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Oak 124, Oak 125 (#486)

Removal Site Evaluation Report

Final | September 27, 2018

Stantec

NAVAJO NATION

AUM Environmental Response Trust-First Phase

Oak 124, Oak 125 (#486) Removal Site Evaluation Report - Final

September 27, 2018

Prepared for:

Navajo Nation AUM Environmental Response Trust – First Phase

Prepared by:

Stantec Consulting Services Inc.

Title and Approval Sheet

Title: Oak 124, Oak 125 Removal Site Evaluation Report - Final

Approvals

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

10/12/2018

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Revision Log

Revision No.	Date	Description
0	January 24, 2018	Submission of Draft RSE report to Agencies for review
1	September 27, 2018	Submission of Final RSE report to Agencies

Sign-off Sheet

This document entitled *Oak 124, Oak 125 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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- Historical documents referenced in this RSE Report (refer to Section 7 for complete citation)
  - Bechtel Environmental Inc, 1996 - Expanded Site Inspection, King Tutt Mesa Aggregate Site, Oak Springs, New Mexico
  - Chenoweth, 1984 – Historical Review of Uranium-Vanadium Production in the Eastern Carrizo Mountains, San Juan County, New Mexico and Apache County, Arizona
  - Chenoweth, 1993 – The Geology, Leasing and Production History of the King Tutt Point Uranium-Vanadium Mines, San Juan County, New Mexico
  - Chenoweth, 1994 – The Geology, Exploration and Production History of the Begay No.1 and Carrizo No. 1 Uranium-Vanadium Mines, San Juan County, New Mexico

- Hendricks, 2001 – An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation
- NSP, 2004 – Draft Site Inspection Report King Tutt Mesa Aggregate Site Red Valley Chapter, Navajo Nation
- NSP, n.d. – Navajo Superfund Program/Navajo Nation Environmental Protection Agency (NNEPA), CERCLA Preliminary Assessment report for: Navajo-Salt Canyon Uranium Mines (CERCLIS Identification (ID) # NND986667467); Navajo-Tent Uranium Mine (ID# NND986667483); Navajo-King Tutt #1 Uranium Mine (ID# NND986675080); Navajo-Junction Claim (ID# NND986675023); Navajo-King Tutt Point Uranium Mine (ID#NND986667434); Williams Point Mine (ID# NND986673283); Navajo-Canyon View (a.k.a., Alongo Claim) Uranium Mine (ID# NND986667533); Navajo-Red Wash Point Uranium Mine (ID# NND986667459); Navajo-Begay Incline Uranium Mine (ID#NND986675031); Navajo-Begay #1 Uranium Mine (ID# NND986667517); Navajo-Begay #2 Uranium Mine (ID# NND986667509); Vanadium Corp. of America (VCA)-Plot 10 (ID# NND983468034); Navajo-Franks Point/VCA Plot #6 Uranium Mine (ID#NND986675049); Navajo-VCA Plot 7 Uranium Mine (ID# NND986667426); Navajo-Upper Salt Rock (ID# NND986667590); Navajo-Carrizo Mine (ID# NND986667491); and, Navajo-VCA Plot #3 (ID# NND986667475)
- TerraSpectra Geomatics, 2004 –
- USEPA, 2007a- - Red Valley Chapter Screening Assessment Report – Review Draft. Navajo Abandoned Uranium Mine Lands Study Arizona, New Mexico, and Utah
- Weston Solutions, 2011 – Reassessment Report King Tutt Mesa Site, Oak Springs, Apache County, Arizona

Executive Summary

Introduction

The Oak 124, Oak 125 site (the Site) is located within the Navajo Nation, Shiprock Bureau of Indian Affairs (BIA) Agency, Red Valley Chapter in northwestern New Mexico, near the border of New Mexico and Arizona. 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 May 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.

[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. Regionally, the Site is located in the King Tutt Mesa mining area. Bedrock on the Site consists of the Jurassic Morrison Formation. The Morrison Formation produced approximately 4.7 million pounds of uranium from areas of Arizona and New Mexico (USEPA, 2007a). 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 on a benched sandstone mesa consisting of an upper bench, bedrock slope and lower bench with an elevation of approximately 5,570 feet above mean sea level. On-site overland surface water flow, when present, is controlled by a decrease in elevation toward the southeast side of the Site from the top of the sandstone mesa toward the edge of the mesa.

Site-specific historical information is minimal; however, it appears that: (1) rim stripping potentially occurred on-site (USEPA, 2007a); (2) no ore was produced from the Site or, if ore was produced, it could have been combined with ore production from other mines for reporting purposes (USEPA, 2007a); and (3) it is unknown if the potential rim stripping was associated with mining activities or exploration activities that occurred on-site.

From 1989 to 2004, the NNEPA and USEPA conducted preliminary assessments (PAs), site inspections (SIs), and an expanded site inspection (ESI) at the King Tutt Mesa (KTM) site. The area of the Site was included in the KTM site. In 2010 Weston Solutions (Weston) performed a surface gamma survey on behalf of the USEPA on the area of the Site.

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 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 to establish ILs for the Site. Data collected from the site gamma radiation survey 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 soil and sediment sampling, subsurface soil 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 and well water.

Findings and Discussion

Surface and subsurface soil and sediment sampling results. One background reference area was selected to develop surface gamma, subsurface static gamma, Ra-226, and metals ILs for the Site. Arsenic, 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. ILs for selenium and molybdenum were not identified because in the background area selenium sample results were non-detect and molybdenum was detected in only one sample. However, because selenium and molybdenum were detected in soil/sediment samples from the Survey Area (i.e., the full areal extent of the Site surface gamma survey), they are also confirmed as COPCs for the Site. Based on the data analyses performed for this report along with the multiple lines of evidence, approximately 3.2 acres, out of the 10.1 acres of the Survey Area (i.e., the full areal extent of the Site surface gamma survey), were estimated to contain TENORM. Of the 3.2 acres that contain TENORM, 0.9 acres contain TENORM exceeding the surface gamma IL. The volume of TENORM in excess of ILs was estimated to be 1,098 cubic yards (yd^3) (839 cubic meters).

Gamma Correlation Study results. The Gamma Correlation Study indicated that surface gamma survey results correlate with Ra-226 concentrations in soil. Therefore, gamma surveys could be used during site assessments as a field screening tool to estimate Ra-226 concentrations in soil, where sampling or gamma surveys are not available. 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. Additional correlation studies may be needed to refine the relationship between gamma and Ra-226.

Water sampling results. One surface water seep sample was collected. The seep water sample analytical results indicated that radionuclides, metals, and general chemistry were all below their respective ILs. Based on these results, there are no confirmed COPCs for the seep and further characterization may not be needed at the seep.

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
ft2	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
BEI	Bechtel Environmental, Inc.
BIA	Bureau of Indian Affairs
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
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
ESI	expanded site inspection
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

KTM	King Tutt Mesa
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
NSP	Navajo Superfund Program
PA	preliminary assessment
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
SI	site inspection
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
Weston	Weston Solutions

Glossary

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.

Escarpment – a long cliff or steep slope separating two comparatively level or more gently sloping surfaces and resulting from erosion or faulting (Merriam-Webster, 2018).

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.

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.

Shaft – A vertical or sloping passageway made in the earth for finding or mining ore and ventilating underground excavations (American Heritage Dictionary, 2016).

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

Stope – The area between two levels of a mine where mining occurs. Accessed through a raise (i.e., a vertical or inclined passageway driven between levels).

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 95^{th} 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 May 2017 at the Oak 124, Oak 125 site (the Site) located in northwestern New Mexico, near the border of New Mexico and Arizona, 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 #486 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 2.6 acres (113,256 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[2]: (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

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

Federal Regulations (CFR) Section 300.5 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; USEPA, 1992).

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)(2011) 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 – 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 *Oak 124, Oak 125 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 *Oak 124, Oak 125 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 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 northwestern New Mexico, near the border of New Mexico and Arizona, and approximately 7.5 miles north of Red Valley, Arizona, as shown in Figure 1-1 inset. The Site is located in the eastern Carrizo Mountain region, within the King Tutt Mesa mining area, as shown in Figure 2-1. A summary of historical mining on the Site is presented below.

Site-specific historical mining information is minimal and the only such information discovered was reported in the *2007 AUM Atlas*. The *2007 AUM Atlas* reported that two historical mining rim strip features were present on-site and that no ore was produced from the Site. However, an important consideration is that even though it was reported that no ore was produced from the Site, the *2007 AUM Atlas* has also reported that sometimes production from multiple mines was reported as a single combined value for one of the mines. In these cases, the mines were included on a single lease, and the ore production reported was inclusive of all of the mines on that single lease (USEPA, 2007a). It is unknown if the Site was part of a multi-mine lease but, it is possible that ore could have been mined from the Site, and combined with reports from other mine ore productions, for a combined reported production value[3].

The only other historical information found was for other AUMs located within the same mining region as the Site, the eastern Carrizo Mountain region within the King Tutt Mesa mining area. Therefore, information regarding historical mining practices and background for the Site are presented on a regional level (i.e., the eastern Carrizo Mountain region within the King Tutt Mesa mining area). A summary of historical mining on the Carrizo Mountain region is presented below.

In 1918, outcrops containing uranium and vanadium were discovered in the Carrizo Mountains, and in April 1921, the first recorded shipment of uraniferous material was shipped from the eastern Carrizo Mountain Region (Chenoweth, 1984). Mining continued in the region until March 1936, when the US Secretary of the Interior closed the Navajo Nation to further claims and mineral prospecting. However, in the late 1930s the US Secretary of the Interior was asked (by whom is unknown) to re-open the Navajo Nation for prospecting and mining. Therefore, in May 1938, the Navajo Nation was re-opened for prospecting and mining by a Congressional Act, which gave the Navajo Nation Tribal Council the authority to enter into leases for Navajo Nation lands with approval of the US Secretary of the Interior. In July 1942, the Bureau of Indian Affairs (BIA) awarded Vanadium Corporation of America an exploration lease for 66,560 acres of the eastern Carrizo Mountain region. The lease was effective from July 1942 through July 1952. In

[3] USEPA (2007a) noted that occasionally the ore mined from multiples sites within one lease were reported collectively. Thus it is possible, but less likely, that ore was mined from Oak 124, Oak 125 but reported for a different mine.

September 1943, the lease was changed from an exploration lease to an operating lease. The operating lease identified 12 mining claims, totaling 436 acres, within the eastern Carrizo Mountain region and six of the 12 mining claims were located on King Tutt Mesa: Red Wash Point, King Tutt Point, Shadyside, Williams Point, Fissure, and Franks Point. The Site (Oak 124, Oak 125) was not included as part of this lease. Five of the six claims located on King Tutt Mesa are shown in Figure 2-2, the location of Fissure is unknown. Of the six claims located on King Tutt Mesa, King Tutt Point and Red Wash Point are located adjacent to or within 1,000 ft of the Site, as shown in Figure 2-2. Vanadium mining in the eastern Carrizo Mountain region began in August 1942, and continued until August 1944, with single shipments in February 1945 and July 1947. Uranium mining subsequently began in 1948 and continued through 1961. (Chenoweth, 1984). Portals, rim strips, and vertical shafts were used to mine the ore from the mines located on King Tutt Mesa using conventional blasting combined with manual labor to remove overburden and ore (USEPA, 2007a).

As shown in Figure 2-1, King Tutt Point was located adjacent to the Site. Historical mine workings at King Tutt Point consisted of a rim stripped area approximately 400 ft by 100 ft, and five portals (Chenoweth, 1993). Two of the portals at King Tutt Point provided access to the main mine shaft, which covered an area of approximately 225 ft by 100 ft. Located to the west and north of the Site is the historical mine Begay No. 1. Historical mine workings of Begay No.1 consisted of a portal, shafts, and multi-level underground workings where an open stope with random pillar mining methods were used with rail haulage (Chenoweth, 1994). Approximately 64 tons of U_3O_8 (uranium oxide), or 58 percent, of the total uranium produced in the eastern Carrizo Mountain region, was mined from King Tutt Mesa (Chenoweth, 1984). One ton (of the 64 tons of U_3O_8) came from King Tutt Point (Chenoweth, 1984), and approximately eight tons (of the 64 tons) came from Begay No.1 (Chenoweth, 1994).

As presented above, site-specific historical information is minimal; however, it appears that: (1) rim stripping potentially occurred on-site; (2) no ore was produced from the Site or, if ore was produced, it could have been combined with ore production from other mines for reporting purposes; and (3) it is unknown if the potential rim stripping was associated with mining activities or exploration activities that occurred on-site.

2.1.2 Ownership and Surrounding Land Use

The Site is located within the Navajo Nation, Shiprock BIA Agency in Section 36 of Township 29 North, Range 21 West, New Mexico Principal Meridian. Land ownership where the Site is located falls under Navajo Trust lands. The Site is located within the Red Valley Chapter of the Navajo Nation, as shown in Figure 1-1, and is in Grazing Unit 12, as designated by the Navajo Nation Division of Natural Resources (NNDNR, 2006). The Site is currently uninhabited. However, one home-site is located to the southeast of and within 0.25 miles of the Site, as shown in Figure 2-1.

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 Red Valley Chapter officials and nearby residents and notified them of the work.

2.1.4 Previous Work at the Site

2.1.4.1 1989 through 2010 King Tutt Mesa Site Assessment Activities

From 1989 to 2004, the NNEPA and USEPA, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act, as amended (CERCLA), conducted preliminary assessments (PAs), site inspections (SIs), and an expanded site inspection (ESI) at 16 AUM sites located on King Tutt Mesa (Bechtel Environmental, Inc. [BEI],1996). The 16 AUM sites were comprised of 28 individual mine sites that were contiguous or in close proximity to each other. Because of their close proximity to each other, the USEPA decided to evaluate them as a single, aggregate site referred to as the King Tutt Mesa (KTM) site. Oak 124, Oak 125 was not originally included as part of the KTM site, but was added to the KTM site later, as discussed below. The RSE Site will be referred to in this RSE Section (i.e., Section 2.1.4) as the Oak 124, Oak 125 site to avoid confusion with the KTM site. Data collected from the PAs, SIs, and ESI for the KTM site were used to perform reclamation work at the KTM site between 1992 and 2002. The PAs, SIs, ESI, and reclamation that occurred at the KTM site included the following:

- 1989 and 1990 – NNEPA conducted PAs at the KTM site. The purpose of the PAs was to review existing information on the KTM site and its environs, to assess the threat(s), if any, posed to public health, welfare, or the environment, and to determine if further action was warranted under CERCLA (Navajo Superfund Program [NSP], n.d.). The date of the NSP/NNEPA, CERCLA Preliminary Assessment report is unknown.

- 1990, 1991, and 1992 – NNEPA conducted SIs at the KTM site. The SIs included the collection of soil, sediment, surface water, and groundwater samples for chemical analyses. No media samples were collected on the Oak 124, Oak 125 site. Media sample results are summarized in the *Draft Site Inspection Report King Tutt Mesa Aggregate Site Red Valley Chapter, Navajo Nation* (NSP, 2004).

- 1992 – Reclamation work began at the KTM site by NAML (BEI, 1996).

- 1994 through 1996 – BEI performed an ESI at the KTM site, on behalf of the USEPA (BEI, 1996). The ESI included the collection of soil, sediment, surface water, and groundwater samples, for chemical analyses, at various sample locations on the KTM site. No media samples were collected at the Oak 124, Oak 125 site during the ESI. Media sample results are summarized in the *Expanded Site Inspection Report for the King Tutt Mesa Aggregate Site* (BEI, 1996).

- 2002 – NAML completed reclamation activities at 27 of the 28 mine sites included in the KTM site (TerraSpectra Geomatics, 2004). Reclamation work was also completed at seven additional mine sites located within the KTM site boundary, but not included in the original KTM site. Also, four additional mine sites, located within the KTM site boundary, but not included in the original KTM site, were left un-reclaimed by NAML. Oak 124, Oak 125 site was one of the four mine sites listed as un-reclaimed.

- 2004 – NNEPA collected soil, sediment, surface water, and groundwater samples, for chemical analyses, as part of an on-going SI reassessment at the KTM site (NSP, 2004). No samples were collected on the Oak 124, Oak 125 site; refer to Figure 3-5 in NSP (2004) for 2004 SI sample locations. Media sample results are summarized in NSP (2004).

From 1989 through 2004, (when the PAs, SIs, and ESI were performed) site assessment activities did not occur on each individual mine within the KTM site. Therefore, after reviewing the PAs, SIs, and ESI the USEPA decided that further investigations were necessary to more completely evaluate the KTM site (Weston, 2011). From 2008 to 2010, Weston, on behalf of the USEPA, performed a reassessment. The reassessment included the original KTM site and the inclusion of 13 additional mine sites. The Oak 124, Oak 125 site was one of the 13 additional mine sites. The 13 added mine sites were located within the original KTM site boundary but were not included in the 1989 to 2004 PAs, SIs, or ESI. The KTM site was then comprised of 41 individual mine sites. The purpose of the reassessment was to review existing information and collect additional data to assess the relative threat associated with actual or potential releases of hazardous substances at the KTM site. Additional information collected from the KTM site reassessment activities included the following:

- 2008 – Weston, on behalf of the USEPA, performed a surface gamma survey at the KTM site. A portion of the northeast corner of the Oak 124, Oak 125 site was included in the survey and the remainder of the Oak 124, Oak 125 site was not surveyed. Refer to Figure 3-2d in Weston (2011) for surface gamma survey area in relation to the Oak124, Oak125 site.

- 2010 – Weston assessed the 2008 surface gamma survey data and concluded that of the 41 individual mine sites within the KTM site, 32 warranted additional surface gamma surveying. Therefore, in June 2010, Weston, on behalf of the USEPA, performed additional surface gamma surveying at the KTM site. The Oak 124, Oak 125 site was more thoroughly surveyed in 2010 and the highest gamma measurements collected were greater than 11 times the site-specific background levels used for the screening. Refer to Figures A-39 and A-40 in Weston (2011) for the Oak 124, Oak 125 site gamma measurements and survey area. Figures A-39 and A-40 also showed an observed reclamation cap located in the northeast area of the Oak 124, Oak 125 site and the location of an observed waste pile in the northeast corner of the Oak 124, Oak 125 site. The reclamation cap contradicts Table 2-2 in Weston (2011) where the Oak 124, Oak 125 site is reported as un-reclaimed. Table 2-2 in Weston (2011) also reported two rim strip mining features at the Oak 124, Oak 125 site; however, the locations were not shown in the Weston report figures (2011). Table 2-2 in Weston (2011) was a summary of NAML records and was not a separate indication of features identified by Weston at the Oak 124, Oak 125 site.

2.1.4.2 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 Red Valley 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 Red Valley area covered approximately 33.04 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 5 μR/hr to 37μR/hr and excess bismuth (i.e., bismuth activity greater than approximately 3.5 μR/hr) present in approximately 0.1 square miles (65 acres) of the area (*2007 AUM Atlas*). The aerial radiological survey results for the Red Valley area indicated a gross exposure rate range of 2.92 μR/hr to 42.23 μR/hr and excess bismuth (i.e., bismuth activity greater than approximately 3.5 μR/hr) present in approximately 0.32 square miles of the 33.04 square miles of the Red Valley flight area (Hendricks, 2001).

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.

Figure 2-3 presents the regional US Geologic Survey (USGS) topographic map in the vicinity of the Site and shows site topography within a portion of the Colorado Plateau. Figure 2-4 presents Site topography and a current aerial photograph (Cooper Aerial Surveys Company [Cooper; refer to Section 3.2.2.1]), dated June 16, 2017 within a portion of the Colorado Plateau. The Site is located within a portion of San Juan County, New Mexico that is characterized by escarpments (with slopes ranging from 8 to 45 percent) separated by major river washes (refer to Appendix E).

The elevation on-site is approximately 5,570 feet above mean sea level (ft amsl) (refer to Figure 2-4), and the Site is located on a benched sandstone mesa consisting of an upper bench, bedrock slope and lower bench (refer to Figure 2-5). The bedrock slope trends in a southwest to northeast direction (refer to Figure 2-5). The Site includes cliffs and incised ephemeral stream drainages. A photograph of the Site topography is included in Appendix B-1 photograph number 1.

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.

Bedrock on the Site consists of the Jurassic Morrison Formation, which is composed of various rocks of lacustrine and fluvial continental origin, including mudstone, sandstone, limestone, and siltstone (USGS, 1967). Figure 2-6 depicts a regional geology map showing the Site in relation to the regional extent of the Morrison Formation. The sandstone strata of the Morrison Formation contain the majority of uranium ore reserves in the US (USGS, 1967). Deposition of the Morrison Formation may have coincided with uplift of the western basin-and-range region and the beginning of the Nevadan orogeny. The Morrison Formation covers an area of approximately 600,000 square miles (USGS, 1967) and is centered in Wyoming and Colorado, with outcrops in Canada, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Utah, Idaho, New Mexico, and Arizona (Turner and Peterson, 2004). The Morrison Formation produced approximately 4.7 million pounds of uranium from areas of Arizona and New Mexico (USEPA, 2007a).

2.2.2.2 Site Geology

Bedrock outcrops on or adjacent to the Site consist of yellowish-gray to greenish-gray cross-bedded very fine to medium-grained calcareous sandstone interbedded with greenish-gray and reddish–brown claystone of the Salt Wash Member of the Morrison Formation, as shown in Figure 2-7a. A significant portion of the Site consists of shallow or outcropping mineralized bedrock of the Salt Wash Member, as shown in Figure 2-7b.

Unconsolidated deposits on-site are alluvium, colluvium, and eolian deposits consisting of silty sand, poorly graded sand, and poorly graded sand with gravel. During the Site Characterization field activities, boreholes were advanced through the unconsolidated deposits using a hand auger until refusal at bedrock or termination within native material (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 greater than 1.6 ft below ground surface (bgs).

According to the US Department of Agriculture (USDA) Soil Survey for San Juan County, published in 2001, soils on-site that have not been disturbed, are classified as Shalet-Rock Outcrop Complex consisting of eolian soil that is sandy clay loam, shallow in depth, and well drained (USDA, 2001). The Site has bedrock outcrops intermixed with the Shalet soil.

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 298284, Shiprock, New Mexico (Western Regional Climate Center, 2017) located approximately19 miles northeast of the Site, ranges between 43.0 degrees Fahrenheit (°F) in January to 94.6°F in July. Daily temperature extremes reach as high as 109°F in summer and as low as -26°F in winter. Shiprock receives an average annual precipitation of 7.0 inches, with August being the wettest month, averaging 1.0 inch, and June being the driest month, averaging 0.29 inches.

Potential evaporation in the area is greater than the area's average annual precipitation. The potential evaporation noted at the Shiprock, New Mexico weather station averages 73 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 Farmington, New Mexico airport, located approximately 43 miles to the northeast of the Site, had the most complete record of wind conditions. A wind rose for Farmington 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 east (refer to the wind rose on Figure 1-1).

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. The Site is also located within a portion of San Juan County, New Mexico that is characterized by escarpments separated by major river washes (refer to Appendix E). On-site surface water flow (when present) is controlled by a decrease in elevation toward the southeast side of the Site from the top of the sandstone mesa (upper bench) toward the edge of the mesa (refer to Figure 2-5). Numerous dendritic patterned ephemeral drainages are present on-site that drain to the south-southeast, as shown in Figure 2-5. Precipitation run-off on-site either terminates within the unconsolidated deposits or generally drains southeast into an unnamed wash for approximately one mile before joining Red Wash, as shown in Figure 2-1. Red Wash then joins the San Juan River approximately 15 miles northeast of the Site (refer to Figure 1-1 inset).

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 May 2016, Adkins conducted a wildlife survey. In May 2016, Redente Ecological Consultants (Redente), under contract to Stantec, conducted a spring vegetation survey and in July 2016, Redente 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 grasses with a few pinyon-juniper trees (refer to Appendix E). During the surveys, Stantec and/or its subcontractors observed on-site wildlife including common raven, cottontail rabbit, and turkey vulture (refer to Appendix E).

2.2.6 Cultural Resources

In March 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, and interviewed local residents living near the Site (Dinétahdóó, 2016). The interviewed residents stated that a former family member had worked at the mines across the Black Rock Wash (refer to Figure 2-1 and Figure 2-2) and that several of the mines had been reclaimed. The residents however, were unsure which mine was Oak 124, Oak 125 because the mines scattered on top of the mesa and on the northern and southern slopes were known to the residents as “Kerr McGee’s Mine”.

During the cultural resource survey Dinétahdóó identified two archaeological sites. 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 or adjacent sites: historical boreholes, historical drill core/waste rock, berms, potential haul roads, a potential mining disturbed area, an excavation area, and a potential staging area. 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 May 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[4] 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).

[4] (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, 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 1949, 1975, 1997, and 2005 for comparison against a current 2017 image (Cooper, 2017). The selected historical photographs are shown in Figure 3-1a. Due to the low resolution of the historical photographs it was difficult to determine any discernible differences (e.g., mining related) between the historical photographs and the current 2017 image. Figure 3-1b presents a historical aerial photograph comparison of the Site showing the aerial photograph from 1975 and the current 2017 image. The 1975 historical photograph is presented because it provided the best resolution, of the available historical photographs, showing what the Site looked like after mining occurred on King Tutt Mesa (refer to Section 2.1.1). The only observed evidence of mining activities was the potential haul road in the northwestern portion of the Site and to the north of the claim boundary that was visible in the 1975 image. This indicated that the road had been installed sometime prior to that date.

- Two potential rim strip mining features were identified based on: (1) Table 2-2 in Weston (2011); and (2) the review of information provided in the *2007 AUM Atlas*. The locations of the two rim strip features are shown in Figure 2-5. The locations were not shown in the Weston (2011) report figures.

- The current aerial photograph review confirmed that one home-site was located to the southeast of and within 0.25 miles of the Site, 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).

- Five surface 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 east (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 2-5, were marked in the field with stakes and/or flagging and mapped with a global positioning system (GPS).
- Topographic features – The mapped area can be divided into three primary topographic areas: the upper bench, the bedrock slope, and the lower bench, as shown in Figure 2-5. The predominant bedrock outcrop on-site trends northeast to southwest and transects the Site into the lower bench to the south/southeast and the upper bench to the north/northwest. The lower and upper bench are divided by a slope of outcropping bedrock with approximately 20 ft of topographic relief. An overview of the Site topography is also shown in Appendix B-1 photograph number 1.
- Drainages – Drainages were mapped on-site, as shown in Figure 2-5. The drainages were dendritic patterned ephemeral drainages that drained south-southeast onto an adjacent mine claim. Minimal to no alluvial sediments were observed in the drainages within the claim boundary. Drainages located outside the claim boundary and within adjacent mine claims were not addressed as part of this RSE. Refer to Appendix B-1 photograph numbers 7 and 9 for photograph representations of these drainages.
- Potential haul roads – Two potential haul roads were mapped, as shown in Figure 2-5. One of the potential haul roads ran approximately east-west, intersected the northwest corner of the claim boundary, and meet up with the second potential haul road that ran roughly northwest to southeast. The road that ran approximately east-west terminated at an excavation located on the King Tutt Point mine, located to the west of the Site (refer to Figure 2-5).
- Historical boreholes - Numerous historical boreholes were mapped, as shown in Figure 2-5. The boreholes observed on the mesa top were 1 to 2 inches in diameter and cased with plastic liners that stuck up less than 1 ft above ground surface (ags). The plastic liners sticking above the ground surface did not appear to present a significant safety hazard, any more than a small tree or boulder would. Therefore, an interim action was not necessary to address the plastic liners sticking up above the ground surface. Refer to Appendix B-1 photograph number 4 for a photographic representation of one of the historical boreholes. One borehole was located in the north-northwest corner of the Site and the remaining boreholes were located outside of the claim boundary. The boreholes could potentially be

historical exploration boreholes. Field personnel also observed pieces of rock core near the boreholes.

- Berms – Four earthen, engineered berms were mapped, as shown in Figure 2-5. Two of the earthen berms were located northeast of the claim boundary, and field personnel noted that the berms appeared to have been engineered to control and divert surface water flow (when present) into drainage channels that transected the northeast corner of the Site (refer to Appendix B-1 photograph number 2). The two other mapped earthen berms were located on the neighboring eastern Begay No. 1 claim, as shown in Figure 2-5. The northern berm was constructed perpendicular to the surface water flow direction within the drainage, and the southern berm was constructed perpendicular and parallel to the surface water flow direction. The berms were constructed of boulder-sized rock, lined with erosion fabric below the rock, and appeared to be installed to slow the flow of surface water (when present) through the drainage channel they were constructed across and along (refer to Appendix B-1 photograph number 3).

- Potential mining disturbed area – A potential mining disturbed area was mapped, as shown in Figure 2-5. The area was a circular feature built of stacked, sandstone rocks located in the southwestern area of the Site. The perimeter of the feature measured approximately 12 ft to 15 ft in diameter and was less than 2 ft high. Dinétahdóó reported the feature was associated with historical mining but did not provide details regarding the purpose of the feature (Dinétahdóó, 2016).

- Potential staging area – A potential staging area was mapped, as shown in Figure 2-5. The potential staging area was referred to as a waste pile by Weston (2011). The area was a rectangular feature built of stacked, sandstone rocks located along the northeast corner claim boundary. Rocks were stacked on three of the four sides of the feature and the fourth side was left open (refer to Appendix B-1 photograph numbers 5 and 6). Dinétahdóó reported that the feature was associated with historical mining, but did not provide details regarding the purpose of the feature (Dinétahdóó, 2016). Feld personnel observed that the feature could have potentially been used during historical mining activities for ore staging or load-out.

- Livestock – Field personnel observed livestock present in pens located near the home-site.

- Water feature – Field personnel assessed the five water features identified from the desktop study, as shown in Figure 2-1. The water features and field personnel observations are included in Table 3-1. In addition, during site mapping activities field personnel mapped two water features (Red Wash and numerous minor seeps), as shown in Figure 2-1and described in Table 3-1. Red Wash contains flowing surface water following storm events but does not regularly contain water. The minor seeps were observed in an arroyo located south of and hydraulically downgradient from the Site, where water seepage occurred along the contact between the sandstone beds on a vertical wall. A photograph of one of the minor seeps is shown in Appendix B-2 photograph number 13

- Structures – One home-site was located southeast of and within 0.25 miles of the Site, as shown in Figure 2-1.

- Ground cover – ground cover and vegetation observed on-site are discussed in Sections 2.2.2.2 and 2.2.5, respectively.

Field personnel did not observe the reclamation cap reported by Weston (2011). Field personnel also did not observe evidence of the two rim strip features identified in the desk top study. Field personnel examined the north and south rim strip locations, as mapped by USEAP (2007a), and did not identify any features indicative of historical rim stripping. In addition, USEPA (2007a) mapped the south rim strip location (refer to Figure 2-5) in an improbable location for rim stripping (i.e., rim stripping generally occurs along bedrock outcrops, and the location is shown in an area of limited soil cover with no distinct bedrock outcrops).

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 Red Valley 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 analysis, 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 one potential background reference area (BG-1) for the Site, as shown in Figure 3-2 and Appendix B-2 photograph number 14. BG-1 was also selected as a suitable background reference area for the Site for the following reasons:

- BG-1 encompassed an area of 5,048 ft^2 (approximately 0.12 acres), was located 900 ft northwest of the Site, and was crosswind and hydrologically up-gradient from the Site. Geologically, BG-1 represented areas of the Site that had a mix of bedrock outcrops of the Morrison Formation and unconsolidated deposits, as discussed in Section 2.2.2 and shown in Figure 2-7b. The vegetation and ground cover at BG-1 were similar to the Site.

The background reference area was located on the same mesa as the Site, had similar characteristics as the Site (i.e., it was located at the junction of the mesa top and mesa sidewall: refer to Figures 2-7a and 3-3), and there was no visual evidence of mining-related impacts.

The potential background reference area was 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 the area. Stantec does not view the size of the selected background reference area as affecting the validity of the background concentrations. The size was based on professional judgment that the identified area was generally representative of the Site.

The background reference area was 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 area. The ILs derived from the background reference area 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 May and July 2016, Redente performed a spring and a summer vegetation survey as part of the Site Clearance field investigations. Complete details of the vegetation surveys, including the *NNDFW Biological Resources Compliance Form*, are included in Appendix E and summarized below.

In preparation for the vegetation surveys, 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[5]. A copy of this letter is included in Appendix E.

The NNDFW listed five T&E plant species that may occur on-site: alcove death camas (G3), alcove bog-orchid (G3), Rydberg's thistle (G4), Parish's alkali grass (G4), and Navajo sedge (USFWS threatened). The USFWS listed three T&E plant species that may occur on-site: Knowlton's cactus, Mancos milkvetch, and Mesa Verde cactus. Alcove death camas is a native perennial forb that grows in hanging gardens, seeps, and alcoves mostly on the Navajo Sandstone formation. This species is endemic to the Colorado Plateau in southern Utah and northern Arizona at elevations from 3,698 ft to 6,999 ft amsl. Alcove bog-orchid is a native perennial forb that grows in seeps, hanging gardens, and moist stream areas from the desert shrub to the Pinyon Juniper communities. This species is found in New Mexico, Utah, and Arizona at elevations from 4,003 ft to 7,201 ft amsl. Rydberg's thistle is a native perennial forb that occurs in hanging gardens, seeps, and stream banks below hanging gardens at elevations from 3,297 ft to 6,946 ft amsl. Its distribution includes southern San Juan County along with Coconino and Apache Counties in Arizona. 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 seeps, springs and seasonally wet areas and washes at elevations from 5,000 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. Knowlton's cactus is one of the rarest cacti in the US and is known to occur only in a very limited area in San Juan County, New Mexico on alluvial deposits that form rolling-gravelly hills dominated by pinyon, juniper, and black sagebrush. Mancos milkvetch is a native perennial forb that grows in small depressions and sand-filled cracks in light colored sandstone on or near ledges and mesa tops in San Juan County, New Mexico and Montezuma County, Colorado from 4,921 ft to 5,905 ft amsl. Mesa Verde cactus is a native cacti that grows in clay-rich soils on the tops of hills, on benches and slopes mostly in saltbush communities with low plant cover and occurs in San Juan County, New Mexico and Montezuma County, Colorado at elevations from 4,898 ft to 5,945 ft amsl.

[5] 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).

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 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 the T&E species, specifically alkali seeps, seeps and hanging gardens, rolling-gravelly hills, small depressions and sand-filled cracks in light colored sandstone on or near ledges and mesa tops, and clay-rich soils.

Redente did not identify any of the eight T&E species at the Site, based on observations he made during the on-site survey, even though the Site was a likely habitat for the T&E species. Observed vegetation communities on-site were predominantly desert grassland with sporadic shrubs.

Wildlife Survey - In May 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 seven ESA-species with the potential to occur in the area of the Site; two birds (southwestern willow flycatcher and western yellow-billed cuckoo), three fish (Colorado pikeminnow, Zuni bluehead sucker, and razorback sucker), and two mammals (Canada lynx and New Mexico meadow jumping mouse). 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"[6] in the areas of the Site: black-throated sparrow, Brewer's sparrow, gray 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 March 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[7]).

The survey included the areas within the claim boundary and the 100-ft claim boundary buffer, as shown in Figure 2-5. The survey identified two archaeological sites. For confidentiality reasons, details regarding the archaeological sites 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 one of the archaeological sites be flagged and that an archaeologist monitor all ground disturbing activities, including soil sampling, within 50 ft of the archaeological boundaries. Dinétahdóó did not recommend marking or avoidance for the second archaeological site. 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.

[6] 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.
[7] Call with Sadie Hoskie, Tamara Billie of NNHPD, and Linda Reeves, June 8, 2018.

Dinétahdóó also escorted field personnel during the attempted collection of a subsurface soil sample at the background reference area (refer to Section 3.3.1.1). The Trust and NNHPD agreed that Dinétahdóó's archeologist would be present because the subsurface sample location was 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 soil and sediment sampling, subsurface soil 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 area selected for the Site. Refer to Section 3.2.2.2 for an explanation of the selection of the background reference area 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 area 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 area was selected based on a variety of factors, including *MARSSIM* criteria, which indicated whether the area was 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 area 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 survey was initially performed in May 2016. However, the initial survey did not extend to include the entire area inclusive of where surface soil samples were collected (refer to Figure 3-3). Therefore, a second surface gamma survey was performed in May 2017, and extended to include the entire area where surface soil samples were collected. ERG performed the surface gamma survey 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 survey by walking the background reference area 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 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 survey 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 survey was also used to collect static one-minute gamma measurements at the ground surface and down-hole (subsurface) at borehole location S486-SCX-004. 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, in October 2016, from the background reference area:

- BG-1 – Eleven surface soil grab samples were collected from 11 locations. No subsurface soil samples were collected from BG-1. Borehole S486-SCX-004 was attempted at BG-1 but the hand auger met refusal on bedrock at 0.5 ft bgs. A grab sample was collected from 0 ft to 0.4 ft bgs at borehole S486-SCX-004 but this was categorized as a surface sample.

The lack of subsurface soil samples from BG-1 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 soil/sediment sampling and subsurface soil 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 approximate centerline of the southeastern extent of the potential haul road was surveyed, but the shoulders were not; and the approximate shoulders of the northwestern extent of the potential haul road was surveyed, but the centerline was not. These were due to miscommunication with field personnel and are identified as potential data gaps in Section 4.9. In addition, the portion of the potential haul road located northwest of the Site that enters the King Tutt Point claim was not surveyed (refer to Figure 2-5) due to miscommunication with field personnel. This is not identified as a data gap because per the USEPA the un-scanned portion was actually scanned by Cyprus Amax in 2017, as part of its site investigations for Kit Tutt Point.

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 soil and sediment samples, subsurface soil samples, and surface water samples were also collected and used to evaluate mining-related impacts (refer to Section 3.3.2).

In October 2016, the surface gamma survey was performed using the methods and equipment described in Section 3.3.1.1. 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. Of note, the Site is adjacent to and surrounded by three other claim boundaries and the 100-ft buffer extends into these adjacent claims (refer to Figure 2-5). Therefore, the surface gamma survey was not extended beyond: (1) the 100-ft buffer into these other claims; and (2) into drainages down-gradient of the Site that drain directly onto other claims. A decision was made between the Trust and the Agencies to not extend the surface gamma survey into adjacent claims. 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 area to determine if additional surface gamma surveying was needed.

The full areal extent of the surface gamma survey was 10.1 acres and is referred to as the Survey Area, as shown in Figure 3-4. 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 October 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 four of 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.

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 considered. 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 October 2016 and May 2017, samples were collected from the locations shown in Figure 3-6 and are summarized in Table 3-2. The numbers of surface samples collected within specific mine features are listed in Table 3-3. Eighteen surface soil/sediment grab samples were collected from 17 locations in the Survey Area (two surface soil samples were collected from S486-SCX-002). 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 Sampling

Site Characterization activities included subsurface soil 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). Composite samples were collected to provide a screening level assessment across an interval (e.g., soil collected from the potential staging area). Additionally, 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.

Seven boreholes were advanced in the Survey Area through the unconsolidated deposits (from 0.5ft to 1.6 ft bgs; refer to Table 3-2 and Appendix C.2) until refusal at bedrock/ hard rock or the termination reason was unknown at borehole S486-SCX-001 (field personnel neglected recording a reason for termination). 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 silty sand, poorly graded sand, and poorly graded sand with gravel (refer to Appendix C.2 for borehole information). A drill rig was not employed at the Site because exposed bedrock was prevalent and soil/sediment depths were estimated to be shallow.

In October 2016 and May 2017, samples were collected from the locations shown in Figure 3-6 and are summarized in Table 3-2. The numbers of subsurface samples collected within specific mine features are listed in Table 3-3. Four subsurface soil grab or composite samples were collected from four borehole locations in the Survey Area.

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

Five surface water features were identified during the Site Clearance desktop study and two surface water features were identified during the Site Clearance field investigations, as shown in Figure 2-1 and Table 3-1. Six of the seven water features were not sampled for the following reasons: five of the identified features (12-UNK-0027/1050507, RV990413RVS007, Black Rock Wash, Oak Springs Wash/12-26, and RV990413RGVS008 [Red Wash]) only contained flowing surface water following storm events and did not regularly contain water. As a result, surface water from these locations was 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. Additionally, a sample was not collected from the minor seeps located south of, and hydraulically down-gradient, from the Site. At the minor seeps location field personnel observed water seeping down the vertical rock wall, where the wall was wet, but water flow was not sufficient enough to pool so that a sample could be collected. A photograph of one of the minor seeps is shown in Appendix B-2 photograph number 13. One of the seven water features was sampled as detailed below.

On May 23, 2017, a surface water sample (S486-WS-001) was collected from the seep identified as 12-8-9 in the *2007 AUM Atlas*. The seep was located slightly over one mile southwest of the Site in an incised drainage. The seep day-lighted within the bed of the drainage channel, as shown in Appendix B-2 photograph number 11. The flow of water from the seep was visibly slow and the flow rate was not measurable. Therefore, to collect enough water for a sample field personnel dug a hole within the bed of the drainage channel, where water from the seep could collect (refer to Appendix B-2 photograph number 10). Field personnel returned to the collection location after two hours, once enough water had ponded. To collect the surface water sample field personnel used disposable tubing and a peristaltic pump, set at a low flow rate to minimize any sediment disturbance that could occur during sample collection. Field personnel also observed an earthen dam located in the same drainage channel as the seep. The earthen dam measured approximately 8 ft tall by 20 ft long. The location of the earthen dam is shown in Figure 2-1and a photograph of the earthen dam is shown in Appendix B-2 photograph 12.

The water sample collected for dissolved metals analyses was sampled and field filtered using a peristaltic pump, Teflon® tubing, and 0.45-micron inline filter in the field 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 sample was 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, conductivity, turbidity, temperature, and oxidation reduction potential). Salinity was not collected as part of the specified field measurements because the water quality meter the field personnel were using could not measure salinity. This is identified as a data gap in Section 4.9. 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. Investigation of groundwater is not included in the scope of this RSE.

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. US Atomic Energy Commission (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 potentially 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 reported.

- **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 sample locations and results of the background reference area surface gamma survey are shown in Figure 4-1a. Analytical results of the samples collected from BG-1 are summarized in Table 4-1. The gamma measurements and surface soil sample analytical results collected from BG-1 were evaluated statistically to calculate ILs (refer to Appendix D).

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 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 the Site are:

- Arsenic - 6.20 milligrams per kilogram (mg/kg)
- Molybdenum - an IL for molybdenum was not identified because all but one molybdenum sample result in BG-1 were non-detect
- Selenium – an IL for selenium was not identified because selenium sample results in BG-1 were all non-detect
- Uranium - 6.07 mg/kg
- Vanadium - 18.4 mg/kg
- Ra-226 - 4.42 pCi/g
- Surface gamma measurements - 14,600 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 area, one static gamma measurement (17,995 cpm) was collected down-hole at a depth of 0.5 ft bgs in BG-1 (S486-SCX-004). Only one subsurface measurement was obtained because bedrock was encountered at a shallow depth (0.5 ft bgs). For the purposes of this RSE, 17,995 cpm is used as the subsurface static gamma IL. It is important to note that the subsurface static gamma IL may be artificially elevated relative to the surface gamma IL because increases in static gamma measurements with depth can result from: (1) the detector being in closer proximity to mineralized bedrock; and/or (2) the detector being closely surrounded by gamma sources within the borehole versus when the detector is at the ground surface and surrounded by air with gamma sources below the detector (this is also known as geometric effects). However, use of this measurement as an IL is a reasonable approach because geologic conditions within the Survey Area are similar to those at BG-1; in that underlying bedrock is covered by shallow deposits of unconsolidated material that are generally less than 1.0 ft deep (refer to the borehole logs in Appendix C.2).

The subsurface static gamma screening level from BG-1 provides a comparison and assessment tool for the Survey Area and is included as an IL for the Site. However, 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.

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 1ft 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 Figures 4-1a and 4-1b where the calculated surface gamma IL for BG-1 was 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 IL, and the maximum site gamma measurement. The maximum survey measurement was 76,181 cpm, which was greater than 5 times the IL (i.e., 14,600 cpm), and occurred in an area coincident with the potential staging area (refer to Figure 2-5). Surface gamma measurements were greatest in three areas:

1. The northeast corner of the Site, approximately coincident with the potential staging area and a nearby surface water drainage channel associated with the engineered berms (refer to Section 3.2.2.1, and Appendix B-1, photograph numbers 5 and 2 respectively).

2. On the lower bench (refer to Figure 2-5), adjacent to the base of the northeast-trending bedrock slope, located toward the southwest of the Site (refer to Section 3.2.2.1). The area is coincident with the potential mining-disturbed area identified during Site Clearance activities.

3. In two areas on the north/northwest upper bench including: (1) a bedrock outcrop located within the northwest corner of the 100-ft claim boundary; and (2) a portion of the potential haul road that enters/exits the Site along the northern claim boundary (refer to Figure 2-5).

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

1. Due to miscommunication with the field personnel, the approximate center of the southeastern extent of the potential haul road was surveyed, but the shoulders were not; and the approximate shoulders of the northwestern extent of the potential haul road was surveyed, but the center was not.

2. The gamma survey was not extended laterally from the potential haul road 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 six of the seven borehole locations. A surface static gamma measurement was not collected at S486-SCX-002; refer to Appendix C.2. Surface and subsurface static gamma measurement locations are shown in Figures 4-1a and 4-1b. Measurements and corresponding measurement depths are provided in Table 4-2 and are shown on the borehole logs in Appendix C.2.

Survey Area subsurface static gamma measurements exceeded the subsurface static gamma IL of 17,995 cpm in four boreholes (S486-SCX-001, -SCX-003, -SCX-005, and -SCX-007; refer to Table 4-2 and Figures 4-1a and 4-1b). Three of the four boreholes with a subsurface static gamma IL exceedance (S486-SCX-001, -SCX-003 and SCX-005) are also approximately coincident with areas of elevated surface gamma measurements (refer to Section 4.2.1.1). The fourth borehole (S486-SCX-007) is located at the base of the bedrock slope near an area of elevated surface gamma (refer to Figure 4-1b). The highest subsurface static gamma measurement of 200,000 cpm was measured at a depth of 0.25 ft bgs in borehole S486-SCX-001, which is located adjacent to the potential staging area (refer to Figure 2-5). The second highest subsurface static gamma measurement of 196,000 cpm was measured at a depth of 0.6 ft bgs in borehole S486-SCX-003, which is located near the southwest claim boundary (refer to Figure 2-5).

Static gamma measurements at more than one discrete depth were measured at boreholes S486-SCX-001, -SCX-005, -SCX-006, SCX-007 and -SCX-008 (refer to Table 4-2). Static gamma measurements increased with depth in boreholes S486-SCX-003 and -SCX-005, -SCX-006 and -SCX-008, and decreased with depth in borehole S486-SCX-001(refer to Table 4-2). It is important to note that increases in gamma measurements with depth could, in part, be the result of closer proximity to mineralized bedrock that has elevated levels of radionuclides relative to the surface soils, and/or due to geometric effects that can occur down-hole (refer to Section 4.1).

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 (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 0.95 which is within the acceptance criterion of 0.8 to 1.0 described in the *RSE Work Plan* and indicates that surface gamma results correlate 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 radium-226 concentrations. The correlation equation to convert gamma measurements in cpm to predicted surface soil Ra-226 concentrations in pCi/g for the Site is:

Gamma (cpm) = 839 x Surface Soil Ra-226 (pCi/g) + 10,996

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 (9,419 cpm) and greater than the maximum (35,193 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 -1.9 pCi/g and the concentration associated with the maximum mean gamma measurement is 28.8 pCi/g. Therefore, predicted Ra-226 concentrations less than -1.9 pCi/g and greater than 28.8 pCi/g should be limited to qualitative use only. Negative values for Ra-226 are a function of the linear regression equation and are not physically possible. 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 9,419 to 35,193 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 correlation equation predicted Ra-226 concentrations that were less than zero for gamma survey measurements below 10,996 cpm. The predicted concentrations are shown in Figure 4-2a and the values less than zero are located on the lower bench in limited areas on the upper bench, and along the potential haul roads. The elevated predicted Ra-226 concentrations shown in Figure 4-2a 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 -5.3 to 77.7 pCi/g, with a mean of1.2 pCi/g, and a standard deviation, of 5.4 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 three (out of 17) sample locations, the measured Ra-226 laboratory concentrations were within the applicable predicted Ra-226 bin ranges. In two of the three sample locations where the predicted Ra-226 concentration and the Ra-226 concentration detected in the soil/sediment sample did not agree, the predicted concentration was lower than the reported laboratory concentration detected in the soil/sediment sample. The predicted Ra-226 concentration at the remaining sample location (S486-SCX-005, located on the upper bench) was notably higher than the soil sample Ra-226 laboratory concentration. The differences observed between the predicted and actual Ra-226 values 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. However, the correlation may be useful as a screening tool as it provides a representative estimate of Ra-226 concentrations across the Site similar to the actual results.

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 were less than the Ra-226 IL for the majority of the Site. In addition, every soil/sediment sample with a laboratory concentration that exceeded the Ra-226 IL occurred in an area with predicted Ra-226 IL exceedances. The area of the Site where predicted Ra-226 values exceeded the ILs is compared to surface gamma IL exceedances in the surface gamma survey in Section 4.5.

The correlation soil samples 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 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 R2 meets the study DQO (adjusted R2 > 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 18 surface soil/sediment grab samples were collected from 18 locations (17 soil and one sediment) and 4 subsurface soil grab or composite samples were collected from 4 borehole locations (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 Table 4-4. Figure 4-3 presents the spatial patterns, both laterally and vertically, of metals and Ra-226 detections and IL exceedances in the soil/sediment samples.

Concentrations of Ra-226 and metals exceeded their respective ILs in 16 out of 18 surface soil/sediment samples, and in all four subsurface soil samples. The two surface soil sample locations (S486-CX-010, and -SCX-008) where Ra-226 and metals ILs were not exceeded are located in the southwest portion of the Site, near the southeastern claim boundary. In general, the greatest exceedances of Ra-226 and metals ILs were associated with the samples collected from the upper bench and bedrock slope. The maximum concentrations for all analytes were detected at locations S486-SCX-001 and S486-CX-006, both located on the upper bench. S486-SCX-001 was located in the northeast corner of the Site, adjacent to the potential staging area and S486-CX-006 was located adjacent to the potential haul road in the northwest area of the Site. Ra-226 concentrations, metal detections, and IL exceedances in the Survey Area soil/sediment samples are described below:

- Ra-226
  - The Ra-226 IL (4.42 pCi/g) was exceeded in 12 surface soil samples (S486-CX-001, -CX-002, -CX-004, -CX-005, -CX-007, -CX-008, -CX-009, -SCX-001, both -SCX-002 samples, -SCX-003, and -SCX-005) and three subsurface soil samples (S486-SCX-001, -SCX-003, and -SCX-005). The maximum Ra-226 concentration (223 pCi/g) was measured in surface soil sample S486-SCX-001 (0.0-0.3 ft bgs), located in the northeast corner of the Site, adjacent to the potential staging area.
- Uranium
  - The uranium IL (6.07 mg/kg) was exceeded in 11 surface soil samples (S486-CX-001, -CX-002, -CX-004, -CX-005, -CX-007, -CX-009, SCX-001, both -SCX-002 samples, -SCX-003, and -SCX-005) and all four subsurface soil samples (S486-SCX-001, -SCX-003, -SCX-005 and -SCX-007). The maximum uranium concentration detected was 250 mg/kg and occurred in surface soil sample S486-SCX-001(0.0-0.3 ft bgs) located adjacent to the potential staging area in the northeast corner of the Site.

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 15 out of 22 soil/sediment samples from the Survey Area.

- Arsenic
  - The arsenic IL (6.20 mg/kg) was exceeded in three surface soil samples (S486-CX-006, -SCX-003, and -SCX-005) and three subsurface soil samples (S486-SCX-001, -SCX-003 and -SCX-005). The maximum arsenic concentration (17 mg/kg) was measured in a surface soil sample collected from S486-CX-006 (0.0-0.5 ft bgs) located adjacent to the potential haul road in the northwest area of the Site.

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). All arsenic concentrations were within the typical range of regional values in the soil/sediment samples from the Survey Area.

- Molybdenum
  - Molybdenum was detected in six surface soil samples (S486-CX-001, -CX-002, -CX-004, -CX-005, -CX-006 and -SCX-005) and two subsurface soil samples (S486-SCX-001 and -SCX-005). An IL for molybdenum was not identified because all but one molybdenum sample result in BG-1 were non-detect. Of the eight molybdenum detections in the Survey Area, only three exceeded the single measurement in BG-1 (0.33 mg/kg). The maximum molybdenum concentration (0.79 mg/kg) occurred in surface soil sample S486-CX-006 (0.0-0.5 ft bgs) located adjacent to the potential haul road in the northwest area of the Site.

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). All molybdenum concentrations were within the typical range of regional values in soil/sediment samples from the Survey Area.

- Selenium
  - Selenium was detected in eight surface soil samples (S486-CX-003, -CX-006, -CX-007, -CX-008, -SCX-001, -SCX-003, -SCX-005 and -SCX-007) and three subsurface soil samples (S486-SCX-001, -SCX-003 and -SCX-007). Selenium was also detected in the field duplicate of sample S486-CX-001(i.e., S486-CX-001Dup) but was not detected in the normal sample (S486-CX-001). An IL for selenium was not identified because selenium sample results in BG-1 were all non-detect. The maximum selenium concentration in the Survey Area was 4.0 mg/kg and occurred in a subsurface sample from borehole S486-SCX-001(0.3-1.6 ft bgs), located adjacent to the potential staging area in the northeast corner of the Site.

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). All selenium concentrations were within the typical range of regional values in soil/sediment samples from the Survey Area.

- Vanadium
  - The vanadium IL (18.4 mg/kg) was exceeded in 15 surface soil samples (S486-CX-001, -CX-002, --CX-003, CX-004, -CX-005, -CX-007, -CX-008, -CX-009, -SCX-001, both -SCX-002 samples, -SCX-003, -SCX-005, - SCX-006 and SCX-007), and three subsurface soil samples (S486-SCX-001, -SCX-003, and -SCX-007). The maximum vanadium concentration (1,400 mg/kg) was measured in surface soil sample S486-SCX-001 (0.0-0.3 ft bgs), located adjacent to the potential staging area in the northeast corner of the Site.

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 exceeded the maximum regional value in four out of 22 soil/sediment samples.

4.4 CONSTITUENTS OF POTENTIAL CONCERN

Based on the results presented in Sections 4.2 and 4.3, arsenic, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed COPCs for the Site. ILs for selenium and molybdenum were not identified because in the background area selenium sample results were non-detect and molybdenum was detected in only one sample. However, because selenium and molybdenum were detected in soil/sediment samples from the Survey Area, they are also confirmed as COPCs for the Site.

4.5 AREAS THAT EXCEED THE INVESTIGATION LEVELS

The approximate lateral extent of surface gamma IL exceedances in soil/sediment is 1.1 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. Figure 4-4b shows a larger scale views of the Survey Area to better display those areas with multiple, contiguous surface gamma IL exceedances. With the exceptions of sample locations S486-CX-006 and -SCX-006, this area also included all other locations where surface and/or subsurface Ra-226 and metals concentrations exceeded one or more of their respective ILs in soil. An important consideration is that the portions of the Survey Area that extended into the other claims that are adjacent to the Site were excluded from this evaluation (refer to Figure 4-4a where excluded areas are shown in gray). Note that areas within the 100 ft claim boundary to the northwest and northeast of the Site, and not within an adjacent claim boundary, were included.

Figure 4-4c 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 4-4c 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 the same areas of the Site where the surface gamma IL was exceeded.

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, 3.2 acres, out of the 10.1 acres of the Survey Area, were estimated to contain TENORM at the Site. Note that the drainages down-gradient of the Site that drain directly onto other claims and portions of the Survey Area that extended into adjacent claims were excluded from the TENORM evaluation because a decision was made between the Trust and the Agencies to not extend the surface gamma survey into adjacent claims with the exception of gamma surveying the potential haul road where it crosses the Begay No. 1 claim. The TENORM estimate is inclusive of four areas: a northern area, a central area, a southwestern area, and the potential haul road southeast of the Site. The northern area occurs on the upper bench and on the northeast-trending bedrock slope. This area is inclusive of a portion of the potential haul road that enters/exits the Site along the northern claim boundary, as well as the potential staging area in the northeast corner. The central area occurs on the lower bench and is generally located adjacent to the base of the bedrock slope. The southwestern area is also located on the lower bench adjacent to the bedrock slope and is inclusive of the potential mining disturbance located near the southwest claim boundary. The potential haul road southeast of the Site is included in TENORM with the exception of the portion of the potential haul road that is within the Begay No. 1 Site. The area containing TENORM is shown in relation to the lateral extent of IL exceedances in Figure 4-5 and in relation to the gamma measurements in Figure 4-6.

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

- Historical Data Review Conclusions
    - Historical document review identified two rim strip mining features based on the *2007 AUM Atlas.* The locations of the two rim strip features are shown in Figure 2-5). Field personnel examined the north and south rim strip locations, as mapped by USEAP (2007a), and did not identify any features indicative of historical rim stripping. In addition, USEPA (2007a) mapped the south rim strip location (refer to Figure 2-5) in an improbable location for rim stripping (i.e., rim stripping generally occurs along bedrock outcrops, and the location is shown in an area of limited soil cover with no distinct bedrock outcrops). It is unknown if the potential rim stripping was associated with mining activities or exploration activities that occurred on-site.
    - NAML records indicated that no reclamation activities took place at the Site; however, reclamation activities did occur on claims adjacent to the Site.
    - Although historical document review indicated that no ore was produced from the Site, the *2007 AUM Atlas* reported that sometimes production from multiple mines was reported as a single combined value for one of the mines. In these cases, the mines were included on a single lease, and the ore production reported was inclusive of all of the mines on that single lease (USEPA, 2007a).
    - Historical aerial photographs provided limited evidence of mining-related activities at the Site. The only observed evidence of mining activities was the potential haul road in the northwestern portion of the Site and to the north of the claim boundary that was visible in the 1975 image. This indicated that the road had been installed sometime prior to that date.
- Geology/geomorphology
    - Bedrock at the Site consisted of the Jurassic Morrison Formation, which commonly has natural enrichments of uranium, vanadium and Ra-226. 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 (refer to Appendix B-1 photograph number 8). If rim-stripping occurred,

or soil/sediment was disturbed during historical mining activities, it is possible for TENORM to be present on the Site.

- There was a predominant northeast-southwest trending slope of bedrock outcrop that was observed through the central portion of the Site. The bedrock slope had approximately 20 feet of topographic relief and may represent the most likely location for potential rim strip mining activities. Gamma measurements on the bedrock slope did not suggest that a substantial amount of TENORM was present on this slope; however, it is possible that the portions of the slope with the highest radioactivity were removed during historical mining activities.

- Ephemeral drainages were present that could transport NORM/TENORM to the southeast, onto a claim adjacent to the Site. The drainage channel located in the northeast corner of the claim boundary contained sediment that exceeded the surface gamma IL. Surface sediment gamma measurements did not exceed the IL in any other drainage channels on-site. Minimal to no alluvial sediments were observed in the drainages within the claim boundary. Drainages located outside the claim boundary and within adjacent mine claims were not addressed as part of this RSE because a decision was made between the Trust and the Agencies to not extend the surface gamma survey into adjacent claims.

- Disturbance Mapping

  - There was visual evidence documented by both Stantec and Dinétahdóó that identified two areas of potential mining-related disturbances on-site (refer to Section 3.2.2.1): (1) a potential staging area located in the northeast portion of the Site; and (2) a potential mining disturbed area in the southwest portion of the Site.

  - Field personnel were unable to visually identify the two rim strip mining features, and therefore, the locations of the rim strips. However, because the bedrock slope (within the claim boundary) was a geologically appropriate location for potential rim strip mining, this feature was considered to be the most likely location for potential rim-stripping activities.

  - There was visual evidence of two potential haul roads present on or within 0.25 miles of the Site.

  - Two earthen berms were observed northeast of the claim boundary. The berms appeared to have been engineered to control and divert surface water flow into drainage channels that transect the northeast corner of the Site. Surface gamma measurements were also greatest in the areas associated with the berms.

- Site Characterization

  - The northern area (upper bench) was characterized by several areas of elevated surface gamma measurements that primarily included a portion of the potential haul road that exits/enters the Site along the northern claim boundary, small discrete zones on the outcropping bedrock slope, and the majority of the northeast corner of the Site. COPCs were detected in every soil sample (surface and subsurface) on the upper bench and one or more IL was exceeded at every sample location. The highest surface gamma and subsurface static gamma measurements occurred in the northeastern section of the area and were associated with the potential staging area and berm-related drainage channel.

- The central area (lower bench) was characterized by elevated surface gamma measurements that occurred adjacent to the base of the outcropping bedrock slope. IL exceedances included surface gamma and subsurface static gamma, Ra-226, uranium, vanadium and Ra-226. In addition, selenium was detected in all soil samples from this area.

- The southwest area was characterized by a linear trend of elevated surface gamma that occurred primarily on the lower bench, along the base of the outcropping bedrock slope, and included the potential mining disturbed area. IL exceedances included surface gamma and subsurface static gamma, Ra-226, arsenic, uranium, vanadium. In addition, selenium was also detected.

- The potential haul road southeast of the Site was identified as TENORM and surface gamma measurements exceeded the surface gamma IL at two points along the potential haul road.

- The two smaller TENORM areas on the lower bench were identified as TENORM primarily due to the presence of IL exceedances downgradient of the TENORM area on the upper bench.

- No surface or subsurface IL exceedances were detected in the southwestern portion of the Site, near the southeastern claim boundary.

- Metals concentrations in samples collected outside the area of TENORM (S486-CX-010 and -SCX-008) were less than or within the regional concentration values.

- No potential mine waste material was observed at the ground surface. Obvious mine waste was not observed in boreholes that were advanced at the Site, although several boreholes did contain gray soils, which may be evidence of mine waste (S486-SCX-001, -SCX-003, -SCX-006 and -SCX-008). Samples from S486-SCX-001 contained elevated Ra-226 and uranium concentrations, and the borehole was located within the potential staging area and within the TENORM boundary. Both S486-SCX-003 and -SCX-006 are within the TENORM boundary, but -SCX-008 is not. Borehole S486-SCX-008 is in the southern corner of the Site, in an area where there is no evidence of disturbance or mining activity.

- It is important to consider that the subsurface static gamma IL was not used as the only evidence to delineate the vertical extent of TENORM that exceeded the IL within borehole locations at the Site.

The area of the Site considered to contain TENORM (i.e., multiple lines of evidence indicated the presence of mining-related impacts) was 3.2 acres, as shown on Figure 4-7a. Portions of the TENORM exceeded one or more IL, where approximately 0.9 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 two sample locations that were not coincident with areas of the Site that exceeded the surface gamma IL. TENORM that exceeded the ILs in the Survey Area is shown on Figures 4-7a and is compared to mining-related features in Figure 4-7b.

Of note, gamma measurements exceeded the surface gamma IL in the area located on the upper bench, northwest of the claim boundary. However, this area was not included within the TENORM boundary delineation because this area is coincident with a bedrock outcrop that showed no signs of human disturbance and is therefore considered NORM (refer to Figures 4-7a and 4-7b).

4.7 TENORM VOLUME ESTIMATE

The volume estimate of TENORM that exceeded one or more ILs is approximately 1,098 yd^3, as shown in Figure 4-8. The volumes and areas 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 4-8. 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.
- Portions of the areas delineated as exposed bedrock within the TENORM area on Figure 4-8 contain small amounts of colluvium.
- The subsurface static gamma IL value was not used as the only evidence to delineate the vertical extent of TENORM that exceeded the ILs within borehole locations at the Site.
- TENORM on claims adjacent to the Site was related to historical mining that occurred on those claims and not considered for volume calculations, per the Agencies' agreement.

Group Assumptions

- Group 1 (157 yd^3)- Polygons were best fit around areas mapped as exposed bedrock, and soil/sediment classified as TENORM extend to 0.5 ft bgs over 50 percent of those areas, which was based on: (1) mapping that used the current aerial photograph (Cooper, 2017) to delineate the surface extent of soil/sediment overlaying the exposed bedrock; and (2) field observations (including depth to bedrock in boreholes).

- Group 2 (799 yd^3)- TENORM was conservatively assumed to extend to 1.0 ft bgs over the whole area. Volume estimates based on this assumption are conservative considering that some portions of the included areas consist of exposed bedrock.
- Group 3 (79 yd^3) - A polygon was best-fit around the potential staging area (dark blue polygon on Figure 4-8). Soil depth was assumed to extend to 2.0 ft bgs within this area, since S486-SCX-001 was terminated above bedrock at 1.6 ft bgs (the reason for termination was not recorded).
- Group 4 (63 yd^3) – Group 4 consists of the areas of TENORM that exceeded the surface gamma IL along the potential haul road. The vertical extent of TENORM exceeding ILs was assumed to extend to 0.5 ft bgs based on field observations that the potential haul road contained areas of exposed bedrock and followed existing topography (i.e., fill material was not used to create those portions of the road).

4.8 WATER ANALYTICAL RESULTS

The surface water sample collected as part of the Site Characterization activities was analyzed for the constituents listed in Section 3.3.2.3. One of the seven potential water features was sampled. The location of the sampled water feature is shown in Figure 2-1 and included the following:

- Seep 12-8-9 (sample S486-WS-001) located slightly over one mile southwest of the Site in an incised drainage

The analytical results from the sample 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 12-8-9 surface water sample (S486-WS-001) analytical results indicated that radionuclides, metals, and general chemistry were all below their respective ILs. Based on these results, there are no confirmed COPCs for the seep. 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

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

1. Salinity was not collected as part of the specified field measurements because the water quality meter the field personnel were using could not measure salinity. This is considered a minor data gap because no surface water COPCs were confirmed based on the analytical results of the collected seep surface water sample.

2. Due to miscommunication with the field personnel, the approximate center of the southeastern extent of the potential haul road was surveyed, but the shoulders were not; and the approximate shoulders of the northwestern extent of the potential haul road was surveyed, but the center was not.

3. The gamma survey was not extended laterally from the potential haul road where gamma measurements were greater than the IL as the result of 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. 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 database that the USEPA reviewed. It is recommended that the two databases are compared (with additional field work, if necessary) to confirm the locations of water features.

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

3. Subsurface samples were not collected in the potential mining disturbed area and the potential haul roads; further evaluation of these features may be warranted.

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 May 2017. The Site is known as the Oak 124, Oak 125 site and is also identified by the USEPA as AUM identification #486 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. A surface water sample was 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.

Site-specific historical information is minimal; however, it appears that: (1) rim stripping potentially occurred on-site; (2) no ore was produced from the Site or, if ore was produced, it could have been combined with ore production from other mines for reporting purposes; and (3) it is unknown if the potential rim stripping was associated with mining activities or exploration activities that occurred on-site. In addition, in 2002 the Site was listed as un-reclaimed.

One potential background reference area (BG-1) was selected to develop surface gamma, Ra-226, and metals ILs for the Survey Area at the Site. A subsurface static gamma IL was also identified for the Survey Area.

Arsenic, uranium, vanadium, and Ra-226 concentrations and gamma radiation measurements in soil/sediment exceeded their respective ILs and are confirmed COPCs for the Site. ILs for selenium and molybdenum were not identified because in the background area selenium sample results were non-detect and molybdenum was detected in only one sample. However, because selenium and molybdenum were detected in soil/sediment samples from the Survey Area, they are also confirmed as COPCs for the Site.

Results of the Gamma Correlation Study indicated that surface gamma survey results correlate with Ra-226 concentrations in soil. Therefore, gamma surveys could be used during site assessments as a field screening tool to estimate Ra-226 concentrations in soil. Additional correlation studies may be needed to refine the relationship between gamma and Ra-226.

Based on the data analysis performed for the RSE along with the supporting lines of evidence, approximately 3.2 acres out of the 10.1 acres of the Survey Area were estimated to contain TENORM. The areas containing TENORM includes a northern area, central area, southwestern area, and the potential haul road southeast of the Site. The northern area consists of the upper bench and outcropping bedrock slope, and is inclusive of a portion of the potential haul road that exits/enters the Site along the northern claim boundary, as well as the potential staging area in the northeast corner of the claim boundary. The central area is located on the lower bench and is inclusive of the area adjacent to the base of the outcropping bedrock slope. The southwestern area is also located primarily on the lower bench along the base of the outcropping bedrock slope, and is inclusive of the potential mining disturbed area located along the southwestern claim boundary. Within the area of the claim boundary, the areas outside of the TENORM boundary show no signs of disturbance related to mining, and, therefore, are considered areas that contain NORM. The Survey Area was limited to the 100-ft buffer around the Site and potential haul roads. The portions of the Survey Area within claims adjacent to the Site were not evaluated for the presence of TENORM. Of the 3.2 acres that contain TENORM, 0.9 acres contain TENORM exceeding the surface gamma IL; and TENORM that exceeded the ILs at all but two of the soil/sediment sample locations. The volume of unconsolidated TENORM in excess of ILs is estimated to be 1,098 yd^3 (839 cubic meters).

A surface water sample was collected from one seep (12-8-9) and analytical results from the sample (S486-WS-001) indicated that radionuclides, metals, and general chemistry were all below their respective ILs. Based on these results, there are no confirmed COPCs for the seep and further characterization may not be needed at the seep.

Three 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 Oak 124, 125 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 Oak 124, 125 RSE were $380,400. Stantec's costs associated with interim actions (sign installation) were $4,000. In addition, Administrative costs provided by the Trust were estimated currently at $191,500[8,9]. Administrative costs will change due to continued community outreach and close out activities.

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

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TABLES

Table 3-1
Identified Surface Water Features
Oak 124, Oak 125
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
Spring	2007 AUM Atlas[1]	12-UNK-0027/1050507	NA	No surface water observed in this area. This spring is hydraulically upgradient of spring 12-8-9 and may be flowing at times, however; it was not flowing during RSE visits. The two water features were grouped herein because it was assumed that historical water samples were collected at the same water feature.
Spring	2007 AUM Atlas[1]	RV990413RVS007	NA	No surface water observed in this area. This spring is hydraulically down-gradient of seep 12-8-9 and may be flowing at times, however; it was not flowing during RSE visits.
Seep	2007 AUM Atlas[1]	12-8-9[2]	S486-WS-001	This location was sampled as part of RSE field activities on May 23, 2017, sample location S486-WS-001. This surface water feature is located slightly over one mile southwest of the Site.
Drainage Channel	NNDWR	Black Rock Wash	NA	No surface water observed.
Drainage Channel	NNDWR	Oak Springs Wash /12-26	NA	No surface water observed.
Drainage Channel	Stantec/Trustee	RV990413RVS008 (Red Wash)	NA	Contains flowing surface water following storm events and does not regularly contain water. Wash was not sampled as part of the Site Characterization activities in accordance with the requirements of the Trust Agreement and Scope of Work, which require sampling of perennial water features only.
Minor seeps	Stantec/Trustee	Minor seeps	NA	Water seepage was observed in arroyo south of- and hydraulically downgradient from the Site. Seepage occurred along the contact between sandstone beds on a vertical wall. The wall was wet, however; the water was not pooling and a water sample could not be collected.

Notes
NA - Water feature not sampled
NNDWR - Navajo Nation Department of Water Resources
RSE - Removal Site Evaluation
[1] USEPA, 2007a
[2] Seep was given identification number S485-WS-001 for RSE sample collection. Sample collection occurred west of where the *2007 AUM Atlas* located water feature 12-8-9.

Table 3-2
Soil and Sediment Sampling Summary
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Sample Depth (ft bgs)	Sample Media	Sample Category	Sample Collection Method	Survey Area	Sample Date	Easting [1]	Northing [1]	Sample Types		
									Metals, Total	Ra-226	Thorium
Background Reference Area Study - Background Area 1 (BG-1)											
S486-BG1-001	0 - 0.5	soil	SF	grab	NA	10/1/2016	676213.41	4064723.15	N;FD	N;FD	--
S486-BG1-002	0 - 0.5	soil	SF	grab	NA	10/1/2016	676217.009	4064723.689	N	N	--
S486-BG1-003	0 - 0.5	soil	SF	grab	NA	10/1/2016	676220.074	4064721.902	N	N	--
S486-BG1-004	0 - 0.5	soil	SF	grab	NA	10/1/2016	676209.539	4064715.74	N	N	--
S486-BG1-005	0 - 0.5	soil	SF	grab	NA	10/1/2016	676213.954	4064716.762	N;MS;MSD	N	--
S486-BG1-006	0 - 0.5	soil	SF	grab	NA	10/1/2016	676216.992	4064715.684	N	N	--
S486-BG1-007	0 - 0.5	soil	SF	grab	NA	10/1/2016	676221.235	4064717.179	N	N	--
S486-BG1-008	0 - 0.5	soil	SF	grab	NA	10/1/2016	676211.273	4064711.989	N	N	--
S486-BG1-009	0 - 0.5	soil	SF	grab	NA	10/1/2016	676213.45	4064710.193	N	N	--
S486-BG1-010	0 - 0.5	soil	SF	grab	NA	10/1/2016	676216.678	4064712.114	N	N	--
S486-SCX-004	0 - 0.4	soil	SF	grab	NA	10/10/2016	676216.867	4064712.337	N	N	--
Correlation											
S486-C01-001	0 - 0.5	soil	SF	5-point composite	NA	10/7/2016	676440.383	4064380.012	--	N;FD	N;FD
S486-C02-001	0 - 0.5	soil	SF	5-point composite	NA	10/7/2016	676333.954	4064366.292	--	N	N
S486-C03-001	0 - 0.5	soil	SF	5-point composite	NA	10/7/2016	676307.689	4064438.887	--	N	N
S486-C04-001	0 - 0.5	soil	SF	5-point composite	NA	10/7/2016	676404.974	4064460.778	--	N	N
S486-C05-001	0 - 0.5	soil	SF	5-point composite	NA	10/7/2016	676324.607	4064404.314	--	N	N
Characterization											
S486-CX-001	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676473.757	4064475.531	N;FD	N;FD	--
S486-CX-002	0 - 0.5	sediment	SF	grab	Site Survey Area	10/10/2016	676477.159	4064455.618	N	N	--
S486-CX-003	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676426.403	4064453.539	N;MS;MSD	N	--
S486-CX-004	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676427.113	4064471.398	N	N	--
S486-CX-005	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676396.55	4064473.616	N	N	--
S486-CX-006	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676394.575	4064485.177	N	N	--
S486-CX-007	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676399.231	4064422.909	N	N	--
S486-CX-008	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676376.419	4064396.134	N	N	--
S486-CX-009	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676352.418	4064383.102	N	N	--
S486-CX-010	0 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676404.19	4064389.95	N	N	--
S486-SCX-001	0 - 0.3	soil	SF	grab	Site Survey Area	10/10/2016	676471.807	4064476.122	N	N	--
S486-SCX-001	0.3 - 1.6	soil	SB	composite	Site Survey Area	10/10/2016	676471.807	4064476.122	N	N	--
S486-SCX-002	0 - 0.2	soil	SF	grab	Site Survey Area	10/10/2016	676395.572	4064473.413	N	N	--
S486-SCX-002	0.2 - 0.5	soil	SF	grab	Site Survey Area	10/10/2016	676395.572	4064473.413	N	N	--
S486-SCX-003	0 - 0.4	soil	SF	grab	Site Survey Area	10/10/2016	676376.43	4064396.689	N	N	--
S486-SCX-003	0.4 - 0.6	soil	SB	grab	Site Survey Area	10/10/2016	676376.43	4064396.689	N	N	--
S486-SCX-005	0 - 0.5	soil	SF	grab	Site Survey Area	5/19/2017	676405.603	4064460.12	N;FD	N;FD	--
S486-SCX-005	0.5 - 0.8	soil	SB	grab	Site Survey Area	5/19/2017	676405.603	4064460.12	N	N	--
S486-SCX-006	0 - 0.5	soil	SF	grab	Site Survey Area	5/19/2017	676371.283	4064454.787	N	N	--
S486-SCX-007	0 - 0.5	soil	SF	grab	Site Survey Area	5/19/2017	676442.478	4064432.076	N;MS;MSD	N	--
S486-SCX-007	0.5 - 1.1	soil	SB	grab	Site Survey Area	5/19/2017	676442.478	4064432.076	N	N	--
S486-SCX-008	0 - 0.5	soil	SF	grab	Site Survey Area	5/19/2017	676376.371	4064356.151	N	N	--

Notes

--	Not Sampled
N	Normal
FD	Field Duplicate
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NA	Not Applicable
Ra-226	Radium 226
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
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Mine Feature	Surface Samples	Subsurface Samples	Area (sq. ft)	Volume of TENORM exceeding ILs (yd^3)
Potential Staging Area	2	1	171	11.6
Potential Mining Disturbed Area	0	0	700	22.0
Potential Haul Road	2	0	--	74.0
Drainages	1	1	--	*

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 feature varies throughout the Site

-- Discrete volume was not identified for feature

Table 3-4
Water Sampling Summary
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Field Sample Identification	Water Feature Identification	Sample Date	Easting [1]	Northing [1]	Sample Types: Ra-226	Ra-228	Gross Alpha	Metals, Dissolved	Metals, Total	TDS	Anions	Cations
Surface Water												
S486-WS-001	12-8-9	5/23/2017	674761.455	4063861.06	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 Area Soil Sample Analytical Results
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification Date Collected Depth (feet) Analyte (Units)	S486-BG1-001 Dup 10/1/2016 0 - 0.5	S486-BG1-001 10/1/2016 0 - 0.5	S486-BG1-002 10/1/2016 0 - 0.5	S486-BG1-003 10/1/2016 0 - 0.5	S486-BG1-004 10/1/2016 0 - 0.5	S486-BG1-005 10/1/2016 0 - 0.5	S486-BG1-006 10/1/2016 0 - 0.5	S486-BG1-007 10/1/2016 0 - 0.5	S486-BG1-008 10/1/2016 0 - 0.5	S486-BG1-009 10/1/2016 0 - 0.5	S486-BG1-010 10/1/2016 0 - 0.5	S486-SCX-004 10/10/2016 0 - 0.4
Metals[1] (mg/kg)												
Arsenic	1.4	1.5	1.2	6.2	1.4	1.2	1.3	1.5	1.4	0.87	0.68	0.74
Molybdenum	<0.2	<0.22	<0.21	0.33	<0.2	<0.2	<0.2	<0.2	<0.19	<0.2	<0.18	<0.2
Selenium	<1	<1.1	<1	<1.1	<0.99	<1	<1	<1	<0.97	<0.99	<0.88	<0.99
Uranium	1.6	1.8	2.6	5.7	2.1	2.1	2.6	2.8	3.2	2.8	1.9	2
Vanadium	11	13	8.3	15	11	8.2	7.9	6.9	12	9.2	4.8	4.8
Radionuclides (pCi/g)												
Radium-226	1.95 ± 0.37	1.78 ± 0.35	2.2 ± 0.35	3.87 ± 0.61	2 ± 0.36	1.74 ± 0.32	2.18 ± 0.39	2.03 ± 0.34	2.69 ± 0.45	2.91 ± 0.47	1.56 ± 0.3	1.71 ± 0.32

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

Table 4-2
Static Gamma Measurement Summary
Oak 124, Oak 125
Removal Site Evaluation Report - Final
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)
S486-SCX-004	Background Area 1	*	0.0	soil	14,044
S486-SCX-004	Background Area 1	*	0.5	soil	17,995**
S486-SCX-001	Site Survey Area	17,995	0.25	soil	200,000
S486-SCX-001	Site Survey Area	17,995	1.6	soil	120,000
S486-SCX-003	Site Survey Area	17,995	0.6	soil	196,000**
S486-SCX-005	Site Survey Area	--	0.0	soil	27,909
S486-SCX-005	Site Survey Area	17,995	0.5	soil	47,594
S486-SCX-005	Site Survey Area	17,995	0.8	soil	57,632**
S486-SCX-006	Site Survey Area	--	0.0	soil	11,292
S486-SCX-006	Site Survey Area	17,995	0.7	soil	13,343**
S486-SCX-007	Site Survey Area	--	0.0	soil	12,824
S486-SCX-007	Site Survey Area	17,995	0.5	soil	20,400
S486-SCX-007	Site Survey Area	17,995	1.1	soil	23,867**
S486-SCX-008	Site Survey Area	--	0.0	soil	8,863
S486-SCX-008	Site Survey Area	17,995	0.6	soil	10,398**

Notes

Bold	Bolded result indicates measurement exceeds subsurface gamma investigation level
*	The subsurface gamma investigation levels are 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
IL	Investigation Level
RSE	Removal Site Investigation
cpm	counts per minute
ft bgs	feet below ground surface
soil/bedrock	measurement collected at soil/bedrock interface

Table 4-3
Gamma Correlation Study Soil Sample Analytical Results
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification	S486-C01-001 Dup	S486-C01-001	S486-C02-001	S486-C03-001	S486-C04-001	S486-C05-001
Date Collected	10/7/2016	10/7/2016	10/7/2016	10/7/2016	10/7/2016	10/7/2016
Depth (feet)	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 ± 0.23	1.43 ± 0.35 J+	3.45 ± 0.5	29.4 ± 3.6	13.7 ± 1.7	22.6 ± 2.8
Thorium-228	0.385 ± 0.088	0.34 ± 0.075	0.51 ± 0.1	0.326 ± 0.077	0.461 ± 0.097	0.59 ± 0.12
Thorium-230	1.02 ± 0.19	1.04 ± 0.19	2.94 ± 0.47	18.8 ± 2.9	9.5 ± 1.5	15.4 ± 2.4
Thorium-232	0.407 ± 0.089	0.359 ± 0.075	0.58 ± 0.11	0.298 ± 0.069	0.5 ± 0.1	0.53 ± 0.11

Notes
Bold Bolded result indicates positively identified compound
pCi/g picocuries per gram
J+ Data are estimated and are potentially biased high due to associated quality control data

Table 4-4
Site Characterization Soil and Sediment Sample Analytical Results
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Location Identification		S486-CX-001 Dup	S486-CX-001	S486-CX-002	S486-CX-003	S486-CX-004	S486-CX-005	S486-CX-006	S486-CX-007	S486-CX-008	S486-CX-009	S486-CX-010	S486-SCX-001
Date Collected		10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016
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	0 - 0.3
Sample Category		surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface	surface
Sample Collection Method		grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	sediment	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)													
Metals[1] (mg/kg)	Investigation Level												
Arsenic	6.2	3	1.7	1.5	3.6	1.6	1.8	17	4.6	3	4.1	0.75	2.9
Molybdenum	NA	*<0.41 D*	0.21	0.53	<0.21	0.23	0.19	0.79	<0.2	<0.18	<0.2	<0.17	*<0.38 D*
Selenium	NA	1.6	<1	<1	1.1	<0.89	<0.87	3.7	1.7	1	<1	<0.84	1.3
Uranium	6.07	130 D	96	9.3	4 J+	6.9	15	4.1	18	5.2	17	1	250 D
Vanadium	18.4	1300 D	1300 D	27	56	98	100	34	24	44	36	9.9	1400 D
Radionuclides (pCi/g)													
Radium-226	4.42	119 ± 14	74.4 ± 8.9	4.64 ± 0.66	4.07 ± 0.61	14.6 ± 1.9	8.8 ± 1.1 J-	3.47 ± 0.54	17.8 ± 2.3	39.9 ± 4.9	31.1 ± 3.8	1.36 ± 0.29	223 ± 26

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
Italic Italicized result indicates analyte reported to the method detection limit
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, and molybdenum had a single detection in BG-1
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 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

Location Identification		S486-SCX-001	S486-SCX-002	S486-SCX-002	S486-SCX-003	S486-SCX-003	S486-SCX-005	S486-SCX-005	S486-SCX-005 Dup	S486-SCX-006	S486-SCX-007	S486-SCX-007	S486-SCX-008
Date Collected		10/10/2016	10/10/2016	10/10/2016	10/10/2016	10/10/2016	5/19/2017	5/19/2017	5/19/2017	5/19/2017	5/19/2017	5/19/2017	5/19/2017
Depth (feet)		0.3 - 1.6	0 - 0.2	0.2 - 0.5	0 - 0.4	0.4 - 0.6	0 - 0.5	0.5 - 0.8	0 - 0.5	0 - 0.5	0 - 0.5	0.5 - 1.1	0 - 0.5
Sample Category		subsurface	surface	surface	surface	subsurface	surface	subsurface	surface	surface	surface	subsurface	surface
Sample Collection Method		composite	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab	grab
Media		soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil	soil
Analyte (Units)													
Metals[1] (mg/kg)	Investigation Level												
Arsenic	6.2	12	3.2	4	6.3	7.6	7.9	8.6	13	1.3	2.2	2.9	0.44
Molybdenum	NA	0.27	<0.2	<0.18	<0.21	<0.2	0.37	0.27	0.46	<0.2	<0.2	<0.2	<0.2
Selenium	NA	4	<1	<0.92	1.1	1.1	1.1	<1	1.3	<1	1.3	1.6	<1
Uranium	6.07	22	22	20	22	57	16	14	17	3.4	3	12	0.48
Vanadium	18.4	160	700	680	52	110	17	18	20	43	30	70	5.2
Radionuclides (pCi/g)													
Radium-226	4.42	32.6 ± 3.9	9.4 ± 1.2	12.6 ± 1.6	40.3 ± 4.9	51.2 ± 6.1	11.8 ± 1.5	12 ± 1.5	12.5 ± 1.6	2.96 ± 0.45	2.98 ± 0.49	3.18 ± 0.47	0.51 ± 0.2

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
Italic	Italicized result indicates analyte reported to the method detection limit
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, and molybdenum had a single detection in BG-1
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 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 4-5
Summary of Investigation Level Exceedances in Soil/Sediment at Borehole Locations
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Sample Location	Investigation Level Exceedances
S486-SCX-001	As, Mo, Se, U, V, Ra-226, Static Gamma
S486-SCX-002	U, V, Ra-226, Static Gamma
S486-SCX-003	As, Se, U, V, Ra-226, Static Gamma
S486-SCX-005	As, Mo, Se, U, Ra-226, Static Gamma
S486-SCX-006	V
S486-SCX-007	Se, U, V, Static Gamma

Notes
As - Arsenic
Mo - Molybdenum
Ra-226 - Radium 226
Se - Selenium
U - Uranium
V - Vanadium

Table 4-6a
Water Sampling Investigation Level Derivation
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Analyte (Units)	USEPA MCL [(a)]	USEPA Secondary Standard [(b)]	Navajo Nation Surface Water Quality Standards [(c)]	Navajo Nation 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
Oak 124, Oak 125
Removal Site Evaluation Report - Final
Navajo Nation AUM Environmental Response Trust - First Phase

Analyte (Units)	Water Feature Identification / Field Sample Identification / Date Collected / Matrix / Preparation	12-8-9 / S486-WS-001 / 5/23/2017 / Surface Water / Dissolved	12-8-9 / S486-WS-001 / 5/23/2017 / Surface Water / Total
Radionuclides (pCi/L)	Investigation Level		
Ra-226	5 [1]	NS	0.25 ± 0.18
Ra-228	5 [1]	NS	0 ± 0.34
Gross Alpha	--	NS	2.7 ± 1.2
Adjusted Gross Alpha [2]	15	NS	NA
Gross Beta	--	NS	2.8 ± 1.3
Mercury (ng/L)			
Mercury	2000	1.7	4.7 D
Metals [3] (µg/L)			
Antimony	5.6	0.43	<0.3
Arsenic	10	4	4.3
Barium	2000	210	230
Beryllium	4	<0.5	<0.5
Cadmium	5	<0.3	<0.3
Chromium, Total	100	<10	<10
Cobalt	--	<1	<1
Copper	1300	<10	<10
Lead	15	<0.5	<0.5
Molybdenum	--	1.2	1
Nickel	610	<5	<5
Selenium	50	<1	<1
Silver	35	<0.1	<0.1
Thallium	2	<0.2	<0.2
Uranium	30	4.3	4
Vanadium	--	3.2	4.2
Zinc	2100	<20	<20
General Chemistry Parameters (mg/L)			
TDS	500	NS	360
Carbonate	--	NS	<20
Alkalinity, Total (as $CaCO_3$)	--	NS	250
Chloride	250	NS	8.3
Sulfate	250	NS	53
Calcium	--	75000	74000
Sodium	--	34000	33000
Field Parameters			
Oxidation Reduction Potential(millivolts)	--	NS	120.7
pH(pH units)	--	NS	7.16
Specific Conductivity(µS/cm)	--	NS	611
Temperature(°C)	--	NS	15.7
Turbidity(NTU)	--	NS	11.8

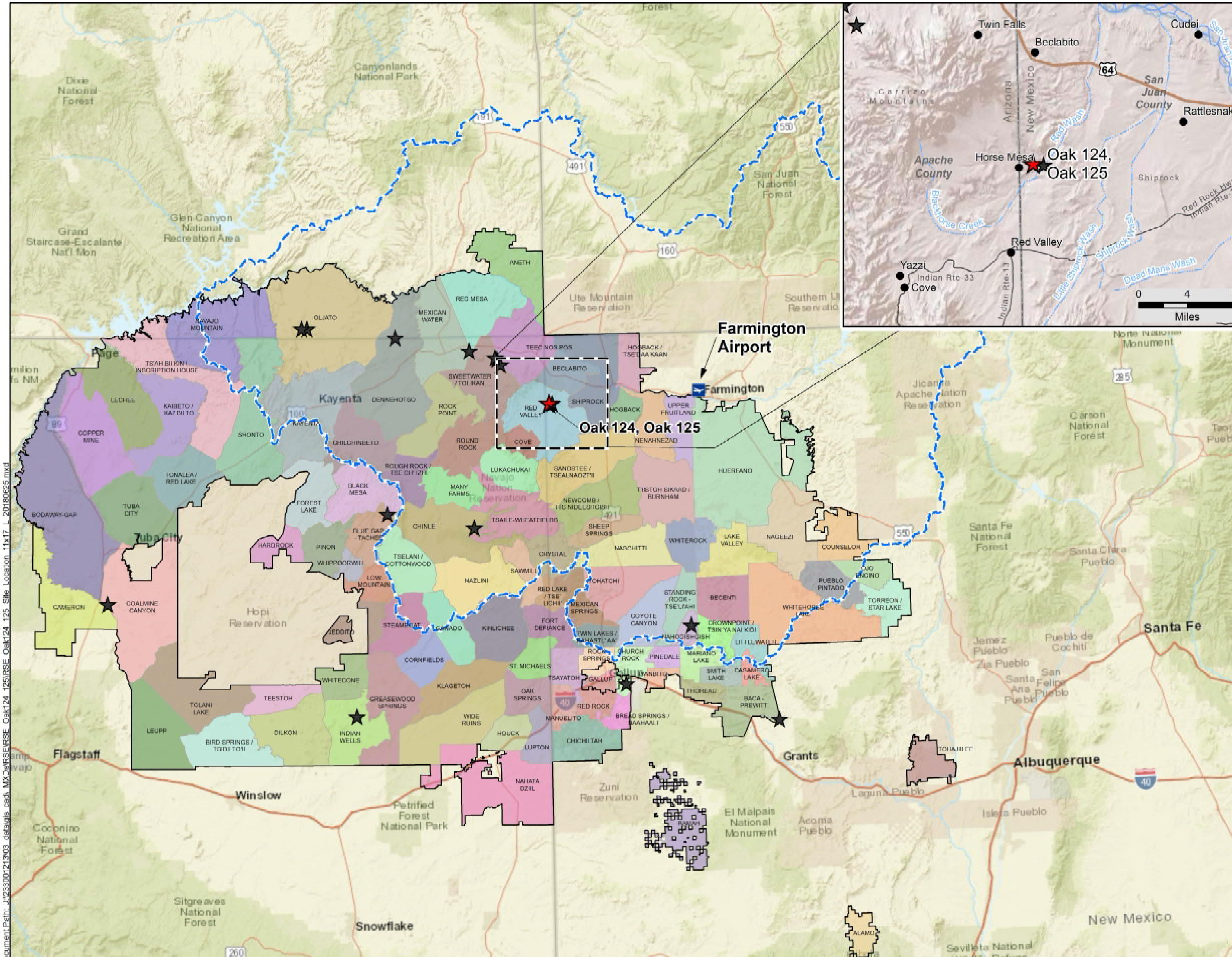
Notes

Bold	Bolded result indicates positively identified compound
°C	Degrees Celsius
µg/L	micrograms per liter
µS/cm	microSiemens per centimeter
mg/L	milligrams per liter
ng/L	nanograms per liter
NTU	nephelometric turbidity unit
pCi/L	picocuries per liter
--	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
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



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NAVAJO NATION

AUM Environmental Response Trust-First Phase

LEGEND

- Oak 124, Oak 125 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

Farmington Airport, New Mexico Wind Rose (KFMN), 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

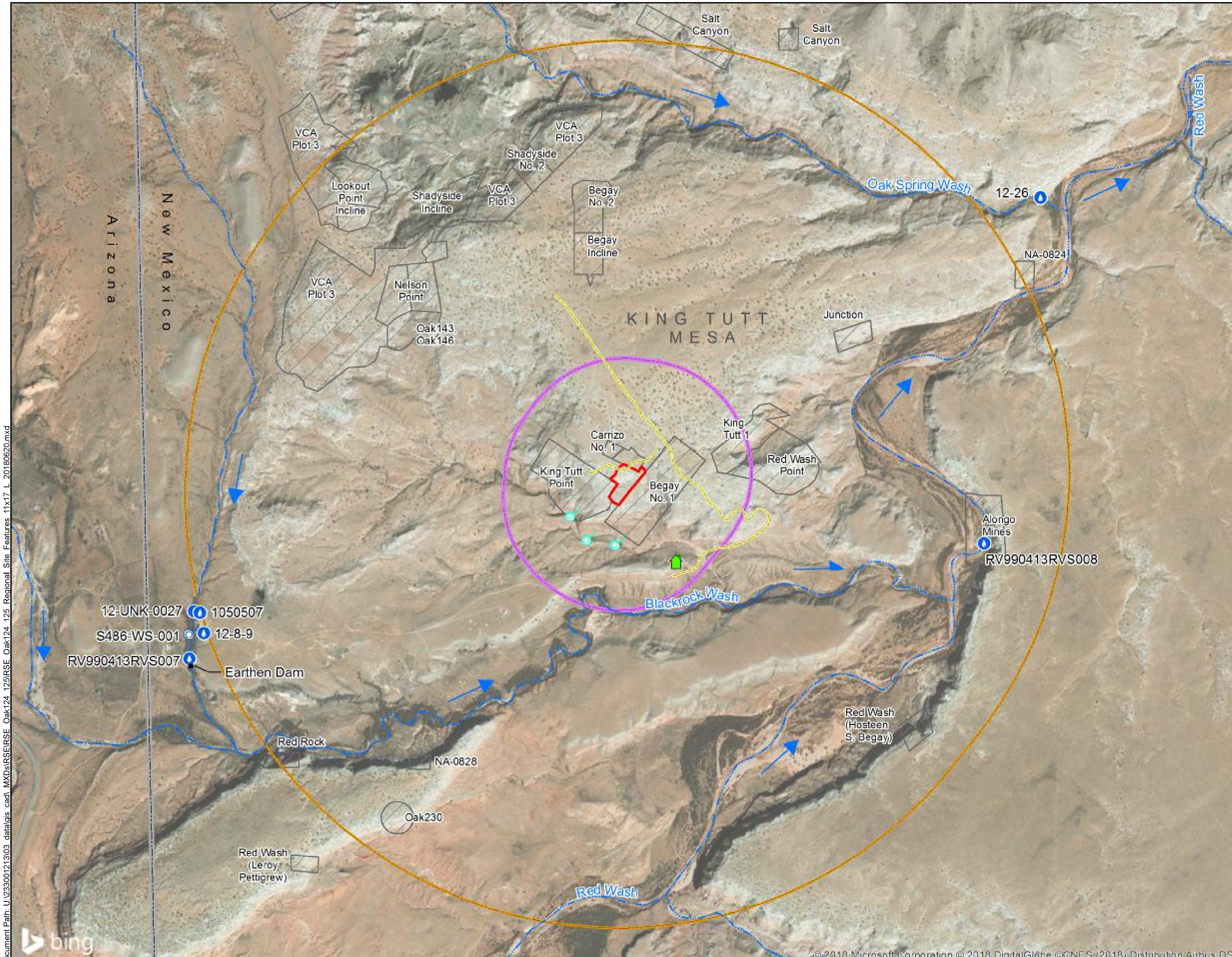
0 25 50

Miles

TITLE: Site Location

PROJECT: Removal Site Evaluation Oak 124, Oak 125 Mine Site

DATE: 6/22/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 1-1	



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Site Clearance Identified Water Feature[1]
- Habitable Building
- Seep Sample Location
- Minor Seep
- Flow Direction
- Potential Haul Road
- Intermittent Stream/River
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- Other Claim Boundary
- State Boundary

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. Minor seeps identified during field mapping.

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 1,200 2,400
Feet

TITLE: Site Features

PROJECT: Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 6/22/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EY

FIGURE: 2-1

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Road
- Intermittent Stream/River
- Claim Boundary
- Other Claim Boundary
- State 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 06/2018.

N W E S

0 2,000 4,000
Feet

TITLE:
Regional Aerial Photograph

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE:	DOCUMENT NAME:
6/22/2018	Removal Site Evaluation Report

Stantec

AUTHOR:	REVIEWER:
CBB	EY

FIGURE:
2-2

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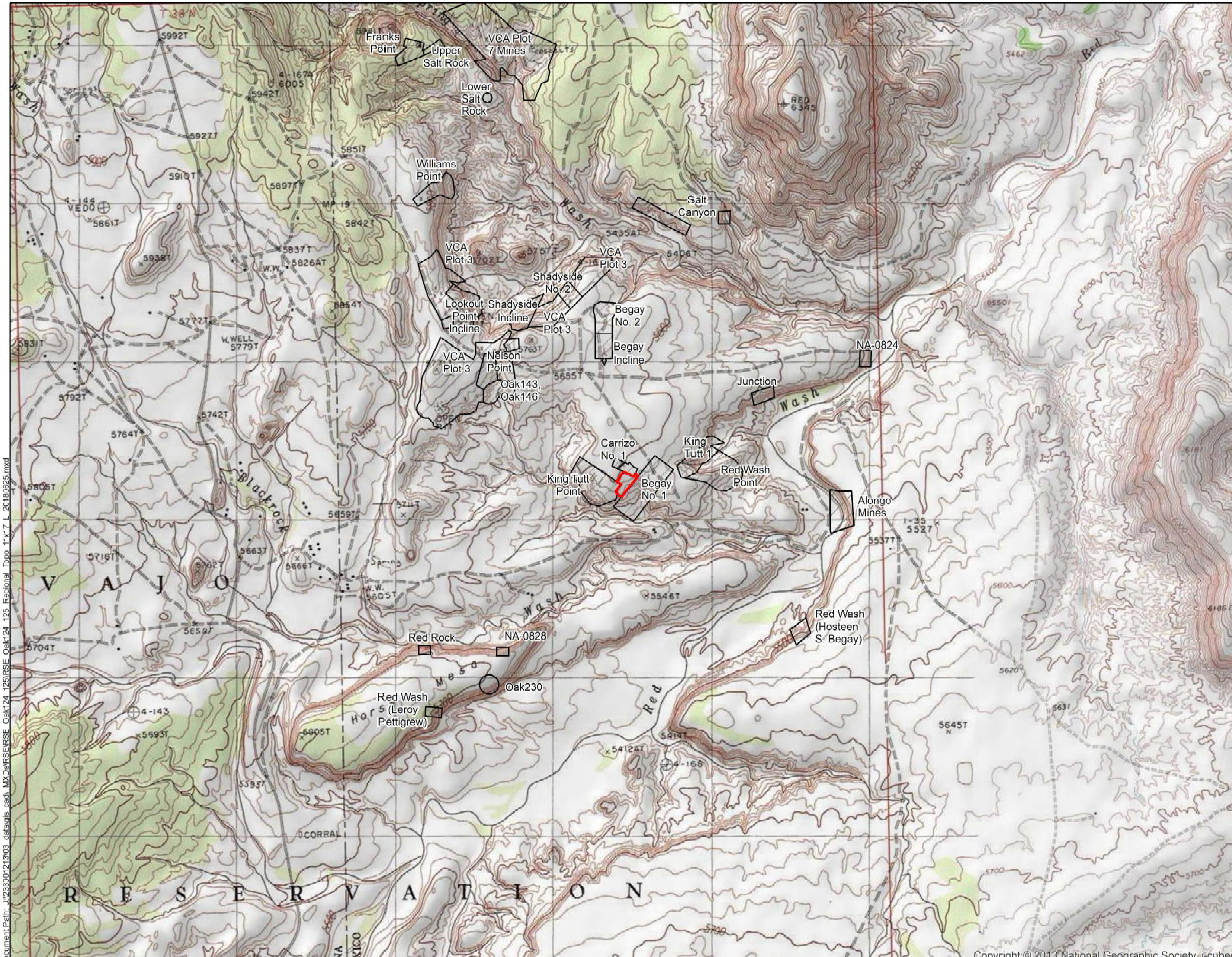

NAVAJO NATION
AUM Environmental Response Trust-First Phase

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
Oak 124, Oak 125 Mine Site

DATE:	DOCUMENT NAME:	
6/22/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EY
	FIGURE: 2-3	

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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Flow Direction
- Drainage
- Index Contour (10 ft Interval)
- Intermediate Contour (2 ft Interval)
- Claim Boundary
- Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

0 100 200
Feet

TITLE:
Site Topography

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 6/25/2018

DOCUMENT NAME: Removal Site Evaluation Report

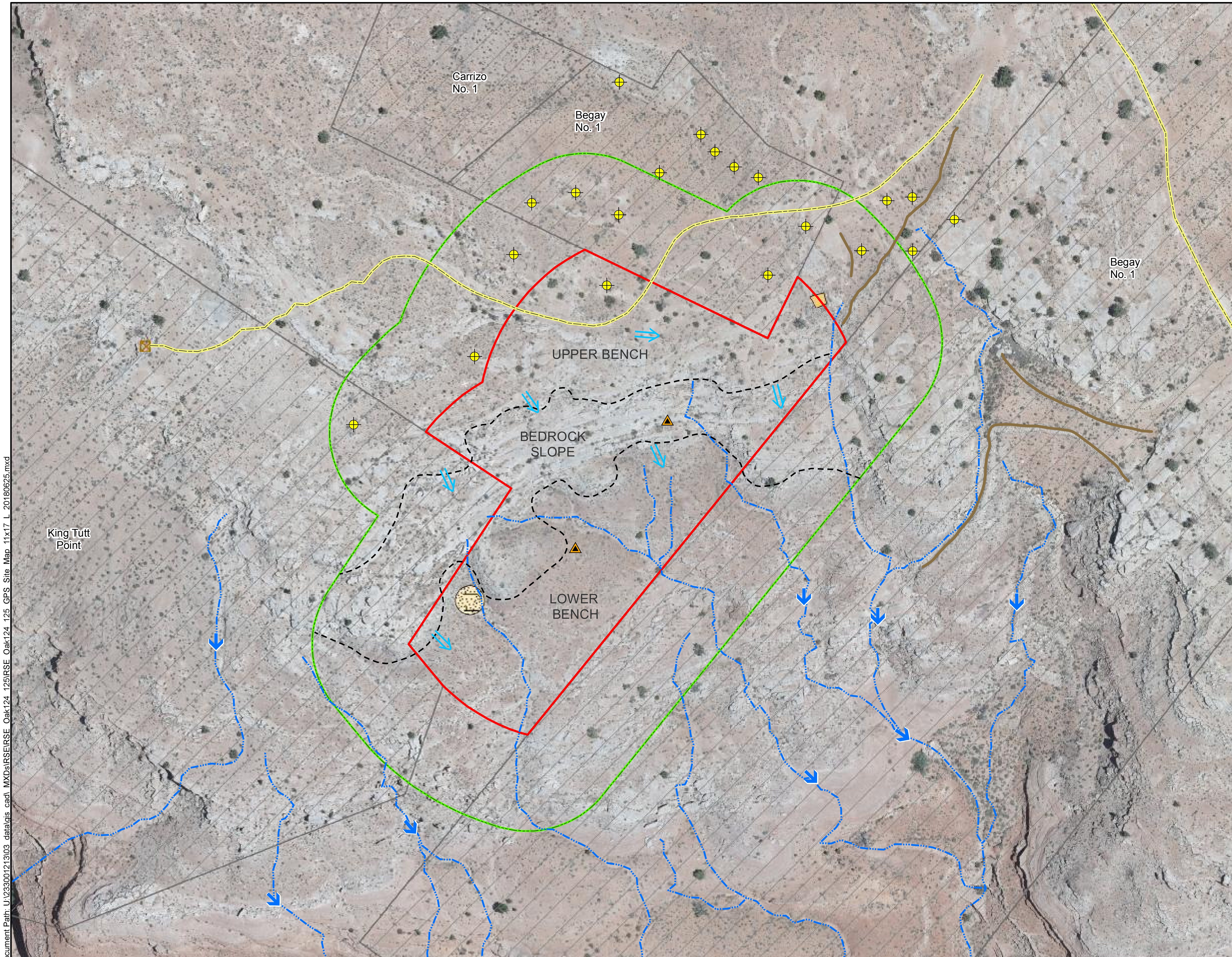
Stantec

AUTHOR: CBB

REVIEWER: EY

FIGURE: 2-4

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Oak124 125\RSE Oak124 125 Site Topo 11x17 L 20180626.mxd



![NAVAJO NATION AUM Environmental Response Trust-First Phase]

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Rim Strip Location per 2007 AUM Atlas[1]
- Historical Borehole
- Flow Direction
- Approximate Overland Water Flow Direction
- Approximate Boundaries of Bedrock Slope
- Berm
- Drainage
- Potential Haul Road
- Potential Mining Disturbed Area
- Excavation
- Potential Staging Area
- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary

NOTE:
1. Rim strips as shown in the 2007 AUM Atlas were not observed during field mapping (USEPA, 2007a).

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 100 200
Feet

TITLE:
Site Map

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 6/25/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EY

FIGURE: 2-5

Stantec

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Oak124 125\RSE Oak124 125 GPS Site Map 11x17 L 20180625.mxd

NAVAJO NATION
AUM Environmental
Response Trust-First Phase

TITLE:
Regional Geology

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 6/20/2018

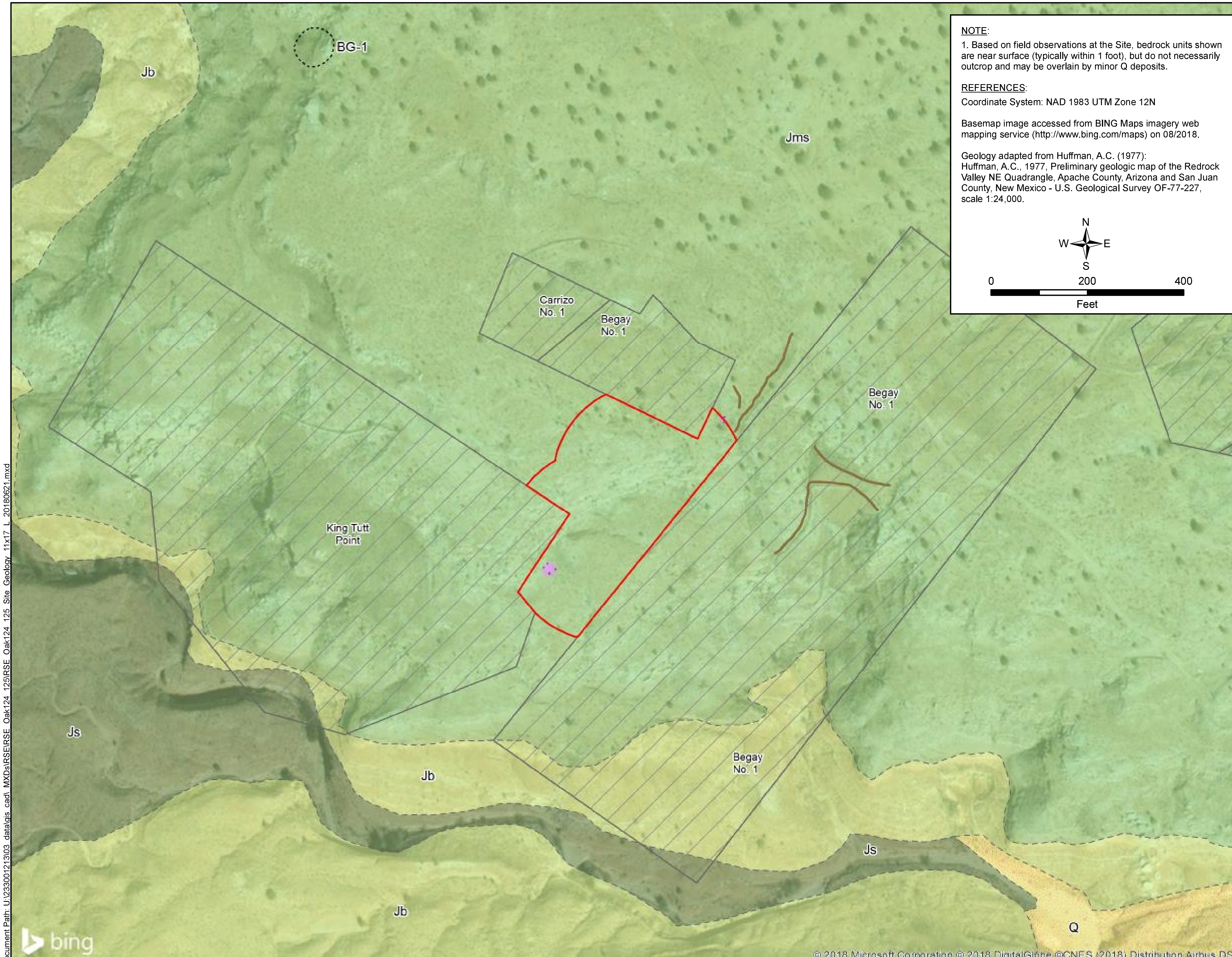
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 2-6



NOTE:
1. 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 08/2018.

Geology adapted from Huffman, A.C. (1977):
Huffman, A.C., 1977, Preliminary geologic map of the Redrock Valley NE Quadrangle, Apache County, Arizona and San Juan County, New Mexico - U.S. Geological Survey OF-77-227, scale 1:24,000.

N W E S

0 200 400
Feet

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Background Reference Area
- Claim Boundary
- Other Claim Boundary
- Berm
- Geologic 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

JURASSIC

- Jms: Salt Wash Member of the Morrison Formation (Upper Jurassic) – Yellowish gray to greenish-gray cross-bedded very fine to medium-grained calcareous sandstone inter-bedded with greenish-gray and reddish-brown claystone
- Jb: Bluff Sandstone (Upper Jurassic)- Moderate reddish-orange to light-brown, fine to medium grained laminated sandstone
- Js: Summerville Formation (Upper Jurassic) – Reddish-brown to light-orange very fine- to fine-grained flat bedded silty sandstone and thin-bedded silty sandstone, claystone, and siltstone; forms banded steep slopes and cliffs

TITLE:	Site Geology
PROJECT:	Removal Site Evaluation Oak 124, Oak 125 Mine Site
DATE: 8/29/2018	DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB	REVIEWER: EY
Stantec	FIGURE: 2-7a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\RSE_Oak124_125_Site_Geology_11x17_L_20180621.mxd

NOTES:

1. Approximately 50% of the areas delineated as exposed bedrock had a thin soil cover.

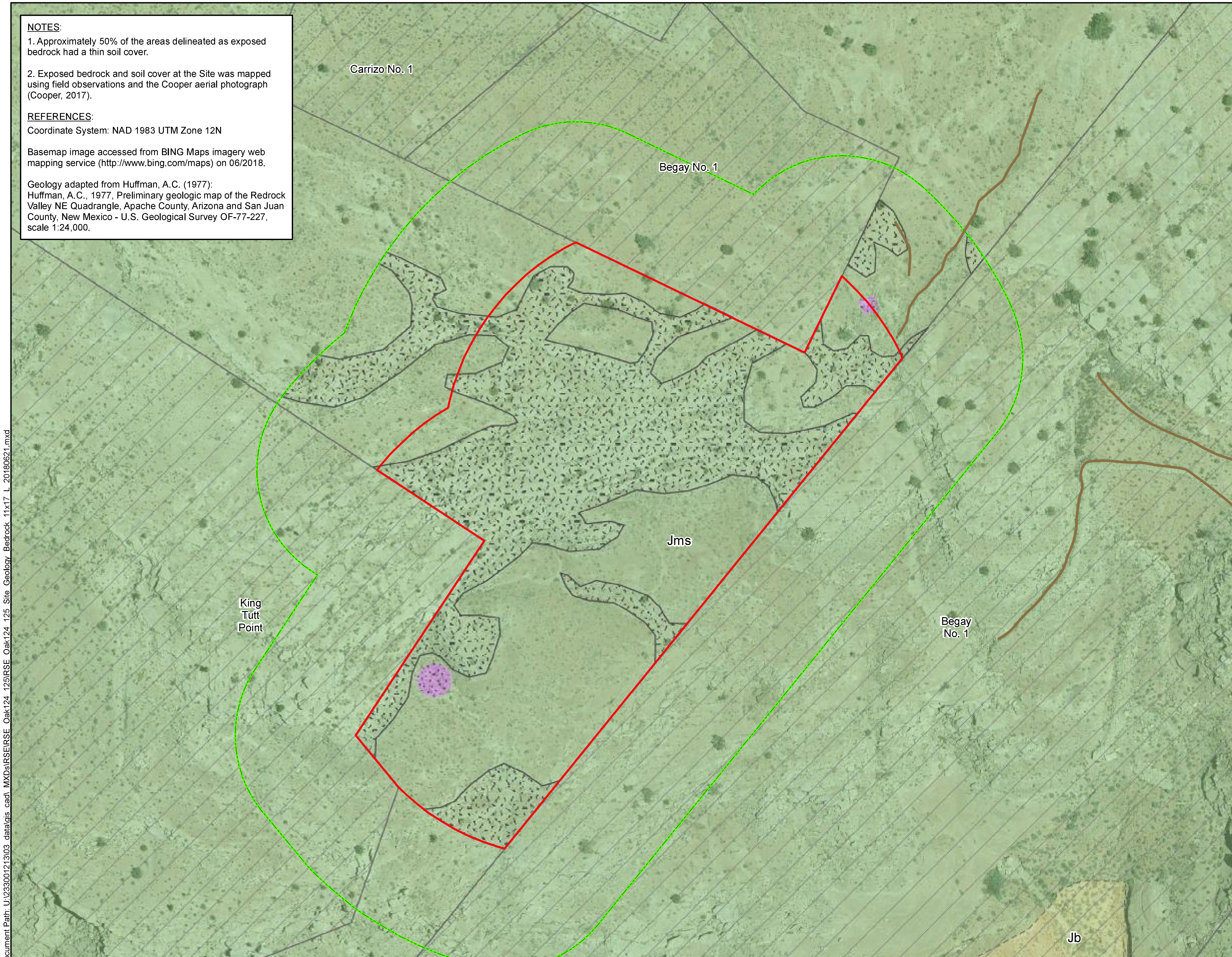
2. Exposed bedrock and soil cover at the Site was mapped using field observations and the Cooper aerial photograph (Cooper, 2017).

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 Huffman, A.C. (1977):
Huffman, A.C., 1977, Preliminary geologic map of the Redrock Valley NE Quadrangle, Apache County, Arizona and San Juan County, New Mexico - U.S. Geological Survey OF-77-227, scale 1:24,000.



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- 100-Foot Claim Buffer
- Other Claim Boundary
- Berm
- Geologic Contact (Inferred)
- Exposed Bedrock[1]

Site Geology

HOLOCENE

- Earthworks: Human-caused disturbance of the land surface potentially related to mining

JURASSIC

- Jms: Salt Wash Member of the Morrison Formation (Upper Jurassic) – Yellowish gray to greenish-gray cross-bedded very fine to medium-grained calcareous sandstone inter-bedded with greenish-gray and reddish-brown claystone
- Jb: Bluff Sandstone (Upper Jurassic)- Moderate reddish-orange to light-brown, fine to medium grained laminated sandstone

N W E S

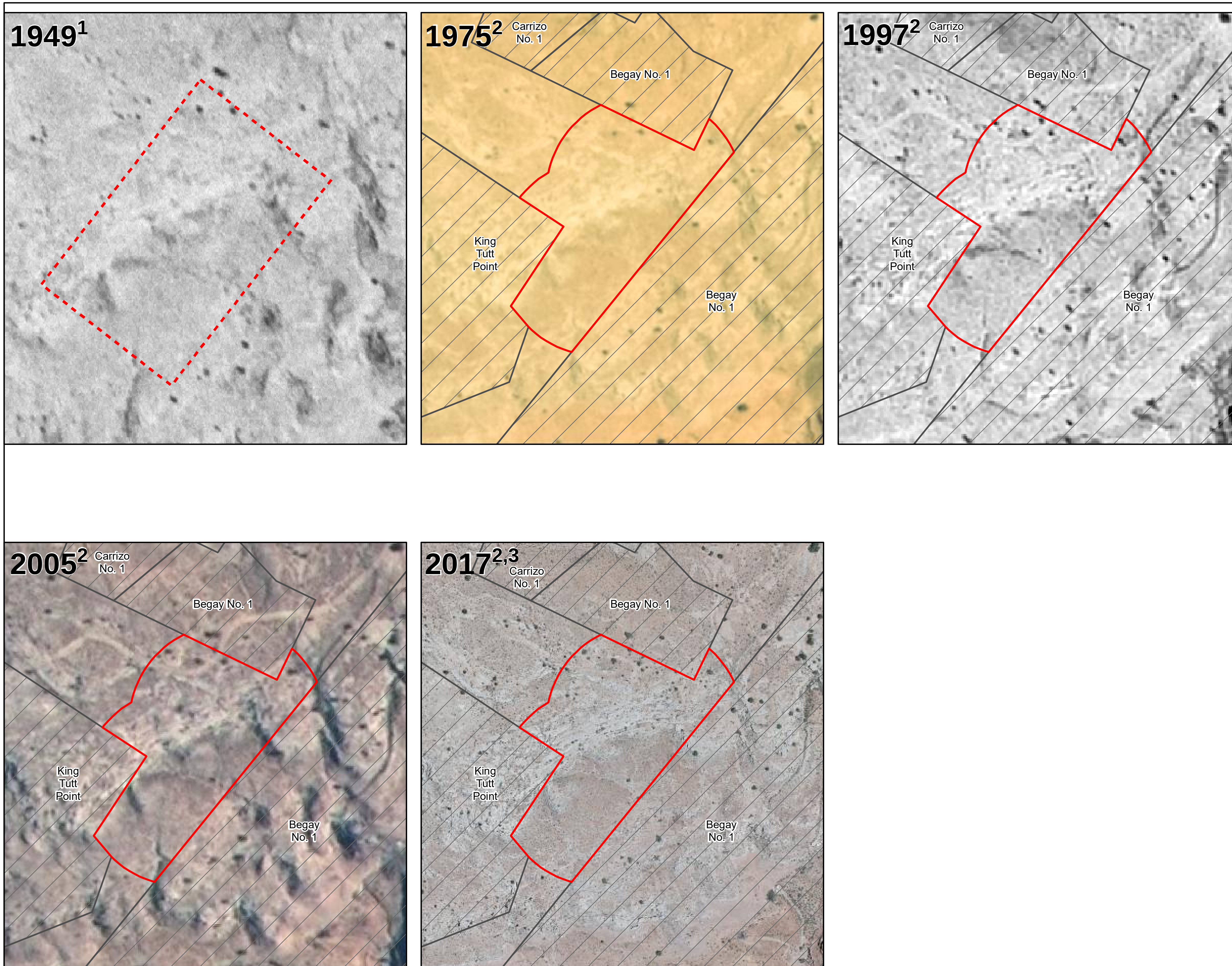
0 80 160
Feet

TITLE:
Site Exposed Bedrock

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE:	DOCUMENT NAME:
6/26/2018	Removal Site Evaluation Report
AUTHOR: CBB	REVIEWER: EY
Stantec	FIGURE: 2-7b

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Oak124_125\RSE_Oak124_125_Site_Geology_Bedrock_11x17_L_20180621.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Oak 124, Oak 125 Claim Boundary
- Approximate Site Location, not georeferenced
- Other Claim Boundary

NOTES:

1. Image is not georeferenced, scale not available.
2. Image is georeferenced. Scale bar applies to these image frames only.
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

0 200 400
Feet

TITLE: Historical Aerial Photograph Comparison

PROJECT: Removal Site Evaluation Oak 124, Oak 125 Mine Site

DATE: 8/29/2018

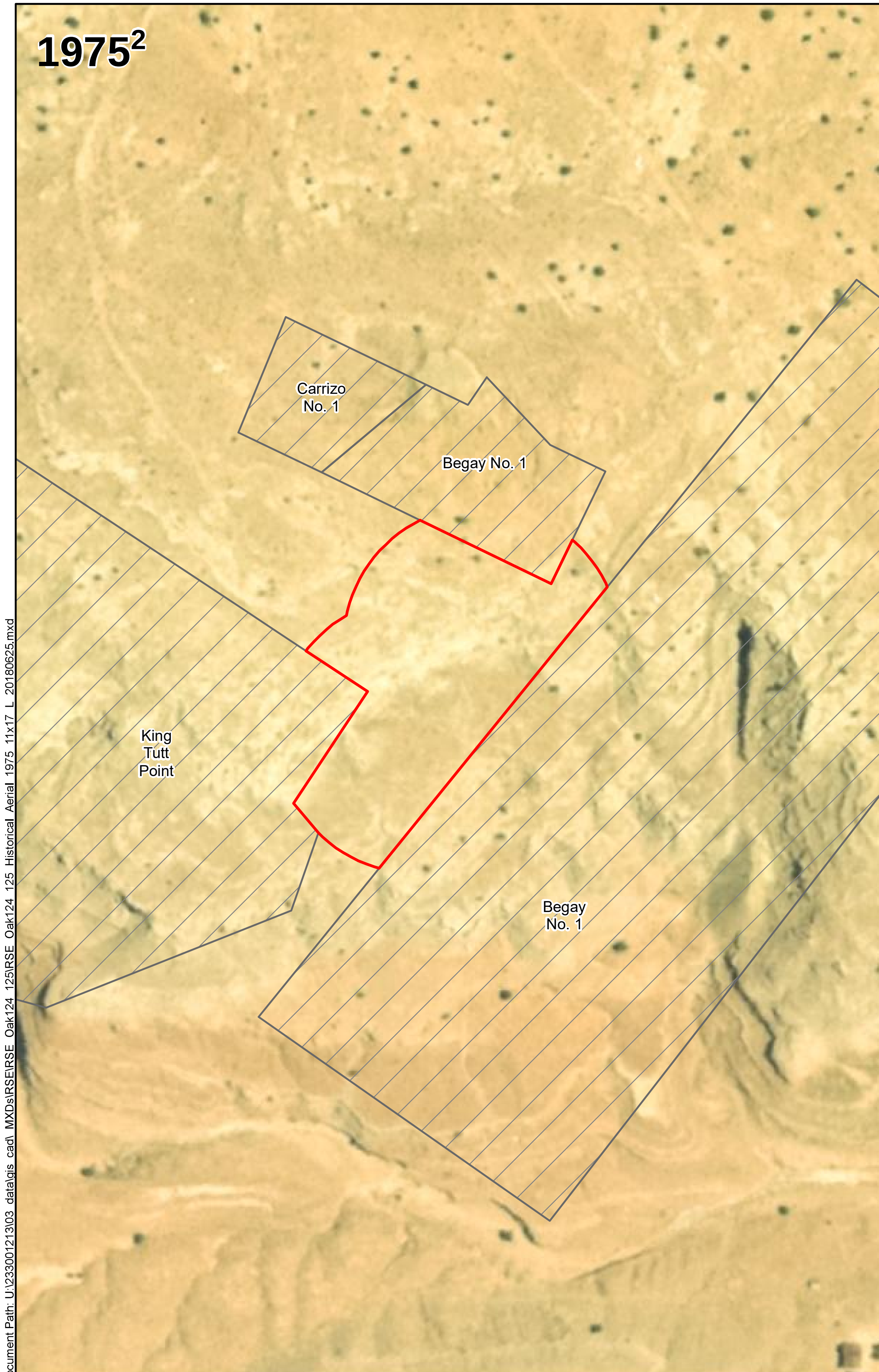
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: EDZ

REVIEWER: CBB

FIGURE: 3-1a

Stantec



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Claim Boundary
- Other Claim Boundary

REFERENCES:

1. Coordinate System: NAD 1983 UTM Zone 12N
2. 1975 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

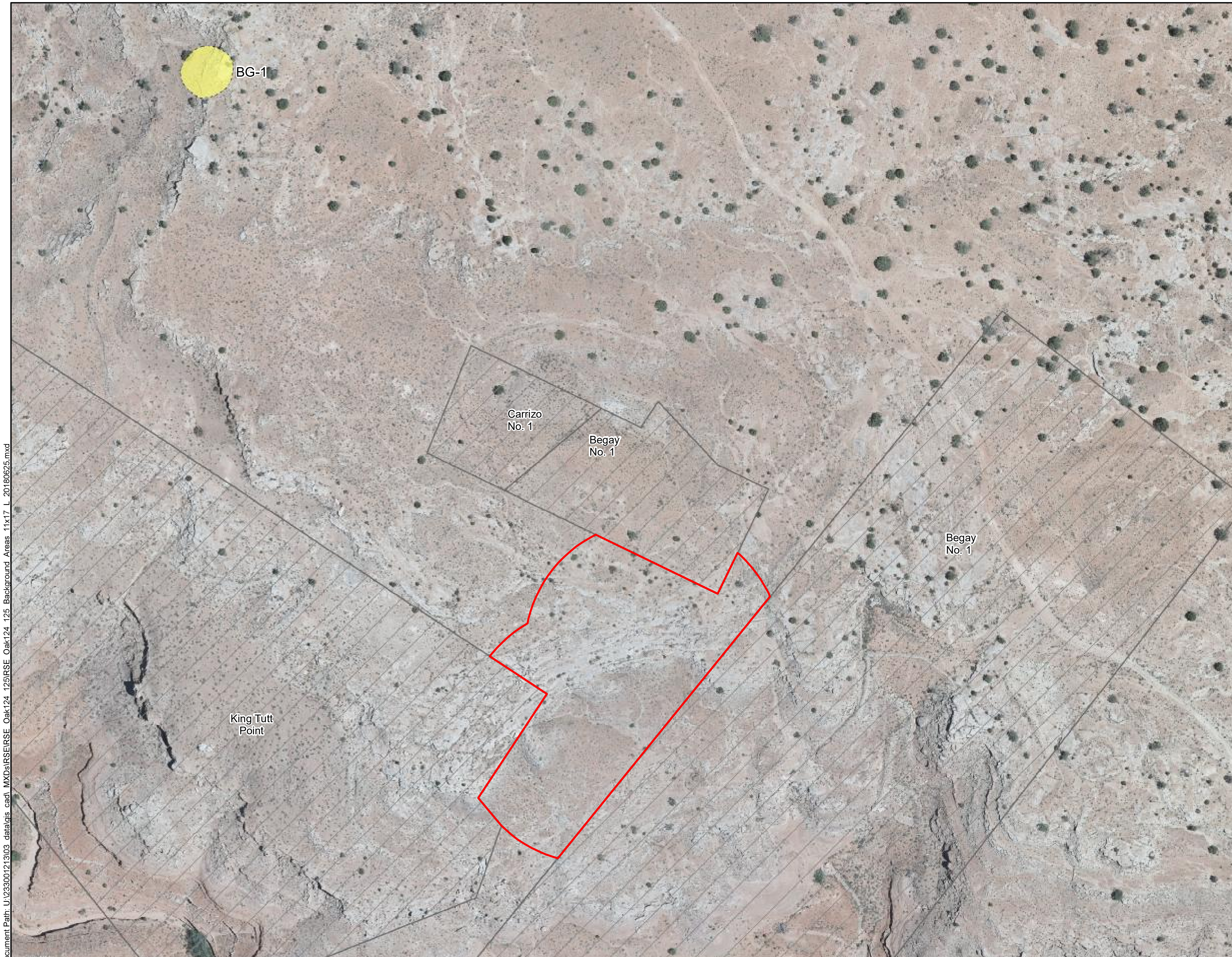
0 200 400
Feet

TITLE: 1975 Historical Aerial Photograph Comparison

PROJECT: Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 8/29/2018	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_Oak124_125\RSE_Oak124_125_Historical_Aerial_1975_11x17_L_20180625.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Background Reference Area
- Claim Boundary
- Other Claim Boundary

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

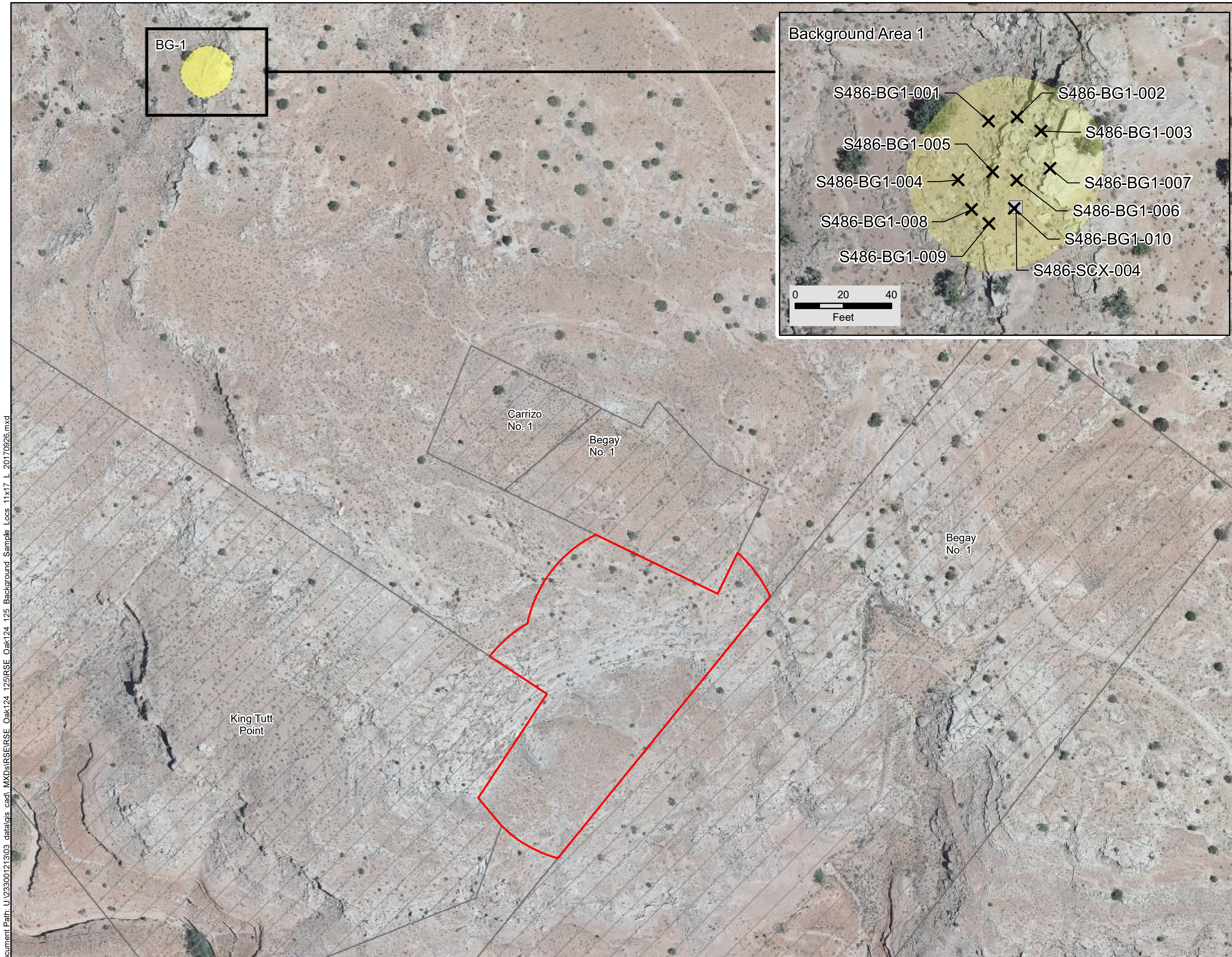
TITLE:
Potential Background Reference Area

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 8/29/2018
DOCUMENT NAME: Removal Site Evaluation Report
AUTHOR: CBB
REVIEWER: EY
FIGURE: 3-2

Stantec

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\RSE_Oak124_125_Background_Areas_11x17_L_20180625.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface Sample Only
- Background Reference Area
- Claim Boundary
- Other Claim Boundary

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: Background Reference Area - Sample Locations

PROJECT: Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 8/29/2018

DOCUMENT NAME: Removal Site Evaluation Report

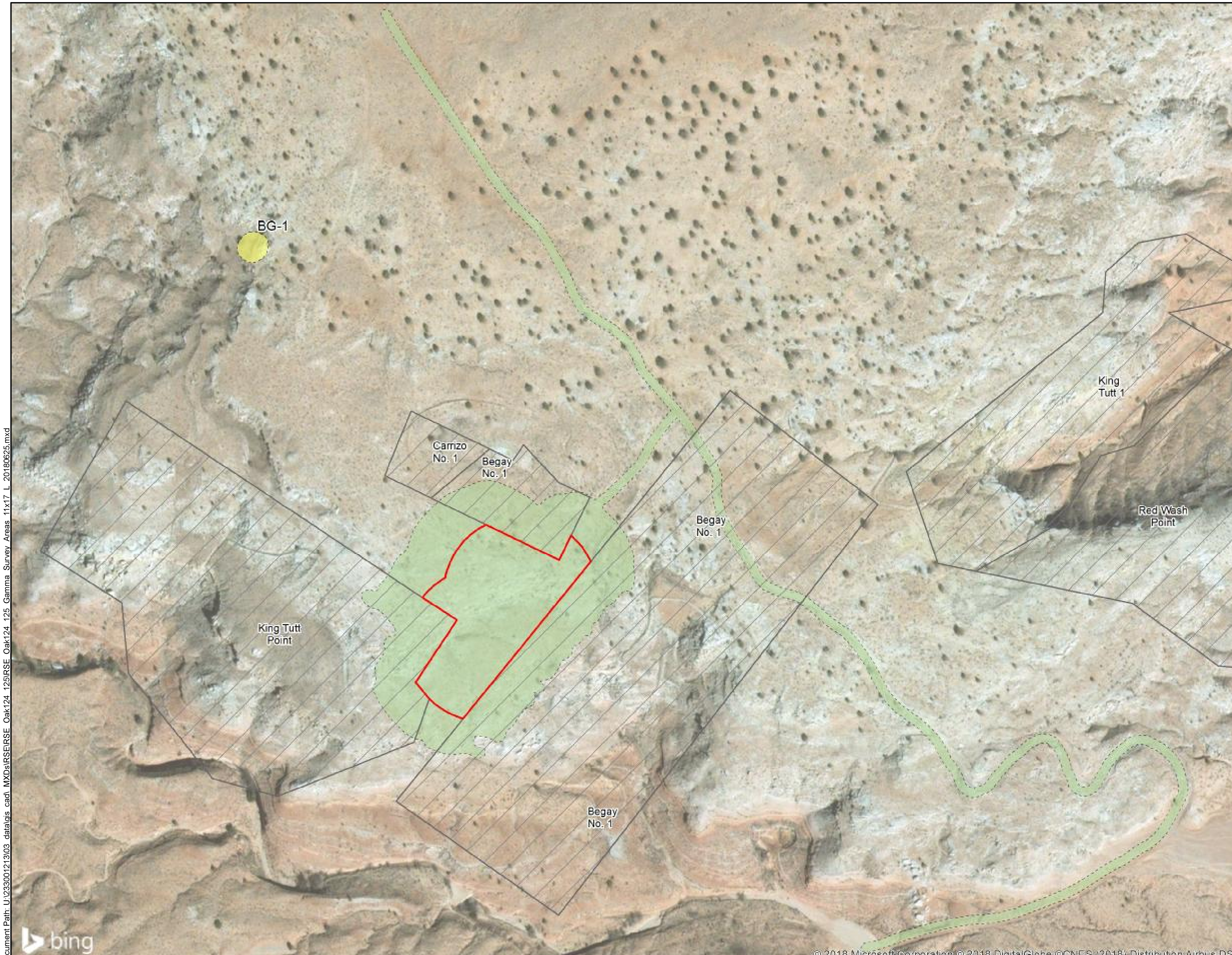
Stantec

AUTHOR: CBB

REVIEWER: EY

FIGURE: 3-3

Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Oak124 125\RSE Oak124 125 Background Sample Locs 11x17 L 20170926.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Background Reference Area
- Gamma Radiation Survey Area
- Claim Boundary
- Other Claim Boundary

NOTE:
Gamma survey area is approximately 10.1 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 08/2018.

N
W E
S

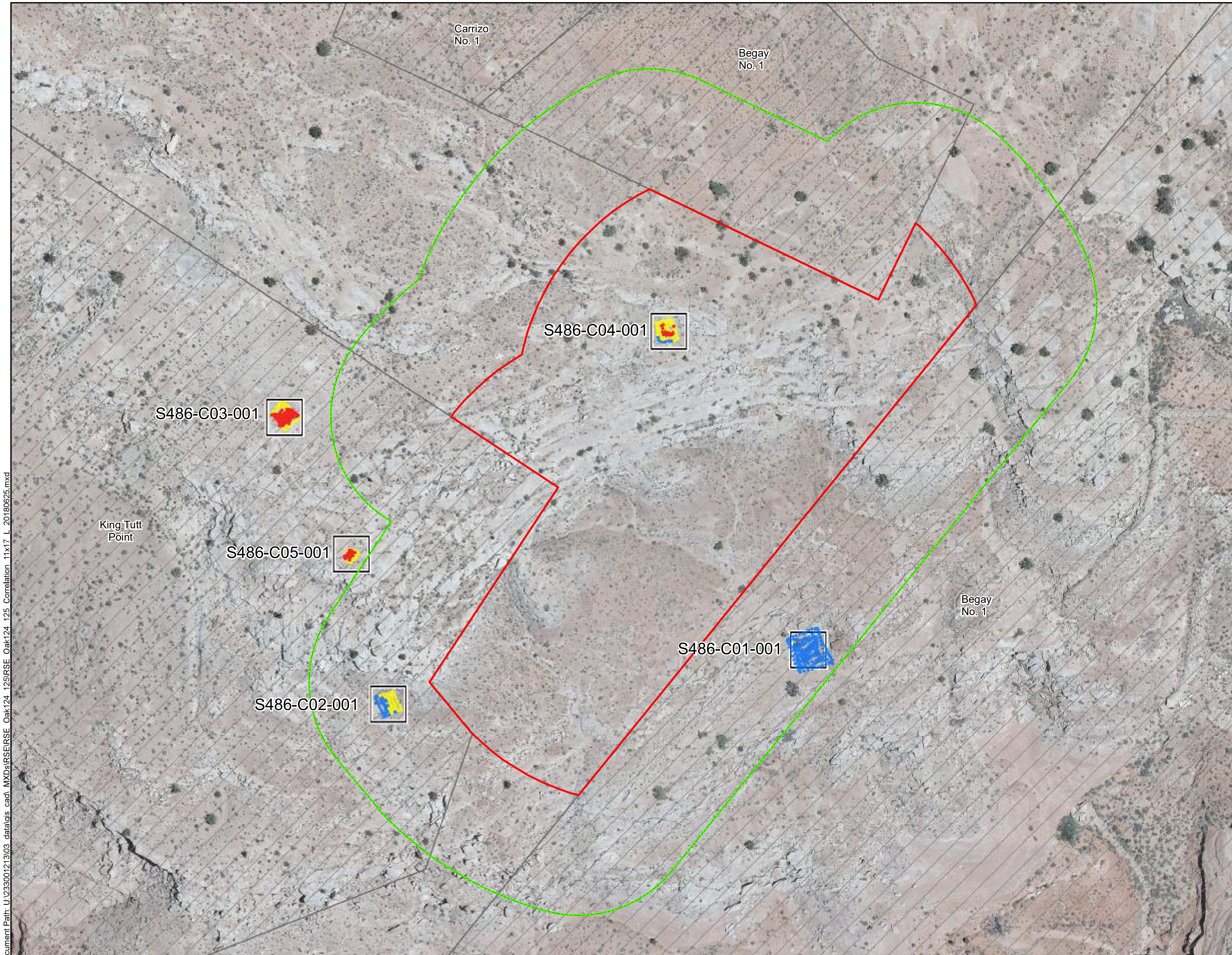
0 250 500
Feet

TITLE:
Gamma Radiation Survey Area

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 8/29/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EY
	FIGURE: 3-4	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\RSE_Oak124_125_Gamma_Survey_Areas_11x17_L_20180625.mxd



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\RSE_Oak124_125_Correlation_11x17_L_20180625.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S486-C01-001 Correlation Location (30'x30')

Claim Boundary

100-Foot Claim Buffer

Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,565 - 14,600 (Minimum - UTL)
- 14,601 - 29,200 (>UTL - 2x UTL)
- 29,201 - 76,181 (>2x UTL - Maximum)

NOTES:
1. UTL = Upper tolerance limit

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

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 80 160
Feet

TITLE:
Gamma Correlation Study Locations

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 6/22/2018

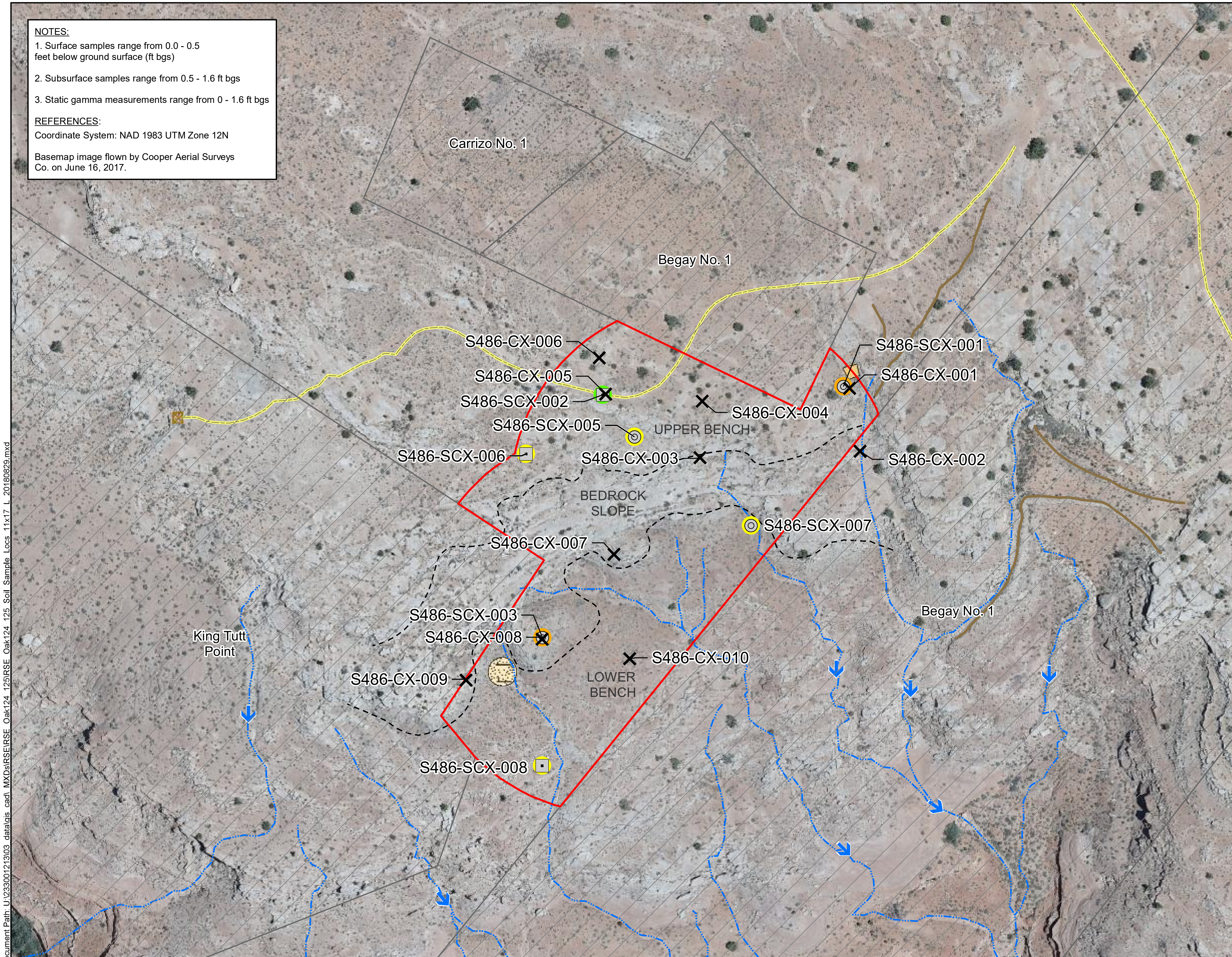
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EY

FIGURE: 3-5



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\RSE_Oak124_125_Soil_Sample_Locs_11x17_L_20180829.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Surface and Subsurface Static Gamma Data
- Subsurface Static Gamma Data Only
- No Static Gamma Data
- Flow Direction
- Drainage
- Approximate Boundaries of Bedrock Slope
- Berm
- Potential Haul Road
- Excavation
- Potential Mining Disturbed Area
- Potential Staging Area
- Claim Boundary
- Other Claim Boundary

N W E S

0 100 200
Feet

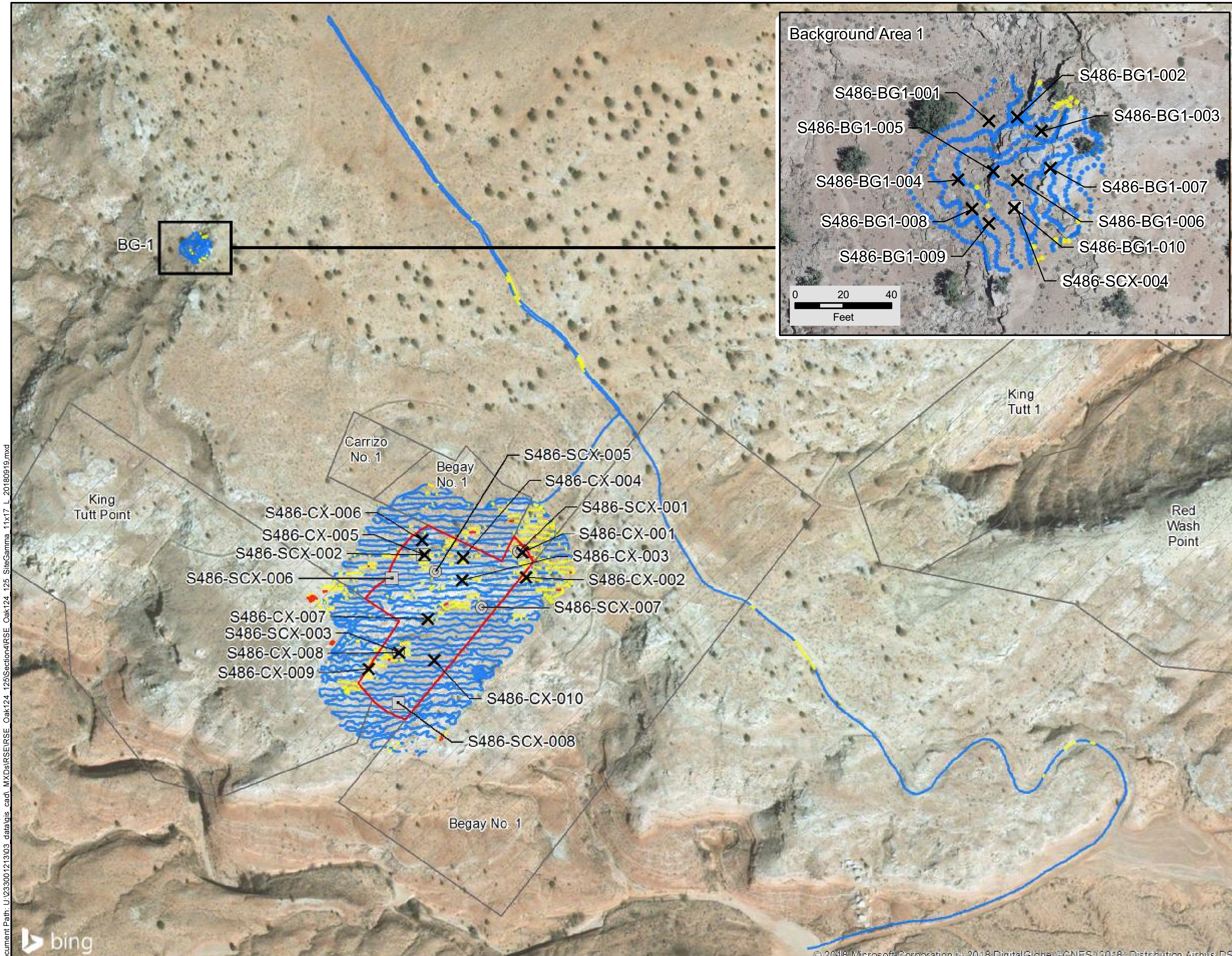
TITLE:
Site Characterization Mining Features and Surface and Subsurface Sample Locations

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/20/2018
DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB
REVIEWER: EDZ
FIGURE: 3-6



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- ✕ Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,565 - 14,600 (Minimum - IL)
- 14,601 - 29,200 (>IL - 2x IL)
- 29,201 - 76,181 (>2x IL - 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 09/2018.

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

N W E S

0 250 500
Feet

TITLE: Gamma Radiation Survey Results

PROJECT: Removal Site Evaluation Oak 124, Oak 125 Mine Site

DATE: 9/19/2018

DOCUMENT NAME: Removal Site Evaluation Report

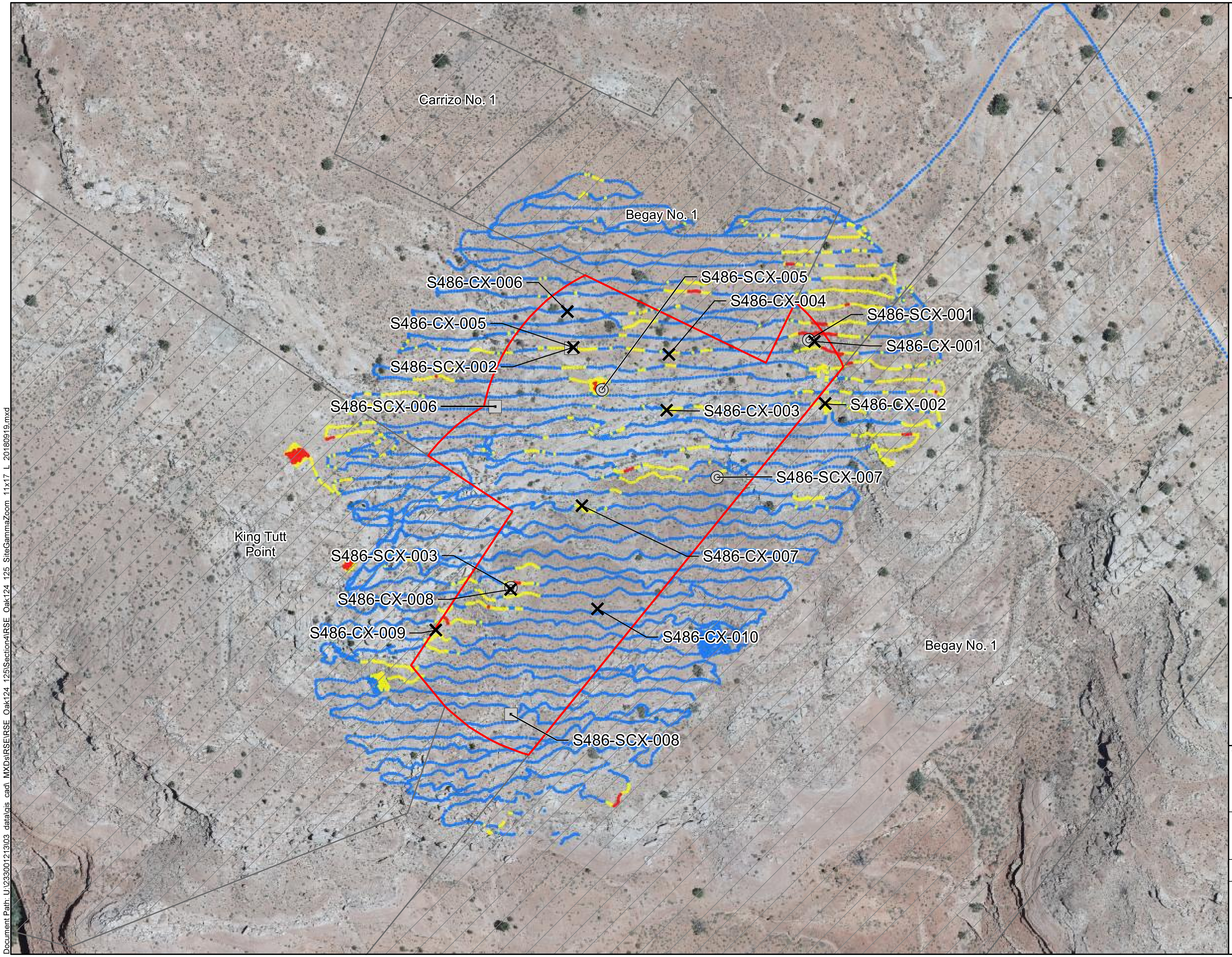
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-1a

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_SiteGamma_11x17_L_20180919.mxd



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,565 - 14,600 (Minimum - IL)
- 14,601 - 29,200 (>IL - 2x IL)
- 29,201 - 76,181 (>2x IL - Maximum)

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N W E S

0 100 200
Feet

TITLE:
Site Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

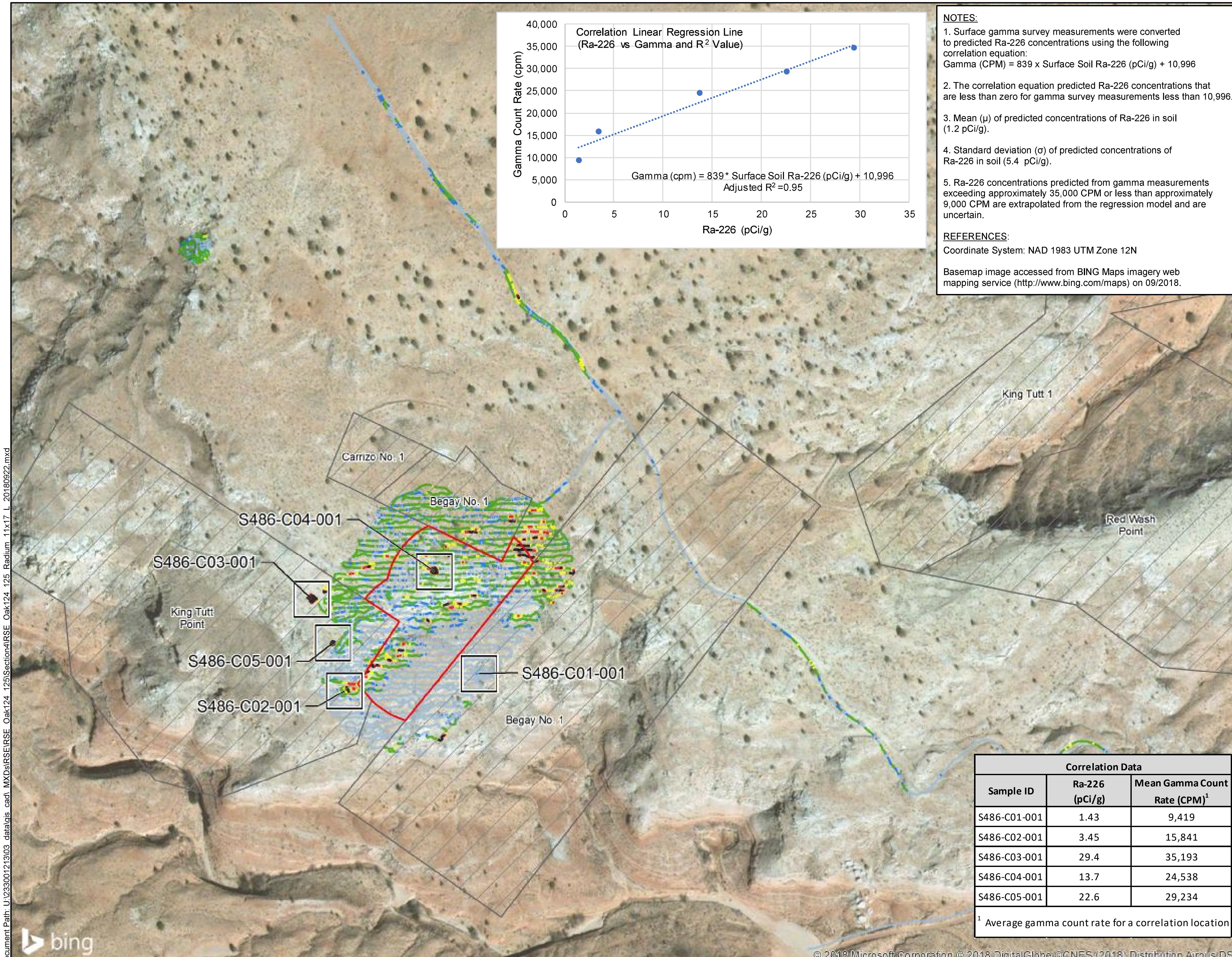
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-1b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_SiteGammaZoom_11x17_L_20180919.mxd



NOTES:

1. Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 839 x Surface Soil Ra-226 (pCi/g) + 10,996

2. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 10,996.

3. Mean (μ) of predicted concentrations of Ra-226 in soil (1.2 pCi/g).

4. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (5.4 pCi/g).

5. Ra-226 concentrations predicted from gamma measurements exceeding approximately 35,000 CPM or less than approximately 9,000 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.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

S486-C01-001 Correlation Location (30'x30')

Claim Boundary

Other Claim Boundary

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

- Less than 0[2]
- 0 - 1.2 (μ)[3]
- 1.3 - 6.6 (μ + 1σ[4])
- 6.7 - 12.0 (μ + 2σ)
- 12.1 - 17.4 (μ + 3σ)
- 17.5 - 77.7[5]

N W E S

0 250 500
Feet

Correlation Data		
Sample ID	Ra-226 (pCi/g)	Mean Gamma Count Rate (CPM)[1]
S486-C01-001	1.43	9,419
S486-C02-001	3.45	15,841
S486-C03-001	29.4	35,193
S486-C04-001	13.7	24,538
S486-C05-001	22.6	29,234

[1] Average gamma count rate for a correlation location

TITLE:
Predicted Ra-226 Concentrations in Soil Using the Correlation Equation

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

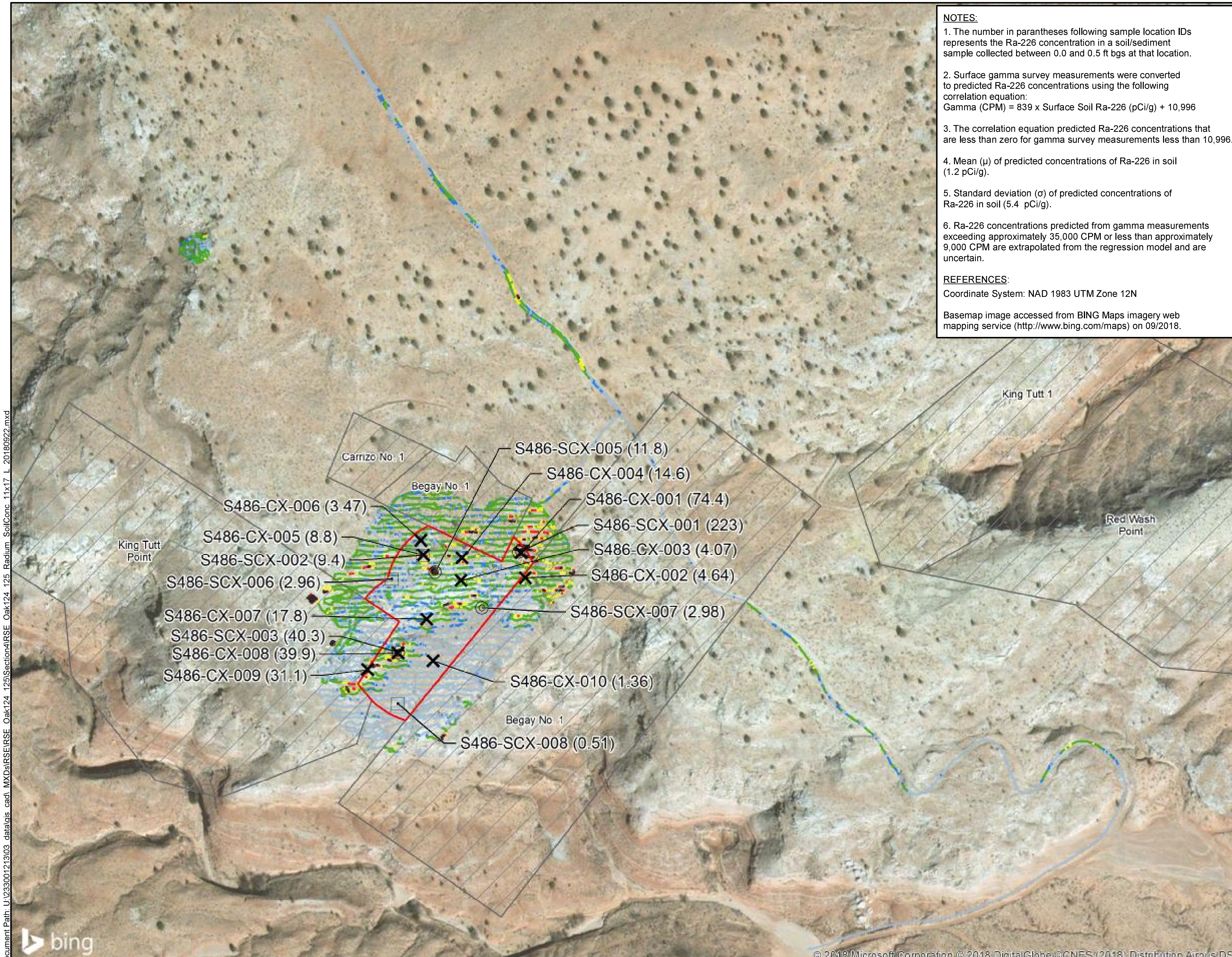
Stantec

AUTHOR: WDC

REVIEWER: CBB

FIGURE: 4-2a

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_Radium_11x17_L_20180922.mxd



NOTES:

1. The number in parantheses 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) = 839 x Surface Soil Ra-226 (pCi/g) + 10,996

3. The correlation equation predicted Ra-226 concentrations that are less than zero for gamma survey measurements less than 10,996.

4. Mean (μ) of predicted concentrations of Ra-226 in soil (1.2 pCi/g).

5. Standard deviation (σ) of predicted concentrations of Ra-226 in soil (5.4 pCi/g).

6. Ra-226 concentrations predicted from gamma measurements exceeding approximately 35,000 CPM or less than approximately 9,000 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.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Claim Boundary
- Other Claim Boundary

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

- Less than 0[3]
- 0 - 1.2 (μ)[4]
- 1.3 - 6.6 (μ + 1σ[5])
- 6.7 - 12.0 (μ + 2σ)
- 12.1 - 17.4 (μ + 3σ)
- 17.5 - 77.7[6]

N W E S

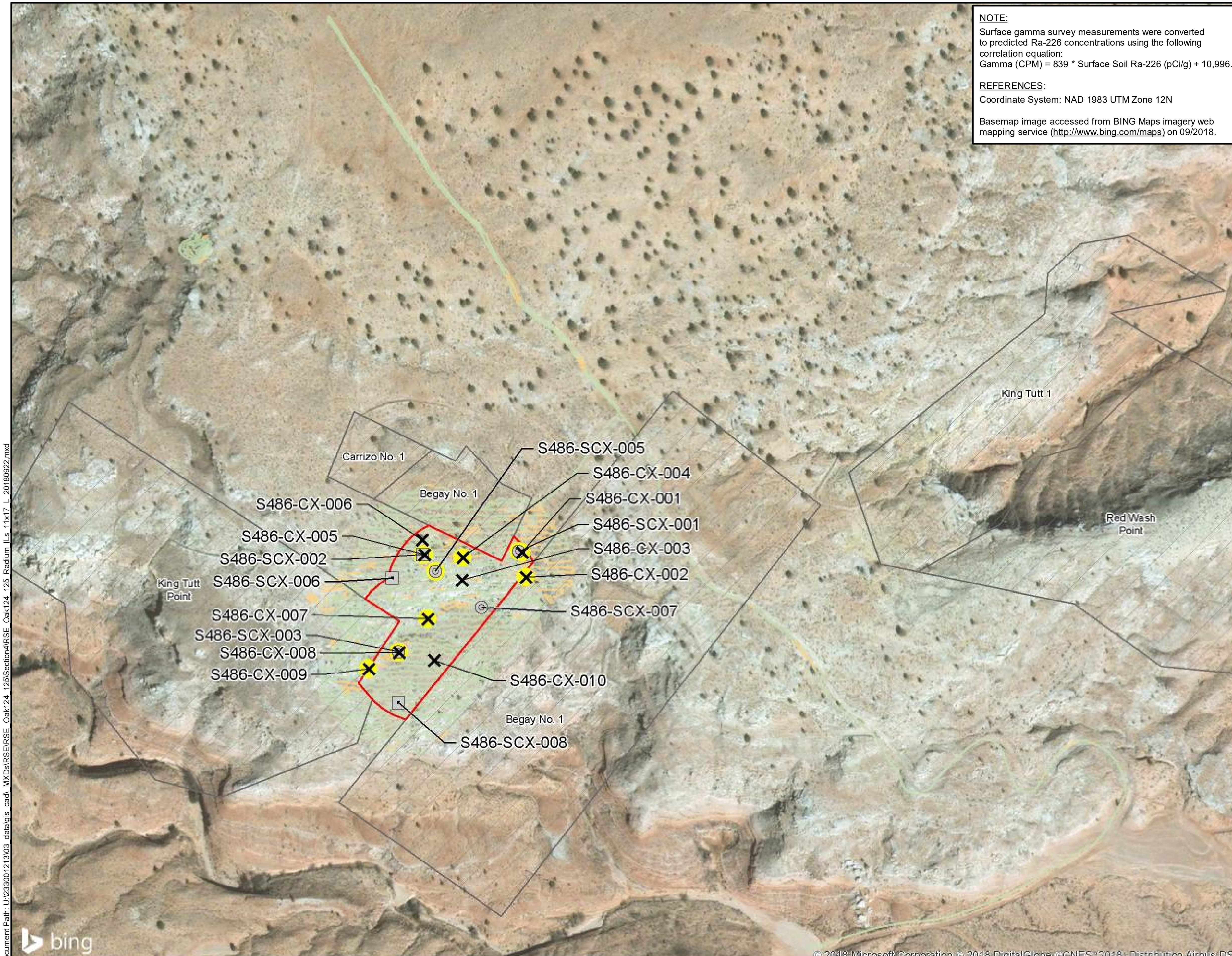
0 250 500
Feet

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

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/26/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 4-2b	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_Radium_SoilConc_11x17_L_20180922.mxd



NOTE:
Surface gamma survey measurements were converted to predicted Ra-226 concentrations using the following correlation equation:
Gamma (CPM) = 839 * Surface Soil Ra-226 (pCi/g) + 10,996.

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.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Ra-226 IL Exceedance in Surface Soil
- Claim Boundary
- Other Claim Boundary

Predicted Ra-226 Concentration (pCi/g)
- -5.3 - 4.4 (IL Not Exceeded)
- 4.5 - 77.7 (IL Exceeded)

N W E S

0 250 500
Feet

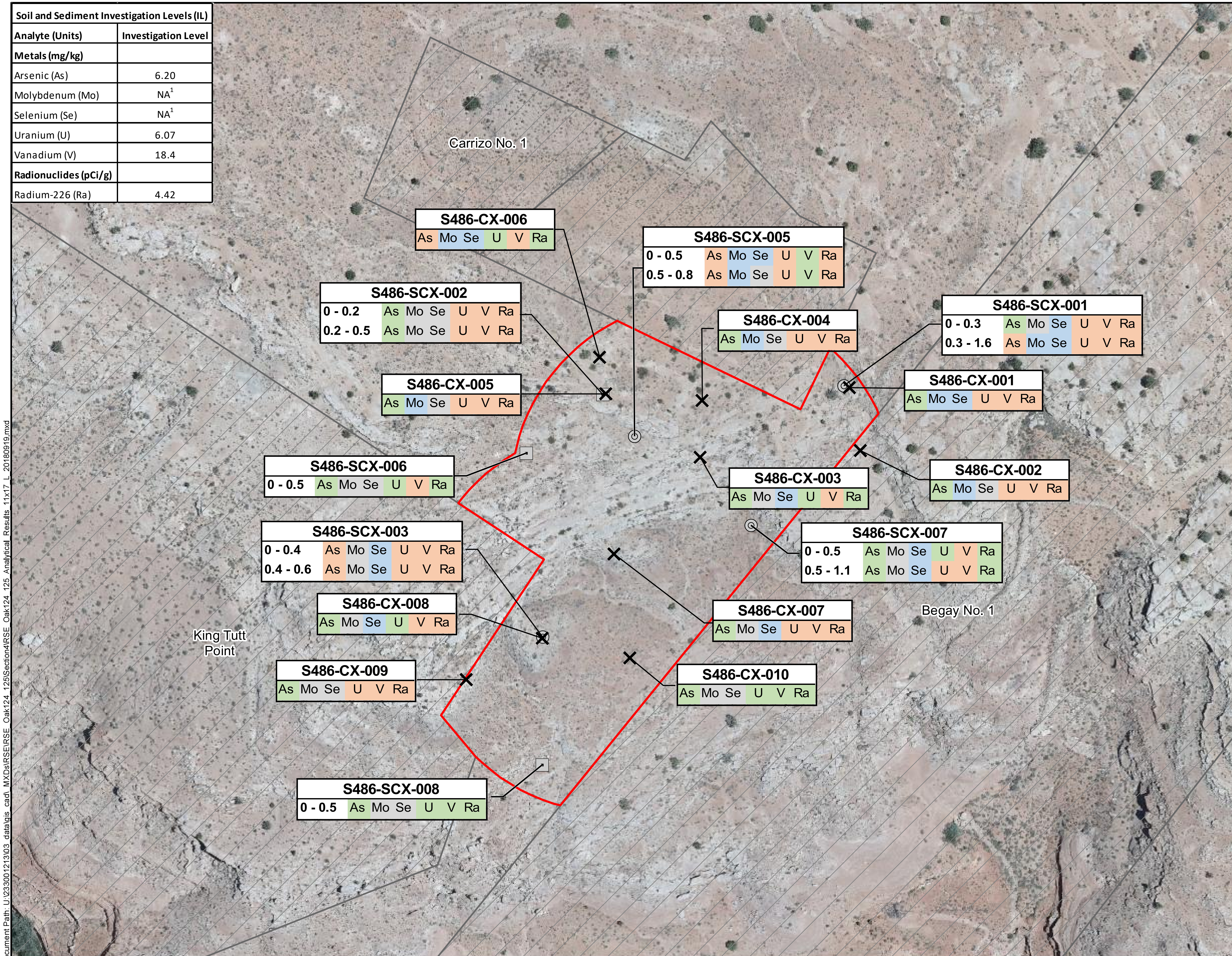
TITLE:
Predicted Ra-226 Concentrations in Soil Compared to Ra-226 ILs

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/22/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: WDC	REVIEWER: CBB
	FIGURE: 4-2c	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_Radium_ILs_11x17_L_20180922.mxd

Soil and Sediment Investigation Levels (IL)	
Analyte (Units)	**Investigation Level**
Metals (mg/kg)	
Arsenic (As)	6.20
Molybdenum (Mo)	NA[1]
Selenium (Se)	NA[1]
Uranium (U)	6.07
Vanadium (V)	18.4
Radionuclides (pCi/g)	
Radium-226 (Ra)	4.42



Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_Analytical_Results_11x17_L_20180919.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Surface Sample Location
- Borehole Location - Surface and Subsurface Samples
- Borehole Location - Surface Samples Only
- Claim Boundary
- Other Claim Boundary
- Investigation Level Not Exceeded
- Investigation Level Exceeded
- Analyte Detected - No Investigation Level[1]
- Non-detect - No Investigation Level[1]

NOTES:

1. No Investigation Level - Analyte was not detected (Se) or had a single detection (Mo) 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 flown by Cooper Aerial Surveys Co. on June 16, 2017.

N E S W

0 100 200
Feet

TITLE:
Surface and Subsurface Metals and Ra-226 Analytical Results

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/19/2018

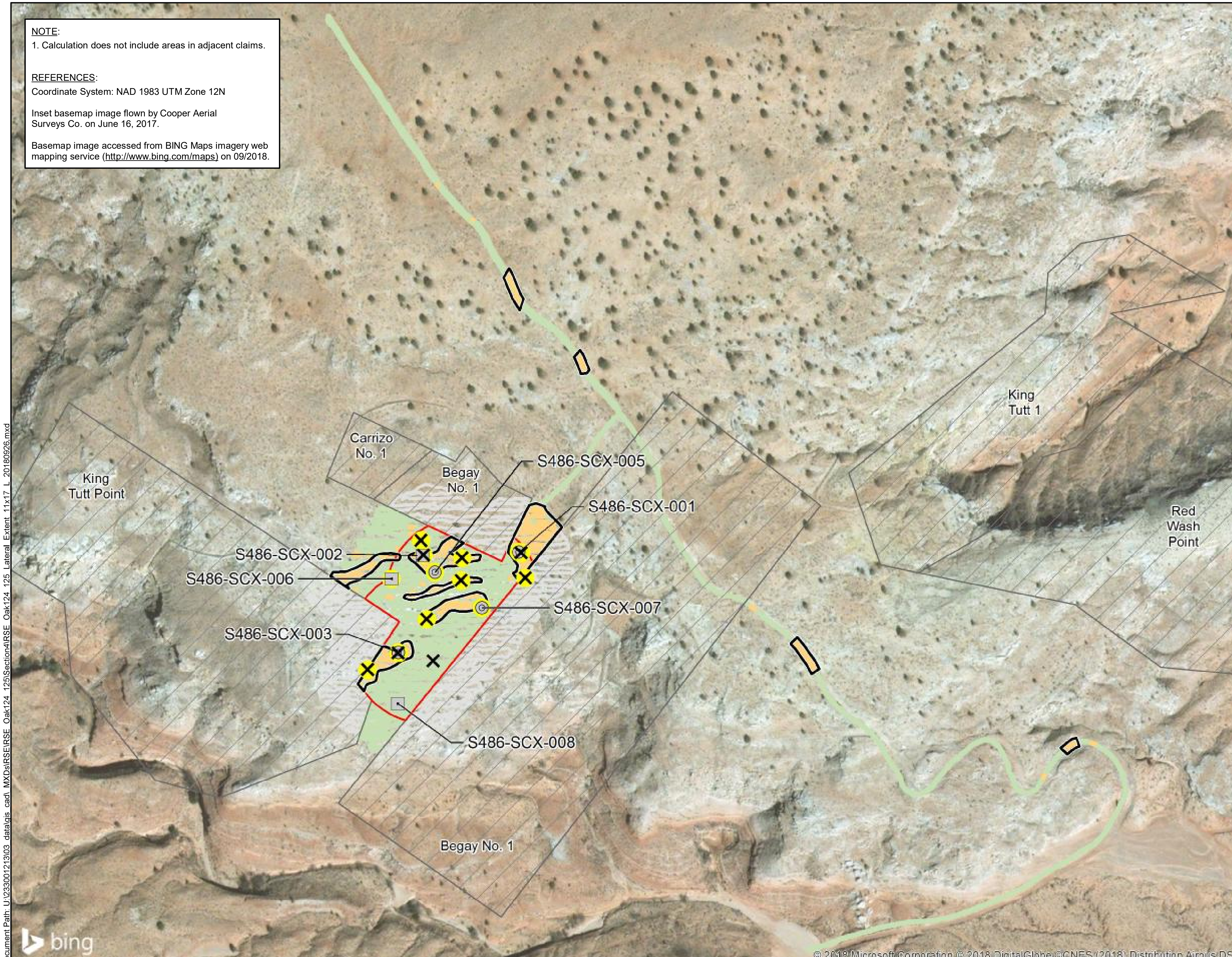
DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-3



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 (1.1 acres)[1]
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,565 - 14,600 (IL Not Exceeded)
- 14,601 - 29,200 (IL Exceeded)
- Gamma data within mine claims adjacent to Oak 124, Oak 125 excluded from evaluation

N / W / E / S

0 250 500

Feet

TITLE:

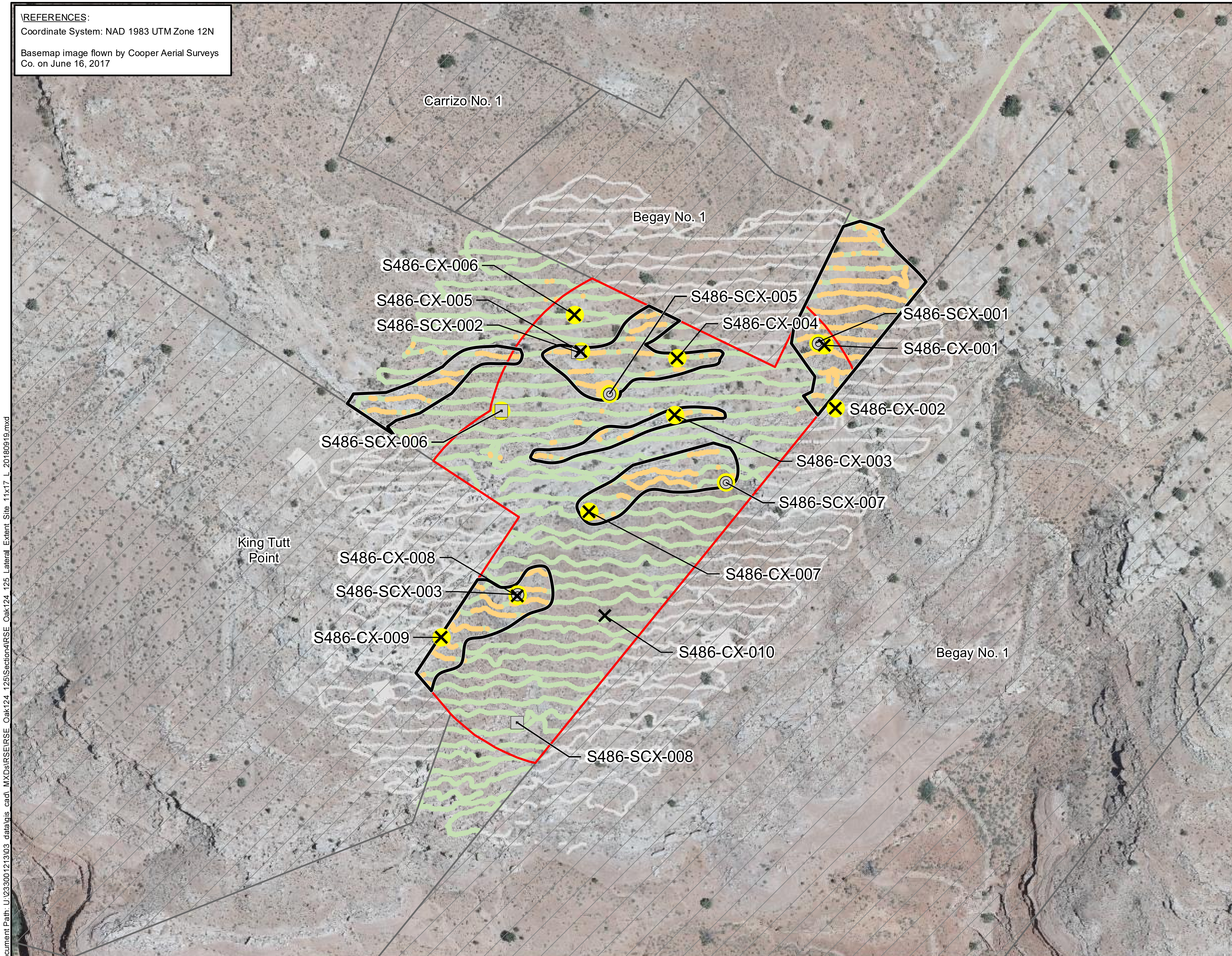
Lateral Extent of Surface and Subsurface IL Exceedances

PROJECT:

Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/26/2018	DOCUMENT NAME: Removal Site Evaluation Report
Stantec	AUTHOR: CBB / REVIEWER: EDZ
	FIGURE: 4-4a

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_Lateral_Extent_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
- IL Exceedance in Unconsolidated Material at Location
- Approximate Area where Surface Gamma IL is Exceeded
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,565 - 14,600 (IL Not Exceeded)
- 14,601 - 29,200 (IL Exceeded)
- Gamma data within mine claims adjacent to Oak 124, Oak 125 excluded from evaluation

N
W E
S

0 100 200
Feet

TITLE:
Lateral Extent of Site Surface and Subsurface IL Exceedances

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/20/2018

DOCUMENT NAME: Removal Site Evaluation Report

AUTHOR: CBB

REVIEWER: EDZ

Stantec

FIGURE: 4-4b

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_Lateral_Extent_Site_11x17_L_20180919.mxd

NOTES:

1. Range of IL Exceedance in unconsolidated materiall selected based on unconsolidated material analytical results, subsurface gamma measurements, and subsurface observations.

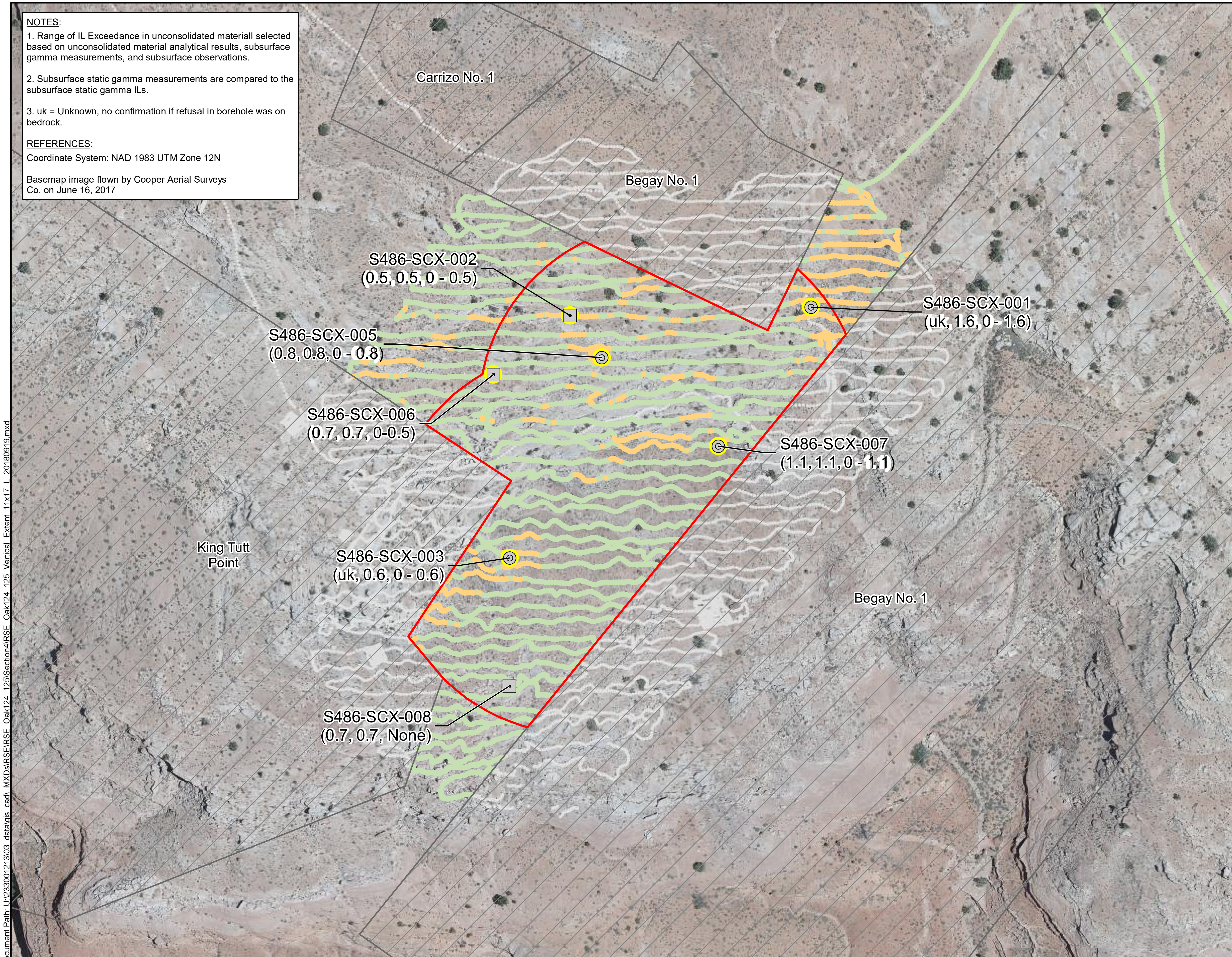
2. Subsurface static gamma measurements are compared to the subsurface static gamma ILs.

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

REFERENCES:

Coordinate System: NAD 1983 UTM Zone 12N

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



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Borehole Location - Surface and Subsurface Samples (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material [1])
- Borehole Location - Surface Samples Only (Depth of Bedrock, Borehole Depth, Depth Range of IL Exceedance in Unconsolidated Material [1])
- IL Exceedance in Unconsolidated Material at Location
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,565 - 14,600 (IL Not Exceeded)
- 14,601 - 29,200 (IL Exceeded)
- Gamma data within mine claims adjacent to Oak 124, Oak 125 excluded from evaluation

N
W E
S

0 100 200
Feet

TITLE:
Vertical Extent of IL Exceedances in Soil

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 9/26/2018

DOCUMENT NAME: Removal Site Evaluation Report

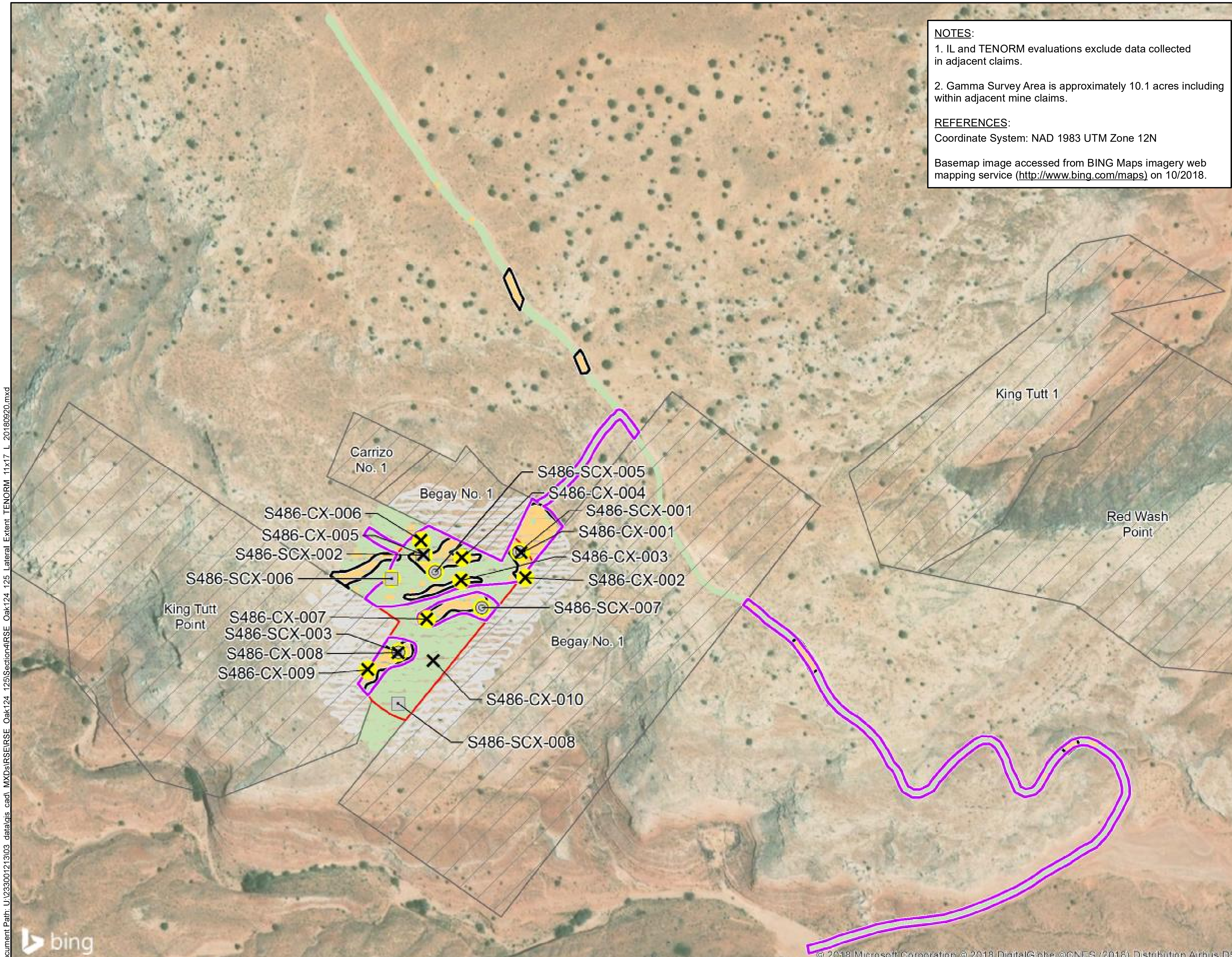
Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-4c

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_Vertical_Extent_11x17_L_20180919.mxd



Document Path: U:\233001213\03 data\gis cad\ MXDs\RSE\RSE Oak124 125\Section4\RSE Oak124 125 Lateral Extent TENORM 11x17 L 20180920.mxd

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
- TENORM (3.2 acres)¹
- Approximate Area where Surface Gamma IL is Exceeded (1.1 acres)¹
- Claim Boundary
- Other Claim Boundary

Gamma Survey²

Counts per Minute (CPM)

- 6,565 - 14,600 (IL Not Exceeded)
- 14,601 - 29,200 (IL Exceeded)
- Gamma data within mine claims adjacent to Oak 124, Oak 125 excluded from evaluation

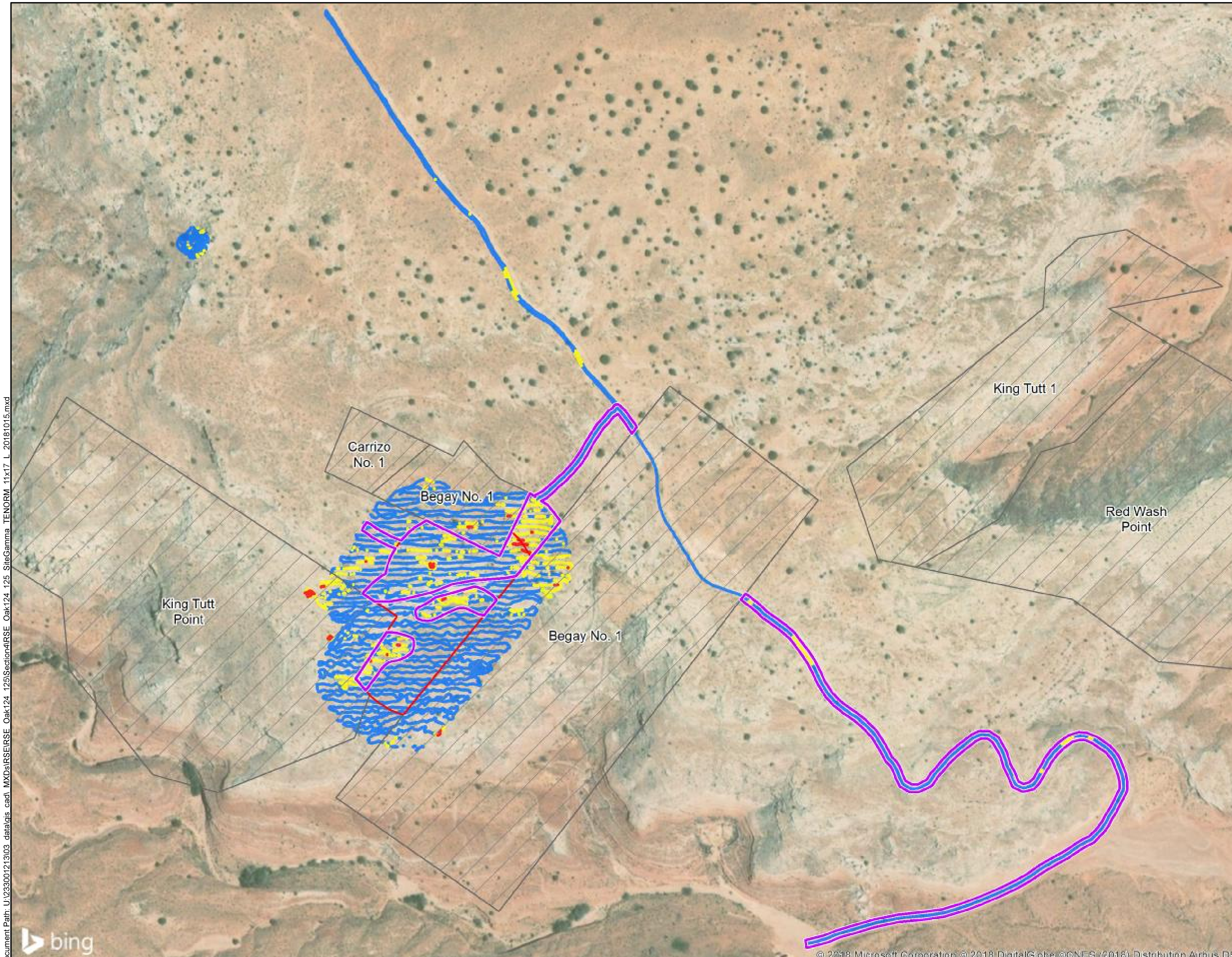
N W E S

0 250 500
Feet

TITLE:
TENORM Compared to Lateral Extent of IL Exceedances

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE:	DOCUMENT NAME:	
10/15/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-5	



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NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

TENORM (3.2 acres)
Claim Boundary
Other Claim Boundary

Gamma Survey
Counts per Minute (CPM)
6,565 - 14,600 (Minimum - IL)
14,601 - 29,200 (>IL - 2x IL)
29,201 - 76,181 (>2x IL - Maximum)

NOTE:
TENORM evaluation excludes data collected in adjacent claims.

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.

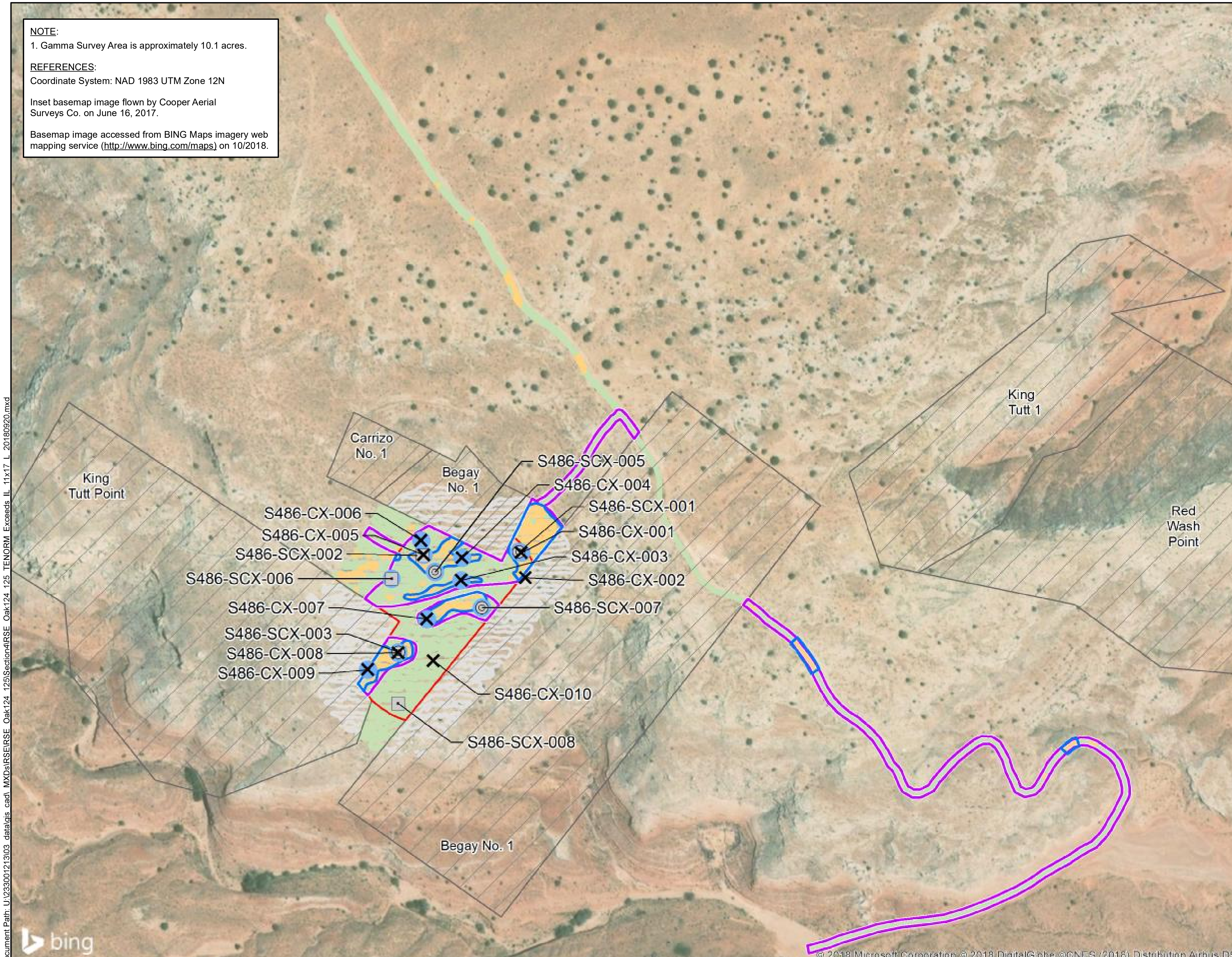
N
W E
S

0 250 500
Feet

TITLE:
TENORM Compared to Gamma Radiation Survey Results

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE:	DOCUMENT NAME:	
10/15/2018	Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-6	



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 (0.9 acres)
- TENORM (3.2 acres)
- Claim Boundary
- Other Claim Boundary

Gamma Survey

Counts per Minute (CPM)

- 6,565 - 14,600 (IL Not Exceeded)
- 14,601 - 29,200 (IL Exceeded)
- Gamma data within mine claims adjacent to Oak 124, Oak 125 excluded from evaluation

N W E S

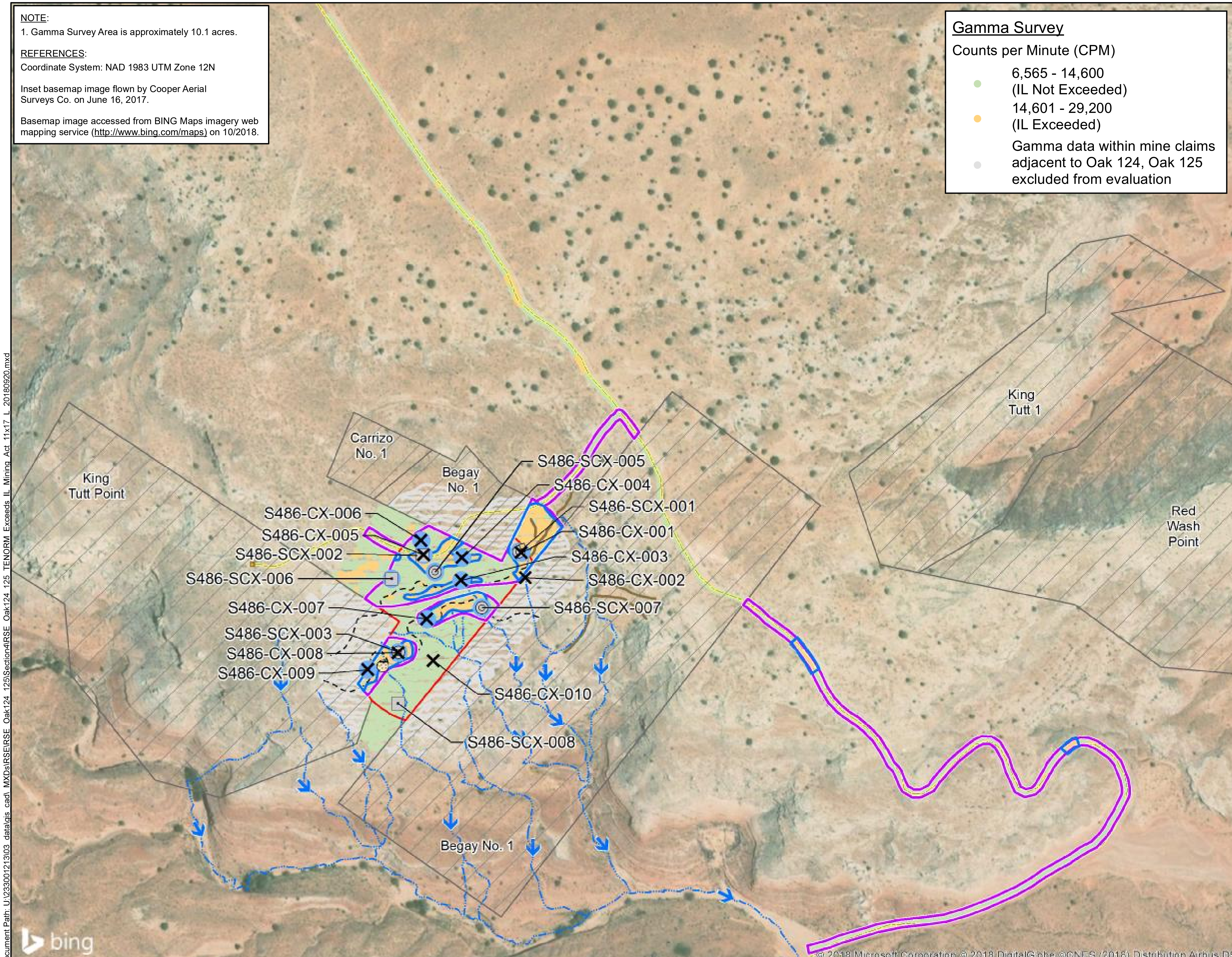
0 250 500
Feet

TITLE:
TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 10/15/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-7a	

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_TENORM_Exceeds_IL_11x17_L_20180920.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
- Flow Direction
- Drainage
- Approximate Boundaries of Bedrock Slope
- Berm
- Potential Haul Road
- Excavation
- Potential Mining Disturbed Area
- Potential Staging Area
- TENORM Area Exceeding Surface Gamma ILs (0.9 acres)
- TENORM (3.2 acres)
- Claim Boundary
- Other Claim Boundary

N W E S

0 250 500
Feet

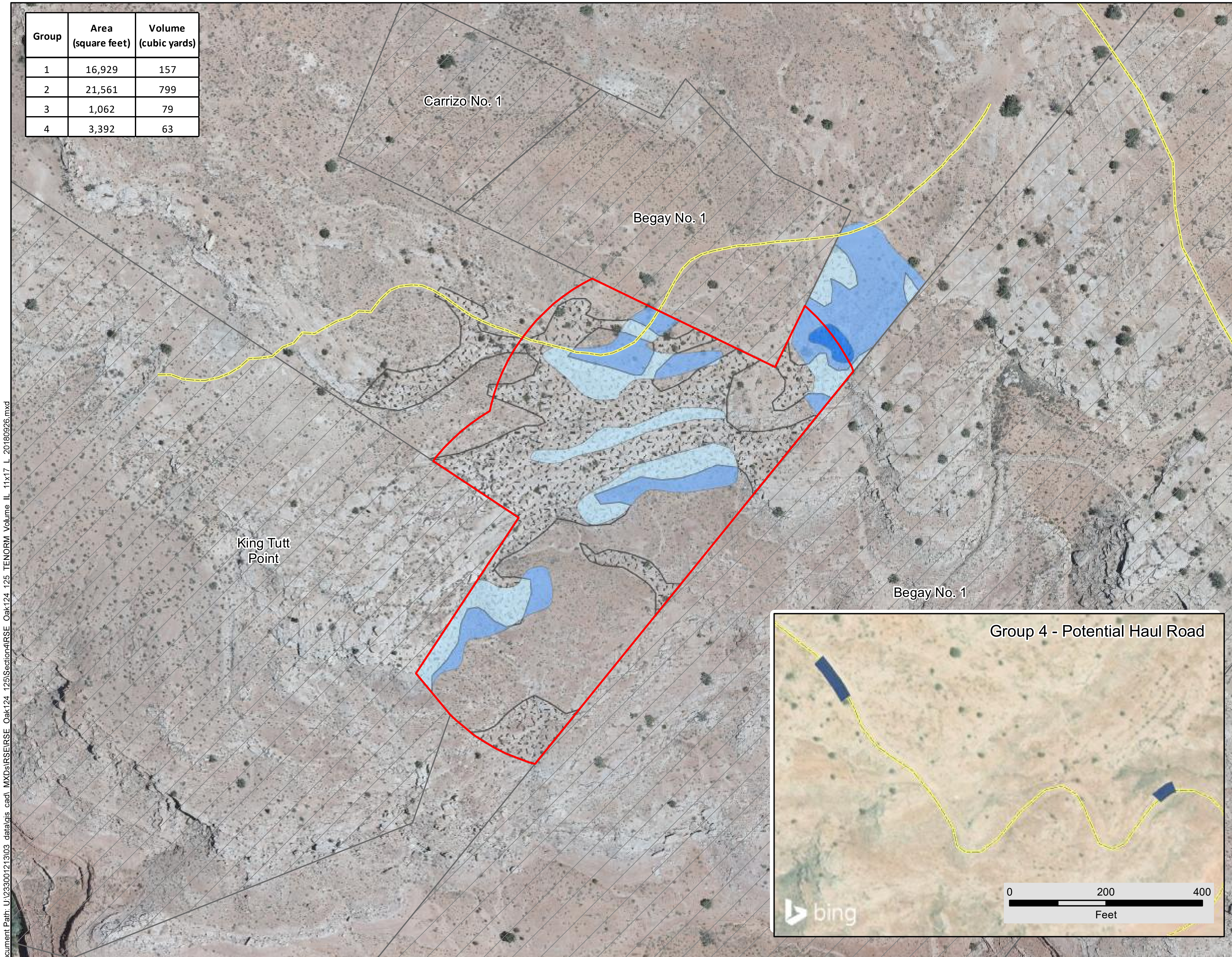
TITLE:
TENORM that Exceeds ILs Compared to Mining-Related Features

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 10/15/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EDZ
	FIGURE: 4-7b	

Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_TENORM_Exceeds_IL_Mining_Act_11x17_L_20180920.mxd

Group	Area (square feet)	Volume (cubic yards)
1	16,929	157
2	21,561	799
3	1,062	79
4	3,392	63



NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Potential Haul Road
- Exposed Bedrock
- Claim Boundary
- Other Claim Boundary

Average TENORM Depth by Group (feet below ground surface)

- Group 1 - 0 - 0.5 ft[1]
- Group 2 - 1 ft
- Group 3 - 2 ft
- Group 4 - 0.5 ft

NOTE:
1. Volume was calculated with the assumption that soil is 0.5 ft deep over 50 percent of the area mapped as bedrock.

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

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

N
W E
S

0 100 200
Feet

TITLE:
Volume Estimate of TENORM that Exceeds ILs

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 10/15/2018

DOCUMENT NAME: Removal Site Evaluation Report

Stantec

AUTHOR: CBB

REVIEWER: EDZ

FIGURE: 4-8

Document Path: U:\233001213\03_data\gis_cad_MXDs\RSE\RSE_Oak124_125\Section4\RSE_Oak124_125_TENORM_Volume_IL_11x17_L_20180926.mxd

APPENDICES

Appendix A Radiological Characterization of the Oak 124, Oak 125 Abandoned Uranium Mine

Radiological Characterization of the Oak 124/Oak 125 Abandoned Uranium Mine

September 18, 2018

prepared for:

Stantec Consulting Services Inc.

2130 Resort Drive, Suite 350
Steamboat Springs, CO 80487

prepared by:

ERG

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
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
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 Oak 124/Oak 125 abandoned uranium mine (AUM) located in the Red Valley Chapter of the Navajo Nation in Red Rock Valley, New Mexico. 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 the results of a 1) Global Positioning System (GPS)-based gamma radiation (gamma) survey and 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils. The field activities addressed in this report were conducted on October 1 and 7, 2016 and May 19, 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 "Oak 124/125 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.

- Gamma count rates in the mine claim are naturally elevated due to the presence of uranium mineralization. Elevated count rates observed in the northeast corner of the mine claim were associated with waste rock.

- One potential Background Reference Area was 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:

$$\text{Gamma Count Rate (cpm)} = 839 \times [\text{radium-226 (pCi/g)}] + 10996$$

- 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 -5.3 to 77.7 pCi/g, with a central tendency (median) of 0.3 pCi/g.

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

- There is evidence that the uranium series radionuclides are in equilibrium, but not secular equilibrium

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

$$\text{Exposure Rate (in microRoentgens per hour [}\mu\text{R/h]) =}$$
$$\text{Gamma Count Rate (cpm) x } 3\text{x}10^{-4} + 9.4541$$

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 11.4 to 32.3, with a central tendency (median) of 12.8 µR/h.

1.0 Introduction

This report addresses the radiological characterization of the Oak 124/Oak 125 abandoned uranium mine (AUM) located in the Red Valley Chapter of the Navajo Nation in Red Rock Valley, New Mexico. 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) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

The activities described here focus on the characterization of gamma radiation (gamma) emitted by uranium series radionuclides in surface soils at the AUM. 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 were conducted on October 1 and 7, 2016 and May 19, 2017 in accordance with the methods described in the RSE Work Plan. The GPS-based radiological survey of land surfaces covered an approximately 10-acre Survey Area that included the mine claim area out to a 100-foot (ft) buffer; roads and drainages within a 0.25-mile radius of the buffer; gamma count rate and exposure rate measurements at fixed points; and gamma count rate measurements and soil sampling for radionuclides and metals in areas centered on these fixed points. 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 “Oak 124/Oak 125 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 “Oak 124/Oak 125 Removal Site Evaluation Report” (Stantec, 2018).

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in one potential Background Reference Area 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.

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 Area	PR303727[a]	254772[a]
Survey Area	PR303727	254772
	PR295014	196086

Notes:
[a]Detection system used in the correlation studies described in Section 3.0.

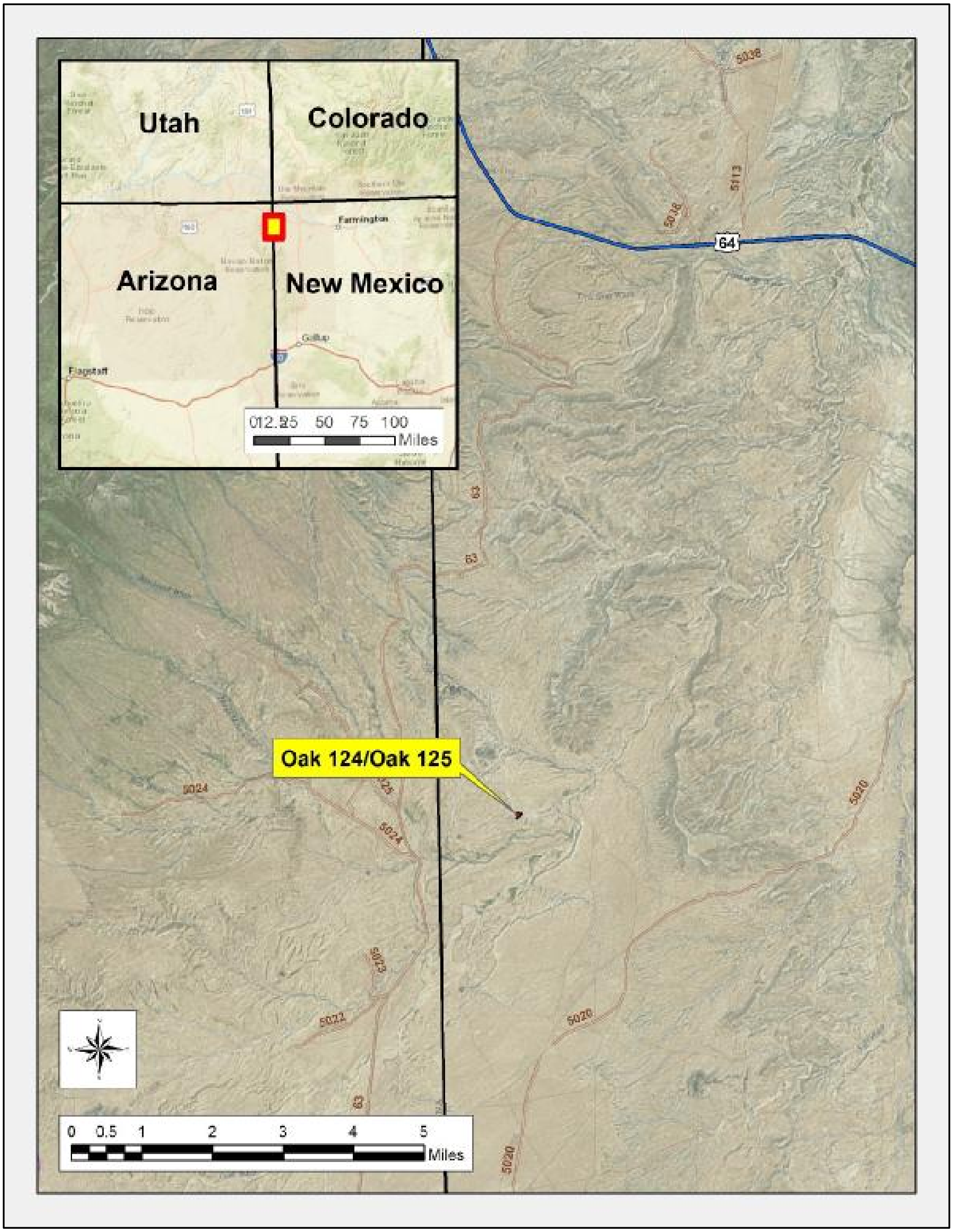


Figure 1. Location of the Oak 124/Oak 125 Abandoned Uranium Mine

2.1 Potential Background Reference Area

One potential Background Reference Area was surveyed, the location and results of which are depicted on Figure 2. BG1 in the figure is Background Reference Area 1.

Table 2 lists a summary of the gamma count rates in BG1, which range from 8,013 to 20,837 counts per minute (cpm), with a mean and median of 11,491 and 11,292 cpm, respectively.

Figure 3 is a histogram of the gamma count rates in BG1. 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. Summary statistics for gamma count rates in the potential Background Reference Area.

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	417	8,013	20,837	11,491	11,292	1,753

Notes:
cpm = counts per minute

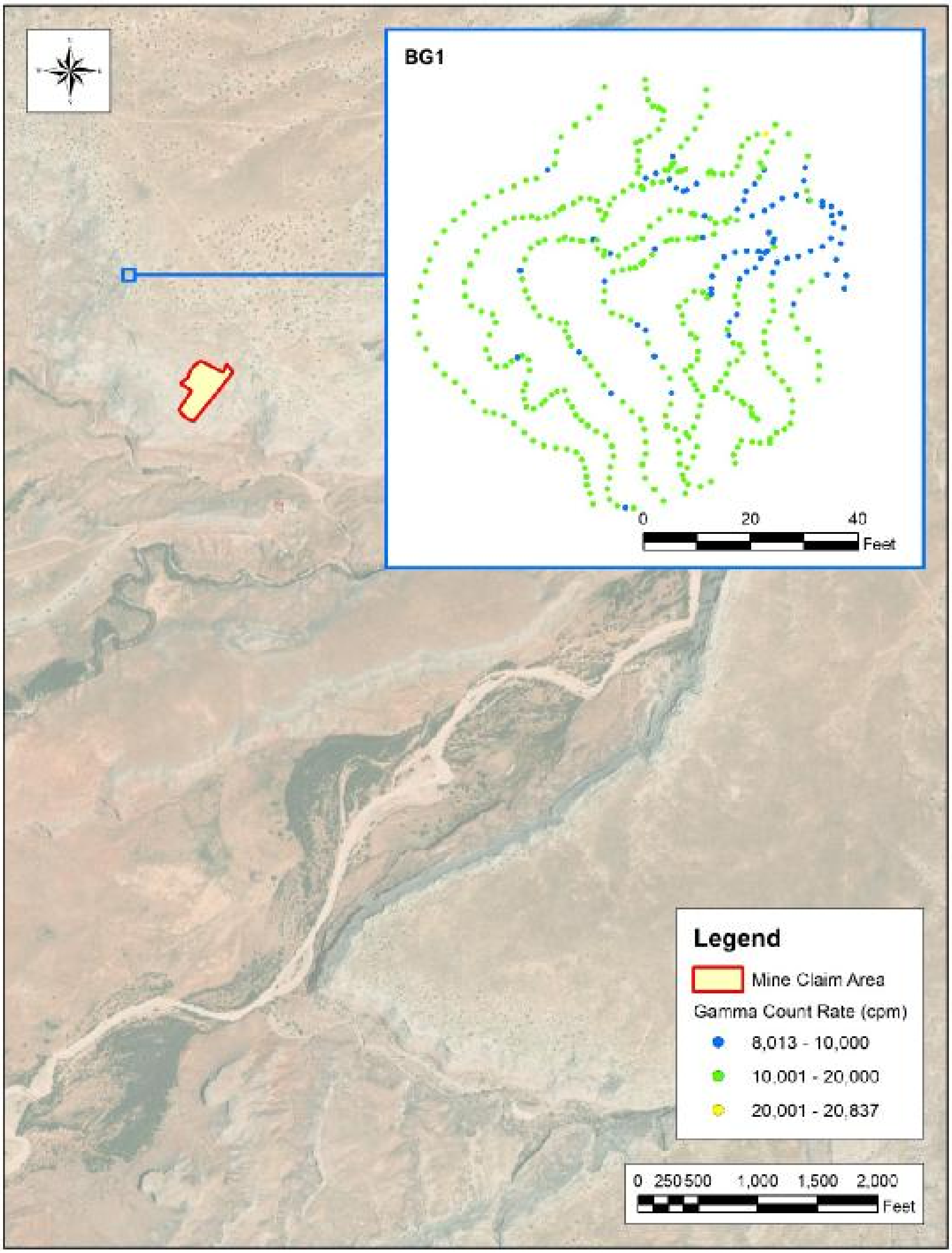


Figure 2. Gamma count rates in the potential Background Reference Area.

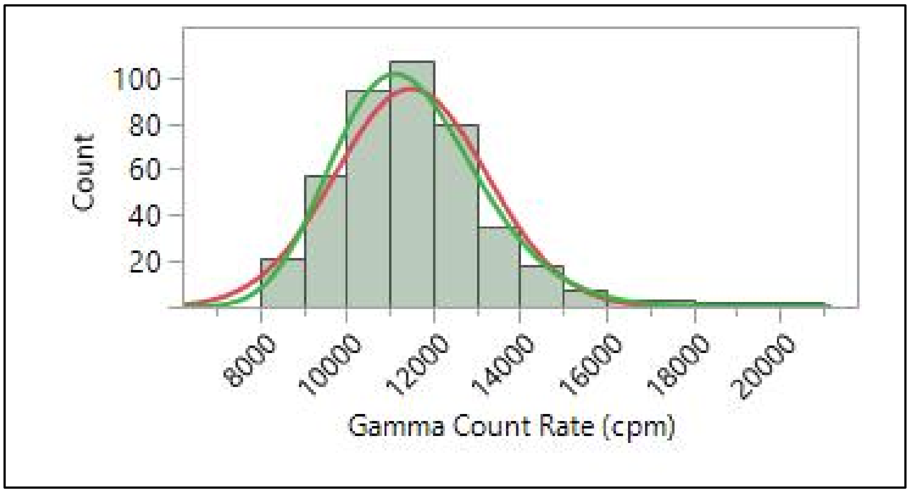


Figure 3. Histogram of gamma count rates in the potential Background Reference Area.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. The highest count rates were observed in the northeast corner of the mine claim and associated with waste rock.

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 (version 5.1.002), 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 9,726, 11,241, and 13,024 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 6,565 to 76,181 cpm and have a central tendency (median) of 11,241 cpm.

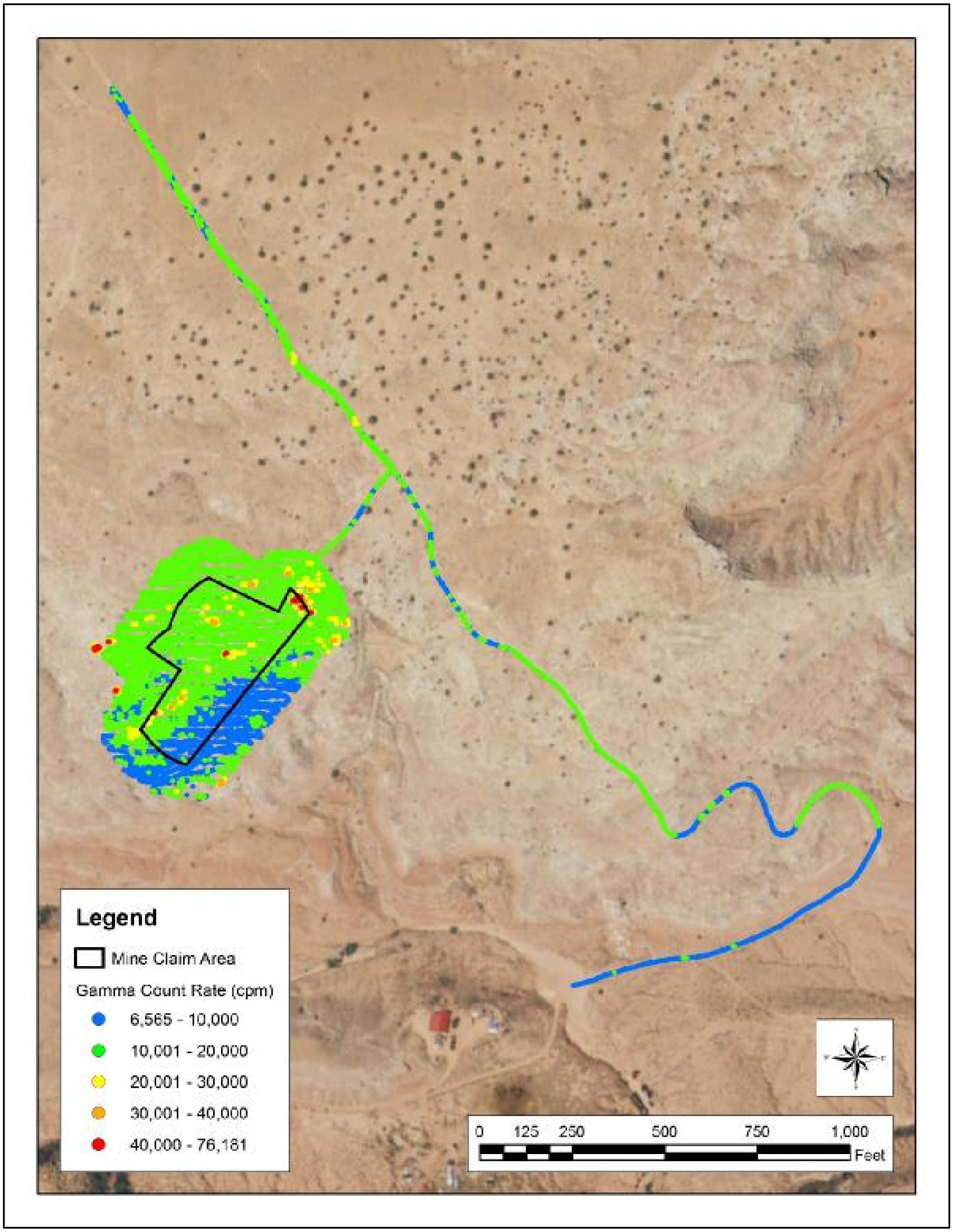


Figure 4. Gamma count rates in the Survey Area.

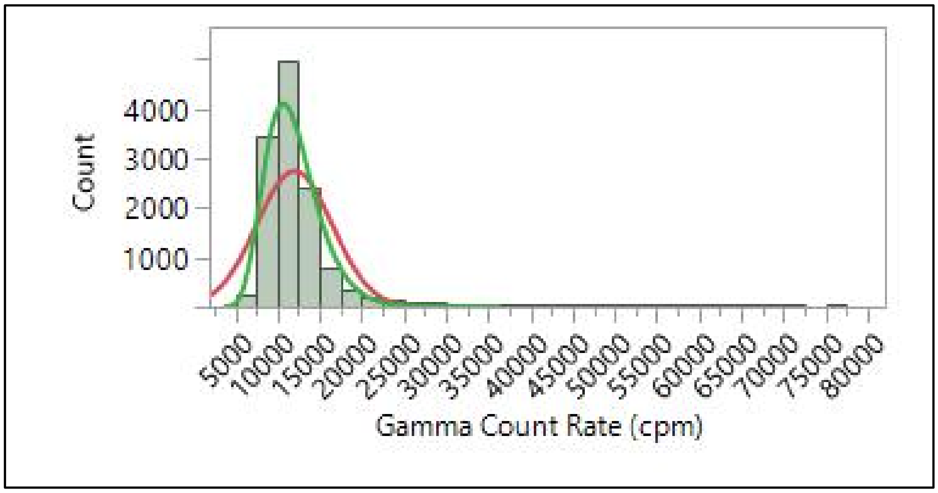


Figure 5. Histogram of gamma count rates in the Survey Area.

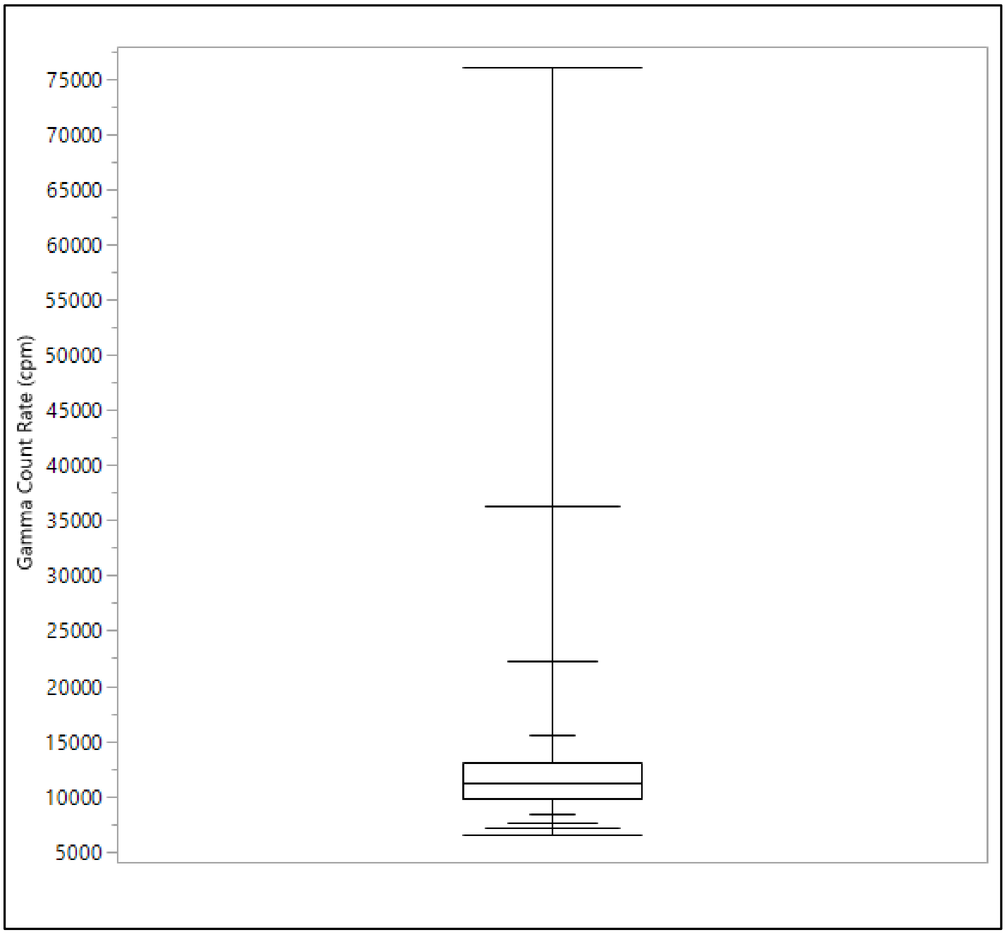


Figure 6. Box plot of gamma count rates in the Survey Area.

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

Parameter	Gamma Count Rate (cpm)
n	12,321
Minimum	6,565
Maximum	76,181
Mean	12,020
Median	11,241
Standard Deviation	4490

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 and thorium concentrations in surface soils and gamma count rates

On October 7, 2016 field personnel made GPS-based gamma count rate measurements and collected five-point composite samples of surface soils in each of the five areas at the AUM. 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 the two could be compared. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

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 measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 9,419 to 35,193 cpm. The concentrations of radium-226 range from 1.43 to 29.4 picocuries per gram (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 “Oak 124/125 Removal Site Evaluation Report” (Stantec, 2018).

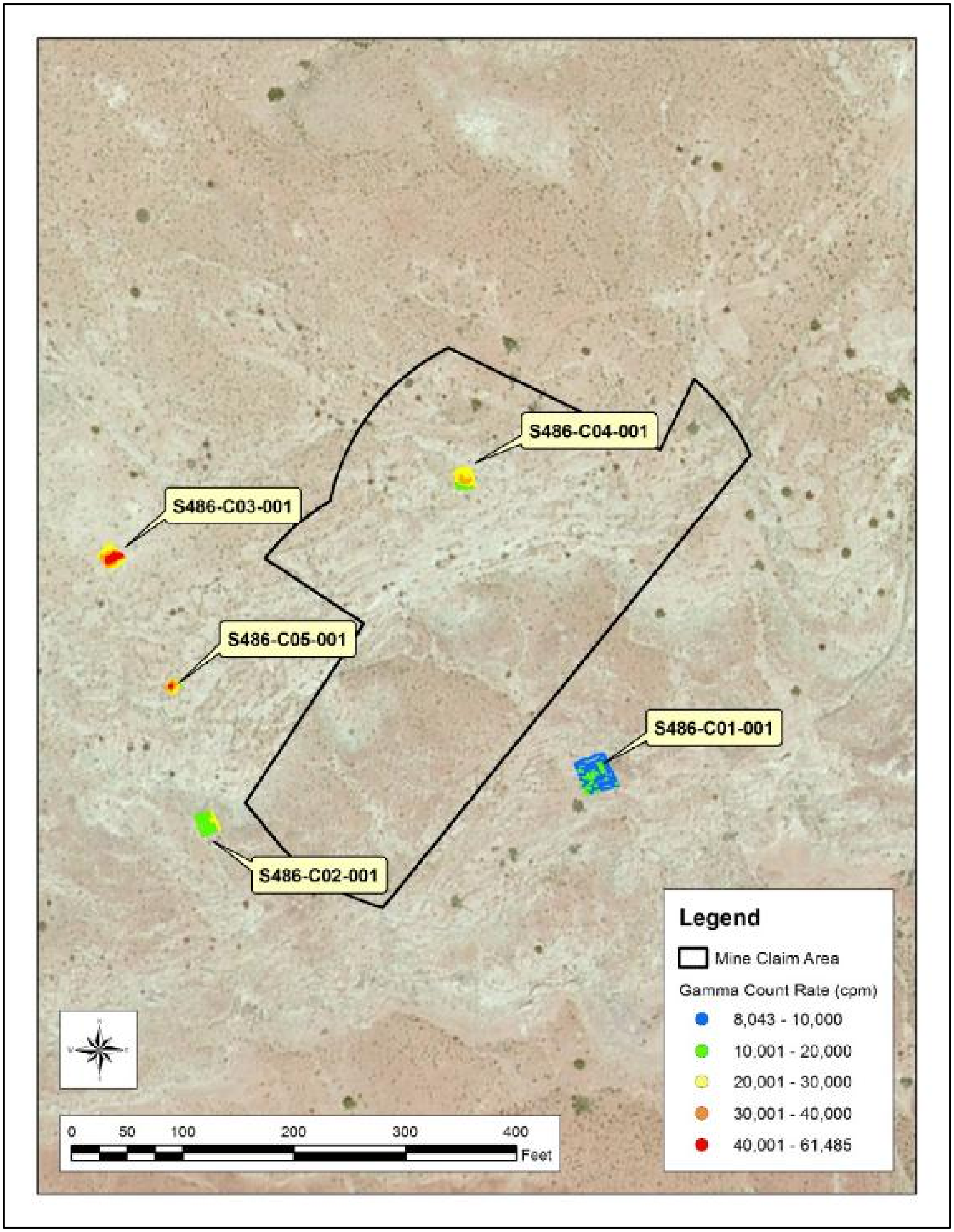


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

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)				Ra-226 (pCi/g)		
Location	Area (m^2)	Mean	Minimum	Maximum	σ	Result	Error ±2σ	MDC
S486-C01-001	104.6	9,419	8,043	11,352	598	1.43	0.35	0.58
S486-C02-001	35.1	15,841	11,658	29,051	3718	3.45	0.5	0.39
S486-C03-001	34.0	35,193	20,280	61,485	10088	29.4	3.6	1
S486-C04-001	34.3	24,538	13,134	32,383	5,088	13.7	1.7	0.6
S486-C05-001	10.8	29,234	16,489	45,938	6,521	22.6	2.8	0.6

Notes:
cpm = counts per minute
MDC = minimum detectable concentration
m^2 =square meters
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	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC	Result	Error ± 2 σ	MDC
S486-C01-001	0.34	0.075	0.039	1.04	0.19	0.07	0.36	0.075	0.005
S486-C02-001	0.51	0.1	0.04	2.94	0.47	0.07	0.58	0.11	0.02
S486-C03-001	0.326	0.077	0.038	18.8	2.9	0.1	0.298	0.069	0.02
S486-C04-001	0.461	0.097	0.038	9.5	1.5	0.1	0.5	0.1	0.02
S486-C05-001	0.59	0.12	0.04	15.4	2.4	0.1	0.53	0.11	0.02

Notes:
MDC = minimum detectable concentration
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, predicting 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 0.95, as expressed in the equation:

Gamma Count Rate (cpm) = 839 x [radium-226 (pCi/g)] + 10996

The root mean square error and p-value for the model are 2.3×10^3 and 0.003, respectively; these parameters are not data quality objectives (DQOs) and are included only as information. The R^2 value for this model exceeds the project DQO of 0.8.

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 -5.3 to 77.7 pCi/g, with a mean and median of 1.2 and 0.3 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.

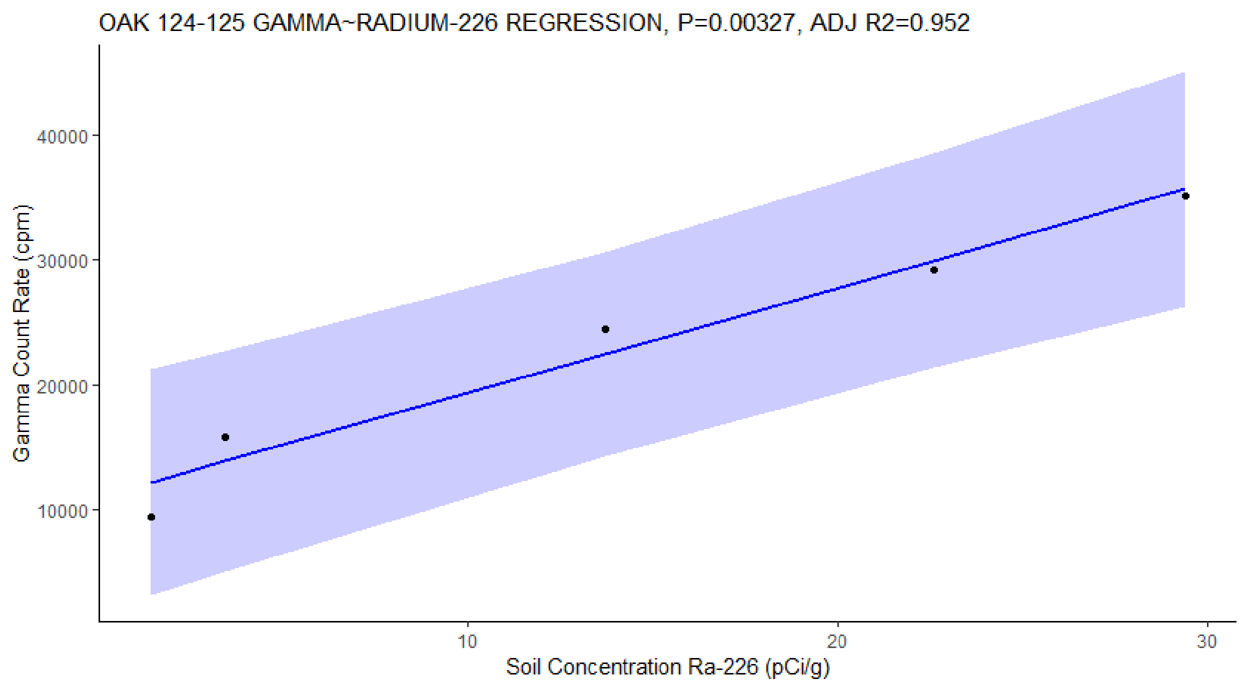


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils (blue line) and 95% prediction intervals plotted (shaded area).

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

Parameter	Radium-226 (pCi/g)
n	12,321
Minimum	-5.3
Maximum	77.7
Mean	1.2
Median	0.3
Standard Deviation	5.4

Notes:
pCi/g = picocuries per gram

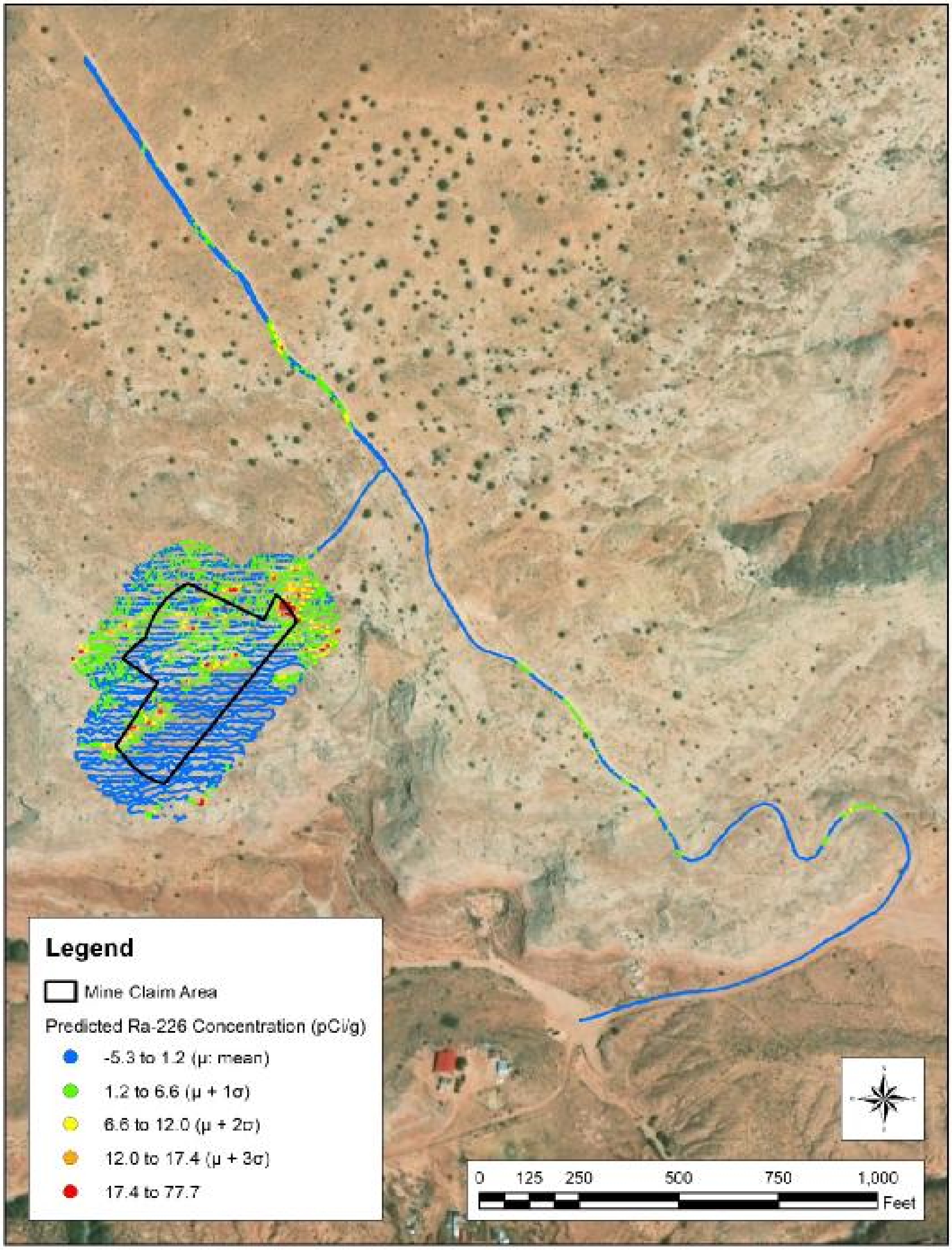


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

Soil concentrations of potassium-40 (K-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-value for radium-226 (0.01) met the significance criterion of $p < 0.05$, while that for thorium-232 was non-significant at 0.32. 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 0.75 with an adjusted R^2 of -0.28. 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 ($p = 0.003$), as described above, and the adjusted R^2 value (0.95) met 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 locations, 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 was not 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 that there is evidence of equilibrium, but not secular equilibrium, among the uranium decay series radionuclides (Figure 10).

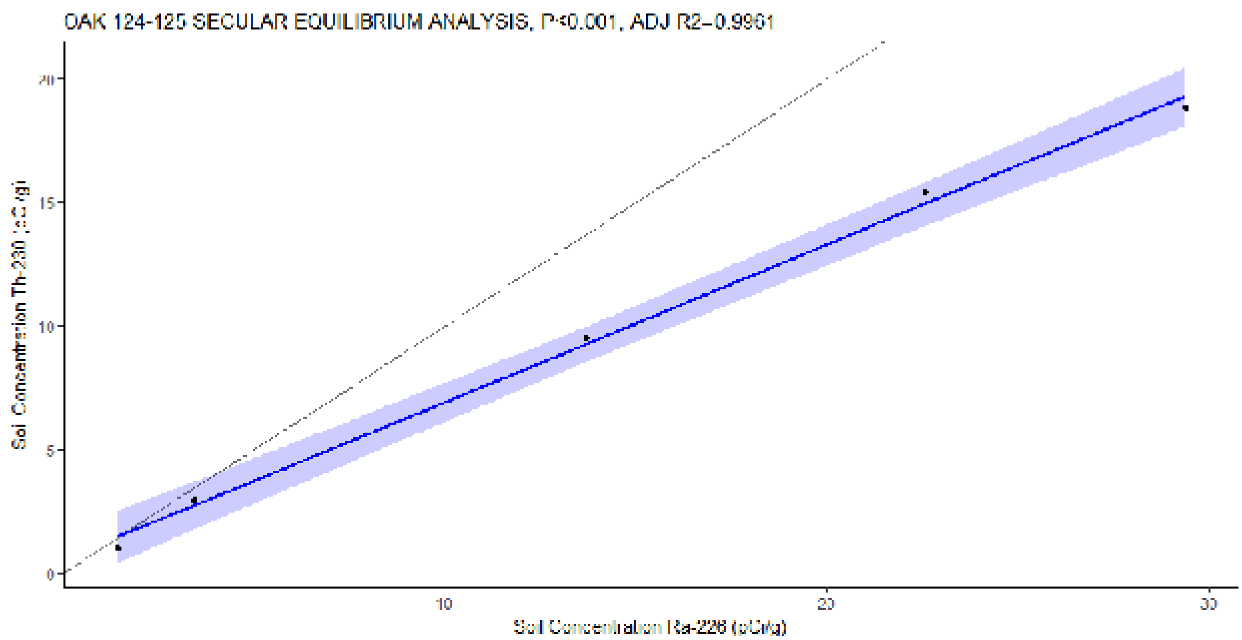


Figure 10. Evaluation of secular equilibrium in the uranium decay series.

3.3 Exposure rates and gamma count rates

Field personnel made co-located one-minute static count rate and exposure rate measurements at the five locations within the Survey Area, 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 on October 7, 2016 at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the two sodium iodide detection systems used in the GPS-based gamma survey of the Survey Area

(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 rate used in the comparison was the mean of these measurements, less those occurring in initial instrument spikes. The HPIC was in current calibration and function checked before and after use. A correction factor of 1.02 was applied to the measured value per the manufacturer's recommendation 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 (one second) exposure rate measurements.

The best predictive relationship between the measurements is linear with a R^2 of 0.9517. The root mean square error and p-value for the correlation are 1.667332 and 0.0046, 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:

$$\text{Exposure Rate } (\mu R/h) = 3 \times 10^{-4} \times \text{Gamma Count Rate (cpm)} + 9.4541$$

Tables 8 and 9 present the exposure rates predicted from the gamma count rate measurements, the spatial and numerical distribution of which mirror those depicted in Figure 4.

Figure 12 presents summary statistics for the predicted exposure rates in the potential Background Reference Area and Survey Area, respectively. The range of predicted exposure rates at BG1 is 11.9 to 15.7 µR/h, with a mean and median of 12.9 and 12.8 µR/h, respectively. The range of predicted exposure rates in the Survey Area is 11.4 to 32.3 µR/h, with a mean and median of 13.1 and 12.8 µR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S486-C01-001	9,747	11.0
S486-C02-001	15,347	14.7
S486-C03-001	60,921	28.1
S486-C04-001	27,827	20.1
S486-C05-001	43,279	21.5

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

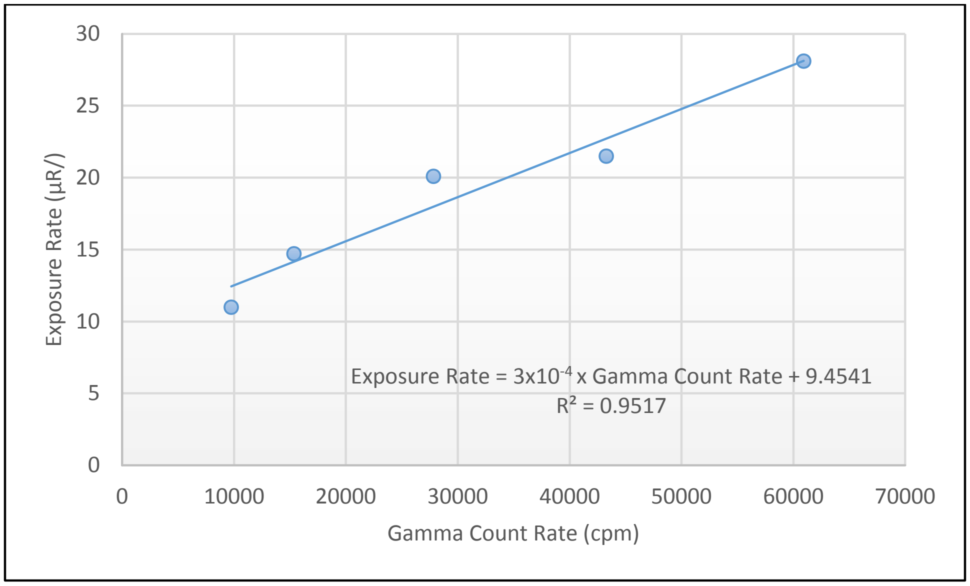


Figure 11. Correlation of gamma count rates and exposure rates.

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

Parameter	Exposure Rate (µR/h)
n	417
Minimum	11.9
Maximum	15.7
Mean	12.9
Median	12.8
Standard Deviation	0.5

Notes:
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	12,321
Minimum	11.4
Maximum	32.3
Mean	13.1
Median	12.8
Standard Deviation	1.3

Notes:
µR/h = microRoentgens per hour

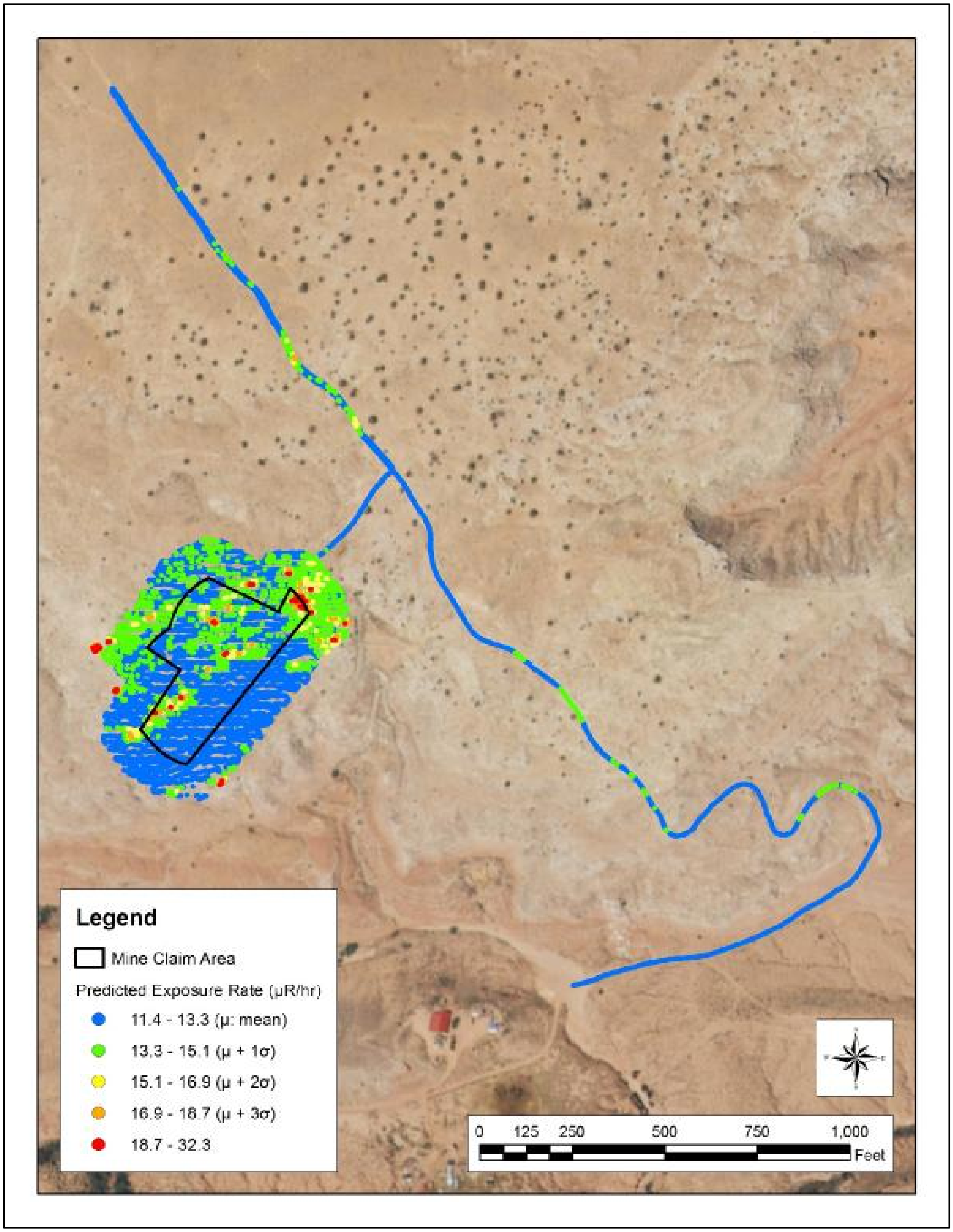


Figure 12. Predicted exposure rates in the Survey Area.

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 ft 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.
- Gamma count rates in the mine claim are naturally elevated due to the presence of uranium mineralization. Elevated count rates observed in the northeast corner of the mine claim were associated with waste rock.
- One potential Background Reference Area was 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) = 839 x [radium-226 (pCi/g)] + 10996

- 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 -5.3 to 77.7 pCi/g, with a central tendency (median) of 0.3 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 the uranium series radionuclides 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 (μR/h) = Gamma Count Rate (cpm) x 3×10^{-4} + 9.4541

- The distribution of exposure rates predicted using this model is rightward tailed. The values in the Survey Area range from 11.4 to 32.3, with a central tendency (median) of 12.8 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. Oak 124/Oak 125 Removal Site Evaluation Report, September 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 ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V

✔ F/S Response Check ✔ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch Other:

✔ Geotropism ✔ Audio Check

✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.75 inches Hg

Source Distance: ☐ Contact ✔ 6 inches ☐ Other: Threshold: 10 mV Temperature: 74 °F

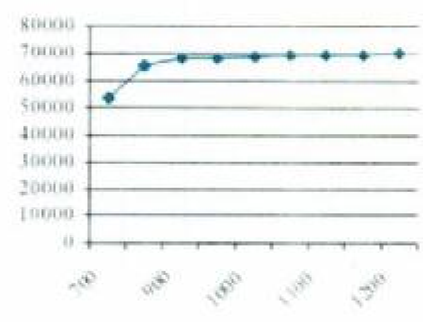
Source Geometry: ✔ Side ☐ Below ☐ Other: Window: Relative Humidity: 20 %

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 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: [signature] Calibration Date: 7-6-16 Calibration Due: 7-6-17

Reviewed By: [signature] Date: 7/20/16

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

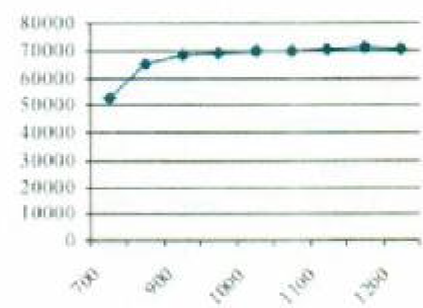
✔ Mechanical Check ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.24 inches Hg
Source Distance: ☐ Contact ✔ 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 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: [signature] Calibration Date: ~~1 March 17~~ 2/28/17 CSH Calibration Due: ~~1 March~~ 2/28/18 CSH 18

Reviewed By: [signature] Date: 3-1-17

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:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

✓ Mechanical Check ✓ THR/WIN Operation HV Check (+/- 2.5%): ✓ 500 V ✓ 1000 V ✓ 1500 V

✓ F/S Response Check ✓ Reset Check Cable Length: 39-inch ✓ 72-inch Other:

✓ Geotropism ✓ Audio Check

✓ Meter Zeroed ✓ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.78 inches Hg

Source Distance: Contact ✓ 6 inches Other: Threshold: 10 mV Temperature: 74 °F

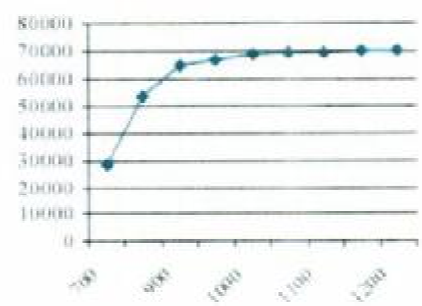
Source Geometry: ✓ Side Below Other: Window: Relative Humidity: 20 %

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 8 16 Calibration Due: 7-8-17

Reviewed By: Date: 7/20/16

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 Hardison Reviewed By: Angela Roper

Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED
CALIBRATION CERT #1866.01

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				CALIBRATION		
BEAM		EXPOSURE RATE		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
Richard Hardison
Title: Calibration Technician

Reviewed By: [signature]
Title: Calibration Physicist

Checked By: [signature] **Prepared By:** REH

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:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
9-27-16	1126	6.1	1002	99	45988	6844	39144	NW	NA-0904
9-27-16	1619	5.9	997	99	44136	6788	37340	NW	NA-0904
9-28-16	1027	5.9	1001	99	44612	6242	38370	NW	Comfort Suites Parking lot
9-28-16	1754	5.9	1000	99	43583	6742	36841	NW	NA-0928
9-29-16	0936	5.9	1001	100	44695	5574	39121	NW	Comfort Suites Parking Lot
9-29-16	1600	5.8	1002	99	46024	6760	39264	NW	NA-0928
9-30-16	0920	5.8	1002	99	44958	5748	39210	NW	NA-0904
9-30-16	1436	5.7	998	99	44138	6240	37898	NW	NA-0504
10-1-16	0913	5.7	1002	100	43656	5047	38609	NW	Oak 124/125
10-1-16	1605	5.6	995	99	43105	6275	36830	NW	Alonzo
10-3-16	0950	5.7	1001	99	44914	5611	39303	NW	Barton 3
10-3-16	1220	5.6	995	99	45923	5670	40105	NW	Barton 3

Reviewed by: [signature] Review Date: 11-29-16

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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.:	254772
Cal. Due Date:	7-14-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-19-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
10-4-16	0925	5.7	1003	99	45635	6378	39254	NW	Tsosie 1
10-4-16	1720	5.6	1008	99	46987	6720	40267	NW	Comfort Suites Parking lot
10-5-16	0620	5.7	1007	99	47335	6804	40531	NW	Comfort Suites Parking lot
10-5-16	1542	5.5	999	99	45375	6342	39033	NW	Tsosie 1
10-6-16	0900	5.5	1003	99	43705	6364	37341	NW	Tsosie 1
10-6-16	1713	5.5	1000	99	44279	6053	38226	NW	Comfort Suites Parking Lot
10-7-16	0902	5.5	1006	99	44457	6003	38404	NW	Oak 124/125
10-7-16	1627	5.5	999	99	46103	6751	39352	NW	Comfort Suites Parking Lot
10-8-16	0903	5.6	1003	99	45434	6365	39069	NW	Red Valley Intersection
10-8-16	1653	5.5	999	99	45185	6467	38718	NW	Comfort Suites Parking Lot
10-10-16	0958	5.5	1004	100	42755	5579	37176	NW	Oak 124/125
10-10-16	1919	5.5	959	99	51651	6930	44721	NW	Oak 124/125

Reviewed by: MM Review Date: 11/29/16

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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.:	254792
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-18

Comments:
NW/NRT

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	999	100	36519	5067	31452	NW	Mitten
5-23-17	1426	5.4	994	100	35848	4830	31018	NW	Gouldings lodge
5-24-17	0757	5.4	997	100	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: [signature] Review Date: 11/08/17

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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:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNGRT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
9-27-16	1121	5.7	1100	100	45851	6762	39089	NW	NA-0904
9-27-16	1619	5.6	1094	99	45492	6313	39179	NW	NA-0904
9-28-16	1026	5.7	1100	100	44929	6287	38642	NW	NA-0904
9-28-16	1754	5.6	1098	100	44643	6434	38209	NW	Comfort Suites Parking Lot
9-29-16	0940	5.6	1100	99	43453	5654	37799	NW	NA-0928
9-29-16	1603	5.5	1101	100	44586	6525	38061	NW	Comfort Suites Parking Lot
9-30-16	0415	5.5	1102	100	44975	5236	39739	NW	NA-0928
9-30-16	1433	5.4	1096	100	44003	5827	38176	NW	NA-0904
10-1-16	0925	5.5	1102	100	42929	5140	37789	NW	Oak 124/125
10-1-16	1605	5.3	1092	100	44650	6271	38379	NW	Monzo
10-3-16	0946	5.5	1100	100	43679	4995	38684	NW	Barton 3
10-3-16	1225	5.4	1099	100	45921	5361	40560	NW	Barton 3

Reviewed by: MT Review Date: 11/29/16

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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

(2)

METER	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR 295014
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: 6-16-94

Distance to Source: 6 Inches

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
10-4-16	0936	5.5	1102	100	46804	6042	40762	NW	Tsosie 1
10-4-16	1720	5.4	1106	100	46032	6898	39134	NW	Comfort Suites Parking Lot
10-5-16	0622	5.4	1109	101	45794	6834	38960	NW	Comfort Suites Parking Lot
10-5-16	1548	5.3	1097	99	46608	6021	40587	NW	Tsosie 1
10-6-16	0904	5.4	1103	100	44521	6273	38248	NW	Comfort Suites Parking Lot
10-6-16	1218	5.3	1099	100	45178	6311	38867	NW	Comfort Suites Parking Lot
10-7-16	0859	5.4	1104	100	44101	5226	38875	NW	Ock 124/125
10-7-16	1633	5.4	1098	99	44930	6832	38098	NW	Comfort Suites Parking Lot
10-8-16	0908	5.4	1104	100	45110	6201	38909	NW	Red Valley Intersection
10-8-16	1658	5.3	1098	99	45810	6196	39614	NW	Comfort Suites Parking Lot
10-12-16	1331	5.4	1099	99	46496	6519	39977	NW	Barton 3
10-12-16	1614	5.4	1097	100	44509	6060	38449	NW	Comfort Suites Parking Lot

Reviewed by: [signature]

Review Date: 11/29/16

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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:	GE
Model:	RSS-131
Serial No.:	07J00KM1
Cal. Due Date:	6-29-17

DETECTOR	
Manufacturer:	SAME AS METER
Model:	
Serial No.:	
Cal. Due Date:	

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: Contact - housing

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts (mR/h)	BKG Counts	Net Counts	Initials	Note(s): Project reference points
10-7-16	0545	~6.18	~400	~NA~	~26.7	~9.5	~17.2	NW	Comfort Suites Room - Farmington
10-7-16	2040	~6.16	~400	NA	~26.5	~8.7	~17.8	NW	Comfort Suites Room - Farmington
10-11-16	0634	~6.2	~400	NA	~25	~10.5	~14.5	NW	Comfort Suites Room - Farmington
10-11-16	1801	~6.3	~400	NA	~25.5	~10.1	~14.4	NW	Comfort Suites Room - Farmington
10-12-16	0548	~6.3	~400	NA	~26.5	~10	~16.5	NW	Comfort Suites Room - Farmington
10-12-16	1640	~6.3	~400	NA	~26.4	~10	~16.4	NW	Comfort Suites Room - Farmington
10-13-16	0608	~6.3	~400	NA	~27	~9.8	~17.2	NW	Comfort Suites Room - Farmington
10-13-16	1950	~6.3	~400	NA	~26.3	~9.5	~16.8	NW	Comfort Suites Room - Farmington
10-14-16	0630	~6.4	~400	NA	~26.4	~9.5	~16.9	NW	Comfort Suites Room - Farmington
10-14-16	1547	~6.2	~400	NA	~30	~12	~18	NW	Comfort Suites Room - Farmington
10-25-16	0539	~6.3	~400	NA	~29	~11	~18	NW	Best Western Room - Flagstaff
10-27-16	1255				DID	NOT	USE		

Reviewed by: [signature] Review Date: 11-29-16

ERG Form ITC.201.A

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 10:19	0.0534	Correlation Location 1
10/07/2016 10:19	0.093	Correlation Location 1
10/07/2016 10:20	0.0803	Correlation Location 1
10/07/2016 10:20	0.054	Correlation Location 1
10/07/2016 10:20	0.0348	Correlation Location 1
10/07/2016 10:20	0.0232	Correlation Location 1
10/07/2016 10:20	0.017	Correlation Location 1
10/07/2016 10:20	0.0139	Correlation Location 1
10/07/2016 10:20	0.0127	Correlation Location 1
10/07/2016 10:20	0.0122	Correlation Location 1
10/07/2016 10:20	0.0115	Correlation Location 1
10/07/2016 10:20	0.0108	Correlation Location 1
10/07/2016 10:21	0.0105	Correlation Location 1
10/07/2016 10:21	0.0105	Correlation Location 1
10/07/2016 10:21	0.0105	Correlation Location 1
10/07/2016 10:21	0.0108	Correlation Location 1
10/07/2016 10:21	0.0108	Correlation Location 1
10/07/2016 10:21	0.0106	Correlation Location 1
10/07/2016 10:21	0.011	Correlation Location 1
10/07/2016 10:21	0.0115	Correlation Location 1
10/07/2016 10:21	0.0117	Correlation Location 1
10/07/2016 10:21	0.0114	Correlation Location 1
10/07/2016 10:22	0.0106	Correlation Location 1
10/07/2016 10:22	0.01	Correlation Location 1
10/07/2016 10:22	0.01	Correlation Location 1
10/07/2016 10:22	0.0105	Correlation Location 1
10/07/2016 10:22	0.0108	Correlation Location 1
10/07/2016 10:22	0.0105	Correlation Location 1
10/07/2016 10:22	0.0105	Correlation Location 1
10/07/2016 10:22	0.0106	Correlation Location 1
10/07/2016 10:22	0.0109	Correlation Location 1
10/07/2016 10:22	0.0108	Correlation Location 1
10/07/2016 10:23	0.0108	Correlation Location 1
10/07/2016 10:23	0.0109	Correlation Location 1
10/07/2016 10:23	0.0105	Correlation Location 1
10/07/2016 10:23	0.0108	Correlation Location 1
10/07/2016 10:23	0.0111	Correlation Location 1
10/07/2016 10:23	0.0116	Correlation Location 1
10/07/2016 10:23	0.0117	Correlation Location 1
10/07/2016 10:23	0.0114	Correlation Location 1
10/07/2016 10:23	0.0106	Correlation Location 1
10/07/2016 10:23	0.0109	Correlation Location 1
10/07/2016 10:24	0.011	Correlation Location 1
10/07/2016 10:24	0.0111	Correlation Location 1
10/07/2016 10:24	0.0111	Correlation Location 1
10/07/2016 10:24	0.0114	Correlation Location 1
10/07/2016 10:24	0.0111	Correlation Location 1
10/07/2016 10:24	0.0109	Correlation Location 1
10/07/2016 10:24	0.0105	Correlation Location 1
10/07/2016 10:24	0.0105	Correlation Location 1
10/07/2016 10:24	0.0108	Correlation Location 1
10/07/2016 10:24	0.0112	Correlation Location 1
10/07/2016 10:25	0.0117	Correlation Location 1
10/07/2016 10:25	0.0115	Correlation Location 1
10/07/2016 10:25	0.0111	Correlation Location 1
10/07/2016 10:25	0.0111	Correlation Location 1
10/07/2016 10:25	0.0112	Correlation Location 1
10/07/2016 10:25	0.0109	Correlation Location 1
10/07/2016 10:25	0.0106	Correlation Location 1
10/07/2016 10:25	0.0108	Correlation Location 1

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 10:25	0.0108	Correlation Location 1
10/07/2016 10:25	0.0106	Correlation Location 1
10/07/2016 10:26	0.0109	Correlation Location 1
10/07/2016 10:26	0.0111	Correlation Location 1
10/07/2016 10:26	0.0108	Correlation Location 1
10/07/2016 10:26	0.0106	Correlation Location 1
10/07/2016 10:26	0.0108	Correlation Location 1
10/07/2016 10:26	0.0111	Correlation Location 1
10/07/2016 10:26	0.0112	Correlation Location 1
10/07/2016 10:26	0.011	Correlation Location 1
10/07/2016 10:26	0.0112	Correlation Location 1
10/07/2016 10:26	0.0111	Correlation Location 1
10/07/2016 10:27	0.0108	Correlation Location 1
10/07/2016 10:27	0.0111	Correlation Location 1
10/07/2016 10:27	0.0114	Correlation Location 1
10/07/2016 10:27	0.0114	Correlation Location 1
10/07/2016 10:27	0.0111	Correlation Location 1
10/07/2016 10:27	0.0112	Correlation Location 1
10/07/2016 10:27	0.011	Correlation Location 1
10/07/2016 10:27	0.0106	Correlation Location 1
10/07/2016 10:27	0.0105	Correlation Location 1
10/07/2016 10:27	0.0105	Correlation Location 1
10/07/2016 10:28	0.0105	Correlation Location 1
10/07/2016 10:28	0.0106	Correlation Location 1
10/07/2016 10:28	0.0108	Correlation Location 1
10/07/2016 10:28	0.0112	Correlation Location 1
10/07/2016 10:28	0.0118	Correlation Location 1
10/07/2016 10:28	0.0115	Correlation Location 1
10/07/2016 10:28	0.0111	Correlation Location 1
10/07/2016 10:28	0.0109	Correlation Location 1
10/07/2016 10:28	0.0106	Correlation Location 1
10/07/2016 10:28	0.0106	Correlation Location 1
10/07/2016 10:29	0.0109	Correlation Location 1
10/07/2016 10:29	0.0116	Correlation Location 1
10/07/2016 10:29	0.0118	Correlation Location 1
10/07/2016 10:29	0.0116	Correlation Location 1
10/07/2016 10:29	0.0115	Correlation Location 1
10/07/2016 10:29	0.0115	Correlation Location 1
10/07/2016 10:29	0.0114	Correlation Location 1
10/07/2016 10:29	0.0111	Correlation Location 1
10/07/2016 10:29	0.0115	Correlation Location 1
10/07/2016 10:29	0.0117	Correlation Location 1
10/07/2016 10:30	0.0115	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:30	0.011	Correlation Location 1
10/07/2016 10:30	0.0114	Correlation Location 1
10/07/2016 10:30	0.0114	Correlation Location 1
10/07/2016 10:30	0.0111	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:30	0.0114	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:31	0.0112	Correlation Location 1
10/07/2016 10:31	0.0112	Correlation Location 1
10/07/2016 11:05	0.0544	Correlation Location 2
10/07/2016 11:05	0.095	Correlation Location 2
10/07/2016 11:05	0.0836	Correlation Location 2
10/07/2016 11:05	0.058	Correlation Location 2
10/07/2016 11:05	0.0385	Correlation Location 2
10/07/2016 11:06	0.0267	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:06	0.02	Correlation Location 2
10/07/2016 11:06	0.0169	Correlation Location 2
10/07/2016 11:06	0.0155	Correlation Location 2
10/07/2016 11:06	0.015	Correlation Location 2
10/07/2016 11:06	0.0149	Correlation Location 2
10/07/2016 11:06	0.0149	Correlation Location 2
10/07/2016 11:06	0.0148	Correlation Location 2
10/07/2016 11:06	0.0147	Correlation Location 2
10/07/2016 11:06	0.0146	Correlation Location 2
10/07/2016 11:07	0.0145	Correlation Location 2
10/07/2016 11:07	0.0142	Correlation Location 2
10/07/2016 11:07	0.0141	Correlation Location 2
10/07/2016 11:07	0.0144	Correlation Location 2
10/07/2016 11:07	0.0147	Correlation Location 2
10/07/2016 11:07	0.0148	Correlation Location 2
10/07/2016 11:07	0.0143	Correlation Location 2
10/07/2016 11:07	0.014	Correlation Location 2
10/07/2016 11:07	0.0141	Correlation Location 2
10/07/2016 11:07	0.0144	Correlation Location 2
10/07/2016 11:08	0.0145	Correlation Location 2
10/07/2016 11:08	0.0145	Correlation Location 2
10/07/2016 11:08	0.0146	Correlation Location 2
10/07/2016 11:08	0.0143	Correlation Location 2
10/07/2016 11:08	0.0141	Correlation Location 2
10/07/2016 11:08	0.0143	Correlation Location 2
10/07/2016 11:08	0.0145	Correlation Location 2
10/07/2016 11:08	0.0143	Correlation Location 2
10/07/2016 11:08	0.0141	Correlation Location 2
10/07/2016 11:08	0.0141	Correlation Location 2
10/07/2016 11:09	0.0141	Correlation Location 2
10/07/2016 11:09	0.0144	Correlation Location 2
10/07/2016 11:09	0.0145	Correlation Location 2
10/07/2016 11:09	0.0146	Correlation Location 2
10/07/2016 11:09	0.0145	Correlation Location 2
10/07/2016 11:09	0.0145	Correlation Location 2
10/07/2016 11:09	0.0147	Correlation Location 2
10/07/2016 11:09	0.0147	Correlation Location 2
10/07/2016 11:09	0.0149	Correlation Location 2
10/07/2016 11:09	0.0148	Correlation Location 2
10/07/2016 11:10	0.0145	Correlation Location 2
10/07/2016 11:10	0.0142	Correlation Location 2
10/07/2016 11:10	0.0141	Correlation Location 2
10/07/2016 11:10	0.0142	Correlation Location 2
10/07/2016 11:10	0.0146	Correlation Location 2
10/07/2016 11:10	0.0151	Correlation Location 2
10/07/2016 11:10	0.0152	Correlation Location 2
10/07/2016 11:10	0.0148	Correlation Location 2
10/07/2016 11:10	0.0147	Correlation Location 2
10/07/2016 11:10	0.0147	Correlation Location 2
10/07/2016 11:11	0.0146	Correlation Location 2
10/07/2016 11:11	0.0147	Correlation Location 2
10/07/2016 11:11	0.0148	Correlation Location 2
10/07/2016 11:11	0.015	Correlation Location 2
10/07/2016 11:11	0.0153	Correlation Location 2
10/07/2016 11:11	0.0151	Correlation Location 2
10/07/2016 11:11	0.0148	Correlation Location 2
10/07/2016 11:11	0.0148	Correlation Location 2
10/07/2016 11:11	0.0152	Correlation Location 2
10/07/2016 11:11	0.0151	Correlation Location 2
10/07/2016 11:12	0.0147	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:12	0.0153	Correlation Location 2
10/07/2016 11:12	0.0148	Correlation Location 2
10/07/2016 11:12	0.0148	Correlation Location 2
10/07/2016 11:12	0.0147	Correlation Location 2
10/07/2016 11:12	0.0146	Correlation Location 2
10/07/2016 11:12	0.0146	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:13	0.0149	Correlation Location 2
10/07/2016 11:13	0.0147	Correlation Location 2
10/07/2016 11:13	0.0143	Correlation Location 2
10/07/2016 11:13	0.014	Correlation Location 2
10/07/2016 11:13	0.0139	Correlation Location 2
10/07/2016 11:13	0.0145	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:14	0.0146	Correlation Location 2
10/07/2016 11:14	0.0145	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.0146	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.015	Correlation Location 2
10/07/2016 11:14	0.0151	Correlation Location 2
10/07/2016 11:14	0.0149	Correlation Location 2
10/07/2016 11:15	0.0153	Correlation Location 2
10/07/2016 11:15	0.0158	Correlation Location 2
10/07/2016 11:15	0.0156	Correlation Location 2
10/07/2016 11:15	0.0154	Correlation Location 2
10/07/2016 11:15	0.0152	Correlation Location 2
10/07/2016 11:15	0.0152	Correlation Location 2
10/07/2016 11:15	0.0152	Correlation Location 2
10/07/2016 11:15	0.015	Correlation Location 2
10/07/2016 11:15	0.0146	Correlation Location 2
10/07/2016 11:15	0.0145	Correlation Location 2
10/07/2016 11:16	0.0144	Correlation Location 2
10/07/2016 11:16	0.0144	Correlation Location 2
10/07/2016 11:16	0.0147	Correlation Location 2
10/07/2016 11:16	0.0148	Correlation Location 2
10/07/2016 11:16	0.0144	Correlation Location 2
10/07/2016 11:16	0.0146	Correlation Location 2
10/07/2016 11:16	0.0148	Correlation Location 2
10/07/2016 11:50	0.0566	Correlation Location 3
10/07/2016 11:51	0.1012	Correlation Location 3
10/07/2016 11:51	0.0938	Correlation Location 3
10/07/2016 11:51	0.0701	Correlation Location 3
10/07/2016 11:51	0.0514	Correlation Location 3
10/07/2016 11:51	0.0403	Correlation Location 3
10/07/2016 11:51	0.0344	Correlation Location 3
10/07/2016 11:51	0.0311	Correlation Location 3
10/07/2016 11:51	0.0295	Correlation Location 3
10/07/2016 11:51	0.0287	Correlation Location 3
10/07/2016 11:51	0.0288	Correlation Location 3
10/07/2016 11:52	0.0282	Correlation Location 3
10/07/2016 11:52	0.028	Correlation Location 3
10/07/2016 11:52	0.028	Correlation Location 3
10/07/2016 11:52	0.0283	Correlation Location 3
10/07/2016 11:52	0.0285	Correlation Location 3
10/07/2016 11:52	0.0287	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:12	0.0149	Correlation Location 2
10/07/2016 11:12	0.0153	Correlation Location 2
10/07/2016 11:12	0.0155	Correlation Location 2
10/07/2016 11:52	0.0284	Correlation Location 3
10/07/2016 11:53	0.0282	Correlation Location 3
10/07/2016 11:53	0.0276	Correlation Location 3
10/07/2016 11:53	0.0275	Correlation Location 3
10/07/2016 11:53	0.0276	Correlation Location 3
10/07/2016 11:53	0.0272	Correlation Location 3
10/07/2016 11:53	0.028	Correlation Location 3
10/07/2016 11:53	0.0288	Correlation Location 3
10/07/2016 11:53	0.0286	Correlation Location 3
10/07/2016 11:53	0.0282	Correlation Location 3
10/07/2016 11:53	0.028	Correlation Location 3
10/07/2016 11:54	0.0276	Correlation Location 3
10/07/2016 11:54	0.0279	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.0282	Correlation Location 3
10/07/2016 11:54	0.0282	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.0282	Correlation Location 3
10/07/2016 11:54	0.0286	Correlation Location 3
10/07/2016 11:55	0.0286	Correlation Location 3
10/07/2016 11:55	0.0283	Correlation Location 3
10/07/2016 11:55	0.028	Correlation Location 3
10/07/2016 11:55	0.0282	Correlation Location 3
10/07/2016 11:55	0.0278	Correlation Location 3
10/07/2016 11:55	0.0278	Correlation Location 3
10/07/2016 11:55	0.028	Correlation Location 3
10/07/2016 11:55	0.0283	Correlation Location 3
10/07/2016 11:55	0.0282	Correlation Location 3
10/07/2016 11:55	0.0279	Correlation Location 3
10/07/2016 11:56	0.0277	Correlation Location 3
10/07/2016 11:56	0.0279	Correlation Location 3
10/07/2016 11:56	0.0277	Correlation Location 3
10/07/2016 11:56	0.0278	Correlation Location 3
10/07/2016 11:56	0.0278	Correlation Location 3
10/07/2016 11:56	0.028	Correlation Location 3
10/07/2016 11:56	0.028	Correlation Location 3
10/07/2016 11:56	0.028	Correlation Location 3
10/07/2016 11:56	0.028	Correlation Location 3
10/07/2016 11:56	0.0282	Correlation Location 3
10/07/2016 11:57	0.0285	Correlation Location 3
10/07/2016 11:57	0.0288	Correlation Location 3
10/07/2016 11:57	0.0289	Correlation Location 3
10/07/2016 11:57	0.0284	Correlation Location 3
10/07/2016 11:57	0.028	Correlation Location 3
10/07/2016 11:57	0.0278	Correlation Location 3
10/07/2016 11:57	0.028	Correlation Location 3
10/07/2016 11:57	0.028	Correlation Location 3
10/07/2016 11:57	0.0278	Correlation Location 3
10/07/2016 11:57	0.0283	Correlation Location 3
10/07/2016 11:58	0.0286	Correlation Location 3
10/07/2016 11:58	0.0285	Correlation Location 3
10/07/2016 11:58	0.0284	Correlation Location 3
10/07/2016 11:58	0.0284	Correlation Location 3
10/07/2016 11:58	0.028	Correlation Location 3
10/07/2016 11:58	0.0277	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:52	0.0283	Correlation Location 3
10/07/2016 11:52	0.0279	Correlation Location 3
10/07/2016 11:52	0.0283	Correlation Location 3
10/07/2016 11:59	0.028	Correlation Location 3
10/07/2016 11:59	0.0277	Correlation Location 3
10/07/2016 11:59	0.028	Correlation Location 3
10/07/2016 11:59	0.0283	Correlation Location 3
10/07/2016 11:59	0.0282	Correlation Location 3
10/07/2016 11:59	0.028	Correlation Location 3
10/07/2016 11:59	0.0279	Correlation Location 3
10/07/2016 11:59	0.0278	Correlation Location 3
10/07/2016 12:00	0.0278	Correlation Location 3
10/07/2016 12:00	0.0282	Correlation Location 3
10/07/2016 12:00	0.0289	Correlation Location 3
10/07/2016 12:00	0.0287	Correlation Location 3
10/07/2016 12:00	0.028	Correlation Location 3
10/07/2016 12:00	0.0276	Correlation Location 3
10/07/2016 12:00	0.0275	Correlation Location 3
10/07/2016 12:00	0.0278	Correlation Location 3
10/07/2016 12:00	0.0279	Correlation Location 3
10/07/2016 12:00	0.0277	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.0287	Correlation Location 3
10/07/2016 12:01	0.029	Correlation Location 3
10/07/2016 12:01	0.0288	Correlation Location 3
10/07/2016 12:01	0.0283	Correlation Location 3
10/07/2016 12:01	0.0282	Correlation Location 3
10/07/2016 12:01	0.0285	Correlation Location 3
10/07/2016 12:02	0.028	Correlation Location 3
10/07/2016 12:02	0.0275	Correlation Location 3
10/07/2016 12:02	0.028	Correlation Location 3
10/07/2016 12:02	0.0283	Correlation Location 3
10/07/2016 12:02	0.0284	Correlation Location 3
10/07/2016 12:30	0.0551	Correlation Location 4
10/07/2016 12:31	0.0976	Correlation Location 4
10/07/2016 12:31	0.0875	Correlation Location 4
10/07/2016 12:31	0.063	Correlation Location 4
10/07/2016 12:31	0.0446	Correlation Location 4
10/07/2016 12:31	0.0328	Correlation Location 4
10/07/2016 12:31	0.0262	Correlation Location 4
10/07/2016 12:31	0.023	Correlation Location 4
10/07/2016 12:31	0.0217	Correlation Location 4
10/07/2016 12:31	0.021	Correlation Location 4
10/07/2016 12:31	0.0204	Correlation Location 4
10/07/2016 12:32	0.02	Correlation Location 4
10/07/2016 12:32	0.0205	Correlation Location 4
10/07/2016 12:32	0.0202	Correlation Location 4
10/07/2016 12:32	0.02	Correlation Location 4
10/07/2016 12:32	0.0198	Correlation Location 4
10/07/2016 12:32	0.0196	Correlation Location 4
10/07/2016 12:32	0.0198	Correlation Location 4
10/07/2016 12:32	0.0201	Correlation Location 4
10/07/2016 12:32	0.0202	Correlation Location 4
10/07/2016 12:32	0.0205	Correlation Location 4
10/07/2016 12:33	0.0205	Correlation Location 4
10/07/2016 12:33	0.0204	Correlation Location 4
10/07/2016 12:33	0.0201	Correlation Location 4

Date and Time	Exposure Rate (mR/h)	Location	Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:58	0.0275	Correlation Location 3	10/07/2016 12:33	0.0198	Correlation Location 4
10/07/2016 11:58	0.0274	Correlation Location 3	10/07/2016 12:33	0.02	Correlation Location 4
10/07/2016 11:58	0.028	Correlation Location 3	10/07/2016 12:33	0.0202	Correlation Location 4
10/07/2016 11:58	0.0286	Correlation Location 3	10/07/2016 12:33	0.021	Correlation Location 4
10/07/2016 11:59	0.0289	Correlation Location 3	10/07/2016 12:33	0.0211	Correlation Location 4
10/07/2016 11:59	0.0287	Correlation Location 3	10/07/2016 12:33	0.021	Correlation Location 4
10/07/2016 12:33	0.021	Correlation Location 4	10/07/2016 12:40	0.0199	Correlation Location 4
10/07/2016 12:34	0.0209	Correlation Location 4	10/07/2016 12:40	0.02	Correlation Location 4
10/07/2016 12:34	0.0206	Correlation Location 4	10/07/2016 12:40	0.0202	Correlation Location 4
10/07/2016 12:34	0.0202	Correlation Location 4	10/07/2016 12:40	0.0204	Correlation Location 4
10/07/2016 12:34	0.0201	Correlation Location 4	10/07/2016 12:40	0.0202	Correlation Location 4
10/07/2016 12:34	0.0201	Correlation Location 4	10/07/2016 12:40	0.0205	Correlation Location 4
10/07/2016 12:34	0.0199	Correlation Location 4	10/07/2016 12:40	0.021	Correlation Location 4
10/07/2016 12:34	0.0196	Correlation Location 4	10/07/2016 12:40	0.021	Correlation Location 4
10/07/2016 12:34	0.0194	Correlation Location 4	10/07/2016 12:41	0.0209	Correlation Location 4
10/07/2016 12:34	0.0196	Correlation Location 4	10/07/2016 12:41	0.0211	Correlation Location 4
10/07/2016 12:34	0.0197	Correlation Location 4	10/07/2016 12:41	0.0208	Correlation Location 4
10/07/2016 12:35	0.0192	Correlation Location 4	10/07/2016 12:41	0.0202	Correlation Location 4
10/07/2016 12:35	0.019	Correlation Location 4	10/07/2016 12:41	0.0199	Correlation Location 4
10/07/2016 12:35	0.0197	Correlation Location 4	10/07/2016 12:41	0.0197	Correlation Location 4
10/07/2016 12:35	0.0199	Correlation Location 4	10/07/2016 12:41	0.0196	Correlation Location 4
10/07/2016 12:35	0.0194	Correlation Location 4	10/07/2016 12:41	0.0199	Correlation Location 4
10/07/2016 12:35	0.0196	Correlation Location 4	10/07/2016 12:41	0.0201	Correlation Location 4
10/07/2016 12:35	0.02	Correlation Location 4	10/07/2016 12:41	0.0202	Correlation Location 4
10/07/2016 12:35	0.0199	Correlation Location 4	10/07/2016 12:42	0.0202	Correlation Location 4
10/07/2016 12:35	0.0198	Correlation Location 4	10/07/2016 12:42	0.02	Correlation Location 4
10/07/2016 12:35	0.0197	Correlation Location 4	10/07/2016 12:42	0.0198	Correlation Location 4
10/07/2016 12:36	0.0194	Correlation Location 4	10/07/2016 12:42	0.02	Correlation Location 4
10/07/2016 12:36	0.0196	Correlation Location 4	10/07/2016 13:44	0.0552	Correlation Location 5
10/07/2016 12:36	0.0196	Correlation Location 4	10/07/2016 13:44	0.0978	Correlation Location 5
10/07/2016 12:36	0.0194	Correlation Location 4	10/07/2016 13:44	0.0882	Correlation Location 5
10/07/2016 12:36	0.0197	Correlation Location 4	10/07/2016 13:44	0.0639	Correlation Location 5
10/07/2016 12:36	0.0197	Correlation Location 4	10/07/2016 13:44	0.0449	Correlation Location 5
10/07/2016 12:36	0.0199	Correlation Location 4	10/07/2016 13:44	0.0335	Correlation Location 5
10/07/2016 12:36	0.0198	Correlation Location 4	10/07/2016 13:45	0.0274	Correlation Location 5
10/07/2016 12:36	0.0199	Correlation Location 4	10/07/2016 13:45	0.0243	Correlation Location 5
10/07/2016 12:36	0.0204	Correlation Location 4	10/07/2016 13:45	0.023	Correlation Location 5
10/07/2016 12:37	0.0211	Correlation Location 4	10/07/2016 13:45	0.0223	Correlation Location 5
10/07/2016 12:37	0.0209	Correlation Location 4	10/07/2016 13:45	0.0218	Correlation Location 5
10/07/2016 12:37	0.0207	Correlation Location 4	10/07/2016 13:45	0.0216	Correlation Location 5
10/07/2016 12:37	0.0206	Correlation Location 4	10/07/2016 13:45	0.0211	Correlation Location 5
10/07/2016 12:37	0.0205	Correlation Location 4	10/07/2016 13:45	0.0209	Correlation Location 5
10/07/2016 12:37	0.0205	Correlation Location 4	10/07/2016 13:45	0.0209	Correlation Location 5
10/07/2016 12:37	0.0206	Correlation Location 4	10/07/2016 13:45	0.0213	Correlation Location 5
10/07/2016 12:37	0.0209	Correlation Location 4	10/07/2016 13:46	0.022	Correlation Location 5
10/07/2016 12:37	0.0207	Correlation Location 4	10/07/2016 13:46	0.0223	Correlation Location 5
10/07/2016 12:37	0.0204	Correlation Location 4	10/07/2016 13:46	0.0221	Correlation Location 5
10/07/2016 12:38	0.02	Correlation Location 4	10/07/2016 13:46	0.0215	Correlation Location 5
10/07/2016 12:38	0.0198	Correlation Location 4	10/07/2016 13:46	0.0216	Correlation Location 5
10/07/2016 12:38	0.0199	Correlation Location 4	10/07/2016 13:46	0.0218	Correlation Location 5
10/07/2016 12:38	0.0201	Correlation Location 4	10/07/2016 13:46	0.0221	Correlation Location 5
10/07/2016 12:38	0.02	Correlation Location 4	10/07/2016 13:46	0.0223	Correlation Location 5
10/07/2016 12:38	0.02	Correlation Location 4	10/07/2016 13:46	0.0227	Correlation Location 5
10/07/2016 12:38	0.0197	Correlation Location 4	10/07/2016 13:46	0.0225	Correlation Location 5
10/07/2016 12:38	0.0196	Correlation Location 4	10/07/2016 13:47	0.0217	Correlation Location 5
10/07/2016 12:38	0.0199	Correlation Location 4	10/07/2016 13:47	0.021	Correlation Location 5
10/07/2016 12:38	0.02	Correlation Location 4	10/07/2016 13:47	0.0208	Correlation Location 5
10/07/2016 12:39	0.02	Correlation Location 4	10/07/2016 13:47	0.0213	Correlation Location 5
10/07/2016 12:39	0.02	Correlation Location 4	10/07/2016 13:47	0.0216	Correlation Location 5
10/07/2016 12:39	0.0201	Correlation Location 4	10/07/2016 13:47	0.0216	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 12:39	0.0201	Correlation Location 4
10/07/2016 12:39	0.02	Correlation Location 4
10/07/2016 12:39	0.0198	Correlation Location 4
10/07/2016 12:39	0.0197	Correlation Location 4
10/07/2016 12:39	0.0198	Correlation Location 4
10/07/2016 12:39	0.0209	Correlation Location 4
10/07/2016 12:39	0.0211	Correlation Location 4
10/07/2016 12:40	0.0206	Correlation Location 4
10/07/2016 12:40	0.0201	Correlation Location 4
10/07/2016 13:48	0.0213	Correlation Location 5
10/07/2016 13:48	0.0215	Correlation Location 5
10/07/2016 13:48	0.0217	Correlation Location 5
10/07/2016 13:48	0.0218	Correlation Location 5
10/07/2016 13:48	0.022	Correlation Location 5
10/07/2016 13:49	0.0219	Correlation Location 5
10/07/2016 13:49	0.0216	Correlation Location 5
10/07/2016 13:49	0.0213	Correlation Location 5
10/07/2016 13:49	0.0213	Correlation Location 5
10/07/2016 13:49	0.0208	Correlation Location 5
10/07/2016 13:49	0.0208	Correlation Location 5
10/07/2016 13:49	0.0211	Correlation Location 5
10/07/2016 13:49	0.0213	Correlation Location 5
10/07/2016 13:49	0.0211	Correlation Location 5
10/07/2016 13:49	0.0215	Correlation Location 5
10/07/2016 13:50	0.0217	Correlation Location 5
10/07/2016 13:50	0.0219	Correlation Location 5
10/07/2016 13:50	0.0217	Correlation Location 5
10/07/2016 13:50	0.0216	Correlation Location 5
10/07/2016 13:50	0.0217	Correlation Location 5
10/07/2016 13:50	0.0215	Correlation Location 5
10/07/2016 13:50	0.0211	Correlation Location 5
10/07/2016 13:50	0.0208	Correlation Location 5
10/07/2016 13:50	0.0206	Correlation Location 5
10/07/2016 13:50	0.0206	Correlation Location 5
10/07/2016 13:51	0.0208	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0213	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0215	Correlation Location 5
10/07/2016 13:51	0.022	Correlation Location 5
10/07/2016 13:52	0.0223	Correlation Location 5
10/07/2016 13:52	0.0223	Correlation Location 5
10/07/2016 13:52	0.0221	Correlation Location 5
10/07/2016 13:52	0.0217	Correlation Location 5
10/07/2016 13:52	0.0216	Correlation Location 5
10/07/2016 13:52	0.0218	Correlation Location 5
10/07/2016 13:52	0.0215	Correlation Location 5
10/07/2016 13:52	0.0217	Correlation Location 5
10/07/2016 13:52	0.0218	Correlation Location 5
10/07/2016 13:52	0.0216	Correlation Location 5
10/07/2016 13:53	0.0217	Correlation Location 5
10/07/2016 13:53	0.0216	Correlation Location 5
10/07/2016 13:53	0.0216	Correlation Location 5
10/07/2016 13:53	0.0215	Correlation Location 5
10/07/2016 13:53	0.0218	Correlation Location 5
10/07/2016 13:53	0.0213	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 13:47	0.0217	Correlation Location 5
10/07/2016 13:47	0.0216	Correlation Location 5
10/07/2016 13:47	0.0216	Correlation Location 5
10/07/2016 13:47	0.0215	Correlation Location 5
10/07/2016 13:48	0.0211	Correlation Location 5
10/07/2016 13:48	0.0211	Correlation Location 5
10/07/2016 13:48	0.0208	Correlation Location 5
10/07/2016 13:48	0.0208	Correlation Location 5
10/07/2016 13:48	0.0211	Correlation Location 5
10/07/2016 13:54	0.0216	Correlation Location 5
10/07/2016 13:54	0.0222	Correlation Location 5
10/07/2016 13:55	0.0223	Correlation Location 5
10/07/2016 13:55	0.0222	Correlation Location 5
10/07/2016 13:55	0.0219	Correlation Location 5
10/07/2016 13:55	0.0217	Correlation Location 5
10/07/2016 13:55	0.0216	Correlation Location 5
10/07/2016 13:55	0.0218	Correlation Location 5
10/07/2016 13:55	0.0217	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 13:53	0.0211	Correlation Location 5
10/07/2016 13:53	0.0217	Correlation Location 5
10/07/2016 13:53	0.0221	Correlation Location 5
10/07/2016 13:53	0.0223	Correlation Location 5
10/07/2016 13:54	0.0221	Correlation Location 5
10/07/2016 13:54	0.0216	Correlation Location 5
10/07/2016 13:54	0.0213	Correlation Location 5
10/07/2016 13:54	0.0215	Correlation Location 5
10/07/2016 13:54	0.0218	Correlation Location 5
10/07/2016 13:54	0.0216	Correlation Location 5
10/07/2016 13:54	0.0213	Correlation Location 5
10/07/2016 13:54	0.0211	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location

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.

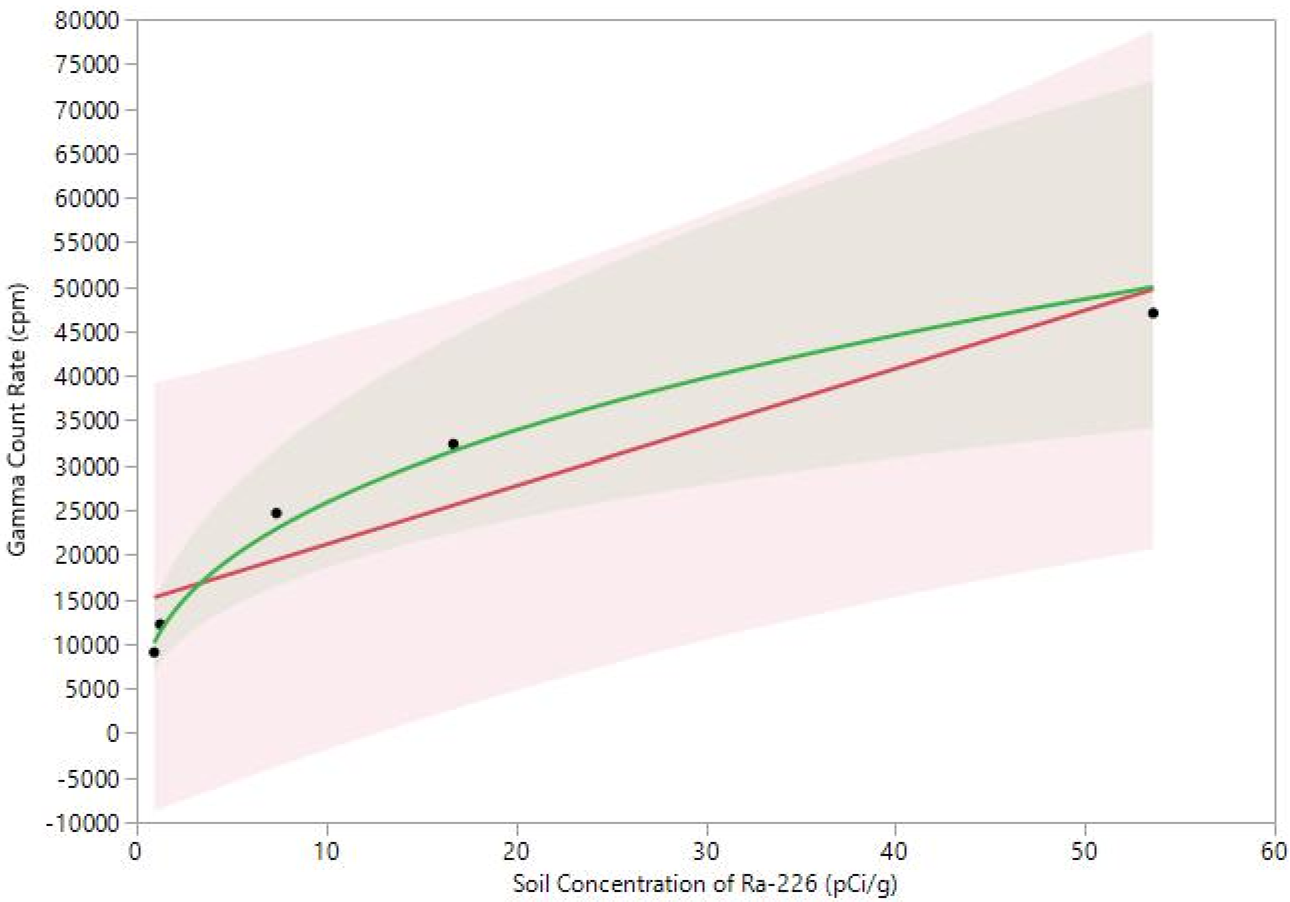

Figure 1. Regression models (linear versus power curve) for gamma count rate regressed on radium-226 showing 95% UPLs (upper prediction limits). Both models meet the study DQO for adjusted R^2 (greater than 0.8). Gamma count rate is not an especially strong predictor of soil concentration of radium-226 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.

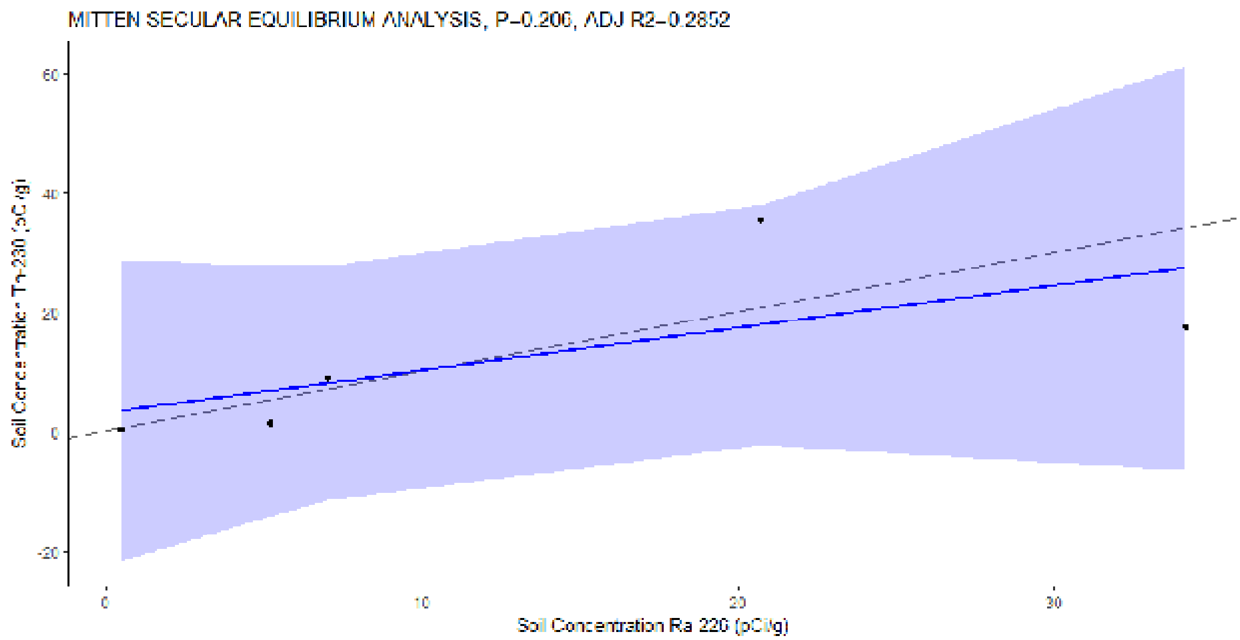

Figure 2. Result for Mitten secular equilibrium analysis, showing failure to meet p-value and adjusted R^2 criteria, i.e., the data are poorly correlated.

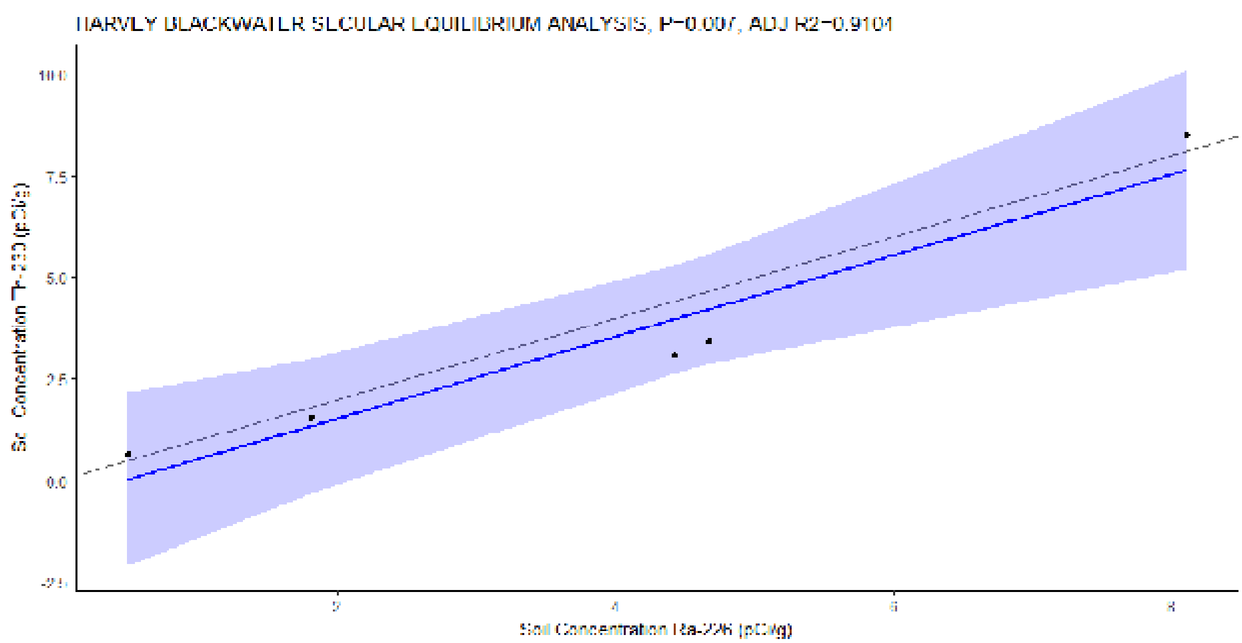

Figure 3. Result for Harvey Blackwater secular equilibrium analysis, showing excellent correlation between the data and the y=x line, i.e., Th-230 and Ra-226 are in secular equilibrium.

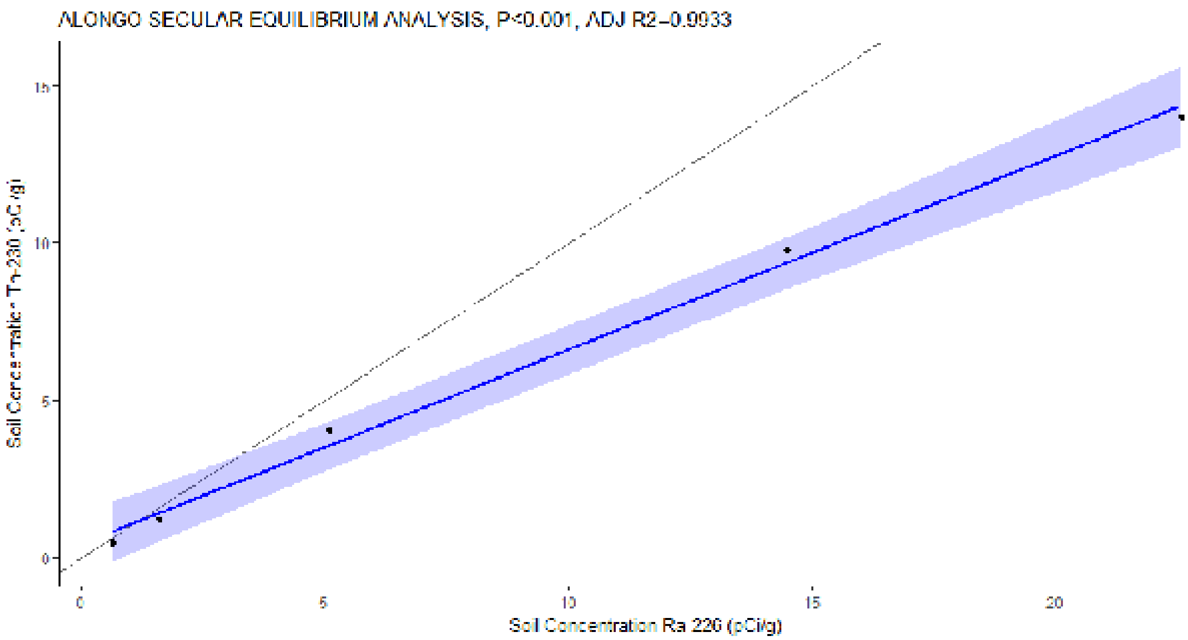

Figure 4. Result for Alongo Mines secular equilibrium analysis, showing excellent correlation between the data, but poor agreement with the y=x line, i.e., Th-230 and Ra-226 are in equilibrium, but not secular equilibrium.

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 "Oak124/Oak125 Abandoned Uranium Mine"

Disclaimer: Data and analytical methods used in this Preliminary Report are superseded by the Final Report.

Radiological Characterization of the Oak 124, Oak 125 Abandoned Uranium Mine

Preliminary

December 14, 2017

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Acronyms

ANSI	American National Standards Institute
AUM	abandoned uranium mine
BG1	Background Reference Area 1
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
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 Oak 124, Oak 125 abandoned uranium mine (AUM) located in the Red Valley Chapter of the Navajo Nation in Red Rock Valley, New Mexico. 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 the results of a 1) Global Positioning System (GPS)-based gamma radiation (gamma) survey and 2) comparisons of the gamma count rates at this AUM to exposure rates and concentrations of radium-226 in surface soils. The field activities addressed in this report were conducted on October 1 and 7, 2016 and May 9, 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 "Oak 124, 125 Removal Site Evaluation Report" (Stantec, 2017).

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.
- Gamma count rates in the mine claim are naturally elevated due to the presence of uranium mineralization. Elevated count rates observed in the northeast corner of the mine claim were associated with waste rock.
- One potential Background Reference Area was 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:

$$\text{Radium-226 Concentration (picocuries per gram [pCi/g])} = 7\times10^{-11}\,(\text{Gamma Count Rate [in counts per minute, cpm]})^{2.5609}$$

- 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 0.4 to 222.3, 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:

$$\text{Exposure Rate (in microRoentgens per hour [}\mu\text{R/h]) =} \\ \text{Gamma Count Rate (cpm)} \times 3\text{x}10^{-4} + 9.4541$$

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 11.4 to 32.3, with a central tendency (median) of 12.8 μR/h.

1.0 Introduction

This report addresses the radiological characterization of the Oak 124, Oak 125 abandoned uranium mine (AUM) located in the Red Valley Chapter of the Navajo Nation in Red Rock Valley, New Mexico. 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) on behalf of the Navajo Nation AUM Environmental Response Trust – First Phase.

The activities described here focus on the characterization of gamma radiation (gamma) emitted by uranium series radionuclides in surface soils at the AUM. This report provides the results of a 1) Global Positioning System (GPS)-based gamma radiation (gamma) survey and 2) comparisons of gamma count rates to exposure rates and concentrations of radium-226 in surface soils.

The field activities were conducted on October 1 and 7, 2016 and May 19, 2017 in accordance with the methods described in the RSE Work Plan. The GPS-based radiological survey of land surfaces covered an approximately 7-acre Survey Area that included the mine claim area out to a 100-foot (ft) buffer; roads and drainages within a 0.25-mile radius of the buffer; gamma count rate and exposure rate measurements at fixed points; and gamma count rate measurements and soil sampling for radionuclides and metals in areas centered on these fixed points.

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 continuing RSE are addressed in “Oak 124, Oak 125 Removal Site Evaluation Report” (Stantec, 2017).

Figure 1 shows the location of the AUM. Background information that is pertinent to the characterization of this AUM is presented in the “Oak 124, Oak 125 Removal Site Evaluation Report” (Stantec, 2017).

2.0 GPS-Based Gamma Surveys

This section addresses the GPS-based surveys conducted in one potential Background Reference Area 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.

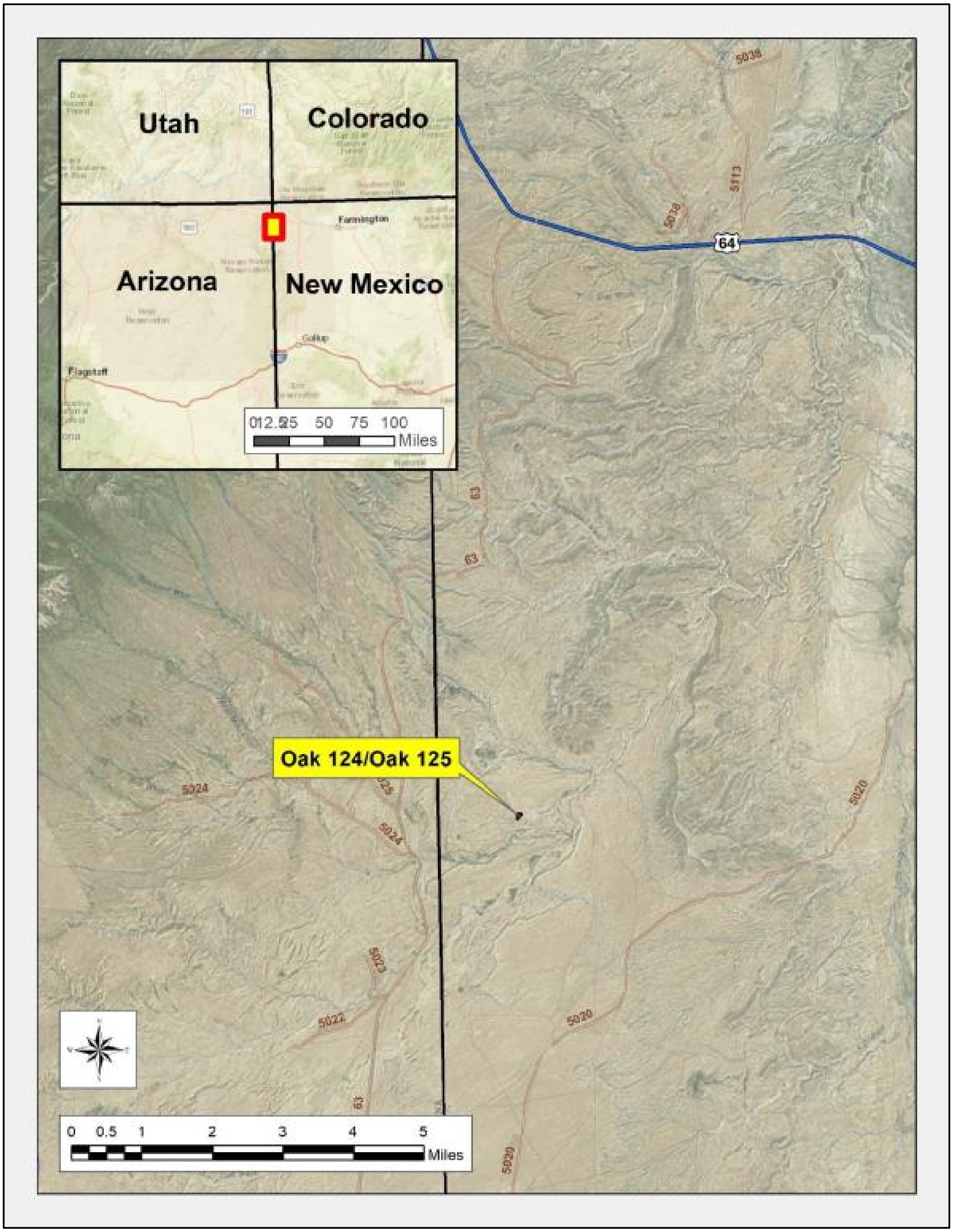


Figure 1. Location of the Oak 124, Oak 125 Abandoned Uranium Mine

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 Area	PR303727[a]	254772[a]
Survey Area	PR303727	254772
	PR295014	196086

Notes:
[a]Detection system used in the correlation studies described in Section 3.0.

2.1 Potential Background Reference Area

One potential Background Reference Area was surveyed, the location and results of which are depicted on Figure 2. BG1 in the figure is Background Reference Area 1.

Table 2 lists a summary of the gamma count rates in BG1, which range from 8,013 to 20,837 counts per minute (cpm), with a mean and median of 11,491 and 11,292 cpm, respectively.

Figure 3 is a histogram of the gamma count rates in BG1. 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. Summary statistics for gamma count rates in the potential Background Reference Area.

	Gamma Count Rate (cpm)					
Potential Background Reference Area	**n**	**Minimum**	**Maximum**	**Mean**	**Median**	**Standard Deviation**
1	417	8,013	20,837	11,491	11,292	1,753

Notes:
cpm = counts per minute

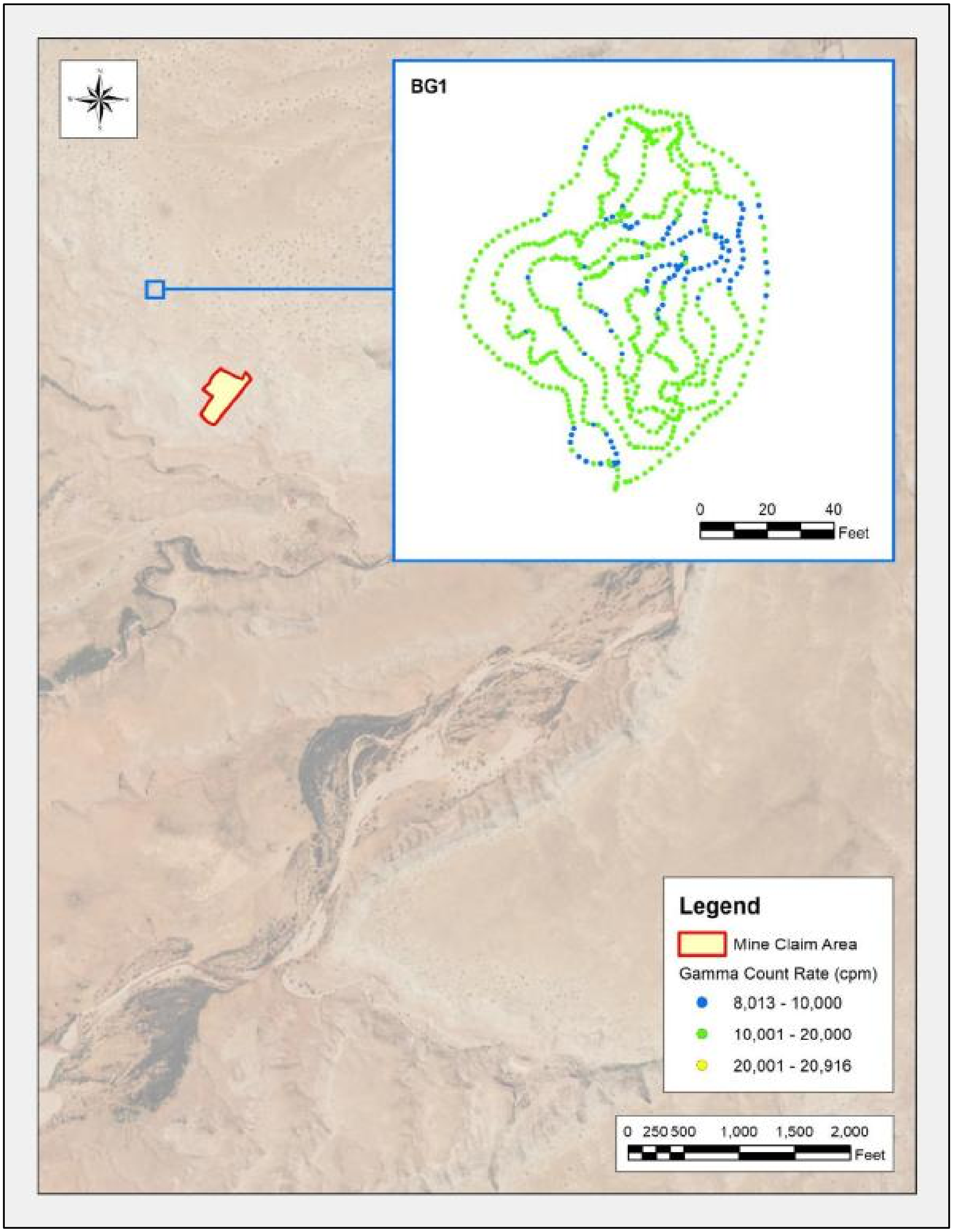


Figure 2. Gamma count rates in the potential Background Reference Area.

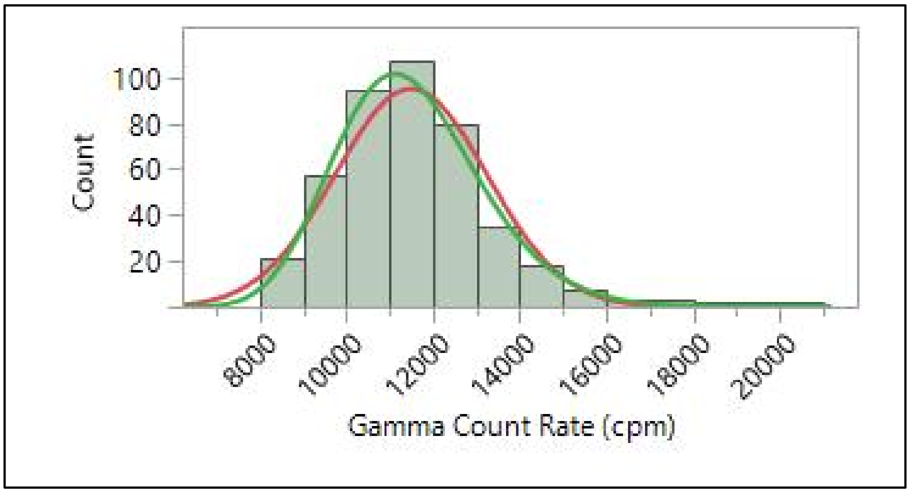


Figure 3. Histogram of gamma count rates in the potential Background Reference Area.

2.2 Survey Area

The gamma count rates observed in the Survey Area are depicted in Figure 4. The highest count rates were observed in the northeast corner of the mine claim and associated with waste rock.

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 (version 5.1.002), is not defined; 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 9,726, 11,241, and 13,024 cpm, respectively.

Table 3 is a statistical summary of the measurements, which range from 6,565 to 76,181 cpm and have a central tendency (median) of 11,241 cpm.

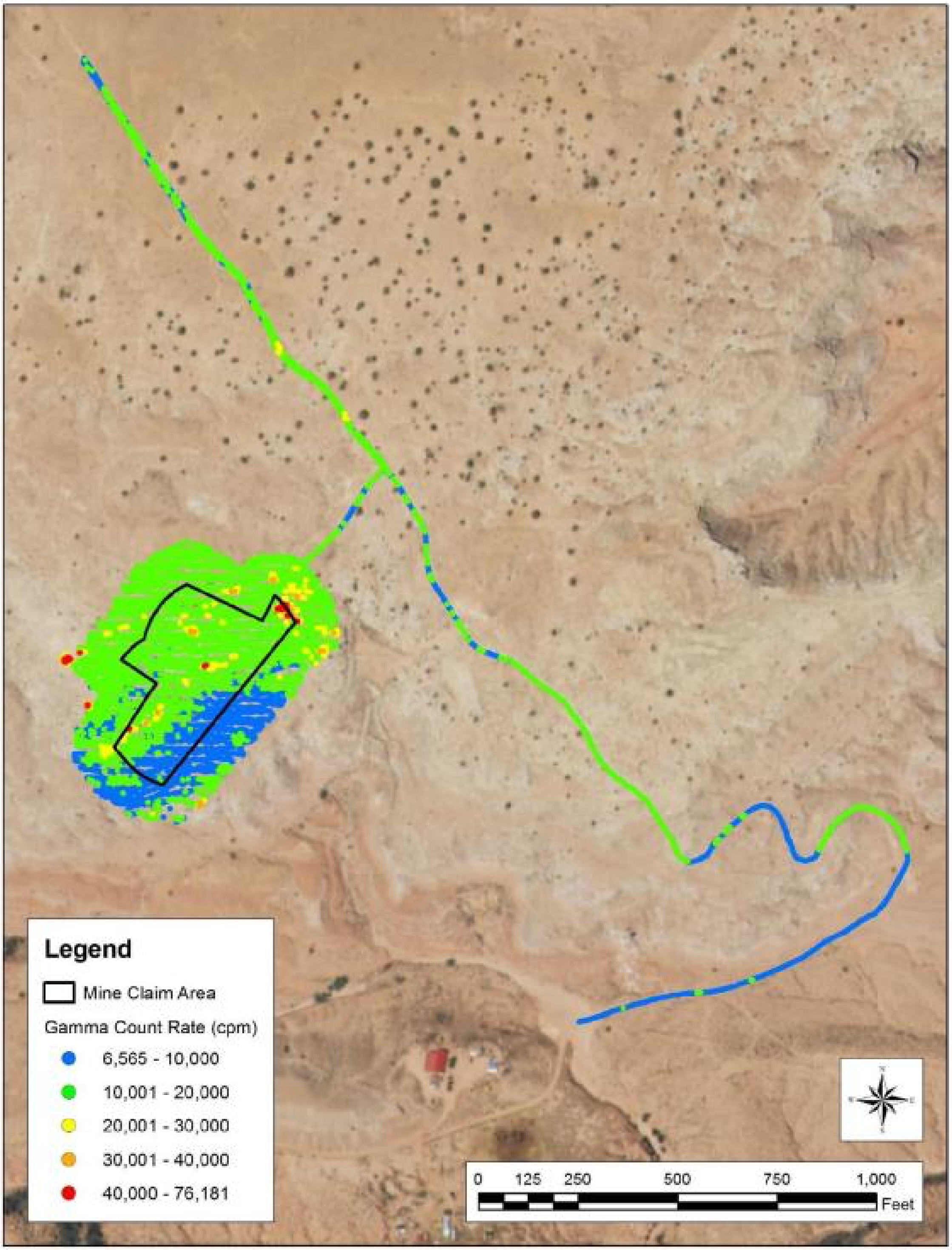


Figure 4. Gamma count rates in the Survey Area.

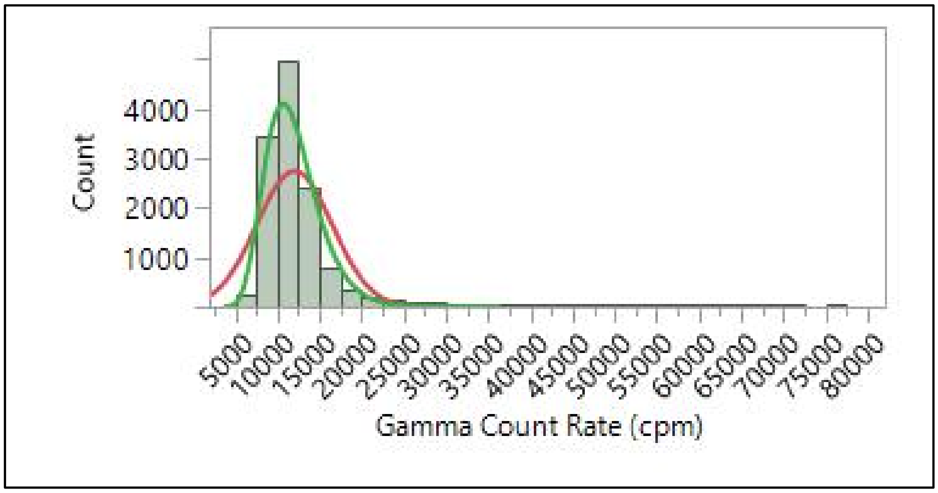


Figure 5. Histogram of gamma count rates in the Survey Area.

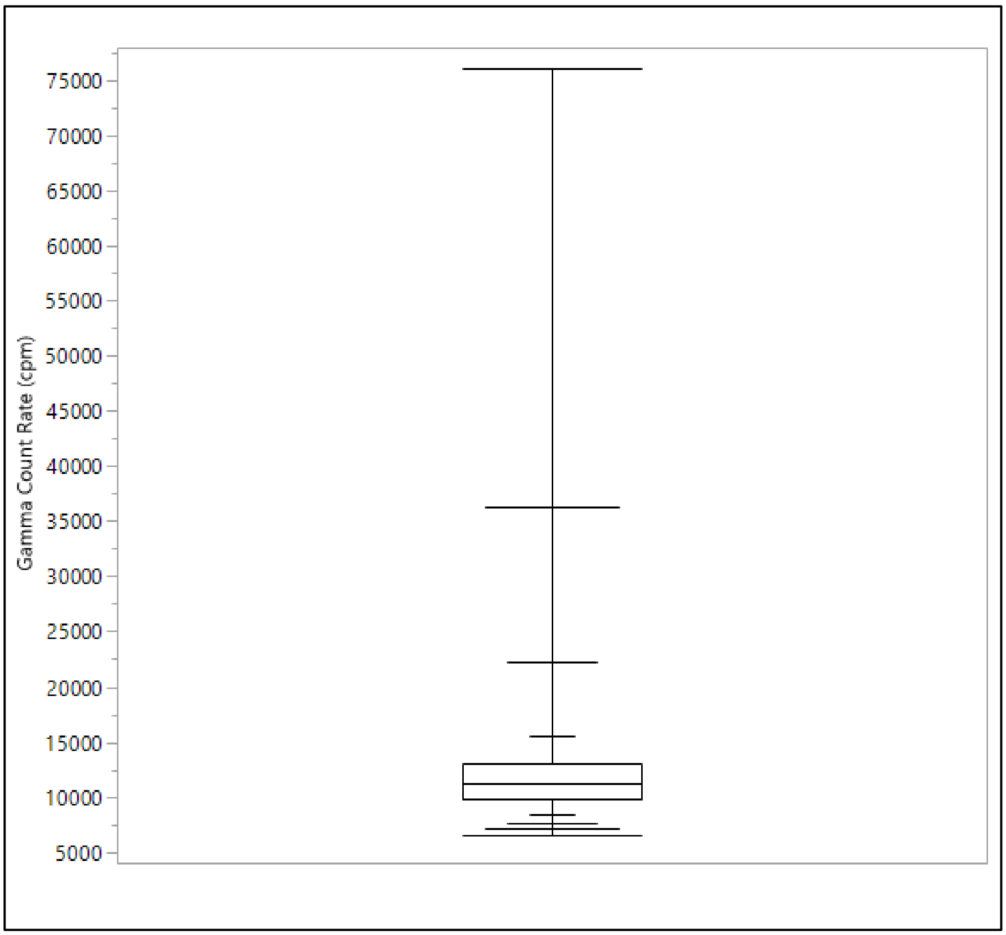


Figure 6. Box plot of gamma count rates in the Survey Area.

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

Parameter	Gamma Count Rate (cpm)
n	12,321
Minimum	6,565
Maximum	76,181
Mean	12,020
Median	11,241
Standard Deviation	4,490

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 and thorium concentrations in surface soils and gamma count rates

On October 7, 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 the two could be compared. Figure 7 shows the GPS-based gamma count rate measurements in the five areas (labeled with location identifiers).

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 measurements and radium-226 concentrations in the soil samples. The means of the gamma count rate measurements range from 9,419 to 34,694 cpm. The concentrations of radium-226 range from 1.21 to 29.4 picocuries per gram (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, Laboratory Analytical Data and Data Usability Report in “Oak 124, 125 Removal Site Evaluation Report” (Stantec, 2017).

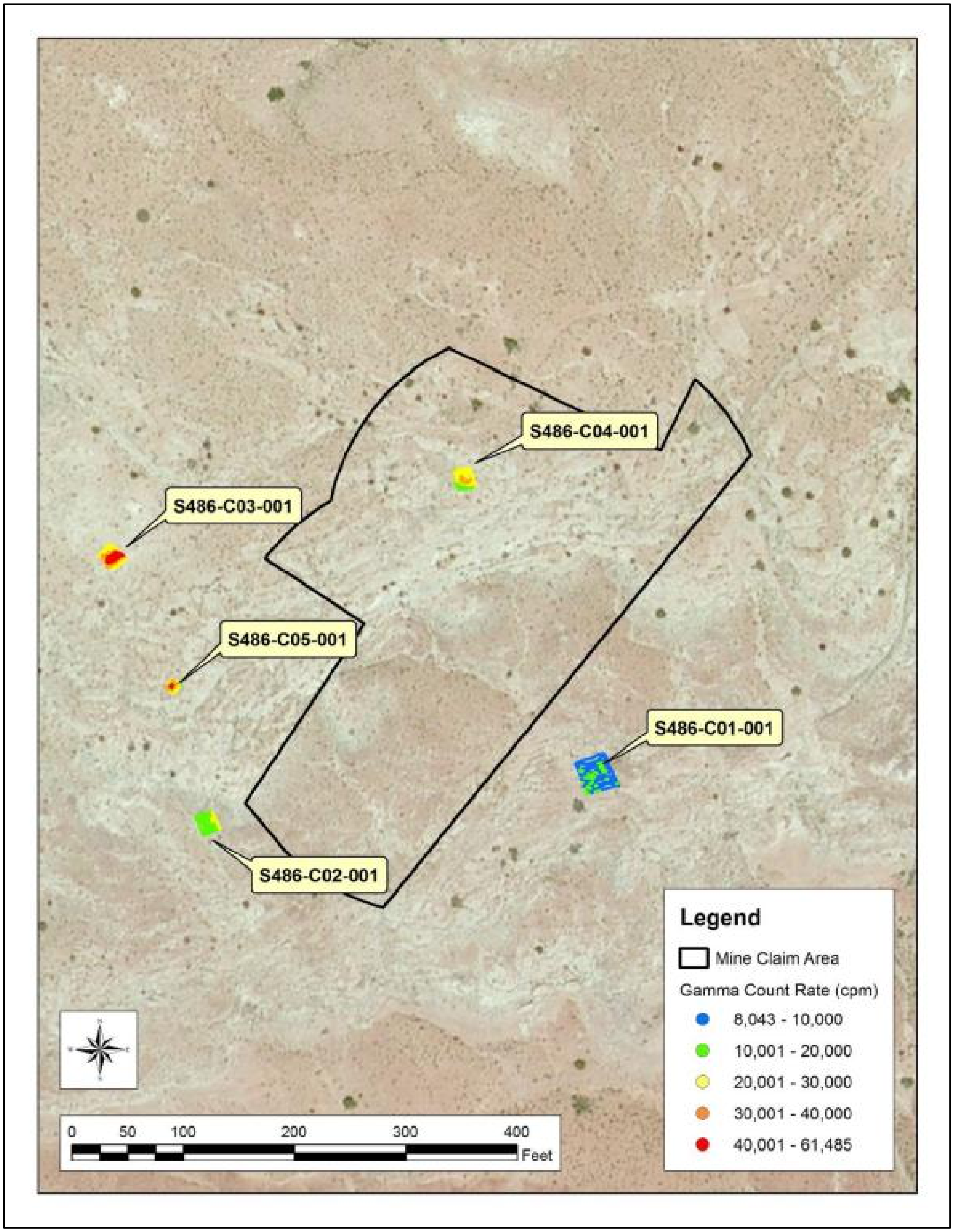


Figure 7. GPS-based gamma count rate measurements made for the correlation study.

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)				Ra-226 (pCi/g)		
Location	Mean	Minimum	Maximum	σ	Result	Error ±1σ	MDL
S486-C01-201	9,419	8,043	11,352	597	1.21	0.29	0.44
S486-C02-001	15,841	11,658	29,051	3,698	3.45	0.5	0.39
S486-C03-001	34,694	20,280	61,485	9,983	29.4	3.6	1
S486-C04-001	24,537	13,134	32,383	5,074	13.7	1.7	0.6
S486-C05-001	29,234	16,489	45,938	6,484	22.6	2.8	0.6

Notes:
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	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL	Result	Error ± 1 σ	MDL
S486-C01-201	0.35	0.08	0.04	1.03	0.19	0.07	0.36	0.08	0.01
S486-C02-001	0.51	0.1	0.04	2.94	0.47	0.07	0.58	0.11	0.02
S486-C03-001	0.326	0.077	0.038	18.8	2.9	0.1	0.298	0.069	0.02
S486-C04-001	0.461	0.097	0.038	9.5	1.5	0.1	0.5	0.1	0.02
S486-C05-001	0.59	0.12	0.04	15.4	2.4	0.1	0.53	0.11	0.02

Notes:
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation

A model was made of the results in Table 4, 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 0.9908, as expressed in the equation:

$$\text{Radium-226 concentration (pCi/g)} = 7 \times 10^{-11} \times \text{Gamma Count Rate (cpm)}^{2.5609}$$

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 correlation are 0.149208 and 0.0004, respectively; these parameters are not data quality objectives (DQOs) and are included only as information.

Thorium-232 and thorium-228, isotopes in the thorium series, are similar and at most 0.59 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.

The equation above 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 0.4 to 222.3 pCi/g, with a mean and median of 2.7 and 1.7 pCi/g, respectively. Note that the radium-226 concentrations predicted from gamma count rate measurements exceeding approximately 35,000 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.

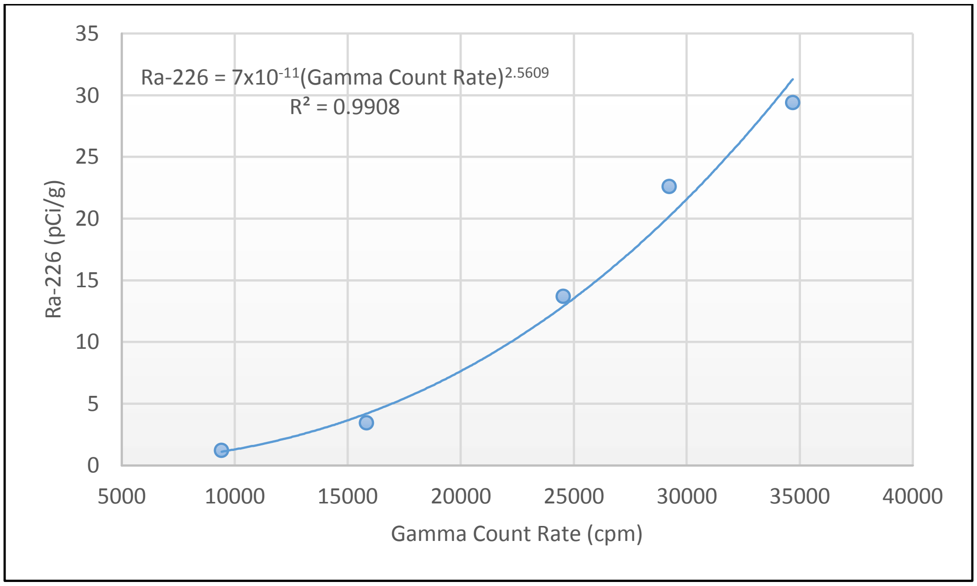


Figure 8. Correlation of gamma count rates and concentrations of radium-226 in surface soils.

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

Parameter	Radium-226 (pCi/g)
n	12,321
Minimum	0.4
Maximum	222.3
Mean	2.7
Median	1.7
Standard Deviation	7.5

Notes:
pCi/g = picocuries per gram

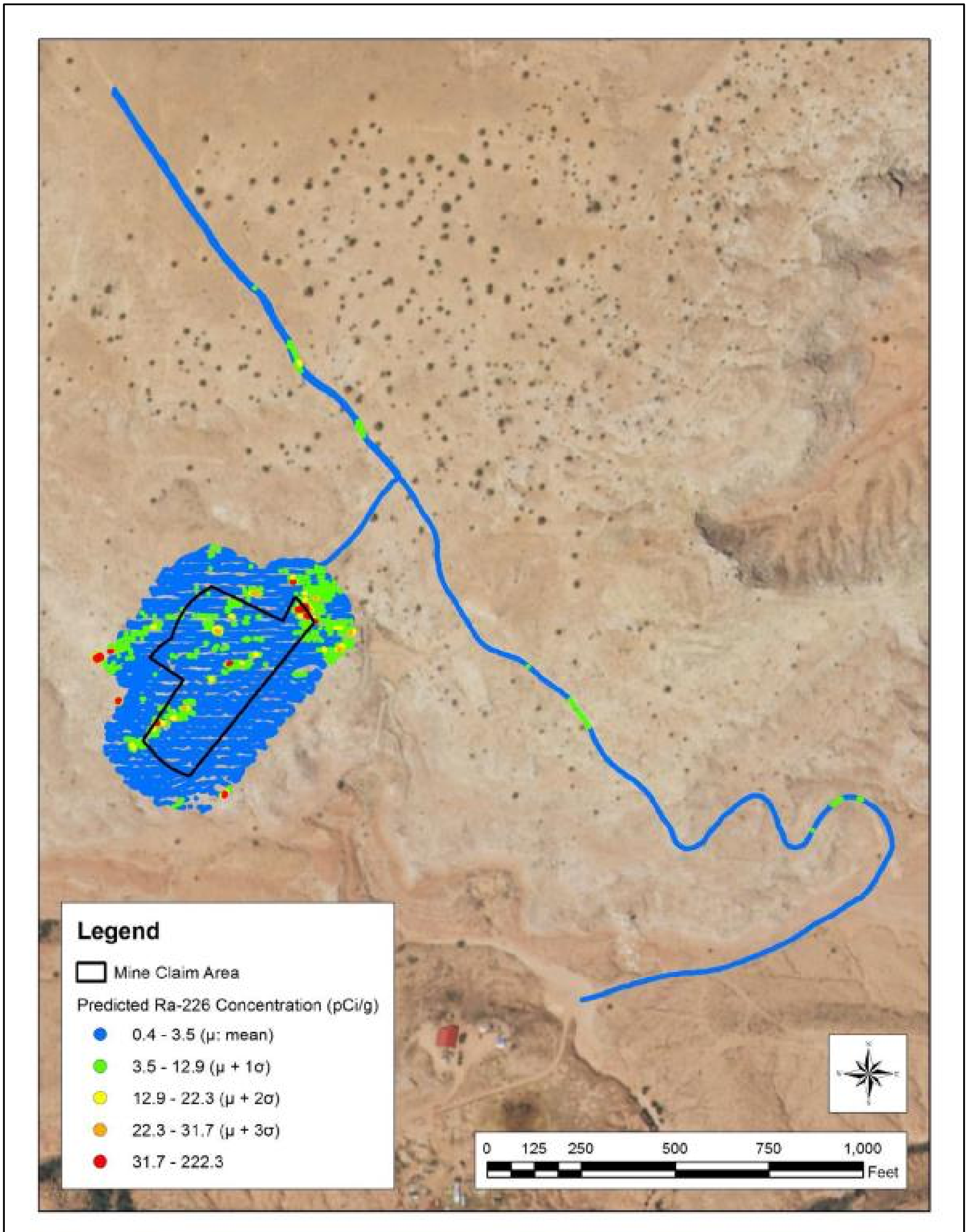


Figure 9. Predicted concentrations of radium-226 in the Survey Area.

3.2 Equilibrium in the uranium series

Secular equilibrium occurs when the activities of a parent radionuclide and its decay products 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 five correlation samples are 1.2 (Sample S486-C01-001), 1.2 (Sample S486-C02-001), 1.6 (Sample S486-C03-001), 1.4 (Sample S486-C04-001), and 1.5 (Sample S486-C05-001), 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 five 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.

3.3 Exposure rates and gamma count rates

Field personnel made co-located one-minute static count rate and exposure rate measurements at the five locations within the Survey Area, representing the range of gamma count rates obtained in the GPS-based gamma survey. Figure 5 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 on October 7, 2016 at 0.5 m and 1 m above the ground surface, respectively. The gamma count rate measurements were made using one of the two sodium iodide detection systems used in the GPS-based gamma survey of the Survey Area (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 rate used in the comparison was the mean of these 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 (one second) exposure rate measurements.

The Pearson's Correlation Coefficient (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 best predictive relationship between the measurements is linear with a R^2 of 0.9517, strongly indicating a positive correlation. The root mean square error and p-value for the correlation are 1.667332 and 0.0046, 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:

$$\text{Exposure Rate } (\mu R/h) = 3\text{x}10^{-4} \text{ x Gamma Count Rate (cpm)} + 9.4541$$

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 Area and Survey Area, respectively. The range of predicted exposure rates at BG1 is 11.9 to 15.7 µR/h, with a mean and median of 12.9 and 12.8 µR/h, respectively. The range of predicted exposure rates in the Survey Area is 11.4 to 32.3 µR/h, with a mean and median of 13.1 and 12.8 µR/h, respectively.

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

Location	Gamma Count Rate (cpm)	Exposure Rate (µR/h)
S486-C01-201	9,747	11.0
S486-C02-001	15,347	14.7
S486-C03-001	60,921	28.1
S486-C04-001	27,827	20.1
S486-C05-001	43,279	21.5

Notes:
cpm = counts per minute
µR/h = microRoentgens per hour

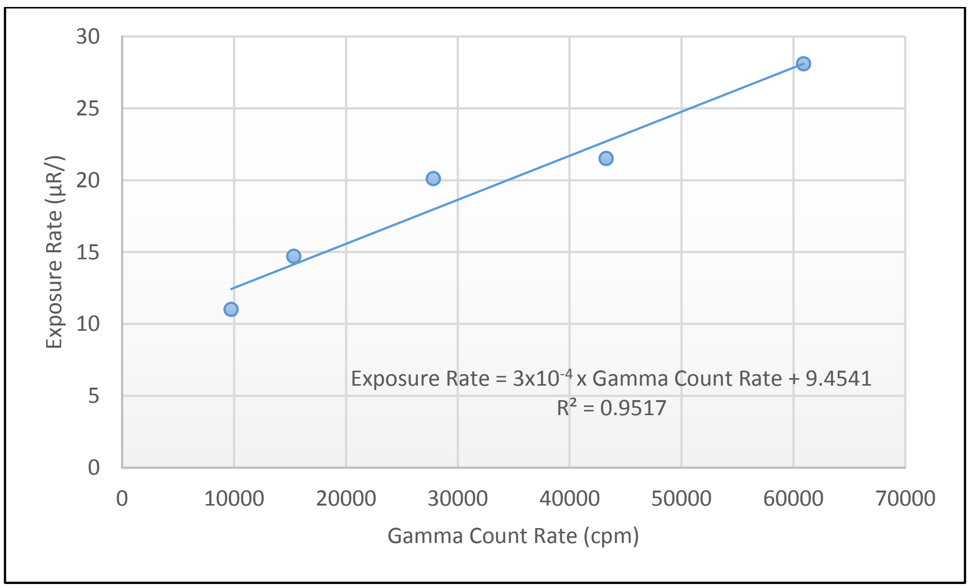


Figure 10. Correlation of gamma count rates and exposure rates.

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

Parameter	Exposure Rate (µR/h)
n	417
Minimum	11.9
Maximum	15.7
Mean	12.9
Median	12.8
Standard Deviation	0.5

Notes:
µR/h = microRoentgens per hour

Table 9. Predicted exposure rates in the Survey Area.

Parameter	Exposure Rate (µR/h)
n	12,321
Minimum	11.4
Maximum	32.3
Mean	13.1
Median	12.8
Standard Deviation	1.3

Notes:
µR/h = microRoentgens per hour

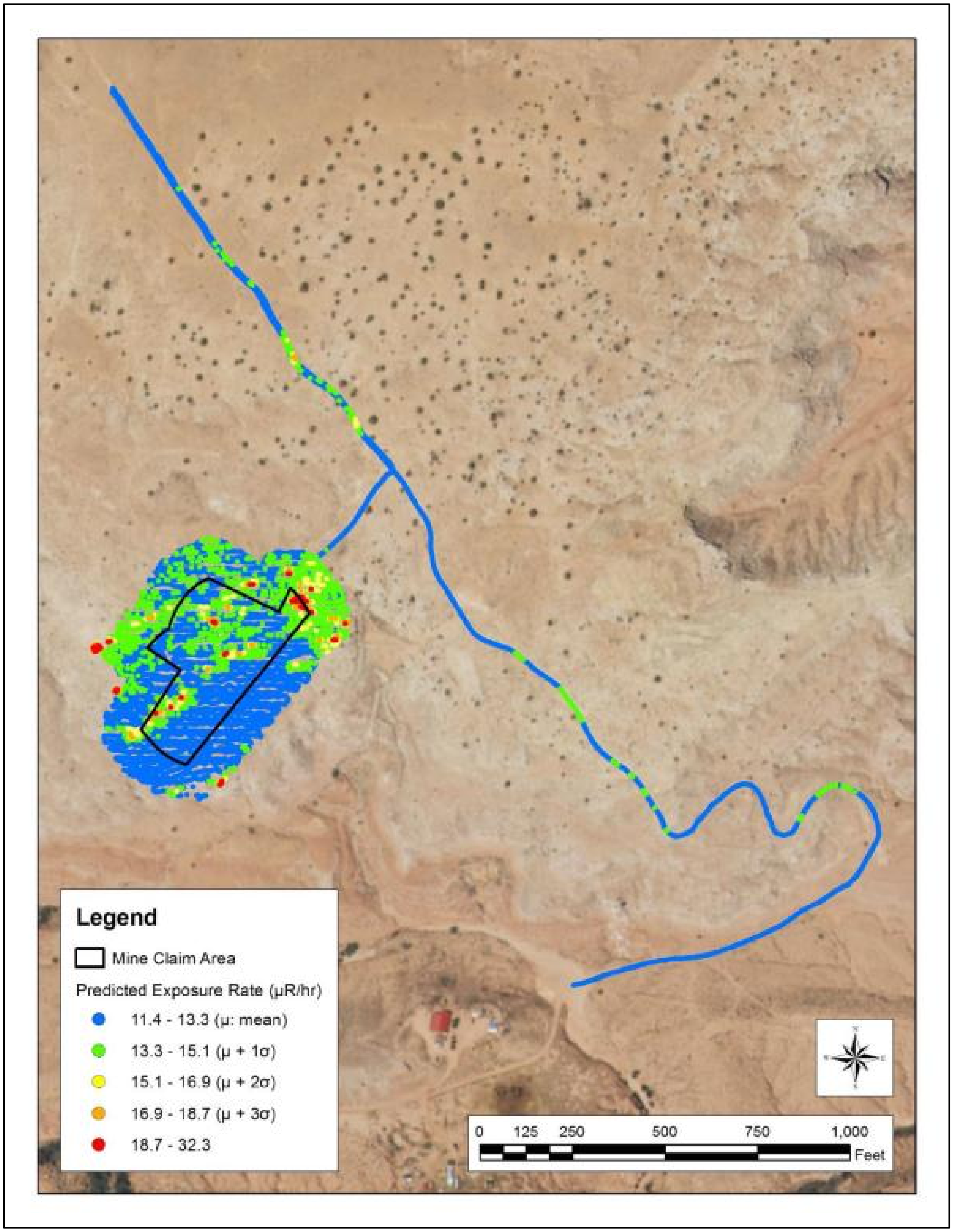


Figure 11. Predicted exposure rates in the Survey Area.

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 ft 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.

- Gamma count rates in the mine claim are naturally elevated due to the presence of uranium mineralization. Elevated count rates observed in the northeast corner of the mine claim were associated with waste rock.

- One potential Background Reference Area was 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:

$$\text{Radium-226 Concentration (pCi/g)} = 7\text{x}10^{-11}\,(\text{Gamma Count Rate [cpm]})^{2.5609}$$

- 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 0.4 to 222.3, 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:

$$\text{Exposure Rate } (\mu\text{R/h}) = \text{Gamma Count Rate (cpm) x } 3\text{x}10^{-4} + 9.4541$$

- The distribution of exposure rates predicted using this model resembles a lognormal distribution. The values in the Survey Area range from 11.4 to 32.3, with a central tendency (median) of 12.8 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, 2017. Oak 124, Oak 125 Removal Site Evaluation Report, December 2017.

Appendix A Instrument calibration and completed function check forms

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

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

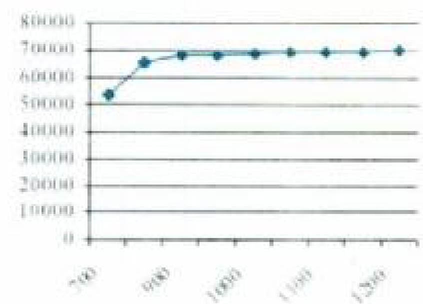
✔ Mechanical Check ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: 39-inch ✔ 72-inch Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.75 inches Hg
Source Distance: Contact ✔ 6 inches 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

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 ✔ THR/WIN Operation
✔ F/S Response Check ✔ Reset Check
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC)
Source Distance: ☐ Contact ✔ 6 inches ☐ Other:
Source Geometry: ✔ Side ☐ Below ☐ Other:

HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
Cable Length: ☐ 39-inch ✔ 72-inch ☐ Other:
Threshold: 10 mV
Window:

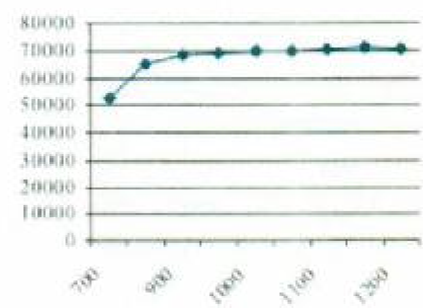
Barometric Pressure: 24.24 inches Hg
Temperature: 78 °F
Relative Humidity: 20 %

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: [signature]
Reviewed By: [signature]

Calibration Date: ~~2 March 17~~ 2/28/17 ESH
Calibration Due: ~~2 March~~ 2/28/18 ESH 18

Date: 3-1-17

ERG Form ITC. 101.A

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

ERG

Certificate of Calibration

Calibration and Voltage Plateau

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	196086
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR295014

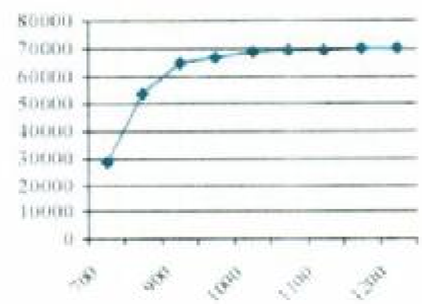
✔ Mechanical Check ✔ THR/WIN Operation HV Check (+/- 2.5%): ✔ 500 V ✔ 1000 V ✔ 1500 V
✔ F/S Response Check ✔ Reset Check Cable Length: 39-inch ✔ 72-inch Other:
✔ Geotropism ✔ Audio Check
✔ Meter Zeroed ✔ Battery Check (Min 4.4 VDC) Barometric Pressure: 24.78 inches Hg
Source Distance: Contact ✔ 6 inches 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: 7-8-16 Calibration Due: 7-8-17

Reviewed By: Date: 7/20/16

ERG Form ITC. 101.A

K&S Associates, Inc.
1926 Elm Tree Drive
Nashville, Tennessee 37210-3718
Phone 800-522-2325 Fax 615-871-0856

ACCREDITED
CALIBRATION CERT #1666.01

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 Hardison Reviewed By: Angela Roper
Richard Hardison
Title: Calibration Technician Title: Calibration Physicist

Log: M-53 Page: 73

K&S Associates, Inc
Nashville, Tennessee 37210-3718

ACCREDITED
CALIBRATION CERT

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:** REH

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:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
9-27-16	1126	6.1	1002	99	45988	6844	39144	NW	NA-0904
9-27-16	1617	5.9	997	99	44136	6788	37348	NW	NA-0904
9-28-16	1027	5.9	1001	99	44612	6242	38370	NW	Comfort Suites Parking lot
9-28-16	1754	5.9	1000	99	43583	6742	36841	NW	NA-0928
9-29-16	0936	5.9	1001	100	44695	5574	39121	NW	Comfort Suites Parking Lot
9-29-16	1600	5.8	1002	99	46024	6760	39264	NW	NA-0928
9-30-16	0920	5.8	1002	99	44958	5748	39210	NW	NA-0904
9-30-16	1436	5.7	998	99	44138	6240	37898	NW	NA-0504
10-1-16	0913	5.7	1002	100	43656	5047	38609	NW	Oak 124/125
10-1-16	1605	5.6	995	99	43105	6275	36830	NW	Alonzo
10-3-16	0950	5.7	1001	99	44914	5611	39303	NW	Barton 3
10-3-16	1220	5.6	995	99	45923	5670	40105	NW	Barton 3

Reviewed by: [signature] 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:	7-14-17

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	7-19-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-6-94 Distance to Source: 6 inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project reference points
10-4-16	0925	5.7	1003	99	45635	6378	39254	NW	Tsosie 1
10-4-16	1720	5.6	1008	99	46987	6720	40267	NW	Comfort Suites Parking lot
10-5-16	0620	5.7	1007	99	47335	6804	40531	NW	Comfort Suites Parking lot
10-5-16	1542	5.5	999	99	45375	6342	39033	NW	Tsosie 1
10-6-16	0900	5.5	1003	99	43705	6364	37341	NW	Tsosie 1
10-6-16	1713	5.5	1000	99	44279	6053	38226	NW	Comfort Suites Parking Lot
10-7-16	0902	5.5	1006	99	44457	6003	38404	NW	Oak 124/125
10-7-16	1627	5.5	999	99	46103	6751	39352	NW	Comfort Suites Parking Lot
10-8-16	0903	5.6	1003	99	45434	6365	39069	NW	Red Valley Intersection
10-8-16	1653	5.5	999	99	45185	6467	38718	NW	Comfort Suites Parking Lot
10-10-16	0958	5.5	1004	100	42755	5579	37176	NW	Oak 124/125
10-10-16	1919	5.5	999	99	51651	6930	44721	NW	Oak 124/125

Reviewed by: MP

Review Date: 11/29/16

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.:	254792
Cal. Due Date:	2-28-18

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR303727
Cal. Due Date:	2-28-18

Comments:
NNWRT

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	999	100	36519	5067	31452	NW	Mitten
5-23-17	1426	5.4	994	100	35848	4830	31018	NW	Gouldings lodge
5-24-17	0757	5.4	997	100	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: [signature] Review Date: 11/08/17

(2)

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:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR295014
Cal. Due Date:	7-9-17

Comments:
NNGRT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
9-27-16	1121	5.7	1100	100	45851	6762	39089	NW	NA-0904
9-27-16	1619	5.6	1094	99	45492	6313	39179	NW	NA-0904
9-28-16	1026	5.7	1100	100	44929	6287	38642	NW	NA-0904
9-28-16	1754	5.6	1098	100	44643	6434	38209	NW	Comfort Suites Parking Lot
9-29-16	0940	5.6	1100	99	43453	5654	37799	NW	NA-0928
9-29-16	1603	5.5	1101	100	44586	6525	38061	NW	Comfort Suites Parking Lot
9-30-16	0415	5.5	1102	100	44975	5236	39739	NW	NA-0928
9-30-16	1433	5.4	1096	100	44003	5827	38176	NW	NA-0904
10-1-16	0925	5.5	1102	100	42929	5140	37789	NW	Oak 124/125
10-1-16	1605	5.3	1092	100	44650	6271	38379	NW	Mongo
10-3-16	0946	5.5	1100	100	43679	4995	38684	NW	Barton 3
10-3-16	1225	5.4	1099	100	45921	5361	40560	NW	Barton 3

Reviewed by: MA Review Date: 11/29/16

(2)

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:	44-10
Serial No.:	196086
Cal. Due Date:	7-9-17

DETECTOR	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	PR 295014
Cal. Due Date:	7-9-17

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: 6 Inches

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts	BKG Counts	Net Counts	Initials	Note(s): Project Reference Points
10-4-16	0936	5.5	1102	100	46804	6042	40762	NW	Tsosie 1
10-4-16	1720	5.4	1106	100	46032	6898	39134	NW	Comfort Suites Parking Lot
10-5-16	0622	5.4	1109	101	45794	6834	38960	NW	Comfort Suites Parking Lot
10-5-16	1548	5.3	1097	99	46608	6021	40587	NW	Tsosie 1
10-6-16	0904	5.4	1103	100	44521	6273	38248	NW	Comfort Suites Parking Lot
10-6-16	1718	5.3	1099	100	45178	6311	38867	NW	Comfort Suites Parking Lot
10-7-16	0859	5.4	1104	100	44101	5226	38875	NW	Oak 124/125
10-7-16	1633	5.4	1098	99	44930	6832	38098	NW	Comfort Suites Parking Lot
10-8-16	0908	5.4	1104	100	45110	6201	38909	NW	Red Valley Intersection
10-8-16	1658	5.3	1098	99	45810	6196	39614	NW	Comfort Suites Parking Lot
10-12-16	1331	5.4	1099	99	46496	6519	39977	NW	Barton 3
10-12-16	1614	5.4	1097	100	44509	6060	38449	NW	Comfort Suites Parking Lot

Reviewed by: [signature] 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:	GE
Model:	RSS-131
Serial No.:	07J00KMI
Cal. Due Date:	6-29-17

DETECTOR	
Manufacturer:	SAME AS METER
Model:	
Serial No.:	
Cal. Due Date:	

Comments:
NNERT

Source: Cs-137 Activity: 5.12 uCi Source Date: 6-16-94 Distance to Source: Contact - housing

Serial No.: 333-94 Emission Rate: NA cpm/emissions

Date	Time	Battery	High Voltage	Threshhold	Source Counts (mR/h)	BKG Counts	Net Counts	Initials	Note(s): Project reference points
10-7-16	0545	~6.18	~400	~NA~	~26.7	~9.5	~17.2	NW	Comfort Suites Room - Farmington
10-7-16	2040	~6.16	~400	NA	~26.5	~8.7	~17.8	NW	Comfort Suites Room - Farmington
10-11-16	0634	~6.2	~400	NA	~25	~10.5	~14.5	NW	Comfort Suites Room - Farmington
10-11-16	1801	~6.3	~400	NA	~25.5	~10.1	~14.4	NW	Comfort Suites Room - Farmington
10-12-16	0548	~6.3	~400	NA	~26.5	~10	~16.5	NW	Comfort Suites Room - Farmington
10-12-16	1640	~6.3	~400	NA	~26.4	~10	~16.4	NW	Comfort Suites Room - Farmington
10-13-16	0608	~6.3	~400	NA	~27	~9.8	~17.2	NW	Comfort Suites Room - Farmington
10-13-16	1950	~6.3	~400	NA	~26.3	~9.5	~16.8	NW	Comfort Suites Room - Farmington
10-14-16	0630	~6.4	~400	NA	~26.4	~9.5	~16.9	NW	Comfort Suites Room - Farmington
10-14-16	1547	~6.2	~400	NA	~30	~12	~18	NW	Comfort Suites Room - Farmington
10-25-16	0539	~6.3	~400	NA	~29	~11	~18	NW	Best Western Room - Flagstaff
10-27-16	1255				DID	NOT	USE		

Reviewed by: [signature]

Review Date: 11-29-16

Appendix B Exposure Rate Measurements

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 10:19	0.0534	Correlation Location 1
10/07/2016 10:19	0.093	Correlation Location 1
10/07/2016 10:20	0.0803	Correlation Location 1
10/07/2016 10:20	0.054	Correlation Location 1
10/07/2016 10:20	0.0348	Correlation Location 1
10/07/2016 10:20	0.0232	Correlation Location 1
10/07/2016 10:20	0.017	Correlation Location 1
10/07/2016 10:20	0.0139	Correlation Location 1
10/07/2016 10:20	0.0127	Correlation Location 1
10/07/2016 10:20	0.0122	Correlation Location 1
10/07/2016 10:20	0.0115	Correlation Location 1
10/07/2016 10:20	0.0108	Correlation Location 1
10/07/2016 10:21	0.0105	Correlation Location 1
10/07/2016 10:21	0.0105	Correlation Location 1
10/07/2016 10:21	0.0105	Correlation Location 1
10/07/2016 10:21	0.0108	Correlation Location 1
10/07/2016 10:21	0.0108	Correlation Location 1
10/07/2016 10:21	0.0106	Correlation Location 1
10/07/2016 10:21	0.011	Correlation Location 1
10/07/2016 10:21	0.0115	Correlation Location 1
10/07/2016 10:21	0.0117	Correlation Location 1
10/07/2016 10:21	0.0114	Correlation Location 1
10/07/2016 10:22	0.0106	Correlation Location 1
10/07/2016 10:22	0.01	Correlation Location 1
10/07/2016 10:22	0.01	Correlation Location 1
10/07/2016 10:22	0.0105	Correlation Location 1
10/07/2016 10:22	0.0108	Correlation Location 1
10/07/2016 10:22	0.0105	Correlation Location 1
10/07/2016 10:22	0.0105	Correlation Location 1
10/07/2016 10:22	0.0106	Correlation Location 1
10/07/2016 10:22	0.0109	Correlation Location 1
10/07/2016 10:22	0.0108	Correlation Location 1
10/07/2016 10:23	0.0108	Correlation Location 1
10/07/2016 10:23	0.0109	Correlation Location 1
10/07/2016 10:23	0.0105	Correlation Location 1
10/07/2016 10:23	0.0108	Correlation Location 1
10/07/2016 10:23	0.0111	Correlation Location 1
10/07/2016 10:23	0.0116	Correlation Location 1
10/07/2016 10:23	0.0117	Correlation Location 1
10/07/2016 10:23	0.0114	Correlation Location 1
10/07/2016 10:23	0.0106	Correlation Location 1
10/07/2016 10:23	0.0109	Correlation Location 1
10/07/2016 10:24	0.011	Correlation Location 1
10/07/2016 10:24	0.0111	Correlation Location 1
10/07/2016 10:24	0.0111	Correlation Location 1
10/07/2016 10:24	0.0114	Correlation Location 1
10/07/2016 10:24	0.0111	Correlation Location 1
10/07/2016 10:24	0.0109	Correlation Location 1
10/07/2016 10:24	0.0105	Correlation Location 1
10/07/2016 10:24	0.0105	Correlation Location 1
10/07/2016 10:24	0.0108	Correlation Location 1
10/07/2016 10:24	0.0112	Correlation Location 1
10/07/2016 10:25	0.0117	Correlation Location 1
10/07/2016 10:25	0.0115	Correlation Location 1
10/07/2016 10:25	0.0111	Correlation Location 1
10/07/2016 10:25	0.0111	Correlation Location 1
10/07/2016 10:25	0.0112	Correlation Location 1
10/07/2016 10:25	0.0109	Correlation Location 1
10/07/2016 10:25	0.0106	Correlation Location 1
10/07/2016 10:25	0.0108	Correlation Location 1
10/07/2016 10:25	0.0108	Correlation Location 1
10/07/2016 10:25	0.0106	Correlation Location 1
10/07/2016 10:26	0.0109	Correlation Location 1
10/07/2016 10:26	0.0111	Correlation Location 1
10/07/2016 10:26	0.0108	Correlation Location 1
10/07/2016 10:26	0.0106	Correlation Location 1
10/07/2016 10:26	0.0108	Correlation Location 1
10/07/2016 10:26	0.0111	Correlation Location 1
10/07/2016 10:26	0.0112	Correlation Location 1
10/07/2016 10:26	0.011	Correlation Location 1
10/07/2016 10:26	0.0112	Correlation Location 1
10/07/2016 10:26	0.0111	Correlation Location 1
10/07/2016 10:27	0.0108	Correlation Location 1
10/07/2016 10:27	0.0111	Correlation Location 1
10/07/2016 10:27	0.0114	Correlation Location 1
10/07/2016 10:27	0.0114	Correlation Location 1
10/07/2016 10:27	0.0111	Correlation Location 1
10/07/2016 10:27	0.0112	Correlation Location 1
10/07/2016 10:27	0.011	Correlation Location 1
10/07/2016 10:27	0.0106	Correlation Location 1
10/07/2016 10:27	0.0105	Correlation Location 1
10/07/2016 10:27	0.0105	Correlation Location 1
10/07/2016 10:28	0.0105	Correlation Location 1
10/07/2016 10:28	0.0106	Correlation Location 1
10/07/2016 10:28	0.0108	Correlation Location 1
10/07/2016 10:28	0.0112	Correlation Location 1
10/07/2016 10:28	0.0118	Correlation Location 1
10/07/2016 10:28	0.0115	Correlation Location 1
10/07/2016 10:28	0.0111	Correlation Location 1
10/07/2016 10:28	0.0109	Correlation Location 1
10/07/2016 10:28	0.0106	Correlation Location 1
10/07/2016 10:28	0.0106	Correlation Location 1
10/07/2016 10:29	0.0109	Correlation Location 1
10/07/2016 10:29	0.0116	Correlation Location 1
10/07/2016 10:29	0.0118	Correlation Location 1
10/07/2016 10:29	0.0116	Correlation Location 1
10/07/2016 10:29	0.0115	Correlation Location 1
10/07/2016 10:29	0.0115	Correlation Location 1
10/07/2016 10:29	0.0114	Correlation Location 1
10/07/2016 10:29	0.0111	Correlation Location 1
10/07/2016 10:29	0.0115	Correlation Location 1
10/07/2016 10:29	0.0117	Correlation Location 1
10/07/2016 10:30	0.0115	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:30	0.011	Correlation Location 1
10/07/2016 10:30	0.0114	Correlation Location 1
10/07/2016 10:30	0.0114	Correlation Location 1
10/07/2016 10:30	0.0111	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:30	0.0114	Correlation Location 1
10/07/2016 10:30	0.0112	Correlation Location 1
10/07/2016 10:31	0.0112	Correlation Location 1
10/07/2016 10:31	0.0112	Correlation Location 1
10/07/2016 11:05	0.0544	Correlation Location 2
10/07/2016 11:05	0.095	Correlation Location 2
10/07/2016 11:05	0.0836	Correlation Location 2
10/07/2016 11:05	0.058	Correlation Location 2
10/07/2016 11:05	0.0385	Correlation Location 2
10/07/2016 11:06	0.0267	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:06	0.02	Correlation Location 2
10/07/2016 11:06	0.0169	Correlation Location 2
10/07/2016 11:06	0.0155	Correlation Location 2
10/07/2016 11:06	0.015	Correlation Location 2
10/07/2016 11:06	0.0149	Correlation Location 2
10/07/2016 11:06	0.0149	Correlation Location 2
10/07/2016 11:06	0.0148	Correlation Location 2
10/07/2016 11:06	0.0147	Correlation Location 2
10/07/2016 11:06	0.0146	Correlation Location 2
10/07/2016 11:07	0.0145	Correlation Location 2
10/07/2016 11:07	0.0142	Correlation Location 2
10/07/2016 11:07	0.0141	Correlation Location 2
10/07/2016 11:07	0.0144	Correlation Location 2
10/07/2016 11:07	0.0147	Correlation Location 2
10/07/2016 11:07	0.0148	Correlation Location 2
10/07/2016 11:07	0.0143	Correlation Location 2
10/07/2016 11:07	0.014	Correlation Location 2
10/07/2016 11:07	0.0141	Correlation Location 2
10/07/2016 11:07	0.0144	Correlation Location 2
10/07/2016 11:08	0.0145	Correlation Location 2
10/07/2016 11:08	0.0145	Correlation Location 2
10/07/2016 11:08	0.0146	Correlation Location 2
10/07/2016 11:08	0.0143	Correlation Location 2
10/07/2016 11:08	0.0141	Correlation Location 2
10/07/2016 11:08	0.0143	Correlation Location 2
10/07/2016 11:08	0.0145	Correlation Location 2
10/07/2016 11:08	0.0143	Correlation Location 2
10/07/2016 11:08	0.0141	Correlation Location 2
10/07/2016 11:08	0.0141	Correlation Location 2
10/07/2016 11:09	0.0141	Correlation Location 2
10/07/2016 11:09	0.0144	Correlation Location 2
10/07/2016 11:09	0.0145	Correlation Location 2
10/07/2016 11:09	0.0146	Correlation Location 2
10/07/2016 11:09	0.0145	Correlation Location 2
10/07/2016 11:09	0.0145	Correlation Location 2
10/07/2016 11:09	0.0147	Correlation Location 2
10/07/2016 11:09	0.0147	Correlation Location 2
10/07/2016 11:09	0.0149	Correlation Location 2
10/07/2016 11:09	0.0148	Correlation Location 2
10/07/2016 11:10	0.0145	Correlation Location 2
10/07/2016 11:10	0.0142	Correlation Location 2
10/07/2016 11:10	0.0141	Correlation Location 2
10/07/2016 11:10	0.0142	Correlation Location 2
10/07/2016 11:10	0.0146	Correlation Location 2
10/07/2016 11:10	0.0151	Correlation Location 2
10/07/2016 11:10	0.0152	Correlation Location 2
10/07/2016 11:10	0.0148	Correlation Location 2
10/07/2016 11:10	0.0147	Correlation Location 2
10/07/2016 11:10	0.0147	Correlation Location 2
10/07/2016 11:11	0.0146	Correlation Location 2
10/07/2016 11:11	0.0147	Correlation Location 2
10/07/2016 11:11	0.0148	Correlation Location 2
10/07/2016 11:11	0.015	Correlation Location 2
10/07/2016 11:11	0.0153	Correlation Location 2
10/07/2016 11:11	0.0151	Correlation Location 2
10/07/2016 11:11	0.0148	Correlation Location 2
10/07/2016 11:11	0.0148	Correlation Location 2
10/07/2016 11:11	0.0152	Correlation Location 2
10/07/2016 11:11	0.0151	Correlation Location 2
10/07/2016 11:12	0.0147	Correlation Location 2

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:12	0.0153	Correlation Location 2
10/07/2016 11:12	0.0148	Correlation Location 2
10/07/2016 11:12	0.0148	Correlation Location 2
10/07/2016 11:12	0.0147	Correlation Location 2
10/07/2016 11:12	0.0146	Correlation Location 2
10/07/2016 11:12	0.0146	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:13	0.0149	Correlation Location 2
10/07/2016 11:13	0.0147	Correlation Location 2
10/07/2016 11:13	0.0143	Correlation Location 2
10/07/2016 11:13	0.014	Correlation Location 2
10/07/2016 11:13	0.0139	Correlation Location 2
10/07/2016 11:13	0.0145	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:13	0.0148	Correlation Location 2
10/07/2016 11:14	0.0146	Correlation Location 2
10/07/2016 11:14	0.0145	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.0146	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.0148	Correlation Location 2
10/07/2016 11:14	0.015	Correlation Location 2
10/07/2016 11:14	0.0151	Correlation Location 2
10/07/2016 11:14	0.0149	Correlation Location 2
10/07/2016 11:15	0.0153	Correlation Location 2
10/07/2016 11:15	0.0158	Correlation Location 2
10/07/2016 11:15	0.0156	Correlation Location 2
10/07/2016 11:15	0.0154	Correlation Location 2
10/07/2016 11:15	0.0152	Correlation Location 2
10/07/2016 11:15	0.0152	Correlation Location 2
10/07/2016 11:15	0.0152	Correlation Location 2
10/07/2016 11:15	0.015	Correlation Location 2
10/07/2016 11:15	0.0146	Correlation Location 2
10/07/2016 11:15	0.0145	Correlation Location 2
10/07/2016 11:16	0.0144	Correlation Location 2
10/07/2016 11:16	0.0144	Correlation Location 2
10/07/2016 11:16	0.0147	Correlation Location 2
10/07/2016 11:16	0.0148	Correlation Location 2
10/07/2016 11:16	0.0144	Correlation Location 2
10/07/2016 11:16	0.0146	Correlation Location 2
10/07/2016 11:16	0.0148	Correlation Location 2
10/07/2016 11:50	0.0566	Correlation Location 3
10/07/2016 11:51	0.1012	Correlation Location 3
10/07/2016 11:51	0.0938	Correlation Location 3
10/07/2016 11:51	0.0701	Correlation Location 3
10/07/2016 11:51	0.0514	Correlation Location 3
10/07/2016 11:51	0.0403	Correlation Location 3
10/07/2016 11:51	0.0344	Correlation Location 3
10/07/2016 11:51	0.0311	Correlation Location 3
10/07/2016 11:51	0.0295	Correlation Location 3
10/07/2016 11:51	0.0287	Correlation Location 3
10/07/2016 11:51	0.0288	Correlation Location 3
10/07/2016 11:52	0.0282	Correlation Location 3
10/07/2016 11:52	0.028	Correlation Location 3
10/07/2016 11:52	0.028	Correlation Location 3
10/07/2016 11:52	0.0283	Correlation Location 3
10/07/2016 11:52	0.0285	Correlation Location 3
10/07/2016 11:52	0.0287	Correlation Location 3

Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 11:12	0.0149	Correlation Location 2
10/07/2016 11:12	0.0153	Correlation Location 2
10/07/2016 11:12	0.0155	Correlation Location 2
10/07/2016 11:52	0.0284	Correlation Location 3
10/07/2016 11:53	0.0282	Correlation Location 3
10/07/2016 11:53	0.0276	Correlation Location 3
10/07/2016 11:53	0.0275	Correlation Location 3
10/07/2016 11:53	0.0276	Correlation Location 3
10/07/2016 11:53	0.0272	Correlation Location 3
10/07/2016 11:53	0.028	Correlation Location 3
10/07/2016 11:53	0.0288	Correlation Location 3
10/07/2016 11:53	0.0286	Correlation Location 3
10/07/2016 11:53	0.0282	Correlation Location 3
10/07/2016 11:53	0.028	Correlation Location 3
10/07/2016 11:54	0.0276	Correlation Location 3
10/07/2016 11:54	0.0279	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.0282	Correlation Location 3
10/07/2016 11:54	0.0282	Correlation Location 3
10/07/2016 11:54	0.028	Correlation Location 3
10/07/2016 11:54	0.0282	Correlation Location 3
10/07/2016 11:54	0.0286	Correlation Location 3
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10/07/2016 11:55	0.0283	Correlation Location 3
10/07/2016 11:55	0.028	Correlation Location 3
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10/07/2016 11:57	0.0289	Correlation Location 3
10/07/2016 11:57	0.0284	Correlation Location 3
10/07/2016 11:57	0.028	Correlation Location 3
10/07/2016 11:57	0.0278	Correlation Location 3
10/07/2016 11:57	0.028	Correlation Location 3
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10/07/2016 11:58	0.0285	Correlation Location 3
10/07/2016 11:58	0.0284	Correlation Location 3
10/07/2016 11:58	0.0284	Correlation Location 3
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Date and Time	Exposure Rate (mR/h)	Location
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10/07/2016 11:59	0.0277	Correlation Location 3
10/07/2016 11:59	0.028	Correlation Location 3
10/07/2016 11:59	0.0283	Correlation Location 3
10/07/2016 11:59	0.0282	Correlation Location 3
10/07/2016 11:59	0.028	Correlation Location 3
10/07/2016 11:59	0.0279	Correlation Location 3
10/07/2016 11:59	0.0278	Correlation Location 3
10/07/2016 12:00	0.0278	Correlation Location 3
10/07/2016 12:00	0.0282	Correlation Location 3
10/07/2016 12:00	0.0289	Correlation Location 3
10/07/2016 12:00	0.0287	Correlation Location 3
10/07/2016 12:00	0.028	Correlation Location 3
10/07/2016 12:00	0.0276	Correlation Location 3
10/07/2016 12:00	0.0275	Correlation Location 3
10/07/2016 12:00	0.0278	Correlation Location 3
10/07/2016 12:00	0.0279	Correlation Location 3
10/07/2016 12:00	0.0277	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.028	Correlation Location 3
10/07/2016 12:01	0.0287	Correlation Location 3
10/07/2016 12:01	0.029	Correlation Location 3
10/07/2016 12:01	0.0288	Correlation Location 3
10/07/2016 12:01	0.0283	Correlation Location 3
10/07/2016 12:01	0.0282	Correlation Location 3
10/07/2016 12:01	0.0285	Correlation Location 3
10/07/2016 12:02	0.028	Correlation Location 3
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10/07/2016 12:31	0.021	Correlation Location 4
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10/07/2016 12:33	0.0204	Correlation Location 4
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Date and Time	Exposure Rate (mR/h)	Location	Date and Time	Exposure Rate (mR/h)	Location
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10/07/2016 11:58	0.0274	Correlation Location 3	10/07/2016 12:33	0.02	Correlation Location 4
10/07/2016 11:58	0.028	Correlation Location 3	10/07/2016 12:33	0.0202	Correlation Location 4
10/07/2016 11:58	0.0286	Correlation Location 3	10/07/2016 12:33	0.021	Correlation Location 4
10/07/2016 11:59	0.0289	Correlation Location 3	10/07/2016 12:33	0.0211	Correlation Location 4
10/07/2016 11:59	0.0287	Correlation Location 3	10/07/2016 12:33	0.021	Correlation Location 4
10/07/2016 12:33	0.021	Correlation Location 4	10/07/2016 12:40	0.0199	Correlation Location 4
10/07/2016 12:34	0.0209	Correlation Location 4	10/07/2016 12:40	0.02	Correlation Location 4
10/07/2016 12:34	0.0206	Correlation Location 4	10/07/2016 12:40	0.0202	Correlation Location 4
10/07/2016 12:34	0.0202	Correlation Location 4	10/07/2016 12:40	0.0204	Correlation Location 4
10/07/2016 12:34	0.0201	Correlation Location 4	10/07/2016 12:40	0.0202	Correlation Location 4
10/07/2016 12:34	0.0201	Correlation Location 4	10/07/2016 12:40	0.0205	Correlation Location 4
10/07/2016 12:34	0.0199	Correlation Location 4	10/07/2016 12:40	0.021	Correlation Location 4
10/07/2016 12:34	0.0196	Correlation Location 4	10/07/2016 12:40	0.021	Correlation Location 4
10/07/2016 12:34	0.0194	Correlation Location 4	10/07/2016 12:41	0.0209	Correlation Location 4
10/07/2016 12:34	0.0196	Correlation Location 4	10/07/2016 12:41	0.0211	Correlation Location 4
10/07/2016 12:34	0.0197	Correlation Location 4	10/07/2016 12:41	0.0208	Correlation Location 4
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10/07/2016 12:35	0.0197	Correlation Location 4	10/07/2016 12:41	0.0197	Correlation Location 4
10/07/2016 12:35	0.0199	Correlation Location 4	10/07/2016 12:41	0.0196	Correlation Location 4
10/07/2016 12:35	0.0194	Correlation Location 4	10/07/2016 12:41	0.0199	Correlation Location 4
10/07/2016 12:35	0.0196	Correlation Location 4	10/07/2016 12:41	0.0201	Correlation Location 4
10/07/2016 12:35	0.02	Correlation Location 4	10/07/2016 12:41	0.0202	Correlation Location 4
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10/07/2016 12:36	0.0197	Correlation Location 4	10/07/2016 13:44	0.0449	Correlation Location 5
10/07/2016 12:36	0.0199	Correlation Location 4	10/07/2016 13:44	0.0335	Correlation Location 5
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10/07/2016 12:36	0.0204	Correlation Location 4	10/07/2016 13:45	0.023	Correlation Location 5
10/07/2016 12:37	0.0211	Correlation Location 4	10/07/2016 13:45	0.0223	Correlation Location 5
10/07/2016 12:37	0.0209	Correlation Location 4	10/07/2016 13:45	0.0218	Correlation Location 5
10/07/2016 12:37	0.0207	Correlation Location 4	10/07/2016 13:45	0.0216	Correlation Location 5
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10/07/2016 12:38	0.0201	Correlation Location 4	10/07/2016 13:46	0.0221	Correlation Location 5
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10/07/2016 12:38	0.02	Correlation Location 4	10/07/2016 13:47	0.0208	Correlation Location 5
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10/07/2016 12:39	0.02	Correlation Location 4	10/07/2016 13:47	0.0216	Correlation Location 5
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Date and Time	Exposure Rate (mR/h)	Location
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10/07/2016 12:39	0.0197	Correlation Location 4
10/07/2016 12:39	0.0198	Correlation Location 4
10/07/2016 12:39	0.0209	Correlation Location 4
10/07/2016 12:39	0.0211	Correlation Location 4
10/07/2016 12:40	0.0206	Correlation Location 4
10/07/2016 12:40	0.0201	Correlation Location 4
10/07/2016 13:48	0.0213	Correlation Location 5
10/07/2016 13:48	0.0215	Correlation Location 5
10/07/2016 13:48	0.0217	Correlation Location 5
10/07/2016 13:48	0.0218	Correlation Location 5
10/07/2016 13:48	0.022	Correlation Location 5
10/07/2016 13:49	0.0219	Correlation Location 5
10/07/2016 13:49	0.0216	Correlation Location 5
10/07/2016 13:49	0.0213	Correlation Location 5
10/07/2016 13:49	0.0213	Correlation Location 5
10/07/2016 13:49	0.0208	Correlation Location 5
10/07/2016 13:49	0.0208	Correlation Location 5
10/07/2016 13:49	0.0211	Correlation Location 5
10/07/2016 13:49	0.0213	Correlation Location 5
10/07/2016 13:49	0.0211	Correlation Location 5
10/07/2016 13:49	0.0215	Correlation Location 5
10/07/2016 13:50	0.0217	Correlation Location 5
10/07/2016 13:50	0.0219	Correlation Location 5
10/07/2016 13:50	0.0217	Correlation Location 5
10/07/2016 13:50	0.0216	Correlation Location 5
10/07/2016 13:50	0.0217	Correlation Location 5
10/07/2016 13:50	0.0215	Correlation Location 5
10/07/2016 13:50	0.0211	Correlation Location 5
10/07/2016 13:50	0.0208	Correlation Location 5
10/07/2016 13:50	0.0206	Correlation Location 5
10/07/2016 13:50	0.0206	Correlation Location 5
10/07/2016 13:51	0.0208	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0213	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
10/07/2016 13:51	0.0211	Correlation Location 5
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10/07/2016 13:52	0.0223	Correlation Location 5
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10/07/2016 13:52	0.0221	Correlation Location 5
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10/07/2016 13:52	0.0216	Correlation Location 5
10/07/2016 13:52	0.0218	Correlation Location 5
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10/07/2016 13:52	0.0218	Correlation Location 5
10/07/2016 13:52	0.0216	Correlation Location 5
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10/07/2016 13:53	0.0216	Correlation Location 5
10/07/2016 13:53	0.0215	Correlation Location 5
10/07/2016 13:53	0.0218	Correlation Location 5
10/07/2016 13:53	0.0213	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location
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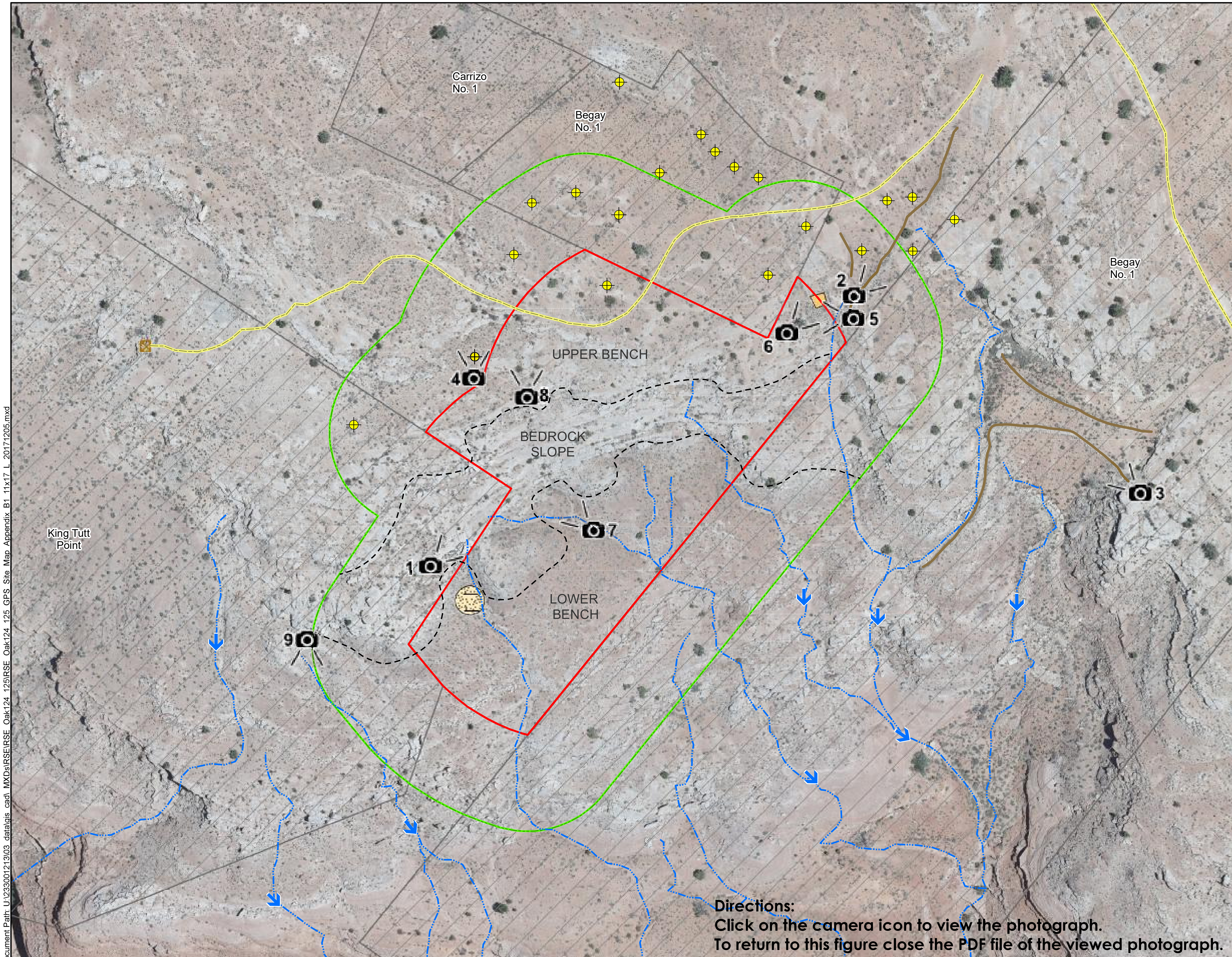
10/07/2016 13:47	0.0216	Correlation Location 5
10/07/2016 13:47	0.0215	Correlation Location 5
10/07/2016 13:48	0.0211	Correlation Location 5
10/07/2016 13:48	0.0211	Correlation Location 5
10/07/2016 13:48	0.0208	Correlation Location 5
10/07/2016 13:48	0.0208	Correlation Location 5
10/07/2016 13:48	0.0211	Correlation Location 5
10/07/2016 13:54	0.0216	Correlation Location 5
10/07/2016 13:54	0.0222	Correlation Location 5
10/07/2016 13:55	0.0223	Correlation Location 5
10/07/2016 13:55	0.0222	Correlation Location 5
10/07/2016 13:55	0.0219	Correlation Location 5
10/07/2016 13:55	0.0217	Correlation Location 5
10/07/2016 13:55	0.0216	Correlation Location 5
10/07/2016 13:55	0.0218	Correlation Location 5
10/07/2016 13:55	0.0217	Correlation Location 5

Date and Time	Exposure Rate (mR/h)	Location	Date and Time	Exposure Rate (mR/h)	Location
10/07/2016 13:53	0.0211	Correlation Location 5			
10/07/2016 13:53	0.0217	Correlation Location 5			
10/07/2016 13:53	0.0221	Correlation Location 5			
10/07/2016 13:53	0.0223	Correlation Location 5			
10/07/2016 13:54	0.0221	Correlation Location 5			
10/07/2016 13:54	0.0216	Correlation Location 5			
10/07/2016 13:54	0.0213	Correlation Location 5			
10/07/2016 13:54	0.0215	Correlation Location 5			
10/07/2016 13:54	0.0218	Correlation Location 5			
10/07/2016 13:54	0.0216	Correlation Location 5			
10/07/2016 13:54	0.0213	Correlation Location 5			
10/07/2016 13:54	0.0211	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.

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Historical Borehole
- Flow Direction
- Approximate Boundaries of Bedrock Slope
- Berm
- Drainage
- Potential Haul Road
- Potential Mining Disturbed Area
- Excavation
- Potential Staging Area
- Claim Boundary
- 100-Foot Claim Buffer
- 100 Other Claim Boundary

REFERENCES:
Coordinate System: NAD 1983 UTM Zone 12N

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

N
W E
S

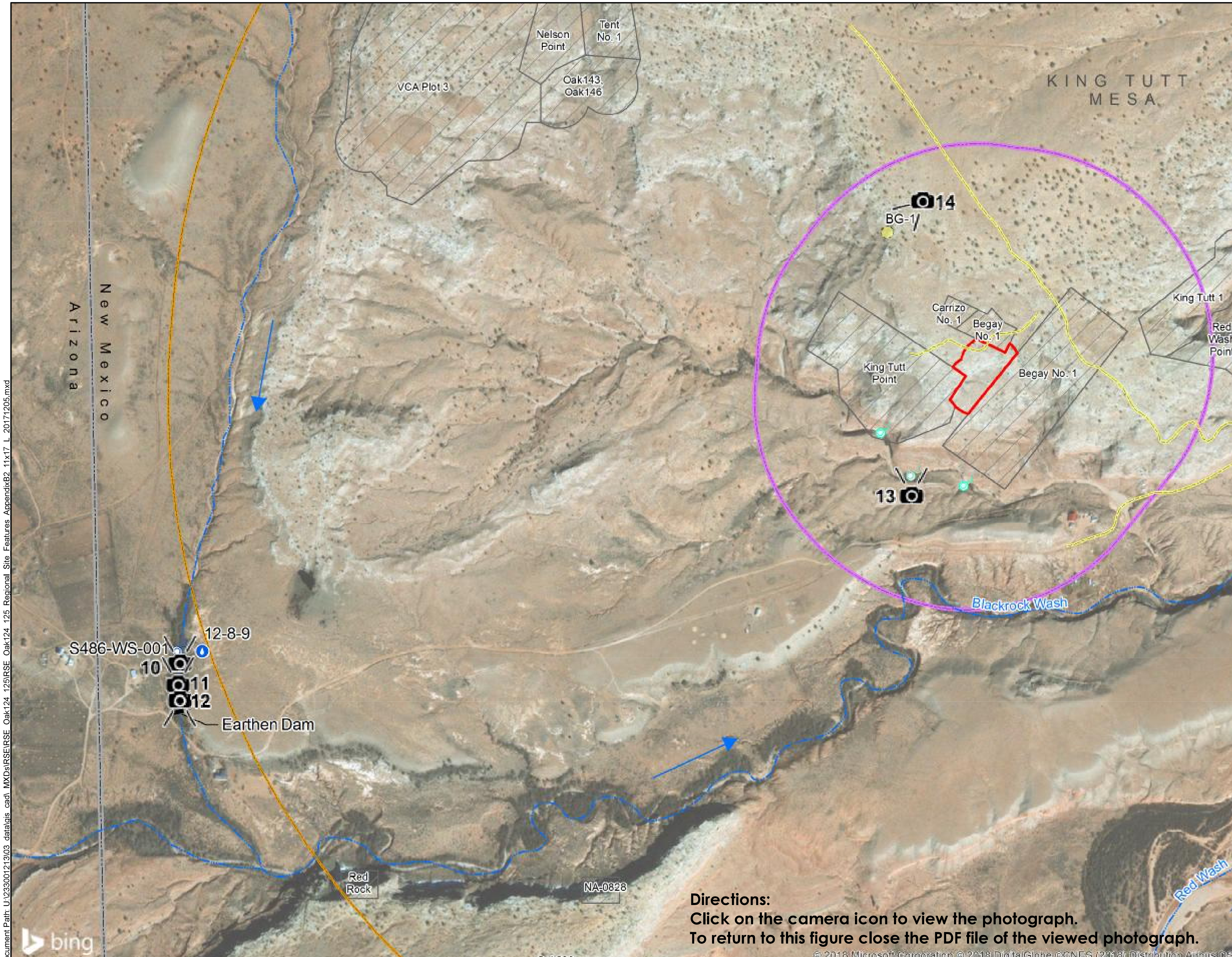
0 100 200
Feet

TITLE:
Site Photographs

PROJECT:
Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 6/26/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EY
	FIGURE: B-1	

Document Path: U:\23300121303 data\gis cad\MXDs\RSE\RSE Oak124 125\RSE Oak124 125 GPS Site Map Appendix B1 11x17 L 20171205.mxd



Document Path: U:\233001213\03_data\gis_cad\MXDs\RSE\RSE_Oak124_125\RSE_Oak124_125_Regional_Site_Features_AppendixB2_11x17_L_20171205.mxd

NAVAJO NATION
AUM Environmental Response Trust-First Phase

LEGEND

- Photograph Indicating Direction Taken
- Site Clearance Identified Water Feature
- Seep Sample Location
- Minor Seep
- Flow Direction
- Potential Haul Road
- Intermittent Stream/River
- Background Reference Area (BG-1)
- Claim Boundary
- 1/4-Mile Claim Boundary Buffer
- 1-Mile Claim Boundary Buffer
- 100 Other Claim Boundary
- State Boundary

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. Minor seeps identified during field mapping.

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

0 650 1,300
Feet

TITLE:

Regional Site Photographs

PROJECT:

Removal Site Evaluation
Oak 124, Oak 125 Mine Site

DATE: 6/26/2018	DOCUMENT NAME: Removal Site Evaluation Report	
Stantec	AUTHOR: CBB	REVIEWER: EY
	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 S486 (Oak 124, Oak 125)

SAMPLE I.D. S486-BG1-001 (201, dup)

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1029

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS Sunny, 70's

FIELD USCS DESCRIPTIONS Clayey ~~sandy gr~~ silty sand, medium gravels, v. low clay

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, ziploc

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (Oak 124, Oak 125)

SAMPLE I.D. S486-BG1-002

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1049

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 70's, Sunny

FIELD USCS DESCRIPTIONS Sandy silt

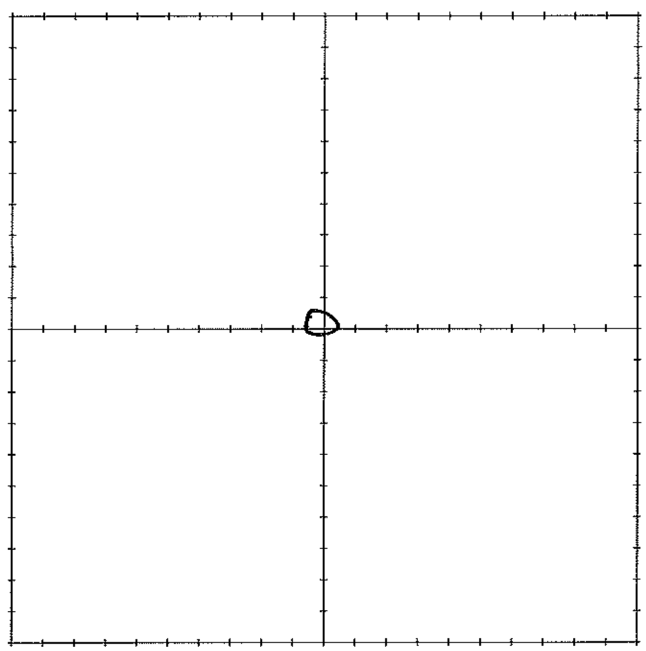
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (Dal 124, Dal 125)

SAMPLE I.D. S486-BG1-003

SAMPLE COLLECTION DATE 10/11/16

SAMPLE COLLECTION TIME 1101

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 70's, Sunny

FIELD USCS DESCRIPTIONS Silty Sand

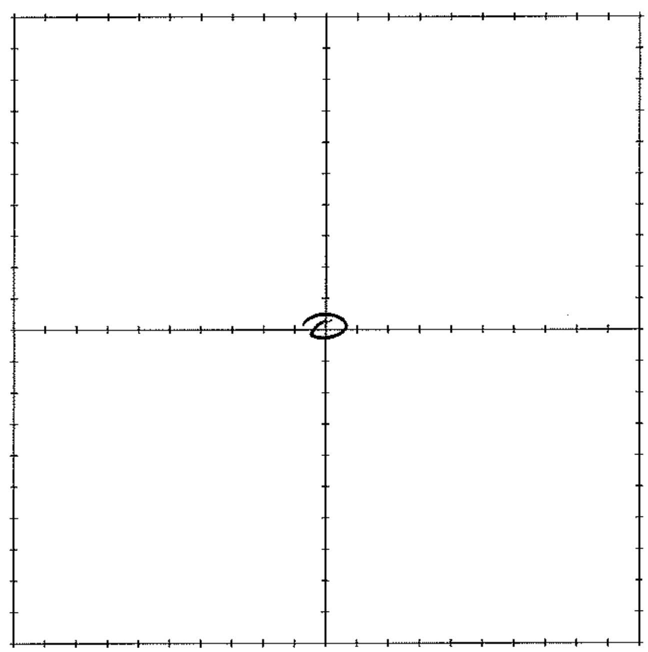
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (OAU124, OAU125)

SAMPLE I.D. S486-BG1-004

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1119

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 70's, sunny

FIELD USCS DESCRIPTIONS Gravelly silty sand

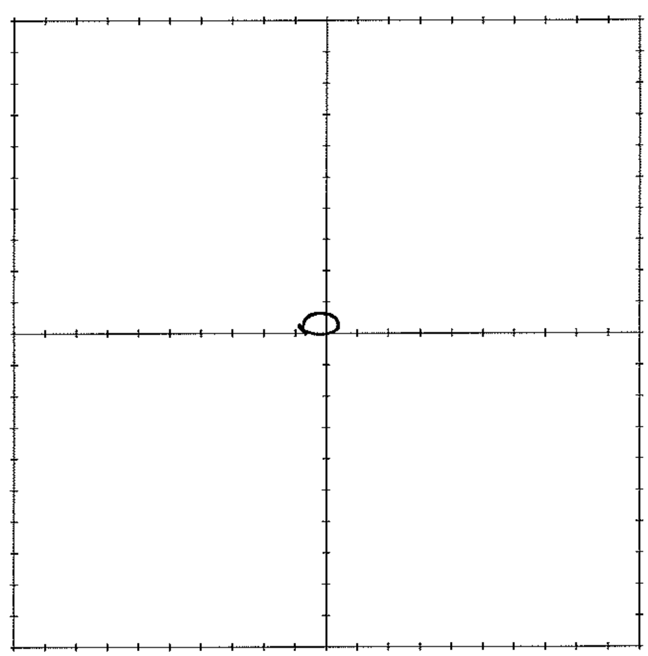
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☑ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (OqL 124, OqL 125)

SAMPLE I.D. S486 - BG1 - 005 (MS, MSD)

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1123

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 70's, sunny

FIELD USCS DESCRIPTIONS Silty sand

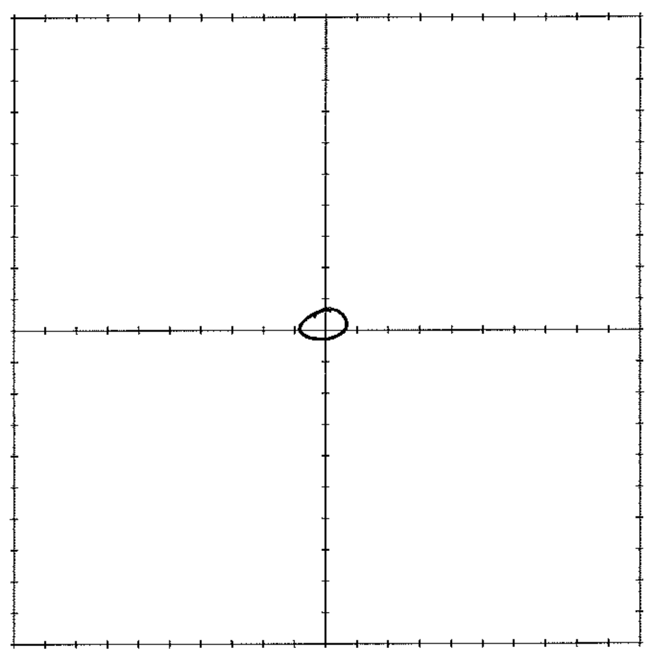
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (Oqa 124, Oqa 125)

SAMPLE I.D. S486-BG1-006

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1138

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 70's, sunny

FIELD USCS DESCRIPTIONS Siltx sand, trace clay

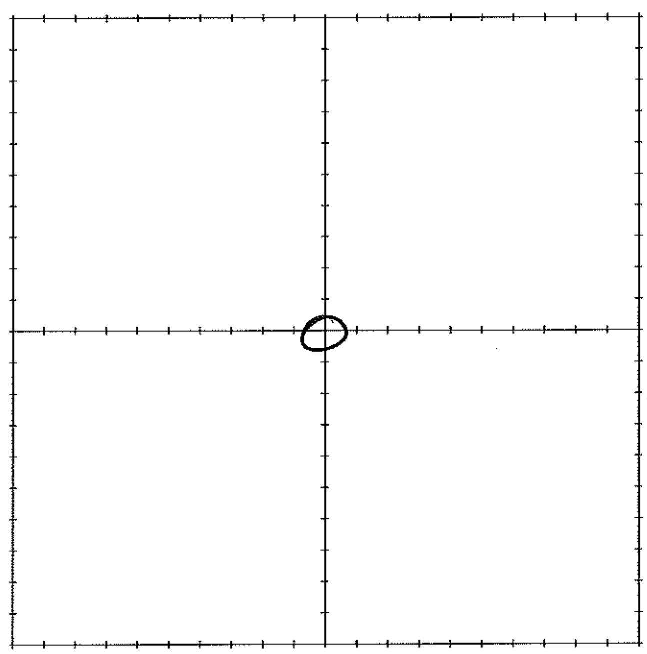
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☑ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ~~☑ DRY~~ ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals.



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (Oaa 124, Oqc 125)

SAMPLE I.D. S486-BG1-007

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1147

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 70's, sunny

FIELD USCS DESCRIPTIONS silty sand, trace clay

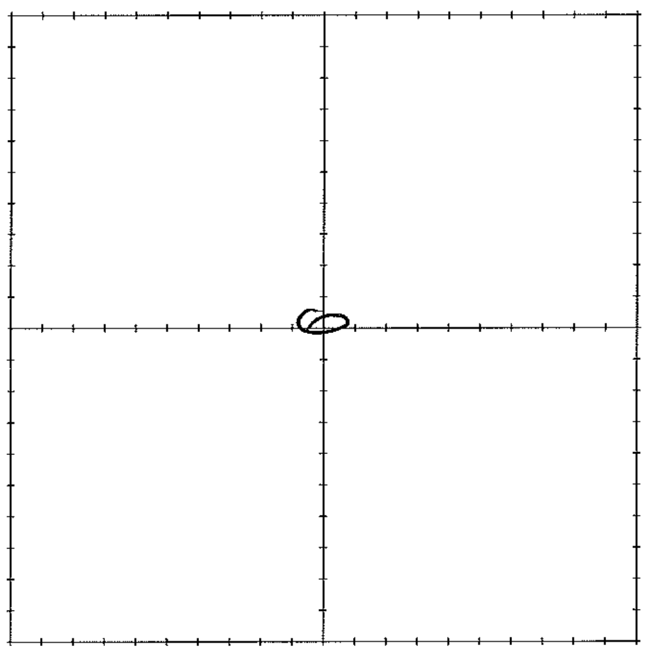
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☑ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (Oqu 124, Oqu 125)

SAMPLE I.D. S486-BG1-008

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1157

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 70's, Sunny

FIELD USCS DESCRIPTIONS Silty Sand, trace clay, v. little gravels

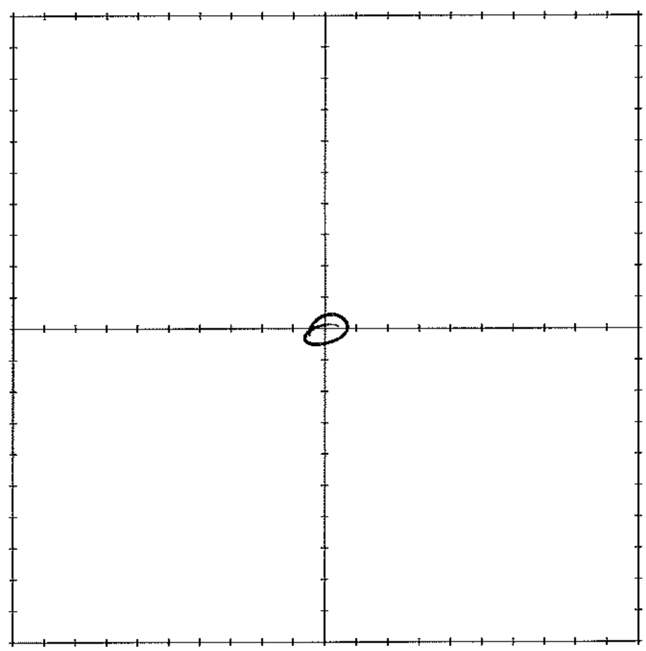
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☑ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486(Oql 124, Oql 125)

SAMPLE I.D. S486-BG1-009

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1205

SAMPLE COLLECTED BY KJS

WEATHER CONDITIONS 70's, Sunny

FIELD USCS DESCRIPTIONS Silty Sand

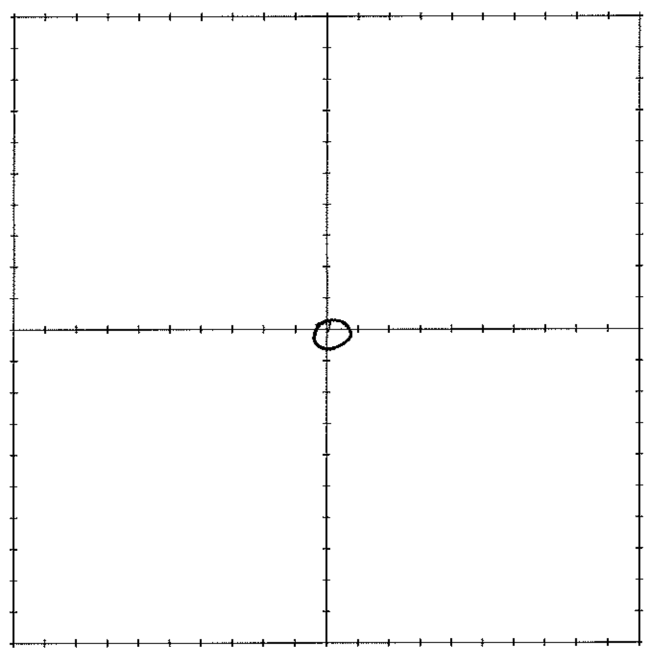
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☑ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486 (Oak 124, Oak 125)

SAMPLE I.D. S486 - BGL-010

SAMPLE COLLECTION DATE 10/1/16

SAMPLE COLLECTION TIME 1211

SAMPLE COLLECTED BY KJJ

WEATHER CONDITIONS 70's, sunny

FIELD USCS DESCRIPTIONS Silty sand

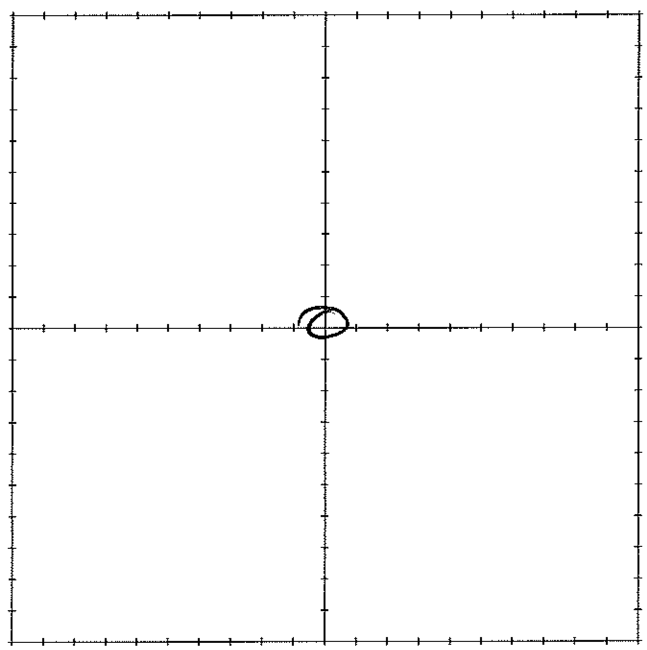
MAJOR DIVISIONS: ☐ OH ☐ CH ☐ MH ☐ OH ☐ CL ☐ ML ☐ SC
☑ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☑ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 2 ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-C01-001 (Oak 124, Oak 125)

SAMPLE I.D. S486-C01-001

SAMPLE COLLECTION DATE 10/7/16

SAMPLE COLLECTION TIME 1026

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Brown Silt

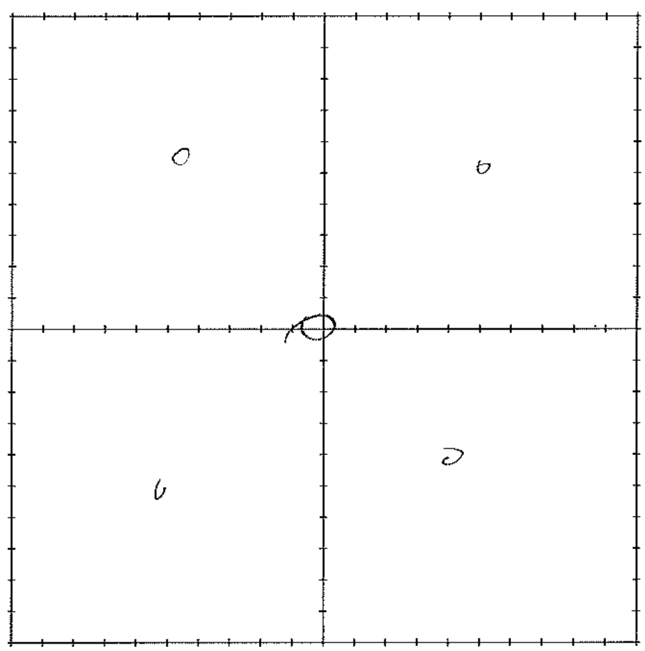
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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 S486-C01-201 (Oak 124, Oak 125)

SAMPLE I.D. S486-C01-201

SAMPLE COLLECTION DATE 10/7/16

SAMPLE COLLECTION TIME 1026

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 60's, Sunny

FIELD USCS DESCRIPTIONS Brown silt

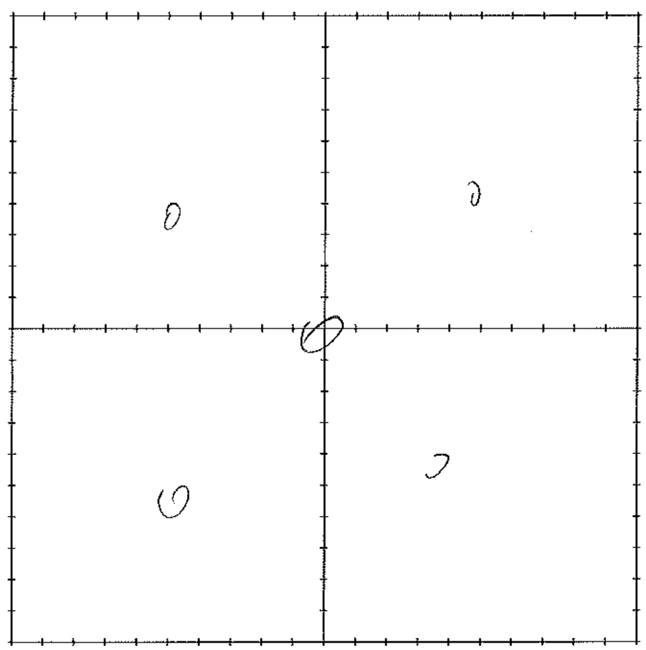
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-C02-001 (Oak 124, Oak 125)

SAMPLE I.D. S486-C02-001

SAMPLE COLLECTION DATE 10/9/16

SAMPLE COLLECTION TIME 1117

SAMPLE COLLECTED BY C. Lere

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Brown silt

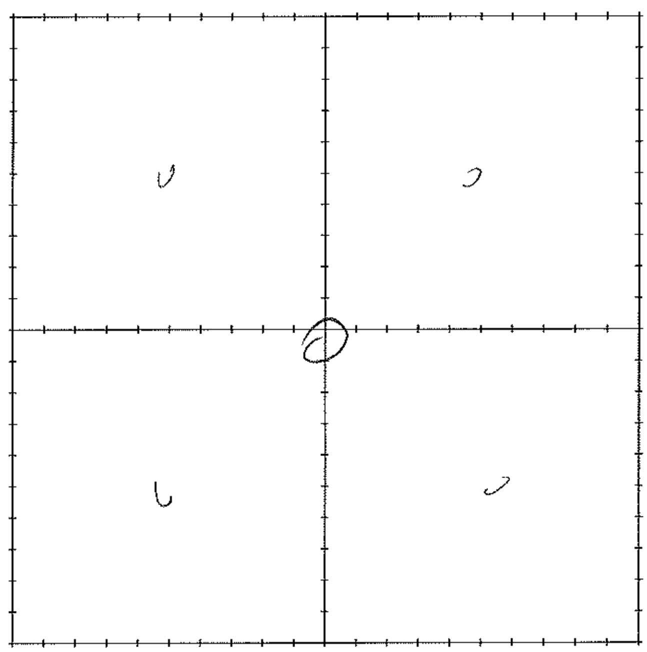
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-L03-001 (Oak 124, Oak 125)

SAMPLE I.D. S486-L03-001

SAMPLE COLLECTION DATE 10/7/16

SAMPLE COLLECTION TIME 1153

SAMPLE COLLECTED BY J. Garvey

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Brown Silt

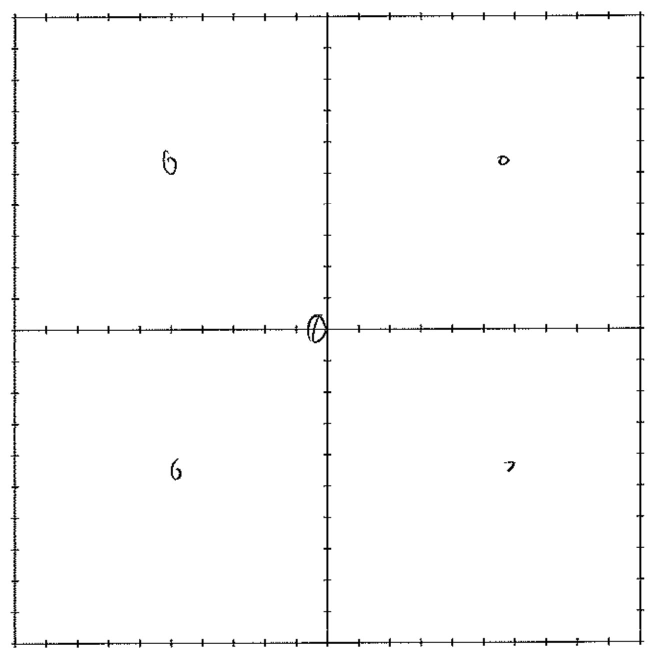
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-C04-001 (Oak 124, Oak 125)

SAMPLE I.D. S486-C04-001

SAMPLE COLLECTION DATE 10/7/16

SAMPLE COLLECTION TIME 1234

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS 60's, sunny

FIELD USCS DESCRIPTIONS Brown silt

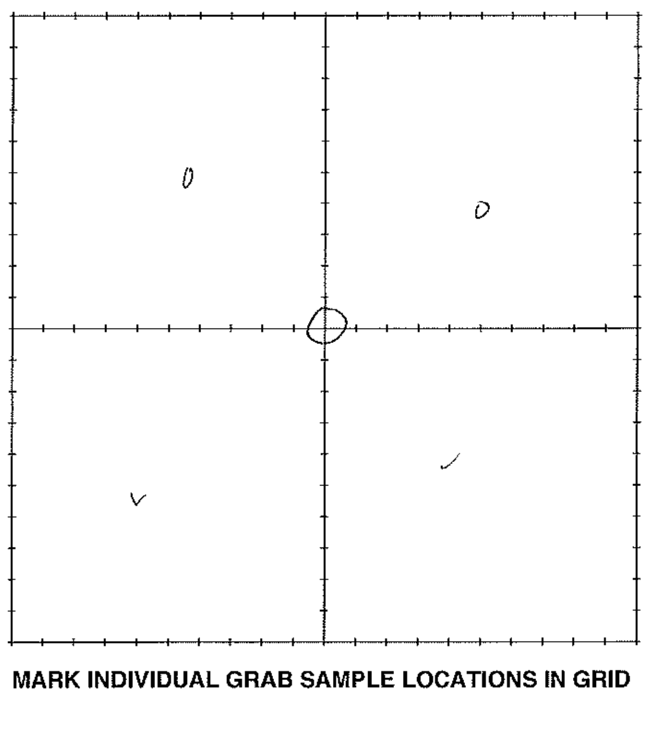
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Thorium



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: S486-C05-001 (Oak 124, Oak 125)

SAMPLE I.D.: S486-C05-001

SAMPLE COLLECTION DATE: 10/7/16

SAMPLE COLLECTION TIME: 1445

SAMPLE COLLECTED BY: C. Lee

WEATHER CONDITIONS: 60's, sunny

FIELD USCS DESCRIPTIONS: Brown silt

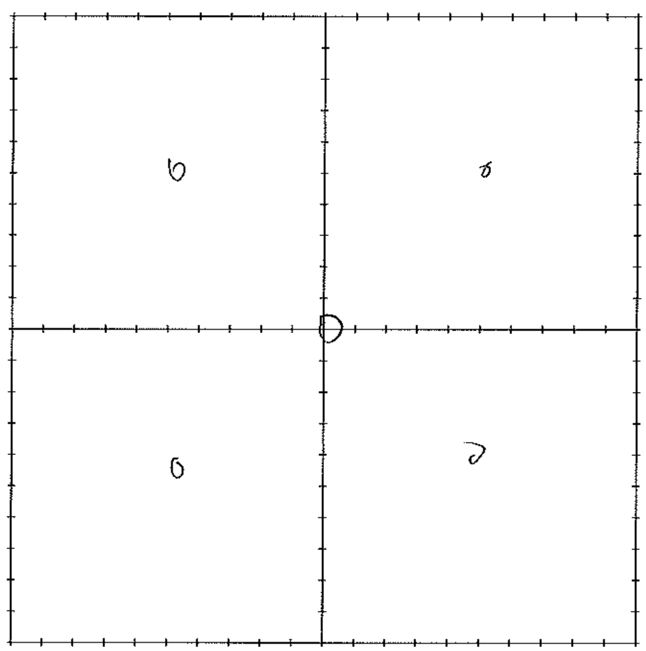
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

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: S486-CX-001 (Oak 124, Oak 125)

SAMPLE I.D.: S486-CX-001

SAMPLE COLLECTION DATE: 10/10/16

SAMPLE COLLECTION TIME: 1430

SAMPLE COLLECTED BY: C. Lee

WEATHER CONDITIONS: 60's, clear

FIELD USCS DESCRIPTIONS: Brown sandy 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, Ziploch

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-201 (Oak 124, 125)

SAMPLE I.D. S486-CX-201

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1430

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Brown, sandy silt

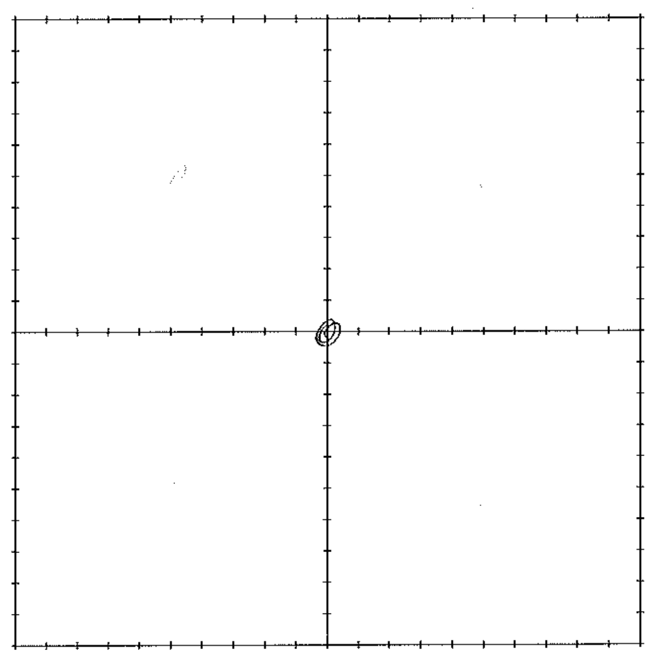
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☒ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-002 (Oak 124, Oak 125)

SAMPLE I.D. S486-CX-002

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1445

SAMPLE COLLECTED BY CCL

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Brown, sandy silt

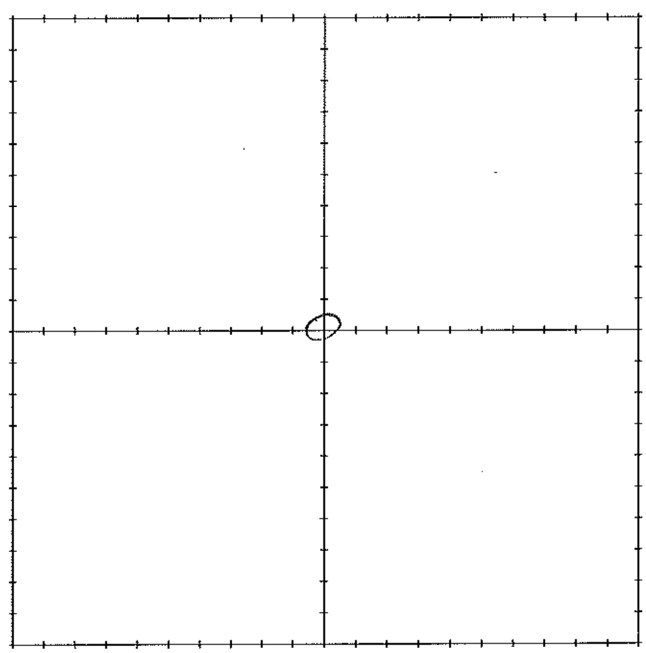
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-003 (Oak 124, 125)

SAMPLE I.D. S486-CX-003

SAMPLE COLLECTION DATE 10/10/14

SAMPLE COLLECTION TIME 1455

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Brown, sandy silt

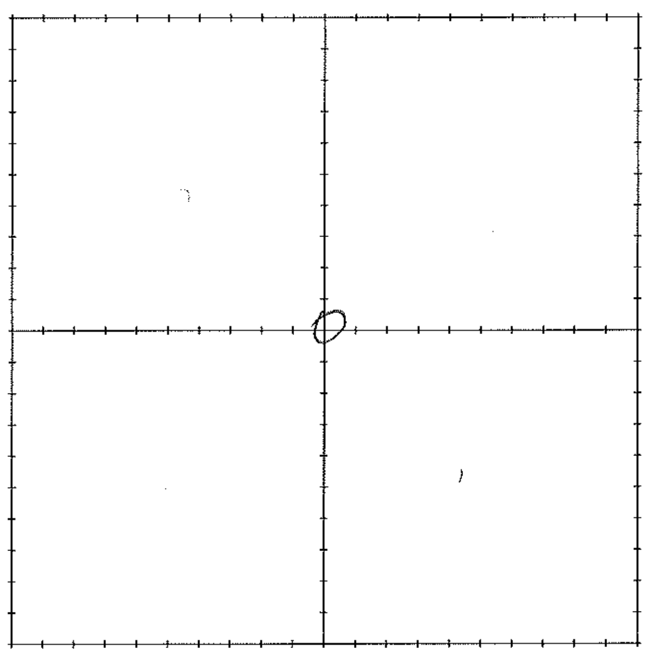
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-003 (Oak 124, Oak 125)

SAMPLE I.D. S486-CX-003 MS

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1455

SAMPLE COLLECTED BY C Loe

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Brown-Gray, sandy silt, flaky grains

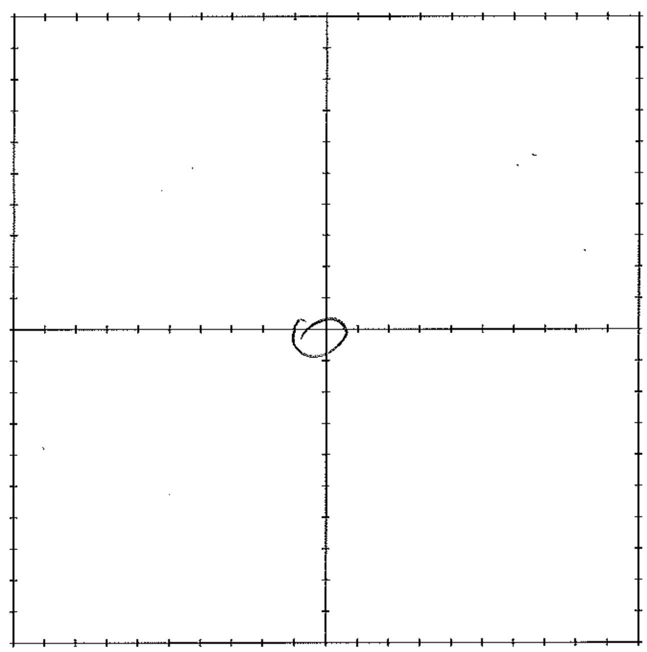
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-003 (Oah124, Oah125)

SAMPLE I.D. S486-CX-003-MSD

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1455

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Brown-gray sandy silt, minor platy fragments

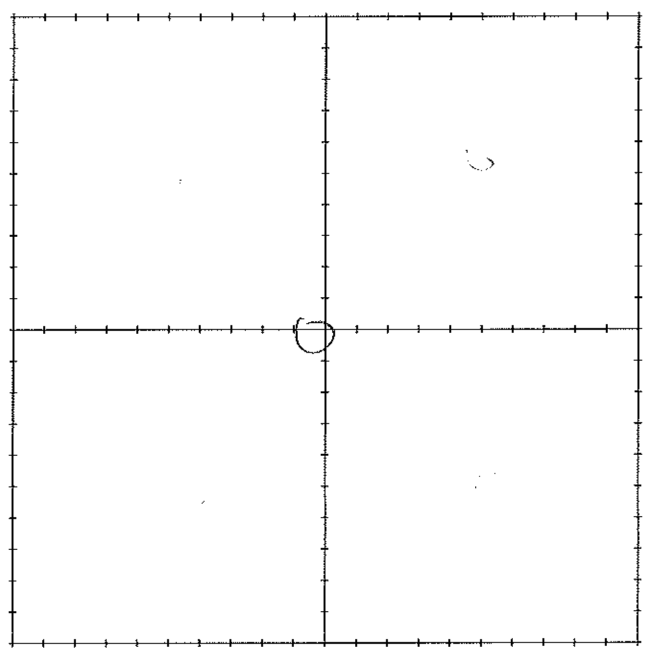
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-004 (Oak 124, Oak 123)

SAMPLE I.D. S486-CX-004

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1510

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Brown silt

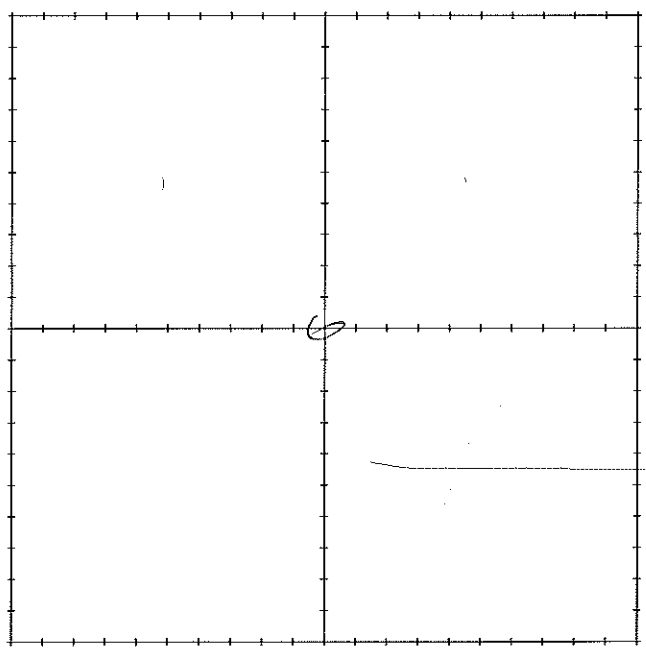
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-005 (Oak 124, Oak 124)

SAMPLE I.D. S486-CX-005

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1520

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Brown silt

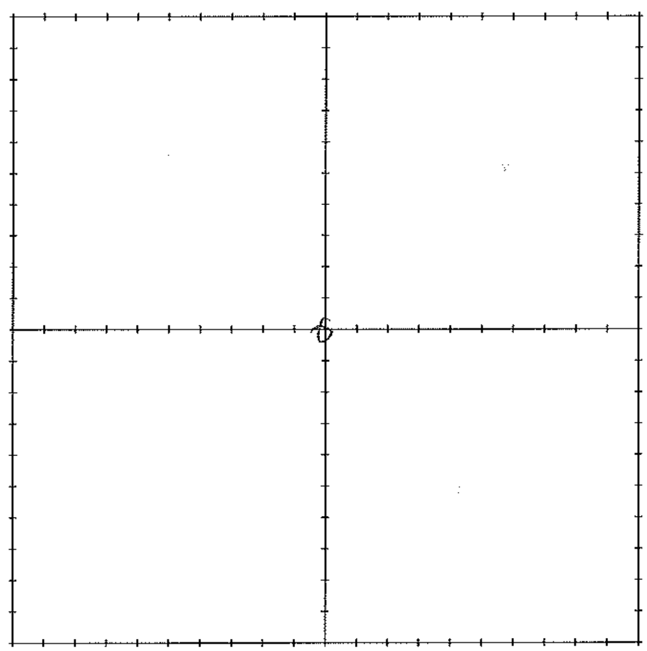
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-CX-006 (OaL 124, OaL 125)

SAMPLE I.D. S486-CX-006

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1525

SAMPLE COLLECTED BY L. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Brown 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, ziplock

ANALYSES: Ra-226, Metals

MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5486-CX-007 (Oak 124, 125)

SAMPLE I.D. 5486-CX-007

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1540

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, Clear

FIELD USCS DESCRIPTIONS Gray, silt, rock frags/flakes

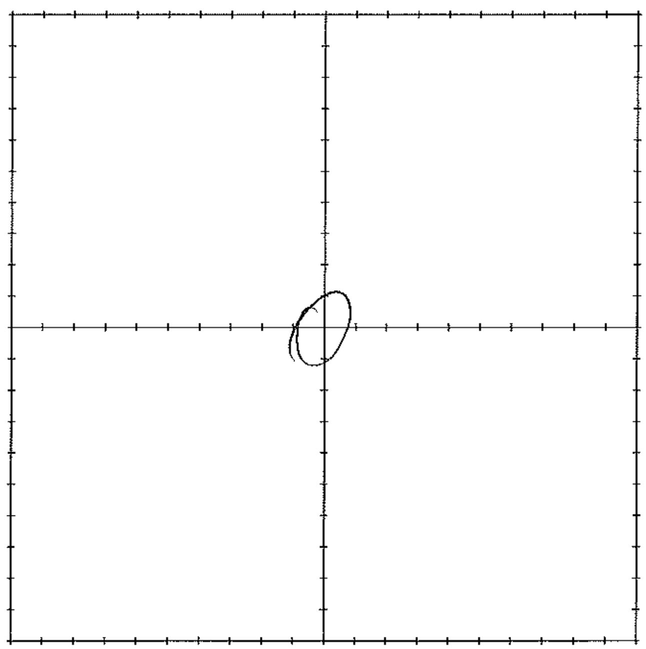
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME S486-LX-008 (Oak 129, Oak 125)

SAMPLE I.D. S486-LX-008

SAMPLE COLLECTION DATE 10/10/16

SAMPLE COLLECTION TIME 1345

SAMPLE COLLECTED BY L. Rodriguez

WEATHER CONDITIONS 50's clear

FIELD USCS DESCRIPTIONS Gray, sandy silt, some flaky gray frags

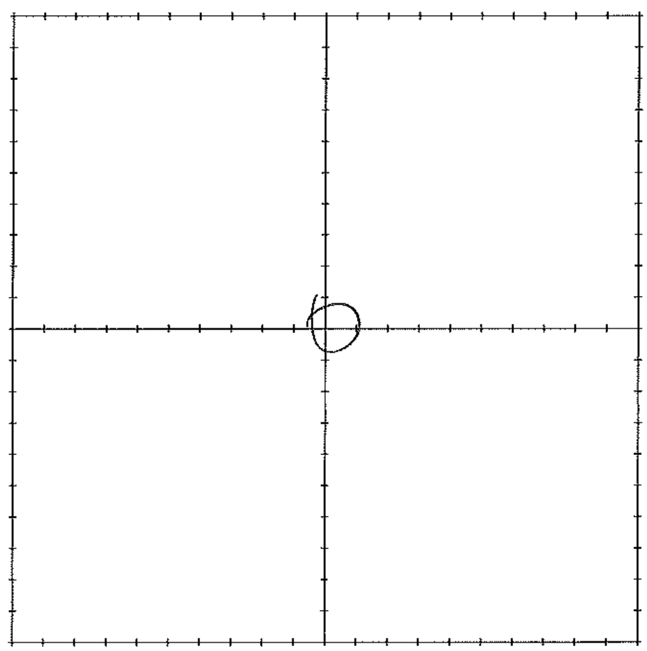
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME 5486-CX-009 (Oan 124, Oan 125)

SAMPLE I.D. 5486-CX-009

SAMPLE COLLECTION DATE 10/10/14

SAMPLE COLLECTION TIME 1555

SAMPLE COLLECTED BY C. Lee

WEATHER CONDITIONS 50's, clear

FIELD USCS DESCRIPTIONS Gray, silty, gray rock frags, flaky

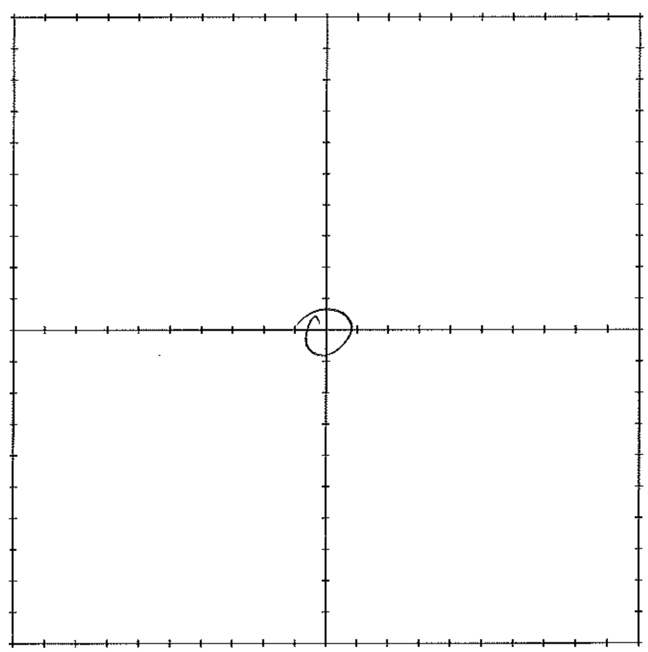
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☒ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☐ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE) 1, ziplock

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

SURFACE SOIL SAMPLE LOG FORM

AREA #/NAME: S486-CX-010 (Oak 124, Oak 125)

SAMPLE I.D.: S486-CX-010

SAMPLE COLLECTION DATE: 10/10/16

SAMPLE COLLECTION TIME: 1605

SAMPLE COLLECTED BY: C. Lee

WEATHER CONDITIONS: 50's, clear

FIELD USCS DESCRIPTIONS: Brown silt

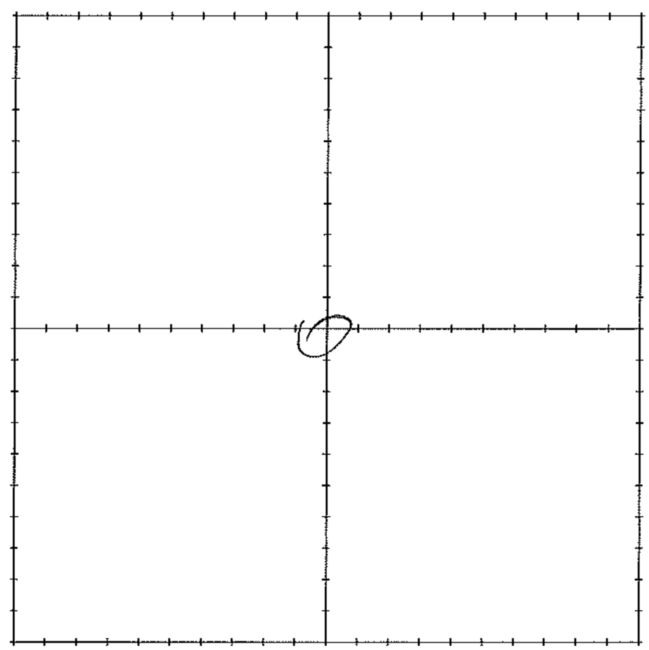
MAJOR DIVISIONS: ☐ OH ☐ CH ☒ MH ☐ OH ☐ CL ☐ ML ☐ SC
☐ SM ☐ SP ☐ SW ☐ GC ☐ GM ☐ GP ☐ GW

QUALIFIERS: ☐ TRACE ☐ MINOR ☐ SOME; SAND SIZE ☐ FINE ☐ MEDIUM ☐ COARSE

MOISTURE: ☒ DRY ☐ MOIST ☐ WET

SAMPLE CONTAINERS (NUMBER AND TYPE): 1, ziploc

ANALYSES: Ra-226, Metals



MARK INDIVIDUAL GRAB SAMPLE LOCATIONS IN GRID

MWH

C.2 Hand Auger Borehole Logs

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S486-SCX-004 (BG-1)**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 676216.87	NORTHING: 4064712.34
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 10/10/2016	DATE STARTED: 10/10/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	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	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND WITH GRAVEL (SM): gray, gravels are sandstone.	14044	S486-SCX-004-1	0-0.4	grab	1.71
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on bedrock.	17995				
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

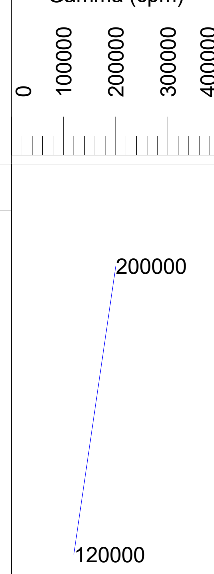
- - - - = approximate contact

BOREHOLE ID:	**S486-SCX-001**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 676471.81	NORTHING: 4064476.12
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 10/10/2016	DATE STARTED: 10/10/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 1.6	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)
0–1.6		SILTY SAND (SM): light gray, fine sand, minor gravels.	S486-SCX-001-1	0-0.3	grab	223
			S486-SCX-001-2	0.3-1.6	comp	32.6
1.6		Terminated hand auger borehole at 1.6 ft. below ground surface. Reason for termination is unknown.				

Gamma (cpm)



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:	**S486-SCX-002**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 676395.57	NORTHING: 4064473.41
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 10/10/2016	DATE STARTED: 10/10/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	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	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND (SM): red.	No down hole gamma	S486-SCX-002-1	0-0.2	grab	9.4
				S486-SCX-002-2	0.2-0.5	grab	12.6
		Terminated hand auger borehole at 0.5 ft. below ground surface. Refusal on bedrock.					
1							
2							
3							
4							
5							

Notes: cpm = counts per minute
pCi/g = picocuries per gram

grab = grab sample
comp = composite sample

- - - - = approximate contact

BOREHOLE ID:	**S486-SCX-003**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 676376.43	NORTHING: 4064396.69
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 10/10/2016	DATE STARTED: 10/10/2016
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.6	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Luis Rodriguez	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 100000 200000 300000 400000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		SILTY SAND (SM): dark gray, dry.		S486-SCX-003-1	0-0.4	grab	40.3
			196000	S486-SCX-003-2	0.4-0.6	grab	51.2
		Terminated hand auger borehole at 0.6 ft. below ground surface. Refusal on bedrock.					
1							
2							
3							
4							
5							

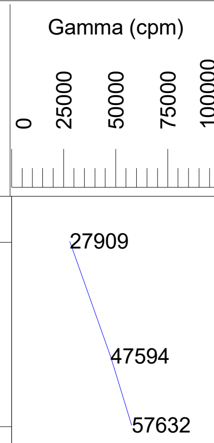
Notes: cpm = counts per minute
pCi/g = picocuries per gram
grab = grab sample
comp = composite sample
- - - - = approximate contact

Stantec | NAVAJO NATION AUM Environmental Response Trust-First Phase

BOREHOLE ID:	**S486-SCX-005**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 676405.6	NORTHING: 4064460.11
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/19/2017	DATE STARTED: 5/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.): 0.8	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Michael Ward	

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 WITH GRAVEL (SP): light brown, gray, loose, unconsolidated, medium grained sand, gravels are subangular, dry.	27909	S486-SCX-005-1 S486-SCX-205-1	0-0.5	grab	11.8 12.5
			47594	S486-SCX-005-2	0.5-0.8	grab	12.0
		Terminated hand auger borehole at 0.8 ft. below ground surface on bedrock.	57632				
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: **S486-SCX-006**
	CLIENT: NNAUMERT
	PROJECT: Removal Site Evaluation
	SITE LOCATION: Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:		NAD 1983 UTM Zone 12N	
DRILLING METHOD:	Hand auger	EASTING:	676371.28	NORTHING:	4064454.78
DRILLING EQUIPMENT:	Hand auger	DATE STARTED:	5/19/2017	DATE STARTED:	5/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):	0.7	BOREHOLE ANGLE:	90 degrees
		LOGGED BY:	Michael Ward		

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): light brown, gray, loose, dry, unconsolidated, medium to fine grained sand.	11292	S486-SCX-006-1	0-0.5	grab	2.96
		Terminated hand auger borehole at 0.7 ft. below ground surface. Refusal on hard rock.	13343				
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:	S486-SCX-007
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 676442.47	NORTHING: 4064432.07
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/19/2017	DATE STARTED: 5/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):1.1	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Michael Ward	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND WITH GRAVEL (SP): brown, dark red, loose, dry, unconsolidated.	12824	S486-SCX-007-1	0-0.5	grab	2.98
			20400	S486-SCX-007-2	0.5-1.1	grab	3.18
1		Terminated hand auger borehole at 1.1 ft. below ground surface. Refusal on hard rock or bedrock.	23867				
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:	**S486-SCX-008**
CLIENT:	NNAUMERT
PROJECT:	Removal Site Evaluation
SITE LOCATION:	Oak 124, Oak 125

DRILLING CONTRACTOR:	Stantec	COORDINATE SYSTEM:	NAD 1983 UTM Zone 12N
DRILLING METHOD:	Hand auger	EASTING: 676376.37	NORTHING: 4064356.15
DRILLING EQUIPMENT:	Hand auger	DATE STARTED: 5/19/2017	DATE STARTED: 5/19/2017
SAMPLING METHOD:	Regular hand auger, 3 inch diameter	TOTAL DEPTH (ft.):0.7	BOREHOLE ANGLE: 90 degrees
		LOGGED BY: Michael Ward	

DEPTH (feet)	LITHOLOGICAL GRAPHIC	LITHOLOGICAL DESCRIPTION	Gamma (cpm) 0 25000 50000 75000 100000	SAMPLE IDENTIFICATION	SAMPLE INTERVAL (ft bgl)	SAMPLE TYPE	LAB RESULTS RA-226 (pCi/g)
0		POORLY GRADED SAND (SP): red on surface, light gray to brown with depth, loose, dry, unconsolidated.	8863	S486-SCX-008-1	0-0.5	grab	0.51
			10398				
		Terminated hand auger borehole at 0.7 ft. below ground surface on bedrock.					
1							
2							
3							
4							
5							

SUBSURFACE SAMPLE INFORMATION

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 5, 23, 17 **Arrival Time** 1400

Field Personnel
Joan Kester / Kelly Johnson

SITE DESCRIPTION

Entered 6/16/2017

Surface Water ☒ **Well Water** ☐

Station Name SEEP Near OAK 124, OAK 125 **Station Number** 12-8-9

Site Description Seep ~100 ft long in drainage wet SW with Algae & lots of organics from Trees

Water Characteristics (color, odor, appearance): Clear, no odor, small worms 3-5 mm, beetle type bug

SAMPLE COLLECTION

Collection Method: 1L bottle, Horizontal-bottle, Swing-sampler, Other( ). Up-stream / Across-stream

Sample ID: S486-WS-001 **Sample Time:** 1423

Field Measurements

Parameter	Sample 1 (normal sample)	Sample 2 (field dup or MS)	Sample 3 (MSD)
Time	1423		
pH	7.16		
Conductivity (µS/cm)	611		
Turbidity (NTU)	11.8		
Water Temperature (°C)	15.7°		
Salinity			
Oxidation Reduction Potential (mV)	120.7 mV		

- Had to dig Hole & wait an hour before sampling
~ 6 ft across and about 25 ft down where water first appears

Sample ID S486-WS-001 LOC ID Same
Time 1423

SURFACE WATER FLOW MEASUREMENT FORM

Project: Removal Site Evaluation Navajo Nation AUM Environmental Response Trust – First Phase

Date 5 / 23 / 2017 **Time** 1423 **Station Number** S486-WS-001

Oak124, Oak125

Field Personnel: K-Johnson J. Kester

Spring

12-8-9

Flow by Capture Method

Measurement Number	Time (sec)	Volume (L)

not measurable

Entered 6/16/2017

Appendix D Statistical Evaluation

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 Oak 124, Oak 125 Site (Site). The evaluation includes comparing background reference area (BG-1) 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 for both the Site Survey Area and BG-1, which was selected as representative of Site conditions (refer to RSE Report Section 2.2.2 and 3.2.2.2 and Appendix D.1 for information regarding background reference area selection). BG-1 was located on the same mesa as the Site, had similar character (located at the junction of the mesa top and mesa sidewall) as can be seen in RSE Report Figures 2-7a and 3-3, and no visual evidence of impact. BG-1 encompassed an area of 5,048 ft^2 (approximately 0.12 acres), was located 900 feet northwest of the Site, and crosswind and hydraulically up-gradient from the Site. Geologically, BG-1 represents areas of the Site that have a mix of bedrock outcrops of the Morrison Formation and unconsolidated deposits. The vegetation and ground cover at BG-1 are similar to the Site. The gamma radiation survey data and soil sample analytical results for BG-1 and the Survey Area 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 the Survey Area (box plots, probability plots, hypothesis testing with Wilcoxon Mann-Whitney test). Soil sample and gamma radiation survey results were compared between BG-1 and the Survey Area 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, soil samples were collected randomly. Potential outliers in the BG-1 dataset were examined using box plots, 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.

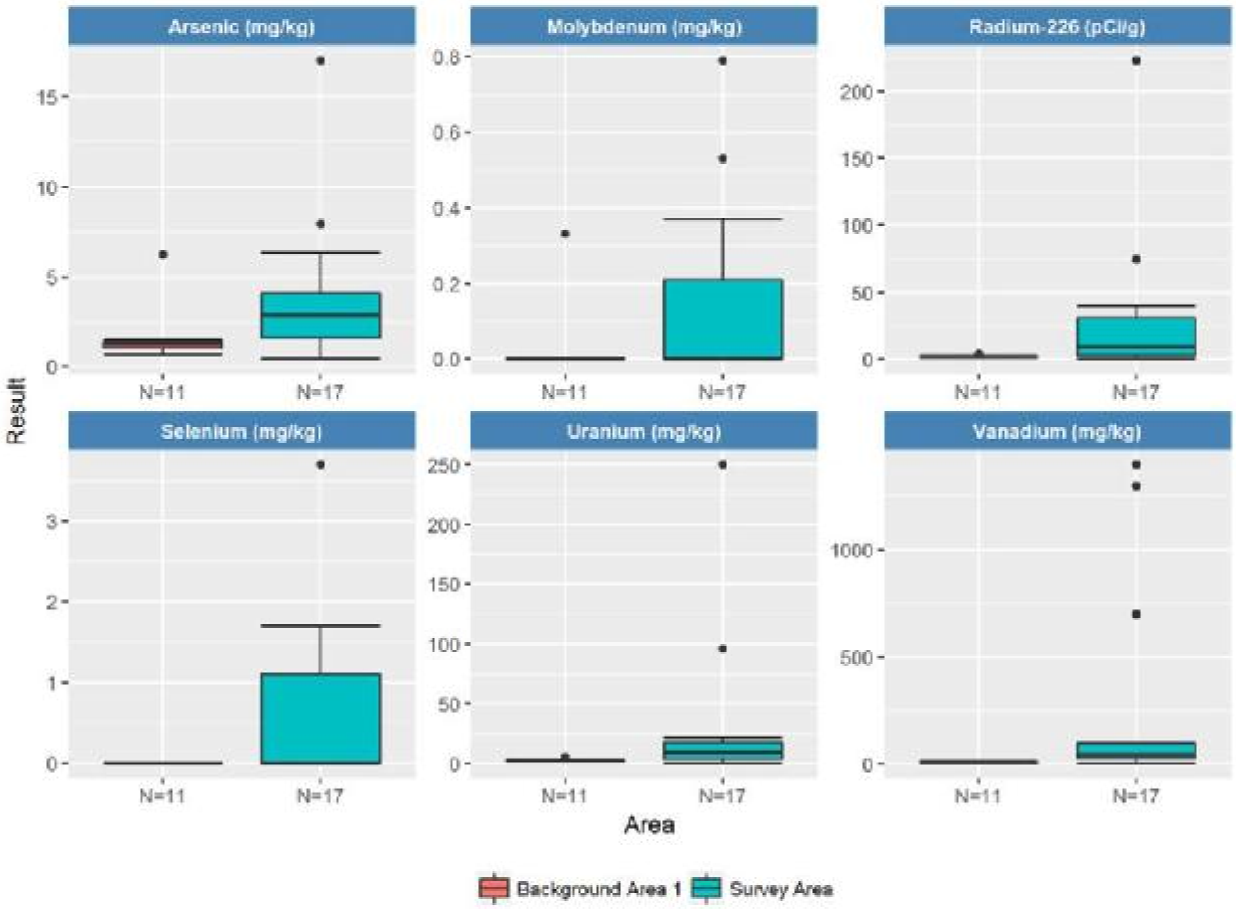
In the Survey Area at the Site, soil samples were collected using a judgmental sampling approach. Specifically, some sample locations were selected to characterize areas of higher gamma radiation and, as a result, potential outlier values are not unexpected in the Survey Area sample statistics. Potential 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 Area to BG-1 are still presented for qualitative assessment. However, potential outlier values in the Survey Area were not evaluated further nor removed from the dataset.

3.1.1 Box Plots

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 Box Plots

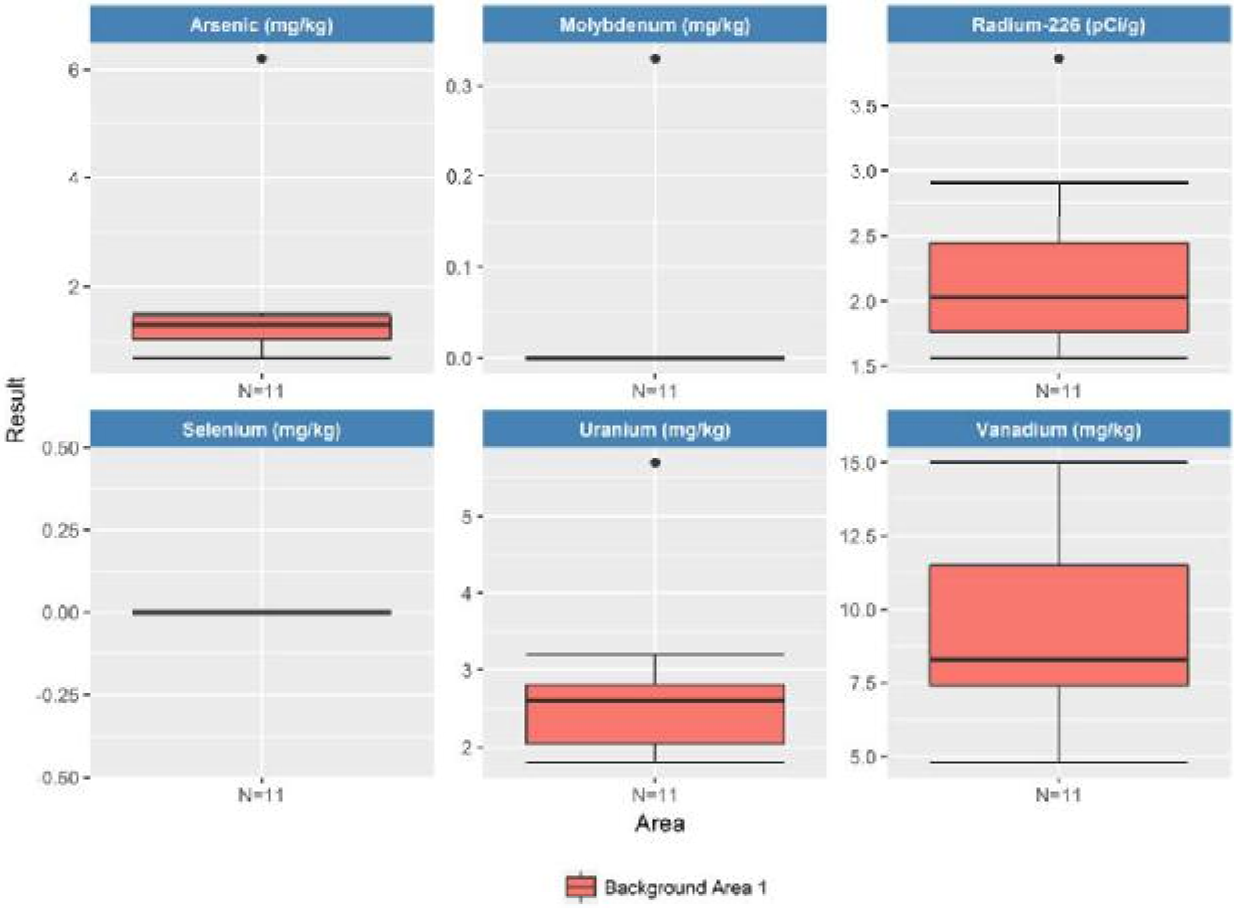
Figure 1A. Survey Area and Background Area 1 (BG-1) Soil Sample Box Plots



The soil sample box plots shown on Figure 1A depict differences in the data distribution for analytical constituent concentrations between BG-1 and the Survey Area. Some potential outlier values are shown for both BG-1 and the Survey Area at the Site.

Potential outlier values that are of greatest concern are those in the BG-1 datasets, as the data from BG-1 are used to determine ILs. Background reference area data are presented alone in Figure 1B.

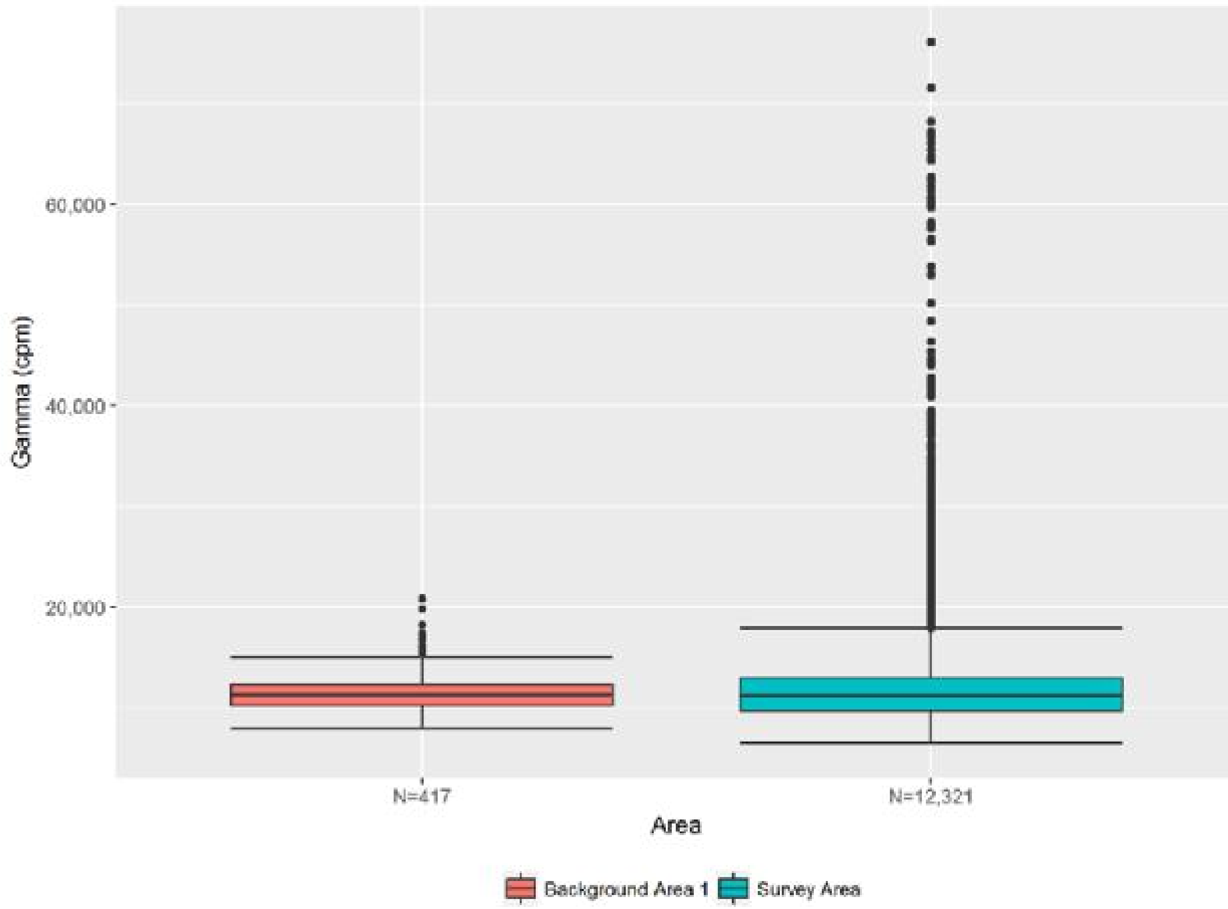
Figure 1B. Background Area 1 (BG-1) Soil Sample Box Plots



One value each for arsenic, molybdenum, Ra-226, and uranium were identified as potential outliers (i.e., outside 1.5 times the interquartile range above the 75th percentile) in the box plots in Figure 1B for the BG-1 datasets.

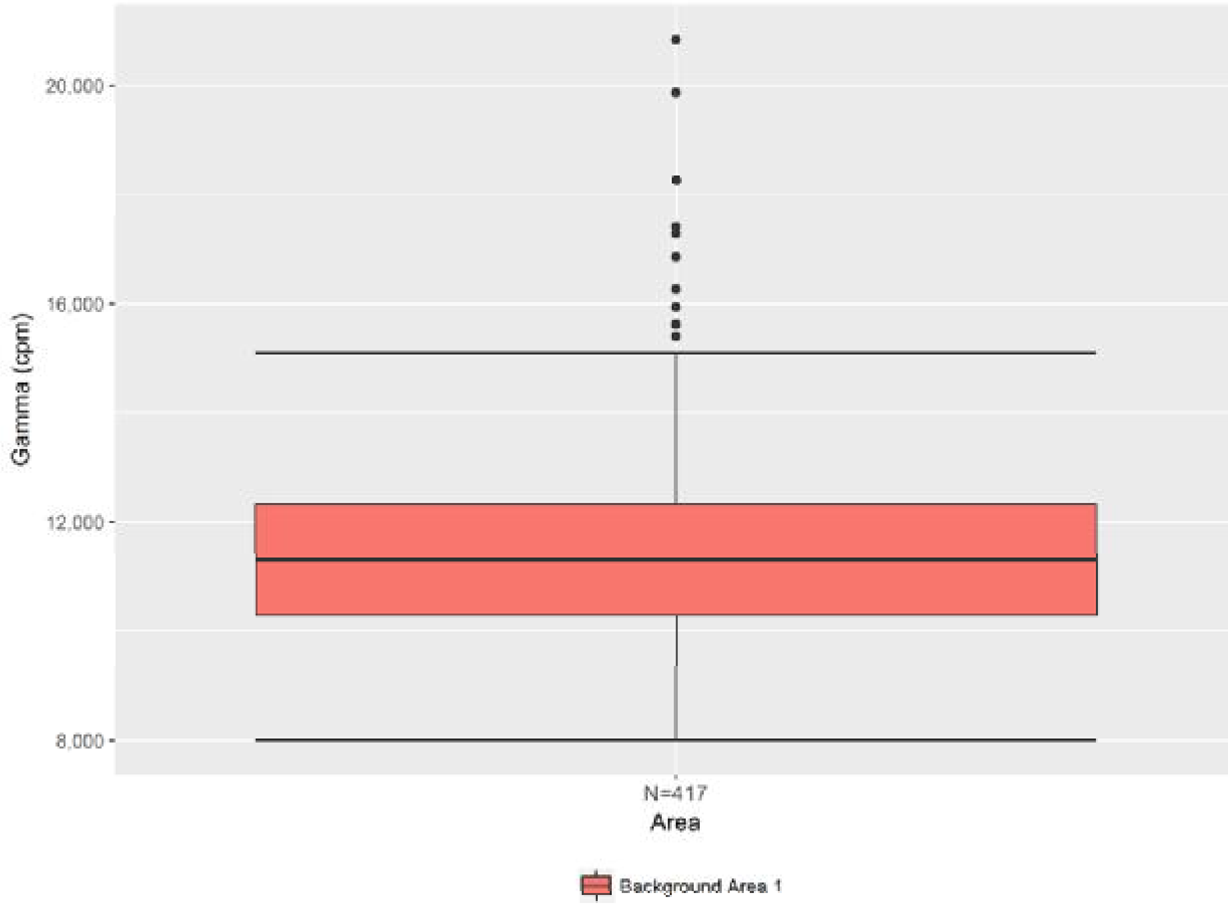
3.1.2 Gamma Radiation Results Box Plots

Figure 2A. Survey Area and Background Area 1 (BG-1) Gamma Radiation Box Plots



The gamma radiation survey results box plot shown on Figure 2A depict differences in the data distribution for gamma measurements between BG-1 and the Survey Area. The large number of potential outlier values in the Survey Area box plot indicate high skewness or possibly non-normally distributed data, instead of outlier values. This was further evaluated with the use of probability plots in Section 3.1.3 and statistical testing on the 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 Area, as would be expected in areas with varying levels of mineralization, naturally occurring radioactive material (NORM) and potential TENORM.

Figure 2B. Background Area 1 (BG-1) Gamma Radiation Box Plots



There are 11 potential outlier values shown for gamma data in the BG-1 dataset, as shown in Figure 2B. However, they are within the ranges of background gamma survey results measured at other sites, 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 box plot evaluation alone.

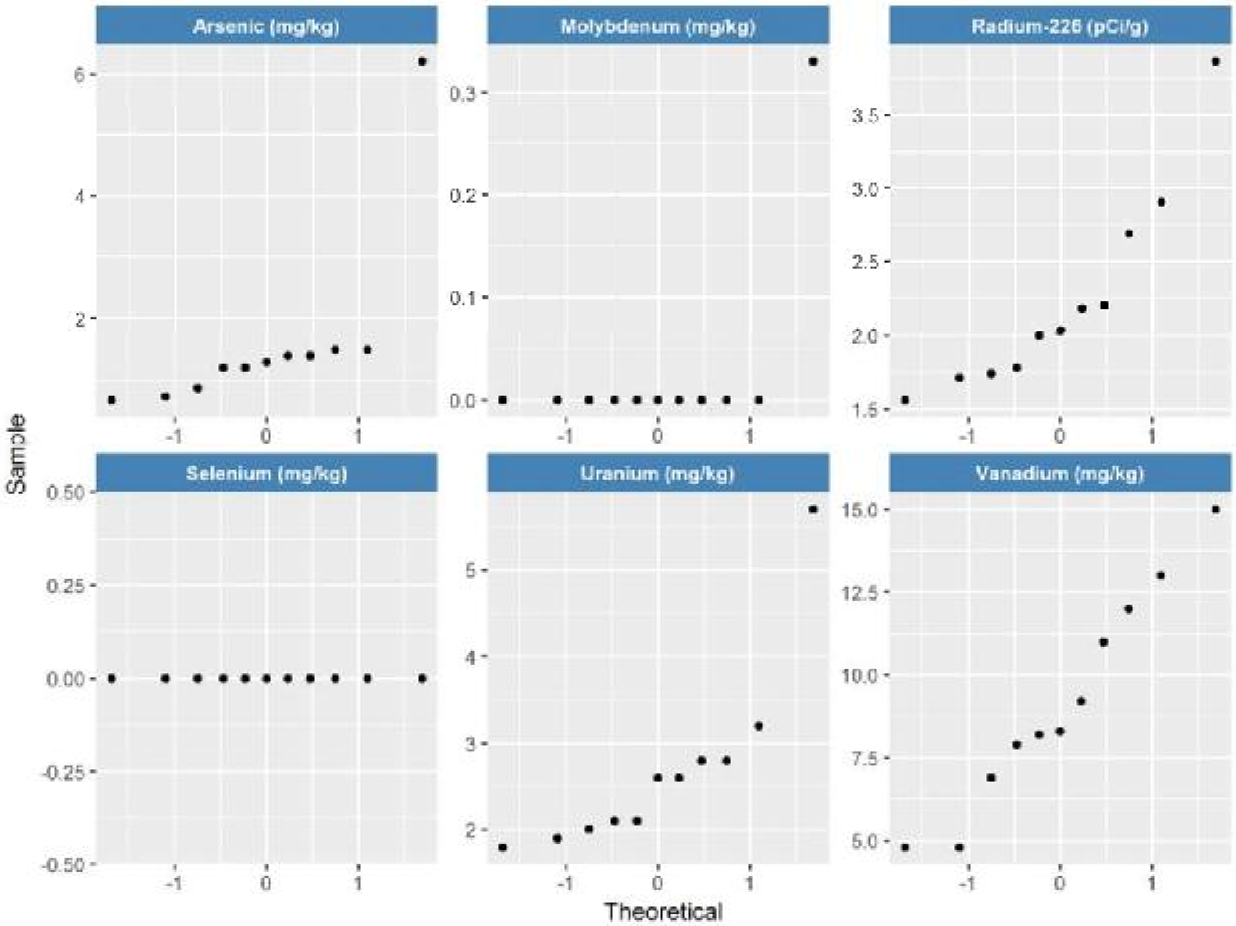
3.1.3 Probability Plots

The normal probability plot is a graphical technique for assessing whether or not a data set 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, 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.

3.1.3.1 Soil Sample Results Probability Plots

Figure 3 depicts the probability plots for metals and Ra-226 results at BG-1.

Figure 3. Background Area 1 (BG-1) Soil Sample Probability Plots

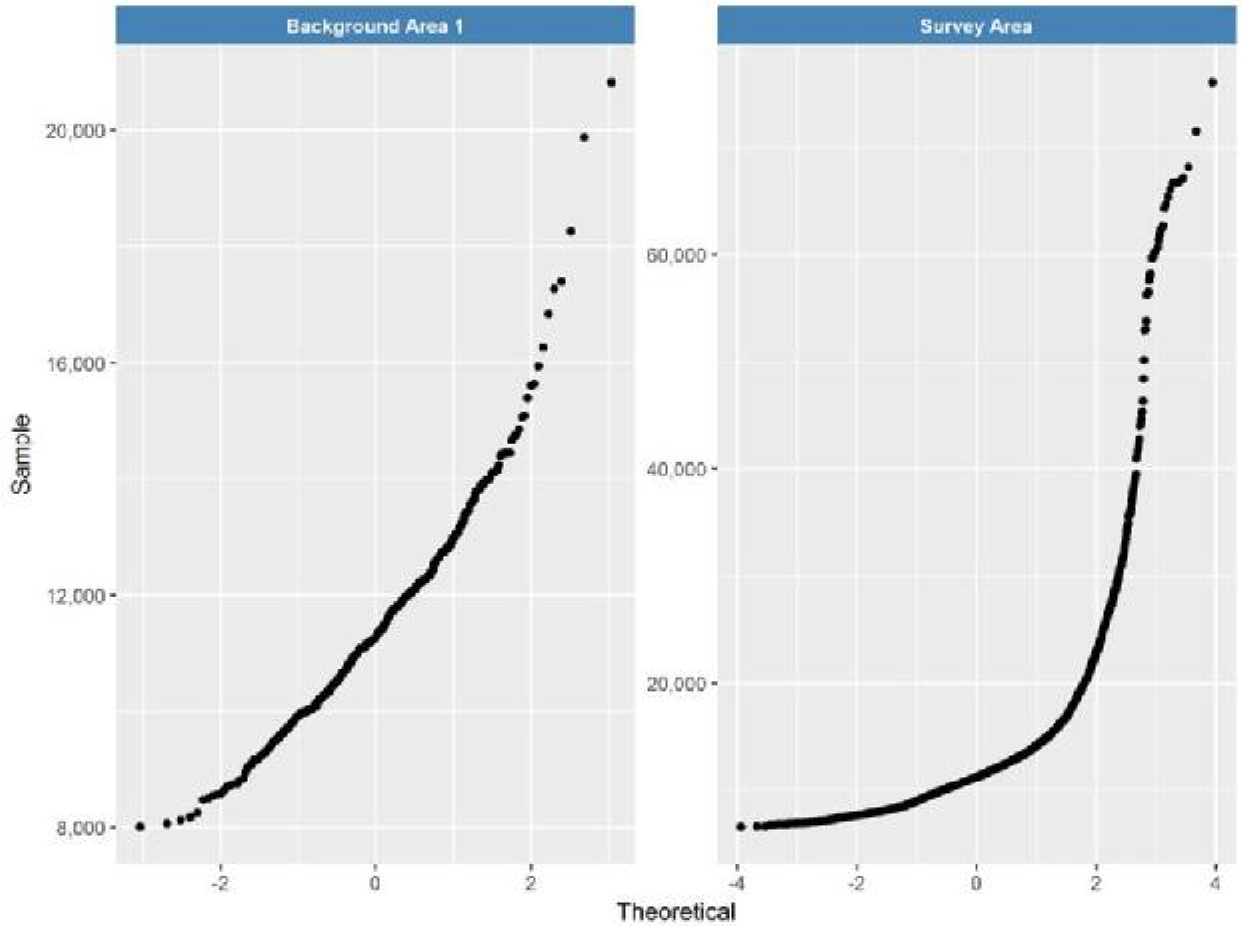


One value each for arsenic, molybdenum, Ra-226, and uranium were identified as potential outliers (i.e., outside 1.5 times the interquartile range) in the box plots in Figure 1B. When viewed in the probability plots in Figure 3, several of these values do appear to be substantially higher than the rest of their respective datasets. The maximum concentrations of arsenic, Ra-226, and uranium were tested for statistical significance as potential outliers in Section 3.1.4. The elevated point in the plot for molybdenum is the single detected value for this analyte in the BG-1 dataset, and therefore this point was not evaluated as a potential outlier. All 11 soil samples at BG-1 were non-detect for selenium (Se).

3.1.3.2 Gamma Survey Results Probability Plots

Figure 4 depicts the probability plots for gamma radiation results at BG-1 and the Survey Area.

Figure 4. Survey Area and Background Area 1 (BG-1) Gamma Probability Plots



The bulk of the gamma survey results indicate a normal distribution in the BG-1 dataset, and likely a non-normal distribution in the Survey Area dataset (Figure 4). When viewed in the probability plot, the 11 highest BG-1 gamma values, identified as potential outliers in the box plot 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 plot for the Survey Area gamma results confirms that the gamma radiation data are more log-normally distributed than the BG-1 gamma results. This suggests that these higher values are not potential outliers, but rather are representative of the spatial variability of gamma radiation in the Survey Area.

3.1.4 Potential Soil Sample Data Outliers

Four high potential outlier results, one value each for arsenic, molybdenum, Ra-226, and uranium are identified in the box plots in Figure 1A for BG-1. These values are:

- Arsenic: 6.20 mg/kg
- Molybdenum: 0.330 mg/kg
- Ra-226: 3.87 pCi/g
- Uranium: 5.70 mg/kg

The highest arsenic and uranium values do appear to be potential outliers relative to the rest of their respective datasets when viewed in the probability plots in Figure 3, while the Ra-226 value appears to conform to the general distribution of the BG-1 Ra-226 dataset. As noted in Section 3.1.3.1, the elevated molybdenum value in Figure 3 is the single detect in the 11 samples. Statistics cannot be performed on the non-detect results in the molybdenum dataset; the maximum concentrations of arsenic, uranium, and Ra-226 were tested for statistical significance as potential outliers.

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 at the 95% confidence level on each of the three, soil sample potential outlier values for arsenic, Ra-226 and uranium in the BG-1 datasets. The results of the Dixon’s Test are summarized in Table 1.

Table 1. Summary of Dixon's Test on Potential Outliers at Background Area 1 (BG-1)

Constituent	Location ID	Method	Hypothesis	p_Value	Conclusion
Arsenic	S486-BG1-003	Dixon test for potential outliers	Highest value 6.20 is a potential outlier	< 0.05	Hypothesis accepted
Ra-226	S486-BG1-003	Dixon test for potential outliers	Highest value 3.87 is a potential outlier	> 0.05	Hypothesis rejected
Uranium	S486-BG1-003	Dixon test for potential outliers	Highest value 5.70 is a potential outlier	< 0.05	Hypothesis accepted

The potential outlier test confirms that two of the three potential outliers tested, those for arsenic and uranium, are statistically significant (p value <0.05). The statistically significant potential outlier values for arsenic and uranium were further investigated by reviewing sample forms, field notes, laboratory reports and interviewing field staff. Field staff and field notes did not indicate anything abnormal about the locations where these samples were collected, and the laboratory reports do not show any data quality flags were applied to these values that would call their accuracy into question. While these two values are confirmed as potential outliers, they are thought to be representative of the natural variation at BG-1 as no scientific reason was found to justify removing the values from their respective datasets. However, descriptive statistics were calculated with and without these values for comparison (Section 3.3.1).

3.1.5 Potential Gamma Data Outliers

There were 11 potential outlier values observed for the BG-1 gamma dataset shown in the box plot in Figure 2B. When viewed in the probability plot in Figure 4, the 11 values appeared to conform to the general distribution of the BG-1 gamma dataset (i.e., the bulk of the data form a straight line). Because the number of values in the BG-1 gamma dataset is >30, Dixon's Test was not appropriate for potential outlier testing. Instead, because the values appear to be 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.

Table 2. Potential Gamma Outlier Interquartile Range, Z Score, t Score and Chi Squared Score Results

Value (cpm)	Interquartile Range Result	Z Score Result	t Score Result	Chi Sq Score Result
20,837	High	Potential Outlier	Potential Outlier	Potential Outlier
19,874	High	Potential Outlier	Potential Outlier	Potential Outlier
18,259	High	Potential Outlier	Potential Outlier	Potential Outlier
17,404	High	Potential Outlier	Potential Outlier	Potential Outlier
17,277	High	Potential Outlier	Potential Outlier	Potential Outlier
16,852	High	Potential Outlier	Potential Outlier	Potential Outlier
16,269	High	Potential Outlier	Potential Outlier	Potential Outlier
15,940	High	Potential Outlier	Potential Outlier	Potential Outlier
15,638	High	Potential Outlier	Potential Outlier	Potential Outlier
15,612	High	Potential Outlier	Potential Outlier	Potential Outlier
15,401	High	Potential Outlier	Potential Outlier	Potential Outlier

cpm Counts per minute

These 11 potential outlier values represent 2.6 percent of the 417 result dataset. One explanation for the potential outliers in the gamma radiation dataset may be the presence of a localized source of radiation within the BG-1 area (e.g., greater level of mineralization). The 11 potential outliers were not observed to be collocated, indicating that they are representative of the spatial variation in gamma radiation at BG-1. There is no scientific reason to reject these values; however, descriptive statistics were calculated with and without these values for comparison (Section 3.3.2).

Potential outlier values for the Survey Area gamma dataset appear in the Figure 2A box plots. However, because of the non-linear shape and continuous distribution of gamma results shown in the probability plot in Figure 4, these values are considered to be representative of the heterogeneous nature of radioactive materials within the Survey Area and are not outlier values. Figures 4-1a and 4-1b of the RSE Report show that while gamma results for the majority of the Survey Area are within the range of background, localized areas of elevated gamma results are present.

3.2 COMPARE DATA POPULATIONS

Group comparison analyses provide insight into the relative concentrations of constituents between background reference areas and the Survey Area. 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 only one background reference area was selected to represent the 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, topographic gradient, distance from the site being represented, wind direction and non-impacted conditions 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 BG-1 and the Survey Area. Relative data distributions were investigated by evaluating the box plots and probability plots in Figures 1A through 4, and by hypothesis testing with the non-parametric Mann-Whitney test, as applicable.

3.2.1 Evaluation of Box Plots

3.2.1.1 Soil Sample Box Plots

The box plot comparison in Figures 1A and 1B suggests that mean metals and Ra-226 values may differ between BG-1 and the Survey Area. When interpreting the soil sample box plots in Figures 1A and 1B, it is important to note that samples at BG-1 were collected randomly, while samples in the Survey Area were collected judgmentally.

Observations from the box plots in Figures 1A and 1B indicate:

- Arsenic. Arsenic results appear elevated in the Survey Area with respect to BG -1.
- Molybdenum. Molybdenum results appear elevated in the Survey Area with respect to BG-1.
- Ra-226. Ra-226 results appear elevated in the Survey Area with respect to BG-1.
- Selenium. Selenium results appear elevated in the Survey Area with respect to BG-1.
- Uranium. Uranium results appear elevated in the Survey Area with respect to BG-1.
- Vanadium. Vanadium results appear elevated in the Survey Area with respect to BG-1.

3.2.1.2 Gamma Radiation Box Plots and Probability Plots

The box plot comparison in Figures 2A and 2B suggests that mean, median and interquartile range values are similar between BG-1 and the Survey Area. Gamma radiation data distributions between BG-1 and the Survey Area are not similar (normal vs. non-normal, respectively).

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 BG-1 were collected randomly, while soil samples in the Survey Area 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 BG-1 and the Survey Area. Gamma radiation data, however, do represent non-judgmental sampling, and so the Mann-Whitney test was appropriate for comparison between BG-1 and the Survey Area (Table 3). Therefore, the test was performed 2-sided on the BG-1 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., 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 Area 1 (BG-1) vs Survey Area	0.449	No Significant Difference
Background Area 1 (BG-1) vs Background Area 1 (BG-1) Potential Outliers Excluded	0.513	No Significant Difference
Background Area 1 (BG-1) Potential Outliers Excluded vs Survey Area	0.975	No Significant Difference

The results of the Mann-Whitney testing on gamma radiation survey results in Table 3 indicate the following:

- Mean gamma results are not shown to be statistically elevated in the Survey Area with respect to BG-1 according to the Mann-Whitney test results in Table 3. However, BG-1 may not fully represent the degree of natural mineralization present at the Survey Area, as indicated by the lower maximum counts at BG-1 relative to the Survey Area, though the bulk of the data overlap as shown in the box plots in Figures 2A and 2B.

- The inclusion or removal of potential outlier values has no effect on the results of the Mann-Whitney test between BG-1 and the Survey Area (i.e., there is no statistically significant difference in gamma results between the Survey Area and BG-1 with and without BG-1 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 included gamma radiation, arsenic, uranium, vanadium, and Ra-226. There was only one detected value for molybdenum in the soil sample dataset, and the dataset for selenium was 100 percent non-detect; therefore, no statistics were calculated for these constituents.

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 soil sample results.

Table 4. Summary of Soil Sampling Results

Area	Statistic	Arsenic (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Ra-226 (pCi/g)
Background Area 1 (BG-1) All Data	Total Number of Observations	11	11	11	11	11	11
	Percent Non-Detects	--	91%	100%	--	--	--
	Minimum[1]	0.680	--	--	1.80	4.80	1.56
	Minimum Detect[2]	--	0.330	--	--	--	--
	Mean[1]	1.64	--	--	2.69	9.19	2.24
	Mean Detects[2]	--	0.330	--	--	--	--
	Maximum[1]	6.20	--	--	5.70	15.0	3.87
	Maximum Detect[2]	--	0.330	--	--	--	--
	Distribution	Unknown	Not Calculated	Not Calculated	Gamma	Normal	Gamma
	Coefficient of Variation[1]	0.943	--	--	0.406	0.355	0.303
	UCL Type	95% Chebyshev (Mean, Sd) UCL	Not Calculated	Not Calculated	95% Adjusted Gamma UCL	95% Student's-t UCL	95% Adjusted Gamma UCL
	UCL Result	3.66	Not Calculated	Not Calculated	3.41	11.0	2.71
	UTL Type	UTL Non-Parametric	Not Calculated	Not Calculated	UTL Gamma WH	UTL Normal	UTL Gamma WH
	UTL Result	6.20	Not Calculated	Not Calculated	6.07	18.4	4.42
Background Area 1 (BG-1) Excluding Potential Outliers[3]	Total Number of Observations	10	--	--	10	--	10
	Minimum[1]	0.680	--	--	1.80	--	1.56
	Mean[1]	1.18	--	--	2.39	--	2.08
	Maximum[1]	1.50	--	--	3.20	--	2.91
	Distribution	Normal	--	--	Normal	--	Normal
	Coefficient of Variation[1]	0.262	--	--	0.197	--	0.209
	UCL Type	95% Student's-t UCL	--	--	95% Student's-t UCL	--	95% Student's-t UCL
	UCL Result	1.36	--	--	2.66	--	2.33
	UTL Type	UTL Normal	--	--	UTL Normal	--	UTL Normal
	UTL Result	2.08	--	--	3.76	--	3.35
Survey Area	Total Number of Observations	17	17	17	17	17	17
	Percent Non-Detects	--	65%	53%	--	--	--
	Minimum[1]	0.440	--	--	0.480	5.20	0.510
	Minimum Detect[2]	--	0.190	1.00	--	--	--
	Mean[1]	3.76	--	--	29.0	234	28.9
	Mean Detects[2]	--	0.387	1.54	--	--	--
	Maximum[1]	17.0	--	--	250	1,400	223
	Maximum Detect[2]	--	0.790	3.70	--	--	--
	Distribution	Gamma	Normal	Normal	Unknown	Unknown	Gamma
	Coefficient of Variation[1]	1.05	--	--	2.10	1.93	1.86
	CV Detects[2]	--	0.610	0.586	--	--	--
	UCL Type	95% Adjusted Gamma UCL	95% KM (t) UCL	95% KM (t) UCL	99% Chebyshev (Mean, Sd) UCL	99% Chebyshev (Mean, Sd) UCL	95% Adjusted Gamma UCL
	UCL Result	5.81	0.265	1.18	176	1,321	60.1
	UTL Type	UTL Gamma WH	UTL KM Normal	UTL KM Normal	UTL Non-Parametric	UTL Non-Parametric	UTL Gamma WH
	UTL Result	15.7	0.689	3.09	250	1,400	185

[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] No potential outliers were identified for molybdenum, selenium or vanadium in this area.
CV Coefficient of variation
KM Kaplan 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

As described in Section 3.2.1.1, arsenic, molybdenum, selenium, uranium, vanadium, and Ra-226 results appear elevated at the Survey Area relative to BG-1. Molybdenum was detected only once, and selenium was not detected, in samples collected from BG-1. However, an important consideration when comparing concentrations of metals and Ra-226 between BG-1 and the Survey Area is that the background reference area was selected to be 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 BG-1 was conducted in a random manner, whereas soil sampling for metals and Ra-226 in the Survey Area was judgmental. As a result, it's not surprising that metals and Ra-226 concentrations in the Survey Area appear to be elevated relative to concentrations in BG-1. It should be noted, however, that concentrations of several of the metals measured in the Survey Area 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 maximum detected concentration of arsenic in the Survey Area is within the typical range reported for Western U.S soils, and may not be related to the uranium mineralization. The maximum concentrations recorded for uranium and vanadium in the Survey Area were above the typical range reported for Western U.S soils. These concentrations were detected in soils associated with the potential staging area, potential haul road, and an area where rim stripping may have occurred in the southwestern area of the Site (see RSE Report Section 4.6). Elevated Ra-226 concentrations were also detected in these Survey Area locations.

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 Area 1 (BG-1) All Data	Total Number of Observations	417
	Minimum	8,013
	Mean	11,491
	Median	11,292
	Maximum	20,837
	Distribution	Normal
	Coefficient of Variation	0.153
	UCL Result	11,632
	UTL Type	UTL Normal
	UTL Result	14,600
Background Area 1 (BG-1) Excluding Potential Outliers	Total Number of Observations	406
	Minimum	8,013
	Mean	11,336
	Median	11,246
	Maximum	15,091
	Distribution	Normal
	Coefficient of Variation	0.130
	UCL Result	11,456
	UTL Type	UTL Normal
	UTL Result	13,947
Survey Area	Total Number of Observations	12,321
	Minimum	6,565
	Mean	12,020
	Median	11,241
	Maximum	76,181
	Distribution	Normal
	Coefficient of Variation	0.374
	UCL Result	12,086
	UTL Type	UTL Normal
	UTL Result	19,508

cpm Counts per minute

The box plots in Figures 2A and 2B indicate that some of the very highest gamma results measured within the Survey Area exceed the maximum gamma results measured in BG-1. As indicated in Table 3 and by the Mann-Whitney test, however, the mean gamma value for the

Survey Area is not statistically elevated compared to the mean gamma value for BG-1, and the bulk of gamma values in each area overlap. The background reference area was selected to represent the geology present in the region around the Site that were not disturbed by mining; the fact that the background reference area was not historically selected as part of a mine claim is consistent with the elevated gamma results at the Survey Area relative to BG-1 in spite of the amount of overlap between the datasets.

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 the Survey Area, based on BG-1, are presented in Tables 4 and 5 and in Section 3.3 and are as follows:

- Arsenic (mg/kg): 6.20
- Molybdenum (mg/kg): None (10/11 results non-detect)
- Selenium (mg/kg): None (all results non-detect)
- Uranium (mg/kg): 6.07
- Vanadium (mg/kg): 18.4
- Ra-226 (pCi/g): 4.42
- Gamma radiation measurements (cpm): 14,600

5.0 REFERENCES

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Appendix E Cultural and Biological Resource Clearance Documents

BIOLOGICAL EVALUATION

For the Proposed:

Oak 124 / Oak 125
Abandon Uranium Mine - Environmental Response Trust Project

Sponsored by:

MWH Global / 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 Navajo Nation AUM Environmental Response Trust—First Phase was established to evaluate certain abandoned uranium mines located across the Navajo Nation. The project requires investigation of these sites prior to potential remediation activities in the future. MWH Global, a division of Stantec (MWH), will conduct exploratory activities at the Oak 124 / Oak 125 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

The Oak 124 / Oak 125 site is located in San Juan County New Mexico, approximately 20 miles southwest of Shiprock, NM at an elevation of approximately 5,580 feet. Global Positioning System coordinates are 36°42'33” N by 109°1'30” W NAD 83. The site is located on Navajo Tribal Trust Lands within the Bureau of Indian Affairs (BIA) Shiprock Agency. The legal description of the project surface location is as follows: Section 36, Township 29 North, Range 21 West, New Mexico Principal Meridian. Project area maps are provided in Appendix A.

2.2. Estimated Disturbance

MWH proposes a phased approach to scientific investigations at the Oak 124 / Oak 125 AUM. The study area encompasses the claim boundary and a 100-foot perimeter buffer zone for a total of approximately 6.9 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 Oak 124 / Oak 125 includes the mine boundary and a 100-foot perimeter buffer zone for a total of approximately 6.9 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 northwestern New Mexico within the USEPA designated Arizona/New Mexico Plateau Level III Ecoregion. The Arizona/New Mexico Plateau occurs primarily in Arizona, Colorado, and New Mexico, with a small portion in Nevada. This ecoregion is approximately 45,870,500 acres, and the elevation ranges from 2,165 to 11,949 feet. The ecoregion’s landscapes include low mountains, hills, mesas, foothills, irregular plains, alkaline basins, some sand dunes, and wetlands. This ecoregion is a large transitional region between the semiarid grasslands to the east, the drier shrublands and woodlands to the north, and the lower, hotter, less vegetated areas to the west and south.

The Oak 124 / Oak 125 PPA is located approximately 0.5 mile northeast of Horse Mesa and 1.0 mile southeast of an igneous plug rock formation. Terrain is moderately sloping with deeply cut washes located to the southeast and south.

Flora

Vegetation communities found within the Arizona/New Mexico Plateau ecoregion 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 Oak 124 / Oak 125 site consists of rocky soils with sporadic shrubs and grasses and a few piñon-juniper trees.

Fauna

Wildlife or evidence of wildlife observed within or near the PPA included turkey vulture (*Cathartes aura*), common raven (*Corvus corax*), and cottontail rabbit (*Sylvilagus* sp.). No signs of consistent raptor use such as whitewash or nests were observed. No prairie dog (*Cynomys* sp.) burrows were recorded within the PPA or immediate vicinity. 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 southeasterly though an unnamed wash for one mile into Red Wash. Red Wash joins the San Juan River approximately 15 miles north of the project area. 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 15 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.

The results of Redente's spring 2016 plant surveys will be incorporated into this report. A follow up plant survey will be completed in July 2016 by Redente. Results from the July survey will be presented in a subsequent document and attached to this report as Appendix C.

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 (02ENNM00-2016-SLI-0466) on April 20, 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 by 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.

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 IPaC Official Species List for the Oak 124 / Oak 125 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 dense riparian 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 appropriate riparian habitat for species to occur.
FISHES				

Table 1: USFWS IPaC Official Species List for the Oak 124 / Oak 125 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
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.
Razorback sucker (*Xyrauchen texanus*)	Endangered with Designated Critical Habitat	Restricted to the Colorado River and a few warm-water tributaries; rare in Colorado River in Marble Canyon and the mouth of the Little Colorado River, and San Juan arm of Lake Powell.	Pre- and post-spawning suckers mostly use low-flow areas (backwaters over sand and silt substrate, deep eddies, and impoundments). Young-of-year use warm backwaters along shorelines. Irrigation canals and ponds connected to San Juan River 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.
Zuni bluehead sucker (*Catostomus discobolus yarrowi*)	Endangered	Native to headwater streams of the Little Colorado River in east-central AZ and west-central NM; current range in NM is limited to the upper Río Nutria drainage.[2]	Low-velocity pools and pool-runs with seasonally dense perilithic and periphytic algae, particularly shady, cobble/boulder/bedrock substrates in streams with frequent runs and pools.[2]	No potential. Action area does not provide suitable habitat for species to occur.
MAMMALS				
Canada lynx (*Lynx canadensis*)	Threatened	Rocky Mountains	Moist boreal (spruce-fir) forests and in the western US, subalpine forests that have cold, snowy winters and a high-density snowshoe hare prey base.[1,2]	Project area does not provide suitable habitat for species to occur.

Table 1: USFWS IPaC Official Species List for the Oak 124 / Oak 125 Project

Species	Status	Occurrence Within Region	Habitat	Potential to Occur within Action Area
New Mexico meadow jumping mouse (*Zapus hudsonius luteus*)	Endangered	Endemic to New Mexico, Arizona, and a small area of southern Colorado.[1]	Nests in dry soils, but requires moist, streamside, dense riparian/wetland vegetation up to an elevation of about 8,000 feet; appears to only utilize two riparian community types: 1) persistent emergent herbaceous wetlands (i.e., beaked sedge and reed canary grass alliances); and 2) scrub-shrub wetlands (i.e., riparian areas along perennial streams that are composed of willows and alders). It especially uses microhabitats of patches or stringers of tall dense sedges on moist soil along the edge of permanent water.[1]	Project area does not provide suitable habitat for species to occur.
PLANTS				
Knowlton's Cactus (*Pediocactus knowltonii*)	Endangered	One viable population along Los Piños River in San Juan County.[2]	Occurs on tertiary alluvial deposits that have formed gravelly, dark, sandy loams on slopes or hills. It is found under the shade of trees and shrubs and in open areas in dry piñon-juniper woodlands at 1800-2000 m elevation. [2]	No potential. Action area does not provide suitable habitat for species to occur. No species found during the 2016 Redente surveys.[4]
Mancos Milk-Vetch (*Astragalus humillimus*)	Endangered	Known from 20-square mile area in San Juan County.[2]	Occurs on Point Lookout and Cliff House sandstones, and tan Cretaceous sandstones of the Mesa Verde series.[2]	No potential. Action area does not provide suitable habitat for species to occur. No species found during the 2016 Redente surveys.[4]
Mesa Verde Cactus (*Sclerocactus mesae-verdae*)	Threatened	Known from Hogback ACEC area and Navajo Nation in San Juan County.[2]	Dry low exposed hills and mesas in full sun of Mancos or Fruitland clays in the desert at about 1200-2000 m elevation.[2]	No potential. Action area does not provide suitable habitat for species to occur. No species found during the 2016 Redente surveys.[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 1 includes ten (10) ESA-listed species that have the potential to occur in the project area based on the USFWS IPaC Official Species List. All ten (10) species have been eliminated from further discussion in this report because the action area does not provide suitable habitat for them to occur. None of the species in Table 1 were observed during surveys of the proposed project area or immediate surroundings. No species in Table 1, or critical habitats thereof, exist within or adjacent to the proposed project area. 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, the golden eagle (*Aquila chrysaetos*) is known 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	No potential. Action area does not provide suitable habitat for species to occur.

Species	Status	Habitat Associations	Potential to Occur in Project or Action Area
		wooded/forested habitats; Forage over riparian woodlands, coniferous & deciduous forests, shrublands, prairies. [3]	
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs. [3]	Action area provides potential foraging habitat for species to occur.
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.
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. No species found during the 2016 Redente surveys.[5]
Rydberg's Thistle (*Cirsium rydbergii*)	NESL G4	Hanging gardens, seeps and sometimes stream banks below hanging gardens, 3300-6500 ft. [3]	No potential. Action area does not provide suitable habitat for species to occur. No species found during the 2016 Redente surveys.[5]
Alcove Bog-orchid (*Platanthera zothecina*)	NESL G3	Seeps, hanging gardens, and moist stream areas from the desert shrub to pinion-juniper & Ponderosa pine/mixed conifer communities. Known populations occur between 4000 and 7200ft elevation. [3]	No potential. Action area does not provide suitable habitat for species to occur. No species found during the 2016 Redente surveys.[5]
Alcove Death Camass (*Zigadenus vaginatus*)	NESL G3	Hanging gardens in seeps and alcoves, mostly on Navajo Sandstone, 3700 – 6700ft. [3]	No potential. Action area does not provide suitable habitat for species to occur. No species found during the 2016 Redente surveys.[5]
Navajo sedge *(Carex specuicola)*	USFWS Threatened	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. No species found during the 2016 Redente surveys.[5]

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 eleven (11) NESL and Navajo Species of Concern that have the potential to occur in the project area based on the 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*), American peregrine falcon (*Falco peregrinus*), Parish's alkali grass *(Puccinellia parishii)*, Rydberg's thistle (*Cirsium rydbergii*), Navajo sedge (*Carex specuicola*), Alcove

death camass (*Zigadenus vaginatus*), and Alcove bog orchid (*Platanthera zothecina*). None of these species were observed during surveys of the proposed project area or immediate surroundings. There would be no direct, indirect or cumulative impacts to these species.

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			
Golden eagle (*Aquila chrysaetos*)	NESL G3	In the west, mostly open habitats in mountainous, canyon terrain. Nests primarily on cliffs.[3]	Action area provides potential foraging habitat for species to occur.
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.

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 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.	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	No suitable habitat is present within the action area for species to occur.

	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.	
Loggerhead shrike (*Lanius ludovicianus*)	Open country interspersed with improved pastures, grasslands, and hayfields. Nests in sagebrush areas, desert scrub, and woodland edges.	No suitable habitat is present within 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.	Marginal habitat is present within the action area for species to occur. Lack of significant sagebrush shrubland likely a limiting factor.
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.	Marginal 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.	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 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 Oak 124 / Oak 125 includes the ERT mine boundary and a 100-foot perimeter buffer zone for a total of approximately 6.9 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

Due to the mobility of adult raptors and the lack of appropriate nesting sites in the vicinity of the proposed project area, it is unlikely that the proposed project would result in 1) injury to a raptor, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. Short term audial and visual disturbances associated with the Phase II activity could cause minor indirect habitat loss by temporarily deterring raptors from using available habitat adjacent to the proposed project area.

5.1.2. Migratory Birds

The PPA encompasses approximately 6.9 acres of potential migratory bird habitat in the form of Great Basin Desert scrub. 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 minor.

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 6.9 acres of potential migratory bird habitat in the form of Great Basin Desert scrub. 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 15 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 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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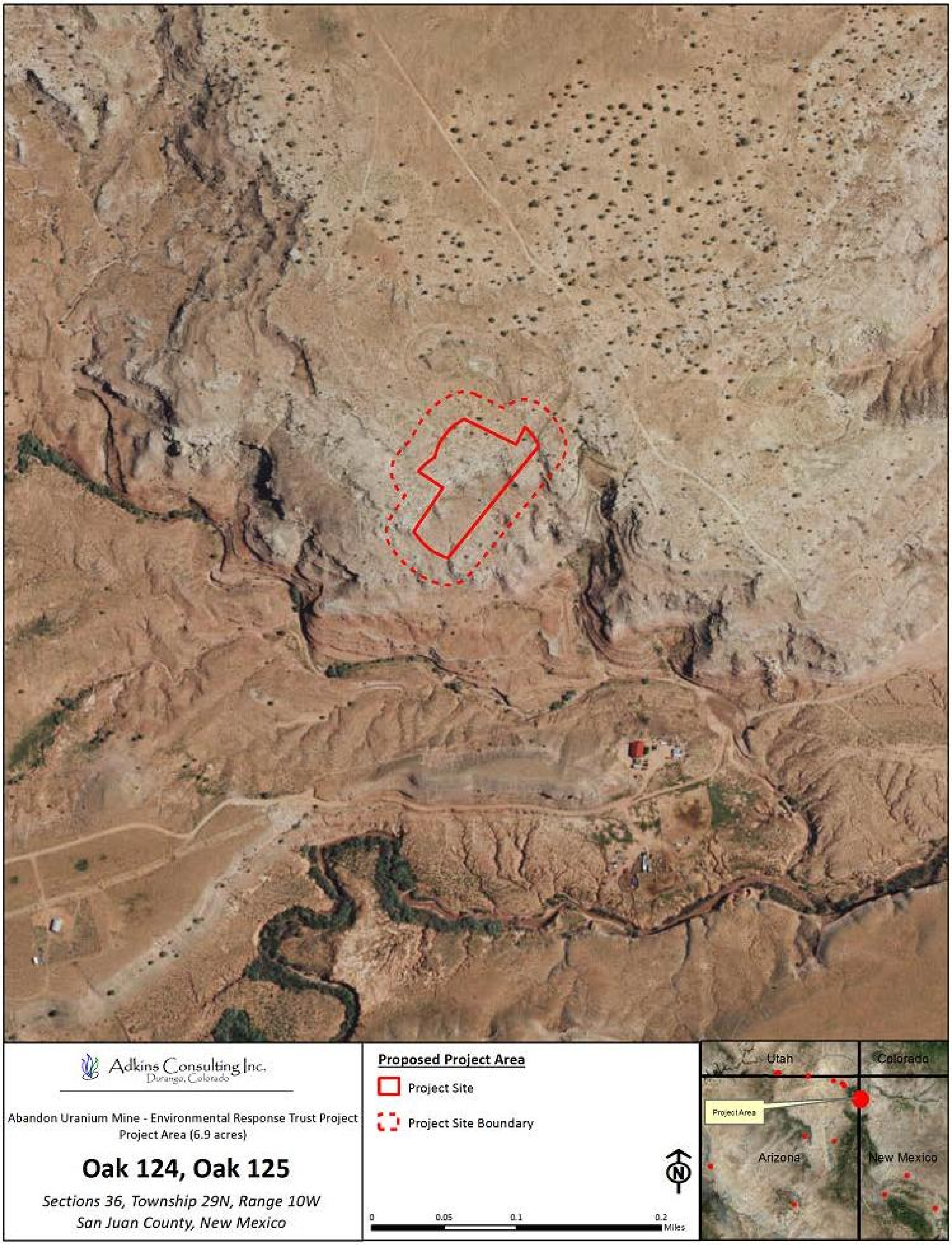
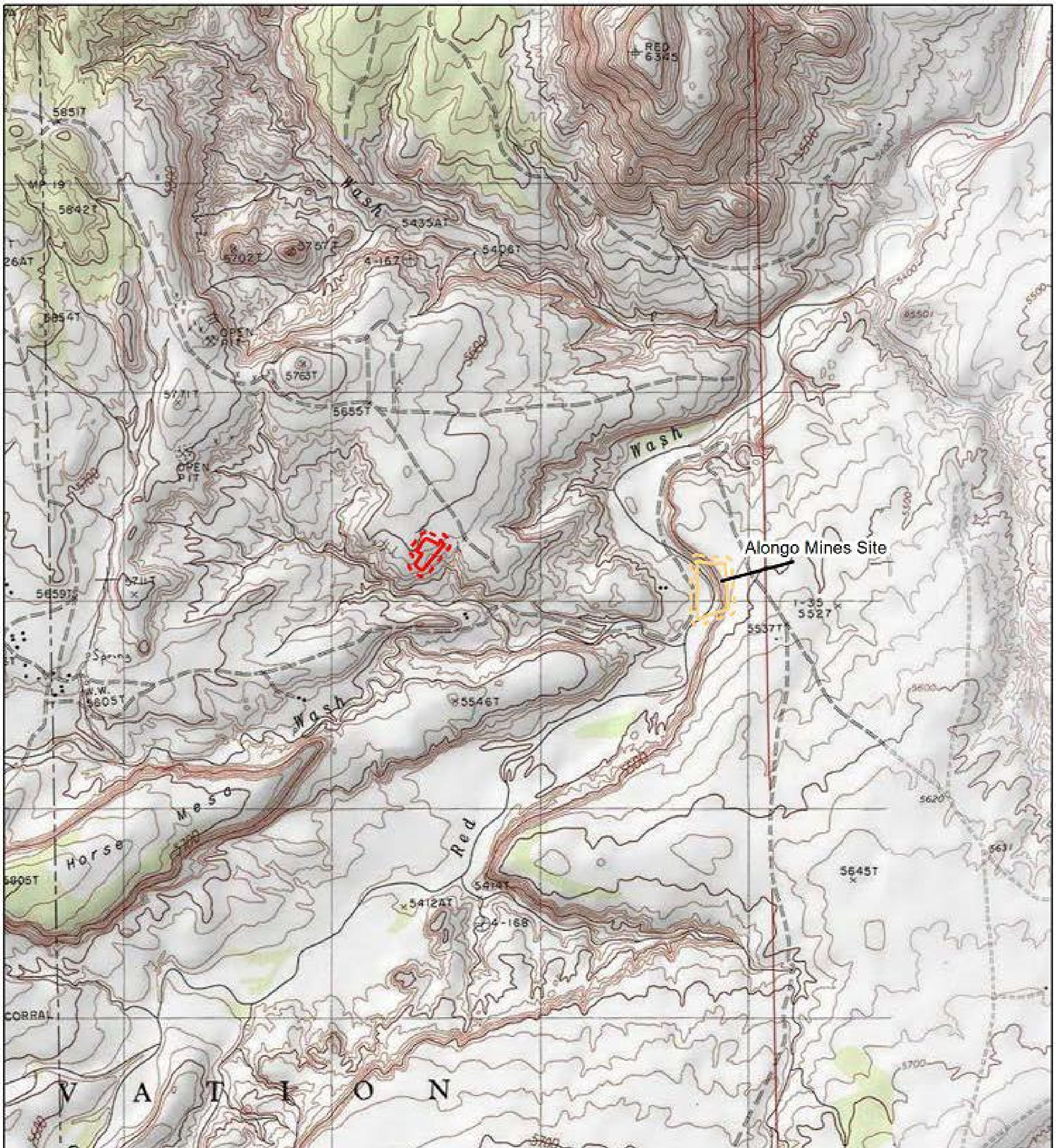
APPENDIX A. MAPS





Adkins Consulting Inc.
Durango, Colorado

Abandon Uranium Mine - Environmental Response Trust Project
Project Area (6.9 acres)

Oak 124, Oak 125

Sections 36, Township 29N, Range 10W
San Juan County, New Mexico

Proposed Project Area

- Project Site
- Project Site Boundary

0 0.25 0.5 1 Miles

APPENDIX B. PHOTOGRAPHS

General habitat in PPA

Panoramic View from PPA

APPENDIX C. REDENTE PLANT SURVEY REPORT

Navajo Nation AUM Environmental Response Trust

Plant Survey Report for Species of Concern At Oak 124, Oak 125 Project Site San Juan County, New Mexico July 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 Oak 124, Oak 125 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

Oak 124, Oak 125 is located in San Juan County New Mexico, approximately 32 km (20 miles) west of Shiprock, New Mexico at an elevation of approximately 1,703 m (5,586 ft). Global Positioning System coordinates are 36° 42' 17" N by 109° 01' 30" W (North American Datum of 1983). The site is located on Tribal Trust Land (TTL).

Environmental Setting

Climate

The climate of the Oak 124, Oak 125 site is classified as semi-arid, with an average annual precipitation of 200 mm (7.8 in) with the greatest precipitation months occurring in July and August (USDA 2001). Average annual temperature is 12.7° C (55° F).

Soils

The U.S. Department of Agriculture (USDA) Soil Survey for San Juan County was published in 2001 in cooperation with the Bureau of Indian Affairs and the Navajo Nation. This area of San Juan County is mainly escarpments separated by major riverwashes, with slopes that range from 8 to 45%. The general mapping unit for the area is Shalet-Rock Outcrop Complex and the soil type is Shalet; an eolian soil that is classified as a sandy clay loam and is shallow in depth and well drained (USDA 2001). The site is characterized by rock outcrops intermixed with the Shalet soil.

Plant Community Type

The vegetation on the Oak 124, Oak 125 site is part of the Colorado Plateau Shrub-Grassland type (USDA 2001). The most common species on the site include blue grama (*Bouteloua gracilis*), alkali sacaton (*Sporobolus airoides*), Indian ricegrass (*Achnatherum hymenoides*), broom snakeweed (*Gutierrizia sarathrae*), shadscale saltbush (Atriplex confertifolia), Bigelow sagebrush (*Artemisia bigelovii*), Mormon tea (*Ephedra viridis*), and oneseeded juniper (*Juniperus monosperma*).

Land Use

The land type on the Oak 124, Oak 125 site is rangeland and the principal land uses are domestic grazing and 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 identified five plant species of concern that may occur in the project area— Parish's alkaligrass (*Puccinellia parishii*), Alcove death camas (*Zigadenus vaginatus*), Alcove bog-orchid (*Platanthera zothecina*), Rydberg's thistle (*Cirsium rydbergii*), and Navajo sedge (*Carex specuicola*). The USFWS listed Knowlton's cactus (*Pediocactus knowltonii*), Manco's milkvetch (*Astragalus humillimus*), and Mesa Verde cactus (*Sclerocactus mesae-verdae*) as additional threatened species that may occur in the 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 spring (May) and summer (July) of 2016 during the appropriate season to observe the phenological characteristics of the special status plant species that were necessary for identification (Table 1).

Table 1. Species of Concern and Survey Period

Species of Concern	Survey Period
Rydberg's thistle (*Cirsium rydbergii*)	May
Knowlton's cactus (*Pediocactus knowltonii*)	May
Manco's milkvetch (*Astragalus humillimus*)	May
Mesa Verde cactus (*Sclerocactus mesae-verdae*)	May
Parish's alkaligrass (*Puccinellia parishii*)	May
Alcove death camas (*Zigadenus vaginatus*)	July
Alcove bog-orchid (*Platanthera zothecina*)	July
Navajo sedge (*Carex specuicola*)	July

The botanical survey team was assisted during the survey by GIS trained staff from MWH with training specifically in the use of the Trimble GeoExplorer 6000 Series and 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 meandering "transect" lines through each area and looked for suitable habitat for these species, such as alkali seeps for *Puccinellia parishii,* seeps and hanging gardens for *Cirsium rydbergii, Platanthera zothecina, Zigadenus vaginatus* and *Carex specuicola*, rolling-gravelly hills for *Pediocactus knowltonii*, small depressions and sand-filled cracks in light colored sandstone on or near ledges and mesa tops for *Astragalus humillimus*, and clay –rich soils for *Sclerocactus mesae-verdae*. The most emphasis was placed in areas with suitable habitat for the species of concern. If a 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

A total of 8 plant species of concern were identified as potentially occurring within the proximity of the project area. These species included *Zigadenus vaginatus*, *Puccinellia parishii*, *Platanthera zothecina*, *Cirsium rydbergii*, *Carex specuicola Pediocactus knowltonii*, *Astragalus humillimus*, and *Sclerocactus mesae-verdae*.

Zigadenus vaginatus is a native perennial forb that grows in hanging gardens in seeps and alcoves, mostly on Navajo sandstone. This species is endemic to the Colorado Plateau in southern Utah and northern Arizona at elevations between 1,127 and 2,042 m (3,698 and 6,999 ft). *Puccinellia parishii* 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 seeps, springs and seasonally wet areas and washes at elevations between 1,525 and 2,195 m (5,003 and 7,201 ft). *Platanthera zothecina* is a native perennial forb that grows in seeps, hanging gardens and moist stream areas from the desert shrub to the Pinyon-Juniper communities. This species is found in New Mexico, Utah and Arizona at elevations between 1,220 and 2,195 m (4,003 and 7,201 ft). *Cirsium rydbergii* is a native perennial forb that occurs in hanging gardens, seeps and stream banks below hanging gardens at elevations between 1,005 and 1,980 m (3,297 and 6,946 ft). Its distribution includes southern San Juan County along with Coconino and Apache Counties in Arizona. *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. *Pediocactus knowltonii* is one of the rarest cacti in the U.S. and is known to occur only in a very limited area in San Juan County, New Mexico. Its habitat occurs on alluvial deposits that form rolling-gravelly hills dominated by pinyon, juniper and black sagebrush. *Astragalus humillimus* is a native perennial forb that grows in small depressions and sand-filled cracks in light colored sandstone on or near ledges and mesa tops in San Juan County New Mexico and Montezuma County Colorado between 1,500 and 1,800 m (4,921 and 5,905 ft). *Sclerocactus mesae-verdae* is a native cacti that grows in clay-rich soils on the tops of hills, on benches and slopes mostly in saltbush communities with low plant cover. It occurs in San Juan County in New Mexico and Montezuma County in Colorado at elevations between 1,493 and 1,675 m (4,898 and 5,945 ft).

The survey at Oak 124, Oak 125 on May 6 and July 20, 2016 did not identify any of the eight species that have been listed as potential species of concern for this site. Many of the species occur in seeps, alcoves or hanging gardens (i.e. *Zigadenus vaginatus*, (*Puccinellia parishii*, *Platanthera zothecina*, *Cirsium rydbergii*, and *Carex specuicola*) that were not found on the site. There were seasonally wet areas, but there was no evidence of alkalinity on the soil surface from salt accumulation, a characteristic important for *Puccinellia parishii*. Habitat for *Pediocactus knowltonii*, *Astragalus humillimus*, and *Sclerocactus mesae-verdae* was not identified at Oak 124, Oak 125.

Photo #1—Overview of general landscape and plant community at Oak 124, Oak 125.

Photo #2—Overview of general landscape and plant community at Oak 124, Oak 125.

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USFWS. 1996. Guidelines for Conducting and Reporting Botanical Inventories for Federally Listed, Proposed, and Candidate Plants. Sacramento Fish and Wildlife Office, Sacramento, California.

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

PO Box 1480
Window Rock, AZ
86515

P 928.871.6472
F 928.871.7603

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.
- **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.
- **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.
- **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

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.

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	Tamara Billie	9/9/16
Conditions:	☑ Yes	☐ No	The Navajo Nation Historic Preservation Office	Date
Navajo Region Approval	☑ Yes	☐ No	[signature]	SEP 2 8 2016
			BIA – Navajo Regional Office Acting	Date

6/21/16

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.: Oak 124/Oak 125 - 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 6.9 acres.

LOCATION: 36°42'33"N 109°01'30"W, Red Valley Chapter, San Juan County, New Mexico

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-Oak 124/Oak 125 Abandoned Uranium Mine Project/AUG 2016/Lori Gregory, Plant Survey Report for Species of Concern At Oak 124/Oak 125 Project Site/JUL 2016/Redente Ecological Consultants

SIGNIFICANT BIOLOGICAL RESOURCES FOUND: Area 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.

<u>POTENTIAL IMPACTS</u>

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/17 NOV 2016

COPIES TO: (add categories as necessary)

☐ ______________________________ ☐ ______________________________

2 NTC § 164 Recommendation: Signature Date

☒ Approval

☐ Conditional Approval (with memo)

☐ Disapproval (with memo)

☐ Categorical Exclusion (with request letter)

☐ None (with memo)

11/18/16

Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife

*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.

.·`..·`..·`..·`...·`..·`..·`..·`..·`..·`..·`..·`..·`..·`...·`..·`..·`..·`..·`.

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 Oak 124, Oak 125 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 1, 2016 and May 23, 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. The sample result was qualified with a "J+" flag to indicate the data were estimated and potentially biased high. All MS/MSD RPDs were within acceptance criteria.

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. All RPDs were within acceptance criteria.

Serial Dilution Evaluation. All serial dilution percent differences were within acceptance criteria.

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 and two radium-226. 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 six 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 two samples analyzed for radium-226. The sample density exceeded the limit of +/- 15% of the density of the calibration standard. Cases that exceed the limit of +/- 15% of the density of the calibration standard were qualified with a “J+” flag for those results that may be biased high and a “J-“ flag for those results that may be 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 reported.

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
Oak 124, Oak 125
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
S486-C01-001	10/7/16	E901.1	Radium-226	1.43	pCi/g	Result Verification		±15%	J+	Result is estimated, potentially biased high. Sample density differs by more than 15% of LCS density.
S486-CX-003	10/10/16	SW6020	Uranium	4	mg/kg	MS MSD	137% 197%	75% - 125% 75% - 125%	J+	Result is estimated, potentially biased high. MS and MSD recovery above acceptance criteria.
S486-CX-005	10/10/16	E901.1	Radium-226	8.8	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
LCS laboratory control sample
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
Oak 124, Oak 125
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 (%)
S486-C01-001/S486-C01-201	10/7/2016	Radium-226	1.43	1.00	pCi/g	35
S486-CX-001/S486-CX-201	10/10/2016	Arsenic	1.7	3	mg/kg	55
S486-CX-001/S486-CX-201	10/10/2016	Radium-226	74.4	119	pCi/g	46
S486-SCX-005-1/S486-SCX-205-1	5/19/2017	Arsenic	7.9	13	mg/kg	49

Notes
mg/kg milligrams per kilogram
pCi/g picocuries per gram
RPD relative percent difference