey Area A, BG-2, or BG-3 (i.e., there is a statistically significant difference in gamma results between BG-1 and these other areas with and without potential outlier values included).

3.3 DESCRIPTIVE STATISTICS

Descriptive statistics, including the upper confidence limit (UCL) of the mean and the 95-95 upper tolerance limit (UTL), were calculated from gamma survey data and soil sample results. Descriptive statistics are important for any data evaluation to present the basic statistics of a dataset with regards to its limits (maximum and minimum), central tendencies (mean and median) as well as data dispersion (coefficient of variance). The ILs for the Site also are taken from the descriptive statistics, namely the 95-95 UTL. The UTL value is selected by ProUCL as the maximum value in the dataset when the data are determined to be non-parametric. The parameters and constituents evaluated include gamma radiation, arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226.

Statistics were calculated using Environmental Protection Agency (EPA) ProUCL version 5.1 software. Statistical methodology employed by the software is documented in the *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations* (EPA, 2015). In the case of non-detect results, ProUCL does not recommend detection limit substitution methods (e.g., 1/2 the detection limit), considering these methods to be imprecise and out of date (EPA, 2015). The software instead calculates descriptive statistics for the detected results only, and follows various methods accordingly to calculate UCL and UTL values based on the percentage of non-detect results present in the dataset and on the distribution of the data (i.e., normal, lognormal, gamma, or unknown distribution).

Descriptive statistics for soil samples and gamma radiation survey results have been calculated with and without the potential outlier values previously identified, as applicable. Select descriptive statistics for these constituents are presented in Tables 4 and 5.

3.3.1 Soil Sample Analytical Results Summary

Table 4 presents the descriptive statistics output from the ProUCL software for the soil sample results.

As described in Section 3.2.1.1, results for all analytical constituents appear elevated at Survey Area C relative to the other Survey Areas and background reference areas. Additionally, arsenic, uranium, vanadium, and Ra-226 results appear elevated at Survey Area A relative to Survey Area B and the background reference areas. Selenium was detected only once, at Survey Area C. An important consideration when comparing concentrations of metals and Ra-226 between background reference areas and Survey Areas is that the selection of background reference areas is intended to identify areas that are representative of the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized, naturally elevated uranium concentrations (see RSE Report Section 3.2.2.2). In addition, soil sampling for metals and Ra-226 in background reference areas was conducted in a random manner, whereas soil sampling for metals and Ra-226 in the Survey Areas was judgmental. As a result, it is not surprising that some metals and Ra-226 concentrations in the Survey Areas appear to be elevated relative to concentrations in background reference areas. It should be noted, however, that concentrations of several of the metals analyzed for in the Survey Areas are within the range of metals concentrations typically observed in Western U.S. soils (United States Geological Survey [USGS], 1984):

- Arsenic (mean = 5.5 mg/kg; range <0.10 – 97 mg/kg)
- Molybdenum (mean = 0.85 mg/kg; range <3 – 7 mg/kg)
- Selenium (mean = 0.23 mg/kg; range <0.1 – 4.3 mg/kg)
- Uranium (mean = 2.5 mg/kg; range 0.68 – 7.9 mg/kg)
- Vanadium (mean = 70 mg/kg; range 7 – 500 mg/kg)

As shown in Table 4, the range of arsenic, molybdenum, selenium and vanadium concentrations in the Survey Areas are within typical ranges reported for Western U.S soils, and may not be related to the uranium mineralization. Exceptions to the above are uranium and Ra-226; elevated concentrations of these constituents in the Survey Areas are likely attributable to residual uranium concentrations and Ra-226 concentrations associated with the mining-related disturbances at the Site.

Table 4. Summary of Soil Sampling Results

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	10	10	10	10	10	10
	Percent Non-Detects	--	--	100%	--	--	--
	Minimum[1]	2.10	0.570	--	1.30	13.0	1.26
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	2.93	1.45	--	1.85	14.5	1.53
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	2.65	1.35	--	1.55	14.0	1.40
	Maximum[1]	4.60	2.50	--	3.50	16.0	2.15
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.276	0.479	--	0.397	0.081	0.202
	UCL Type	95% Student's-t UCL	95% Student's-t UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	3.40	1.85	Not Calculated	2.28	15.2	1.71
	UTL Type	UTL Normal	UTL Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	5.28	3.47	Not Calculated	3.99	17.9	2.43
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	18%	100%	--	--	--
	Minimum[1]	0.640	--	--	0.180	3.40	0.360
	Minimum Detect[2]	--	0.170	--	--	--	--
	Mean[1]	1.04	--	--	0.265	6.03	0.558
	Mean Detects[2]	--	0.349	--	--	--	--
	Median[1]	0.980	--	--	0.240	6.40	0.550
	Median Detects[2]	--	0.310	--	--	--	--
	Maximum[1]	2.10	--	--	0.430	7.20	0.750
	Maximum Detect[2]	--	0.620	--	--	--	--
	Distribution	Gamma	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.394	--	--	0.290	0.201	0.223
	CV Detects[2]	--	0.431	--	--	--	--
	UCL Type	95% Adjusted Gamma UCL	95% KM (t) UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	1.32	0.394	Not Calculated	0.307	6.69	0.626
	UTL Type	UTL Gamma WH	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	2.36	0.786	Not Calculated	0.482	9.45	0.909

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Background Reference Area 2 (BG-2) Excluding Potential Outliers[3]	Total Number of Observations	10	--	--	--	--	--
	Minimum[1]	0.640	--	--	--	--	--
	Mean[1]	0.933	--	--	--	--	--
	Median[1]	0.965	--	--	--	--	--
	Maximum[1]	1.40	--	--	--	--	--
	Distribution	Normal	--	--	--	--	--
	Coefficient of Variation[1]	0.237	--	--	--	--	--
	UCL Type	95% Student's-t UCL	--	--	--	--	--
	UCL Result	1.06	--	--	--	--	--
	UTL Type	UTL Normal	--	--	--	--	--
	UTL Result	1.58	--	--	--	--	--
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	--	100%	--	--	--
	Minimum[1]	5.90	0.290	--	0.380	9.90	1.12
	Minimum Detect[2]	--	--	--	--	--	--
	Mean[1]	10.4	0.668	--	0.515	12.6	1.39
	Mean Detects[2]	--	--	--	--	--	--
	Median[1]	7.90	0.480	--	0.510	12.0	1.34
	Maximum[1]	32.0	1.70	--	0.710	19.0	1.87
	Maximum Detect[2]	--	--	--	--	--	--
	Distribution	Normal	Gamma	Not Calculated	Normal	Gamma	Normal
	Coefficient of Variation[1]	0.730	0.719	--	0.157	0.192	0.174
	UCL Type	95% Student's-t UCL	95% Adjusted Gamma UCL	Not Calculated	95% Student's-t UCL	95% Adjusted Gamma UCL	95% Student's-t UCL
	UCL Result	14.5	1.03	Not Calculated	0.560	14.2	1.53
	UTL Type	UTL Normal	UTL Gamma WH	Not Calculated	UTL Normal	UTL Gamma WH	UTL Normal
	UTL Result	31.6	2.42	Not Calculated	0.744	19.9	2.08
Background Reference Area 3 (BG-3) Excluding Potential Outliers[3]	Total Number of Observations	9	9	--	9	10	--
	Minimum[1]	5.90	0.290	--	0.470	9.90	--
	Mean[1]	7.43	0.461	--	0.509	12.0	--
	Median[1]	7.70	0.480	--	0.510	12.0	--
	Maximum[1]	8.30	0.740	--	0.580	14.0	--
	Distribution	Normal	Normal	--	Normal	Normal	--
	Coefficient of Variation[1]	0.106	0.314	--	0.066	0.106	--
	UCL Type	95% Student's-t UCL	95% Student's-t UCL	--	95% Student's-t UCL	95% Student's-t UCL	--
	UCL Result	7.92	0.551	--	0.530	12.7	--
	UTL Type	UTL Normal	UTL Normal	--	UTL Normal	UTL Normal	--
	UTL Result	9.82	0.900	--	0.611	15.7	--

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area A	Total Number of Observations	7	7	7	7	7	7
	Percent Non-Detects	--	14%	100%	--	--	--
	Minimum[1]	2.20	--	--	0.750	12.0	1.01
	Minimum Detect[2]	--	0.450	--	--	--	--
	Mean[1]	16.3	--	--	34.6-	25.3	26.5
	Mean Detects[2]	--	2.49	--	--	--	--
	Median[1]	16.0	--	--	25.0	25.0	8.30
	Median Detects[2]	--	1.14	--	--	--	--
	Maximum[1]	41.0	--	--	120	42.0	71.9
	Maximum Detect[2]	--	10.0	--	--	--	--
	Distribution	Normal	Normal	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation[1]	0.914	--	--	1.28	0.381	1.13
	CV Detects[2]	--	1.49	--	--	--	--
	UCL Type	95% Student's-t UCL	95% KM Bootstrap t UCL	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	27.3	14.2	Not Calculated	67.2	32.4	48.5
	UTL Type	UTL Normal	UTL KM Normal	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	67.0	13.2	Not Calculated	185	58.0	129
Survey Area B	Total Number of Observations	16	16	16	16	16	16
	Percent Non-Detects	--	6%	100%	--	--	--
	Minimum[1]	0.810	--	--	0.400	4.30	0.640
	Minimum Detect[2]	--	0.230	--	--	--	--
	Mean[1]	3.58	--	--	6.79	8.96	3.45
	Mean Detects[2]	--	0.953	--	--	--	--
	Median[1]	2.75	--	--	1.45	9.15	1.27
	Median Detects[2]	--	0.470	--	--	--	--
	Maximum[1]	19.0	--	--	78.0	19.0	34.8
	Maximum Detect[2]	--	5.10	--	--	--	--
	Distribution	Unknown	Unknown	Not Calculated	Unknown	Gamma	Unknown
	Coefficient of Variation[1]	1.18	--	--	2.81	0.367	2.43
	CV Detects[2]	--	1.37	--	--	--	--
	UCL Type	95% Chebyshev (Mean, Sd) UCL	95% KM (Chebyshev) UCL	Not Calculated	95% Chebyshev (Mean, Sd) UCL	95% Adjusted Gamma UCL	95% Chebyshev (Mean, Sd) UCL
	UCL Result	8.18	2.30	Not Calculated	27.6	10.7	12.6
	UTL Type	UTL Non-Parametric	Non-Parametric -Max	Not Calculated	UTL Non-Parametric	UTL Gamma WH	UTL Non-Parametric
	UTL Result	19.0	5.10	Not Calculated	78.0	18.6	34.8

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
Survey Area C	Total Number of Observations	3	3	3	3	3	3
	Percent Non-Detects	--	33%	67%	--	--	--
	Minimum¹	6.60	--	--	0.410	3.00	0.830
	Minimum Detect²	--	0.400	1.20	--	--	--
	Mean¹	55.4	--	--	74.1	30.3	37.3
	Mean Detects²	--	5.70	1.20	--	--	--
	Median¹	9.50	--	--	1.90	5.00	1.07
	Median Detects²	--	5.70	--	--	--	--
	Maximum¹	150	--	--	220	83.0	110
	Maximum Detect²	--	11.0	1.20	--	--	--
	Distribution	Normal	Not Calculated	Not Calculated	Normal	Normal	Normal
	Coefficient of Variation¹	1.48	--	--	1.71	1.50	1.69
	CV Detects²	--	1.32	--	--	--	--
	UCL Type	95% Student's-t UCL	Not Calculated	Not Calculated	95% Student's-t UCL	95% Student's-t UCL	95% Student's-t UCL
	UCL Result	194	Not Calculated	Not Calculated	287	107	143
	UTL Type	UTL Normal	Not Calculated	Not Calculated	UTL Normal	UTL Normal	UTL Normal
	UTL Result	683	Not Calculated	Not Calculated	1,041	380	519

¹	This statistic is reported by ProUCL when the dataset contains 100 percent detections.
²	This statistic is reported by ProUCL when non-detect values exist in the dataset. The value reported is calculated using detections only.
³	Statistics shown are for the constituents where potential outliers were identified, calculated with the potential outliers removed.
CV	Coefficient of variation
KM	Kapplan Meier
mg/kg	Milligrams per kilogram
--	Not applicable
pCi/g	Picocuries per gram
WH	Wilson Hilferty
Note	The UTL result that is shown on the table is based on the output from ProUCL. ProUCL evaluates the data and provides all possible UCLs from its UCL module for three possible data distributions, then identifies a recommended UCL value. ProUCL does not identify a recommended UTL value. The UTLs are therefore based on the distribution of the recommended UCL. Please refer to *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations* (EPA, 2015) for further information

3.3.2 Gamma Radiation Results Summary

Table 5 presents the descriptive statistics output from the ProUCL software for the gamma radiation survey results.

Table 5. Summary of Walk-over Gamma Results

Area	Statistic	Gamma (cpm)
Background Reference Area 1 (BG-1) All Data	Total Number of Observations	991
	Minimum	10,232
	Mean	12,942
	Median	12,790
	Maximum	19,378
	Distribution	Normal
	Coefficient of Variation	0.094
	UCL Type	95% Student's-t UCL
	UCL Result	13,006
	UTL Type	UTL Normal
	UTL Result	15,036
Background Reference Area 1 (BG-1) Excluding Potential Outliers	Total Number of Observations	960
	Minimum	10,232
	Mean	12,816
	Median	12,751
	Maximum	15,685
	Distribution	Gamma
	Coefficient of Variation	0.077
	UCL Type	95% Approximate Gamma UCL
	UCL Result	12,869
	UTL Type	UTL Gamma WH
	UTL Result	14,573
Background Reference Area 2 (BG-2) All Data	Total Number of Observations	199
	Minimum	6,349
	Mean	8,898
	Median	8,726
	Maximum	12,135
	Distribution	Normal
	Coefficient of Variation	0.142
	UCL Type	95% Student's-t UCL
	UCL Result	9,046
	UTL Type	UTL Normal
	UTL Result	11,220

Area	Statistic	Gamma (cpm)
Background Reference Area 3 (BG-3) All Data	Total Number of Observations	241
	Minimum	7,773
	Mean	10,630
	Median	10,514
	Maximum	13,471
	Distribution	Normal
	Coefficient of Variation	0.105
	UCL Type	95% Student's-t UCL
	UCL Result	10,748
	UTL Type	UTL Normal
	UTL Result	12,649
Survey Area A	Total Number of Observations	15,459
	Minimum	6,916
	Mean	25,026
	Median	13,984
	Maximum	328,342
	Distribution	Not Calculated
	Coefficient of Variation	1.14
	UCL Type	95% Chebyshev (Mean
	UCL Result	26,027
	UTL Type	UTL Non-Parametric
	UTL Result	77,623
Survey Area B	Total Number of Observations	67,993
	Minimum	4,867
	Mean	12,013
	Median	9,894
	Maximum	215,310
	Distribution	Normal
	Coefficient of Variation	0.742
	UCL Type	95% Student's-t UCL
	UCL Result	12,069
	UTL Type	UTL Normal
	UTL Result	26,756
Survey Area C	Total Number of Observations	7,433
	Minimum	4,955
	Mean	10,657
	Median	9,156
	Maximum	295,008
	Distribution	Normal
	Coefficient of Variation	1.03
	UCL Type	95% Student's-t UCL
	UCL Result	10,865
	UTL Type	UTL Normal
	UTL Result	28,953

As noted for metals and Ra-226 in Section 3.3.1, gamma results measured within the Survey Areas appeared to be elevated relative to gamma results measured in background reference areas because background reference areas were selected to represent the geology present in the region around the Site, whereas the Site was selected as a mine claim because it is in an area of mineralized bedrock likely to have localized naturally elevated uranium concentrations.

Therefore, it’s not surprising that gamma results within the Survey Areas are somewhat higher than gamma results at the background reference areas. Elevated gamma results in portions of the Survey Areas are likely attributable to historic waste piles, as well as a higher degree of natural mineralization within the Survey Areas relative to the background reference areas.

4.0 INVESTIGATION LEVELS

The calculated 95-95 UTL values described in Section 3.3 are used as the ILs for gamma measurement results and soil sampling results because they reflect the natural variability in the background data, and provide an upper limit from background data to be used for single-point comparisons to Survey Area data. The ILs for analytical results of soil samples and gamma radiation results in Survey Areas A, B and C are based on Background Reference Areas BG-1, BG-2 and BG-3, respectively.

4.1 SURVEY AREA A INVESTIGATION LEVELS

- Arsenic (mg/kg): 5.28
- Molybdenum (mg/kg): 3.47
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 3.99
- Vanadium (mg/kg): 17.9
- Ra-226 (pCi/g): 2.43
- Gamma radiation measurements (cpm): 15,036

4.2 SURVEY AREA B INVESTIGATION LEVELS

- Arsenic (mg/kg): 2.36
- Molybdenum (mg/kg): 0.786
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 0.482
- Vanadium (mg/kg): 9.45
- Ra-226 (pCi/g): 0.909
- Gamma radiation measurements (cpm): 11,220

4.3 SURVEY AREA C INVESTIGATION LEVELS

- Arsenic (mg/kg): 31.6
- Molybdenum (mg/kg): 2.42
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 0.744
- Vanadium (mg/kg): 19.9
- Ra-226 (pCi/g): 2.08
- Gamma radiation measurements (cpm): 12,649

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

Charles Keith
Abandon Uranium Mine Project

Sponsored by:

MWH Global, a division of Stantec

Prepared by:

Adkins Consulting, Inc.
180 East 12th Street, Unit 5
Durango, Colorado 81301

Revised August 2016
June 2016

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1. INTRODUCTION AND PROJECT BACKGROUND

The federal Endangered Species Act (ESA) of 1973, 16 U.S.C. §1531 et seq., requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by each agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat [USFWS 1998]. This report describes the potential for federal ESA-listed species and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive flora and fauna to occur in the proposed action area. The action area with regard to the ESA is defined as any area that may be directly or indirectly impacted by the proposed action [50 CFR §402.02]. This report is intended to provide the responsible official with information to make determinations of effect on species with special conservation status.

As the result of settlement by the United States, the US established funding to address certain abandoned uranium mines located across Navajo lands. For this funding, scientific investigation of these sites is required prior to potential remediation activities in the future. MWH Global, a division of Stantec (MWH), will conduct exploratory activities at the Charles Keith abandoned uranium mine (AUM) such as pedestrian gamma surveys, mapping, well sampling, and surface soil sampling within the mine claim boundaries and surrounding buffer zone. Subsequent earthwork and long term monitoring may be involved after final approval by the Navajo Nation Environmental Protection Agency (NNEPA) in conjunction with the U. S. Environmental Protection Agency (USEPA).

In support of this project, MWH contracted Adkins Consulting, Inc. (ACI) to conduct surveys for ESA-listed fauna and Navajo Nation Endangered Species List (NESL) endangered, threatened, candidate, or otherwise designated sensitive fauna. MWH contracted Redente Ecological Consultants (Redente) to conduct surveys for NESL and ESA-listed plant species. The results of the 2016 Redente biological investigations will be incorporated in Sections 4.2 and 4.3 of this report and can be found in entirety attached as Appendix C.

The objectives of the biological surveys were as follows:

- To compile a list of ESA-listed or NESL species potentially occurring in the proposed action area.
- To provide a physical and biological description of the proposed action area.
- To determine the presence of ESA-listed or NESL species in the proposed action area.
- To assess potential impacts the proposed action may have on any ESA-listed or NESL species present in the area.
- To assess potential impacts to species protected under the Migratory Bird Treaty Act (MBTA).

2. PROJECT DESCRIPTION

2.1. Location

Charles Keith is located in San Juan County, Utah, approximately 9 miles northwest of Monument Valley, Utah at an elevation of approximately 5,100 feet. Global Positioning System coordinates are 37°2'30.4” N by 110°18'30.9” W NAD 83. The site is located on Navajo Tribal Trust Lands within the Bureau of Indian Affairs (BIA) Tuba City Agency. The legal description of the project surface location is as follows: Section 13, Township 43 South, Range 14 East, Salt Lake Principal Meridian. Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the Charles Keith AUM. The study area encompasses the claim boundary and a 100-foot perimeter buffer zone for a total of approximately 18.3 acres. Please refer to Appendix A for maps delineating the mine claim boundary and buffer zone.

The project will also include a walkover survey for gamma radiation across a small area known as the “background area”. Please refer to Appendix A for a map of the background sample areas. A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas.

- Phase I: Spring of 2016 activity would entail pedestrian biological surveys and land surveying. Fall of 2016 work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. In 2016 there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.
- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect one or more soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

3. AFFECTED ENVIRONMENT

3.1. Proposed Project Area (PPA)

The proposed project area (PPA) at Charles Keith includes the mine boundary and a 100-foot perimeter buffer zone for a total of approximately 18.3 acres. The affected environment or action area includes any area that may be directly or indirectly impacted by the proposed activities. Project area maps are provided in Appendix A.

3.1.1. Environmental Setting

Project activities would occur in southeastern Utah located within the USEPA designated Colorado Plateau Level III Ecoregion. The Colorado Plateau ecoregion is located Utah and Colorado with extensions in New Mexico and Arizona. It has an area of 32,387 square miles. The Colorado Plateau is an uplifted, eroded, and deeply dissected tableland. Its benches, mesas, buttes, salt valleys, cliffs, and canyons are formed in and underlain by thick layers of sedimentary rock. The ecoregion has a broad latitudinal range, from the Uinta Basin in the north to the arid canyon lands along the border of Arizona and New Mexico.

Charles Keith is situated on a northwest facing slope on the northern end of Oljeto Mesa with Oljeto Valley to the southwest. Residences from the small community of Oljeto, Utah are located approximately 0.5 mile southwest of the site. Terrain is steep with sandstone cliffs surrounding the PPA.

Flora

Vegetation communities found within the region include shrublands with big sagebrush, rabbitbrush, winterfat, shadscale saltbush, and greasewood; and grasslands of blue grama, Western wheatgrass, green needlegrass, and needle-and-thread grass. Higher elevations may support piñon pine and juniper woodlands. The Charles Keith site is steep sandstone with sporadic shrubs and pinon-juniper.

Fauna

Wildlife or evidence of wildlife observed within the PPA included common raven (*Corvus corax*) and cottontail rabbit (*Sylvilagus* sp.). No prairie dog (*Cynomys* sp.) burrows were recorded within the PPA or immediate vicinity.

An active raven nest with two young in the nest was observed along the eastern wall of the canyon. Further analysis of sensitive species can be found in Section 4 of this document.

Hydrology/Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value.

Run-off from precipitation in the project area generally drains west to Oljeto Wash located 0.5 mile southwest. Oljeto Wash drains north for 20 miles and joins the San Juan River approximately 10 miles east of Lake Powell. There are no wetlands, seeps, springs, or riparian areas within the proposed project area. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. There is no suitable habitat for ESA-listed fish, nor critical habitats thereof, within 20 miles of the PPA.

Cumulative impacts to surface waters would be negligible. Surface-disturbing activities other than the proposed action that may cause accelerated erosion include, but are not limited to, construction of roads, other facilities, and installation of trenches for utilities; road maintenance such as grading or ditch-cleaning; public recreational activities; vegetation manipulation and management activities; natural and prescribed fires; and livestock grazing. Because the proposed action would have a negligible impact to downstream surface water quality, the cumulative impact also would be negligible when added to other past, present, and reasonably foreseeable activities.

4. THREATENED, ENDANGERED, AND SENSITIVE SPECIES EVALUATION

The Endangered Species Act (ESA) of 1973 requires all federal departments and agencies to conserve threatened, endangered, and critical and sensitive species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service (USFWS) on all actions authorized, funded, or carried out by the agency to ensure that the action will not likely jeopardize the continued existence of any threatened and endangered species or adversely modify critical habitat.

4.1. Methods

4.1.1. Off-site Methods

Prior to conducting fieldwork, ACI compiled data on animal species listed under the ESA. Informal consultation was initiated by requesting an Official Species List from the USFWS Information, Planning, and Conservation System (IPaC) website (http://ecos.fws.gov/ipac/). ACI received the Official Species List (06E23000-2016-SLI-0208) on April 7, 2016. See Table 1 for USFWS-listed threatened, endangered, or candidate species with potential to occur in the PPA.

The Navajo Nation Department of Fish and Wildlife (NNDFW), Navajo Natural Heritage Program (File # 15mwh101) sent MWH a NESL information letter dated 29 December, 2015. The letter suggests biologists determine habitat suitability within the project area for the provided list of species of concern with potential to occur on the 7.5-minute quadrangles containing the project boundaries. The Navajo species of concern listed in the NESL information letter are included in Table 2.a below.

In addition to the above listed species, ACI reviewed species protected under the MBTA with potential to occur in the proposed project and action area (Table 3).

4.1.2. On-site Survey Methods

An on-site pedestrian survey was conducted in April 2016 by ACI personnel under a permit issued NNDFW. The purpose of the survey was to assess habitat potential for ESA-listed or NESL animal species. Field biologists with considerable experience identifying local wildlife species lead survey crews. The survey consisted of walking transects ten feet apart throughout the PPA including a survey buffer of approximately 50 feet beyond the PPA edge of disturbance. The surrounding areas were visually inspected with binoculars for nests, raptors, or past signs of raptor use. Weather conditions were clear and visibility was good.

Follow up surveys were conducted at the site specifically targeting Golden eagle (*Aquila chrysaetos*), Ferruginous hawk (*Buteo regalis*), and American peregrine falcon (*Falco peregrinus*) following Navajo Natural Heritage Program (NNHP) guidelines. All wildlife species observed in the action area were recorded, and digital photos were taken (Appendix B). Follow up survey details including date, site conditions and methods can be found on summary sheets attached as Appendix E.

Redente conducted surveys for plant species of concern. The results of the 2016 Redente biological investigations will be incorporated in Sections 4.2 and 4.3 of this report and can be found in entirety attached as Appendix C.

4.2. ESA-Listed Species Analysis and Results

4.2.1. Species from the USFWS IPaC Official Species List

Table 1 includes ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. Biologists evaluated habitat suitability within and surrounding the PPA for the species in Table 1.

Table 1: USFWS Species List for the Charles Keith Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
BIRDS				
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Endangered with Designated Critical Habitat	Summer/breeding range.[2]	Breeds in dense riparian habitat.[2]	No potential. Action area does not provide suitable habitat for species to occur.
Mexican spotted owl (*Strix occidentalis lucida*)	Threatened with Designated Critical Habitat	Year-round range.[1]	Mixed conifer forests. Typically where unlogged, uneven-aged, closed-canopy forests occur in steep canyons.[1]	No potential. Action area does not provide suitable habitat for species to occur.
Western Yellow-Billed Cuckoo (*Coccyzus americanus*)	Threatened	Possible rare summer/breeding occurrences.[2]	In the southwestern U.S., associated with riparian woodlands dominated by cottonwood or willow trees. In New Mexico, native or exotic species may be used.[2]	No potential. Action area does not provide suitable habitat for species to occur.

Table 1: USFWS Species List for the Charles Keith Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
California condor *(Gymnogyps californianus)*	Exp. Population, Non Essential	In northern Arizona, condors are located primarily near the Vermilion cliffs, Grand Canyon and Coconnino County.[3]	Large areas of remote country for foraging, roosting, and nesting. Roost on large trees or snags, or on isolated rocky outcrops and cliffs. Nests are located in shallow caves and rock crevices on cliffs where there is minimal disturbance. Foraging habitat includes open grasslands and oak savanna foothills that support populations of large mammals such as deer and cattle.[1]	No potential. Action area does not provide suitable habitat for species to occur. Nearby human activity and lack of prey base limiting factors.
Gunnison sage-grouse *(Centrocercus minimus)*	Threatened	Utah population is near Monticello[1]	Sagebrush with a diversity of grasses and forbs and healthy wetland and riparian ecosystems. Requires sagebrush for cover and fall and winter food.[1]	No potential. Action area does not provide suitable habitat for species to occur.
FISHES				
Colorado pikeminnow *(Ptychocheilus lucius)*	Endangered	Upper Colorado River from WY to NM. On the Navajo Nation documented throughout the San Juan River (SJR), from Shiprock to Lake Powell; mouth of the Mancos River used during spring runoff.[3]	Backwaters and flooded riparian areas during spring runoff, and migrate large distances (15-64 km in the SJR) to spawn in riffle-run areas with cobble/gravel substrates. Young-of-year use warm backwaters along shorelines. Irrigation canals and ponds connected to SJR may be potential habitat.[3]	No potential. No perennial waters in or near the PPA. Action area is within the San Juan River watershed; however, negligible effects from the project to any drainage system are expected.
Greenback Cutthroat trout *(Oncorhynchus clarki stomias)*	Threatened	San Juan County Utah[1]	Cold water streams and cold water lakes with adequate stream spawning habitat present during spring. Generally require clear, cold, well-oxygenated water.[1]	No potential. No perennial waters in or near the PPA. Action area is within the San Juan River watershed; however, negligible effects from the project to any drainage system are expected.

Table 1: USFWS Species List for the Charles Keith Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
Razorback sucker *(Xyrauchen texanus)*	Endangered	Known to occur in San Juan River.[2]	Slow areas, backwaters, and eddies of medium to large rivers and their impoundments. Often associated with sand, mud, and rock substrate in areas with sparse aquatic vegetation, where temperatures are moderate to warm.[2]	No potential. No perennial waters in or near the PPA. Action area is within the San Juan River watershed; however, negligible effects from the project to any drainage system are expected.
PLANTS				
Navajo sedge *(Carex specuicola)*	Threatened with Designated Critical Habitat	From the Navajo Creek drainage in Coconino Co, east to the Tsegi Canyon Watershed in Navajo Co, south to the Rock Point/Mexican Water & Canyon de Chelly National Monument, Apache Co, AZ area. Also known from Chinle Creek, San Juan Co, UT.[3]	Typically found in seeps and hanging gardens, on vertical sandstone cliffs and alcoves. Known populations occur from 4600ft to 7200ft.[3]	No potential. Action area does not provide suitable habitat for species to occur.[4]

[1]USFWS; [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008; [4]Redente 2016

4.2.2. ESA-Listed Species Eliminated From Further Consideration

Table Table 1 includes nine (9) ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. All of the species in Table 1 have been eliminated from further discussion in this report. There would be no direct, indirect or cumulative impacts to the species in Table 1.

4.3. NESL Species Analysis and Results

4.3.1. Navajo Endangered Species List (NESL) and Species of Concern

Table 2.a lists species of concern with potential to occur on the 7.5-minute quadrangle(s) containing the project boundaries. According to the NESL information letter received from the NNFWD found in Appendix D, there are no known species to occur within three miles of project site. Biologists evaluated the potential for species of concern listed in the table below to occur within the project area.

Additionally, the NESL information letter requested that the potential for black-footed ferret (*Mustela nigripes*) be evaluated if prairie dog towns of sufficient size (per NFWD guidelines) occur in the project area, and that potential for Parish’s alkali grass (*Puccinellia parishii*) be evaluated if wetland conditions exist that contain white alkaline crusts. Species listed by the USFWS in Table 1 are not reiterated here.

Table 2.a: Navajo Endangered Species List (NESL) and Species of Concern

Species	**Status**	**Habitat Associations**	**Potential to Occur in Project or Action Area**
		ANIMALS	
Black-footed ferret (*Mustela nigripes*)	USFWS Endangered	Open habitat, including grasslands, steppe, and shrub steppe. Closely associated with prairie dog colonies. At least 40 hectares of prairie dog colony required to support one ferret.[1]	No potential. Action area does not provide suitable habitat for species to occur. Action area does not provide prairie dog colonies of sufficient size
Northern Leopard Frog (*Lithobates pipiens*)	NESL G2	Springs, slow streams, marshes, bogs, ponds, canals, flood plains, reservoirs, and lakes; usually permanent water with rooted aquatic vegetation. In summer, commonly inhabits wet meadows and fields. Takes cover underwater, in damp niches, or in caves when inactive. Over winters usually underwater. Eggs are laid and larvae develop in shallow, still, permanent water (typically), generally in areas well exposed to sunlight.[3,4]	No potential. Action area does not provide suitable habitat for species to occur.
Mountain plover *(Charadrius montanus)*	NESL G4	Typically nests in flat (<2% slope) to slightly rolling expanses of grassland, semi-desert, or badland, in an area with short, sparse vegetation, large bare areas (often >1/3 of total area), and that is typically disturbed (e.g. grazed); may also nest in plowed or fallow cultivation fields. Nest is a scrape in dirt often next to a grass clump or old cow manure pile. Migration habitat is similar to breeding habitat.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.
American peregrine falcon (*Falco peregrinus*)	NESL G4 NM-T	Nests on steep cliffs >30 m tall (typically >45 m) in a scrape on sheltered ledges or potholes. Foraging habitat quality is an important factor; often, but not always, extensive wetland and/or forest habitat is within the falcon's hunting range of <=12 km. Nest in ledges or potholes on cliffs in wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies. [3]	Action area provides potential foraging habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,3]	Action area provides potential foraging habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.
Ferruginous hawk (*Buteo regalis*)	NESL G3	Breed in open country, usually prairies, plains and badlands; semi- desert grass-shrub, sagebrush-grass & piñon-juniper	Action area provides potential foraging habitat for species to occur. Sandstone

Species	**Status**	**Habitat Associations**	**Potential to Occur in Project or Action Area**
		plant associations. [3]	cliffs within and surrounding the site provide potential nesting habitat.
PLANTS			
Parish's alkali grass (*Puccinellia parishii*)	NESL G4 NM-E	Alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes. Elevation: 2600-7200 feet.[2,3]	No potential. Action area does not provide suitable habitat for species to occur.

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.3.2. NESL Species Eliminated From Further Consideration

Table 2.a includes seven (7) NESL and Navajo Species of Concern that have the potential to occur in the project area based on general geographical association. The following species have been eliminated from further discussion in this report because the action area does not provide suitable habitat for them to occur: Northern Leopard Frog (*Lithobates pipiens*), Mountain plover *(Charadrius montanus),* Black-footed ferret (*Mustela nigripes*) and Parish's alkali grass (*Puccinellia parishii*). None of these species were observed during surveys of the proposed project area or immediate surroundings. Critical habitats of these species do not exist within or adjacent to the proposed project area. There would be no direct, indirect or cumulative impacts to these species.

Habitat potential was assessed for the American peregrine falcon (*Falco peregrinus*) within the action area. ACI biologists determined the cliffs within and surrounding the site to be potential nesting habitat for this species and conducted follow up surveys to closely examine the cliff faces for any signs of use. Sixteen hours of observation following Navajo Natural Heritage Program (NNHP) protocol were conducted during April 2016. ACI biologists saw no sign of use by this species and concluded the habitat was not likely to be used by American peregrine falcon based on this detailed study. Survey results were discussed with Chad Smith, NNDFW zoologist, and with his concurrence, no further surveys were conducted. The project site was eliminated as potential nesting habitat for the following reasons: Cliff walls are approximately 100 feet in height but are somewhat sloped and ledged, some sheer faces are present but are relatively short (less than 50 feet), and the surrounding area does not provide the preferred extensive riparian or forested foraging habitat for this species (Chad Smith--NNDFW zoologist, personal communication, May 9th, 2016).

4.3.3. NESL Species Warranting Further Analysis

Table 2.b lists NESL and Navajo Species of Concern with potential to occur within the proposed project area based on habitat suitability or actual record of observation.

Table 2.b: NESL and Navajo Species of Concern Warranting Further Analysis

Species	**Status**	**Habitat Associations**	**Potential to Occur in Project or Action Area**
ANIMALS			

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[1,3]	Action area provides potential foraging habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.
Ferruginous hawk (*Buteo regalis*)	NESL G3	Breed in open country, usually prairies, plains and badlands; semi-desert grass-shrub, sagebrush-grass & piñon-juniper plant associations. [3]	Action area provides potential foraging habitat for species to occur. Sandstone cliffs within and surrounding the site provide potential nesting habitat.

Species are listed by the NESL as; Group 2: Endangered (survival or recruitment in jeopardy); Group 3: Endangered (survival or recruitment in jeopardy in foreseeable future); and Group 4: Species of Consideration. NESL Species with New Mexico State Endangered or Threatened status are labeled as NM-T or NM-E.

Sources: [1]New Mexico Natural Heritage Program 2010, [2]NatureServe Explorer; [3]Navajo Endangered Species List, Species Accounts 2008, [4] IUCN Red List, [5]Redente 2016, [6] Hammerson et al 2004.

4.4. Migratory Bird Species

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Under the Act, taking, killing or possessing migratory birds is unlawful.

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and Bald and Golden Eagle Protection Act (BGEPA). The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles.

In preparation for conducting the migratory bird survey, information from the New Mexico Partners In Flight website (http://www.hawksaloft.org/pif.shtml), the New Mexico PIF highest priority list of species of concern by vegetation type, the USFWS's Division of Migratory Bird Management website (http://www.fws.gov/migratorybirds/), and the 2002 Birds of Conservation Concern Report for the Southern Rockies/Colorado Plateau Bird Conservation Region (BCR) No. 16, were used to develop a list of high priority migratory bird species with potential to occur in the area of the proposed action. Species addressed previously and will not be reiterated here.

Table 3: Priority Birds of Conservation Concern with Potential to Occur in the Project Area

Species Name	Habitat Associations	Potential to Occur in the Project Area
Black-throated sparrow (*Amphispiza bilineata*)	Xeric habitats dominated by open shrubs with areas of bare ground.	No suitable habitat is present within the action area for species to occur.
Brewer's sparrow (*Spizella breweri*)	Closely associated with sagebrush, preferring dense stands broken up with grassy areas.	No suitable habitat is present within the action area for species to occur.
Gray vireo (*Vireo vicinior*)	Open stands of piñon pine and Utah juniper (5,800 – 7,200 ft) with a shrub component and mostly bare ground; antelope bitterbrush, mountain mahogany, Utah serviceberry and big sagebrush often present. Broad, flat or gently sloped canyons, in areas with rock outcroppings, or near ridge-tops.	No suitable habitat is present within the action area for species to occur.
Loggerhead shrike	Open country interspersed with improved	No suitable habitat is present within

(*Lanius ludovicianus*)	pastures, grasslands, and hayfields. Nests in sagebrush areas, desert scrub, and woodland edges.	the action area for species to occur.
Mountain bluebird (*Sialia currucoides*)	Open piñon-juniper woodlands, mountain meadows, and sagebrush shrublands; requires larger trees and snags for cavity nesting.	No suitable habitat is present within the action area for species to occur.
Mourning dove (*Zenaida macroura*)	Open country, scattered trees, and woodland edges. Feeds on ground in grasslands and agricultural fields. Roost in woodlands in the winter. Nests in trees or on ground.	No suitable habitat is present within the action area for species to occur.
Sage sparrow (*Amphispiza belli*)	Large and contiguous areas of tall and dense sagebrush. Negatively associated with seral mosaics and patchy shrublands and abundance of greasewood.	No suitable habitat is present within the action area for species to occur.
Sage thrasher (*Oreoscoptes montanus*)	Shrub-steppe dominated by big sagebrush.	No suitable habitat is present within the action area for species to occur.
Scaled quail (*Callipepla squamata*)	Brushy arroyos, cactus flats, sagebrush or mesquite plains, desert grasslands, Plains grasslands, and agricultural areas. Good breeding habitat has a diverse grass composition, with varied forbs and scattered shrubs.	No suitable habitat present within the action area for species to occur. Lack of diverse grass composition with varied forbs likely a limiting factor.
Swainson's hawk (*Buteo swainsoni*)	A mixture of grassland, cropland, and shrub vegetation; nests on utility poles and in isolated trees in rangeland. Nest densities higher in agricultural areas.	No suitable habitat is present within the action area for species to occur.
Vesper sparrow (*Pooecetes gramineus*)	Dry montane meadows, grasslands, prairie, and sagebrush steppe with grass component; nests on ground at base of grass clumps.	No suitable habitat present within the action area for species to occur. Lack of significant grassland/prairie component a limiting factor.
Bald eagle (*Haliaeetus leucocephalus*)	Near lakes, rivers and cottonwood galleries. Nests near surface water in large trees. May forage terrestrially in winter	No suitable habitat present within the action area for species to occur.
Bendire's thrasher (*Toxostoma bendirei*)	Typically inhabits sparse desert shrubland & open woodland with scattered shrubs; breeds in scattered locations in AZ, central & western portions of NM; most common in southwest NM.	No suitable habitat is present within the action area for species to occur.
Piñon jay (*Gymnorhinus cyanocephalus*)	Foothills throughout CO and NM wherever large blocks of piñon-juniper woodland habitat occurs.	No suitable habitat present within the action area for species to occur.
Prairie falcon (*Falco mexicanus*)	Arid, open country, grasslands or desert scrub, rangeland; nests on cliff ledges, trees, power structures.	Action area provides potential foraging and nesting habitat for species to occur.

5. EFFECTS ANALYSIS

Effects or impacts can be either long term (permanent or residual) or short term (incidental or temporary). Short-term impacts affect the environment for only a limited period and then the environment reverts rapidly back to pre-action conditions. Long-term impacts are substantial and permanent alterations to the pre-existing environmental condition. Direct effects are those effects that are caused by the action and occur in the same time and place as the action. Indirect effects are those effects that are caused by or will result from the proposed action and are later in time but still reasonably certain to occur [USFWS 1998].

5.1. Direct and Indirect Effects

The PPA at Charles Keith includes the mine boundary and a 100-foot perimeter buffer zone for a total of approximately 18.3 acres. The project will also include a walkover survey for gamma radiation across a small area known as the “background area” (see Appendix A for map). A few soil samples approximately 3 inches in diameter and up to 6 inches deep will be collected by hand in these areas. The proposed action would result in a short term increase in human activity within the PPA at varying degrees depending on the project phase:

- Phase I: Spring of 2016 activity would entail pedestrian biological surveys and land surveying. During 2016, work would entail pedestrian activity including gamma surveys, mapping, well sampling, and surface soil sampling. For this phase, there will be a maximum of 5 people onsite for no more than 5 to 7 days. Surface disturbance would be minimal and noise would be light.

- Phase II: Beginning in 2017, equipment including an excavator or small mobile drilling unit may be used to collect one or more soil samples. Up to 8 people may be onsite all day for a period of one week. Equipment travel would be confined to a temporary travel corridor approximately 20 feet in width. Within the travel corridor, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site.

Best Management Practices (BMPs) incorporated into project design will reduce potential impacts including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

5.1.1. Golden eagle, Ferruginous hawk

Habitat potential was assessed for the golden eagle and ferruginous hawk within the action area. ACI biologists determined the sandstone cliffs within and surrounding the site to be potential nesting habitat for this species and conducted follow up surveys to closely examine the cliff faces for any signs of use. Observations following Navajo Natural Heritage Program (NNHP) protocol were conducted during April 2016. ACI biologists did not see any sign of use by these species including old or inactive nests.

Phase I:
Noise and surface disturbance will be low and short term during pedestrian survey activity. Adult raptors would not be directly impacted by Phase I because of their mobility and ability to avoid areas of human activity. The area is not currently occupied as a nest territory; Phase I activities that may occur within the breeding season are unlikely to discourage adults from selecting the area as a new nest territory. Direct and indirect effects from Phase I are expected to be short term and negligible.

Phase II:
During Phase II, noise may be moderate for a short duration, and surface disturbance will be light to moderate within a minimal footprint at the study area. No permanent structures will be left on site. Adult raptors would not be directly harmed by Phase II activities because of their mobility and ability to avoid areas of human activity. The area is not currently occupied as a nest territory; Phase II activities that may occur within the breeding season may discourage adults from selecting the area as a new nest territory. Nest initiation or new nesting activity within the PPA is not expected to be directly impacted if activities occur outside of the raptor breeding season for the region: for golden eagle, 15 January to 15 July; and for ferruginous hawk, 1 March to 1 May for nests with no eggs and until mid to late July for productive nests (Navajo Nation Division of Natural Resources, Department of Fish and Wildlife 2008b).

5.1.2. Migratory Birds

The PPA encompasses approximately 18.3 acres of potential migratory bird habitat mainly in the form of rocky ledges. No trees would be removed as a result of the proposed project.

Phase I:
Noise and surface disturbance will be low during pedestrian survey activity. Adult migratory birds would not be directly impacted by Phase I because of their mobility and ability to avoid areas of human activity. Minor human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time. Direct and indirect effects are expected to be short term and negligible.

Phase II:
Adult migratory birds would not be directly harmed by the activities because of their mobility and ability to avoid areas of human activity. During Phase II, noise may be moderate but for a short duration, and surface disturbance will be light to moderate but confined to a minimal footprint within the study area. No permanent structures will be left on site. Direct impacts are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15); however, surface disturbance will be confined to a minimal footprint (likely less than one acre) within the study area. The increased human presence during project activities within the breeding season may indirectly disturb or displace adults from nests and foraging habitats for a short period of time.

5.2. Cumulative Effects

Cumulative impacts of an action include the total effects on a resource or ecosystem. Cumulative effects in the context of the Endangered Species Act pertain to non-Federal actions, and are reasonably certain to occur in the action area [USFWS 1998].

5.2.1. Golden eagle, Ferruginous hawk

Additional existing surface disturbances within the action area include unimproved access roads to the residences nearby, all-terrain vehicle use and active wildlife and livestock grazing. Local plant and animal pest control are also activities that may occur in the vicinity. These foreseeable actions would cumulatively impact raptors through habitat loss or contamination. Human activity may also increase available prey base if the activity leads to an increase in rodent population numbers. The intensity of indirect effects would be dependent upon the species, its life history, time of year and/or day and the type and level of human and vehicular activity is occurring.

5.2.2. Migratory Birds

With the implementation of BMPs discussed in Section 5.1, the cumulative impact of the proposed action on migratory birds would be low based on the minimal surface disturbance involved and the availability of adjacent similar habitats.

6. CONCLUSIONS

U.S. Fish and Wildlife Service Listed Species (USFWS)

ACI conducted informal consultation with the USFWS and received an Official Species List for the proposed project area. Qualified ACI biologists evaluated habitat suitability within and surrounding the PPA for these species and concluded the potential does not exist for USFWS-listed species to occur within the proposed project area. No further consultation with the USFWS is required.

Migratory Birds

The proposed action phases would result in varying degrees of noise and surface disturbance within approximately 18.3 acres of potential migratory bird habitat mainly in the form of rocky ledges. During Phase I, noise and surface disturbance will be low during pedestrian survey activity. Direct and indirect effects are expected to be short term and negligible. For Phase II, the total surface disturbance is unknown at this point; however equipment movement would be confined to only a few temporary travel corridors. Within the travel corridors, vegetation and surface soil would sustain some disturbance but would not be bladed or bulldozed. Possible direct impacts would be short term and are more likely if surface disturbing activities occur during the breeding season (April 1 through August 15). Effects to potential habitat for migratory birds is anticipated to be minor and short term due to the limited degree of vegetation and soil disruption and the abundance of adjacent habitat for these species.

Wetlands

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value. No impacts to wetlands are anticipated. The proposed project activities would contribute to a negligible increase in sedimentation down gradient of the project area. This increase is not anticipated to be a factor due to the distance from perennial waters. There is no suitable habitat for ESA-listed fish, nor critical habitats thereof, within 20 miles of the PPA.

Navajo Endangered Species List (NESL) and Species of Concern

Two (2) NESL and Navajo species of concern have potential to occur within of near the PPA based on habitat suitability or actual record of observation. Based on site surveys, ACI determined the PPA contains potential foraging and nesting habitat for the following: golden eagle and ferruginous hawk.

Potential effects to these species are discussed in detail in Section 5 above. The short term increased human activity and ground disturbance associated with Phase II of the project may have some impact on these species; however, with the implementation of recommendations discussed in Section 7 below, it is unlikely that the proposed action would result in detriment to the two (2) NESL and Navajo species of concern.

7. RECOMMENDATIONS FOR AVOIDANCE

ACI recommends that the proponent implement standard Best Management Practices (BMPs) designed to protect sensitive wildlife species during project activity including: confining equipment travel to PPA boundary, minimizing travel corridors as much as practicable, limiting truck and equipment travel within the PPA when surfaces are wet and soil may become deeply rutted, and using previously disturbed areas for travel when possible.

8. SUPPORTING INFORMATION

8.1. Consultation and Coordination

John Nystedt, Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001

Pam Kyselka, Project Reviewer and
Chad Smith, Zoologist
Navajo Nation Department of Fish and Wildlife
Natural Heritage Program
PO Box 1480
Window Rock, AZ 86515

8.2. Report Preparers and Certification

Adkins Consulting, Inc.
180 E. 12th Street, Unit 5
Durango, Colorado 81301
Lori Gregory, Biologist; Sarah McCloskey, Field Biologist; Arnold Clifford, Lead Field Biologist

It is believed by Adkins Consulting that the proposed action would not violate any of the provisions of the Endangered Species Act of 1973, as amended. Conclusions are based on actual field examination and are correct to the best of my knowledge.

1 August 2016

______________________________ ________
Lori Gregory
Wildlife Biologist
Adkins Consulting
505.787.4088

Date

8.3. References

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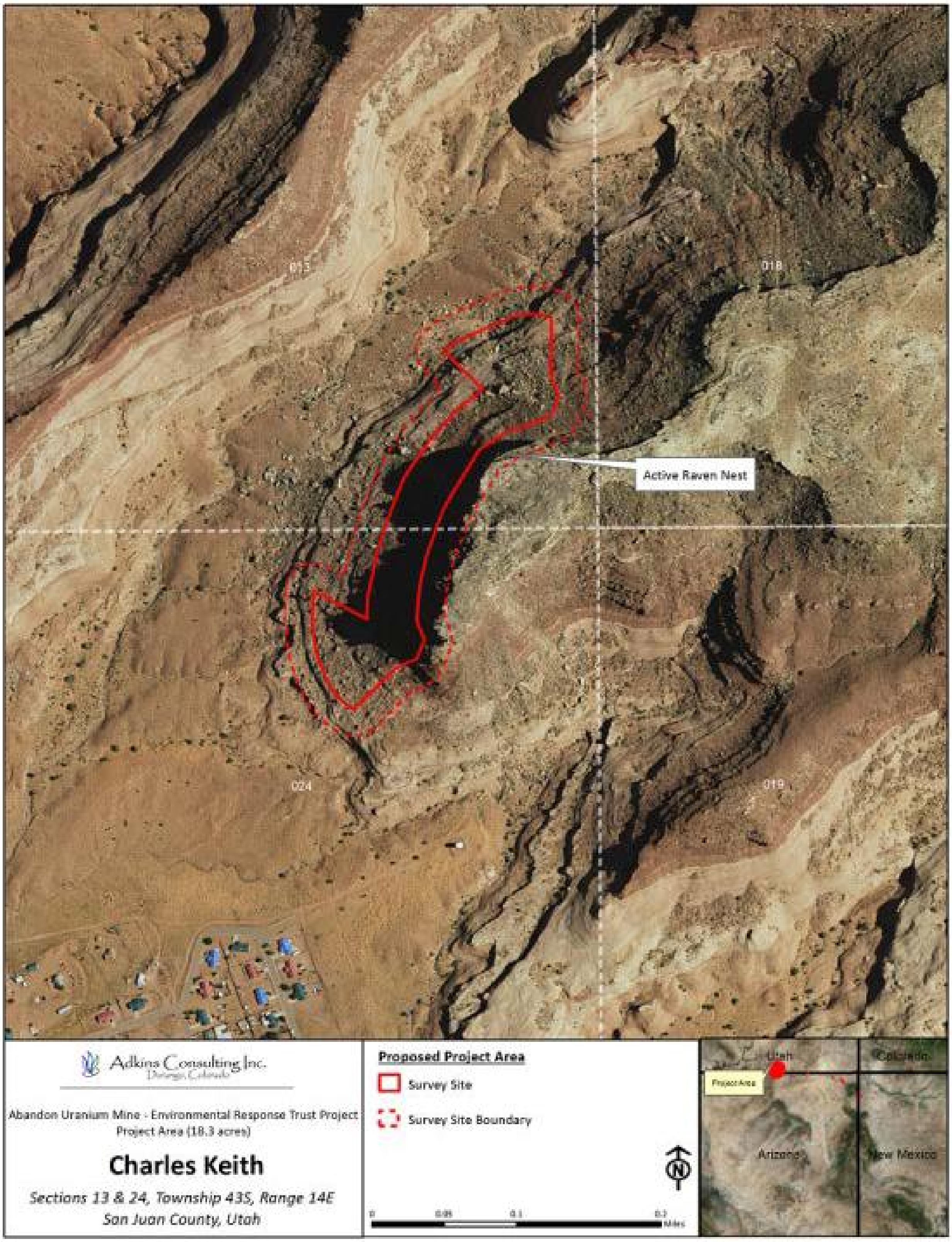
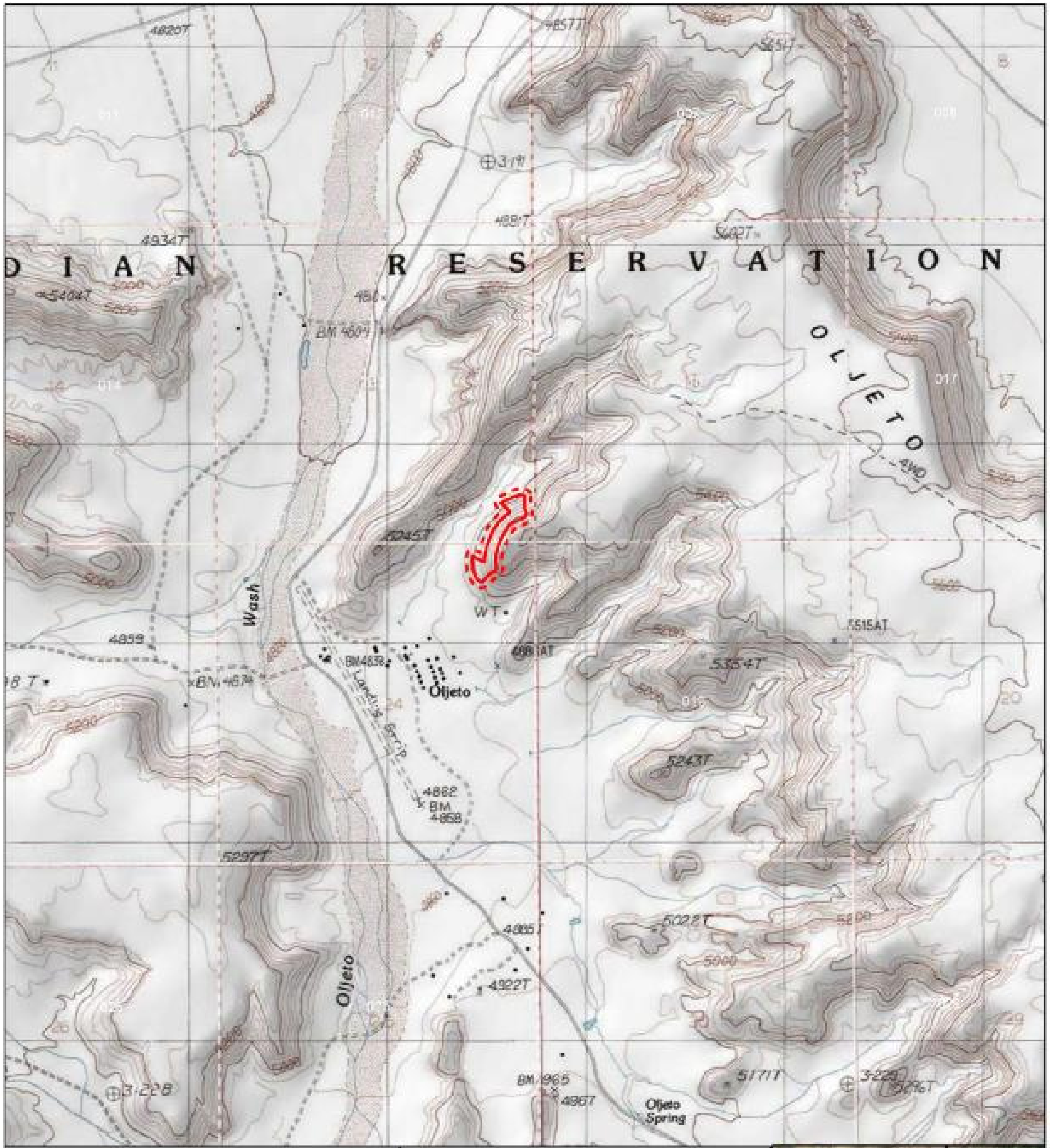
APPENDIX A. MAPS





Adkins Consulting Inc.
Durango, Colorado

Abandon Uranium Mine - Environmental Response Trust Project
Project Area (18.3 acres)

Charles Keith

Sections 13 & 24, Township 43S, Range 14E
San Juan County, Utah

Proposed Project Area

🟥 Survey Site

⬚ Survey Site Boundary

N

0 0.25 0.5 1 Miles

APPENDIX B. PHOTOGRAPHS

Looking north from PPA

Looking northwest from PPA

View northeast part way up canyon that runs at base of PPA

Top of canyon looking southwest

View east from west side of PPA

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust

Plant Survey Report for Species of Concern At Charles Keith Project Site

San Juan County, Utah

August 2016

Prepared by:
Redente Ecological Consultants
1322 Alene Circle
Fort Collins, CO 80525

TABLE OF CONTENTS

INTRODUCTION

Purpose of Report

A biological survey was conducted at the Charles Keith site as part of the Navajo Nation AUM Environmental Response Trust Project. The purpose of the survey is to determine if plant species of concern are present within the claim boundary and extending 100 feet around the site. Biological clearance is required at each site prior to any site investigation to determine if the project may affect potential species-of-concern or potential federal threatened and endangered (T&Es) species and/or critical habitat.

Site Location

Charles Keith is located in San Juan County Utah, just to the north of Oljato, Utah at an elevation of approximately 1,585 m (5,200 ft). Global Positioning System coordinates are 37° 02' 31" N by 110° 18' 30" W (North American Datum of 1983). The site is located on Tribal Trust Land (TTL).

Environmental Setting

Climate

The climate of the Charles Keith site is classified as arid, with an average annual precipitation of 182 mm (7.2 in) with the greatest precipitation months occurring between July and October (USDA 1980). Average annual temperature is 13.9° C (57° F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for the Navajo Indian Reservation—San Juan County, Utah was published in 1980 in cooperation with the Bureau of Indian Affairs. The survey includes the area where Charles Keith is located. The Mota-Moenkopie-Rock Outcrop is the primary soil mapping unit on the Charles Keith site. The soil is classified as Moenkopie and is formed in residuum from sandstone and shale. The soil is well drained and the rock outcrop consists of exposed interbedded sandstone and shale bedrock.

Plant Community Type

The vegetation on the Charles Keith site is part of the Colorado Plateau Shrub-Grassland type (USDA 1980). The most common species on the site include blue grama (*Bouteloua gracilis*), Indian ricegrass (*Achnatherum hymenoides*), galleta (*Pleuraphis jamesii*), alkali sacaton (*Sporobolus airoides*), broom snakeweed (*Gutierrizia sarathrae*), shadscale saltbush (Atriplex confertifolia), fourwing saltbush (*Atriplex canescens*), blackbrush (*Coleogyne ramosissima*), Mormon tea (*Ephedra viridis*), rubber rabbitbrush (*Ericamera nauseosa*), cliffrose (*Purshia stansburiana*), and yucca (*Yucca baileyi*).

Land Use

The land type on the Charles Keith site is rangeland and the principal land use is wildlife habitat.

REGULATORY SETTING

The survey for vegetation species-of-concern was conducted according to the Navajo Natural Heritage Program (NNHP) guidelines and the Endangered Species Act (ESA), including the procedures set forth in the *Biological Resource Land Use Clearance Policies and Procedures* (RCP), RCS-44-08 (NNDFW 2008), the Species Accounts document (NNHP 2008), and the USFWS survey protocols and recommendations. Data requests for species of concern were submitted to the NNHP and for federal T&E species to the USFWS. NNHP responded to the request for species of concern with a letter to MWH dated 19 November 2015. The letter provided a list of species of concern known to occur within the proximity of the project area. The list of species included their status as either NESL (Navajo Endangered Species List), Federally Endangered, Federally Threatened, or Federal Candidate. Species were further classified as G2, G3 or G4. G2 includes endangered species or subspecies whose prospects of survival or recruitment are in jeopardy. G3 includes endangered species or subspecies whose prospects of survival or recruitment are likely to be in jeopardy in the foreseeable future. G4 are “candidates” and includes those species or subspecies which may be endangered but for which we lack sufficient information to support being listed.

The Navajo Natural Heritage Program and the USFWS listed Navajo sedge (*Carex specuicola*) as the one endangered plant species of concern that may occur in the project area.

METHODS

Study Area

The area evaluated for plant species of concern was defined by the claim boundary, with an additional 100 foot buffer around all sides.

Database Queries and Literature Review

Prior to initiating field surveys, a target list of all potentially occurring species of concern identified by NNHP and the USFWS was compiled. Ecologic and taxonomic information was reviewed for each species prior to initiating field work to better understand ecological characteristics of the species, habitat requirements and key taxonomic indicators for proper identification (ANPS 2000).

Rare Plant Survey Protocols

The plant survey followed currently accepted resource agency protocols and guidelines, for conducting and reporting botanical inventories for special status plant species (USFWS 1996). According to these protocols, rare plant surveys were conducted by botanists with considerable experience with the local flora. All species observed during the surveys were identified to the degree necessary to correctly identify the species and determine if the plant had special status. The survey was conducted in the summer (July) of 2016 during the appropriate season to observe the phenological characteristics of the special status plant species that were necessary for identification.

The botanical survey team was assisted during the survey by GIS trained staff from MWH with training specifically in the use of the Garmin Montana 600. The GPS operator was also instructed in sight identification of species of concern to help delineate points or polygons and other data collection and data management tasks. GPS units were preloaded for the plant team with background and data files that showed the aerial photographic base map, the site boundaries, and the study area, so team members could clearly identify their exact location in the field at all times.

2016 Field Survey

The project site was surveyed by a field botanist. The botanist walked “transect” lines through each area and looked for suitable habitat for *Carex specuicola*, specifically seeps and hanging gardens. The most emphasis was placed in areas with suitable habitat for the species of concern. If the species of concern was identified, the location would be recorded using the point or polygon feature in the GPS units. Further, the population size was planned to be obtained either by direct counts, estimations, or by sampling the population.

Field botanists documented every field visit on field forms, by area, and took photographs of field conditions and species of concern, if found on site. The botanist also recorded all plant communities and plant species observed during each field visit. Plant community types were also photographed to document site conditions (Photos #1 and #2).

RESULTS

One plant species of concern, *Carex specuicola*, was identified as potentially occurring within the proximity of the project area. *Carex specuicola* is a native perennial grass-like plant that grows in seeps and hanging gardens primarily on sandstone cliffs and alcoves. Known populations occur at elevations between 1,402 and 2,195 m (4,600 and 7,201 ft) in San Juan County and northern Arizona.

The survey at Charles Keith on July 22, 2016 did not identify *Carex specuicola* on the Charles Keith site. This species occurs in seeps, alcoves or hanging gardens and this habitat was not found on the site.

Photo #1—Overview of general landscape and plant community at Charles Keith.

Photo #2—Overview of general landscape and plant community at Charles Keith.

REFERENCES

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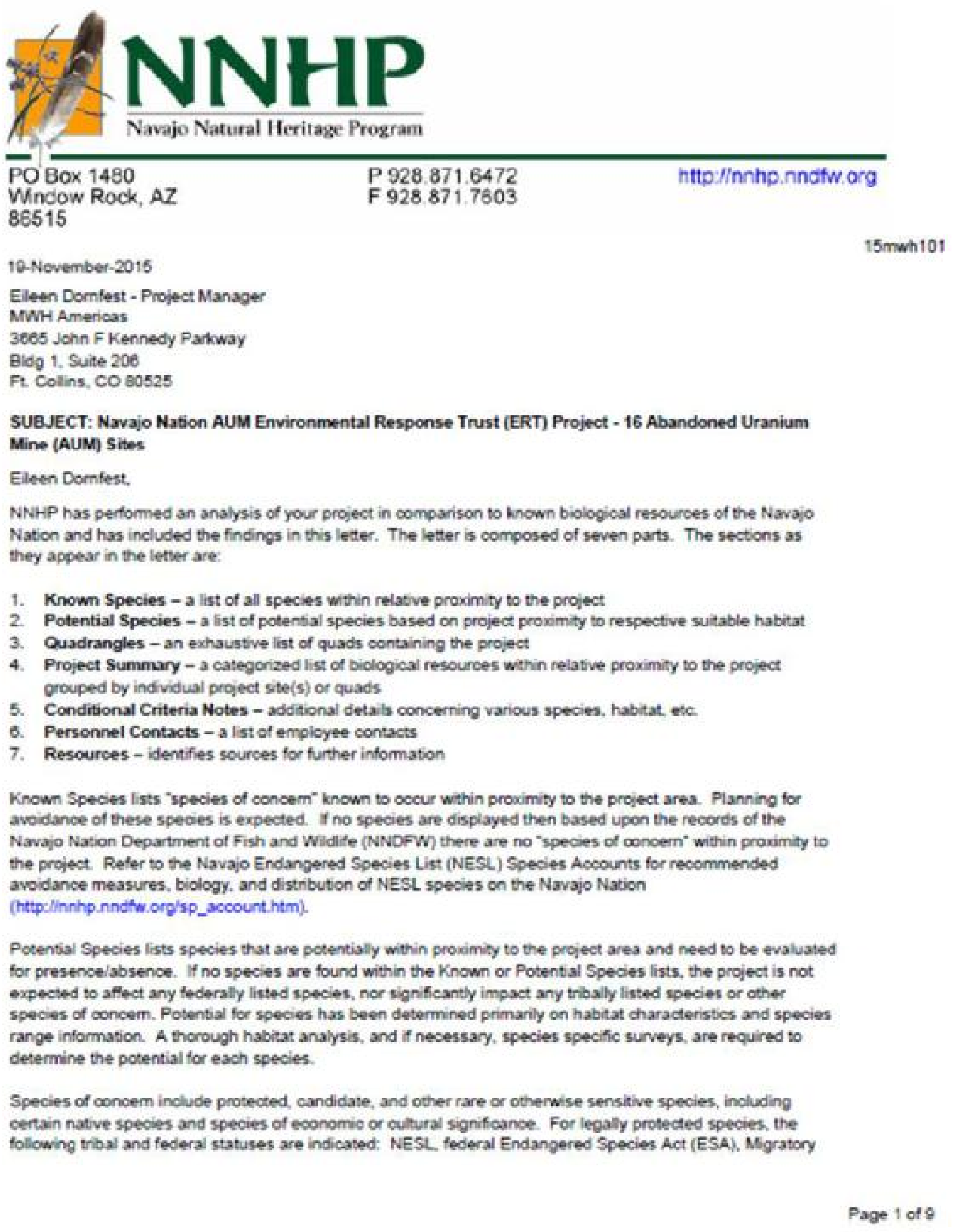
LIST OF PREPARERS

Redente, Edward F. Plant Ecologist. B.A., M.S. and Ph.D. Over 40 years of experience in plant ecology and plant survey studies throughout the semi-arid and arid western U.S. Author or Co-author of over 200 publications.

APPENDIX D. NESL LETTER



NNHP
Navajo Natural Heritage Program

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http://nnhp.nndfw.org

15mwh101

19-November-2015

Eileen Dornfest - Project Manager
MWH Americas
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525

SUBJECT: Navajo Nation AUM Environmental Response Trust (ERT) Project - 16 Abandoned Uranium Mine (AUM) Sites

Eileen Dornfest,

NNHP has performed an analysis of your project in comparison to known biological resources of the Navajo Nation and has included the findings in this letter. The letter is composed of seven parts. The sections as they appear in the letter are:

1. **Known Species** – a list of all species within relative proximity to the project
2. **Potential Species** – a list of potential species based on project proximity to respective suitable habitat
3. **Quadrangles** – an exhaustive list of quads containing the project
4. **Project Summary** – a categorized list of biological resources within relative proximity to the project grouped by individual project site(s) or quads
5. **Conditional Criteria Notes** – additional details concerning various species, habitat, etc.
6. **Personnel Contacts** – a list of employee contacts
7. **Resources** – identifies sources for further information

Known Species lists "species of concern" known to occur within proximity to the project area. Planning for avoidance of these species is expected. If no species are displayed then based upon the records of the Navajo Nation Department of Fish and Wildlife (NNDFW) there are no "species of concern" within proximity to the project. Refer to the Navajo Endangered Species List (NESL) Species Accounts for recommended avoidance measures, biology, and distribution of NESL species on the Navajo Nation (http://nnhp.nndfw.org/sp_account.htm).

Potential Species lists species that are potentially within proximity to the project area and need to be evaluated for presence/absence. If no species are found within the Known or Potential Species lists, the project is not expected to affect any federally listed species, nor significantly impact any tribally listed species or other species of concern. Potential for species has been determined primarily on habitat characteristics and species range information. A thorough habitat analysis, and if necessary, species specific surveys, are required to determine the potential for each species.

Species of concern include protected, candidate, and other rare or otherwise sensitive species, including certain native species and species of economic or cultural significance. For legally protected species, the following tribal and federal statuses are indicated: NESL, federal Endangered Species Act (ESA), Migratory

Bird Treaty Act (MBTA), and Eagle Protection Act (EPA). No legal protection is afforded species with only ESA candidate, NESL group 4 status, and species listed on the Sensitive Species List. Please be aware of these species during surveys and inform the NNDFW of observations. Reported observations of these species and documenting them in project planning and management is important for conservation and may contribute to ensuring they will not be up listed in the future.

In any and all correspondence with NNDFW or NNHP concerning this project please cite the Data Request Code associated with this document. It can be found in this report on the top right corner of the every page. Additionally please cite this code in any biological evaluation documents returned to our office.

1. Known Species *(NESL=Navajo Endangered Species List, FE=Federally Endangered, FT=Federally Threatened, FC=Federal Candidate)*

Species

AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4

**All or parts of this project currently are within areas protected by the Golden and Bald Eagle Nest Protection Regulations; consult with NNDFW zoologist or EA Reviewer for more information and recommendations.

2. Potential Species

Species

ALGO = Allium gooddingii / Gooding's Onion NESL G3
AMPE = Amsonia peeblesii / Peebles' Blue-star NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
ASBE = Astragalus beathii / Beath Milk-vetch NESL G4
ASNA = Astragalus naturitensis / Naturita Milk-vetch NESL G3
ASWE = Asclepias welshii / Welsh's Milkweed NESL G3 FT
ATCU = Athene cunicularia / Burrowing Owl NESL G4
BURE = Buteo regalis / Ferruginous Hawk NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
CHMO = Charadrius montanus / Mountain Plover NESL G4
CIME = Cinclus mexicanus / American Dipper NESL G3
CIRY = Cirsium rydbergii / Rydberg's Thistle NESL G4
CYUT = Cystopteris utahensis / Utah Bladder-fern NESL G4
EMTREX = Empidonax traillii extimus / Southwestern Willow Flycatcher NESL G2 FE
ERAC = Erigeron acomanus / Acoma Fleabane NESL G3
ERRH = Erigeron rhizomatus / Rhizome Fleabane/zuni Fleabane NESL G2 FT
ERRO = Errazurizia rotundata / Round Dunebroom NESL G3
ERSI = Erigeron sivinskii / Sivinski's Fleabane NESL G4
FAPE = Falco peregrinus / Peregrine Falcon NESL G4
GIRO = Gila robusta / Roundtail Chub NESL G2
LENA = Lesquerella navajoensis / Navajo Bladderpod NESL G3
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
MUNI = Mustela nigripes / Black-footed Ferret NESL G2 FE

PEAMCI = Perognathus amplus cineris / Wupatki Pocket Mouse NESL G4
PLZO = Platanthera zothecina / Alcove Bog-orchid NESL G3
PRSP = Primula specuicola / Cave Primrose NESL G4
PTLU = Ptchocheilus lucius / Colorado Pikeminnow NESL G2
PUPA = Puccinellia parishii / Parish's Alkali Grass NESL G4
SAPAER = Salvia pachyphylla ssp eremopictus / Arizona Rose Sage NESL G4
STOCLU = Strix occidentalis lucida / Mexican Spotted Owl NESL G3 FT
VUMA = Vulpes macrotis / Kit Fox NESL G4
ZIVA = Zigadenus vaginatus / Alcove Death Camass NESL G3

3. Quadrangles (7.5 Minute)

Quadrangles

Cameron SE (35111-G3) / AZ
Dalton Pass (35108-F3) / NM
Del Muerto (36109-B4) / AZ
Dos Lomas (35107-C7) / NM
Gallup East (35108-E6) / NM
Garnet Ridge (36109-H7) / AZ, UT
Horse Mesa (36109-F1) / AZ, NM
Indian Wells (35110-D1) / AZ
Mexican Hat SE (37109-A7) / UT, AZ
Oljeto (37110-A3) / UT, AZ
Toh Atin Mesa East (36109-H3) / AZ, UT
Toh Atin Mesa West (36109-H4) / AZ, UT

4. Project Summary *(EO1 Mile/EO 3 Miles=elements occuring within 1 & 3 miles., MSO=mexican spotted owl PACs, POTS=potential species, RCP=Biological Areas)*

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Alongo Mines	None	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Barton 3	None	None	Toh Atin Mesa West (36109-H4) / AZ, UT	None	PTLU, GIRO, EMTREX, CHMO, BURE, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP	Area 3
Boyd Tisi No. 2 Western	None	AMPE, PEAMCI, LIPI	Cameron SE (35111-G3) / AZ	None	LIPI, PEAMCI, FAPE, EMTREX, BURE, AQCH, ERRO, ASBE, AMPE	Area 3
Charles Keith	None	None	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 1, Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Eunice Becenti	None	None	Gallup East (35108-E6) / NM	None	FAPE, EMTREX, ATCU, AQCH, LENA, ERSI, ERRH, ERAC	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Garnet Ridge (36109-H7) / AZ, UT	None	VUMA, LIPI, FAPE, EMTREX, CIME, BURE, ATCU, AQCH, ZIVA, PUPA, PRSP, PLZO, CIRY, CASP, ASWE	Area 3
Harvey Blackwater No. 3	AQCH	AQCH, PUPA	Mexican Hat SE (37109-A7) / UT, AZ	None	VUMA, FAPE, EMTREX, ATCU, AQCH, ZIVA, PLZO, CIRY, CASP, ASWE	Area 1
Hoskie Tso No. 1	AQCH	AQCH	Indian Wells (35110-D1) / AZ	None	FAPE, CHMO, BURE, ATCU, AQCH, SAPAER	Area 3
Mitten No. 3	None	AQCH	Oljeto (37110-A3) / UT, AZ	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH	Area 3
NA-0904	None	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
NA-0928	None	None	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, ATCU, AQCH, PUPA	Area 3
Oak124, Oak125	AQCH	AQCH	Horse Mesa (36109-F1) / AZ, NM	None	LIPI, FAPE, EMTREX, CHMO, BURE, AQCH, ZIVA, PUPA, PLZO, CIRY, CASP	Area 3
Occurrence B	None	AQCH, CASP	Del Muerto (36109-B4) / AZ	None	LIPI, FAPE, EMTREX, CIME, AQCH, ZIVA, PLZO, CYUT, CIRY, CASP, ALGO	Area 3
Section 26 (Desiddero Group)	None	None	Dos Lomas (35107-C7) / NM	None	FAPE, CHMO, ATCU, AQCH	Area 3
Standing Rock	None	None	Dalton Pass (35108-F3) / NM	None	VUMA, MUNI, FAPE, CHMO, BURE, ATCU, AQCH, ERSI, ASNA	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
Tsosie 1	AQCH	AQCH	Toh Atin Mesa East (36109-H3) / AZ, UT	None	STOCLU, LIPI, PTLU, GIRO, FAPE, EMTREX, CHMO, AQCH, PUPA	Area 1, Area 3

5. Conditional Criteria Notes

(Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)

A. **Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.
The following is a brief summary of six (6) wildlife areas:
1.***Highly Sensitive Area*** – recommended no development with few exceptions.
2.***Moderately Sensitive Area*** – moderate restrictions on development to avoid sensitive species/habitats.
3.***Less Sensitive Area*** – fewest restrictions on development.
4.*Community Development Area* – areas in and around towns with few or no restrictions on development.
5.***Biological Preserve*** – no development unless compatible with the purpose of this area.
6.*Recreation* ***Area*** – no development unless compatible with the purpose of this area.
None - outside the boundaries of the Navajo Nation
This is not intended to be a full description of the RCP please refer to the our website for additional information at http://www.nndfw.org/clup.htm.

B. **Raptors** – If raptors are known to occur within 1 mile of project location: Contact Chad Smith at 871-7070 regarding your evaluation of potential impacts and mitigation.
o **Golden and Bald Eagles**- If Golden or Bald Eagle are known to occur within 1 mile of the project, decision makers need to ensure that they are not in violation of the Golden and Bald Eagle Nest Protection Regulations found at http://nnhp.nndfw.org/docs_reps/gben.pdf.
o **Ferruginous Hawks** – Refer to "Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection" http://nnhp.nndfw.org/docs_reps.htm for relevant information on avoiding impacts to Ferruginous Hawks within 1 mile of project location.
o **Mexican Spotted Owl** - Please refer to the Navajo Nation Mexican Spotted Owl Management Plan http://nnhp.nndfw.org/docs_reps.htm for relevant information on proper project planning near/within spotted owl protected activity centers and habitat.

C. **Surveys** – Biological surveys need to be conducted during the appropriate season to ensure they are complete and accurate please refer to NN Species Accounts http://nnhp.nndfw.org/sp_account.htm. Surveyors on the Navajo Nation must be permitted by the Director, NNDFW. Contact Jeff Cole at (928) 871-7068 for permitting procedures. Questions pertaining to surveys should be directed to the NNDFW Zoologist (Chad Smith) for animals at 871-7070, and Botanist (Andrea Hazelton) for plants at (928)523-3221. Questions regarding biological evaluation should be directed to Jeff Cole at 871-7068.

D. **Oil/Gas Lease Sales** – Any settling or evaporation pits that could hold contaminants should be lined and covered. Covering pits, with a net or other material, will deter waterfowl and other migratory bird use. Lining pits will protect ground water quality.

E. **Power line Projects** – These projects need to ensure that they do not violate the regulations set forth in the Navajo Nation Raptor Electrocution Prevention Regulations found at http://nnhp.nndfw.org/docs_reps/repr.pdf.

F. **Guy Wires** – Does the project design include guy wires for structural support? If so, and if bird species may occur in relatively high concentrations in the project area, then guy wires should be equipped with highly visual markers to reduce the potential mortality due to bird-guy wire collisions. Examples of visual markers include aviation balls and bird flight diverters. Birds can be expected to occur in relatively high concentrations along migration routes (e.g., rivers, ridges or other distinctive linear topographic features) or where important habitat for breeding, feeding, roosting, etc. occurs. The U.S. Fish and Wildlife Service recommends marking guy wires with at least one marker per 100 meters of wire.

G. **San Juan River** – On 21 March 1994 (Federal Register, Vol. 59, No. 54), the U.S. Fish and Wildlife Service designated portions of the San Juan River (SJR) as critical habitat for Ptychocheilus lucius (Colorado pikeminnow) and Xyrauchen texanus (Razorback sucker). Colorado pikeminnow critical habitat includes the SJR and its 100-year floodplain from the State Route 371 Bridge in T29N, R13W, sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian) up to the full pool elevation. Razorback sucker critical habitat includes the SJR and its 100-year floodplain from the Hogback Diversion in T29N, R16W, sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian). All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of critical habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

H. **Little Colorado River** - On 21 March 1994 (Federal Register, Vol. 59, No. 54) the U.S. Fish and Wildlife Service designated Critical Habitat along portions of the Colorado and Little Colorado Rivers (LCR) for Gila cypha (humpback chub). Within or adjacent to the Navajo Nation this critical habitat includes the LCR and its 100-year floodplain from river mile 8 in T32N R6E, sec. 12 (Salt and Gila River Meridian) to its confluence with the Colorado River in T32N R5E sec. 1 (S&GRM) and the Colorado River and 100-year floodplain from Nautuloid Canyon (River Mile 34) T36N R5E sec. 35 (S&GRM) to its confluence with the LCR. All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of Critical Habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

I. **Wetlands** – In Arizona and New Mexico, potential impacts to wetlands should also be evaluated. The U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI) maps should be examined to determine whether areas classified as wetlands are located close enough to the project site(s) to be impacted. In cases where the maps are inconclusive (e.g., due to their small scale), field surveys must be completed. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. NWI maps are available for examination at the Navajo Natural Heritage Program (NNHP) office, or may be purchased through the U.S. Geological Survey (order forms are available through the NNHP). The NNHP has complete coverage of the Navajo Nation, excluding Utah, at 1:100,000 scale; and coverage at 1:24,000 scale in the southwestern portion of the Navajo Nation. In Utah, the U.S. Fish & Wildlife Service's National Wetlands Inventory maps are not yet available for the Utah portion of the Navajo Nation, therefore, field surveys should be completed to determine whether wetlands are located close enough to the project site(s) to be impacted. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. For more information contact the Navajo Environmental Protection Agency's Water Quality Program.

J. **Life Length of Data Request** – The information in this report was identified by the NNHP and NNDFW's biologists and computerized database, and is based on data available at the time of this response. If project planning takes more than two (02) years from the date of this response, verification of the information provided herein is necessary. It should not be regarded as the final statement on the occurrence of any species, nor should it substitute for on-site surveys. Also, because the NNDFW information is continually updated, any given information response is only wholly appropriate for its respective request.

K. **Ground Water Pumping** - Projects involving the ground water pumping for mining operations, agricultural projects or commercial wells (including municipal wells) will have to provide an analysis on the effects to surface water and address potential impacts on all aquatic and/or wetlands species listed below. NESL Species potentially impacted by ground water pumping: Carex specuicola (Navajo Sedge), Cirsium rydbergii (Rydberg's Thistle), Primula specuicola (Cave Primrose), Platanthera zothecina (Alcove Bog Orchid), Puccinellia parishii (Parish Alkali Grass), Zigadenus vaginatus (Alcove Death Camas), Perityle specuicola (Alcove Rock Daisy), Symphyotrichum welshii (Welsh's American-aster), Coccyzus americanus (Yellow-billed Cuckoo), Empidonax traillii extimus (Southwestern Willow Flycatcher), Rana pipiens (Northern Leopard Frog), Gila cypha (Humpback Chub), Gila robusta (Roundtail Chub), Ptychocheilus lucius (Colorado Pikeminnow), Xyrauchen texanus (Razorback Sucker), Cinclus mexicanus (American Dipper), Speyeria nokomis (Western Seep Fritillary), Aechmophorus clarkia (Clark's Grebe), Ceryle alcyon (Belted Kingfisher), Dendroica petechia (Yellow Warbler), Porzana carolina (Sora), Catostomus discobolus (Bluehead Sucker), Cottus bairdi (Mottled Sculpin), Oxyloma kanabense (Kanab Ambersnail)

6. Personnel Contacts

Wildlife Manager
Sam Diswood
928.871.7062
sdiswood@nndfw.org

Zoologist
Chad Smith
928.871.7070
csmith@nndfw.org

Botanist
Vacant

Biological Reviewer
Pamela Kyselka
928.871.7065
pkyselka@nndfw.org

GIS Supervisor
Dexter D Prall
928.645.2898
prall@nndfw.org

Wildlife Tech
Sonja Detsoi
928.871.6472
sdetsoi@nndfw.org

7. Resources

National Environmental Policy Act

Navajo Endangered Species List:
http://nnhp.nndfw.org/endangered.htm

Species Accounts:
http://nnhp.nndfw.org/sp_account.htm

Biological Investigation Permit Application
http://nnhp.nndfw.org/study_permit.htm

Navajo Nation Sensitive Species List
http://nnhp.nndfw.org/study_permit.htm

Various Species Management and/or Document and Reports
http://nnhp.nndfw.org/docs_reps.htm

Consultant List
(Coming Soon)

Dexter D Prall

Digitally signed by Dexter D Prall
DN: cn=Dexter D Prall, o=Navajo Nation
Department of Fish and Wildlife, ou=Navajo
Natural Heritage Program,
email=prall@nndfw.org, c=US
Date: 2015.11.19 15:56:30 -07'00'

Dexter D Prall, GIS Supervisor - Natural Heritage Program
Navajo Nation Department of Fish and Wildlife

MWH

BUILDING A BETTER WORLD

November 18, 2015

TO: Navajo Natural Heritage Program
Navajo Nation Dept. of Fish and Wildlife
ATTN: Sonja Detsoi and Dexter Prall
P.O. Box 1480
Window Rock, AZ 86515

FROM: MWH Americas
ATTN: Eileen Dornfest, Project Manager
3665 John F Kennedy Parkway
Bldg 1, Suite 206
Ft. Collins, CO 80525
Phone: (970) 377-9410
Fax: (970) 377-9406
E-mail: Eileen.Dornfest@mwhglobal.com

SUBJECT: Request for T and E Information for 16 Abandoned Uranium Mine (AUM) Sites

PROJECT NAME:
Navajo Nation AUM Environmental Response Trust (ERT) Project

LOCATION:
16 AUM Sites (attached in GIS shape files and USGS topographic maps)

SUMMARY DESCRIPTION OF PROJECT:

The work is to be conducted at 16 Abandoned Uranium Mines (AUMs) and includes Removal Site Evaluations (RSEs) according to CERCLA at each of the Sites. The RSEs are site investigations that include the following activities:

- conducting background soil studies
- conducting gamma radiation scans of surface soils
- sampling surface and subsurface soils and sediments related to historic mining operations
- assessing radiation exposure inside mine operations buildings, homes, or other nearby structures (if present at the Sites)
- sampling existing and accessible groundwater wells
- mitigating physical hazards and other interim response actions
- preparing a final written report documenting the work performed and information obtained for each of the Sites

MWH

BUILDING A BETTER WORLD

TOPOGRAPHIC MAPS ATTACHED:

- Blue Gap Quadrangle, Arizona-Apache Co.
- Cameron SE Quadrangle, Arizona-Coconino Co.
- Cameron South Quadrangle, Arizona-Coconino Co.
- Del Muerto Quadrangel, Arizona-Apache Co.
- Five Buttes Quadrangle, Arizona-Navajo Co.
- Garnet Ridge Quadrangle, Arizona-Utah
- Horse Mesa Quadrangle, Arizona-New Mexico
- Indian Wells Quadrangle, Arizona-Navajo Co.
- Tah Chee Wash Quadrangle, Arizona-Apache Co.
- Toh Atin Mesa East Quadrangle, Arizona-Utah
- Toh Atin Mesa West Quadrangle, Arizona-Utah
- Bluewater Quadrangle, New Mexico
- Bread Springs Quadrangle, New Mexico-McKinley Co.
- Dalton Pass Quadrangle, New Mexico-McKinley Co.
- Dos Lomas Quadrangle, New Mexico
- Gallup East Quadrangle, New Mexico-McKinley Co.
- Sand Spring Quadrangle, New Mexico-San Juan Co.
- Standing Rock Quadrangle, New Mexico-McKinley Co.
- Mexican Hat SE Quadrangle, Utah-San Juan Co.
- Oljato Quadrangle, Utah-San Juan Co.

APPENDIX E. NOTES FROM SPECIES SPECIFIC SURVEYS

Adkins Consulting Inc.
Environmental Permitting Services

180 East 12 Street Suite #5
Durango, CO 81301
Phone: 505-793-1140

DAILY REPORT

Field Surveys

PROJECT NAME: NN AUM SITE: Charles Keith

DATE: 4/14/16

WEATHER: Partly cloudy, light breeze with occasional gusts up to 10 MPH, temps mid 60's to high 50's

PERSONNEL ONSITE: Arnold Clifford (Principal Biologist), Sarah McCloskey (Field Assistant)

==

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Golden Eagles, Ferruginous Hawks and Peregrine Falcons.

Purpose: In areas where suitable habitat occurs, a formal survey of the species is to be performed following Navajo Nation survey protocols[1] outlined below:

Golden Eagle – A single pedestrian survey with high-power optics for nest sites or breeding adults from 1 MAR-15 JUN.

Ferruginous Hawk– A single pedestrian survey with high-power optics for nest sites or breeding adults from 1 MAR-15 JUN.

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveyors arrived at the project site at 4:10 p.m. and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) and continuing father down the canyon until dark. Surveyors left the site at 8:15 p.m.

Additional Information: This concludes the required surveys for the Golden Eagle and Ferruginous Hawk at the Charles Keith site. Surveyors will revisit site tomorrow (4/15/16) to complete the morning portion of the Peregrine Falcon survey. One more complete Peregrine Falcon survey (evening and following morning) will be needed at the site before April 30th.

Adkins Consulting Inc.
Environmental Permitting Services
180 East 12 Street Suite #5
Durango, CO 81301
Phone: 505-793-1140

DAILY REPORT

Field Surveys

PROJECT NAME: NN AUM SITE: Charles Keith

DATE: 4/15/16

WEATHER: Partly cloudy, light breeze, temps mid 40’s to high 40’s

PERSONNEL ONSITE: Arnold Clifford (Principal Biologist), Sarah McCloskey (Field Assistant)

===

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Golden Eagles, Ferruginous Hawks and Peregrine Falcons. Surveys were completed for Golden Eagle and Ferruginous Hawk last night (4/14/16). The evening portion of the first Peregrine Falcon survey was also completed the last night.

Purpose: To perform the morning portion of the first Peregrine Falcon survey per Navajo Nation survey protocols[1] outlined below:

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveyors arrived at the project site at 6:20 a.m. at first light and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) and continuing father down the canyon until the 4 hour survey time limit expired. Surveyors left the site at 10:20 a.m.

Additional Information: This concludes the first of two required surveys for Peregrine Falcons. One more complete Peregrine Falcon survey (evening and following morning) will be needed at the site before April 30th.

Adkins Consulting Inc.
Environmental Permitting Services

180 East 12 Street Suite #5
Durango, CO 81301
Phone: 505-793-1140

DAILY REPORT
Field Surveys

PROJECT NAME: NN AUM SITE: Charles Keith

DATE: 4/26/16

WEATHER: Partly cloudy, light breeze with occasional gusts up to 10 MPH, temps mid 50's

PERSONNEL ONSITE: Sarah McCloskey (Principal Biologist), Maria Adkins (Field Assistant)

==

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Golden Eagles, Ferruginous Hawks and Peregrine Falcons. Surveys for Golden Eagle and Ferruginous Hawk were completed during the previous 4/14/16 survey.

Purpose: In areas where suitable habitat occurs, a formal survey of the species is to be performed following Navajo Nation survey protocols[1] outlined below:

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveyors arrived at the project site at 4:00 p.m. and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) and continuing father down the canyon until dark. Surveyors left the site at 8:00 p.m.

Additional Information: Surveyors will revisit site tomorrow (4/27/16) to complete the morning portion of the Peregrine Falcon survey which will be the last survey required before April 30th for the Charles Keith site.

Findings: The raven nest located along the eastern wall of the canyon was still active, two young were observed within the nest. No other raptors were seen or heard in the area.

Adkins Consulting Inc.
Environmental Permitting Services

180 East 12 Street Suite #5
Durango, CO 81301
Phone: 505-793-1140

DAILY REPORT
Field Surveys

PROJECT NAME: NN AUM SITE: Charles Keith

DATE: 4/27/16

WEATHER: Mostly clear, calm, temps mid 40's to high 40's

PERSONNEL ONSITE: Sarah McCloskey (Principal Biologist), Maria Adkins (Field Assistant)

CONTRACTORS ONSITE NOTES:

Background: During the previous habitat assessment survey habitat was documented for Golden Eagles, Ferruginous Hawks and Peregrine Falcons. Surveys were completed for Golden Eagle and Ferruginous Hawk on 4/14/16. The evening portion of the second Peregrine Falcon survey was completed last night.

Purpose: To perform the morning portion of the first Peregrine Falcon survey per Navajo Nation survey protocols[1] outlined below:

Peregrine Falcons - Two 8 hours surveys (4 hours before sunset and 4 hours after sunrise the following day) during each period: 1 FEB-30 APR (surveys during egg-laying/incubation discouraged) & 1 MAY-31 JUL (2 survey preferably prior to JUL). Productivity surveys require >=1 additional visits.

Methods: Surveyors arrived at the project site at 6:30 a.m. at first light and conducted a thorough survey of the project area. Surveys included establishing appropriate vantage points, remaining at those points for 20 to 30 minutes listening for calls and using high powered binoculars to examine cliff faces for signs of nesting (ex. whitewash, nests, single or pairs of adults remaining in the area, etc.) and continuing father down the canyon until the 4 hour survey time limit expired. Surveyors left the site at 10:30 a.m.

Additional Information: This concludes the second of two surveys required for Peregrine Falcons before April 30th. Two more complete Peregrine Falcon survey (two sets of evening and following morning) will be needed at the site before July 31st.

Findings: The raven nest located yesterday was still active. No other raptors were seen or heard in the area.

THE NAVAJO NATION
HISTORIC PRESERVATION DEPARTMENT
PO Box 4950, Window Rock, Arizona 86515
TEL: (928) 871-7198 **FAX:** (928) 871-7886

CULTURAL RESOURCE COMPLIANCE FORM

ROUTE COPIES TO:	**NNHPD NO.: HPD-16-588**
☑ DCRM	**OTHER PROJECT NO.: DCRM 2016-06**

PROJECT TITLE: A Cultural Resource Inventory of Eight Abandoned Uranium Mines (Northern Region) for MWH Americas, Inc. in the Western and Shiprock Agencies of the Navajo Nation, in Utah, Arizona, and New Mexico.

LEAD AGENCY: BIA/NR

SPONSOR: Sadie Hoskie, Trustee, Navajo National AUM, Environmental Response Trust, P.O. Box 3330, Window Rock, AZ 86515

PROJECT DESCRIPTION: The proposed undertaking will involve proposing to complete Removal Site Evaluations to define the horizontal extent of contamination in surface soils and sediments at the eight former uranium mine areas. The proposed undertaking may involve intensive ground disturbance with the use of heavy equipment and hand tools. The area of potential effect is 54.4-acres.

LAND STATUS:	Navajo Tribal Trust													
CHAPTER:	Oljato, Dennehotso, Mexican Water, Sweetwater, and Red Valley													
LOCATION:	T.	43	S.,	R.	24&14	E-	Sec.	14&24;	Oljato	Quadrangle,	San Juan	County	UT	SLPM
	T.	43	S.,	R.	14	E-	Sec.	13;	Oljato	Quadrangle,	San Juan	County	UT	SLPM
	T.	43	S.,	R.	19&23	E-	Sec.	UP;	Garnet Ridge	Quadrangle,	Apache	County	AZ	G&SRPM
	T.	43	N.,	R.	19	E-	Sec.	UP;	Mexican Hat	Quadrangle,	Apache	County	AZ	G&SRPM
	T.	41&40	N.,	R.	27. 28& 23	E-	Sec.	UP;	Toh Atin Mesa West	Quadrangle,	Apache	County	AZ	G&SRPM
	T	29	N.,	R.	21	W-	Sec.	UP;	Horse Mesa	Quadrangle,	San Juan	County	NM	NMPM

PROJECT ARCHAEOLOGIST:	Rena Martin
NAVAJO ANTIQUITIES PERMIT NO.:	B16728
DATE INSPECTED:	4/16/2016, 5/18/2016
DATE OF REPORT:	7/15/2016
TOTAL ACREAGE INSPECTED:	105.2 – ac
METHOD OF INVESTIGATION:	Class III pedestrian inventory with transects spaced 10 m apart.
LIST OF CULTURAL RESOURCES FOUND:	**(8) sites (UT-B-59-8, UT-C-63-12, AZ-I-5-25, AZ- I-7-72, AZ-I-6-79, NM-I-24-87, NM-I-24-88, NM-I-24-89)** **(1) In Use Area** **(23) Isolated Occurrences (IOs)**
LIST OF ELIGIBLE PROPERTIES:	**(8) sites (UT-B-59-8, UT-C-63-12, AZ-I-5-25, AZ-I-7-72, AZ-I-6-79, NM-I-24-87, NM-I-24-88, NM-I-24-89)**
LIST OF NON-ELIGIBLE PROPERTIES:	**(1) In Use Area, (23) IOs**
LIST OF ARCHAEOLOGICAL RESOURCES:	**(5) sites (UT-B-59-8, UT-C-63-12, AZ-I-7-72, AZ-I-6-79, NM-I-24-89)**

EFFECT/CONDITIONS OF COMPLIANCE: No historic properties affected with the following conditions:

Sites: UT-B-59-8, UT-C-63-12, AZ-I-5-25, AZ- I-7-72, AZ-I-6-79, NM-I-24-87, NM-I-24-89:

1. Prior to any construction, the site boundaries will be flagged and/or temporarily fenced under the direction of a qualified archaeologist & shown to the construction foreman.
2. All ground disturbance within the 50 ft. of the site boundaries will be monitored by a qualified archaeologist.
3. No construction, equipment or vehicular traffic will be allowed within the site boundaries.
4. A brief letter/report documenting the result of the monitoring will be submitted to NNHPD within 30 days of monitoring activities.
5. All future maintenance activities shall avoid the site by a minimum of 50 ft. from the site boundaries.

Site NM-I-24-88:

Given the environmental hazards the mine possesses, and the thorough extent of the ethnographic information, all research potential has been exhausted. No further work is warranted.

TCPs.

No effect by proposed undertaking.

In the event of a discovery [*"discovery"* means any previously unidentified or incorrectly identified cultural resources including but not limited to archaeological deposits, human remains, or locations reportedly associated with Native American religious/traditional beliefs or practices], all operations in the immediate vicinity of the discovery must cease, and the Navajo Nation Historic Preservation Department must be notified at (928) 871-7198.

FORM PREPARED BY: **Tamara Billie**
FINALIZED: September 9, 2016

Notification to Proceed Recommended ☑ Yes ☐ No
Conditions: ☑ Yes ☐ No
Tamara Bill 9/9/16
The Navajo Nation Historic Preservation Office Date

Navajo Region Approval ☑ Yes ☐ No
SEP 2 8 2016
Acting BIA – Navajo Regional Office Date

b
11/27/16

NNDFW Review No. 15mwh101-ck

BIOLOGICAL RESOURCES COMPLIANCE FORM
NAVAJO NATION DEPARTMENT OF FISH AND WILDLIFE
P.O. BOX 1480, WINDOW ROCK, ARIZONA 86515-1480

It is the Department's opinion the project described below, with applicable conditions, is in compliance with Tribal and Federal laws protecting biological resources including the Navajo Endangered Species and Environmental Policy Codes, U.S. Endangered Species, Migratory Bird Treaty, Eagle Protection and National Environmental Policy Acts. This form does not preclude or replace consultation with the U.S. Fish and Wildlife Service if a Federally-listed species is affected.

PROJECT NAME & NO.: Charles Keith - Abandoned Uranium Mine Project

DESCRIPTION: Proposed Phase I & II scientific investigations at an abandoned mine site. Phase I would entail biological and land surveying with a maximum of 5 people onsite for no more than 5-7 days. Disturbance would be light. Phase II would require the use of an excavator or a small mobile drilling unit to collect one or more soil samples with up to 8 people onsite for a period of one week. A temporary travel corridor 20 ft. in width would be necessary to move equipment to the site. Disturbance would be light to moderate. No permanent structures would be left onsite. The proposed project area (mine boundary and buffer) would be approximately 18.3 acres.

LOCATION: 37°02'30.4"N 110°18'30.9"W, Oljato Chapter, San Juan County, Utah

REPRESENTATIVE: Lori Gregory, Adkins Consulting, Inc. for MWH Global/Stantec

ACTION AGENCY: U.S. Environmental Protection Agency and Navajo Nation

B.R. REPORT TITLE / DATE / PREPARER: BE-Charles Keith Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At Charles Keith Project Site/AUG 2016/Redente Ecological Consultants

SIGNIFICANT BIOLOGICAL RESOURCES FOUND: Area 1 & 3. Suitable nesting habitat is present in the project area for Migratory Birds not listed under the NESL or ESA. Migratory Birds and their habitats are protected under the Migratory Bird Treaty Act (16 USC §703-712) and Executive Order 13186. Under the EO, all federal agencies are required to consider management impacts to protect migratory non-game birds.

POTENTIAL IMPACTS

NESL SPECIES POTENTIALLY IMPACTED: NA

FEDERALLY-LISTED SPECIES AFFECTED: NA

OTHER SIGNIFICANT IMPACTS TO BIOLOGICAL RESOURCES: NA

AVOIDANCE / MITIGATION MEASURES: Mitigation measures will be implemented to ensure that there are no impacts to migratory birds that could potentially nest in the project area.

CONDITIONS OF COMPLIANCE*: NA

FORM PREPARED BY / DATE: Pamela A. Kyselka/10 NOV 2016

COPIES TO: (add categories as necessary)

☐ ________________________ ☐ ________________________

2 NTC § 164 Recommendation: Signature Date
☒ Approval 11/16/16
☐ Conditional Approval (with memo)
☐ Disapproval (with memo) Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife
☐ Categorical Exclusion (with request letter)
☐ None (with memo)

*I understand and accept the conditions of compliance, and acknowledge that lack of signature may be grounds for the Department not recommending the above described project for approval to the Tribal Decision-maker.

Representative's signature Date

From: Nystedt, John
To: Justin Peterson
Cc: Lori Gregory; Pam Kyselka; tbillie@navajo-nsn.gov; Harrilene Yazzie; Melissa Mata
Subject: Navajo Nation AUM Environmental Response Trust - -First Phase
Date: Monday, November 07, 2016 4:08:30 PM
Attachments: image001.png

Justin,

Thank you for your November 6, 2016, email. This email documents our response regarding the subject project, in compliance with section 7 of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.). Based on the information you provided, we believe no endangered or threatened species or critical habitat will be affected by this project; nor is this project likely to jeopardize the continued existence of any proposed species or adversely modify any proposed critical habitat. No further review is required for this project at this time. Should project plans change or if new information on the distribution of listed or proposed species becomes available, this determination may need to be reconsidered. In all future communication on this project, please refer to consultation numbers given below.

In keeping with our trust responsibilities to American Indian Tribes, by copy of this email, we will notify the Navajo Nation, which may be affected by the proposed action and encourage you to invite the Bureau of Indian Affairs to participate in the review of your proposed action.

Should you require further assistance or if you have any questions, please contact me as indicated below, or my supervisor, Brenda Smith, at 556-2157. Thank you for your continued efforts to conserve endangered species.

Claim 28	02EAAZ00-2016-SLI-0358
Section 26 (Desiddero Group)	02ENNM00-2016-SLI-0447
Mitten #3	06E23000-2016-SLI-0210
NA-0904	02EAAZ00-2016-SLI-0363
Occurrence B	02EAAZ00-2016-SLI-0361
Standing Rock	02ENNM00-2016-SLI-0448
Alongo Mines	02ENNM00-2016-SLI-0465
Tsosie 1*	02EAAZ00-2016-SLI-0364
Boyd Tisi No. 2 Western	02EAAZ00-2016-SLI-0355
Harvey Blackwater #3	02EAAZ00-2016-SLI-0356 / 06E23000-2016-SLI-0207
Oak 124/125	02ENNM00-2016-SLI-0466
NA-0928	02EAAZ00-2016-SLI-0360
Hoskie Tso #1	02EAAZ00-2016-SLI-0362
Charles Keith	06E23000-2016-SLI-0208
Barton 3	02EAAZ00-2016-SLI-0354
Eunice Becenti	02ENNM00-2016-SLI-0444

* It is our understanding that the Tsosie No. 1 site has been put on hold indefinitely due to access issues. However, provided the results of the survey were negative (i.e., no potential for

any ESA-listed species) then we would come to the same conclusion, above, as for the other 15 projects.

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Fish and Wildlife Biologist/AESO Tribal Coordinator
USFWS AZ Ecological Services Office - Flagstaff Suboffice
Southwest Forest Science Complex, 2500 S Pine Knoll Dr, Rm 232
Flagstaff, AZ 86001-6381 (928) 556-2160 Fax-2121 Cell:(602) 478-3797
http://www.fws.gov/southwest/es/arizona/

Appendix F Data Usability Report, Laboratory Analytical Data, and Data Validation Reports

F.1 Data Usability Report

F.2 Laboratory Analytical Data and Data Validation Reports

(provided in a separate electronic file due to its file size and length)

F.1 Data Usability Report

DATA USABILITY REPORT

1.0 INTRODUCTION

This data usability report presents a summary of the validation results for the sample data collected from the Charles Keith Site (the Site) as part of the Removal Site Evaluation (RSE) performed for the Navajo Nation AUM Environmental Response Trust—First Phase. The purpose of the validation was to ascertain the data usability measured against the data quality objectives (DQOs) and confirm that results obtained are scientifically defensible.

Samples were collected between October 17, 2016 and August 24, 2017 and were analyzed by ALS Environmental of Ft. Collins, Colorado, for all methods except mercury in water. ACZ Laboratories, Inc. of Steamboat Springs, Colorado, analyzed water samples for mercury. Samples were analyzed for one or more of the following:

- Radium-226 in soil by United States Environmental Protection Agency (USEPA) Method 901.1
- Metals in soil by USEPA Method SW6020
- Isotopic thorium in soil by USDOEAS-06/EMSL/LV
- Radium-226 in water by USEPA Method 903.1
- Radium-228 in water by USEPA Method 904
- Gross alpha/beta in water by USEPA Method 900
- Total and dissolved metals in water by USEPA 200.8
- Total dissolved solids in water by USEPA 160.1
- Alkalinity in water by USEPA 310.1
- Chloride and sulfate in water by USEPA 300.0
- Total and dissolved mercury in water by USEPA Method 1631

Samples were collected and analyzed according to the procedures and specific criteria presented in the Quality Assurance Project Plan, Navajo Nation AUM Environmental Response Trust (QAPP), (MWH 2016).

Project data were validated as follows:

- Laboratory Data Consultants, Inc. (LDC) of Carlsbad, California, performed validation of all radiological soil and water data, plus ten percent of the non-radiological data (Level IV only)

- All non-radiological soil and water data were validated by the Stantec Consulting Services Inc. (Stantec; formerly MWH) Project Chemist (Level III only)
- All samples received Level III data validation
- Ten percent of the sample results for all methods received a more detailed Level IV validation

The analytical data were validated based on the results of the following data evaluation parameters or quality control (QC) samples:

- Compliance with the QAPP
- Sample preservation
- Sample extraction and analytical holding times
- Initial calibration (ICAL), initial calibration verification (ICV), and continuing calibration verification (CCV) results
- Method and initial/continuing calibration blank (ICB/CCB) sample results
- Matrix spike/matrix spike duplicate (MS/MSD) sample results
- Laboratory duplicate results
- Serial dilution (metals analysis only)
- Interference check samples (ICS) (metals analysis only)
- Laboratory control sample (LCS) and laboratory control sample duplicate (LCSD) results
- Field duplicate sample results
- Minimum detectable concentration (radiological analyses only)
- Reporting limits
- Sample result verification
- Completeness evaluation
- Comparability evaluation

Sample results that were qualified due to quality control parameters outside of acceptance criteria are listed on Table F.1-1.

2.0 DATA VALIDATION RESULTS

Stantec reviewed the data validation reports and assessed the qualified data against the DQOs for the project. The following summarizes the data validation findings for each of the data evaluation parameters.

2.1 QUALITY ASSURANCE PROJECT PLAN COMPLIANCE EVALUATION

Based on the data validation, all samples were analyzed following the quality control criteria specified in the QAPP, with the following exception: ALS routinely dilutes all metals samples by a factor of 10 times in order to protect their ICP-MS instrument from the adverse effects of running samples with high total dissolved solids. This also includes running a long series of samples (as is common in a production laboratory) with intermediate dissolved solids. The vulnerable parts of the instrument are the nebulizer, which produces an aerosol, and the cones, which disperse the aerosol. These areas form scaly deposits from the samples in the sample solution, despite the nitric acid and other acids present in the digestate. These parts of the instrument periodically need to be taken apart and cleaned, but in a production setting the laboratory wants to avoid any downtime as much as possible. As an ameliorating factor, the laboratory also takes account of this dilution factor up front in the project planning stages. The laboratory will not quote a reporting limit for this instrument that cannot be achieved after the 10 times dilution required for the instrument. Not all of the requested reporting limits can be met using the laboratory's routine protocol. The dilution is narrated by the laboratory merely as a matter of transparency, as well as for the validator's information. The dilution should have no impact on the project's sensitivity goals.

Sample Preservation Evaluation. All samples were preserved as specified in the QAPP.

Holding Time Evaluation. All analytical holding times were met.

Initial Calibration, Initial Calibration Verification, and Continuing Calibration Verification Evaluation. All ICAL, ICV, and CCV results were within acceptance criteria.

Method Blank Evaluation. No sample data were qualified due to method blank results.

Initial and Continuing Calibration Blank Evaluation. No sample data were qualified due to ICB/CCB data.

Matrix Spike/Matrix Spike Duplicate Samples Evaluation. All MS/MSD recoveries were within acceptance criteria with the exception of one MS and MSD for the analysis of uranium and one MS for the analysis of uranium. Table F.1-1 lists the analytes where an MS and/or MSD percent recovery was outside the acceptance criteria. Sample results were qualified with a "J+" flag for results that were estimated and potentially biased high; sample results were qualified with a "J-"

flag for results that were estimated and potentially biased low. One MS/MSD relative percent difference (RPD) for uranium was outside the acceptance criteria; this result was already qualified as estimated with a "J-" flag.

Laboratory Duplicate Sample Evaluation. For some analyses, the laboratory prepared and analyzed a duplicate sample. RPD results were evaluated between the parent and laboratory duplicate samples. Sample results qualified due to laboratory duplicate RPDs outside of the acceptance criteria are listed on Table F.1-1. The sample results were qualified as estimated with a "J" flag if not otherwise qualified.

Serial Dilution Evaluation. All serial dilution percent differences were within acceptance criteria with the exception of one sample for the analysis of vanadium. The sample result associated with the out-of-compliance serial dilution was qualified with a "J" flag (see Table F.1-1).

Interference Check Sample Evaluation. All interference check samples were within acceptance criteria.

Laboratory Control Sample/Laboratory Control Sample Duplicate Evaluation. All LCS and LCSD recoveries were within acceptance criteria. All LCS/LCSD RPDs were within acceptance criteria.

Field Duplicate Evaluation. The RPDs were less than the guidance RPD of 30 percent established in the QAPP for all field duplicate pairs, with the exception of results for two metals. The sample IDs, sample results, and RPDs for those results that did not meet the guidance RPD are listed in Table F.1-2. Sample results were not qualified due to RPDs exceeding the guidance criteria, as described in the QAPP.

Minimum Detectable Concentration Evaluation. All minimum detectable concentrations met reporting limits with the exception of four samples for the analysis of radium-226. However, the reported activity for each of these samples was greater than the achieved minimum detectable concentration and no qualification was needed.

Reporting Limit Evaluation. All sample data were reported to the reporting limit established in the QAPP, with the exception of the metals, as discussed at the beginning of this section related to dilution.

Sample Result Verification. All sample result verifications were acceptable with the exception of 33 samples analyzed for radium-226. The sample density exceeded the limit of +/- 15% of the density of the calibration standard. In all cases the results were qualified with a "J-" flag as estimated, potentially biased low (see Table F.1-1).

Completeness Evaluation. All samples and QC samples were collected as scheduled, resulting in 100 percent sampling completeness for this project. Based on the results of the data validation described in the previous sections, all data are considered valid as qualified. No data were rejected; consequently, analytical completeness was 100 percent, which met the 95 percent analytical completeness goal established in the QAPP.

Comparability Evaluation. Comparability is a qualitative parameter that expresses the confidence that one data set may be compared to another. For this project, sample collection and analysis followed standard methods and the data were reported using standard units of measure as specified in the QAPP. In addition, QC data for this project indicate the data are comparable. As a result, the data from this project should be comparable to other data collected at this Site using similar sample collection and analytical methodology.

3.0 DATA VALIDATION SUMMARY

Precision. Based on the MS/MSD sample, LCS/LCSD sample, laboratory duplicate sample, and field duplicate results, the data are precise as qualified.

Accuracy. Based on the ICAL, ICV, CCV, MS/MSD, and LCS, the data are accurate as qualified.

Representativeness. Based on the results of the sample preservation and holding time evaluation; the method and ICB/CCB blank sample results; the field duplicate sample evaluation; and the RL evaluation the data are considered representative of the Site as reported.

Completeness. All media and QC sample results were valid and collected as scheduled; therefore, completeness for this RSE is 100 percent.

Comparability. Standard methods of sample collection and standard units of measure were used during this project. The analysis performed by the laboratory was in accordance with current USEPA methodology and the QAPP.

Based on the results of the data validation, all data are considered valid as qualified.

Table F.1-1
Summary of Qualified Data
Charles Keith
Removal Site Evaluation Report - Final
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Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S225-BG1-002	10/17/16	E901.1	Radium-226	1.26	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-BG1-003	10/17/16	E901.1	Radium-226	1.32	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-BG1-004	10/17/16	E901.1	Radium-226	1.68	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-BG1-005	10/17/16	SW6020	Uranium	3.5	mg/kg	MS MSD LR	-2% -37% 35%	75% - 125% 75% - 125% 20%	J-	Result is estimated, potentially biased low. MS and MSD recoveries below acceptance criteria. LR RPD outside
S225-BG1-005	10/17/16	SW6020	Molybdenum	2.4	mg/kg	LR	24%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S225-BG1-005	10/17/16	E901.1	Radium-226	2.15	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-BG1-006	10/17/16	E901.1	Radium-226	1.36	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-BG1-009	10/17/16	E901.1	Radium-226	1.99	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-BG1-010	10/17/16	E901.1	Radium-226	1.39	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-BG2-008	10/17/16	E901.1	Radium-226	0.47	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-C05-001	11/2/16	E901.1	Radium-226	3.5	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-CX-004	6/20/17	SW6020	Vanadium	12	mg/kg	Serial Dilution	12%	10%	J	Result is estimated, bias unknown. Serial dilution %D greater than acceptance criteria.

Notes

mg/kg milligrams per kilogram	LR laboratory replicate (duplicate)
pCi/g picocuries per gram	MS matrix spike
%D percent difference	MSD matrix spike duplicate
LCS laboratory control sample	RPD relative percent difference

Table F.1-1
Summary of Qualified Data
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S225-CX-004	6/20/17	E901.1	Radium-226	1.01	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-CX-007	6/20/17	E901.1	Radium-226	1.77	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-CX-008	6/20/17	E901.1	Radium-226	1.62	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-CX-010	6/20/17	E901.1	Radium-226	0.87	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-CX-204	6/20/17	E901.1	Radium-226	1.21	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-002-01	6/20/17	E901.1	Radium-226	8.3	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-003-01	6/20/17	E901.1	Radium-226	46.9	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-003-02	6/20/17	E901.1	Radium-226	21.3	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-004-01	6/20/17	E901.1	Radium-226	53.6	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-004-02	6/20/17	E901.1	Radium-226	32.4	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-007-02	6/21/17	E901.1	Radium-226	0.43	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-008-01	6/21/17	E901.1	Radium-226	0.69	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-009-01	6/21/17	E901.1	Radium-226	0.89	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.

Notes

mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
%D	percent difference
LCS	laboratory control sample
LR	laboratory replicate (duplicate)
MS	matrix spike
MSD	matrix spike duplicate
RPD	relative percent difference

Table F.1-1
Summary of Qualified Data
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase
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Field Sample Identification	Sample Date	Analysis Code	Analyte	Sample Result	Units	QC Type	QC Result	QC Limit	Added Flag	Comment
S225-SCX-010-01	6/21/17	E901.1	Radium-226	1.27	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-011-01	6/21/17	E901.1	Radium-226	2.68	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-012-01	6/21/17	SW6020	Arsenic	2.1	mg/kg	LR	28%	20%	J	Result is estimated, bias unknown. LR RPD outside acceptance criteria.
S225-SCX-012-01	6/21/17	SW6020	Uranium	1.2	mg/kg	MS MS/MSD RPD	162% 29%	75% - 125% 20%	J+	Result is estimated, potentially biased high. MS recovery above acceptance criteria. MS/MSD RPD outside acceptance criteria.
S225-SCX-012-01	6/21/17	E901.1	Radium-226	1.38	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-012-02	6/21/17	E901.1	Radium-226	1.29	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-014-01	6/21/17	E901.1	Radium-226	1.34	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-014-02	6/21/17	E901.1	Radium-226	0.82	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-015-01	6/21/17	E901.1	Radium-226	0.93	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-016-01	6/21/17	E901.1	Radium-226	0.88	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-017-02	6/21/17	E901.1	Radium-226	0.48	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-018-01	6/22/17	E901.1	Radium-226	2.51	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.
S225-SCX-204-01	6/20/17	E901.1	Radium-226	51.5	pCi/g	Result Verification		±15%	J-	Result is estimated, potentially biased low. Sample density differs by more than 15% of LCS density.

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
%D percent difference
LCS laboratory control sample
LR laboratory replicate (duplicate)
MS matrix spike
MSD matrix spike duplicate
RPD relative percent difference

Table F.1-2
Results that did not Meet the Relative Percent Difference Guidance
Charles Keith
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Primary Sample / Duplicate Indentification	Sample Date	Parameter	Primary Result	Duplicate Result	Units	RPD (%)
S225-SCX-004-01/S225-SCX-204-01	6/20/2017	Molybdenum	1.5	2.9	mg/kg	64
S225-SCX-004-01/S225-SCX-204-01	6/20/2017	Uranium	67	170	mg/kg	87

Notes
mg/kg milligrams per kilogram
RPD relative percent difference