

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**Old Church Rock Mine
Removal Assessment Report**

Response, Assessment, and Evaluation Services

Contract No. EP-S9-17-03

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U.S. Environmental Protection Agency**

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ACRONYMS AND ABBREVIATIONS

µg/kg	Microgram per kilogram
AUM	Abandoned uranium mine
BSA	Background study area
BTV	Background threshold value
COPC	Contaminant of Potential Concern
cpm	Counts per minute
CRUMP	Church Rock Uranium Monitoring Project
DQO	Data quality objective
HPIC	High-pressure ionization chamber
HRI	Hydro Resources, Inc.
IL	Investigation level
ISL	In situ leaching
NNHHPD	Navajo Nation Heritage and Historic Preservation Department
NORM	Naturally occurring radioactive material
NRC	U.S. Nuclear Regulatory Commission
OCRM	Old Church Rock Mine
PCB	Polychlorinated biphenyl
pCi/g	Picocurie per gram
ppm	Parts per million
QA/QC	Quality assurance and quality control
Ra-226	Radium-226
SAP	Sampling and analysis plan
TCRA	Time-critical removal action
Tetra Tech	Tetra Tech, Inc.
UCL95	95 percent upper confidence limit
UNC	United Nuclear Corporation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTL95-95	95 percent upper confidence limit with 95 percent confidence



ACRONYMS AND ABBREVIATIONS (CONTINUED)

WCM Westwater Canyon Member of the Morrison Formation

XRF X-ray fluorescence

1.0 INTRODUCTION

This removal assessment report documents and presents the findings of environmental and radiological sampling conducted at the Old Church Rock Mine (OCRM) in the Eastern Abandoned Uranium Mine (AUM) Region of the Navajo Nation near Gallup, McKinley County, New Mexico. Tetra Tech, Inc. (Tetra Tech) prepared this report for the U.S. Environmental Protection Agency (USEPA) under Task Order 0035 of the Response, Assessment, and Evaluation Services contract (EP-S9-17-03).

1.1 PURPOSE

This removal assessment report describes the results of the removal assessment field sampling at OCRM conducted in November 2022 by Tetra Tech. The removal assessment involved site characterization consisting of a multimedia sampling approach at OCRM. The primary objective of the removal assessment was to determine whether contamination present at and surrounding the site warrants immediate action. The removal assessment included characterization of (1) surface gamma radiation, (2) radionuclides and metals in surface soil and sediment, and (3) background radiation and metals levels in nearby, unimpacted alluvial soils. X-ray fluorescence (XRF) surveys were performed to characterize metals in surface soils at the site and one background study area (BSA). The purpose of this evaluation is to assess the data collected from OCRM as a line of evidence in identifying whether an imminent threat exists to nearby populations that would require remedial action at the site in the form of a time-critical removal action (TCRA).

The locations investigated during the removal assessment at OCRM were:

- OCRM fenced area and associated areas of suspected waste disposal
- Areas outside the OCRM fenced area where contamination has come to be located
- Drainages, haul roads, and access roads associated with OCRM
- BSAs relevant to OCRM
- Residential yards near OCRM

A regional map showing the Navajo Nation AUM regions and the location of OCRM is presented on [Figure 1](#).

1.2 DATA QUALITY OBJECTIVES

USEPA's systematic planning process for data collection—the data quality objective (DQO) process—was used to define the objectives for the removal assessment. The focus of the DQO process is on identifying the quality and quantity of data to be collected to make a decision (American National Standards Institute 2014). The DQO process was used in the development of the sampling and analysis plan (SAP) for the removal assessment at OCRM (Tetra Tech 2022).

The objectives of the removal assessment at OCRM were to:

- Assess background levels of radiation and metals in alluvial soil

- Quantify the levels and lateral extent of contamination
- Collect sufficient data to assess the need for a TCRA

Table 1 summarizes the individual study goals, the acceptance criteria for each goal, and the sections of this report relating to each DQO goal.

1.3 REPORT ORGANIZATION

The report is organized into the following sections:

- [Section 2.0](#) provides background information on OCRM, including the site location, operational history, physical setting, geological setting, site features, and cultural and biological features.
- [Section 3.0](#) describes the methods used to conduct the removal assessment, which reflect the requirements of the SAP (Tetra Tech 2022), and any deviations from the SAP.
- [Section 4.0](#) provides the results of the removal assessment.
- [Section 5.0](#) presents conclusions and recommendations for further study at the site.
- [Section 6.0](#) provides the references cited in this report.

Figures and tables are provided following the main text. Additionally, the following appendices provide reports or documentation related to the removal assessment field efforts:

- [Appendix A](#) provides a photographic log of site features observed and site activities conducted.
- [Appendix B](#) is a gamma verification and validation report of the before, during, and after quality assurance and quality control (QA/QC) efforts and details all the steps taken to eliminate erroneous data for the final gamma survey dataset.
- [Appendix C](#) presents the QA/QC efforts conducted for the XRF instruments and the steps taken to eliminate erroneous data.
- [Appendix D](#) details the process of verifying the quality of analytical data received from the contracted laboratory and provides a summary of the QA/QC efforts conducted for soil samples.
- [Appendix E](#) is the gamma-radium correlation report, which develops a mathematical relationship between raw gamma radiation measurements and the actual gamma exposure and actual radium-226 (Ra-226) concentrations in soil at the site.
- [Appendix F](#) provides field documentation for the removal assessment, including field forms and field notes.
- [Appendix G](#) provides laboratory reports for samples collected during the removal assessment.
- [Appendix H](#) is the background investigation report, which establishes baseline levels for gamma radiation and metals at the site.



- [Appendix I](#) provides volume estimates based on existing and collected data for the onsite settling ponds, existing concrete slabs, and waste removal volumes in areas with potential contamination migration concerns.



2.0 SITE BACKGROUND

This section presents background information on OCRM, including the site location, operational history, physical setting, geological setting, site features, and cultural and biological features.

2.1 SITE LOCATION

OCRM includes a 75-acre fenced area and associated contamination in the Eastern AUM Region of the Navajo Nation near Gallup, McKinley County, New Mexico. OCRM is in the Church Rock Chapter of the Navajo Nation. The geographic coordinates at the approximate center of OCRM are 35.620705 degrees north latitude and -108.555226 degrees west longitude. The elevation at OCRM is 6,800 feet above mean sea level. [Figure 1](#) presents a regional map of the Navajo Nation AUM regions and the site location. [Figure 2](#) presents the site location relative to the Public Land Survey System, the Navajo Nation, and other nearby AUM sites. The fenced portion of the site is primarily within Section 17 on Navajo Nation land except for a portion to the north within Section 8, which is privately owned land.

2.2 OPERATIONAL HISTORY

Commercial exploration, development, and mining of uranium near OCRM began in 1957. At OCRM, room-and-pillar mining was used and a concrete-lined shaft was drilled to a depth of 865 feet. The Phillips Petroleum Company began mining operations at OCRM in 1960. This first phase of mining at OCRM resulted in ore production through mineral leases and contracts, which involved several commercial entities, and ended in 1962. Over 75,000 tons of ore was mined from OCRM between 1960 and 1962. Mined ore was transported from the site to the uranium mills in Bluewater and Milan, New Mexico, approximately 50 and 60 miles east of the site (Church Rock Uranium Monitoring Project [CRUMP] 2007). [Figure 3](#) shows historical aerial photographs of the OCRM area before and after Phillips mining operations.

In 1963, the United Nuclear Corporation (UNC) took over mining operations at OCRM though mining did not resume at the site until 1977. Over 200,000 tons of ore was mined from OCRM between 1976 and 1982. Mined ore was transported from the site to the UNC uranium mill at Northeast Church Rock, approximately 3 miles northeast of the site along State Route 566 (CRUMP 2007). [Figure 4](#) shows historical aerial photographs of the OCRM area before and after UNC mining operations.

In 1991, Hydro Resources, Inc. (HRI), a subsidiary of Uranium Resource, Inc., took over the mineral lease rights from UNC with the intention of converting the site into an in situ leaching (ISL) facility under a U.S. Nuclear Regulatory Commission (NRC) license, which is known as the Crownpoint Uranium Solution Mining Project (NRC 1997; CRUMP 2007). In 1998, HRI was granted an NRC license, SUA-1508, authorizing ISL mining at four locations, one of which is at the location of the OCRM (referred to as Church Rock Section 17).

In 2015, Uranium Resource, Inc., on behalf of HRI, applied for the indirect transfer of control of the Crownpoint Uranium Solution Mining Project to Laramide Resources Ltd. This application was approved by NRC in 2016. In 2017, Laramide Resources Ltd. requested for the name HRI be changed to NuFuels (NRC 2017), which was approved in 2018 (NRC 2018).



Since OCRM's closure as a conventional mine in 1982, several investigations have been conducted by multiple agencies to assess the extent of contamination on and near the site. The scope of these investigations is summarized in [Table 2](#).

In addition to the site-specific investigations summarized in [Table 2](#), USEPA conducted Airborne Spectral Photometric Environmental Collection Technology (ASPECT) surveys across the Navajo Nation. These surveys were conducted from June 25 through July 6, 2018 and resulted in the collection of 130,000 1-second gamma spectra. The result of the ASPECT survey in the OCRM area is shown in [Figure 5](#).

2.3 PHYSICAL SETTING

OCRM is on the Colorado Plateau at an elevation of 6,800 feet above mean sea level. The Colorado Plateau frequently experiences severe weather, including thunderstorms, strong winds, and blizzards. Days are typically clear or partly cloudy with monsoonal precipitation patterns in the summer and variable snowfall in the winter. Conditions are hot and dry with occasional high winds and strong thunderstorms during the summer; high winds and cold temperatures characterize the winter months. Rapid weather changes pose danger of flash flooding. Flash floods occur locally as a result of thunderstorm activity from July through September.

Daily temperature and precipitation data from the Western Regional Climate Center (2022) for Station 293422, which is 14.5 miles southwest of OCRM, were examined from 1973 to 2016. Temperatures are highest in July, averaging 87.7 degrees Fahrenheit, and lowest in January and December, averaging just above 13.4 degrees Fahrenheit. The least precipitation occurs in June, and the most in August. Average annual precipitation from 1973 to 2016 was 11.08 inches. The area receives snowfall from October to May.

Based on yearly data recorded from 1972 to 2022 for Gallup, New Mexico, the nearest locale to OCRM with wind data, the average wind speed is 6.9 miles per hour though strong winds greater than 20 miles per hour commonly occur (Iowa State University 2022). The prevailing wind direction is shown on [Figure 6](#).

2.4 GEOLOGICAL SETTING

Geologic maps and historical literature were reviewed as part of a desktop study of the OCRM geology. Relevant maps include the geologic map of the Gallup Quadrangle produced by the U.S. Geological Survey (USGS) (USGS 1990). [Figure 7](#) shows a portion of this USGS map with the surface expressed geology of the site and its vicinity. [Table 3](#) summarizes the characteristics of each geology around the site. [Figure 8](#) shows the soils of the site and the vicinity. Observations during removal assessment site walks confirmed findings of the desktop geology study and provided additional resolution in areas where less detail was available.

North of OCRM where colluvial material interfingers with alluvial material, the clay content of surface soils is higher than in other portions of the site. Colluvium is loose bodies of sediment deposited or built up at the bottom of a low-grade slope or against a barrier on that slope and transported by gravity. Because the Mancos Shale outcrops near the bottom of the cliffs to the north, the bulk of colluvial material is clay derived from the Mancos Shale unit. This clay

content may impact the definitiveness of the gamma surveys performed to assess the lateral extent of radionuclide contamination as part of this study because black marine shales such as the Mancos can adsorb and concentrate heavy metals and radionuclides.

The alluvial and colluvial material at OCRM is underlain by the Cretaceous Mancos Shale, which is underlain by Dakota Sandstone. The Mancos Shale comprises 500 to 800 feet of mudstone and shale near OCRM and is considered to be a major aquitard, preventing surface recharge to the underlying Dakota Sandstone. Beneath Dakota Sandstone, approximately 180 feet of interfingering mudstone and siltstone assigned to the Brushy Basin Member of the Morrison Formation constitute an aquitard that provides confining conditions for groundwater in the underlying Westwater Canyon Member of the Morrison Formation (WCM).

The primary uranium ore body mined at OCRM is present within WCM. Mineral resources at OCRM are contained in roll fronts and elongated tabular deposits (USGS 1975). Mineralization, a geochemical process in which uranium, its progeny, and other metals are preferentially crystallized out of a solution into a formation, varies in thickness but averages 9 feet thick in each zone. Because individual ore bodies are stacked, they have a combined thickness of about 80 feet. Overall, the ore body is 5,300 feet long and up to 1,000 feet wide (NRC 1997).

During mining operations, the mine shaft and vent holes provided a hydraulic connection between Dakota Sandstone and WCM, which caused constant flooding at the bottom of the mine that required approximately 900 gallons per minute to be pumped to the surface. Once at the surface, groundwater was held in a series of five settling ponds to allow fine sediments to settle out of the water. After fine sediments had settled, the water was treated on site by an ion-exchange process, which removed uranium from the groundwater, before being discharged to an unnamed arroyo which passes through the site.

Drainages present on the north side of OCRM run north to south and drain to the Puerco River. [Figure 9](#) shows the watersheds and drainages within the region, and [Figure 10](#) shows the drainages at and near the site.

Soils beneath OCRM are predominantly alluvial material. The soils on the low hills to the north of the site are an admixture of alluvial-colluvial materials that grade into weathered Mancos Shale toward the tops of the hills near the base of the cliffs. The alluvial soils beneath OCRM result from waterborne deposition of sediments transported from sediment source areas exposed in the catchment feeding the unnamed arroyo that passes through the site. Alluvial material underlying OCRM reflect the fine-grained nature of the sedimentary rocks exposed in the sediment source area, which generally consists of clay, silt, sand, and rare fine gravel deposited in interfingering lens-like layers. Where alluvial materials are exposed in the arroyo walls, mudstone, siltstone, and fine sand predominate. [Figure 8](#) shows the soils surrounding OCRM and the vicinity. [Table 4](#) summarizes the characteristics of each soil type identified at the site. [Figure 8](#) provides a map of the soils of the study area.

Soil data, in conjunction with geologic data, were used to establish background concentrations. Soil mapping data from the U.S. Department of Agriculture and Natural Resources Conservation Services (2022) web soil survey database was used to identify the soil types at OCRM.



2.5 SITE FEATURES

Features at OCRM include two closed mine shafts, an ion-exchange building, five settling ponds, former stockpile areas, and concrete pads. An unnamed arroyo runs from north to southwest along the site and drains to the Puerco River. State Route 566 runs northeast to southwest adjacent to the site's southeast fence line. Nearby mine-related sites include a former ISL facility to the north and the Section 16 deposit mine to the southeast; however, these two related sites are not addressed as part of this removal assessment report. In Fall of 2022 during the removal assessment field activities, NuFuels was in the process of conducting a drilling project at the site. The drilling project included surface work to prepare seven drilling pads as well as access roads to travel between the drill pads and a staging area at the site entrance. [Figure 10](#) shows the site location and features. [Table 5](#) describes the site features and dimensions.

2.6 CULTURAL AND BIOLOGICAL FEATURES

Several cultural and biological surveys were conducted at OCRM during its operation as a uranium mine. NRC (1997) provides information regarding the surveys and the features identified at OCRM, as well as the need for additional surveys.

2.6.1 Cultural Features

In 1996, NRC (1997) flagged a 1977 survey of the OCRM area as not adequately meeting compliance with Section 106 of the National Historic Preservation Act and contacted the New Mexico Historic Preservation Division, the Navajo Nation Heritage and Historic Preservation Department (NNHHPD), federal agencies, and other interested parties. NNHHPD agreed that a cultural resources inventory was necessary for HRI's lease area that included verifying and updating previously identified historic properties and archeological sites.

At the request of HRI, the Museum of New Mexico Office of Archaeological Studies conducted a cultural resource investigation of HRI's lease area in 1997. The survey included OCRM (Section 8 and Section 17 lands) and identified 32 sites in the lease area with 12 sites on privately owned land, 20 sites on Bureau of Land Management land, and no sites on Navajo Nation land. Of the 32 sites, 23 had Anasazi artifacts while the remainder had Middle or Late Pueblo II artifacts. No traditional cultural properties were identified within OCRM by chapter officials, traditional practitioners, or local residents (Blinman 1997).

2.6.2 Biological Features

In 1996, NRC (1997) requested U.S. Fish and Wildlife Service (USFWS) concurrence that the proposed Crownpoint Uranium Solution Mining Project would not adversely affect federally listed endangered or threatened species, or their designated critical habitat, in the project area. USFWS provided a list of species of concern and Endangered Species Act-listed endangered, threatened, and candidate species with potential to occur in McKinley County and recommended that additional surveys be conducted in the areas of impact to supplement older biological surveys conducted in 1978.

3.0 METHODS

This section describes methods used during the removal assessment at OCRM as documented in the SAP (Tetra Tech 2022), as well as any deviations from the SAP.

3.1 BACKGROUND INVESTIGATION

Two potential BSAs—BSA-01 and BSA-02—were selected as representative of pre-mining conditions and shared local geology and soils at OCRM. The locations of the BSAs are shown on [Figure 8](#). Both BSAs are at least 0.75 acre (the minimum area to contain 30 100-square-meter plots). BSA-01 is 0.5 mile west of OCRM located in predominantly colluvial soils, and BSA-02 is 0.5 mile south of OCRM located in alluvial soils. Both are upwind of the site and are not within any drainage systems that could carry contamination from OCRM to the background areas.

Surface gamma surveys were conducted at both BSA-01 and BSA-02 to calculate an investigation level (IL) for subsequent gamma surveys across OCRM. Gamma radiation surveys were performed following the methods outlined in the SAP. Once both BSAs had been scanned, the gamma rate data were assessed, and a decision was made with input from USEPA to conduct further investigations at BSA-02. Further discussion regarding the BSA selection process is discussed in [Sections 3.6.1](#) and [4.1](#).

BSA-02 was further investigated through the collection of soil samples, XRF measurements, and static gamma count rates in a 10-by-10-meter plot from a depth of 0 to 3 inches. An XRF measurement and a 10-second static gamma count rate were taken at the center of each plot before collecting the soil sample. XRF measurement results were collected in field notebooks, and the static gamma count rates were collected on a surface soil sample form. Duplicate surface soil samples were collected at a frequency of once every 20 samples. Field documentation is provided in [Appendix F](#).

The BSA soil samples were submitted to an offsite laboratory for metals and radionuclide analyses, and the results were used to calculate the background threshold values (BTv) for the area. [Table 6](#) summarizes the analytical methods for characterizing soils at OCRM and the BSAs.

3.2 GAMMA RADIATION SURVEY

Ludlum Model 44-10 thallium-doped sodium iodide 2- by 2-inch detectors were used at a height of 1 meter above ground surface at a scanning rate of 1 meter per second to measure gamma radiation at OCRM. The gamma count rate data were transmitted to a handheld Mesa 2 tablet at a rate of once per second and logged using RadScout software, which pairs the gamma count rate with the current time and current position via a Juniper Systems Geode sub-meter global positioning system unit.

Gamma radiation surveys were performed following the methods outlined in the SAP. Surface gamma surveys were conducted to assess the extent of radiological contamination across OCRM

and in surrounding areas. The areas of radiological concern selected for gamma surveys in the SAP were:

- The fenced boundary area of OCRM
- The adjacent area to the northeast
- The adjacent area to the east and southeast across State Route 566
- The adjacent unnamed arroyo
- Haul roads (State Route 566 and Blackrock Road)
- Nearby residential yards

Because windblown contamination transport from on-site waste at OCRM is possible, radial surveys originating from the center of the site were conducted in eight directions (four cardinal and four ordinal).

The gamma survey ILs calculated from BSA-02 (see [Section 4.2.1](#)) were used to evaluate where step-outs were necessary to ensure that surface contamination had been laterally delineated beyond the areas of radiological concern identified in the SAP. The use of the IL identified the proposed scope of gamma scanning was insufficient and resulted in significant step-outs in the following areas.

- Areas north and north east of OCRM
- The arroyo delta area southwest of OCRM

[Table 7](#) summarizes the areas scanned, approximate area or distance, and gamma survey method, and also includes additional step-outs not in the SAP that were based on previous site investigations. The additional step-outs are identified and further discussed in [Section 3.6](#).

3.3 SOIL SAMPLE AND X-RAY FLUORESCENCE MEASUREMENT COLLECTION

After the lateral delineation of gamma radiation levels was completed, discrete soil samples were collected biased toward areas with higher levels of gamma radiation. Before sampling, an XRF measurement was taken to verify that elevated levels of nonradioactive contaminants were present. If the XRF measurement did not indicate elevated concentrations of contaminants of potential concern (COPC), the point of sampling was shifted by a few feet within the same area.

Soil samples were collected with a hand trowel from a depth of 0 to 3 inches. Once sampled, the trowel was decontaminated using a combination of dilute Liquinox, deionized water, and paper towels. Surface soil sample and XRF measurement information were logged in either field forms or field notebooks and are presented in [Appendix F](#).

Samples were collected in each of the investigation areas to assess the worst-case scenario for each area and were analyzed for metals and radionuclides.

3.4 GAMMA-RADIUM AND GAMMA-EXPOSURE CORRELATION STUDIES

After completing the lateral delineation of gamma radiation levels, 15 10-by-10-meter plots that demonstrated little variance in gamma radiation readings were selected for further study. Each plot was rescanned using gamma survey equipment but with a scanning transect density of 1 meter which is a closer transect spacing than the 4 meter transect spacing used for the rest of the site as summarized in [Table 7](#). In each plot assessed to demonstrate a high degree of homogeneity in gamma exposure rates, a series of nine grab samples were collected to create a composite sample for analysis.

Within the same correlation plots, a gamma exposure rate correlation study was completed by measuring exposure rate with a high-pressure ionization chamber (HPIC) in the center of each plot. Once the HPIC measured true exposure, gamma survey equipment was used to take static collimated and uncollimated count rate measurements.

A detailed report on the methods and results of the gamma-radium and gamma-exposure correlation studies is presented in [Appendix E](#).

3.5 CULTURAL SURVEYS

Cultural resource surveys were completed concurrently with the removal assessment fieldwork from November 14 through November 20, 2022, by Dinétahdóó Cultural Resources Management. While shards of pottery were found in multiple areas around OCRM, the primary observation was a fenced-off area marked as an Anasazi ruin site. This fenced area was not entered by field personnel during the removal assessment under any conditions.

3.6 DEVIATIONS FROM SAMPLING AND ANALYSIS PLAN

The following subsections describe the deviations from the SAP (Tetra Tech 2022) and associated justifications and potential impacts.

3.6.1 Background Study Area Selection

Two BSAs (BSA-01 and BSA-02) were scanned with gamma radiation survey equipment. BSA-02 was selected for soil sampling as it was more representative of the quaternary alluvium geology ([Figure 3](#)) and Sparank-San Mateo-Zia complex soil series ([Figure 4](#)) that dominate the area surrounding OCRM.

3.6.2 Background Study Area Soil Sample Depth

Surface soil samples taken from BSA-02 were collected from a depth of 0 to 6 inches instead of a depth of 0 to 3 inches as specified in the SAP. This deviation was due to a miscommunication with the sampling team who are accustomed to background soil sample depths of 0 to 6 inches from other RAES task orders.



3.6.3 Correlation Plots

A total of 15 correlation plots instead of the 10 specified in the SAP were identified and assessed as part of the gamma-radium and gamma-exposure correlation studies. This was done to ensure that at a minimum of 10 correlations plots would be useable once all data and lab results could be assessed together

3.6.4 Gamma Radiation Delineation

The proposed approach to delineating gamma was to scan at a density of 4-m transects until all surveyed areas demonstrated a gamma radiation level below the IL as determined by the background investigations. Initially proposed areas for step-outs were determined to be insufficient and additional areas were added for gamma surveying at a transect spacing of 8-m to reach the gamma IL.

In two areas, reaching the gamma IL were determined to be not feasible. Further discussion is addressed in [Section 4.3.1](#).

3.6.5 Surface Soil Sampling for PCB Analysis

Per technical direction from USEPA, four of the forty gamma-guided surface soil samples were relocated to around the ion exchange building. The samples were collected and analyzed for metals, radionuclides, and polychlorinated biphenyls (PCB). PCBs were added as a COPC due to the discovery of possible PCB-containing transformers in the ion-exchange building after approval of the SAP.

3.7 STATEMENT ON QUALITY ASSURANCE AND QUALITY CONTROL

QA/QC procedures were followed for XRF instruments, gamma survey instruments, and soil sampling during the removal assessment to maintain the quality of the data collected.

A baseline response for XRF instruments was established using certified reference material with varying concentrations of metals. Precision checks were completed for all days that XRF instruments were used to verify the instrument's response. Duplicate XRF measurements were collected at a frequency of 1:20. [Appendix B](#) presents the XRF QA/QC data.

Pre-trip and post-trip background and source checks were conducted for each gamma survey instrument used. Daily function checks were completed for all gamma radiation survey equipment. [Appendix C](#) presents the gamma survey QA/QC.

Soil sampling equipment decontamination procedures were followed to avoid cross contamination between samples. Equipment rinsate and source water blanks were collected and submitted to a laboratory for analysis. Soil sample duplicates were collected at a frequency of once per every 20 soil samples. The soil verification report is included in [Appendix D](#).

[Table 8](#) provides a summary of all QA/QC activities performed.

4.0 RESULTS

The following sections summarize the results of the removal assessment at OCRM and addresses the acceptance criteria specified for each DQO study goal presented in [Table 1](#).

4.1 BACKGROUND INVESTIGATION RESULTS

Gamma walkover surveys were conducted at both BSA-01 and BSA-02. The gamma statistics for both BSAs are summarized in [Table 9](#). Both BSAs demonstrated similar statistics with a difference in mean of less than 2 percent. Further investigation was conducted at BSA-02 as it was more representative of the quaternary alluvium geology ([Figure 3](#)) and Sparank-San Mateo-Zia complex soil series ([Figure 4](#)) that dominate the area surrounding OCRM. Additional background levels may be necessary to evaluate exceedances in areas with higher natural gamma, such as those found in Mancos shale colluvium soils. The gamma dataset for BSA-02 followed a normal distribution based on distribution identification in ProUCL. Following the recommended BTV selection order in ProUCL (USEPA 2022), the BTV calculated for BSA-02 is the normal 95 percent upper confidence limit with 95 percent confidence (UTL95-95) of 14,555 counts per minute (cpm).

BSA-02 was further assessed with an XRF survey, soil sampling, and 10-second static gamma counts in 30 10-by-10-meter plots. Locations of the co-located soil sample and XRF measurement are provided in [Table 10](#). The background soil sample analytical results are summarized in [Table 11](#), and the background XRF measurements are shown in [Table 12](#).

Two analytes, antimony and silver, were not detected in any of the background soil samples. All analytes detected in soil samples followed a normal distribution in ProUCL, and all BTVs were calculated using the normal UTL95-95. All 95 percent upper confidence limits (UCL95) were calculated using the Student's-t UCL95 recommended by ProUCL.

The raw XRF statistics presented in units of parts per million (ppm) in [Table 12](#) are not correlated to any analytical results and should only be used relative to other XRF measurements. XRF measurements collected during the removal assessment should not be compared to analytical results. To correlate the XRF's raw ppm output, a confirmation study would be needed between XRF measurements and soil analytical results, which is outside of the scope of the removal assessment.

The background investigation report is included in [Appendix H](#).

4.2 GAMMA RADIATION SURVEY RESULTS

The gamma radiation survey at OCRM was performed according to the methods outlined in the SAP and [Section 3.2](#). All gamma radiation survey QA/QC project acceptance criteria for this project were achieved as presented in [Appendix B](#).

4.2.1 Radial Transects – Gamma

Figure 11 shows the gamma radiation survey results for the eight radial transects to assess windblown contamination at OCRM. Each radial transect extended until the gamma IL calculated from the background investigation was met or until terrain conditions halted the survey.

Figure 12 shows the gamma radiation levels in cpm as the transect was traversed away from the middle of OCRM. The gamma BTV of 14,555 cpm is shown as a dotted red line in each chart, and the point at which the fence line is crossed is shown as a vertical gray line. The gamma rates are grouped in 0.01-mile increments to reduce noise in the charts. A consequence of this is the peak gamma rates are not displayed. Table 13 summarizes the gamma statistics relating to traversing each radial transect, including the peak gamma rate observed on each transect.

The distance between a point of interest on a transect and the middle of OCRM at the coordinates of 35.621478 and -108.555794 is calculated using Equation (Eqn-1 below).

$$d = \cos^{-1} \left(\cos \left(\frac{\pi}{180} (90 - lat_c) \right) \right) \cdot \cos \left(\frac{\pi}{180} (90 - lat_t) \right) + \sin \left(\frac{\pi}{180} (90 - lat_c) \right) \cdot \sin \left(\frac{\pi}{180} (90 - lat_t) \right) * \cos \left(\frac{\pi}{180} (lon_c - lon_t) \right) \quad \text{Eqn-1}$$

where:

- D Distance between two decimal coordinates (miles)
- Lat_c Latitude of the centroid coordinate point (decimal)
- Lon_c Longitude of the centroid coordinate point (decimal)
- Lat_t Latitude of the gamma coordinate point on the transect (decimal)
- Lon_t Longitude of the gamma coordinate point on the transect (decimal)

Except for the northern and southwestern radial transects, measurements below the gamma BTV were not achieved inside of the fenced area. The north and northeast radial transects both included segments measuring below the gamma BTV, but after a duration, the observed gamma radiation levels increased back above the gamma BTV. In both cases, the radial transect approached a geologic contact between the quaternary alluvium that dominates the OCRM area and Mancos Shale for the north radial transect and landslide deposits for the northeast radial transect.

4.2.2 Gamma Scanning Results

Figure 13 shows the gamma radiation survey results, and Table 14 summarizes the gamma survey statistics collected in during the removal assessment except for BSAs, correlation plots, homesites, and radial transects which were excluded because they are not included in the site wide gamma data set.

4.2.2.1 Old Church Rock Mine Fenced Area

Figure 14 shows the gamma radiation survey results within the OCRM fenced area, which contained the highest gamma rates observed during the removal assessment. Contamination was largely centered around the existing concrete slabs, indicating previous mine work locations. North of the arroyo, the observed elevated gamma radiation levels identified a waste pile from previous mine work. Gamma survey results near the western fence line indicated a line of elevated gamma radiation levels. Field observations identified the area as a berm composed of mine waste with ore rock buried amongst the berm (see Photographs 4 and 5 in Section A-4 in Appendix A). The full extent of the berm, both inside and outside the fenced area, is shown on Figure 13, north-northeast of the ion-exchange building.

4.2.2.2 Adjacent Step-Outs

Figure 15 shows the gamma radiation survey results within adjacent step-outs at OCRM. Gamma measurements show that contamination has moved off site in every direction except for the southwesternmost fence boundary past the ion-exchange building.

4.2.2.3 Adjacent Unnamed Arroyo

Figure 13 shows the gamma radiation survey results in and along the unnamed arroyo that passes by OCRM. Gamma measurements showed that radiation levels in the arroyo were elevated in portions next to the site but decreased to background approximately 100 meters past the fence boundary to the northeast. In the opposite direction, gamma measurements decreased to background southwest of the berm discussed in Section 4.2.2.1.

4.2.2.4 Haul Roads

Figure 13 shows the gamma radiation survey results for the two former haul roads (present-day State Route 566 and Blackrock Road).

The portion of State Route 566 south of OCRM is mostly unimpacted except for a 0.35-acre isolated area of elevated gamma activity. The portion of State Route 566 that runs along the site boundary and beyond to the northeast is substantially impacted by vehicular transport and wind transport of contamination with gamma radiation levels above the BTV observed 0.5 mile past the OCRM site boundary. Along State Route 566 northeast of the site, vehicular transport of contamination is evident by the elevated gamma levels observed along the road and right-of-way but which decreases to below the BTV once far enough from the road.

Gamma survey results along Blackrock Road, which extends west of OCRM, did not indicate any gamma radiation levels above the BTV. However, conversations with residents noted that Blackrock Road had been reworked within the last month and before the removal assessment with new gravel laid over the old road.

4.2.2.5 Arroyo Flood Delta

Figure 13 shows the gamma radiation survey results in the area southwest of OCRM, south of Blackrock Road, west of State Route 566, and north of the Puerco River. Gamma survey measurements identified a large area of elevated gamma levels across a significant area though gamma readings never exceeded twice the gamma background threshold value.

4.2.2.6 Nearby Residential Yards

Figure 16 shows the gamma radiation survey results in the area of two homesites near OCRM. Gamma survey results for both homesites indicated that gamma radiation levels were below the BTV.

4.3 GAMMA-RADIUM AND GAMMA-EXPOSURE RATE CORRELATION STUDY RESULTS

In total, 15 100-square-meter plots at OCRM were studied with gamma walkover surveys, static gamma surveys co-located with HPIC surveys, visual observation, and composite soil sampling. Table 15 summarizes the locations and sample IDs of composite samples collected during the correlation studies. Figure 17 shows the interpolated gamma radiation survey results.

The data collected in each of the 15 correlation plots was assessed quantitatively and qualitatively using a total of 14 qualifiers. These 14 qualifiers, listed A-N, include:

- A Relative standard deviation (RSD) of unshielded correlation plot greater than 10 percent.
- B Relative percent difference (RPD) between mean and median of unshielded plot data is greater than 1 percent.
- C Visually identified deviations from normal or lognormal for the unshielded correlation plot.
- D RSD of shielded correlation plot data is greater than 20 percent.
- E RPD between mean and median of shielded plot data is greater than 2 percent.
- F Visually identified deviations from normal or lognormal for the shielded correlation plot.
- G The ratio of unshielded to shielded is greater than 5.
- H Visual outliers identified in the regression between unshielded and shielded average gamma count rate.
- I RSD of static gamma count rate data is >10 percent.
- J The ratio of unshielded average walkover to static is <0.90 or >1.10.
- K Visual outliers identified in regression between unshielded walkover and static average gamma count rate.
- L If the RSD of HPIC data is >5 percent.

- M If the RPD between the mean and median of HPIC data is > 1 percent.
- N Visual outliers observed in the regression of HPIC/Static.

One correlation plot, CORR12, failed 7 of the 14 qualifiers and was removed from any correlation analysis. Further details on the removal of this plot are included in [Appendix E](#).

4.3.1 Gamma-Radium Correlation Study Results

[Appendix E](#) contains the detailed gamma-radium correlation study report for OCRM. From the remaining 14 correlation plots at OCRM, two models were developed correlating the raw gamma radiation count measurements to the radium-226 analytical results:

- Model 1, shown on [Figure 18](#), correlates the unshielded gamma count rate (cpm) and surface soil analytical results for Ra-226 across the site. The coefficient of determination value for Model 1 is 0.88.

$$^{226}\text{Ra} \left(\frac{\text{pCi}}{\text{g}} \right) = (0.000629 * [\text{Gamma Count Rate (cpm)}]) - 7.967955 \quad \text{Eqn-2}$$

- Model 2, shown on [Figure 19](#), correlates the unshielded gamma count rate (cpm) to surface soil analytical results for radium in a range limited to less than twice the background concentration of Ra-226. This accounts for the higher percentage of naturally occurring gamma emitters (potassium and thorium) in the observed gamma count rate. The coefficient of determination value for Model 2 is 0.93.

$$^{226}\text{Ra} \left(\frac{\text{pCi}}{\text{g}} \right) = (0.000359 * [\text{Gamma Count Rate (cpm)}]) - 3.134047 \quad \text{Eqn-3}$$

4.3.2 Gamma-Exposure Rate Correlation Study Results

[Appendix E](#) contains the gamma-exposure rate correlation study report for OCRM. From the remaining 14 correlation plots at OCRM, a single model was developed correlating the raw gamma radiation count measurements to the exposure rate measurements with the relationship expressed in Eqn-4 and shown on [Figure 20](#). The coefficient of determination for this model is 0.98. [Figure 21](#) presents the collected gamma measurements at OCRM converted to exposure rate in units of $\mu\text{R/hr}$. [Figure 22](#) shows the interpolated gamma exposure rate.

$$\text{Gamma Exposure} \left(\frac{\mu\text{R}}{\text{hr}} \right) = (0.000482 * [\text{Gamma Count Rate (cpm)}]) + 9.724779 \quad \text{Eqn-4}$$

4.4 SOIL SAMPLING RESULTS

Soil sampling was conducted across OCRM and biased toward areas of high gamma radiation. Of the 39 samples, 4 were collected around the ion-exchange building with additional laboratory analysis for PCBs and 7 were collected at the bottom of onsite ponds. Five of the ponds are former settling ponds, and two of the ponds are depressions with no previously identified use.

For the purposes of this surface soil sampling, XRF measurements were only taken to field verify elevated levels of uranium and other metals that accompanied the elevated gamma readings.

Table 16 summarizes the locations, soil sample IDs, and XRF sample IDs. Figure 23 and Figure 24 show the location of the co-located soil and XRF samples overlayed on an interpolated gamma and interpolated exposure map respectively. Figure 24 shows an enlarged view of the sampling area with sample ID names and site features.

Only the PCB mixture Aroclor-1260 in one sample tested above the minimum detection limit. The other PCB mixtures evaluated were not detected in any samples. As shown in Table 17, sample OCRM-SS2946B-01-111622 collected on the concrete slab in front of the northern door of the ion-exchange building (see Photograph 58 in Section A-2 of Appendix A) had an Aroclor-1260 result of 6.84 micrograms per kilogram ($\mu\text{g/kg}$), which is above the minimum detection limit of 5.73 $\mu\text{g/kg}$. The USEPA (2022) regional screening level for Aroclor-1260 in residential soil is 240 $\mu\text{g/kg}$.

Table 18 summarizes the laboratory analytical results for metals and radionuclides for each of the 39 surface soil samples collected and the laboratory analytical results for PCBs for the four samples collected around the ion-exchange building on site.

4.5 CONTAMINANT OF POTENTIAL CONCERN IDENTIFICATION

COPCs were identified by comparing the UCL95 calculated from the OCRM soil sampling data for each analyte in Table 18 to a COPC threshold value. The COPC threshold value was either (1) a COPC screening value calculated using the Navajo AUM risk calculator for the Kee'da'whíí tééh (full-time Navajo resident) using a target risk of 1E-06 and a hazard quotient of 0.1 (except for lead, which is based on the regional screening level [USEPA 2022] for residential soil), or (2) the BTV calculated for each analyte from the assessment of BSA-02.

If the BTV for an analyte was higher than the risk-based COPC screening level, the BTV was used as the COPC threshold value. If the risk-based COPC screening level for an analyte was higher than the BTV, the risk-based COPC screening level was used as the COPC threshold value.

If the UCL95 for an analyte was higher than the COPC threshold value, the analyte was classified as a COPC. Of the 39 samples collected, all had at least one COPC that exceeded the COPC threshold value.

Table 19 summarizes the comparison of analytical results to the COPC threshold value and identifies barium, molybdenum, Ra-226, selenium, uranium, vanadium, and zinc as COPCs at OCRM. Figure 25 shows the locations and analytical results of the 39 surface soil samples collected around OCRM identified as exceeding the COPC threshold value for one or more COPCs. All surface soil samples collected as part of the removal assessment, outside of BSAs, demonstrated at least one COPC exceedance.

4.6 RADIAL TRANSECTS – X-RAY FLUORESCENCE CONTAMINANTS OF POTENTIAL CONCERN

During the radial transect gamma survey, screening XRF measurements were taken every 100 meters along the radial transects. [Figure 26](#) shows the locations of each XRF sample collected, and [Table 20](#) summarizes the locations and XRF sample IDs collected along the radial transects.

From the list of COPCs in [Section 4.5](#), the XRF is physically capable of detecting barium, molybdenum, selenium, uranium, vanadium, and zinc (not able to detect Ra-226). [Table 21](#) summarizes the XRF findings along the radial transects in each of the four cardinal and four ordinal directions for each COPC and compares the results to the XRF's analyte-specific BTV calculated in the background investigation study ([Appendix H](#)) and summarized in [Table 12](#). In each direction, the XRF results indicated that all COPCs reduced to below the BTV except for the northeastern radial transect.

4.7 ESTIMATED LATERAL EXTENT OF CONTAMINATION

The following subsections discuss the extent of contamination at OCRM and migration off site.

4.7.1 Estimated Lateral Extent of Contamination (Gamma and Radium-226) Above Background

Four considerations were used in estimating the lateral extent of contamination at OCRM:

- Any gamma collection point was considered contaminated if the estimated Ra-226 was greater than 2.0 picocuries per gram (pCi/g), the approximate BTV for Ra-226.
- The gamma-radiation correlation Model 2, defined in [Section 4.3](#), was used to estimate the lateral extent of Ra-226 contamination as the model provides a stronger correlation between gamma count rate and Ra-226 analytical results at low concentrations.
- The gamma-radiation correlation Model 2, defined in [Section 4.3](#), was used to perform a geospatial kriging analysis to estimate the lateral extent of Ra-226 exceeding 2.0 pCi/g. After extracting an aerial extent polygon from the kriged surface, a buffer and smoothing algorithm approach was applied, adding additional areal extent for purposes of uncertainty.
- BSA-02 was used to calculate the BTV as it is more representative of the quaternary alluvium geology ([Figure 3](#)) and Sparank-San Mateo-Zia complex soil series ([Figure 4](#)) that dominate the area surrounding OCRM. Multiple geologic contacts exist with the quaternary alluvium geology around OCRM, which may interfere with assessing whether the observed gamma count rates are a result of contamination migration or a natural increase in gamma-emitting naturally occurring radioactive material (NORM) (that is, uranium and thorium in equilibrium with progeny and potassium-40).

[Figure 27](#) shows the estimated extent of lateral contamination at OCRM, which totals 170 acres of Ra-226 above 2.0 pCi/g estimated by Model 2. In two areas, directly north and to the northeast of the site, the quaternary alluvium geology that dominates OCRM contacts another geology. To

the north, the quaternary alluvium contacts a colluvium formation and the lower tongues of Gallup sandstone. To the northeast, the quaternary alluvium contacts landslide deposits, which sit below the Mancos Shale. The boundaries of the lateral extent of contamination are impacted when the geologic formation changes to colluvium and Gallup sandstone from quaternary alluvium.

4.7.2 Estimated Lateral Extent of Contamination (Gamma and Radium-226) More than Twice Background

For levels greater than twice the Ra-226 background, the gamma-radium correlation Model 1, as described in [Section 4.3](#), is more appropriate to estimate the lateral extent of Ra-226 contamination at OCRM as the contribution from naturally occurring radioactive elements, such as potassium and thorium, is less significant.

[Figure 28](#) shows the estimated extent of lateral contamination at OCRM, which totals 56 acres of Ra-226 above 5.0 pCi/g as estimated by Model 1. The extent of Ra-226 contamination at more than twice background levels concentrated around suspected waste piles with evidence of contamination moving off site primarily to the northeast and aligning with the prevailing winds in the area presented in [Figure 6](#).

4.8 AREAS OF CONCERN

Results from the investigation identified four primary areas of concern at the OCRM site posing potential threats to nearby residents which warrants action under a TCRA (see [Figure 29](#)):

- **Area 1** lies on the south/southeast side of State Route 566 from OCRM and occupies a nearby resident's grazing lands. Contamination was identified in this area as a result of windblown transport as well as an extension of the mine waste piles which were deposited prior to the construction of Route 566. Removing material from this area would mitigate surficial exposure to contamination caused by windblown transport and past mine waste deposition.
- **Area 2** consists of a berm of waste material partially within but primarily outside the western fenced area at OCRM but east of the eastern bank of the unnamed arroyo that runs west of OCRM. Removing material from this area would mitigate the potential for windblown and stormwater transport of contaminants into the arroyo.
- **Area 3** consists of a portion of the unnamed arroyo where the width of Area 3 is defined as from the center point of the arroyo to the eastern or southeastern bank plus an additional 10 feet to the east/southeast. The length of Area 3 stretches from where a road crosses through the arroyo in Section 17 to where the arroyo crosses into Section 8. Removing material from this area would mitigate the potential for windblown and stormwater transport of contaminants into the arroyo.
- **Area 4** consists of the surficial waste material within the fenced area of OCRM site, excluding Area 3 and the areas around the former settling ponds and ion-exchange building. Removing material from this area would mitigate the potential for windblown transport off site.



A fifth area of potential concern consists of a waste disposal area north of the unnamed arroyo in an open field within Section 8. While this area is of concern, because it is located within a fenced area and is not adjacent to the unnamed arroyo, it is not considered to be posing an imminent and substantial threat to the nearby community. It will be addressed along with all other areas of concern through the non-time-critical removal action process.

4.9 VOLUME ESTIMATES

[Table 22](#) summarizes the volume estimates of each area using Ra-226 cleanup criteria of 2, 5, 10, 15, and 25 pCi/g. The volumes are also calculated to show the total estimated volume of waste in each area and the estimated volume of waste if only the first 2 feet of waste exceeding the cleanup criteria were to be removed.

[Appendix I](#) provides a detailed assessment of each area and the methods associated with estimating volumes. This appendix references a 2013 Phase II site characterization draft report (Intera, Inc. 2013) and uses raw downhole gamma data from boring logs in estimating the depth of Ra-226 contamination. No interpretations or calculations made in the draft report were used in the volume estimates in [Appendix I](#). The only information taken from the site characterization report was raw measurements collected by field instruments. However, because the accuracy of the instruments used in the investigation cannot be verified, all volumes derived are estimates.

5.0 CONCLUSIONS AND ADDITIONAL DATA NEEDS

The objectives of the removal assessment at OCRM were to:

- Assess background levels of radiation and metals in soil.
- Quantify the lateral extent of contamination.
- Collect sufficient data to assess TCRA eligibility.

Background levels of radiation, as measured by gamma survey instruments, and concentrations of radionuclides and metals in soil were assessed at BSA-02 and are fully documented in [Appendix H](#). BTVs for 29 metal and radionuclide analytes were identified based on the background investigation and used in tandem with COPC screening values to identify the COPCs at OCRM as barium, molybdenum, Ra-226, selenium, uranium, vanadium, and zinc.

Gamma surveys conducted at OCRM and surrounding areas successfully bounded the lateral extent of gamma radiation except for where quaternary alluvium contacts colluvium and landslide deposits related to the Mancos Shale. At these geologic contacts, black marine shale was observed, which contains higher concentrations of NORM than quaternary alluvium. Further studies should be conducted to better delineate the geologic borders to differentiate between contamination from OCRM and elevated NORM in these border geologies, as well as establish geology-specific BTVs.

Without further background studies to calculate additional geology-specific BTVs and based on the more conservative Model 2 from the gamma-radium correlation study, 170 acres of OCRM and the surrounding area exceed a level of 2.0 pCi/g Ra-226. Based on Model 1 from the gamma-radium correlation study, 56 acres exceed a level of 5 pCi/g Ra-226.

Surficial soil contamination with radionuclides and metals was observed to have migrated off OCRM via windblown and surface water transport mechanisms as well as physical displacement of materials by vehicles along roads. These transport mechanisms continue to pose a threat to the nearby population. The removal assessment identified four areas that pose an ongoing threat to residents and should be considered for response actions under a TCRA:

- Area 1 is an area southeast of the site across State Route 566 where waste material has moved onto a resident's grazing lands.
- Area 2 is a berm of waste material that is migrating to the unnamed arroyo that runs beside the site. The berm's high concentrations of contaminants and proximity to the arroyo pose a threat of waste material migration by wind and surface flow.
- Area 3 is a portion of the east bank of the unnamed arroyo that borders Area 4 but includes material that is eroding and migrating into the arroyo and being carried downstream.
- Area 4 is the largest of the four areas and consists of former waste piles and former areas of mining activities with high concentrations of contaminants that are migrating off site by wind and stormwater transport.

The following sections detail the data gaps identified either in the field or during the post-processing of data that should be addressed in future investigations of OCRM.

5.1 GEOLOGICAL INTERFERENCE ON LATERAL EXTENT

One objective of the removal assessment was to fully characterize the lateral extent of radiological contamination at OCRM using gamma surveys. The surveys were completed as planned except for two areas—one to the north of the site and one to the northeast of the site—where the geologic formations changed.

Further studies are recommended to assess the true lateral extent of contamination at OCRM by:

- Precisely identifying the geologic contacts in each area
- Conducting surface and subsurface sampling to evaluate whether the gamma-emitting radionuclides are a result of windblown transport in those areas or are a natural part of the geologic formation
- Conducting additional background investigations in each geology to appropriately characterize the extent of contamination above background in each area

5.2 ADDITIONAL SOIL CHARACTERIZATION IN AREAS OF LOW GAMMA

The objective of the soil sampling as part of the removal assessment was to identify the highest levels of contaminants on OCRM and to conduct biased sampling in those areas. Because of the biased approach to sampling, the soil sample data collected during the removal assessment are not sufficient to validate the accuracy of the gamma-radium correlations developed for Ra-226 concentrations near background because of few site samples with low Ra-226.

Additional surface soil characterization is recommended across the site to better characterize the nature and extent of contamination.

5.3 WIND DIRECTION

The closest available wind data come from Gallup, New Mexico. However, the presence of the large mesas in the general area of OCRM likely disrupts this expected wind pattern. Wind characterization is recommended at the site to properly assess local wind patterns and their effect on the windblown transport of site materials. A new meteorological station is planned for the nearby Northeast Church Rock mill site which may provide more local meteorological data.

5.4 X-RAY FLUORESCENCE CORRELATION CONFIRMATION STUDY

Appendix B of the 2018 Northern Agency AUMs removal site evaluation report (Tetra Tech 2018) establishes a correlation between XRF instrument raw output (in units of ppm) and soil analytical results (in units of milligram per kilogram) for the Northern AUM Region. If an XRF correlation confirmation study is completed with results that agree with the findings in Appendix B, the correlations established for the Northern AUM Region could potentially be used in the Eastern AUM Region.



5.5 BLACKROCK ROAD

As noted in [Section 4.2.2.4](#), gamma survey results along Blackrock Road, which extends west of OCRM, did not indicate any gamma radiation levels above the BTV. However, conversations with residents noted that Blackrock Road had been reworked within the last month, before the removal assessment, with new gravel laid over the old road. The presence of whether contamination exists underneath Blackrock Road therefore remains an unanswered question. Additional study of the soil underneath the recently covered Blackrock Road should be included in future investigations.

6.0 REFERENCES

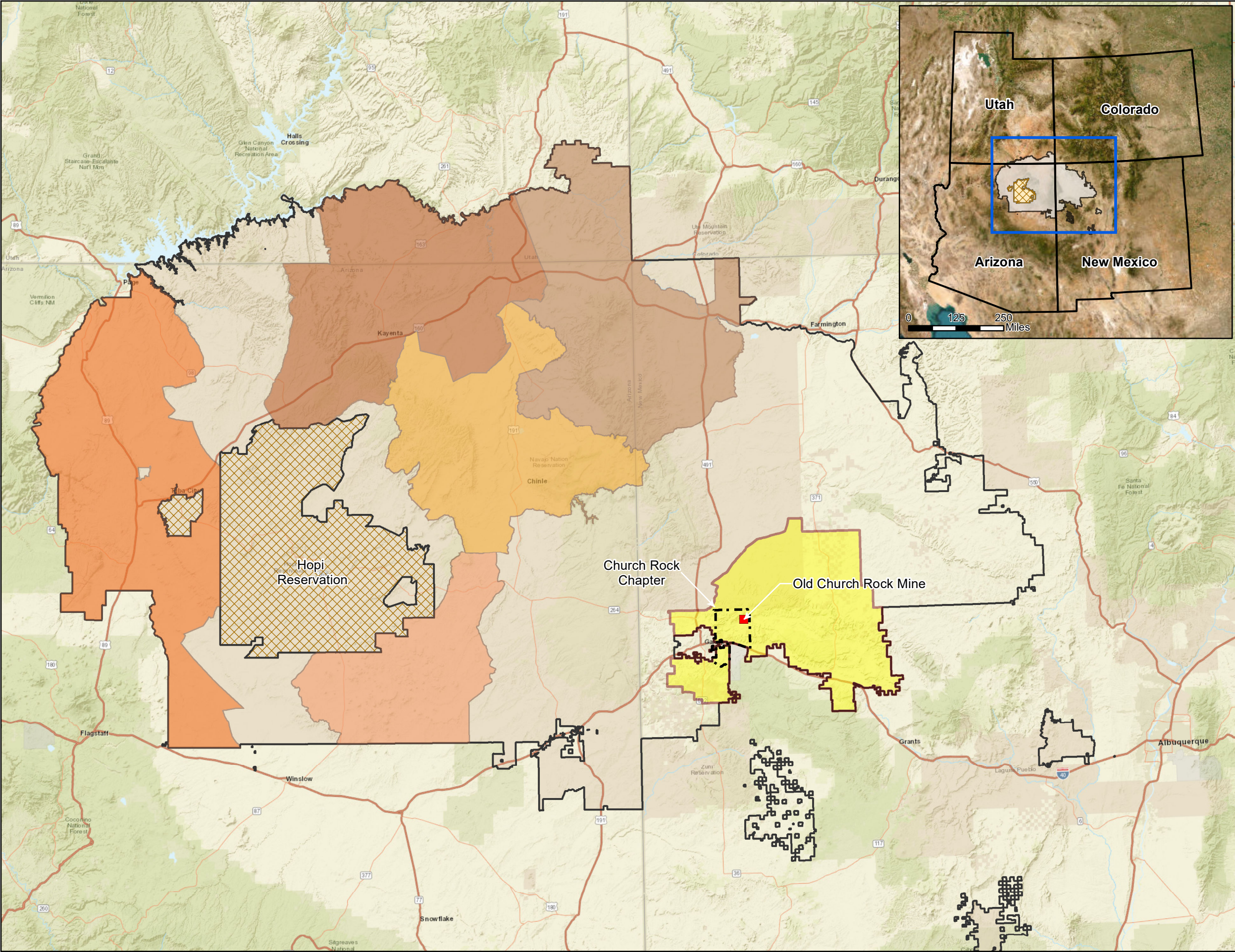
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FIGURES



- Old Church Rock Mine
- Affected Chapter Boundary
- Navajo Nation Boundary
- Hopi Reservation
- Navajo Nation Abandoned Uranium Mine Regions**
- Eastern Region
- Central Region
- Northern Region
- North Central Region
- Southern Region
- Western Region

1 inch = 25 miles

1:1,584,000

25 12.5 0 25 Miles

REGIONAL LOCATION

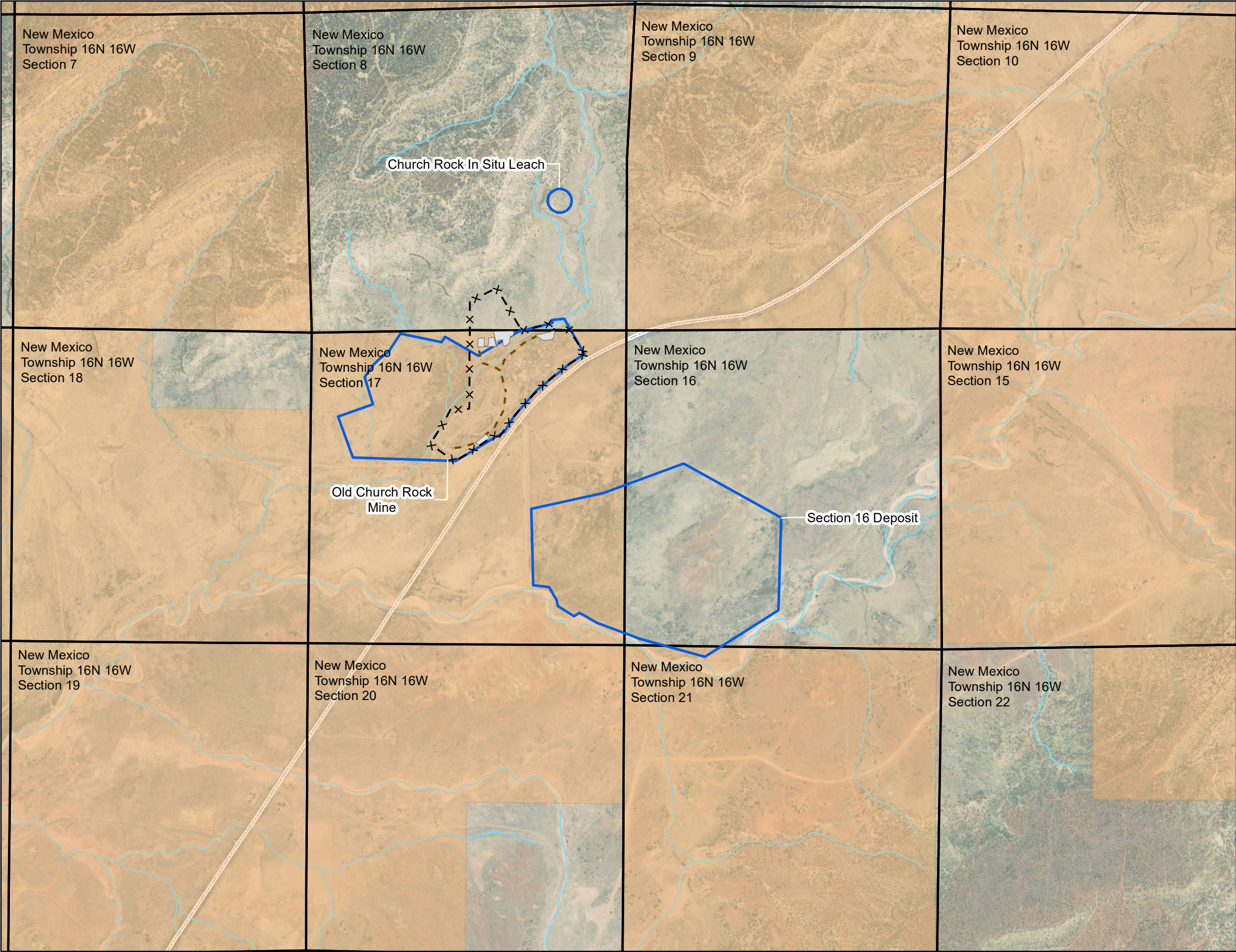
Prepared For: U.S. EPA Region 9



Prepared By:

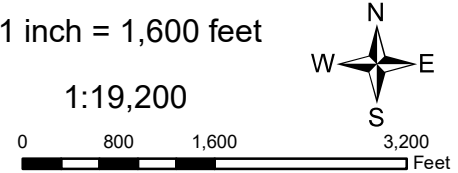
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: NAVAJO NATION	Date: 3/29/2023
Coordinate System: NAD 1983 UTM Zone 12N Transverse Mercator	Figure No.: 1





- X — Fenced Boundary
- Drill Road - Constructed Fall 2022
- Laydown Areas - Constructed Fall 2022
- PLSS Section Boundary
- Navajo Nation Lands
- EPA 2007 Navajo AUM Atlas Polygon
- State Route 566
- Drainage

Notes:
¹Boundary from U.S. Bureau of Indian Affairs, 2010, American Indian and Alaska Native Land Area Representation (AIAN-LAR) Geographic Information System-PLSSFirstDivision, accessed March, 28, 2023 at URL https://biamaps.doi.gov/server/rest/services/DivLTR/BIA_AIAN_National_LAR/MapServer
PLSS Public land survey system



**PUBLIC LAND SURVEY SYSTEM
NAVAJO NATION BOUNDARY
TOWNSHIP MAP**

Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0035		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 3/29/2023	
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse			Figure No.: 2



Historical Imagery 1954



Historical Imagery 1962



**OLD CHURCH ROCK MINE
HISTORICAL AERIAL IMAGERY
1954 AND 1962**

Prepared For: U.S. EPA Region 9



Prepared By:



Task Order No.:
0035

Contract No.:
EP-S9-17-03

Location:
CHURCH ROCK CHAPTER
NAVAJO NATION

Date:
8/15/2022

Coordinate System:

Figure No.:

3



OLD CHURCH ROCK MINE
HISTORICAL AERIAL IMAGERY
1962 AND 1978

Prepared For: U.S. EPA Region 9



Prepared By:



Task Order No.:
0035

Contract No.:
EP-S9-17-03

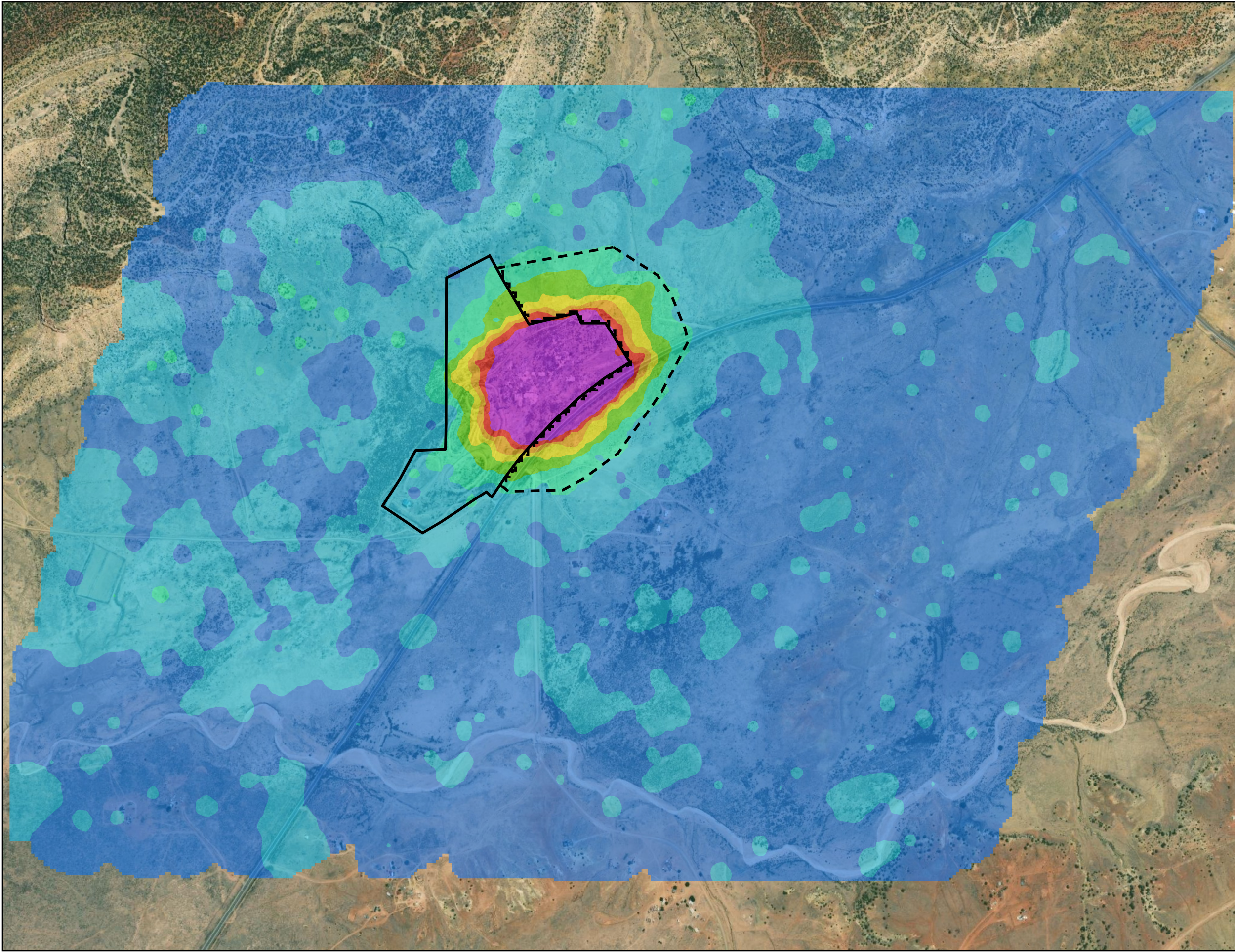
Location:
CHURCH ROCK CHAPTER
NAVAJO NATION

Date:
8/15/2022

Coordinate System:

Figure No.:

4

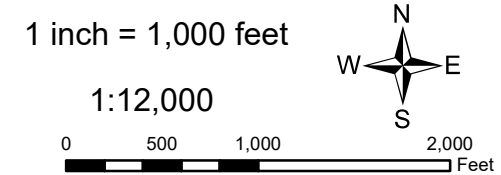


ASPECT net eU
Bismuth-214 Concentration


- < 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- > 7

- Fenced Site Boundary
- ASPECT Step-Out

Notes:
ASPECT Airborne Spectral Photometric
 Environmental Collection
 Technology
eU Esitmated uranium
USEPA U.S. Environmental Protection
 Agency

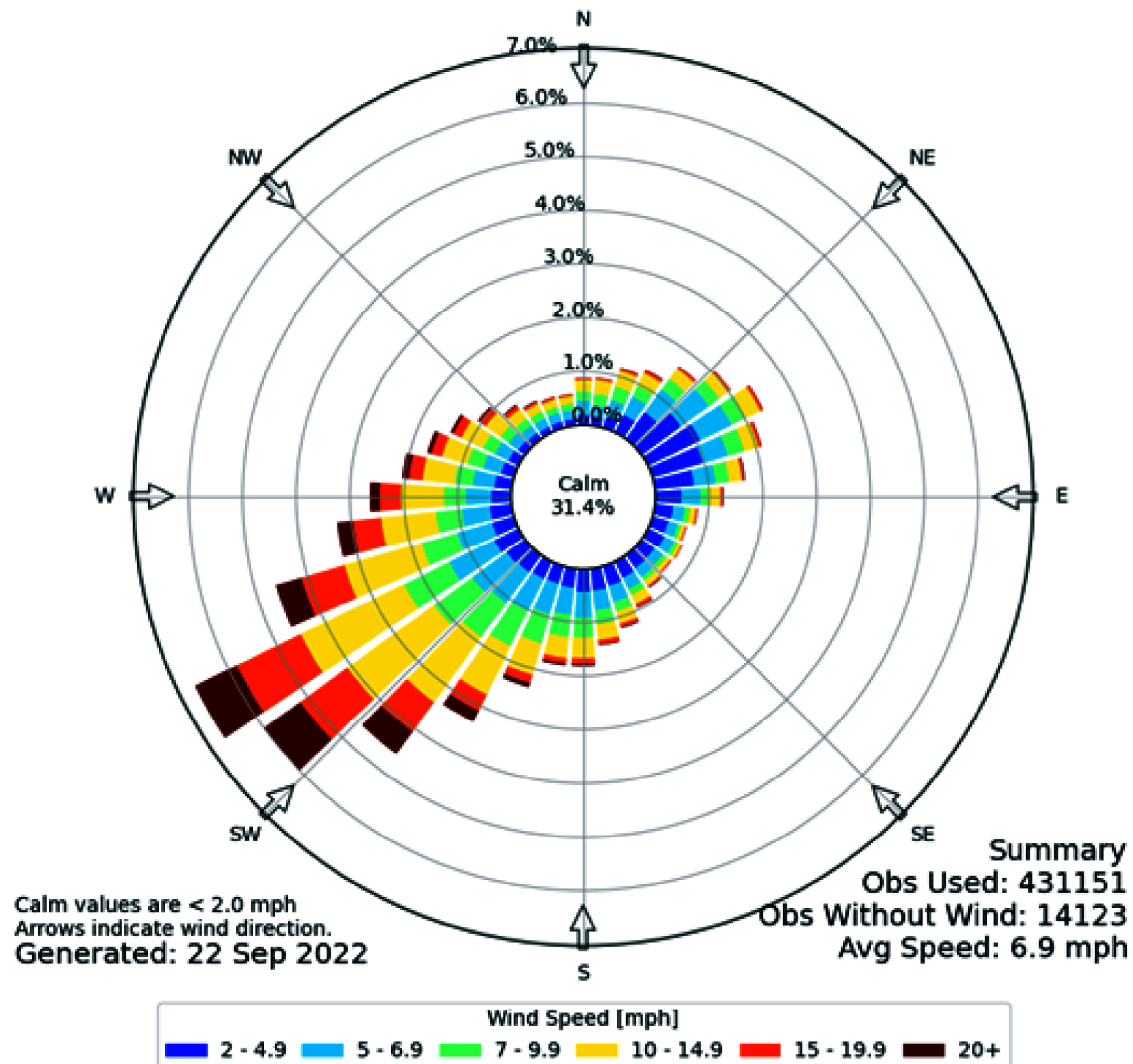


**OLD CHURCH ROCK MINE
AERIAL GAMMA RADIATION SURVEY
(USEPA 2020)**

Prepared For: U.S. EPA Region 9 	Prepared By:  TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/15/2022
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 5



Windrose Plot for [GUP] GALLUP MUNI/CLARKE
Obs Between: 31 Dec 1972 05:00 PM - 22 Sep 2022 12:53 AM America/Denver



GALLUP
NEW MEXICO
PREVALANT WINDS

Prepared For: U.S. EPA Region 9

Prepared By:



Task Order No.:
0035

Contract No.:
EP-S9-17-03

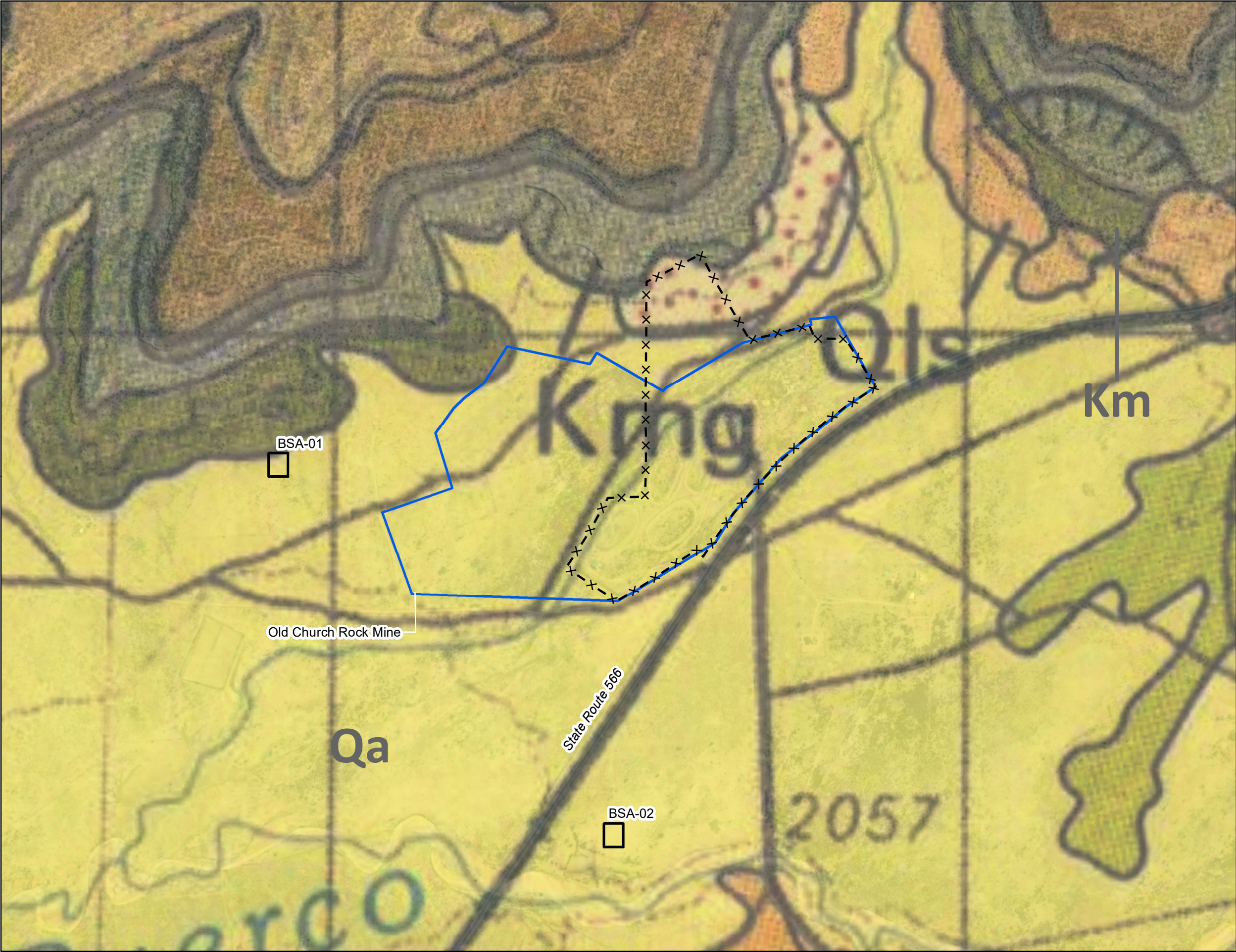
Location:
CHURCH ROCK CHAPTER
NAVAJO NATION

Date:
8/21/2022

Coordinate System:

Figure No.:

6



Geologic Units¹

- Alluvial Deposits (Qa)
- Colluvium (Qc)
- Older Alluvium (Qoa)
- Landslide Deposits (Qls)
- Dalton Sanstone Member, unnamed lower tongue, and Borrego Pass Lentil of Crevasse Canyon Formation, and Mulatto Tongue of Mancos Shale, Undivided (Kcd)
- Dilco Coal Member of Crevasse Canyon Formation (Kcdi)
- Main Body Gallup Sandstone (Kg)
- Lower Tongues of Gallup Sandstone, and Unnamed Tongues of Mancos Shale, Undivided (Kmg)
- Main Body Mancos Shale (Km)
- Twowells Tongue of Dakota Sandstone and Whitewater Arroyo Tongue of Mancos Shale, Undivided (Kdt)

"EPA 2007 Navajo AUM Atlas Polygon

Background Study Area

Fenced Boundary

Note:
¹Dillinger (1990).

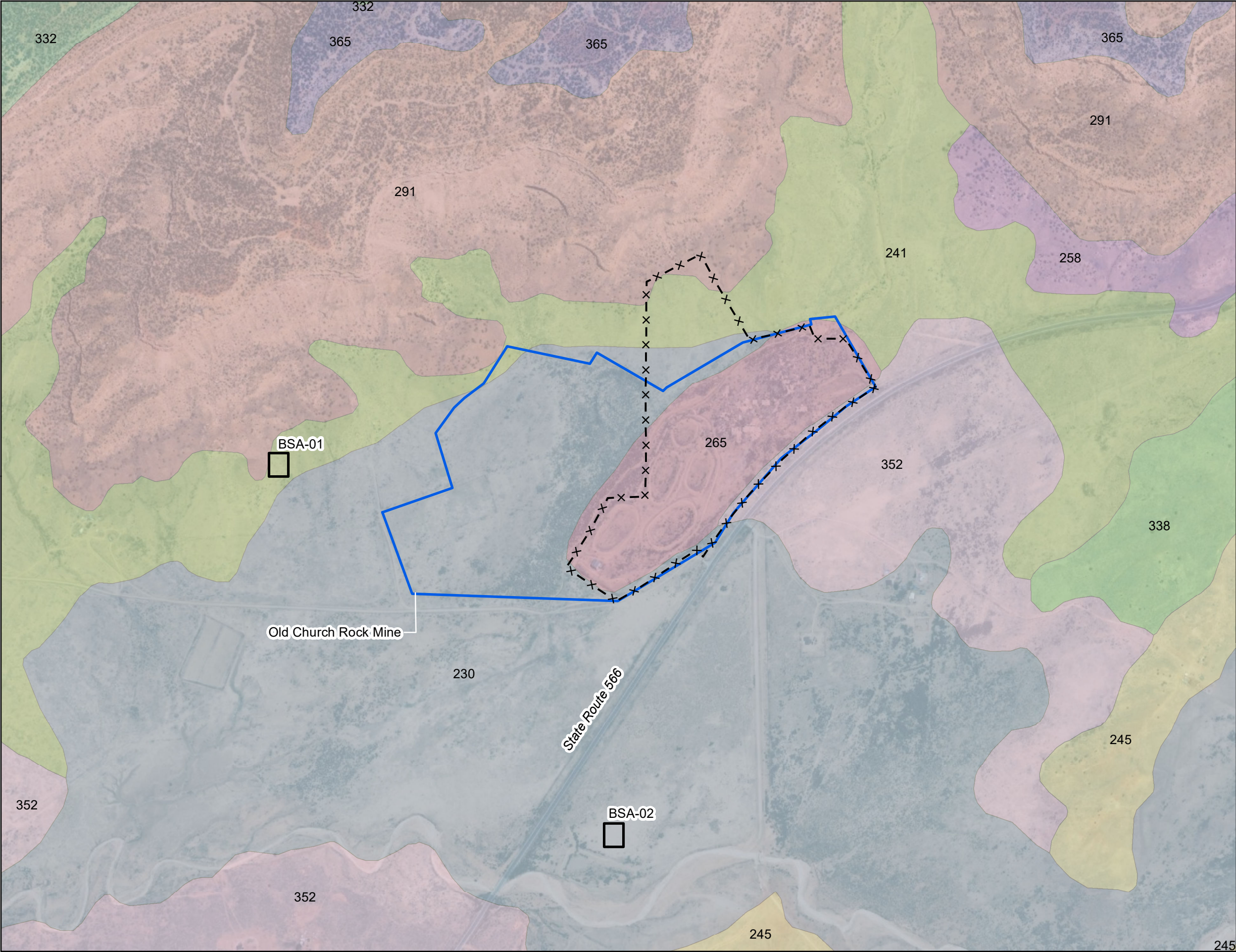
1 inch = 800 feet
1:9,600

0 400 800 1,600 Feet

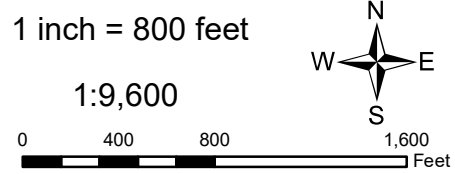
N
W E
S

**OLD CHURCH ROCK MINE
SURFACE EXPRESSED
GEOLOGY**

Prepared For: U.S. EPA Region 9 	Prepared By: TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 7

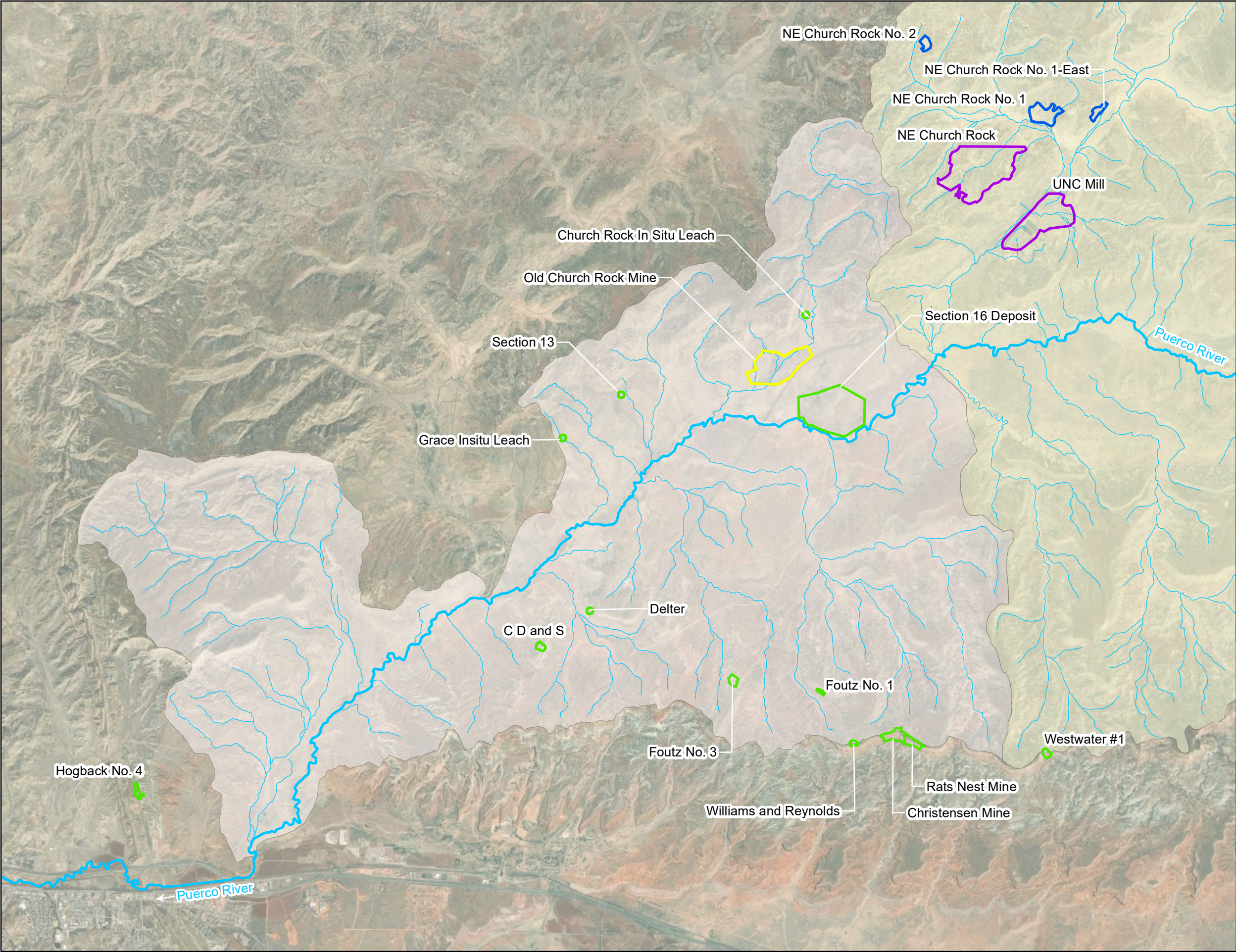


- Soil Units**
- Buckle-Gapmesa-Barboncito complex, 1 to 6 percent slopes (245)
 - Eagleye-Atchee-Rock outcrop complex, 2 to 35 percent slopes (258)
 - Evpark-Arabrab complex, 2 to 6 percent slopes (332)
 - Mentmore loam, 1 to 8 percent slopes (241)
 - Rock outcrop-Eagleye-Atchee complex, 35 to 70 percent slopes (291)
 - Sparank-San Mateo-Zia complex, 0 to 3 percent slopes (230)
 - Uranium mined lands (265)
 - Vessilla-Rock outcrop complex, 2 to 15 percent slopes (365)
 - Zia sandy loam, 1 to 5 percent slopes (352)
 - Zyme-Lockerby association, 5 to 35 percent slopes (338)
- EPA 2007 Navajo AUM Atlas Polygon
- Background Study
- Mine Site Fence Line



**OLD CHURCH ROCK MINE
SOILS**

Prepared For: U.S. EPA Region 9	Prepared By:
	TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 8



Watersheds (Hydrologic Unit Code)

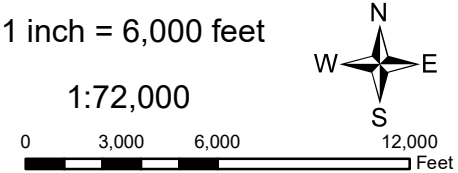
- Town of Pinedale-Puerco
- White Rock Mesa-Puerco

- Puerco River
- Surface Water Pathway



AUM Site Boundaries

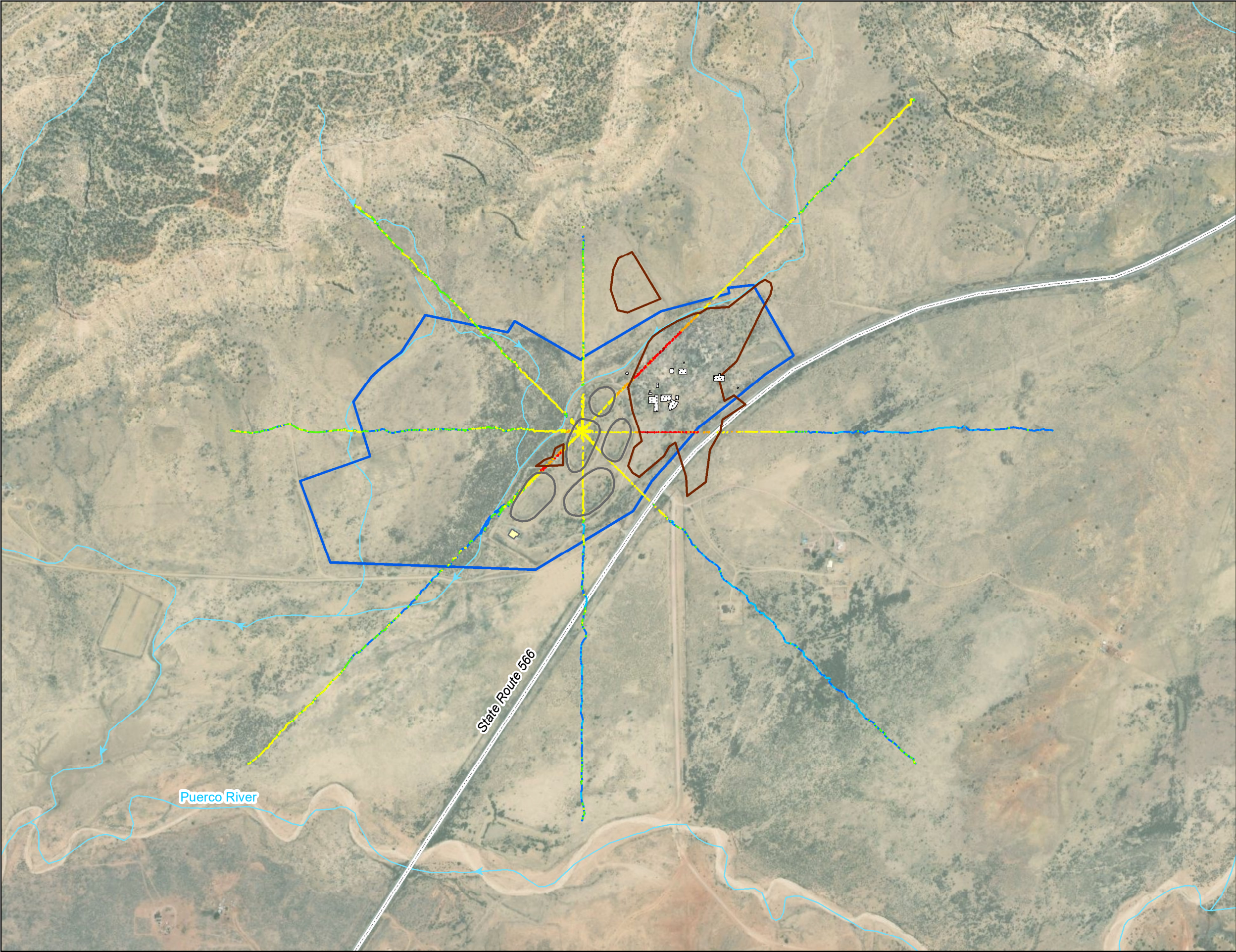
- USEPA Lead
- Other
- Tronox Incorporated
- United Nuclear Corporation

Notes:
AUM Abandoned Uranium Mine
NE Northeast
UNC United Nuclear Corporation
US EPA U. S. Environmental Protection Agency



**OLD CHURCH ROCK MINE
HYDROLOGY**

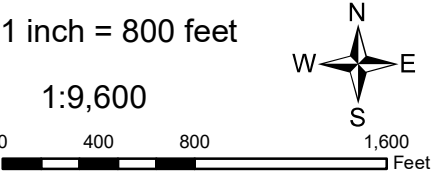
Prepared For: U.S. EPA Region 9 	Prepared By:  TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: NAVAJO NATION	Date: 9/8/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 9



Gamma Reading (cpm)		
●	≤ 11,500	≤ Q1
●	11,500 - 13,228	Q1 - Avg
●	13,228 - 14,555	Avg - BTV ¹
●	14,555 - 29,096	BTV - 2 x BTV
●	29,096 - 72,740	2 x BTV - 5 x BTV
●	72,740 - 181,850	5 x BTV - 12.5 x BTV
●	181,850 - 250,000	12.5 x BTV - 17 x BTV
●	>250,000	17 x BTV ^{>}
▭	2007 EPA Navajo AUM Atlas Polygon	
▨	Concrete Pad	
▭	Former Pond	
▭	Ion-Exchange Building	
▭	Approximate Waste Disposal Area	
---	Community Road	
→	Surface Water Pathway ²	

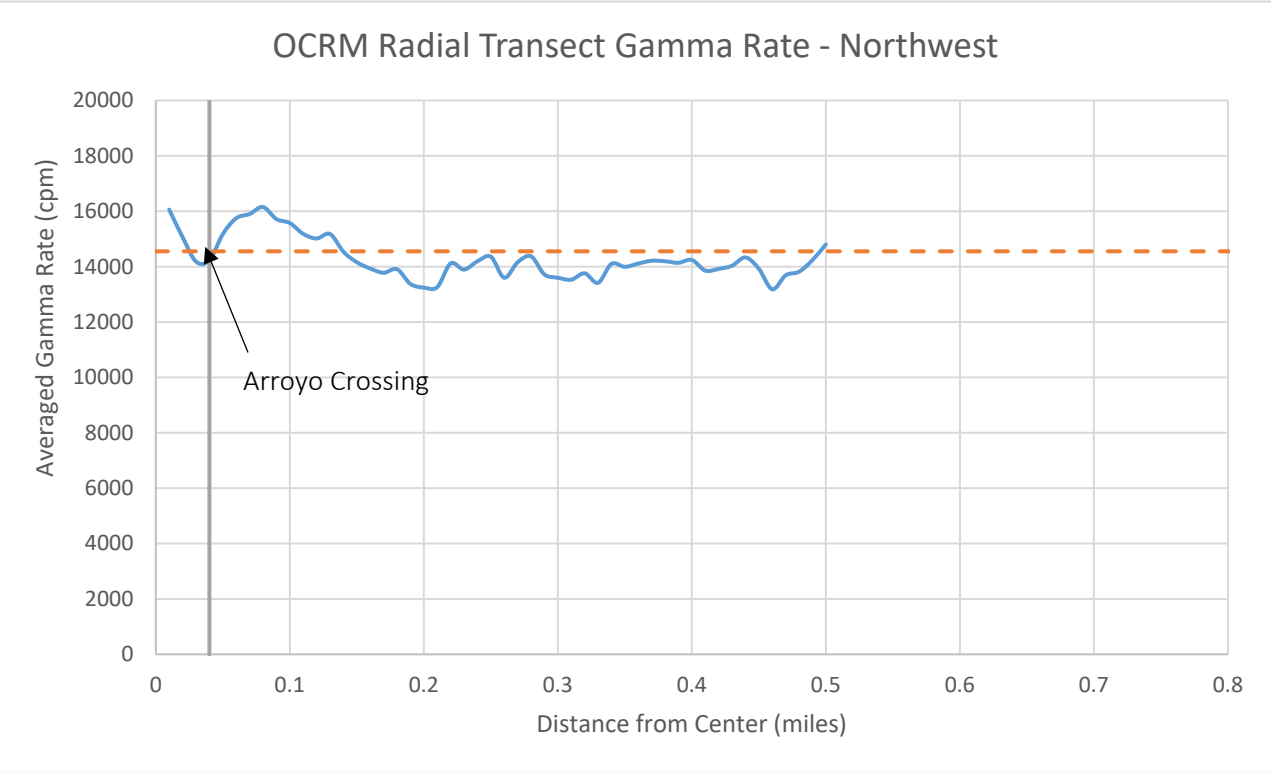
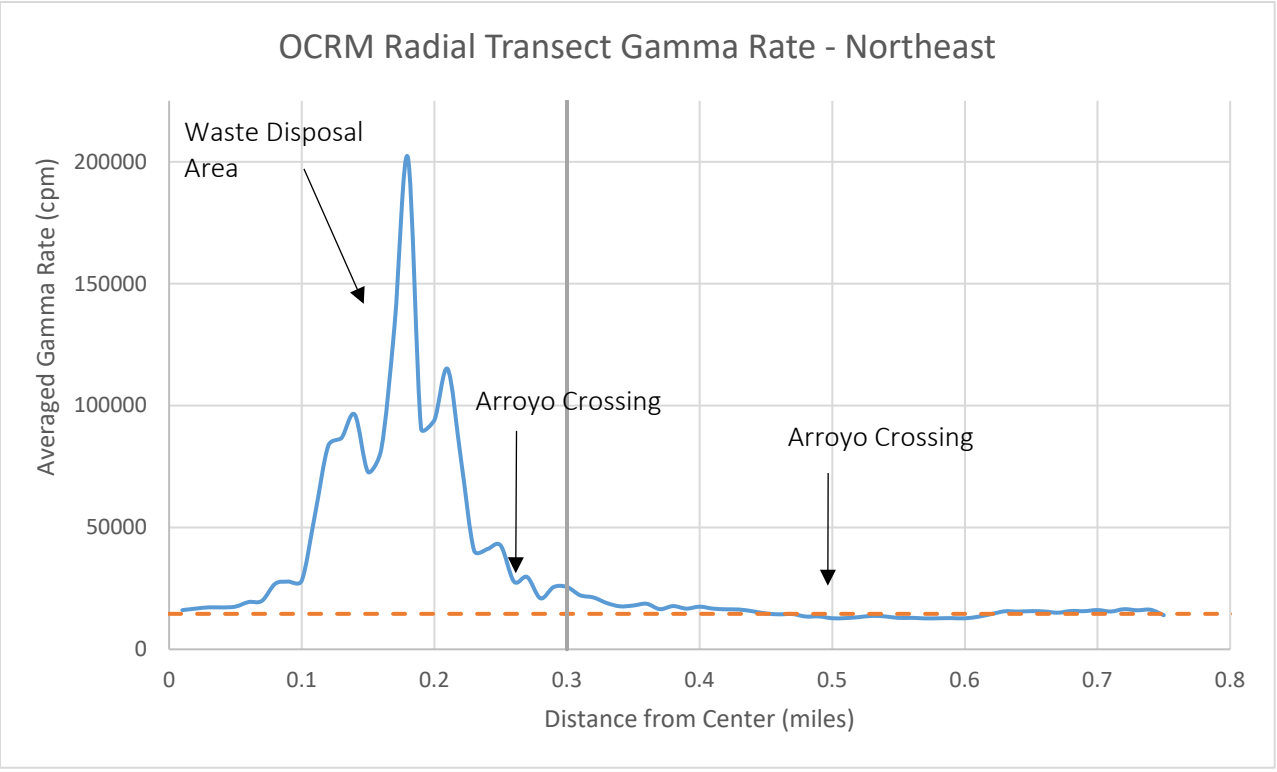
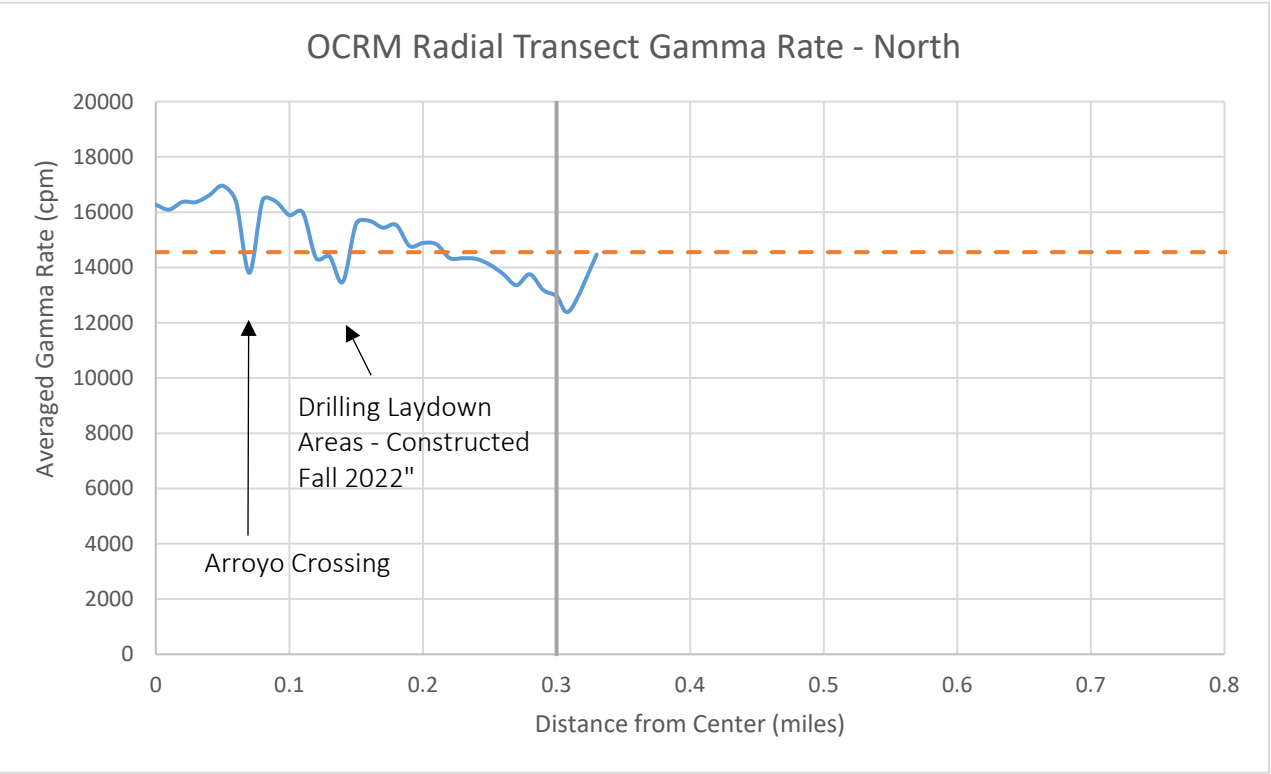
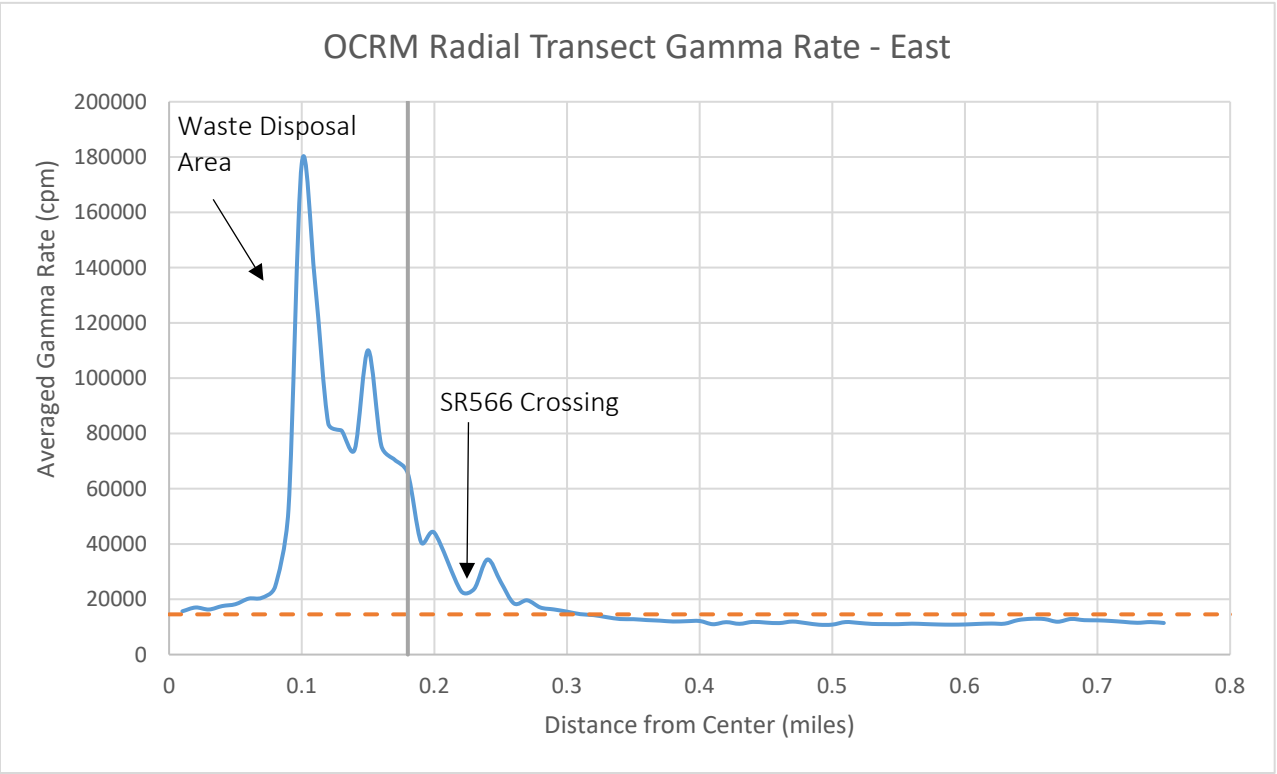
Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.
²All surface water pathways drain to the Puerco River.

AUM	Abandoned uranium mine
Avg	Average value of the background dataset
BTV	Background threshold value
cpm	Counts per minute
Q1	Twenty-fifth percentile of the background dataset
XRF	X-ray fluorescence



OLD CHURCH ROCK MINE
RAW RADIAL GAMMA RADIATION SURVEY

Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0035		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 8/21/2023	
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse			Figure No.: 11



— Average Gamma Rate (cpm)

- - - Gamma BTV

— Fenceline

Notes:

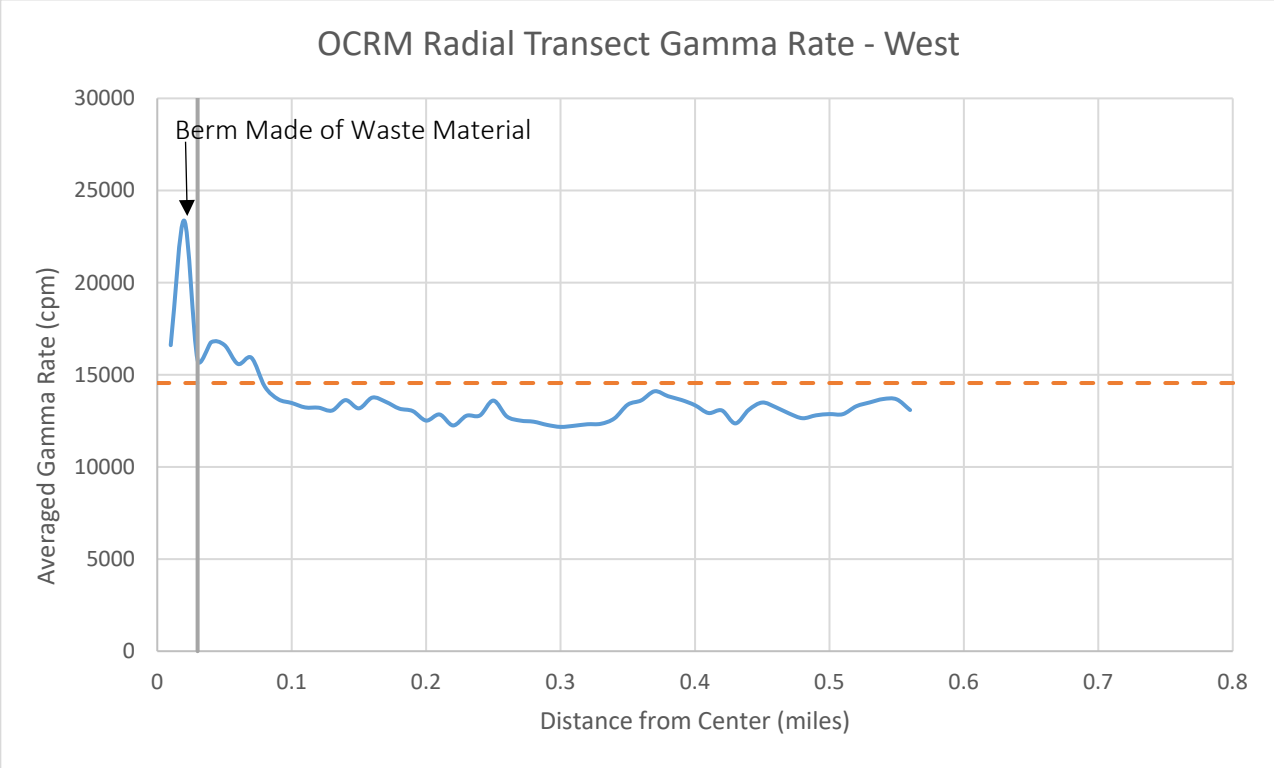
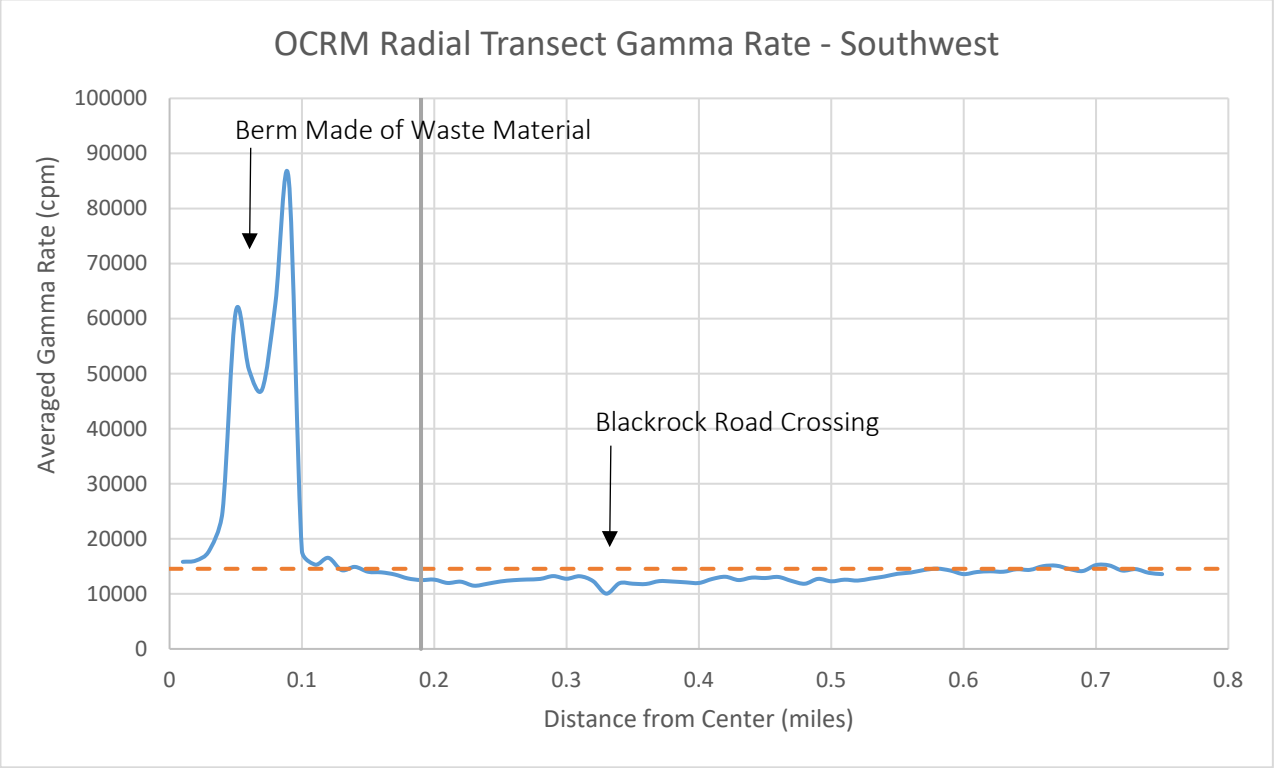
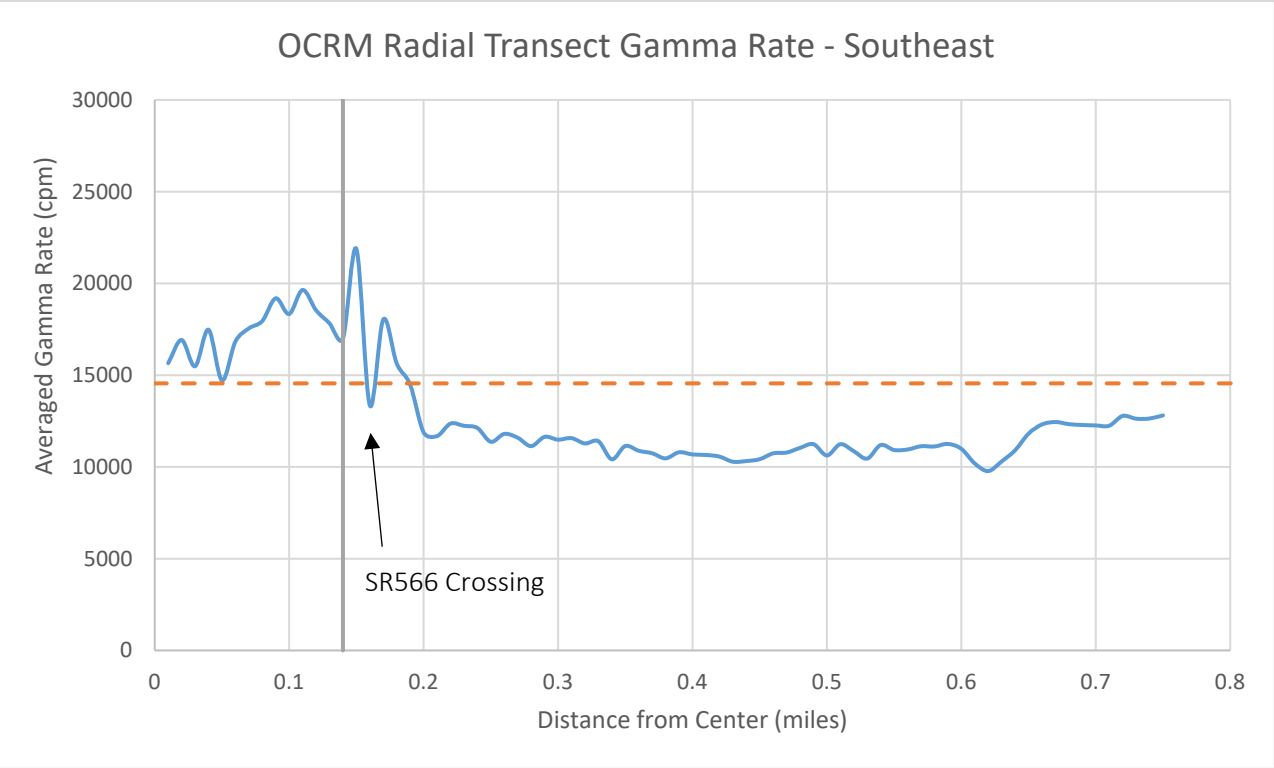
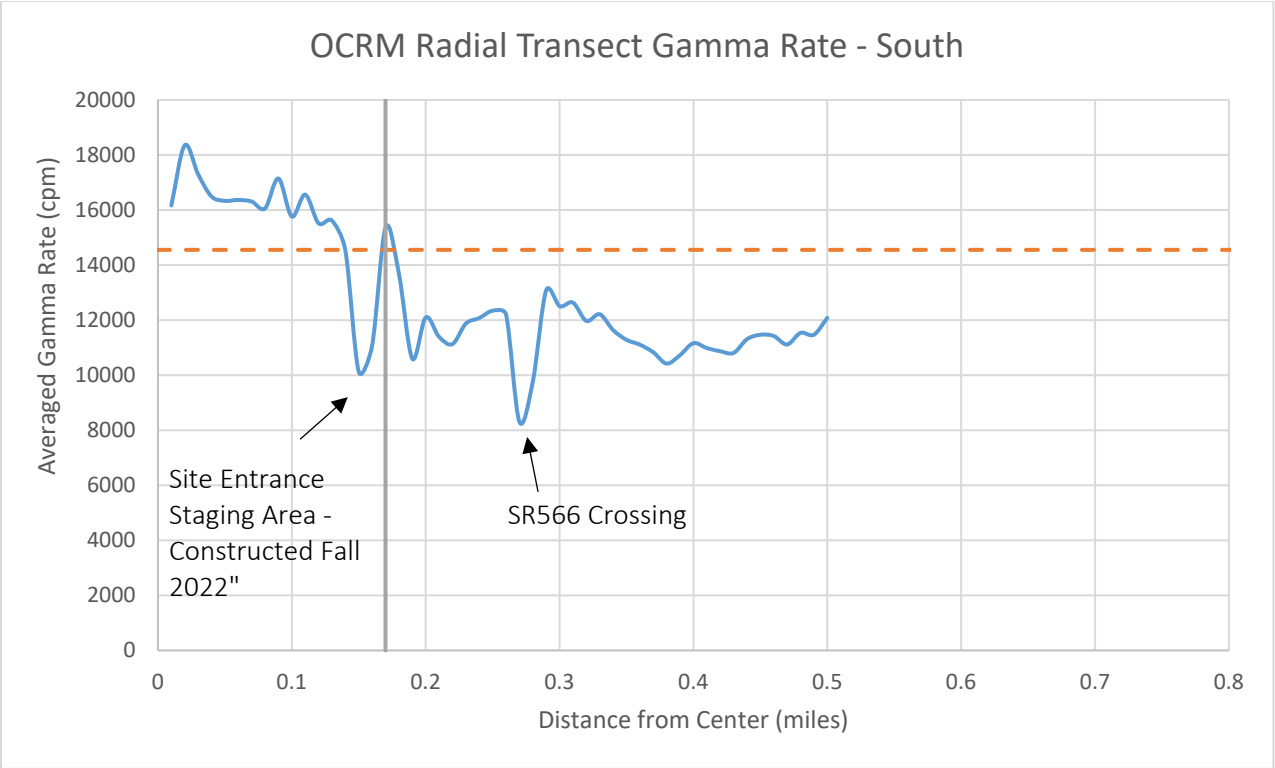
BTV Background threshold value

cpm Counts per minute

OCRMR Old Church Rock Mine

SR566 State Route 566

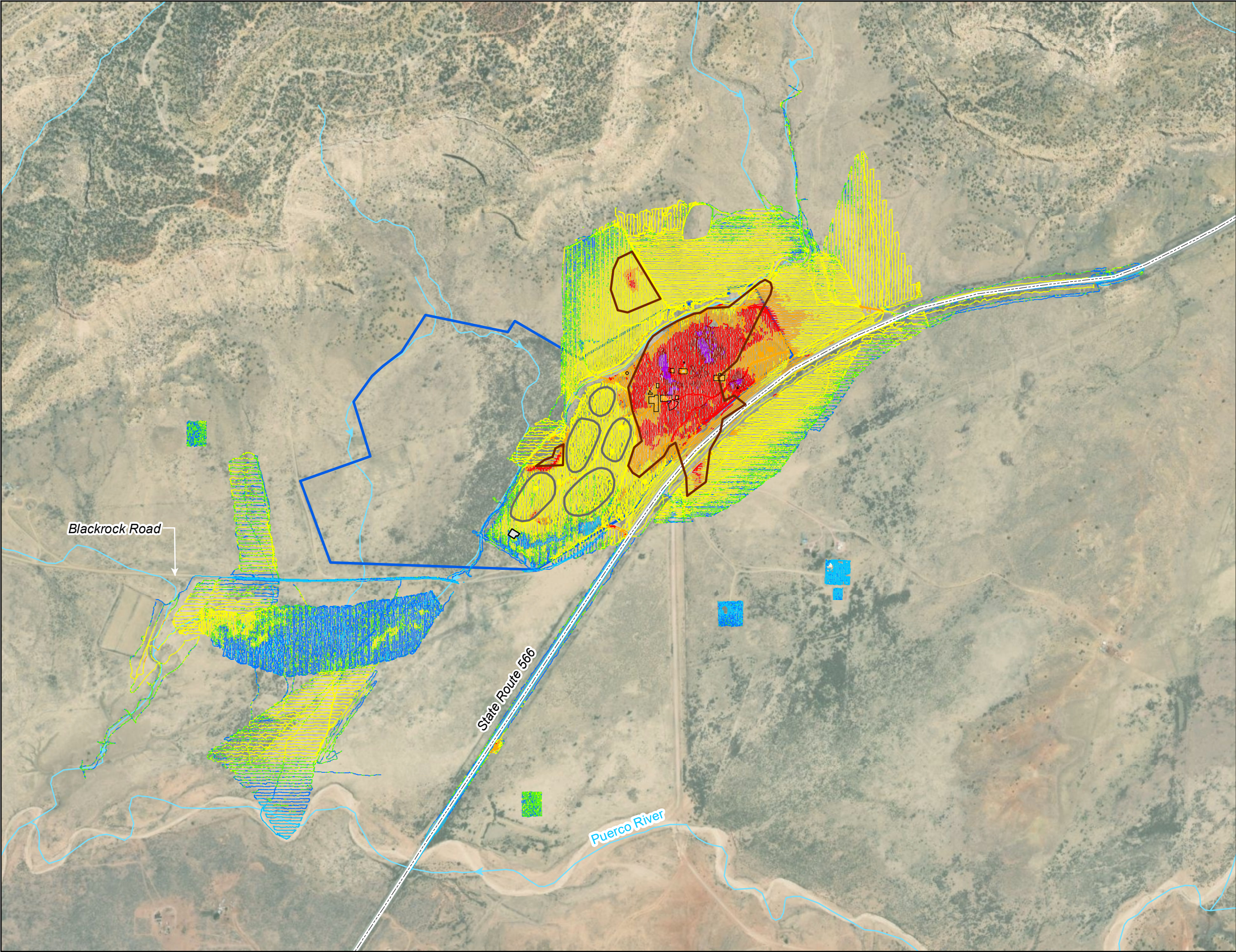
Figure 12. Old Church Rock Mine Radial Transect Gamma Rates vs. Distance from Center Point (Part 1)



— Average Gamma Rate (cpm)
- - - Gamma BTV
— Fenceline

Notes:
BTV Background threshold value
cpm Counts per minute
OCR Old Church Rock Mine
SR566 State Route 566

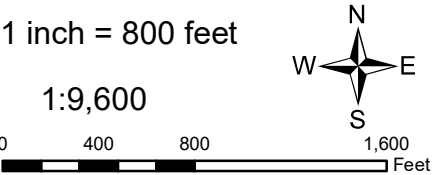
Figure 12. Old Church Rock Mine Radial Transect Gamma Rates vs. Distance from Center Point (Part 2)




Gamma Reading (cpm)		
●	≤ 11,500	≤ Q1
●	11,500 - 13,228	Q1 - Avg
●	13,228 - 14,555	Avg - BTV ¹
●	14,555 - 29,096	BTV - 2 x BTV
●	29,096 - 72,740	2 x BTV - 5 x BTV
●	72,740 - 181,850	5 x BTV - 12.5 x BTV
●	181,850 - 250,000	12.5 x BTV - 17 x BTV
●	>250,000	> 17 x BTV
□	EPA 2007 AUM Navajo Atlas Polygon	

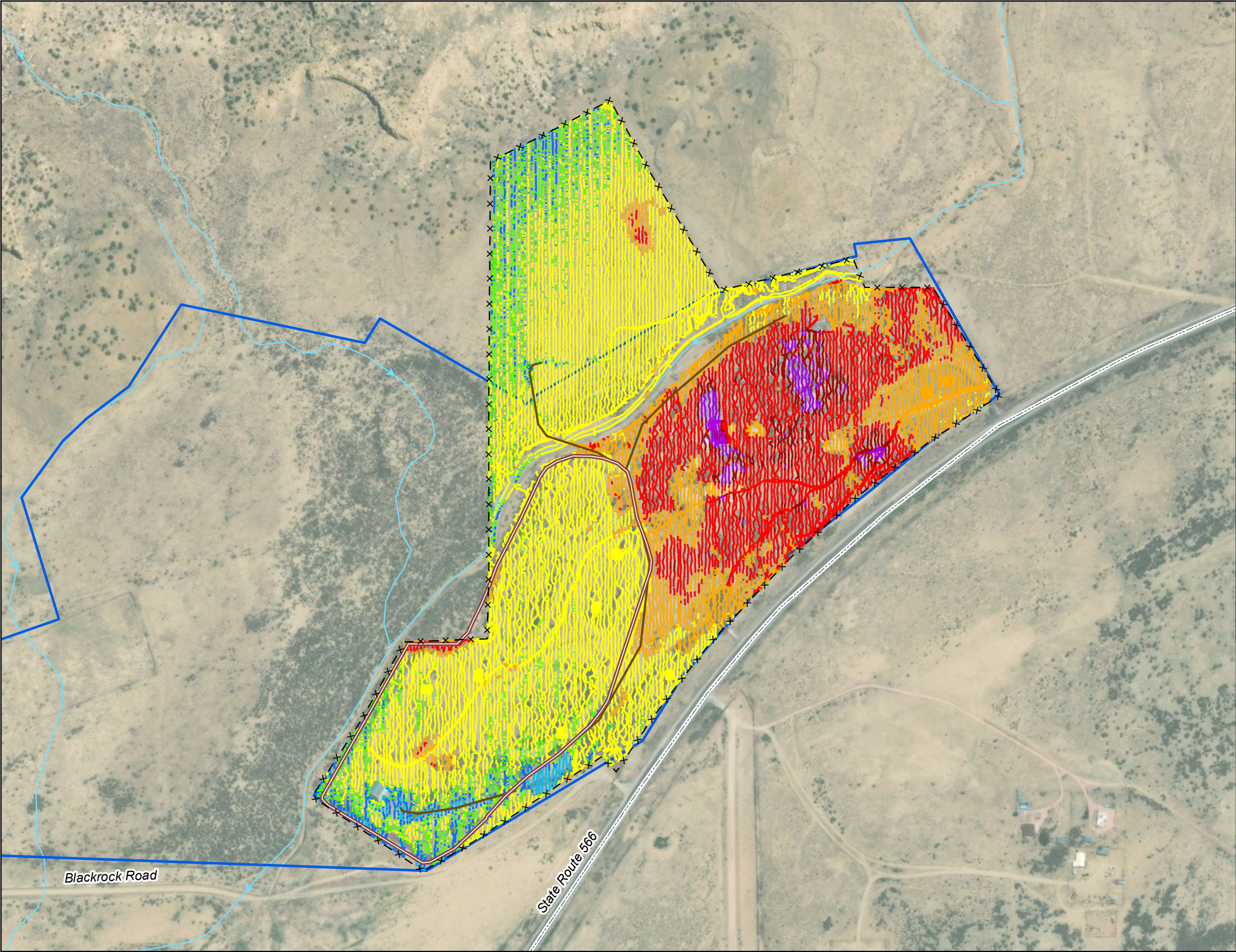
- Site Features**
- Concrete Pad
 - Former Pond
 - Ion-Exchange Building
 - Approximate Waste Disposal Area
 - Community Road
 - Surface Water Pathway²

Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.
²All surface water pathways drain to the Puerco River.
AUM Abandoned uranium mine
Avg Average value of the background dataset
BTV Background threshold value
cpm Counts per minute
Q1 Twenty-fifth percentile of the background dataset



**OLD CHURCH ROCK MINE
RAW GAMMA RADIATION SURVEY**

Prepared For: U.S. EPA Region 9 	Prepared By:  TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/25/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 13



Gamma Reading (cpm)		
●	≤ 11,500	≤ Q1
●	11,500 - 13,228	Q1 - Avg
●	13,228 - 14,555	Avg - BTV ¹
●	14,555 - 29,096	BTV - 2 x BTV
●	29,096 - 72,740	2 x BTV - 5 x BTV
●	72,740 - 181,850	5 x BTV - 12.5 x BTV
●	181,850 - 250,000	12.5 x BTV - 17 x BTV
●	>250,000	> 17 x BTV
□	EPA 2007 AUM Navajo Atlas Polygon	

- Site Features**
- Berm
 - × — Fenced Boundary
 - Drill Road – Fall 2022
 - Community Road
 - Surface Water Pathway²

Notes:

¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.

²All surface water pathways drain to the Puerco River.

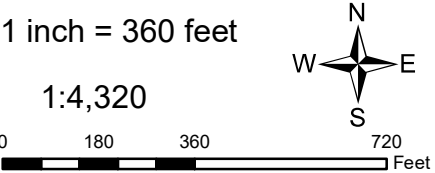
AUM Abandoned uranium mine

Avg Average value of the background dataset



BTV Background threshold value

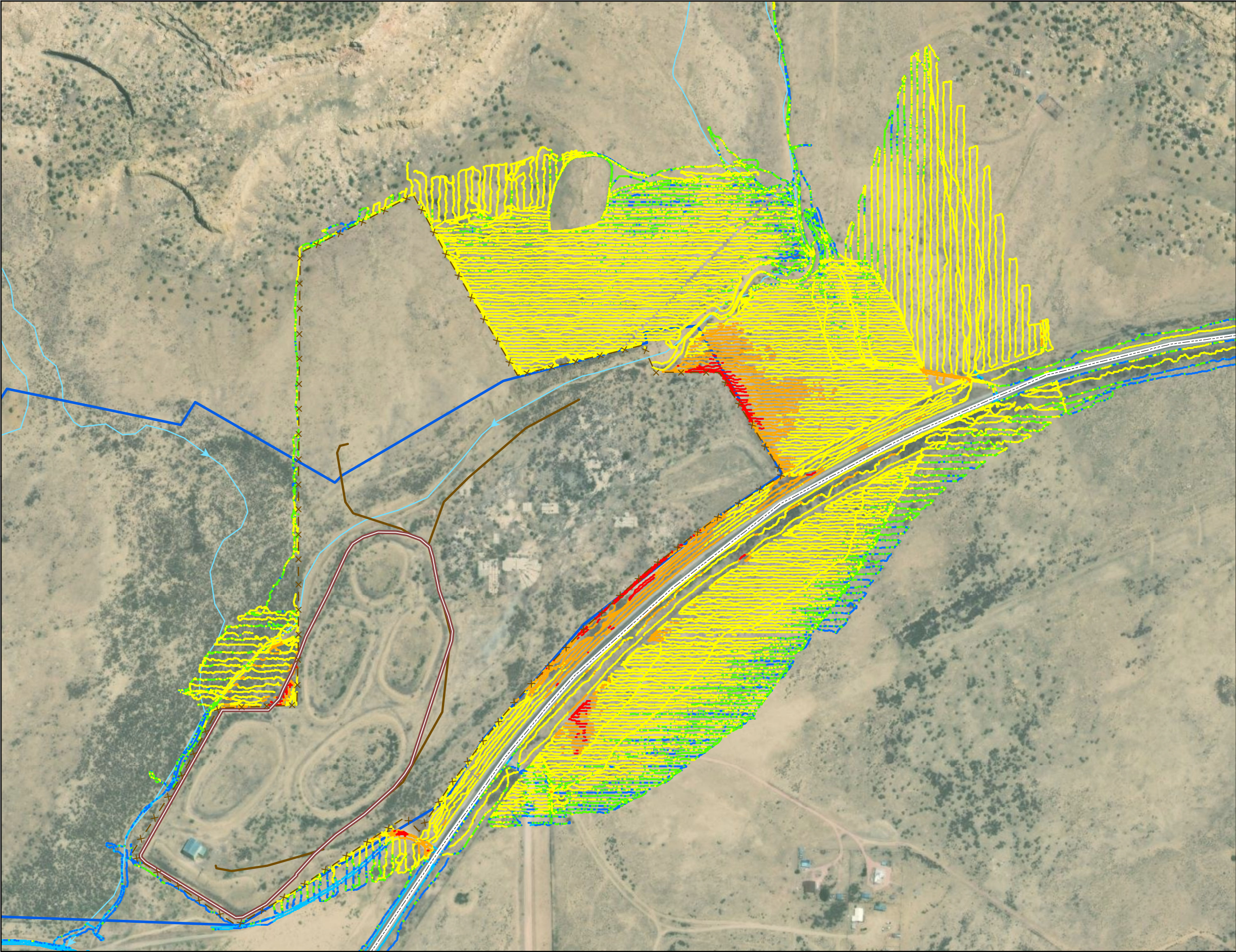
cpm Counts per minute

Q1 Twenty-fifth percentile of the background dataset



**OLD CHURCH ROCK MINE
RAW GAMMA RADIATION SURVEY —
FENCED SITE**

Prepared For: U.S. EPA Region 9	Prepared By:
	 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 9/8/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 14



Gamma Reading (cpm)		
●	≤ 11,500	≤ Q1
●	11,500 - 13,228	Q1 - Avg
●	13,228 - 14,555	Avg - BTV ¹
●	14,555 - 29,096	BTV - 2 x BTV
●	29,096 - 72,740	2 x BTV - 5 x BTV
●	72,740 - 181,850	5 x BTV - 12.5 x BTV
●	181,850 - 250,000	12.5 x BTV - 17 x BTV
●	>250,000	> 17 x BTV
□	EPA 2007 AUM Navajo Atlas Polygon	

- Site Features**
- Berm
 - × — Fenced Boundary
 - Drill Road – Fall 2022
 - Community Road
 - Surface Water Pathway²

Notes:

¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.

²All surface water pathways drain to the Puerco River.

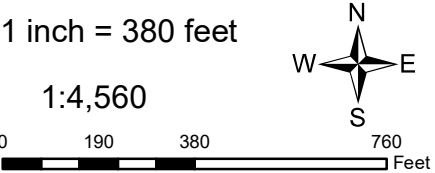
AUM Abandoned uranium mine

Avg Average value of the background dataset

BTV Background threshold value

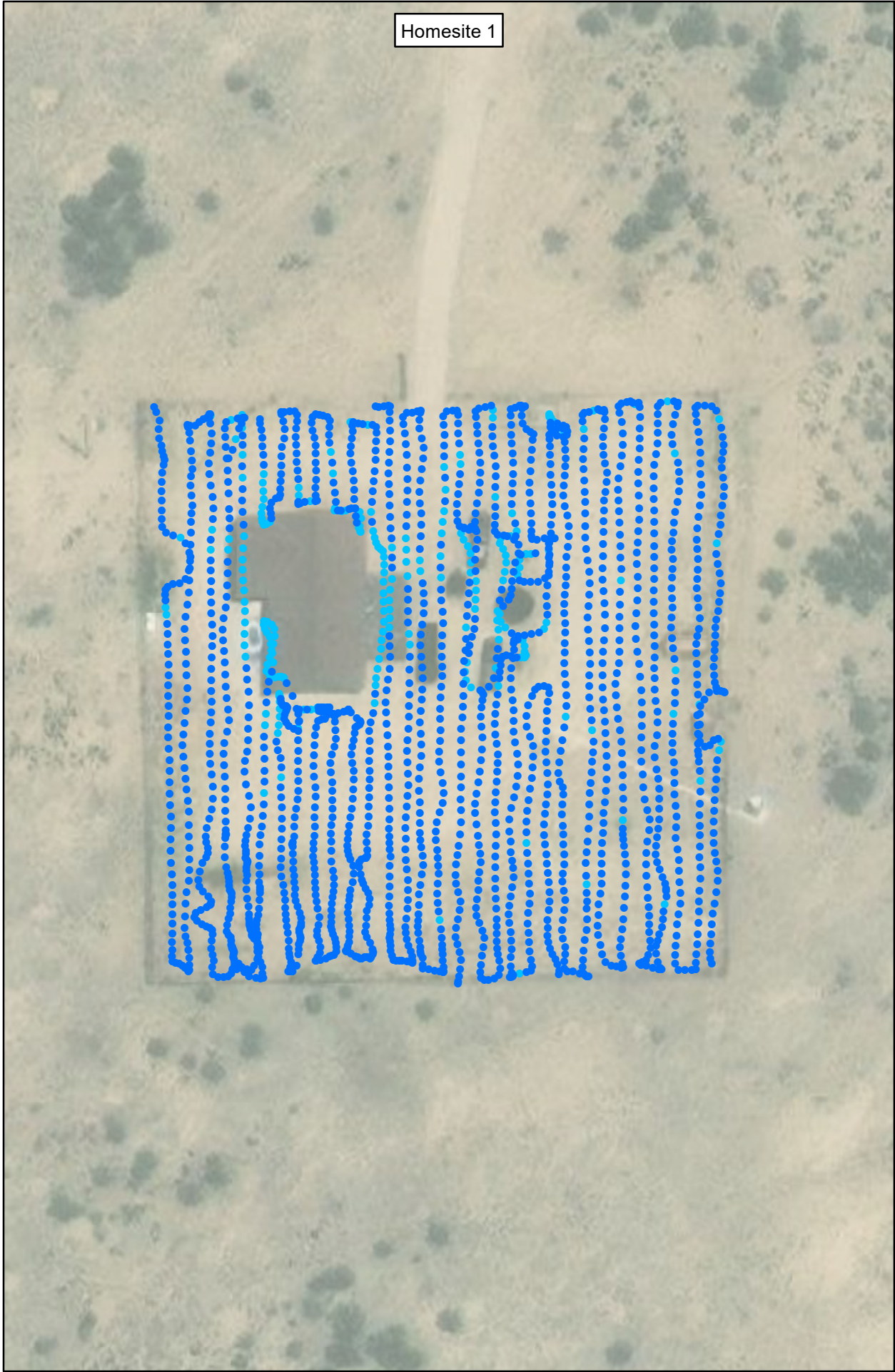
cpm Counts per minute

Q1 Twenty-fifth percentile of the background dataset



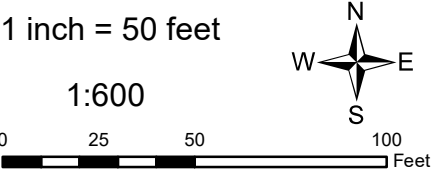
**OLD CHURCH ROCK MINE
RAW GAMMA RADIATION SURVEY —
ADJACENT SETPOUTS**

Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0035		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 9/8/2023	
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse			Figure No.: 15



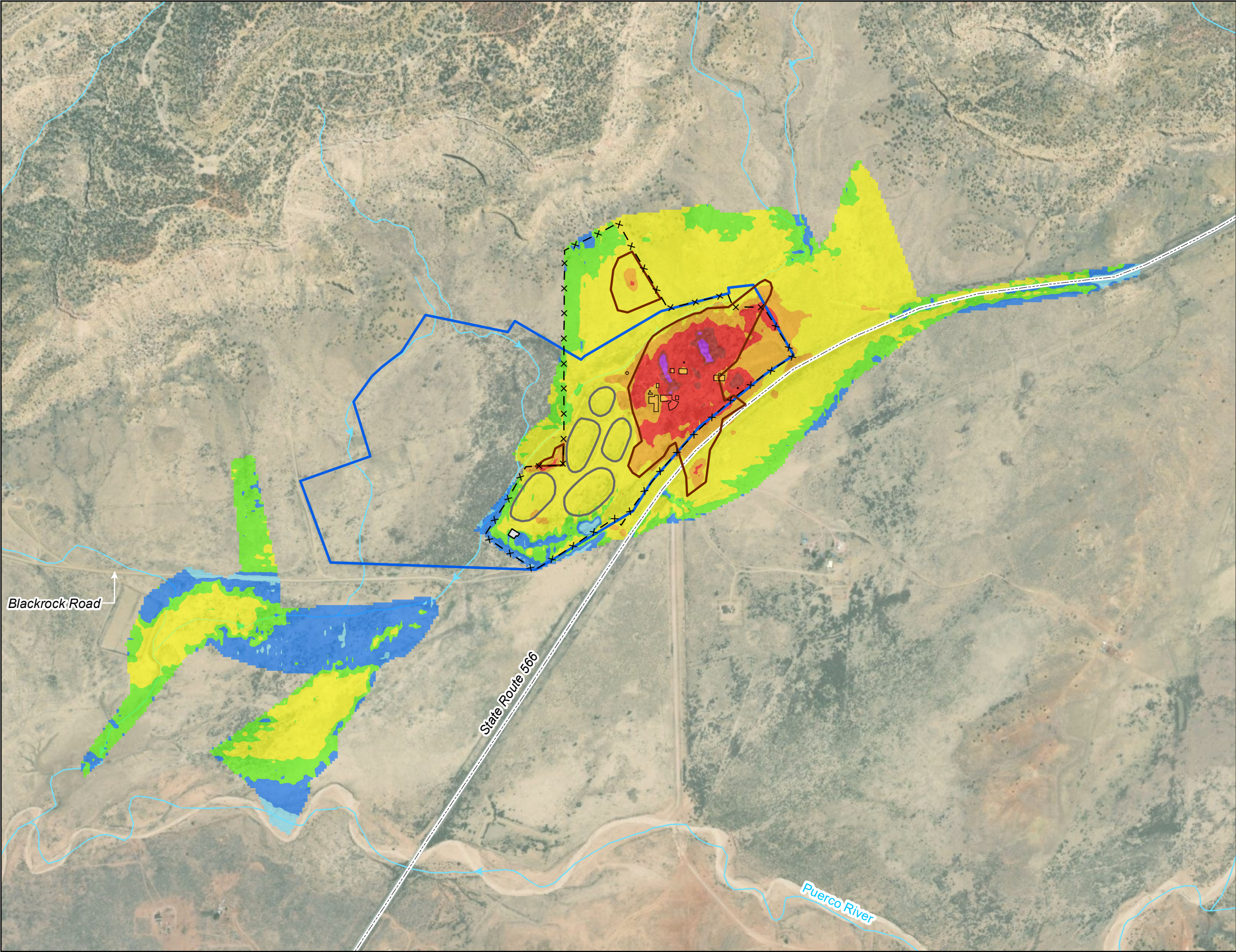
Gamma Count Rate (cpm)		
●	≤ 10,000	≤ Q1
●	10,000 - 14,555	Q1 - Avg
●	14,555 - 20,000	Avg - BTV ¹
●	20,000 - 35,000	BTV - 2 x BTV
●	35,000 - 75,000	2 x BTV - 5 x BTV
●	75,000 - 150,000	5 x BTV - 12.5 x BTV
●	150,000 - 300,000	12.5 x BTV - 17 x BTV
●	> 300,000	> 17 x BTV

Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.
²All surface water pathways drain to the Puerco River.
AUM Abandoned uranium mine
Avg Average value of the background dataset
BTV Background threshold value
cpm Counts per minute
Q1 Twenty-fifth percentile of the background dataset



OLD CHURCH ROCK MINE
RAW GAMMA RADIATION SURVEY –
RESIDENTIAL HOMESITES

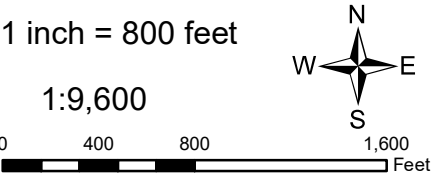
Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0035		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 8/25/2023	
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse			Figure No.: 16



Interpolated Gamma Count Rate (cpm)		
 	≤ 11,500	≤ Q1
 	11,500 - 13,228	Q1 - Avg
 	13,228 - 14,555	Avg - BTV ¹
 	14,555 - 29,096	BTV - 2 x BTV
 	29,096 - 72,740	2 x BTV - 5 x BTV
 	72,740 - 181,850	5 x BTV - 12.5 x BTV
 	181,850 - 250,000	12.5 x BTV - 17 x BTV
 	> 250,000	> 17 x BTV
 	EPA 2007 AUM Navajo Atlas Polygon	

- Site Features**
- × — Fenced Boundary
 - Concrete Pad
 - Former Pond
 - Ion-Exchange Building
 - Approximate Waste Disposal Area
 - Community Road
 - Surface Water Pathway²

Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.
²All surface water pathways drain to the Puerco River. Abandoned uranium mine
AUM Average value of the background dataset
Avg Background threshold value
BTV Counts per minute
cpm Twenty-fifth percentile of the background dataset



**OLD CHURCH ROCK MINE
INTERPOLATED GAMMA
RADIATION SURVEY**

Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0035		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 8/25/2023	
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse			Figure No.: 17

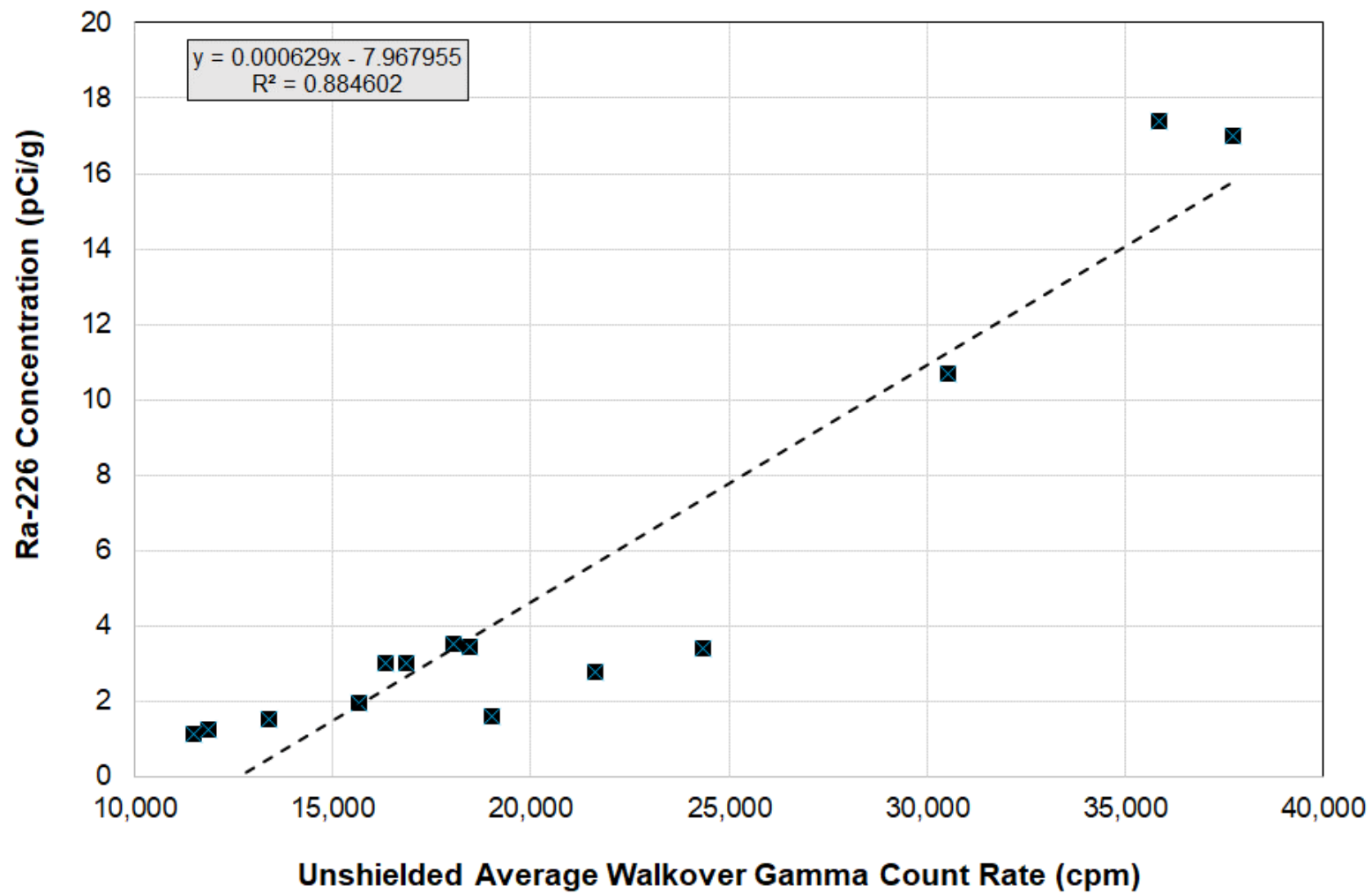


Figure 18. Gamma-Radium Correlation, Linear Regression – Model 1

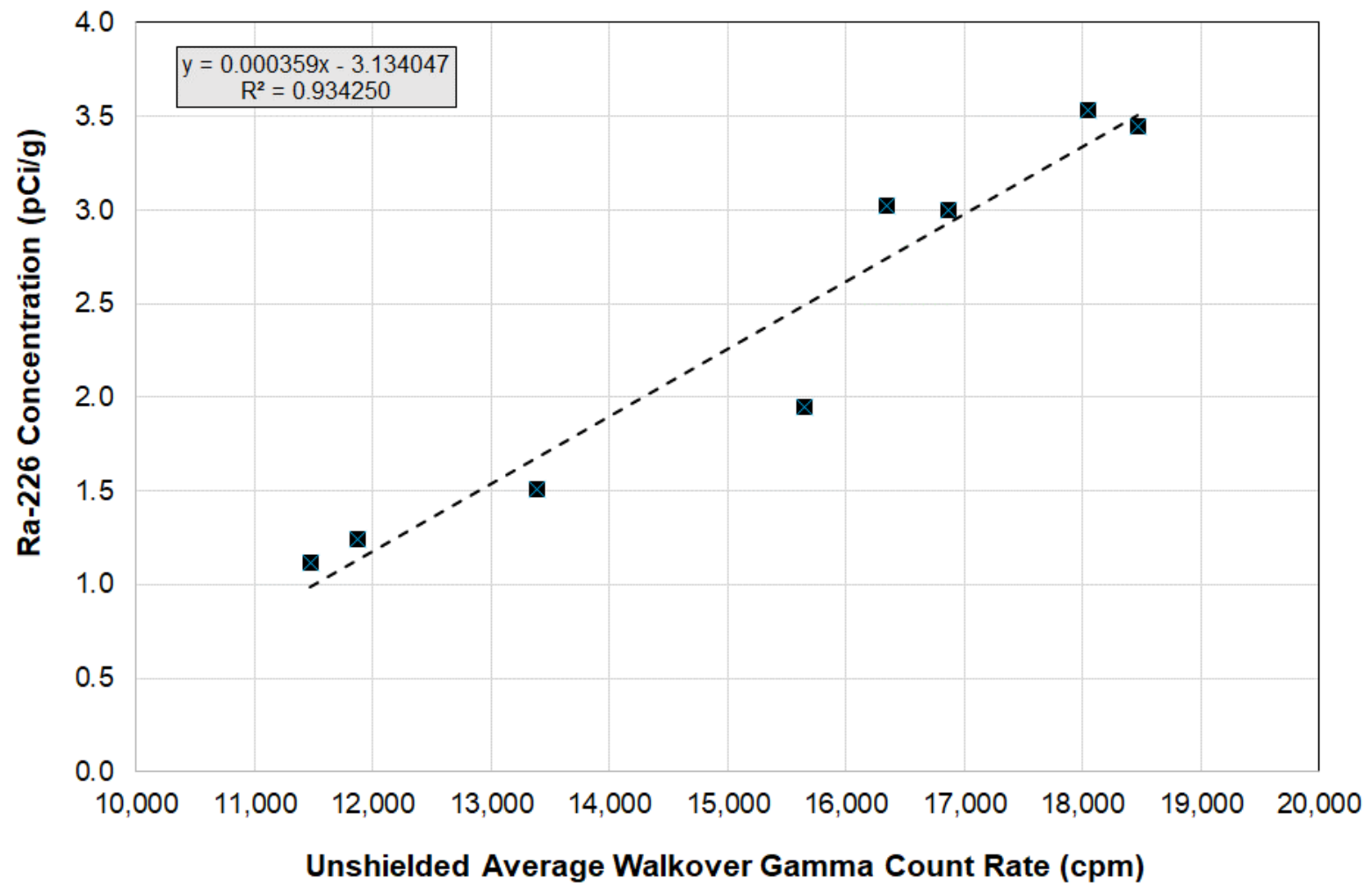


Figure 19. Gamma-Radium Correlation, Linear Regression – Model 2

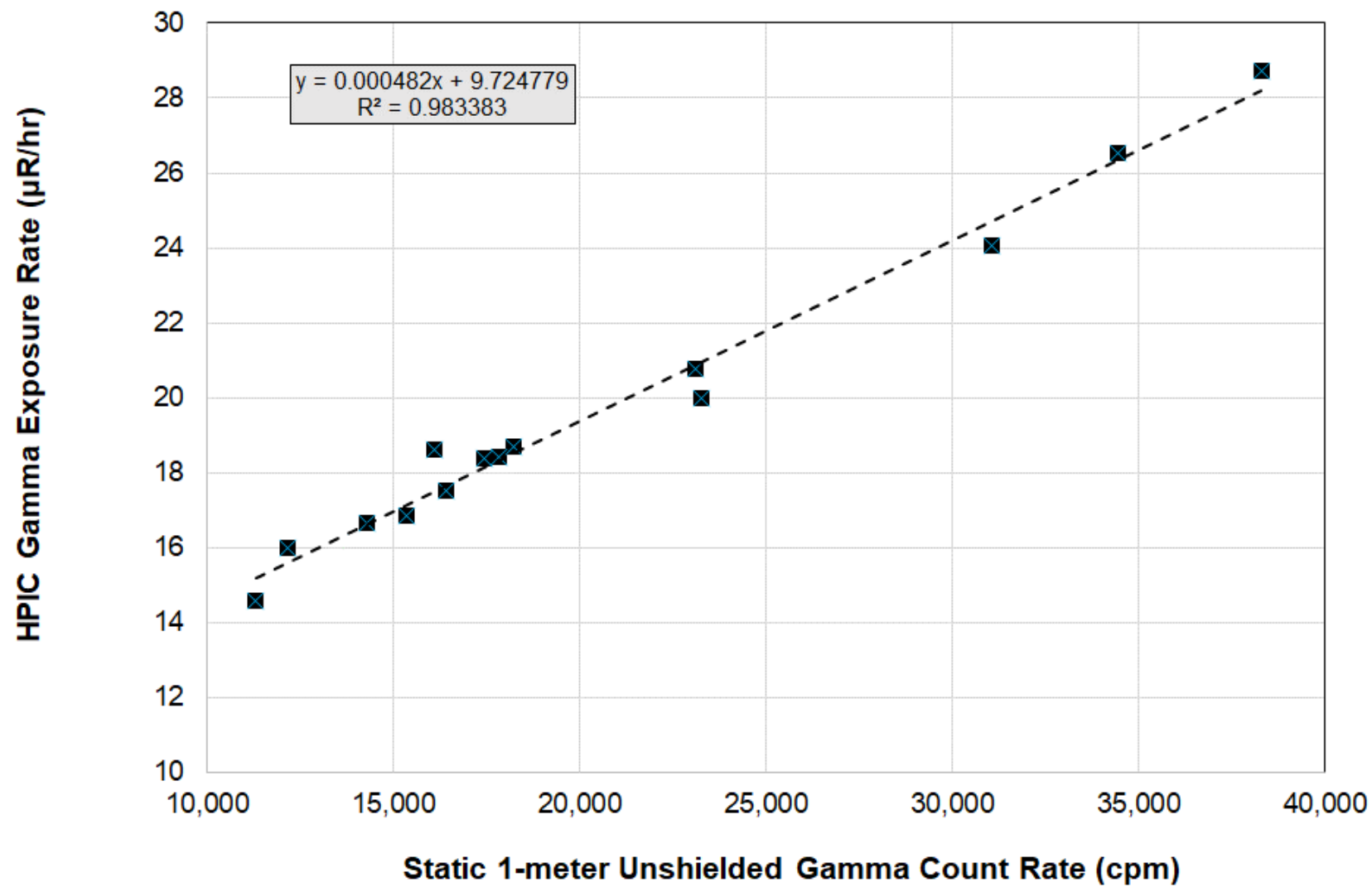
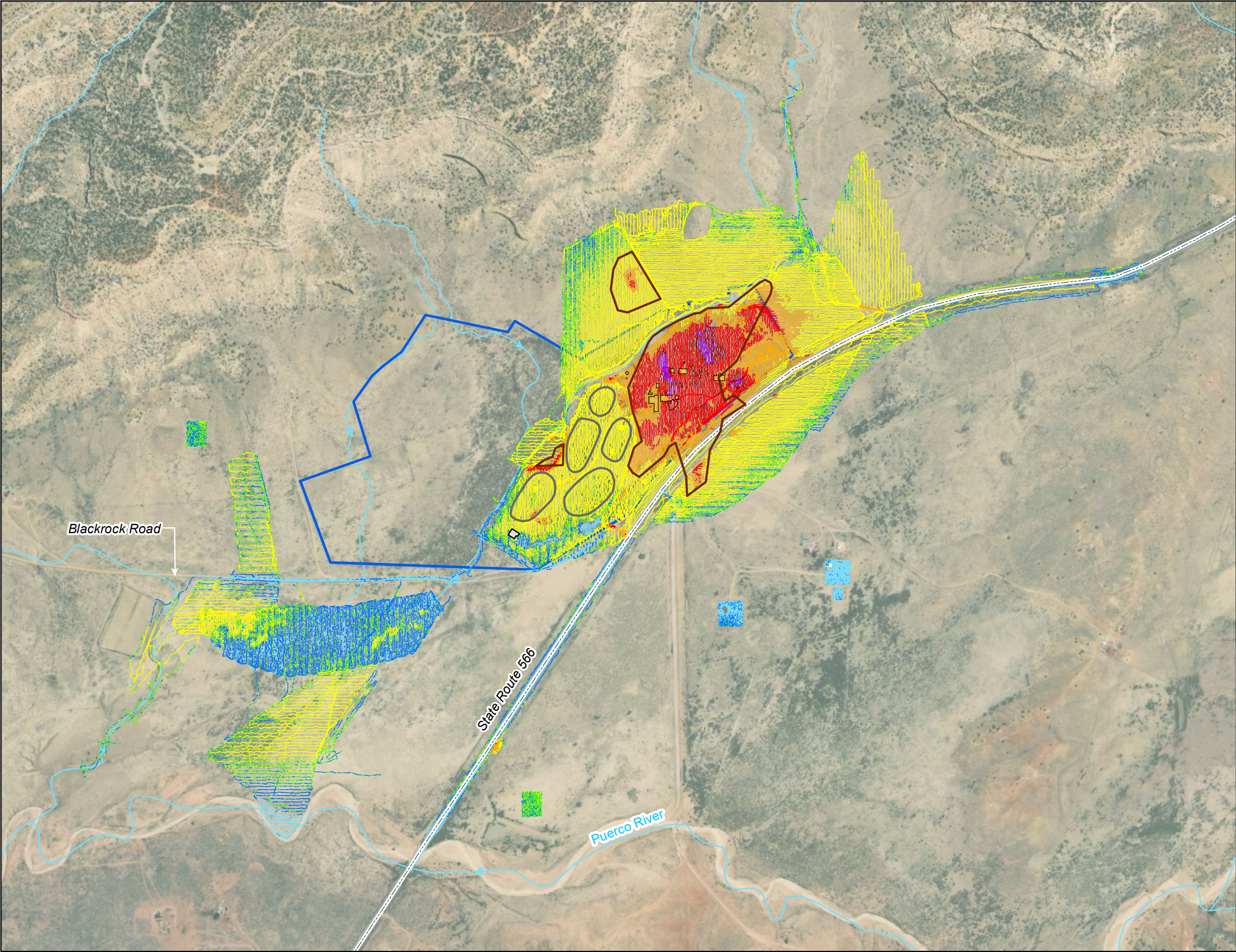


Figure 20. Gamma-Exposure Rate Correlation, Linear Regression



Gamma Exposure Rate ($\mu\text{R/hr}$)

● ≤ 15.3	$\leq \text{Q1}$
● 15.3 - 16.1	Q1 - Avg
● 16.1 - 16.7	Avg - BTV ¹
● 16.7 - 23.7	BTV - 2 x BTV
● 23.7 - 44.8	2 x BTV - 5 x BTV
● 44.8 - 97.4	5 x BTV - 12.5 x BTV
● 97.4 - 130.2	12.5 x BTV - 17 x BTV
● > 130.2	$> 17 \times \text{BTV}$

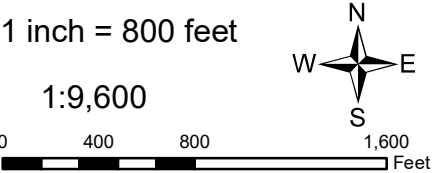
EPA 2007 AUM Navajo Atlas Polygon

Site Features



	Concrete Pad
	Former Pond
	Ion-Exchange Building
	Approximate Waste Disposal Area
	Community Road
→	Surface Water Pathway ²

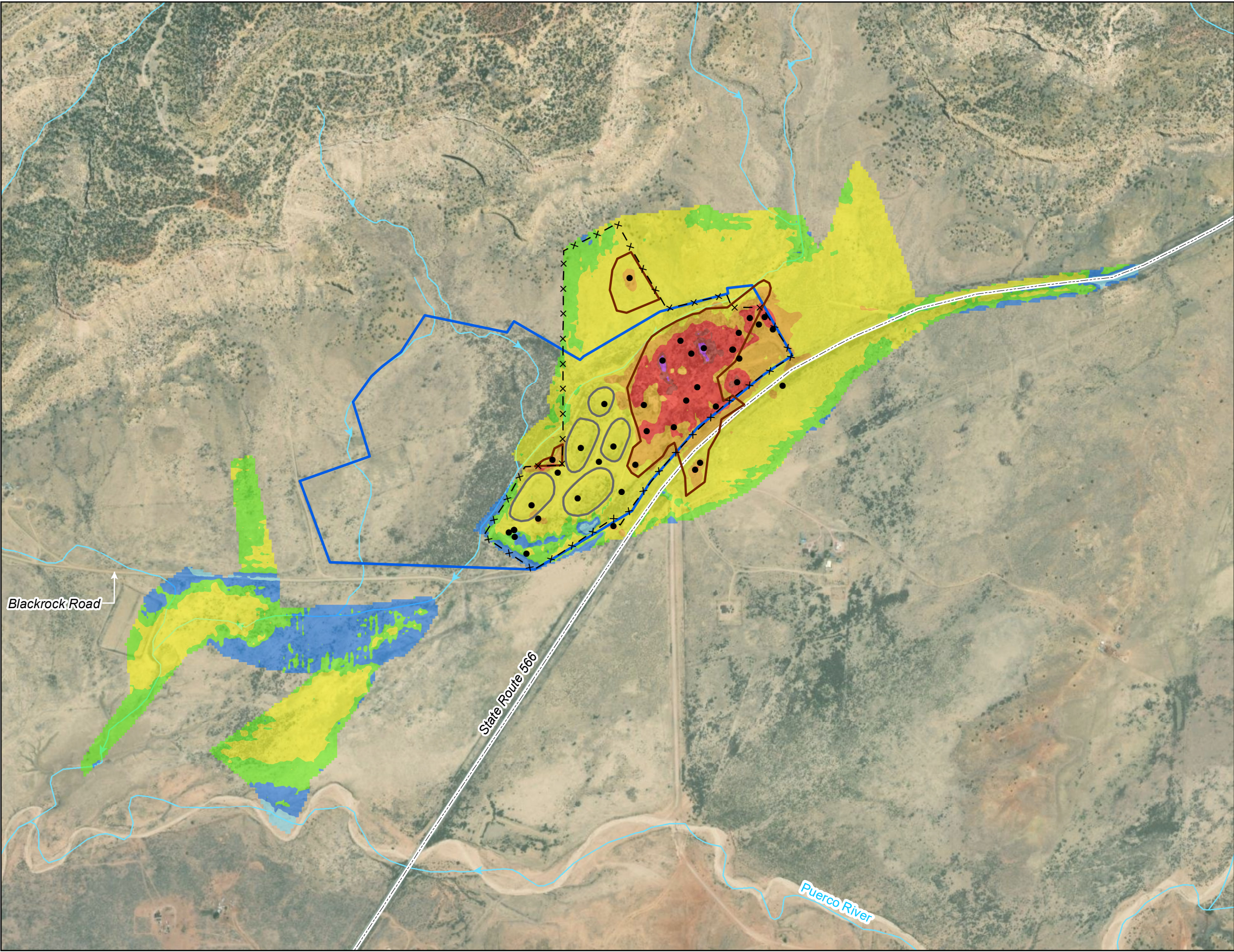
Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.
²All surface water pathways drain to the Puerco River.

$\mu\text{/hr}$ Microrentgen per hour
AUM Abandoned uranium mine
Avg Average value of the background dataset
BTV Background threshold value
cpm Counts per minute
Q1 Twenty-fifth percentile of the background dataset



**OLD CHURCH ROCK MINE
RAW GAMMA EXPOSURE RATE**

Prepared For: U.S. EPA Region 9 	Prepared By:  TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/25/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 21



● Surface Soil Sample Location

Interpolated Estimated Exposure Rate(μR/hr)

≤ 15.3	≤ Q1
15.3 - 16.1	Q1 - Avg
16.1 - 16.7	Avg - BTV ¹
16.7 - 23.7	BTV - 2 x BTV
23.7 - 44.8	2 x BTV - 5 x BTV
44.8 - 97.4	5 x BTV - 12.5 x BTV
97.4 - 130.2	12.5 x BTV - 17 x BTV
>130.2	> 17 x BTV

□ EPA 2007 AUM Navajo Atlas Polygon

Site Features

x — Fenced Boundary

□ Former Pond

□ Approximate Waste Disposal Area

--- Community Road

→ Surface Water Pathway¹

Notes:

¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.

²All surface water pathways drain to the Puerco River.

μR/hr Microrentgen per hour

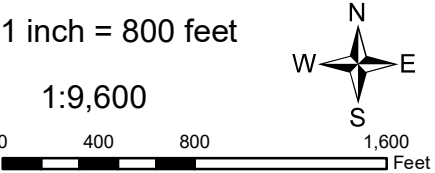
AUM Abandoned uranium mine

Avg Average value of the background dataset



BTV Background threshold value

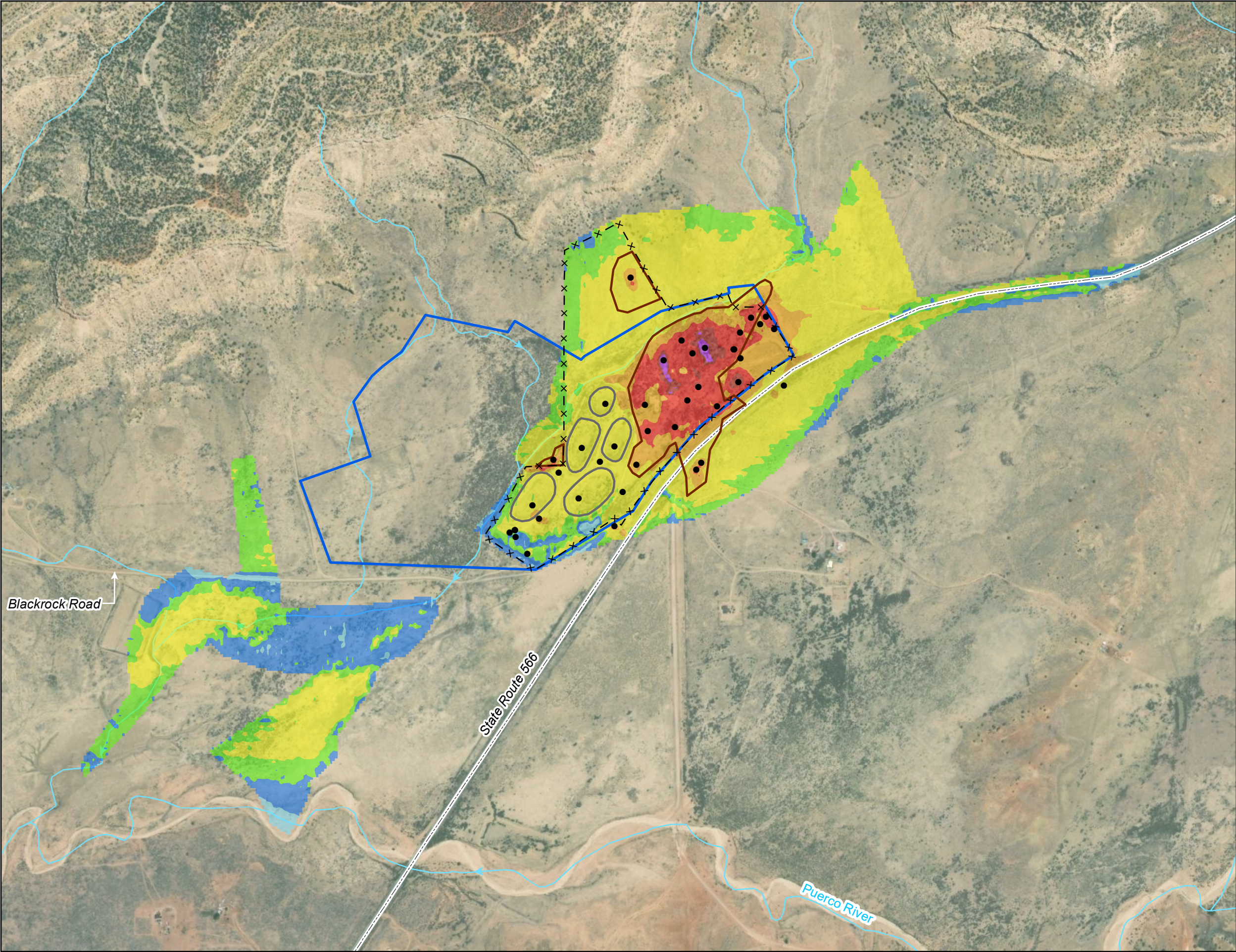
cpm Counts per minute

Q1 Twenty-fifth percentile of the background dataset



**OLD CHURCH ROCK MINE
INTERPOLATED GAMMA
EXPOSURE RATE**

Prepared For: U.S. EPA Region 9	Prepared By:
	 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/25/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 22



● Surface Soil Sample Location

Interpolated Gamma Count Rate (cpm)

≤ 11,500	≤ Q1
11,500 - 13,228	Q1 - Avg
13,228 - 14,555	Avg - BTV ¹
14,555 - 29,096	BTV - 2 x BTV
29,096 - 72,740	2 x BTV - 5 x BTV
72,740 - 181,850	5 x BTV - 12.5 x BTV
181,850 - 250,000	12.5 x BTV - 17 x BTV
> 250,000	> 17 x BTV

EPA 2007 AUM Navajo Atlas Polygon

Site Features

× — Fenced Boundary

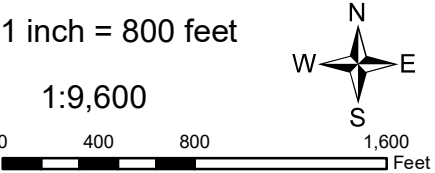
Former Pond

Approximate Waste Disposal Area



Community Road

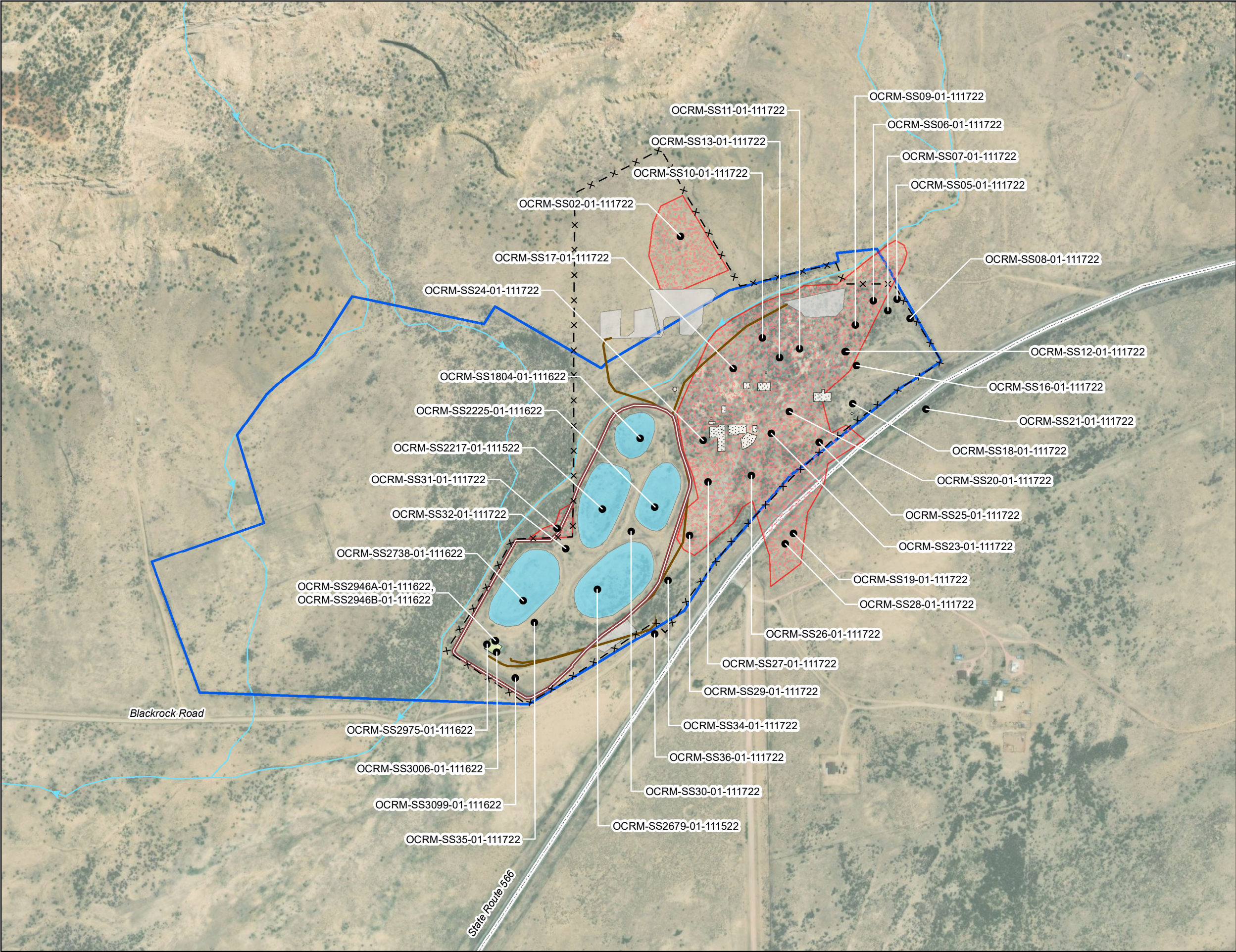
Surface Water Pathway¹

Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.
²All surface water pathways drain to the Puerco River. Abandoned uranium mine
AUM Average value of the background dataset
Avg Background threshold value
BTV Counts per minute
cpm Twenty-fifth percentile of the background dataset



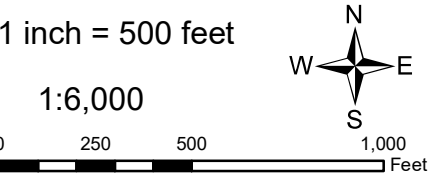
OLD CHURCH ROCK MINE
INTERPOLATED GAMMA
RADIATION SURVEY AND
SURFACE SOIL SAMPLES

Prepared For: U.S. EPA Region 9	Prepared By:
	 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/25/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 23



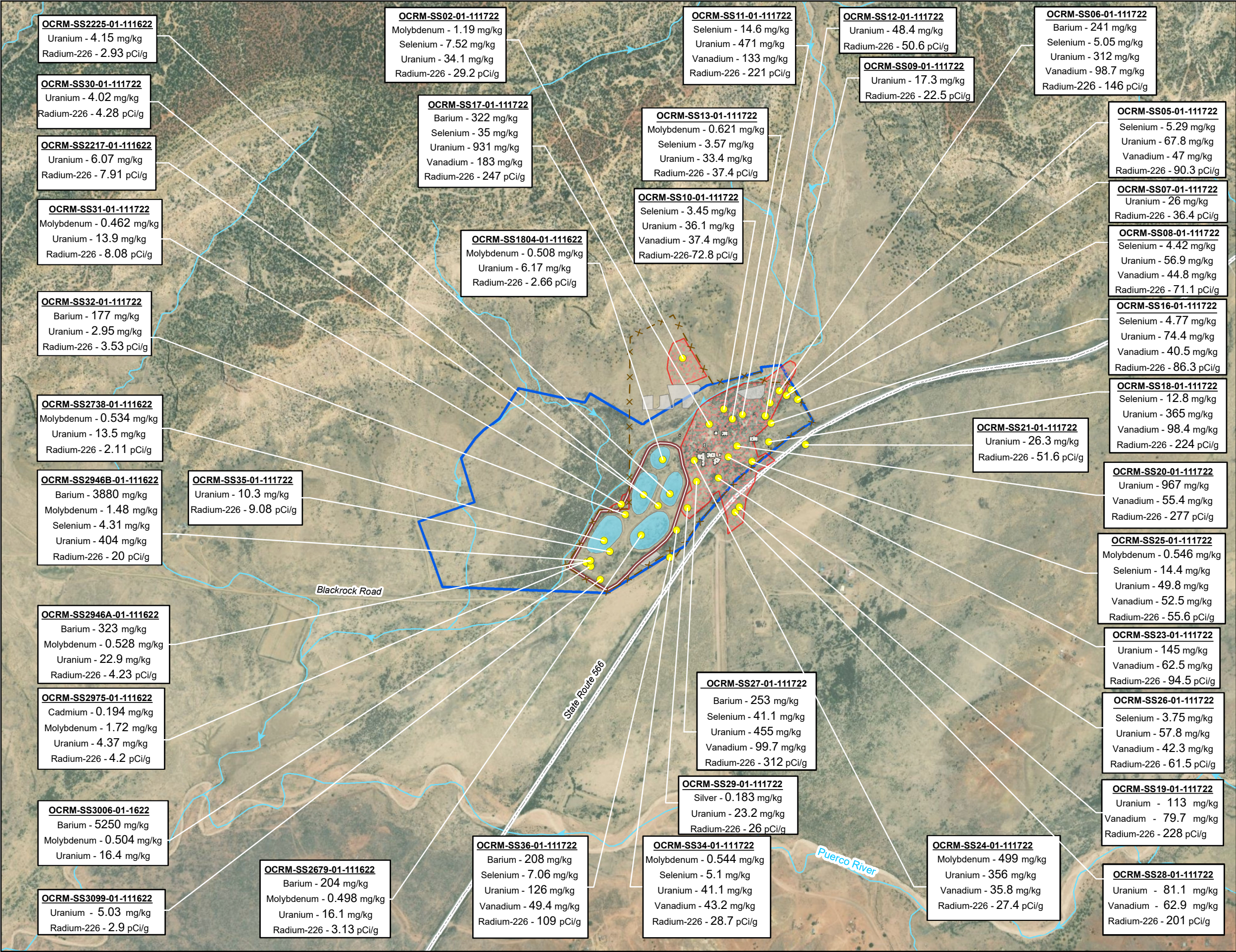
- Surface Soil Sample Location
- EPA 2007 AUM Navajo Atlas Polygon
- Site Features**
- Berm
- x — Fenced Boundary
- Drill Road - Fall 2022
- Concrete Pad
- Former Pond
- Ion-Exchange Building
- Laydown Areas - Fall 2022
- Approximate Waste Disposal Area
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AUM Abandoned uranium mine



**OLD CHURCH ROCK MINE
SOIL SAMPLE LOCATIONS**

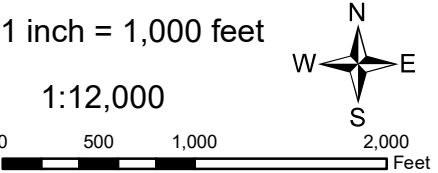
Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0035		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 9/8/2023	
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse			Figure No.: 24





- Surface Soil Sample Location¹
- EPA 2007 Navajo AUM Atlas Polygon
- Site Features**
- Berm
- × — Fenced Boundary
- Concrete Pad
- Former Pond
- Ion-Exchange Building
- Laydown Areas - Fall 2022
- Approximate Waste Disposal Area
- Surface Water Pathway²

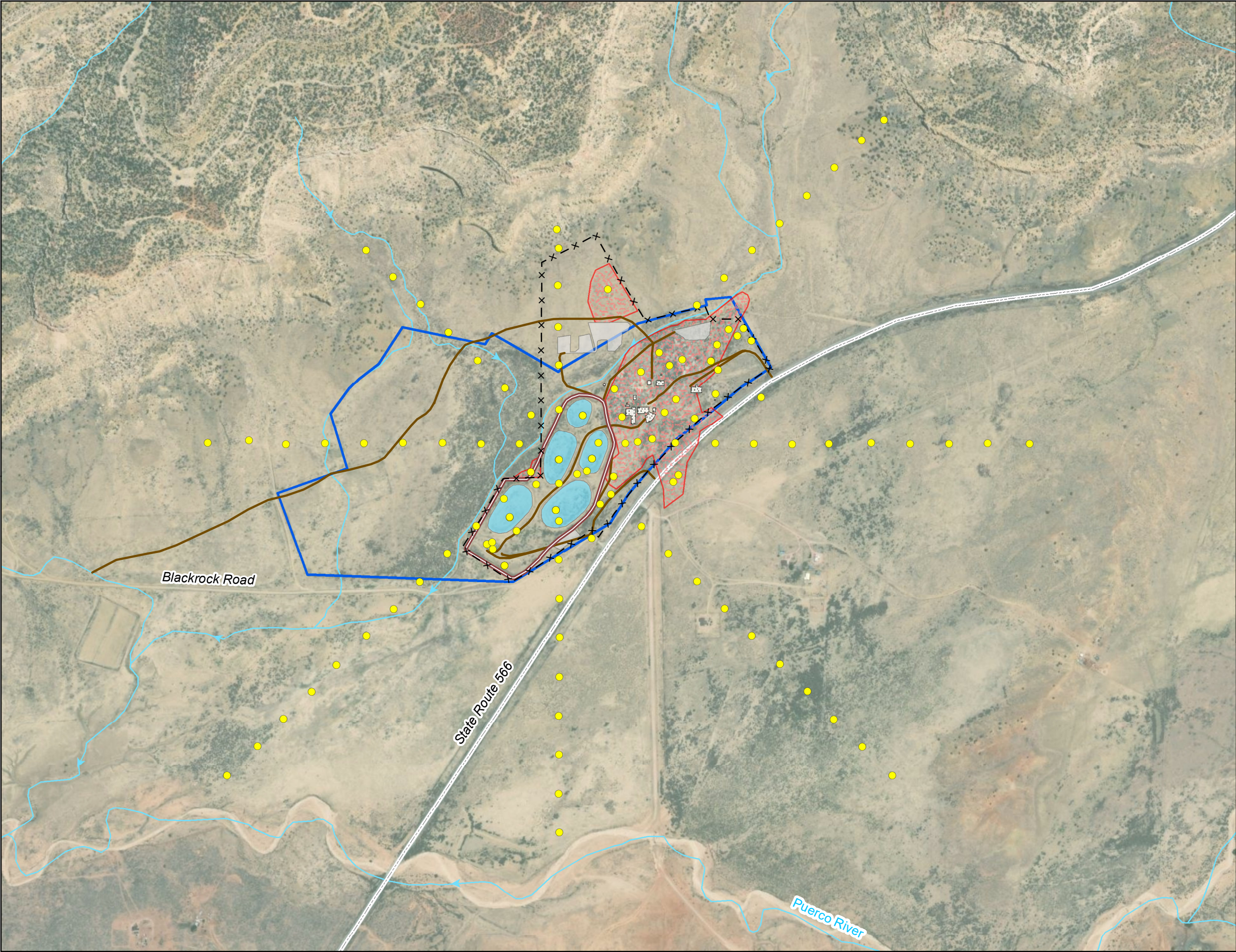
Notes:
¹Results are shown for COPC sample analytes that exceed the COPC threshold value
²All surface water pathways drain to the Puerco River

AUM Abandoned uranium mine
BTM Background threshold value
COPC Contaminant of potential concern
mg/kg Milligram per kilogram
pCi/g Picocurie per gram



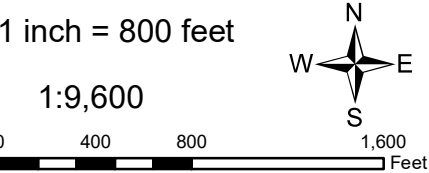
OLD CHURCH ROCK MINE SOIL ANALYTICAL RESULTS EXCEEDING COPC THRESHOLD

Prepared For: U.S. EPA Region 9	Prepared By:
	 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/25/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: 25





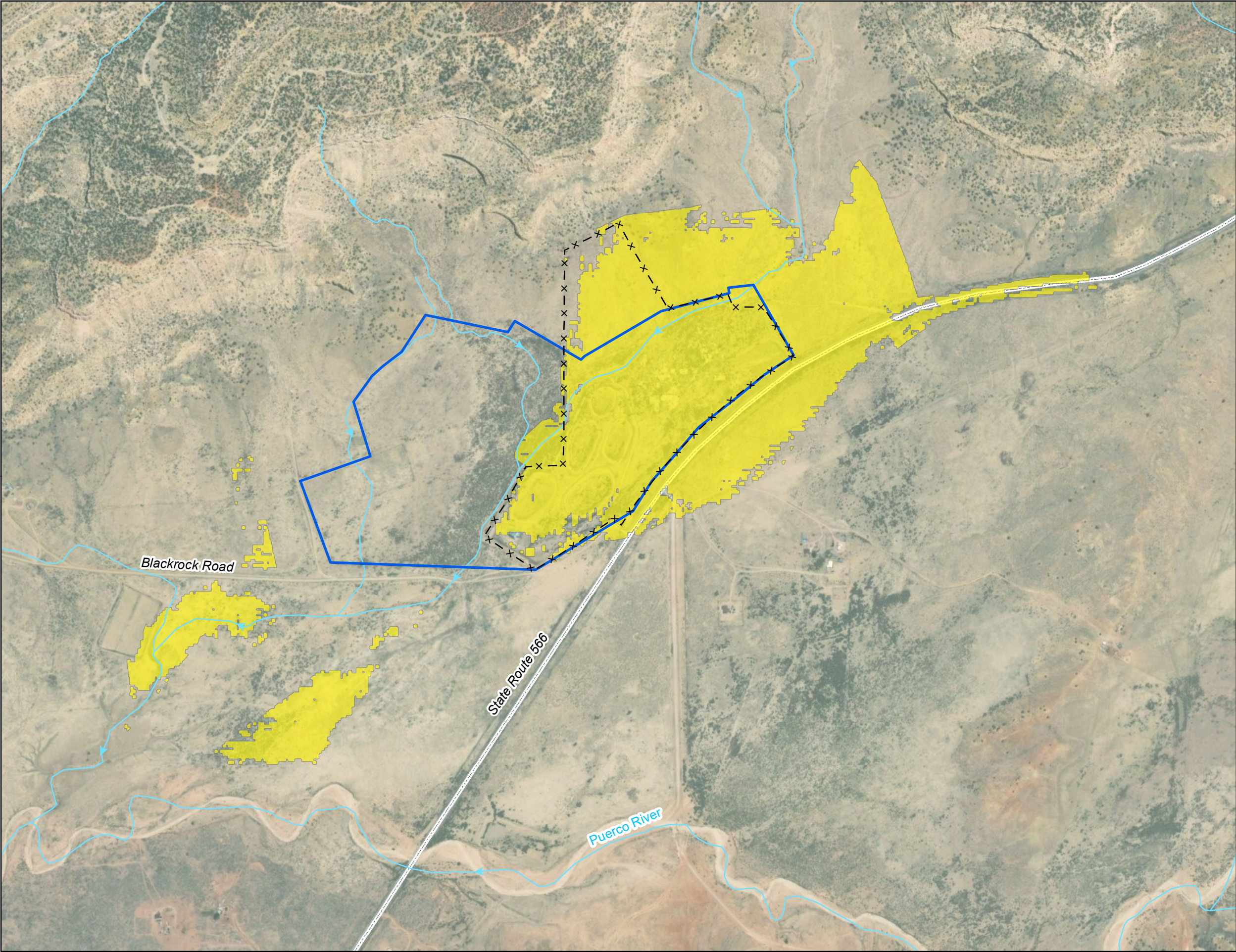
- XRF In Situ Measurement Location
- EPA 2007 AUM Navajo Atlas Polygon
- Site Features**
- Berm
- × — Fenced Boundary
- Drill Road - Fall 2022
- ▨ Concrete Pad
- Former Pond
- Ion-Exchange Building
- Laydown Areas - Fall 2022
- ▨ Approximate Waste Disposal Area
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AUM Abandoned uranium mine
XRF X-ray fluorescence



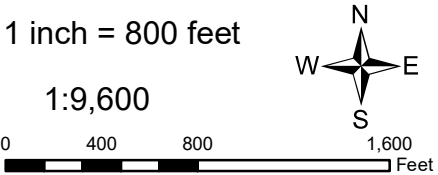
**OLD CHURCH ROCK MINE
XRF SAMPLE LOCATIONS**

Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0035		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 9/8/2023	
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse			Figure No.: 26



- Predicted Removal Action Extent (≥ 2 pCi/g)
- EPA 2007 AUM Navajo Atlas Polygon
- Site Features**
- Fenced Boundary
- Community Road
- Surface Water Pathway²

Notes:
¹All surface water pathways drain to the Puerco River.
pCi/g Picocurie per gram



**OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 2 PCI/G (MODEL 2)**

Prepared For: U.S. EPA Region 9



Prepared By:



Task Order No.:
0035

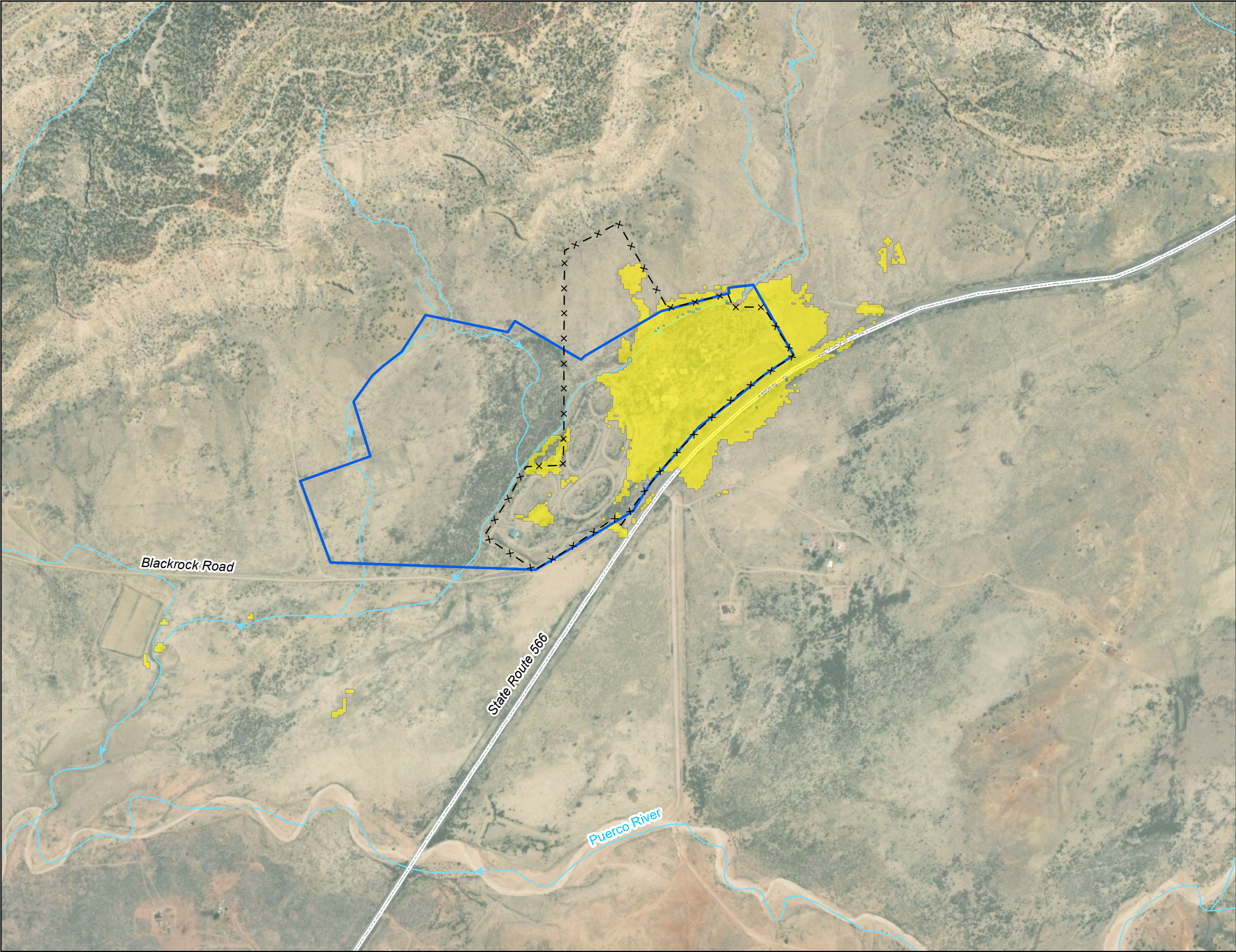
Contract No.:
EP-S9-17-03

Location:
CHURCH ROCK CHAPTER
NAVAJO NATION

Date:
8/25/2023

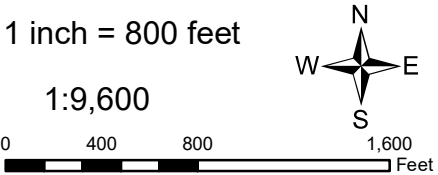
Coordinate System:
NAD 1983 State Plane New Mexico
West FIPS 3003 Feet Transverse

Figure No.:
27



- Predicted Removal Action Extent (≥ 5 pCi/g)
- EPA 2007 AUM Navajo Atlas Polygon
- Site Features**
- Fenced Boundary
- Community Road
- Surface Water Pathway²

Notes:
¹All surface water pathways drain to the Puerco River.
pCi/g Picocurie per gram



**OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 5 PCI/G (MODEL 1)**

Prepared For: U.S. EPA Region 9



Prepared By:



Task Order No.:
0035

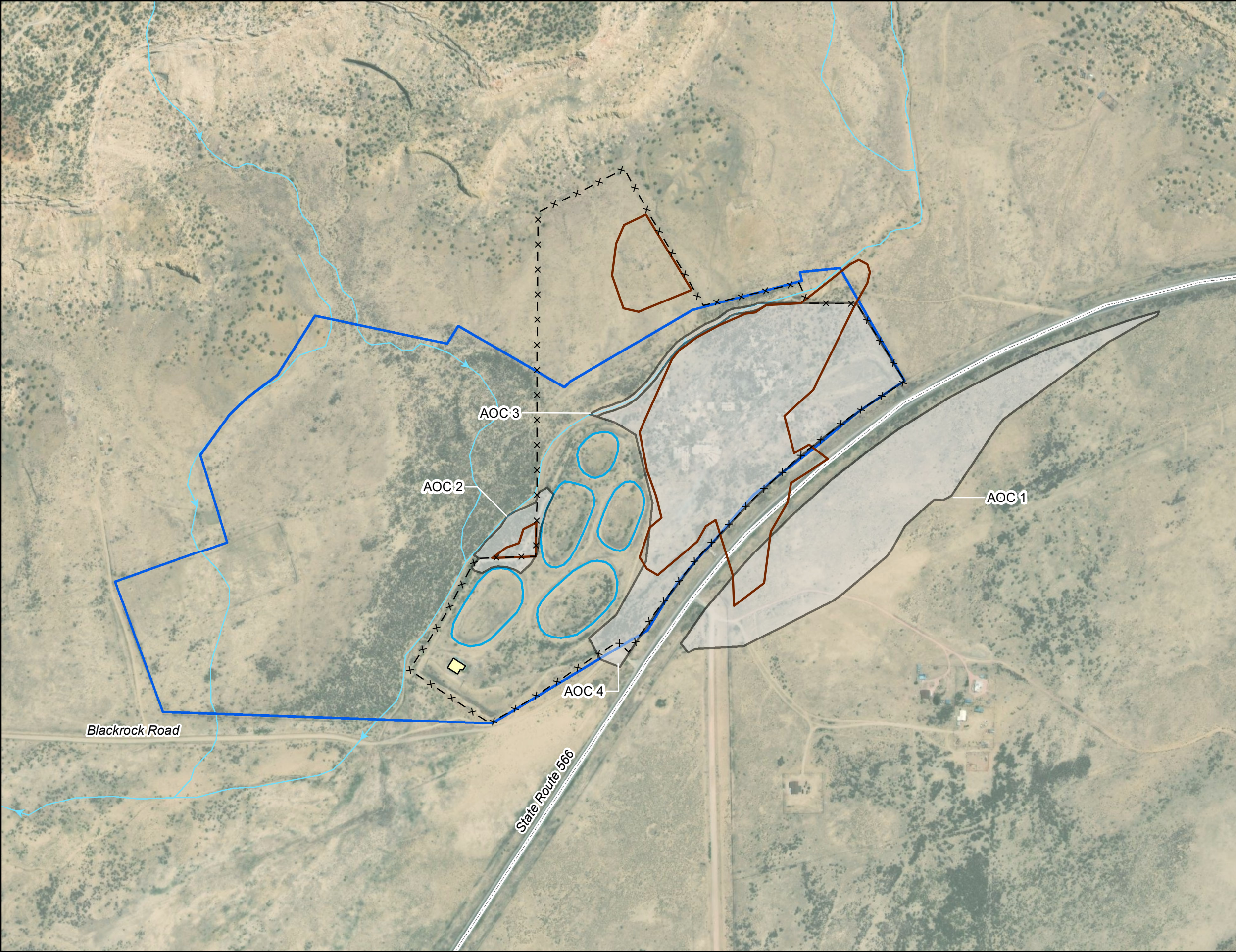
Contract No.:
EP-S9-17-03

Location:
CHURCH ROCK CHAPTER
NAVAJO NATION

Date:
8/25/2023

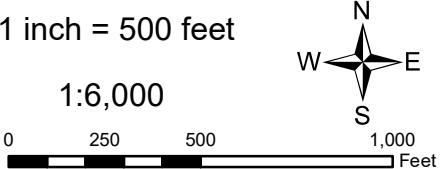
Coordinate System:
NAD 1983 State Plane New Mexico
West FIPS 3003 Feet Transverse

Figure No.:
28



- Area of Concern
- EPA 2007 AUM Navajo Atlas Polygon
- Site Features**
- × — Fenced Boundary
- Former Pond
- Ion-Exchange Building
- Approximate Waste Disposal Area
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AOC Area of concern
AUM Abandoned uranium mine



OLD CHURCH ROCK MINE
AREAS OF CONCERN

Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
Task Order No.: 0016		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 8/25/2023	
Coordinate System: NAD 1983 State Plane Arizona East FIPS 0201 Feet Transverse Mercator			Figure No.: 29

TABLES

Table 1. Summary of Data Quality Objectives

Study Goal	Acceptance Criteria	Discussion Section
What are the background levels of gamma radiation, radionuclides, and metals in soils and sediment that are representative of conditions?	<p>The determination of background will involve a statistically significant dataset generated from gamma surveys and soil sampling for laboratory analysis of the radiochemical and metals parameters. Surveys and soil sampling will be performed on a systematic grid within a background area. BTVs will be developed for gamma radiation based on the UTL95-95 calculated from the background gamma survey data. During report preparation, laboratory analytical data from the BSAs will be used to calculate BTVs and will supersede the screening-level in situ XRF BTVs. During the removal assessment fieldwork activities, ILs will be equivalent to BTVs.</p> <p>Discrete soil samples will be collected in the background area following the same systematic grid developed for gamma surveys. Discrete soil samples will be collected from the approximate centroid of each survey grid. Samples will be collected from 0 to 3 inches bgs and submitted for laboratory analysis of radionuclides and metals. BTVs will be developed based on guidance contained in ProUCL or other statistical software.</p>	Section 4.1, Appendix H
What is the lateral extent of mine-related surficial contamination?	The sampling design relies on both a systematic sampling (linear transects) and paired sampling (laboratory correlation) design. The gamma surveys will be conducted using 4-meter transect spacing at the site. Soil samples will be collected to correlate gamma survey measurements with laboratory radionuclide concentrations. Gamma exposure rate measurements will be collected with HPIC instrumentation to correlate gamma survey measurements with gamma exposure rates.	Section 4.2, Section 4.3
Is there potential for contaminants to migrate off site via surface water pathways?	Individual gamma measurements will be collected along transects aligned with known drainage channels. Gamma measurements will be continuous.	Section 4.2
Has the correlation between gamma survey results and Ra-226 concentrations in surface soils been determined?	<p>The regression analysis will involve plotting the concentrations of Ra-226 in the samples against the associated average gamma measurement from all associated locations. The regression will be fit to a linear model and corrected for interference from other gamma emitting radionuclides in soil and cosmic rays, if applicable. The R^2 for the model will be used as a basic measure of the validity of the correlation, but additional correlation parameters will also be evaluated.</p> <p>An R^2 value of 0.80 will be used as a benchmark for evaluating correlation validity but may be revised based on detailed evaluation of datasets once they have been collected. Previous studies have indicated that a R^2 value of 0.80 is acceptable for predicting Ra-226 concentrations in soil (Johnson, Meyer, and Vidyasagar 2006; Whicker and others 2008)</p>	Section 4.3, Appendix E

Table 1. Summary of Data Quality Objectives

Study Goal	Acceptance Criteria	Discussion Section
Has the correlation between gamma survey results and exposure rates in surface soils been determined?	The regression analysis will involve plotting the true exposure rate measured at the center of each correlation plot against the associated average gamma measurement from all associated locations. The regression will be fit to a linear model. The R^2 for the model will be used as a basic measure of the validity of the correlation, but additional correlation parameters will also be evaluated. An R^2 value of 0.80 will be used as a benchmark for evaluating correlation validity but may be revised based on detailed evaluation of datasets once they have been collected.	Section 4.3, Appendix E

Notes:

bgs	Below ground surface
BSA	Background study area
BTV	Background threshold value
HPIC	High-pressure ionization chamber
IL	Investigation level
R^2	Coefficient of determination
Ra-226	Radium-226
UTL95-95	95 percent upper tolerance limit with 95 percent confidence
XRF	X-ray fluorescence

References:

- Johnson, J.A., H.R. Meyer, and M. Vidyasagar. 2006. "Characterization of Surface Soils at a Former Uranium Mill." *Health Physics*. Volume 90 (Suppl ORS). Pages S29 through S32.
- Whicker, R., P. Cartier, J. Cain, K. Milmine, and M. Griffin. 2008. "Radiological Site Characterizations: Gamma Surveys, Gamma/Ra-226 Correlations and Related Spatial Analysis Techniques." *Health Physics*. Volume 95 (Suppl 5). Pages S180 through S189.

Table 2. Summary of Previous Investigations

Year	Report Name	Responsible Agencies	Activities	Reference
2003–2007	Report of the Church Rock Uranium Monitoring Project	Churchrock Chapter of the Navajo Nation, SRIC, NNEPA, USEPA, NNAMLD, and NMED	Water quality assessment in unregulated water wells, surface radiation survey, uranium in soils assessments, indoor radon concentration assessments, and airborne dust assessment	CRUMP (2007)
2006	Old Church Rock Mine Survey	NNSP	Visual inspection, surface radiation survey, surface soil sampling	NNSP (2006)
2007	Radiological Scoping Survey Summary Report for the Old Church Rock Mine Site	NNSP and NNEPA	Surface radiation survey inside and outside of the fenced facility and along the bank of the nearby arroyo compared to background radiation levels	NNSP (2007)
2009	Site Characterization Report, Old Church Rock Mine, McKinley County, New Mexico	HRI	Surface radiation survey inside and outside of the fenced facility, surface soil sampling, downgradient soil pit assessment, and paleochannel and groundwater determination	Intera, Inc. (2009)
2013	Draft 2013 Phase II Site Characterization Report, Old Church Rock Mine, McKinley County, New Mexico	HRI	Extension to 2009 investigation with additional surface radiation surveys outside of fenced area and subsurface soil sampling	Intera, Inc. (2013)

Notes:

CRUMP	Church Rock Uranium Monitoring Project
HRI	Hydro Resources, Inc.
NMED	New Mexico Environment Department
NNAMLD	Navajo Nation Abandoned Mine Lands Reclamation Department
NNEPA	Navajo Nation Environmental Protection Agency
NNSP	Navajo Nation Superfund Program
SRIC	Southwest Research and Information Center
USEPA	U.S. Environment Protection Agency

References:

Church Rock Uranium Monitoring Project (CRUMP). 2007. "Report of the Church Rock Uranium Monitoring Project." May

Intera, Inc. 2009. "Site Characterization Report Old Church Rock Mine McKinley County, New Mexico." September.

Intera, Inc. 2013. "2013 Phase II Site Characterization Report Old Church Rock Mine McKinley County, New Mexico." September.

Navajo Nation Superfund Program (NNSP). 2006. Letter to the Department of Justice. From Eugene Esplain, Health Physicist, Superfund Program/Waste Regulatory Compliance Dept. To David Taylor, Assistant Attorney General, Department of Justice. August 17.

NNSP. 2007. "Radiological Scoping Survey Summary Report for the Old Church Rock Mine Site." September.

Table 3. Surface Expressed Geology

Geologic Unit Name	Geological Code	Relation to Site	Description	Thickness (ft) ¹
Alluvial Deposits	Qa	Majority of OCRM and surrounding area consists of alluvial deposits	Pale-yellowish-brown to grayish-orange, unconsolidated sandy silt, sand, and gravel; deposited on graded stream valley floors and flood plains since inception of most recent cycle of arroyo cutting. Includes alluvial-fan deposits in a few areas; grades upslope into colluvium.	-
Colluvium	Qc	Colluvium formation lies directly to the north of OCRM's fenceline and a portion of OCRM fenced area, north of the arroyo, sits on colluvium	Poorly sorted silt, sand, and gravel deposited between talus slopes and valley alluvium; includes alluvial-fan deposits in most areas; material is transported and deposited by sheetwash. Mapped mainly in areas where it covers significant amount of underlying bedrock; includes talus deposits in northwestern part of map.	-
Older Alluvium	Qoa	Lies approximately 0.5 miles south of OCRM	Grayish-orange to yellowish-gray, poorly to partly consolidated silt, sand, and gravel; forms terrace deposits above modern valley flood plains and within dissected alluvial plains, fans, and pediments. Thickness ranges from 0-59 ft.	0-59
Landslide Deposits	Qls	Lies approximately 0.25 miles to the Northwest of OCRM's northwestern fenceline	Large masses of bedrock that have detached from cliffs and have slid or slumped as fairly intact units.	-
Main Body Mancos Shale	Km	Sits above landslide deposits (Qis)0.25 miles northeast of the site as well as 0.5 miles west-northwest of OCRM	Main body of Mancos Shale (Upper Cretaceous (Turonian and Cenomanian)) - Light- to dark-gray and dark-olive gray, fissile marine shale and minor interbedded siltstone some scattered thin, discontinuous limestone beds and calcareous sandstone beds and a few bentonite beds. Included in main body of Mancos Shale is Juana Lopez Member, which consists of fossiliferous limestone interbeds usually numbering four or more, and fine-grained calcareous sandstone and dark-gray fissile shale. Juana Lopez Member crops out in ledges between shale units of Juana Lopez interval ranges from 3 to 30 m (10 to 98 ft). Also included in main body is Bridge Creek Limestone Beds of Rio Salado Tongue (equivalent to uppermost member of Greenhorn Limestone), consisting of interbedded thin fossiliferous limestone and dark-gray fissile shale; a good marker bed on geophysical logs and usually ranges in thickness from 0 to 4 m (0 to 13 ft). Basal contact of main body of Mancos Shale with underlying Twowells Tongue of the Dakota Sandstone is sharp. Thickness of main body included unnamed tongues of Mancos Shale up to main body of Gallup Sandstone. Thickens to north. Thickness ranges from 152 to 236 m (500 to 775 ft)	500-775
Dilco Coal Member of Crevasse Canyon Formation	Kcdi	Sits above the Main Body Gallup Sandstone (Kg) formation	Interbedded light to dark-grey and brown shale and siltstone; white to very pale orange to yellowish-brown, very fine grained to medium-grained, well-sorted to poorly sorted sandstone; minor carbonaceous shale, lignite, and lenticular subbituminous coal beds generally less than 14 in thick, but as much as 36 in thick. Most of sandstone characterized by thin planar-horizontal and ripple-laminated beds that are uniform and persistent, but also includes small scale low-angle trough and wedge planar crossbeds in thin lenses. Upper parts of sandstone units are commonly bioturbated. The sandstone probably represents flood-plain, splay, channel-fill, and distributary deposits. The baseal of Dilco Coal Member consists of yellowish-brown to reddish-brown, coarse to very coarse grained, angular to subangular, poorly sorted, trough crossbedded, carbonaceous, feldpathic, slightly calcareous sandstone. This lower part is known as "basal Dilco sandstone" or "Torrivo Member of Gallup sandstone.". It forms lenticular fluvial channels that scour deeply into carbonaceous shale and siltstone and into top of Gallup Sandstone in places. Basal contact is sharp. Unit as a whole thins northeastward.	0-3
Main Body of Dakota Sandstone	Kd	Lies greater than 1 mile southeast of OCRM	Yellow-brown to buff, fine- to medium-grained, well-sorted, massive to thin-bedded, planar- and through-crossbedded, siliceous, cliff-forming quartzose sandstone; lower part contains interbedded light- to dark-gray carbonaceous shale and light-gray to white and tan, coarse-grained, poorly sorted, crossbedded sandstone and common chertpebble conglomerate. Contains lignite and plant remains in many areas. Upper contact with Whitewater Arroyo Tongue of Mancos Shale is sharp to gradational. Lower contact with Morrison Formation is sharp and unconformable. Deposits are of fluvial, lagoonal, deltaic, and shoreface origins. Minor uranium ore deposits are found in basal Dakota Sandstone. Thickness ranges from 50-170 ft.	50-170
Twowells Tongue of Dakota Sandstone and Whitewater Arroyo Tongue of Mancos Shale, Undivided	Kdt	Lies approximately 0.25 miles east-southeast of the OCRM fenceline bordering State Route 566	Twowells Tongue of Dakota Sandstone - Yellowish-brown to buff and light- to dark-yellowish-orange, very fine grained to medium-grained, well-sorted calcareous sandstone. Locally contains fossiliferous oyster beds at top and lenticular beds of silty shale in lower third of unit. Commonly varies from massive, structureless bedding showing bioturbation and vertical trace fossils to thin, horizontal bedding and tabular-planar crossbedding. Upper contact sharp and lower contact gradational; probably deposited as shallow marine offshore sand. Thickness ranges from 2 to 17 m (7 to 56 ft). Whitewater Arroyo Tongue of Mancos Shale - Medium - to dark-grayish-green fossiliferous silty shale; weathers yellowish brown to yellowish gray. Locally contains thin beds of yellowish-brown sandy siltstone and sandy limestone. Upper contact is gradational with overlying Twowells Tongue of Dakota Sandstone. Lower contact with underlying Dakota Sandstone is sharp. Thickens to north and east. Thickness varies from 6 to 34 m (20 to 112 ft).	7-56 20-112

Table 3. Surface Expressed Geology

Geologic Unit Name	Geological Code	Relation to Site	Description	Thickness (ft) ¹
Main Body Gallup Sandstone	Kg	Sits above the Dalton Sandstone Member, unnamed lower tongue, and Borrego Pass Lentil of Crevasse Canyon Formation, and Mulatto Tongue of Mancos Share, Undivided (Kmg) formation	Grayish-pink to very pale orange and pale-brown, very fine grained to medium-grained, well-sorted, thin to thick-bedded calcareous sandstone; near top are very minor amounts of brown carbonaceous shale, gray siltstone, and thin, lenticular subbitminous coal beds. The sandstone varies from horizontal to gently dipping and has undulatory parallel laminae, sets of small- to medium-scale wedge-planar and trough crossbedding, and hummocky crossbedding. Lower contact is gradational and interfingering with Mancos Shale. Deposited as prograding marine foreshore and shoreface sandstone. Thickness ranges from 25 to 177 ft.	25-177
Dalton Sandstone Member, unnamed lower tongue, and Borrego Pass Lentil of Crevasse Canyon Formation, and Mulatto Tongue of Mancos Share, Undivided	Kcd	Site above the Dilco Coal Member of Crevasse Canyon (Kcdi) formation	Dalton Sandstone Member of Crevasse Canyon Formation - Very pale orange to pale-yellowish-gray, very fine-grained to medium-grained, well-sorted, variably calcareous and gypsiferous, massive to thin-bedded, cliff-forming marine sandstone; minor interbeds of sandy mudstone, shale, and limestone; some carbonaceous detritus; locally fossiliferous. Sandstone bedding is gently undulating to gently dipping, hummocky to medium-scale, low-angle trough crossbedding; represents marine progradational facies grading upward from lower shore/ace deposits to upper shoreface and foreshore deposits. Locally split into upper and lower part by upper part of Mulatto Tongue of Mancos Shale. Upper part is more massive; lower part is usually considered as the lower tongue of Dalton Sandstone Member. Dalton Sandstone Member grades vertically and .laterally into overlying Gibson Coal Member of Crevasse Canyon and underlying Mulatto Tongue of Mancos Shale. Where Dalton Sandstone Member overlies the unnamed lower tongue of Crevasse Canyon Formation, contact is sharp except for local grading and interfingering. Dalton Sandstone Member wedges out southwestward about 7 km (4.3 mi) northeast of Gallup and grades northeastward into Mancos Shale. Thickness of Dalton where not split ranges from 12 to 55 m (39 to 180 ft). Thickness of upper unit ranges from 5 to 36 m (16 to 118 ft). Thickness of lower unit ranges from 0 to 22 m (0 to 72 ft).	0-72
			Unnamed lower tongue of Crevasse Canyon Formation - Interbedded sequence of light to dark-gray shale and siltstone; lenticular, white to tan, very fine grained to medium-grained, well-sorted lo poorly sorted sandstone; minor carbonaceous shale beds and lenticular subbituminous coal beds. Occurs between upper and lower units of Dalton Sandstone Member, contacts being sharp and interfingering. Laterally equivalent to upper unit of Mulatto Tongue of Mancos Shale. Confined to area of Big Rock Hill and Hard Ground Flats quadrangles in southwestern part of map area. Thickness ranges from 0 to 36 m (0 to 118 ft).	0-118
			Borrego Pass Lentil of Corrêa (1970) - Pale-grayish-yellow to white, very fine-grained to fine-grained, well-sorted sandstone; medium to coarse grained and poorly sorted in some layers; coarsens upward slightly. Generally thick beds of parallel-bedded and tabular to low-angle wedge-planar crossbedded sets, and locally some medium-scale trough crossbedding. Upper parts commonly burrowed and contain vertical trace fossils. Lower contact gradational with Dileo Coal Member, but in many places is sharp and scoured. Probably represents marine beach-barrier bar deposits. Located in area of Casamero Lake quadrangle in southeast corner of map area. Equivalent to stray sandstone of Sears and others (1941). Thickness ranges from 4.6 to 23 m (15 to 75 ft). Mulatto Tongue of Mancos Shale - Medium- to light-gray and light-greenish- to bluish-gray and yellowish-brown shale, sandy shale, siltstone, and silty claystone; interbedded platy-limestone and pale-gray to yellowish-gray, very line grained to fine-grained calcareous sandstone. The limestone occurs in thin ledges, lenses, pods, and concretions, some being fossiliferous. Many layers are ripple-laminated; some are bioturbated. Slope-forming Mulatto Tongue locally contains a basal conglomeratic sandstone in Casamero Lake area in southeast comer of map area. Northeast of Gallup, Mulatto Tongue is locally split into upper and lower units by lower tongue of Dalton Sandstone Member of Crevasse Canyon Formation. Becomes more sandy to southwest and thickens to northeast from wedge-edge 11 km (7 mi) south of Todilto Park and 19 km (12 mi) northeast of Gallup to a thickness of about 152 m (500 ft) in subsurface near northeast corner of map area. Contact of Mulatto Tongue with overlying Dalton Sandstone Member is gradational and is unconformable with underlying Dileo Coal Member and Borrego Pass Lentil. Thickness of Mulatto Tongue where not split ranges from 27 to 152 m (90 to 500 ft). Thickness of upper tongue ranges from 0 to 19 m (0 to 62 ft) and lower tongue from 0 to 24 m (0 to 79 ft).	15-75 90-500
Lower Tongues of Gallup Sandstone, and Unnamed Tongues of Mancos Shale, Undivided	Kmg	Lies directly north of OCRM's northernmost fenceline	Lower tongues of Gallup Sandstone - Pink to tan to pale-yellowish-gray, fine to medium-grained, well-sorted, parallel-bedded and massive calcareous sandstone; some minor siltstone and silty sandstone beds. Sandstone contains some slump structures and disturbed bedding; occurs usually in two but as many as four tongues interbedded with unnamed tongues of Mancos Shale. Upper contacts are sharp and lower contacts are gradational with underlying marine shale. Most of sandstone tongues rise stratigraphically to west and merge with main body of Gallup Sandstone. Probably deposited as offshore marine sandbars. Thickness of tongues varies from 0 to 18 m (0 to 58 ft).	0-58
			Unnamed tongues of Mancos Shale - Light- to dark-gray fissile shale and minor interbedded siltstone. Similar in lithology to main body of Mancos Shale. Interbedded with lower tongues of Gallup Sandstone. Generally there are two tongues of Mancos in this unit. However, number of tongues of Mancos Shale varies with number of tongues of Gallup Sandstone, and there may be as many as four tongues. Thickness of units ranges from 5 to 43 m (16 to 140 ft) each.	16-140

Notes:

¹ Surficial geologic deposit thicknesses not defined by USGS I-2009 map (Dillinger 1990)

Reference:

Dillinger, J.K. 1990. "Geologic Map and Structure Contour Maps of the Gallup 30'X60' quadrangle, McKinley County, New Mexico." https://ngmdb.usgs.gov/Prodesc/proddesc_10078.htm.

Table 4. Local Soil Types

Soil Complex Number ¹	Soil Complex Name ¹	Relation to Site	Description ¹
265	Uranium Mined Lands	Encompassed by OCRM's primary fenced footprint.	Consists of all areas associated with uranium mine activities, including the mines, shafts, structures, borrow pits, barren tailings, waste rock piles, evaporation ponds, and contaminated waste yards. Unless reclaimed or revegetated, these areas have no agricultural uses.
230	Sparank-San Mateo-Zia complex 0 to 3 percent slopes	Part of the northern fenced portion of OCRM and the surrounding area to the west, south, and southwest consists of Sparank-San Mateo-Zia complex soil. Encompasses BSA-02.	Parent material: Fan and stream alluvium derived from sandstone and shale. Well drained.
241	Mentmore loam, 1 to 8 percent slopes	Part of the northern fenced portion of OCRM and the surrounding area to the northwest and northeast. Encompasses BSA-01.	Parent material: Fan and slope alluvium derived from sandstone and shale. Well drained.
258	Eagleeye-Atchee-Rock outcrop complex 2 to 35 percent slopes	Soil complex lies to the northeast of OCRM.	Parent material: Slope alluvium over residuum weathered from shale. Well drained.
291	Rock outcrop-Eagleeye-Atchee complex 35 to 70 percent slopes	Soil complex touches the northernmost border of the fenced area of OCRM.	Parent material: Slope alluvium over residuum derived from shale. Well drained.
352	Zia sandy loam 1 to 5 percent slopes	Surrounding area to the east and southeast	Parent material: Eolian material and fan and stream alluvium derived from sandstone. Somewhat excessively drained.

Notes:

¹

Soil complex numbers, soil complex names, and soil descriptions from the Web Soil Survey produced by the National Cooperative Soil Survey operated by the U.S. Department of Agriculture Natural Resources Conservation Service (2022).

OCRМ

Old Church Rock Mine

Reference:

U.S. Department of Agriculture and Natural Resources Conservation Service. 2022. "Soil Survey Geographic (SSURGO) Database for New Mexico." <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>.

Table 5. Summary of Site Features

Feature	Reclamation Status	Description	Dimensions
Mine Shafts	Reclaimed	The main mine shaft and escape mine shaft were sealed with concrete and covered by 2-foot-thick shaft collar concrete slabs. These shafts extend to a depth of 865 feet and provide a hydraulic connection between the surface and underlying Dakota Sandstone.	Area of main mine shaft collar pad: 336 SY Volume of main mine shaft collar pad: 224 CY Area of escape mine shaft collar pad: 317 CY Volume of escape mine shaft collar pad: 212 CY
Ventilation Shafts	Unreclaimed	Four ventilation shafts have been identified. These shafts are covered with a circular steel plate and extend upwards from the surface from 1 to 3 feet. These shafts extend to a depth of 865 feet and provide a hydraulic connection between the surface and underlying Dakota Sandstone.	Diameter of ventilation shafts: 42 inches
Suspected Waste Disposal	Unreclaimed	Four areas of suspected waste disposal identified by previous investigations and historical imagery.	-
Haul and Access Roads	N/A	Haul roads are State Route 566 and Blackrock Road.	-
Ion-Exchange Building	Unreclaimed	The former ion-exchange building housed the equipment to remove uranium from the groundwater pumped out of the underground mine workings after first settling out fines in the settling ponds. At the time of the removal assessment field work, the ion-exchange building contained three electrical transformers and additional equipment.	Area of building footprint: 400 SY
Settling Ponds 1-5	Unreclaimed	Five separate settling ponds each surrounded by berms, which prevent precipitation falling outside of the pond area from entering the ponds. The ponds remain dry for most of the year although some water pools in the base of the ponds. Formerly used for settling out fines from the groundwater pumped out of the underground mine workings.	Area of ponds: 30,545 SY Volume of ponds: 88,475 CY
Main Shaft Concrete Pads	Unreclaimed	Includes four separate co-located pads related to the main shaft, including foundation pads and hoist pads located on top of the foundation pads.	Area of concrete pads: 673 SY Volume of concrete pads: 507 CY
Switchgear Concrete Pads	Unreclaimed	Includes four separate co-located pads related to switchgear.	Area of concrete pads: 511 SY Volume of concrete pads: 85 CY
Escape Shaft Concrete Pads	Unreclaimed	Includes three separate co-located pads related to the escape shaft, including foundation pads, hoist pads and headframe slabs located on top of the foundation pads, and a fan pad.	Area of concrete pads: 471 SY Volume of concrete pads: 326 CY
Electrical Equipment Concrete Pads	Unreclaimed	Includes four separate co-located pads related to electrical equipment.	Area of concrete pads: 1,058 SY Volume of concrete pads: 176 CY
Water Tank Concrete Pads and Outfall Pipe	Unreclaimed	Includes two separate co-located pads for housing a water tank and pumping equipment. An outfall pipe jutting out into the unnamed arroyo is approximately 40 yards west of the water tank concrete pad.	Area of concrete pads: 62 SY Volume of concrete pads: 36 CY

Notes:
Dimensions of concrete pads and of the five settling ponds are estimates (see [Appendix I](#)).
CY Cubic yard
SY Square yard

Table 6. Summary of Soil Sampling Analytical Methods

Area	Analyte	Analytical Method	Percentage of Samples Analyzed
BSAs	Metals*	SW6020B, SW6010D	100
	Radium-226	EH300	100
	Radium-228	EH300	100
	Potassium-40	EH300	100
	Uranium-238	EH300 (via Proactinium-234m)	100
	Thorium-232	EH300 (via Actinium-228)	100
	Isotopic Thorium	HASL300	7
	Isotopic Uranium	HASL300	7
OCRM	Metals*	SW6020B, SW6010D	100
	Radium-226	EH300	100
	Radium-228	EH300	100
	Potassium-40	EH300	100
	Uranium-238	EH300 (via Proactinium-234m)	100
	Thorium-232	EH300 (via Actinium-228)	100
	Isotopic Thorium	HASL300	12
	Isotopic Uranium	HASL300	12
	PCBs**	SW8082A	10
Gamma-Radium Correlation Plots	Metals*	SW6020B, SW6010D	100
	Radium-226	EH300	100
	Radium-228	EH300	100
	Potassium-40	EH300	100
	Uranium-238	EH300 (via Proactinium-234m)	100
	Thorium-232	EH300 (via Actinium-228)	100
	Isotopic Thorium	HASL300	100
	Isotopic Uranium	HASL300	100

Notes:

*

Including natural thorium and uranium

**

Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254 Aroclor-1260, Aroclor-1262, and Aroclor-1268, decachlorobiphenyl, and tetrachloro-m-xylene (4cmx) are also analyzed as surrogate analytes to measure reclamation

BSA

Background study area

EH300

Gamma spectrometry

HASL300

Alpha Spectrometry

OCRM

Old Church Rock Mine

PCB

Polychlorinated biphenyl

SW6010D

Inductively coupled plasma - atomic emission spectrometry

SW6020B

Inductively coupled plasma - mass spectrometry

SW8082A

Polychlorinated biphenyls by gas chromatography

Table 7. Summary of Gamma Radiation Survey Areas

Investigation Location	Approximate Area or Distance	Gamma Survey Method
OCRM	75 acres	Scan at 4-meter transects
Step-Outs	110 acres	Scan at 4-meter transects
Additional Step-Outs	80 acres	Scan at 8-meter transects
Residential Yards	2 acres	Scan at 2-meter transects
Drainages	2.2 miles	Scan in center and banks of drainages
Roads	0.5 mile	Scan at road edges
Radial Scans	8 miles	Scan out and back originating from center point
BSAs	1.5 acres	Scan at 2-meter transects
Gamma-Radium and Exposure Rate Correlation Plots	1,500 square meters	Scan at 1-meter or denser transects; collect static 60-second gamma measurements; collect HPIC measurements

Notes:

BSA	Background study area
HPIC	High-pressure ionization chamber
OCRM	Old Church Rock Mine

Table 8. Summary of QA/QC

Field Activity	QA/QC Activity	Summary of QA/QC Results	Appendix
Gamma Survey	Pre-trip background and source checks	Datasets were generated for each detector-meter pair. Each dataset was normally distributed, the coefficient of variation was less than 10 percent, and the mean of each dataset was within +/- 10 percent of the other datasets.	Appendix B Gamma Verification and Validation Report
	Daily background and source checks (daily function checks)	Daily function checks were performed for each detector-meter pair used for gamma scanning. Daily function check average net counts were compared to the average net counts for the pre-trip background and source checks for each detector-meter pair. The average net counts for all detector-meter pairs were within +/- 20 percent for all daily function checks.	
XRF Survey	Initial baseline response check	An instrument-specific response for uranium was established for each instrument used during the removal assessment. Instrument-specific responses to specific certified reference materials were established for comparison to daily precision check measurements.	Appendix C XRF Verification and Validation Report
	Precision check measurements	Precision check measurements were completed daily for each XRF instrument used for XRF surveying. Results of the daily precision checks were within two standard deviations of the baseline measurements.	
	Duplicate field XRF measurements	Duplicate field XRF measurements were completed at the rate of one for every 20 field XRF measurements. All duplicate field XRF measurements were within +/- 30 percent of the primary field XRF measurement.	
Soil Sampling	Field duplicate soil samples	Field duplicate soil samples were completed at the rate of one for every 20 field soil samples. Field duplicate soil samples analytes were all within +/- 30 percent of field soil samples.	Appendix D Soil Data Quality Report
	Equipment rinsate blanks	Equipment rinsate blanks were taken from equipment used for soil sampling with the same distilled water used for cleaning field equipment. Laboratory results indicate equipment did not significantly contribute to the concentrations of analytes.	
	Source water blanks	Source water blanks were taken with the same distilled water used for cleaning field equipment. Laboratory results indicate source water did not significantly contribute to the concentrations of analytes.	

Notes:

QA/QC

XRF

Quality assurance and quality control

X-ray fluorescence

Table 9. Summary Statistics for BSAs – Gamma Survey

BSA	n	Units	Minimum	Maximum	Average	Standard Deviation	RSD	BTV	BTV type	UCL95	UCL95 type
BSA-01	1,842	cpm	10,200	16,200	12,957	834	6%	14,379	Normal UTL95-95	12,989	Normal Student's-t UCL95
BSA-02	1,572	cpm	10,300	16,400	13,215	783	6%	14,553	Normal UTL95-95	13,248	Normal Student's-t UCL95

Notes:

BSA Background study area

BTV Background threshold value

cpm Counts per minute

n Number of datapoints

RSD Relative standard deviation

UCL95 95 percent upper confidence limit

UTL95-95 95 percent upper tolerance limit with 95 percent confidence

Table 10. BSA Soil Sample and XRF Locations and IDs

Location ID	Latitude and Longitude	Sample Date	Sample ID	Duplicate Collected	XRF Reading No.	XRF Sample ID
OCRM-B02-01	(35.61308,-108.557366)	11/16/2022	OCRM-B02-SS01-01-111622	No	931	OCRM-B02-X01
OCRM-B02-02	(35.613076,-108.557245)	11/16/2022	OCRM-B02-SS02-01-111622	No	932	OCRM-B02-X02
OCRM-B02-03	(35.613075,-108.557143)	11/16/2022	OCRM-B02-SS03-01-111622	No	933	OCRM-B02-X03
OCRM-B02-04	(35.613077,-108.557025)	11/16/2022	OCRM-B02-SS04-01-111622	No	934	OCRM-B02-X04
OCRM-B02-05	(35.613081,-108.556908)	11/16/2022	OCRM-B02-SS05-01-111622	No	935	OCRM-B02-X05
OCRM-B02-06	(35.612988,-108.557364)	11/16/2022	OCRM-B02-SS06-01-111622	No	941	OCRM-B02-X06
OCRM-B02-07	(35.612987,-108.557253)	11/16/2022	OCRM-B02-SS07-01-111622	No	940	OCRM-B02-X07
OCRM-B02-08	(35.612997,-108.557129)	11/16/2022	OCRM-B02-SS08-01-111622	No	938	OCRM-B02-X08
OCRM-B02-09	(35.612986,-108.557039)	11/16/2022	OCRM-B02-SS09-01-111622	No	937	OCRM-B02-X09
OCRM-B02-10	(35.612985,-108.556926)	11/16/2022	OCRM-B02-SS10-01-111622	Yes	936	OCRM-B02-X10
OCRM-B02-11	(35.612889,-108.557234)	11/16/2022	OCRM-B02-SS11-01-111622	No	942	OCRM-B02-X11
OCRM-B02-12	(35.612893,-108.557241)	11/16/2022	OCRM-B02-SS12-01-111622	No	943	OCRM-B02-X12
OCRM-B02-13	(35.612903,-108.557131)	11/16/2022	OCRM-B02-SS13-01-111622	No	944	OCRM-B02-X13
OCRM-B02-14	(35.612897,-108.557015)	11/16/2022	OCRM-B02-SS14-01-111622	No	945	OCRM-B02-X14
OCRM-B02-15	(35.612894,-108.556917)	11/16/2022	OCRM-B02-SS15-01-111622	No	946	OCRM-B02-X15
OCRM-B02-16	(35.612808,-108.557342)	11/16/2022	OCRM-B02-SS16-01-111622	No	952	OCRM-B02-X16
OCRM-B02-17	(35.612805,-108.557253)	11/16/2022	OCRM-B02-SS17-01-111622	No	951	OCRM-B02-X17
OCRM-B02-18	(35.612807,-108.557147)	11/16/2022	OCRM-B02-SS18-01-111622	No	950	OCRM-B02-X18
OCRM-B02-19	(35.61281,-108.557026)	11/16/2022	OCRM-B02-SS19-01-111622	No	949	OCRM-B02-X19
OCRM-B02-20	(35.612805,-108.556915)	11/16/2022	OCRM-B02-SS20-01-111622	Yes	947	OCRM-B02-X20
OCRM-B02-21	(35.612713,-108.557348)	11/16/2022	OCRM-B02-SS21-01-111622	No	953	OCRM-B02-X21
OCRM-B02-22	(35.612711,-108.557242)	11/16/2022	OCRM-B02-SS22-01-111622	No	954	OCRM-B02-X22
OCRM-B02-23	(35.612719,-108.557134)	11/16/2022	OCRM-B02-SS23-01-111622	No	955	OCRM-B02-X23
OCRM-B02-24	(35.612719,-108.55702)	11/16/2022	OCRM-B02-SS24-01-111622	No	956	OCRM-B02-X24
OCRM-B02-25	(35.612724,-108.556906)	11/16/2022	OCRM-B02-SS25-01-111622	No	957	OCRM-B02-X25
OCRM-B02-26	(35.612636,-108.55736)	11/16/2022	OCRM-B02-SS26-01-111622	No	963	OCRM-B02-X26
OCRM-B02-27	(35.612632,-108.557234)	11/16/2022	OCRM-B02-SS27-01-111622	No	962	OCRM-B02-X27
OCRM-B02-28	(35.612627,-108.557132)	11/16/2022	OCRM-B02-SS28-01-111622	No	961	OCRM-B02-X28
OCRM-B02-29	(35.612627,-108.557021)	11/16/2022	OCRM-B02-SS29-01-111622	No	960	OCRM-B02-X29
OCRM-B02-30	(35.612618,-108.556913)	11/16/2022	OCRM-B02-SS30-01-111622	No	959	OCRM-B02-X30

Note:

XRF X-ray fluorescence

Table 11. Summary Statistics for BSAs – Soil Sampling

Analyte	n Surface Samples	n Non- Detects	Potential Outliers Present?	Units	Minimum	Maximum	Average	Standard Deviation	RSD	BTV	BTV type	UCL95	UCL95 type
Aluminum	30	0	No	mg/kg	10,400	18,800	15,440	1,727	11%	19,274	Normal UTL95-95	15,976	Normal Student's-t UCL95
Antimony	30	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	30	0	No	mg/kg	4.5	6.8	5.7	0.6	10%	6.969	Normal UTL95-95	5.912	Normal Student's-t UCL95
Barium	30	0	No	mg/kg	119	175	136	13	10%	164.9	Normal UTL95-95	139.8	Normal Student's-t UCL95
Beryllium	30	0	No	mg/kg	0.74	1.13	0.97	0.1	10%	1.184	Normal UTL95-95	1.002	Normal Student's-t UCL95
Cadmium	30	0	No	mg/kg	0.12	0.17	0.15	0.01	9%	0.18	Normal UTL95-95	0.155	Normal Student's-t UCL95
Calcium	30	0	No	mg/kg	5,690	8,680	6,814	614	9%	8,177	Normal UTL95-95	7,004	Normal Student's-t UCL95
Chromium	30	0	No	mg/kg	9.1	14.8	12.2	1.3	10%	15.1	Normal UTL95-95	12.65	Normal Student's-t UCL95
Cobalt	30	0	No	mg/kg	5.9	8.8	7.6	0.7	10%	9.217	Normal UTL95-95	7.823	Normal Student's-t UCL95
Copper	30	0	No	mg/kg	10.5	16	13.7	1.5	11%	16.97	Normal UTL95-95	14.15	Normal Student's-t UCL95
Iron	30	0	No	mg/kg	14,400	21,500	18,367	1,699	9%	22,138	Normal UTL95-95	18,894	Normal Student's-t UCL95
Lead	30	0	No	mg/kg	11.6	17.8	15.1	1.6	11%	18.76	Normal UTL95-95	15.65	Normal Student's-t UCL95
Lithium	30	0	No	mg/kg	10.2	16.5	14.2	1.5	11%	17.61	Normal UTL95-95	14.7	Normal Student's-t UCL95
Magnesium	30	0	No	mg/kg	3,670	4,780	4,283	280	7%	4,905	Normal UTL95-95	4,370	Normal Student's-t UCL95
Manganese	30	0	No	mg/kg	209	273	248	17	7%	285.9	Normal UTL95-95	253.2	Normal Student's-t UCL95
Molybdenum	30	0	No	mg/kg	0.28	0.4	0.34	0.04	10%	0.414	Normal UTL95-95	0.348	Normal Student's-t UCL95
Nickel	30	0	No	mg/kg	7.8	11.9	10.1	1	10%	12.4	Normal UTL95-95	10.39	Normal Student's-t UCL95
Selenium	30	0	No	mg/kg	1.38	2.75	2.01	0.37	19%	2.84	Normal UTL95-95	2.126	Normal Student's-t UCL95
Silver	30	30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sodium	30	0	No	mg/kg	52	76	67	6	9%	81.16	Normal UTL95-95	69.11	Normal Student's-t UCL95
Thallium	30	0	No	mg/kg	0.163	0.26	0.218	0.023	10%	0.269	Normal UTL95-95	0.225	Normal Student's-t UCL95
Thorium	30	0	No	mg/kg	6.6	10.9	9.4	1	11%	11.63	Normal UTL95-95	9.681	Normal Student's-t UCL95
Uranium	30	0	No	mg/kg	0.87	1.29	1.14	0.1	9%	1.363	Normal UTL95-95	1.168	Normal Student's-t UCL95
Vanadium	30	0	No	mg/kg	20.8	31.6	26.9	2.6	10%	32.59	Normal UTL95-95	27.68	Normal Student's-t UCL95
Zinc	30	0	No	mg/kg	43.5	63.6	54	5	10%	66.07	Normal UTL95-95	55.86	Normal Student's-t UCL95
Radium-226	30	0	No	pCi/g	1.13	1.94	1.58	0.18	12%	1.986	Normal UTL95-95	1.633	Normal Student's-t UCL95
Radium-228	30	0	No	pCi/g	1.13	2.2	1.67	0.29	17%	2.303	Normal UTL95-95	1.756	Normal Student's-t UCL95
Potassium-40	30	0	No	pCi/g	17.9	24	20.7	1.1	5%	23.18	Normal UTL95-95	21.06	Normal Student's-t UCL95
Thorium-232	30	0	No	pCi/g	1.1	2.2	1.7	0.3	17%	2.303	Normal UTL95-95	1.756	Normal Student's-t UCL95

Notes:
BSA Background study area
BTV Background threshold value
mg/kg Milligram per kilogram
n Number of samples
N/A Not applicable
pCi/g Picocurie per gram
RSD Relative standard deviation
UCL95 95 percent upper confidence limit
UTL95-95 95 percent upper tolerance limit with 95 percent confidence

Table 12. Summary Statistics for BSAs – XRF¹

Analyte	n	n Non-Detects	RSD	Distribution	BTV Selection Method	BTV (ppm) ²
Arsenic	30	0	13%	Normal	Normal UTL95-95	8.18
Barium	30	30	-	-	-	>LOD
Cobalt	30	5	29%	Normal	Normal UTL95-95	61.1
Chromium	30	0	24%	Normal	Normal UTL95-95	43.0
Copper	30	0	23%	Normal	Normal UTL95-95	15.1
Iron	30	0	10%	Normal	Normal UTL95-95	25,012
Manganese	30	0	12%	Normal	Normal UTL95-95	270
Lead	30	0	11%	Normal	Normal UTL95-95	20.3
Molybdenum	30	24	15%	-	Maximum Recorded Value	1.61
Nickel	30	17	41%	-	Maximum Recorded Value	19.9
Selenium	30	30	-	-	-	>LOD
Thorium	30	0	10%	Normal	Normal UTL95-95	13.4
Uranium	30	0	24%	Gamma	WH Approximate Gamma UTL95-95	5.20
Vanadium	30	1	18%	Normal	Normal UTL95-95	97.3
Zinc	30	0	12%	Normal	Normal UTL95-95	71.6

Notes:

- ¹ Of the analytes detectable in soil samples presented in Table 11, the XRF instrument was unable to detect the following radionuclides and metals: aluminum, beryllium, calcium, lithium, magnesium, silver, sodium, and thallium.
- ² An XRF BTV for Barium and Selenium cannot be calculated as 100% of BSA measurements were non-detects. Any XRF measurement that results in a value greater than the limit of detection ">LOD" will be considered above the BTV.
- Not applicable
- >LOD Greater than the limit of detection
- BSA Background study area
- BTV Background threshold value
- n Number of samples
- ppm Parts per million
- RSD Relative standard deviation
- UTL95-95 95 percent upper tolerance limit with 95 percent confidence
- WH Wilson-Hilferty
- XRF X-ray fluorescence

Table 13. Radial Transect Summary Statistics - Gamma

Transect	Total Distance Traveled (mile)	Distance to Fence Line (mile)	Distance to Gamma BTV (mile)	Peak Gamma (cpm)	Ended Below Gamma BTV
Northeast	0.75	0.30	0.45	235,757	No
East	0.75	0.18	0.33	216,045	Yes
Southeast	0.75	0.14	0.20	27,833	Yes
South	0.50	0.17	0.18	22,400	Yes
Southwest	0.75	0.19	0.15	176,000	Yes
West	0.56	0.03	0.09	36,700	Yes
Northwest	0.50	0.04	0.14	18,868	Yes
North	0.33	0.30	0.27	21,152	No

Notes:

BTV

Background threshold value

cpm

Counts per minute

Table 14. Gamma Radiation Summary Statistics

Statistic	Result	Unit
Site BTV	14,500	cpm
n	252,982	-
Minimum	6,305	cpm
Maximum	476,000	cpm
Average	27,714	cpm
Standard Deviation	37,298	cpm
90 th Percentile	55,000	cpm
95 th Percentile	103,000	cpm
99 th Percentile	200,001	cpm
Relative Standard Deviation	135%	-

Notes:

-	Not applicable
BTV	Background threshold value
cpm	Counts per minute
n	Number

Table 15. Correlation Plot Soil Composite Sample Locations and IDs

Location ID	Latitude and Longitude	Sample Date	Composite Sample ID	Duplicate Collected
OCRM-CORR01	35.617063,-108.564274	11/19/2022	OCRM-CORR01-01-111922	Yes
OCRM-CORR02	35.61719,-108.562775	11/19/2022	OCRM-CORR02-01-111922	No
OCRM-CORR03	35.616687,-108.562582	11/19/2022	OCRM-CORR03-01-111922	No
OCRM-CORR04	35.620141,-108.557067	11/19/2022	OCRM-CORR04-01-111922	No
OCRM-CORR05	35.62025,-108.556436	11/19/2022	OCRM-CORR05-01-111922	No
OCRM-CORR06	35.621247,-108.55564	11/19/2022	OCRM-CORR06-01-111922	No
OCRM-CORR07	35.621017,-108.554923	11/19/2022	OCRM-CORR07-01-111922	No
OCRM-CORR08	35.620337,-108.553975	11/19/2022	OCRM-CORR08-01-111922	No
OCRM-CORR09	35.621577,-108.554643	11/19/2022	OCRM-CORR09-01-111922	No
OCRM-CORR10	35.62249,-108.554888	11/19/2022	OCRM-CORR10-01-111922	No
OCRM-CORR11	35.62231,-108.555111	11/19/2022	OCRM-CORR11-01-111922	No
OCRM-CORR12	35.624046,-108.552897	11/19/2022	OCRM-CORR12-01-111922	No
OCRM-CORR13	35.62327,-108.550713	11/19/2022	OCRM-CORR13-01-111922	No
OCRM-CORR14	35.623072,-108.550607	11/19/2022	OCRM-CORR14-01-111922	No
OCRM-CORR15	35.62327,-108.550216	11/19/2022	OCRM-CORR15-01-111922	No

Table 16. Gamma-Guided Soil Sample and XRF Locations and IDs

Location ID	Latitude and Longitude	Sample Date	Surface Soil Sample ID	Duplicate Collected	XRF Reading No.	XRF Sample ID
OCRM-02	35.625046,-108.554451	11/17/2022	OCRM-SS02-01-111722	No	987	OCRM-X02
OCRM-05	35.624156,-108.550606	11/17/2022	OCRM-SS05-01-111722	No	995	OCRM-X05
OCRM-06	35.624119,-108.551042	11/17/2022	OCRM-SS06-01-111722	No	994	OCRM-X06
OCRM-07	35.623992,-108.550769	11/17/2022	OCRM-SS07-01-111722	No	996	OCRM-X07
OCRM-08	35.623875,-108.550374	11/17/2022	OCRM-SS08-01-111722	No	997	OCRM-X08
OCRM-09	35.623777,-108.551343	11/17/2022	OCRM-SS09-01-111722	No	993	OCRM-X09
OCRM-10	35.623584,-108.552987	11/17/2022	OCRM-SS10-01-111722	No	989	OCRM-X10
OCRM-11	35.623428,-108.552334	11/17/2022	OCRM-SS11-01-111722	No	991	OCRM-X11
OCRM-12	35.623395,-108.551501	11/17/2022	OCRM-SS12-01-111722	Yes	998	OCRM-X12
OCRM-13	35.623298,-108.552681	11/17/2022	OCRM-SS13-01-111722	No	990	OCRM-X13
OCRM-16	35.623193,-108.551314	11/17/2022	OCRM-SS16-01-111722	No	999	OCRM-X16
OCRM-17	35.623137,-108.553495	11/17/2022	OCRM-SS17-01-111722	No	988	OCRM-X17
OCRM-18	35.622647,-108.551379	11/17/2022	OCRM-SS18-01-111722	No	1000	OCRM-X18
OCRM-1804	35.622118,-108.555136	11/16/2022	OCRM-SS1804-01-111622	No	978	OCRM-X1804
OCRM-19	35.62076,-108.552411	11/17/2022	OCRM-SS19-01-111722	No	1026	OCRM-X19
OCRM-20	35.62252,-108.552499	11/17/2022	OCRM-SS20-01-111722	No	1002	OCRM-X20
OCRM-21	35.622571,-108.550082	11/17/2022	OCRM-SS21-01-111722	No	1028	OCRM-X21
OCRM-2217	35.621099,-108.555802	11/16/2022	OCRM-SS2217-01-111622	No	976	OCRM-X2217
OCRM-2225	35.621126,-108.554867	11/16/2022	OCRM-SS2225-01-111622	No	977	OCRM-X2225
OCRM-23	35.6222,-108.552816	11/17/2022	OCRM-SS23-01-111722	No	1003	OCRM-X23
OCRM-24	35.622094,-108.55402	11/17/2022	OCRM-SS24-01-111722	No	1006	OCRM-X24
OCRM-25	35.622079,-108.551967	11/17/2022	OCRM-SS25-01-111722	No	1001	OCRM-X25
OCRM-26	35.621595,-108.553162	11/17/2022	OCRM-SS26-01-111722	No	1004	OCRM-X26
OCRM-2679	35.61993,-108.555877	11/16/2022	OCRM-SS2679-01-111622	No	975	OCRM-X2679
OCRM-27	35.621494,-108.553929	11/17/2022	OCRM-SS27-01-111722	No	1005	OCRM-X27
OCRM-2738	35.619756,-108.557185	11/16/2022	OCRM-SS2738-01-111622	No	974	OCRM-X2738
OCRM-28	35.62061,-108.552554	11/17/2022	OCRM-SS28-01-111722	Yes	1019	OCRM-X28
OCRM-29	35.620718,-108.554249	11/17/2022	OCRM-SS29-01-111722	No	1011	OCRM-X29

Table 16. Gamma-Guided Soil Sample and XRF Locations and IDs

Location ID	Latitude and Longitude	Sample Date	Surface Soil Sample ID	Duplicate Collected	XRF Reading No.	XRF Sample ID
OCRM-2946	35.61918,-108.557671	11/16/2022	OCRM-SS2946A-01-111622	No	972	OCRM-X2946
OCRM-2946	35.61918,-108.557671	11/16/2022	OCRM-SS2946B-01-111622	No	972	OCRM-X2946
OCRM-2975	35.619127,-108.557822	11/16/2022	OCRM-SS2975-01-111622	No	969	OCRM-X2975
OCRM-30	35.620773,-108.555283	11/17/2022	OCRM-SS30-01-111722	No	1010	OCRM-X30
OCRM-3006	35.619015,-108.55765	11/16/2022	OCRM-SS3006-01-111622	No	971	OCRM-X3006
OCRM-3099	35.618639,-108.557315	11/16/2022	OCRM-SS3099-01-111622	No	973	OCRM-X3099
OCRM-31	35.620811,-108.556594	11/17/2022	OCRM-SS31-01-111722	No	1009	OCRM-X31
OCRM-32	35.620517,-108.55644	11/17/2022	OCRM-SS32-01-111722	No	1008	OCRM-X32
OCRM-34	35.620072,-108.554623	11/17/2022	OCRM-SS34-01-111722	No	1013	OCRM-X34
OCRM-35	35.619445,-108.556985	11/17/2022	OCRM-SS35-01-111722	No	1007	OCRM-X35
OCRM-36	35.61929,-108.554855	11/17/2022	OCRM-SS36-01-111722	No	1016	OCRM-X36

Note:

XRF

X-ray fluorescence

Table 17. PCB Mixture Aroclor-1260 Results

Sample ID	Detected	Result (µg/kg)	Qualifier	MDL (µg/kg)
OCRM-SS2975-01-111622	N	1.26	U	1.26
OCRM-SS3006-01-111622	N	1.2	U	1.2
OCRM-SS2946A-01-111622	N	1.39	U	1.39
OCRM-SS2946B-01-111622	Y	6.83	J	5.73

Notes:

µg/kg

Microgram per kilogram

J

Estimated value

MDL

Minimum detection limit

PCB

Polychlorinated biphenyl

U

Not detected

Table 18. Surface Soil Sampling Summary Statistics for Metals and Radionuclides

Analyte	Surface Samples	Non-Detects	Minimum	Maximum	Average	Standard Deviation	Relative Standard Deviation
Metals			mg/kg				
Aluminum	39	0	4,170	17,100	8,616	3,750	44%
Antimony	39	31	0.350	0.990	0.544	0.204	37%
Arsenic	39	0	1.3	7.0	3.6	1.5	43%
Barium	39	0	68	5,250	370	1,002	271%
Beryllium	39	0	0.26	1.12	0.59	0.22	38%
Cadmium	39	0	0.02	1.25	0.13	0.20	150%
Calcium	39	0	1,040	26,800	5,974	4,588	77%
Chromium	39	0	3.4	30.0	8.8	5.5	62%
Cobalt	39	0	2.0	13.6	4.8	2.5	52%
Copper	39	0	3.0	41.9	9.2	7.4	80%
Iron	39	0	5,860	167,000	16,316	25,274	155%
Lead	39	0	4.4	22.7	10.0	4.1	41%
Lithium	39	0	4.3	16.1	8.4	3.5	41%
Magnesium	39	0	1,030	7,490	2,762	1,276	46%
Manganese	39	0	79	319	182	66	36%
Molybdenum	39	1	0.09	499.00	13.56	80.88	597%
Nickel	39	0	1.9	28.7	6.7	4.9	74%
Selenium	39	0	0.61	41.10	5.40	8.46	156%
Silver	39	31	0.107	0.248	0.173	0.047	27%
Sodium	39	0	26	797	97	148	152%
Thallium	39	22	0.140	0.755	0.232	0.140	61%
Thorium	39	0	2.7	11.1	5.8	2.2	38%
Uranium	39	0	2.95	967.00	139.60	233.85	168%
Vanadium	39	0	18.2	183.0	47.0	34.4	73%
Zinc	39	0	11	1880	82	296	363%
Radioisotopes			pCi/g				
Radium-226	39	0	1.98	312	73.95	88.92	120%
Radium-228	39	16	0.66	2.38	1.308	0.373	29%
Potassium-40	39	0	14.6	24.4	19.43	2.014	10%
Thorium-232	39	11	0.66	4.87	1.411	0.761	54%
PCBs			µg/kg				
Aroclor-1016	4	4	-	-	-	-	-
Aroclor-1221	4	4	-	-	-	-	-
Aroclor-1232	4	4	-	-	-	-	-
Aroclor-1242	4	4	-	-	-	-	-
Aroclor-1248	4	4	-	-	-	-	-
Aroclor-1254	4	4	-	-	-	-	-
Aroclor-1260	4	3	6.83	6.83	6.83	-	-
Aroclor-1262	4	4	-	-	-	-	-
Aroclor-1268	4	4	-	-	-	-	-

Table 18. Surface Soil Sampling Summary Statistics for Metals and Radionuclides

Notes:

Summary statistics are calculated for detected values only.

µg/kg Microgram per kilogram

mg/kg Milligram per kilogram

n Number of samples

- Not applicable

PCB Polychlorinated biphenyl

pCi/g Picocurie per gram

Table 19. COPC Identification

Analyte	n Samples	n Non-Detects	BTV ¹	Risk-Based COPC Screening ^{2,3}	COPC Threshold Value	Units	Site UCL95	Site UCL95 > Threshold ⁴	COPC
Aluminum	39	0	1,9274	1,200	19,274	mg/kg	9,628.0	FALSE	No
Antimony	39	31	n/a	0.381	0.381	mg/kg	0.381	FALSE	No
Arsenic	39	0	6.969	0.0231	6.969	mg/kg	4.0	FALSE	No
Barium	39	0	164.9	124	164.9	mg/kg	1,069.0	TRUE	Yes
Beryllium	39	0	1.184	2.78	2.78	mg/kg	0.7	FALSE	No
Cadmium	39	0	0.18	0.0417	0.18	mg/kg	0.2	FALSE	No
Chromium	39	0	15.1	1,810	1810	mg/kg	10.4	FALSE	No
Cobalt	39	0	9.217	0.193	9.217	mg/kg	5.6	FALSE	No
Copper	39	0	16.97	6.32	16.97	mg/kg	11.0	FALSE	No
Iron	39	0	22,138	552	22,138	mg/kg	17,670.5	FALSE	No
Lead	39	0	18.76	400	400	mg/kg	11.1	FALSE	No
Lithium	39	0	17.61		17.61	mg/kg	9.3	FALSE	No
Manganese	39	0	285.9	3.23	285.9	mg/kg	199.5	FALSE	No
Molybdenum	39	1	0.414	1.21	1.21	mg/kg	69.0	TRUE	Yes
Nickel	39	0	12.4	18.2	18.2	mg/kg	8.0	FALSE	No
Selenium	39	0	2.84	1.7	2.84	mg/kg	11.3	TRUE	Yes
Silver	39	31	n/a	1.9	1.9	mg/kg	0.1	FALSE	No
Thallium	39	22	0.269	0.00537	0.269	mg/kg	0.2	FALSE	No
Thorium	39	0	11.63		11.63	mg/kg	6.4	FALSE	No
Uranium	39	0	1.363	0.282	1.363	mg/kg	302.8	TRUE	Yes
Vanadium	39	0	32.59	6.46	32.59	mg/kg	71.0	TRUE	Yes
Zinc	39	0	66.07	147	147	mg/kg	288	TRUE	Yes
Radium-226	39	0	1.986	0.000523	1.986	pCi/g	109.2	TRUE	Yes

Notes:

Yellow rows indicate analytes identified as COPCs.

¹ From Table 11.

² The COPC screening levels are calculated using the Navajo Abandoned Uranium Mine risk calculator for the Kee'da'whíí tééh (full-time Navajo residential) using a target risk of 1E-06 and target hazard quotient of 0.1 except for lead, which is based on the regional screening level for residential soil.

³ No risk-based COPC screening values are available for lithium and thorium.

⁴ From Table 18.

BTV Background threshold value

COPC Contaminant of potential concern

mg/kg Milligram per kilogram

n Number

pCi/g Picocurie per gram

UCL95 95 percent upper confidence limit

Table 20. Radial Transect XRF Locations and IDs

Location ID	Latitude and Longitude	Sample Date	XRF Reading No.	XRF Sample ID
OCRM-RTE-01	35.621494,-108.554689	11/19/2022	1116	OCRM-RTE-X01
OCRM-RTE-02	35.621522,-108.553575	11/19/2022	1115	OCRM-RTE-X02
OCRM-RTE-03	35.621507,-108.552504	11/19/2022	1114	OCRM-RTE-X03
OCRM-RTE-04	35.621507,-108.551379	11/19/2022	1081	OCRM-RTE-X04
OCRM-RTE-05	35.621503,-108.550281	11/19/2022	1083	OCRM-RTE-X05
OCRM-RTE-06	35.621493,-108.549193	11/19/2022	1084	OCRM-RTE-X06
OCRM-RTE-07	35.621503,-108.548152	11/19/2022	1085	OCRM-RTE-X07
OCRM-RTE-08	35.621542,-108.546961	11/19/2022	1086	OCRM-RTE-X08
OCRM-RTE-09	35.62152,-108.54586	11/19/2022	1087	OCRM-RTE-X09
OCRM-RTE-10	35.621525,-108.544751	11/19/2022	1088	OCRM-RTE-X10
OCRM-RTE-11	35.621553,-108.543663	11/19/2022	1089	OCRM-RTE-X11
OCRM-RTE-12	35.621544,-108.542478	11/19/2022	1090	OCRM-RTE-X12
OCRM-RTNE-02	35.622744,-108.554244	11/19/2022	1117	OCRM-RTNE-X02
OCRM-RTNE-05	35.624691,-108.551929	11/19/2022	1095	OCRM-RTNE-X05
OCRM-RTNE-06	35.625325,-108.551156	11/19/2022	1094	OCRM-RTNE-X06
OCRM-RTNE-07	35.625973,-108.550374	11/19/2022	1093	OCRM-RTNE-X07
OCRM-RTNE-08	35.626598,-108.549603	11/18/2022	1054	OCRM-RTNE-X08
OCRM-RTNE-09	35.627242,-108.548832	11/18/2022	1055	OCRM-RTNE-X09
OCRM-RTNE-10	35.627897,-108.548058	11/18/2022	1056	OCRM-RTNE-X10
OCRM-RTNE-11	35.628537,-108.547292	11/19/2022	1091	OCRM-RTNE-X11
OCRM-RTNE-12	35.628999,-108.546662	11/19/2022	1092	OCRM-RTNE-X12
OCRM-RTNW-01	35.622122,-108.556594	11/19/2022	1105	OCRM-RTNW-X01
OCRM-RTNW-02	35.622744,-108.557342	11/19/2022	1104	OCRM-RTNW-X02
OCRM-RTNW-03	35.62338,-108.558125	11/19/2022	1103	OCRM-RTNW-X03
OCRM-RTNW-04	35.624029,-108.558953	11/19/2022	1102	OCRM-RTNW-X04
OCRM-RTNW-05	35.624666,-108.559746	11/19/2022	1101	OCRM-RTNW-X05
OCRM-RTNW-06	35.625297,-108.560532	11/19/2022	1100	OCRM-RTNW-X06
OCRM-RTNW-07	35.625908,-108.561306	11/19/2022	1098	OCRM-RTNW-X07
OCRM-RTN-02	35.622252,-108.555805	11/19/2022	1118	OCRM-RTN-X02
OCRM-RTN-03	35.623281,-108.555823	11/19/2022	1119	OCRM-RTN-X03
OCRM-RTN-04	35.624164,-108.555852	11/19/2022	1120	OCRM-RTN-X04
OCRM-RTN-05	35.625094,-108.555828	11/19/2022	1121	OCRM-RTN-X05
OCRM-RTN-06	35.625985,-108.555849	11/19/2022	1097	OCRM-RTN-X06
OCRM-RTN-07	35.626422,-108.555905	11/19/2022	1096	OCRM-RTN-X07
OCRM-RTSE-01	35.620841,-108.555006	11/19/2022	1111	OCRM-RTSE-X01
OCRM-RTSE-02	35.620314,-108.554314	11/19/2022	1112	OCRM-RTSE-X02
OCRM-RTSE-03	35.619571,-108.553445	11/19/2022	1080	OCRM-RTSE-X03
OCRM-RTSE-04	35.618942,-108.552677	11/19/2022	1079	OCRM-RTSE-X04
OCRM-RTSE-05	35.618311,-108.551861	11/19/2022	1078	OCRM-RTSE-X05
OCRM-RTSE-06	35.617679,-108.551074	11/19/2022	1077	OCRM-RTSE-X06

Table 20. Radial Transect XRF Locations and IDs

Location ID	Latitude and Longitude	Sample Date	XRF Reading No.	XRF Sample ID
OCRM-RTSE-07	35.617052,-108.550307	11/19/2022	1076	OCRM-RTSE-X07
OCRM-RTSE-08	35.61641,-108.549499	11/19/2022	1075	OCRM-RTSE-X08
OCRM-RTSE-09	35.615777,-108.548715	11/19/2022	1074	OCRM-RTSE-X09
OCRM-RTSE-10	35.615139,-108.54796	11/19/2022	1073	OCRM-RTSE-X10
OCRM-RTSE-11	35.614514,-108.547152	11/19/2022	1072	OCRM-RTSE-X11
OCRM-RTSE-12	35.613857,-108.546295	11/19/2022	1071	OCRM-RTSE-X12
OCRM-RTSW-04	35.618908,-108.558946	11/18/2022	1043	OCRM-RTSW-X04
OCRM-RTSW-05	35.61824,-108.559715	11/18/2022	1042	OCRM-RTSW-X05
OCRM-RTSW-06	35.617612,-108.560451	11/18/2022	1041	OCRM-RTSW-X06
OCRM-RTSW-07	35.61699,-108.561217	11/18/2022	1040	OCRM-RTSW-X07
OCRM-RTSW-08	35.616319,-108.562064	11/18/2022	1039	OCRM-RTSW-X08
OCRM-RTSW-09	35.615692,-108.562753	11/18/2022	1038	OCRM-RTSW-X09
OCRM-RTSW-10	35.615052,-108.563549	11/18/2022	1037	OCRM-RTSW-X10
OCRM-RTSW-11	35.614421,-108.56428	11/18/2022	1036	OCRM-RTSW-X11
OCRM-RTSW-12	35.613738,-108.565129	11/18/2022	1035	OCRM-RTSW-X12
OCRM-RTS-01	35.620554,-108.555788	11/19/2022	1110	OCRM-RTS-X01
OCRM-RTS-02	35.619683,-108.555783	11/19/2022	1106	OCRM-RTS-X02
OCRM-RTS-03	35.618783,-108.55578	11/19/2022	1063	OCRM-RTS-X03
OCRM-RTS-04	35.617882,-108.555762	11/19/2022	1064	OCRM-RTS-X04
OCRM-RTS-05	35.616992,-108.555737	11/19/2022	1065	OCRM-RTS-X05
OCRM-RTS-06	35.616078,-108.555741	11/19/2022	1066	OCRM-RTS-X06
OCRM-RTS-07	35.615166,-108.555752	11/19/2022	1067	OCRM-RTS-X07
OCRM-RTS-08	35.614272,-108.555737	11/19/2022	1068	OCRM-RTS-X08
OCRM-RTS-09	35.613373,-108.555737	11/19/2022	1069	OCRM-RTS-X09
OCRM-RTS-10	35.612481,-108.555706	11/19/2022	1070	OCRM-RTS-X10
OCRM-RTW-01	35.621464,-108.556919	11/18/2022	1044	OCRM-RTW-X01
OCRM-RTW-02	35.621458,-108.558003	11/18/2022	1045	OCRM-RTW-X02
OCRM-RTW-02	35.621458,-108.558003	11/19/2022	1045	OCRM-RTW-X02
OCRM-RTW-03	35.62147,-108.559102	11/18/2022	1046	OCRM-RTW-X03
OCRM-RTW-04	35.621459,-108.560221	11/18/2022	1047	OCRM-RTW-X04
OCRM-RTW-05	35.621443,-108.561323	11/18/2022	1048	OCRM-RTW-X05
OCRM-RTW-06	35.621433,-108.56243	11/18/2022	1049	OCRM-RTW-X06
OCRM-RTW-07	35.621407,-108.563529	11/18/2022	1050	OCRM-RTW-X07
OCRM-RTW-08	35.621492,-108.564588	11/18/2022	1051	OCRM-RTW-X08
OCRM-RTW-09	35.621426,-108.565747	11/18/2022	1052	OCRM-RTW-X09

Note:

XRF X-ray fluorescence

Table 21. Radial Transect Summary Statistics - XRF

Transect	Barium			Molybdenum			Selenium			Uranium			Vanadium			Zinc			All COPCs below BTVs				
	Min (ppm)	Max (ppm)	n > BTV	Min (ppm)	Max (ppm)	n > BTV	Min (ppm)	Max (ppm)	n > BTV	Min (ppm)	Max (ppm)	n > BTV	Min (ppm)	Max (ppm)	n > BTV	Min (ppm)	Max (ppm)	n > BTV	Sample ID	Latitude	Longitude	Distance from Center (mile)	Distance from Fence Line (mile)
NE	0	0	0	0	105	3	0	676	3	2	1,271	5	0	3,630	1	37	1,777	3	*	*	*	>0.75	>0.45
E	0	0	0	0	101	3	0	586	3	0	1,025	3	0	3,690	3	23	1,714	3	OCRM-RTE-X04	35.621507	-108.551379	0.25	0.07
SE	0	0	0	0	96	3	0	545	2	0	945	2	0	4,102	2	22	1,746	3	OCRM-RTSE-X03***	35.619571	-108.553445	0.19	0.05
S	0	0	0	0	105	2	0	605	2	0	990	3	56	3,750	2	18	1,882	2	OCRM-RTS-X03	35.618783	-108.55578	0.19	0.02
SW	0	0	0	0	104	3	0	740	2	3	1,180	4	0	3,902	2	45	2,518	5	OCRM-RTSW-X07	35.61699	-108.561217	0.44	0.25
W	0	0	0	0	4	3	0	0	0	3	6	2	0	45	0	27	80	2	OCRM-RTW-X07	35.621407	-108.563529	0.43	0.40
NW	0	0	0	0	0	0	0	0	0	0	4	0	0	58	0	26	70	0	OCRM-RTNW-X01	35.622122	-108.556594	0.06	0.02
N	0	0	0	0	100	2	0	520	1	0	938	3	0	3,119	1	44	1,544	1	OCRM-RTN-X06	35.625985	-108.555849	0.31	0.01

Notes:
Distances between two global positioning system coordinate points were calculated using Equation 1.
* No clear point at which all COPCs are consistently below the BTV. Measurements at OCRM-RTNE-X07 and OCRM-RTNE-X09 demonstrated all COPCs below the BTV, but measurements before, between, and after showed exceedances.
<LOD Less than the limit of detection
BTV Background threshold value
COPC Contaminant of potential concern
N Number
ppm Parts per million
XRF X-ray fluorescence

Table 22. Appendix I Section 4 Summary Areas of Concern - Estimated of Volumes of Removal at Various Cleanup Levels

Area of Concern	Target Radium-226 Cleanup Concentration (pCi/g)	Total Impacted Surface Area (acres)	Average Depth (feet)	Total Estimated Volume Maximum Estimated Depth (CY)	Total Estimated Volume Maximum 2 feet bgs (CY)
Total Site	2	170	5.28	1,447,277	532,983
	5	56	5.31	477,479	171,499
	10	36	5.27	305,224	108,338
	15	29	3.81	224,461	84,167
	25	22	4.82	168,821	59,050
Area 1 - Offsite Grazing Area*	2	15	5.26	130,970	47,993
	5	-	-	-	-
	10	-	-	-	-
	15	-	-	-	-
	25	-	-	-	-
Area 2 - Waste Material Berm	2	2.1	5.54	18,453	6,694
	5	1.4	3.00	6,839	3,629
	10	0.8	0.51	628	628
	15	0.6	0.53	512	512
	25	0.3	0.60	341	341
Area 3 - Arroyo Bank	2	0.8	6.07	7,462	2,458
	5	0.6	6.24	6,004	2,458
	10	0.1	5.57	953	319
	15	0	0	0	0
	25	0	0	0	0
Area 4 - Main Site	2	29	6.08	281,909	91,228
	5	27	5.85	257,797	83,403
	10	26	5.57	233,728	80,543
	15	24	5.28	201,761	70,314
	25	20	5.12	162,839	54,502

Notes:
[Appendix I](#) references a 2013 Phase II site characterization draft report (Intera, Inc. 2013) and uses raw downhole gamma data from boring logs in estimating the depth of radium-226 contamination. No interpretations or calculations made in the draft report were used in the volume estimates in [Appendix I](#). The only information taken from the site characterization report was raw measurements collected by field instruments. However, because the accuracy of the instruments used in the investigation cannot be verified, all volumes derived are estimates.
* Area 1 cleanup volumes are only estimated for 2.0 pCi/g because the critical exposure pathway to residents is through animal product consumption.
- Not applicable
bgs Below ground surface
CY Cubic yard
pCi/g Picocurie per gram

Reference:
Intera, Inc. 2013. “2013 Phase II Site Characterization Report Old Church Rock Mine McKinley County, New Mexico.” Draft. September.

APPENDIX A

PHOTOGRAPHIC LOG

APPENDIX A-1: GAMMA-RADIUM CORRELATION PHOTOS

The following photographs were taken during RAES Task Order 0035 in November 2022.



PHOTOGRAPH 1

DATE: 11/19/2022

LOCATION:

OCRM-CORR02

35.61719, -108.563

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR02.



PHOTOGRAPH 2

DATE: 11/19/2022

LOCATION:

OCRM-CORR02

35.61719, -108.563

DESCRIPTION:

HPIC within the centroid of OCRM-CORR02 correlation plot.



PHOTOGRAPH 3

DATE: 11/19/2022

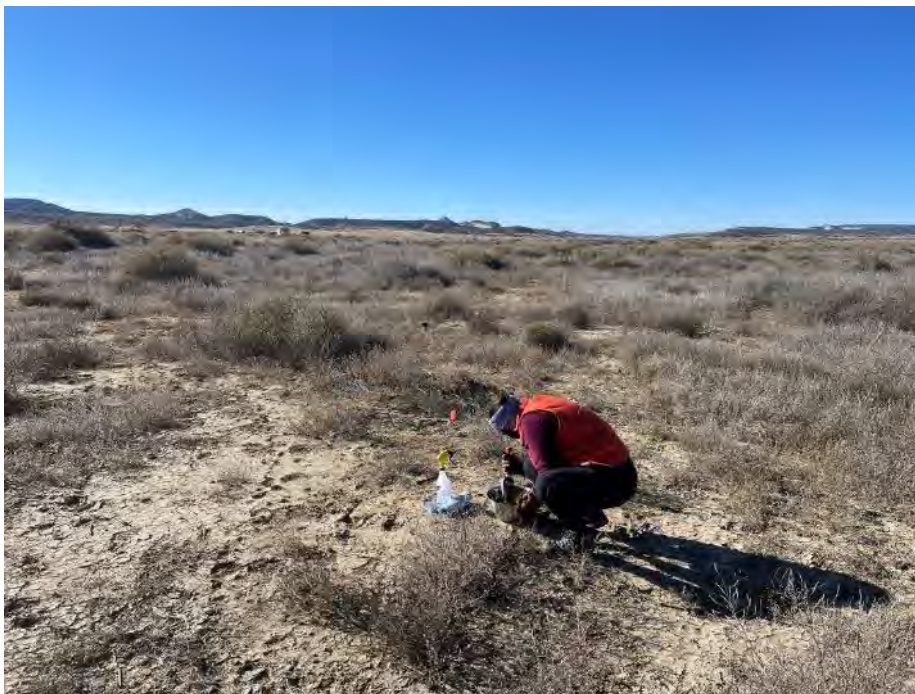
LOCATION:

OCRM-CORR02

35.61719, -108.563

DESCRIPTION:

Composite soil collected from within the OCRM-CORR02 correlation plot.



PHOTOGRAPH 4

DATE: 11/19/2022

LOCATION:

OCRM-CORR01

35.61706, -108.564

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR01.



PHOTOGRAPH 5

DATE: 11/19/2022

LOCATION:

OCRM-CORR01

35.61706, -108.564

DESCRIPTION:

HPIC within the centroid of OCRM-CORR01 correlation plot.



PHOTOGRAPH 6

DATE: 11/19/2022

LOCATION:

OCRM-CORR01

35.61706, -108.564

DESCRIPTION:

Composite soil collected from within the OCRM-CORR01 correlation plot.



PHOTOGRAPH 7

DATE: 11/19/2022

LOCATION:

OCRM-CORR03

35.6166,-108.5625

DESCRIPTION:

HPIC within the centroid of OCRM-CORR03 correlation plot.



PHOTOGRAPH 8

DATE: 11/19/2022

LOCATION:

OCRM-CORR04

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR04.



PHOTOGRAPH 9

DATE: 11/19/2022

LOCATION:
OCRM-CORR04

DESCRIPTION:
HPIC within the centroid of OCRM-CORR04 correlation plot.



PHOTOGRAPH 10

DATE: 11/19/2022

LOCATION:
OCRM-CORR04

DESCRIPTION:
Composite soil collected from within the OCRM-CORR04 correlation plot.



PHOTOGRAPH 11

DATE: 11/19/2022

LOCATION:
OCRM-CORR05

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR05.



PHOTOGRAPH 12

DATE: 11/19/2022

LOCATION:
OCRM-CORR05
35.6202,-108.5564

DESCRIPTION:

HPIC within the centroid of OCRM-CORR05 correlation plot.



PHOTOGRAPH 13

DATE: 11/19/2022

LOCATION:

OCRM-CORR05

35.6202, -108.5564

DESCRIPTION:

Composite soil collected from within the OCRM-CORR05 correlation plot.



PHOTOGRAPH 14

DATE: 11/19/2022

LOCATION:

OCRM-CORR06

35.6212, -108.5556

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR06.



PHOTOGRAPH 15

DATE: 11/19/2022

LOCATION:

OCRM-CORR06

35.6212, -108.5556

DESCRIPTION:

HPIC within the centroid of OCRM-CORR06 correlation plot.



PHOTOGRAPH 16

DATE: 11/19/2022

LOCATION:

OCRM-CORR06

35.6212, -108.5556

DESCRIPTION:

Composite soil collected from within the OCRM-CORR06 correlation plot.



PHOTOGRAPH 17

DATE: 11/19/2022

LOCATION:

OCRM-CORR07

35.6210, -108.5549

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR07.



PHOTOGRAPH 18

DATE: 11/19/2022

LOCATION:

OCRM-CORR07

35.6210, -108.5549

DESCRIPTION:

Composite soil collected from within the OCRM-CORR07 correlation plot.



PHOTOGRAPH 19

DATE: 11/19/2022

LOCATION:

OCRM-CORR08

35.6203, -108.5539

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR08.



PHOTOGRAPH 20

DATE: 11/19/2022

LOCATION:

OCRM-CORR08

35.6203, -108.5539

DESCRIPTION:

Composite soil collected from within the OCRM-CORR08 correlation plot.



PHOTOGRAPH 21

DATE: 11/19/2022

LOCATION:

OCRM-CORR09

35.6215, -108.5546

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR09.



PHOTOGRAPH 22

DATE: 11/19/2022

LOCATION:

OCRM-CORR09

35.6215, -108.5546

DESCRIPTION:

Composite soil collected from within the OCRM-CORR09 correlation plot.



PHOTOGRAPH 23

DATE: 11/19/2022

LOCATION:

OCRM-CORR10

35.62248, -108.5548

DESCRIPTION:

HPIC within the centroid of OCRM-CORR10 correlation plot.



PHOTOGRAPH 24

DATE: 11/19/2022

LOCATION:

OCRM-CORR10

35.62248, -108.5548

DESCRIPTION:

Composite soil collected from within the OCRM-CORR10 correlation plot.



PHOTOGRAPH 25

DATE: 11/19/2022

LOCATION:

OCRM-CORR11

35.6223, -108.5551

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR11.



PHOTOGRAPH 26

DATE: 11/19/2022

LOCATION:

OCRM-CORR11

35.6223, -108.5551

DESCRIPTION:

HPIC within the centroid of OCRM-CORR11 correlation plot.



PHOTOGRAPH 27

DATE: 11/19/2022

LOCATION:

OCRM-CORR11

35.6223, - 108.5551

DESCRIPTION:

Composite soil collected from within the OCRM-CORR11 correlation plot.



PHOTOGRAPH 28

DATE: 11/19/2022

LOCATION:

OCRM-CORR12

35.6240, -108.5528

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR12.



PHOTOGRAPH 29

DATE: 11/19/2022

LOCATION:

OCRM-CORR12

35.6240, -108.5528

DESCRIPTION:

HPIC within the centroid of OCRM-CORR12 correlation plot.



PHOTOGRAPH 30

DATE: 11/19/2022

LOCATION:

OCRM-CORR12

35.6240, -108.5528

DESCRIPTION:

Composite soil collected from within the OCRM-CORR12 correlation plot.



PHOTOGRAPH 31

DATE: 11/19/2022

LOCATION:

OCRM-CORR13

35.6232, -108.5507

DESCRIPTION:

Composite soil collected from within the OCRM-CORR13 correlation plot.



PHOTOGRAPH 32

DATE: 11/19/2022

LOCATION:

OCRM-CORR14

35.6230, -108.5506

DESCRIPTION:

Composite soil collected from within the OCRM-CORR14 correlation plot.



PHOTOGRAPH 33

DATE: 11/19/2022

LOCATION:

OCRM-CORR15

35.6232, -108.5502

DESCRIPTION:

Gamma-radium correlation plot location OCRM-CORR15.



PHOTOGRAPH 34

DATE: 11/19/2022

LOCATION:

OCRM-CORR15

35.6232, -108.5502

DESCRIPTION:

Composite soil collected from within the OCRM-CORR15 correlation plot.

APPENDIX A-2: SURFACE SOIL SAMPLING PHOTOS

The following photographs were taken during RAES Task Order 0035 in November 2022.



PHOTOGRAPH 1

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS01

35.6130, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS01-
111622.



PHOTOGRAPH 2

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS02

35.6130, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS02-
111622.



PHOTOGRAPH 3

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS03

35.6130, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS03-
111622.



PHOTOGRAPH 4

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS04

35.6130, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS04-
111622.



PHOTOGRAPH 5

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS05

35.6130, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS05-
111622.



PHOTOGRAPH 6

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS06

35.6129, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS06-
111622.



PHOTOGRAPH 7

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS07

35.6129, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS07-
111622.



PHOTOGRAPH 8

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS08

35.6129, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS08-
111622.



PHOTOGRAPH 9

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS09

35.6129, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS09-
111622.



PHOTOGRAPH 10

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS10

35.6129, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS10-
111622.



PHOTOGRAPH 11

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS11

35.6128, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS11-
111622.



PHOTOGRAPH 12

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS12

35.6128, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS12-
111622.



PHOTOGRAPH 13

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS13

35.6129, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS13-
111622.



PHOTOGRAPH 14

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS14

35.6128, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS14-
111622.



PHOTOGRAPH 15

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS15

35.6128, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS15-
111622.



PHOTOGRAPH 16

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS16

35.6128, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS16-
111622.



PHOTOGRAPH 17

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS17

35.6128, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS17-
111622.



PHOTOGRAPH 18

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS18

35.6128, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS18-
111622.



PHOTOGRAPH 19

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS19

35.6128, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS19-
111622.



PHOTOGRAPH 20

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS20

35.6128, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS20-
111622.



PHOTOGRAPH 21

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS21

35.6127, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS21-
111622.



PHOTOGRAPH 22

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS22

35.6127, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS22-
111622.



PHOTOGRAPH 23

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS23

35.6127, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS23-
111622.



PHOTOGRAPH 24

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS24

35.6127, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS24-
111622.



PHOTOGRAPH 25

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS25

35.6127, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS25-
111622.



PHOTOGRAPH 26

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS26

35.6126, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS26-
111622.



PHOTOGRAPH 27

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS27

35.6126, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS27-
111622.



PHOTOGRAPH 28

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS28

35.6126, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS28-
111622.



PHOTOGRAPH 29

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS29

35.6126, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS29-
111622.



PHOTOGRAPH 30

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS30

35.6126, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS30-
111622.



PHOTOGRAPH 31

DATE: 11/17/2022

LOCATION:

OCRM-SS02-01

35.6250, -108.5544

DESCRIPTION:

Surface soil sample
OCRM-SS02-01-
111722.



PHOTOGRAPH 32

DATE: 11/17/2022

LOCATION:

OCRM-SS05-01

35.6241, -108.5506

DESCRIPTION:

Surface soil sample
OCRM-SS05-01-
111722.



PHOTOGRAPH 33

DATE: 11/17/2022

LOCATION:

OCRM-SS06-01

35.6241, -108.5510

DESCRIPTION:

Surface soil sample
OCRM-SS06-01-
111722.



PHOTOGRAPH 34

DATE: 11/17/2022

LOCATION:

OCRM-SS07-01

35.6239, -108.5507

DESCRIPTION:

Surface soil sample
OCRM-SS07-01-
111722.



PHOTOGRAPH 35

DATE: 11/17/2022

LOCATION:

OCRM-SS09-01

35.6237, -108.5513

DESCRIPTION:

Surface soil sample
OCRM-SS09-01-
111722.



PHOTOGRAPH 36

DATE: 11/17/2022

LOCATION:

OCRM-SS10-01

35.6235, -108.5529

DESCRIPTION:

Surface soil sample
OCRM-SS10-01-
111722.



PHOTOGRAPH 37

DATE: 11/17/2022

LOCATION:

OCRM-SS11-01

35.6234, -108.5523

DESCRIPTION:

Surface soil sample
OCRM-SS11-01-
111722.



PHOTOGRAPH 38

DATE: 11/17/2022

LOCATION:

OCRM-SS12-01

35.6233, -108.5515

DESCRIPTION:

Surface soil sample
OCRM-SS12-01-
111722.



PHOTOGRAPH 39

DATE: 11/17/2022

LOCATION:

OCRM-SS13-01

35.6232, -108.5526

DESCRIPTION:

Surface soil sample
OCRM-SS13-01-
111722.



PHOTOGRAPH 40

DATE: 11/17/2022

LOCATION:

OCRM-SS16-01

DESCRIPTION:

Surface soil sample
OCRM-SS16-01-
111722.



PHOTOGRAPH 41

DATE: 11/17/2022

LOCATION:

OCRM-SS17-01

35.6231, -108.5534

DESCRIPTION:

Surface soil sample
OCRM-SS17-01-
111722.



PHOTOGRAPH 42

DATE: 11/17/2022

LOCATION:

OCRM-SS18-01

35.6226, -108.5513

DESCRIPTION:

Surface soil sample
OCRM-SS18-01-
111722.



PHOTOGRAPH 43

DATE: 11/16/2022

LOCATION:

OCRM-SS1804-01

35.6221, -108.5551

DESCRIPTION:

Surface soil sample
OCRM-SS1804-01-
111622.



PHOTOGRAPH 44

DATE: 11/17/2022

LOCATION:

OCRM-SS19-01

35.6207, -108.5524

DESCRIPTION:

Surface soil sample
OCRM-SS19-01-
111722.



PHOTOGRAPH 45

DATE: 11/17/2022

LOCATION:

OCRM-SS20-01

35.6225, -108.5524

DESCRIPTION:

Surface soil sample
OCRM-SS20-01-
111722.



PHOTOGRAPH 46

DATE: 11/17/2022

LOCATION:

OCRM-SS21-01

35.6225, -108.5500

DESCRIPTION:

Surface soil sample
OCRM-SS21-01-
111722.



PHOTOGRAPH 47

DATE: 11/15/2022

LOCATION:

OCRM-SS2217-01

35.6210, -108.5557

DESCRIPTION:

Surface soil sample
OCRM-SS2215-01-
111522.



PHOTOGRAPH 48

DATE: 11/16/2022

LOCATION:

OCRM-SS2225-01

35.6211, -108.5548

DESCRIPTION:

Surface soil sample
OCRM-SS2225-01-
111622.



PHOTOGRAPH 49

DATE: 11/17/2022

LOCATION:

OCRM-SS24-01

35.6220, -108.5540

DESCRIPTION:

Surface soil sample
OCRM-SS24-01-
111722.



PHOTOGRAPH 50

DATE: 11/17/2022

LOCATION:

OCRM-SS25-01

35.6220, -108.5519

DESCRIPTION:

Surface soil sample
OCRM-SS25-01-
111722.



PHOTOGRAPH 51

DATE: 11/17/2022

LOCATION:

OCRM-SS26-01

35.6215, -108.5531

DESCRIPTION:

Surface soil sample
OCRM-SS26-01-
111722.



PHOTOGRAPH 52

DATE: 11/15/2022

LOCATION:

OCRM-SS2679-01

35.6199, -108.5558

DESCRIPTION:

Surface soil sample
OCRM-SS2679-01-
111522.



PHOTOGRAPH 53

DATE: 11/17/2022

LOCATION:

OCRM-SS27-01

35.6214, -108.5539

DESCRIPTION:

Surface soil sample
OCRM-SS27-01-
111722.



PHOTOGRAPH 54

DATE: 11/16/2022

LOCATION:

OCRM-SS2738-01

35.6197, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-SS2738-01-
111622.



PHOTOGRAPH 55

DATE: 11/17/2022

LOCATION:

OCRM-SS28-01

35.6206, -108.5525

DESCRIPTION:

Surface soil sample
OCRM-SS28-01-
111722.



PHOTOGRAPH 56

DATE: 11/17/2022

LOCATION:

OCRM-SS29-01

35.6207, -108.5542

DESCRIPTION:

Surface soil sample
OCRM-SS29-01-
111722.



PHOTOGRAPH 57

DATE: 11/16/2022

LOCATION:
OCRM-SS2946A-01

DESCRIPTION:
Surface soil sample
OCRM-SS2946A-
01-111622.



PHOTOGRAPH 58

DATE: 11/16/2022

LOCATION:
OCRM-SS2946B-01

DESCRIPTION:
Surface soil sample
OCRM-SS2946B-01-
111622.



PHOTOGRAPH 59

DATE: 11/17/2022

LOCATION:

OCRM-SS30-01

35.6207, -108.5552

DESCRIPTION:

Surface soil sample
OCRM-SS30-01-
111722.



PHOTOGRAPH 60

DATE: 11/16/2022

LOCATION:

OCRM-SS3006-01

DESCRIPTION:

Surface soil sample
OCRM-SS3006-01-
111622.



PHOTOGRAPH 61

DATE: 11/16/2022

LOCATION:

OCRM-SS3099-01

35.6186, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-SS3099-01-
111622.



PHOTOGRAPH 62

DATE: 11/17/2022

LOCATION:

OCRM-SS31-01

35.6208, -108.5565

DESCRIPTION:

Surface soil sample
OCRM-SS31-01-
111722.



PHOTOGRAPH 63

DATE: 11/17/2022

LOCATION:

OCRM-SS32-01

35.6205, -108.5564

DESCRIPTION:

Surface soil sample
OCRM-SS32-01-
111722.



PHOTOGRAPH 64

DATE: 11/17/2022

LOCATION:

OCRM-SS34-01

35.6200, -108.5546

DESCRIPTION:

Surface soil sample
OCRM-SS34-01-
111722.



PHOTOGRAPH 65

DATE: 11/17/2022

LOCATION:

OCRM-SS35-01

35.6194, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-SS35-01-
111722.



PHOTOGRAPH 66

DATE: 11/17/2022

LOCATION:

OCRM-SS36-01

35.6192, -108.5548

DESCRIPTION:

Surface soil sample
OCRM-SS36-01-
111722.



PHOTOGRAPH 67

DATE: 11/18/2022

LOCATION:

OCRM-RTSW-
XS08-01

35.6163, -108.5620

DESCRIPTION:

Surface soil sample
OCR-RTSW-XS08-
01-111822

APPENDIX A-3: XRF IN SITU PHOTOS

The following photographs were taken during RAES Task Order 0035 in November 2022.



PHOTOGRAPH 1

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-01

35.6128, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-01.



PHOTOGRAPH 2

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-01

35.6130, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-01.



PHOTOGRAPH 3

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-02

35.6130, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-02.



PHOTOGRAPH 4

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-05

35.6130, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-05.



PHOTOGRAPH 5

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-06

35.6129, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-06.



PHOTOGRAPH 6

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-07

35.6129, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-07.



PHOTOGRAPH 7

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-08

35.6129, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-08.



PHOTOGRAPH 8

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-10

35.6129, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-10.



PHOTOGRAPH 9

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-11

35.6129, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-11.



PHOTOGRAPH 10

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-12

35.6129, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-12.



PHOTOGRAPH 11

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-13

35.6129, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-13.



PHOTOGRAPH 12

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-14

35.6129, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-14.



PHOTOGRAPH 13

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-15

35.6129, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-15.



PHOTOGRAPH 14

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-17

35.6128, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-17.



PHOTOGRAPH 15

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-19

35.6128, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-19.



PHOTOGRAPH 16

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-20

35.6128, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-20.



PHOTOGRAPH 17

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-21

35.6127, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-21.



PHOTOGRAPH 18

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-22

35.6127, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-22.



PHOTOGRAPH 19

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-23

35.6127, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-23.



PHOTOGRAPH 20

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-24

35.6127, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-24.



PHOTOGRAPH 21

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-25

35.6127, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-25.



PHOTOGRAPH 22

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-27

35.6126, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-27.



PHOTOGRAPH 23

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-28

35.6126, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-28.



PHOTOGRAPH 24

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-29

35.6126, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-29.



PHOTOGRAPH 25

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-30

35.6126, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-30.



PHOTOGRAPH 26

DATE: 11/16/2022

LOCATION:

OCRM-X1804

35.6221, -108.5551

DESCRIPTION:

XRF measurement at
OCRM-X1804.



PHOTOGRAPH 27

DATE: 11/16/2022

LOCATION:

OCRM-X2217

35.6210, -108.5558

DESCRIPTION:

XRF measurement at
OCRM-X2217.



PHOTOGRAPH 28

DATE: 11/16/2022

LOCATION:

OCRM-X2225

35.6211, -108.5548

DESCRIPTION:

XRF measurement at
OCRM-X2225.



PHOTOGRAPH 30

DATE: 11/16/2022

LOCATION:

OCRM-X2679

35.6199, -108.5558

DESCRIPTION:

XRF measurement at
OCRM-X2679.



PHOTOGRAPH 31

DATE: 11/16/2022

LOCATION:

OCRM-X2738

35.6197, -108.5571

DESCRIPTION:

XRF measurement at
OCRM-X2738.



PHOTOGRAPH 32

DATE: 11/16/2022

LOCATION:

OCRM-X3099

35.6186, -108.5573

DESCRIPTION:

XRF measurement at
OCRM-X3099.



PHOTOGRAPH 33

DATE: 11/19/2022

LOCATION:

OCR-RTE-X02

35.6215, -108.5535

DESCRIPTION:

XRF measurement at
OCR-RTE-X02.



PHOTOGRAPH 34

DATE: 11/19/2022

LOCATION:

OCR-RTE-X03

35.6215, -108.5525

DESCRIPTION:

XRF measurement at
OCR-RTE-X03.



PHOTOGRAPH 35

DATE: 11/19/2022

LOCATION:

OCR-RTE-X04

35.6215, -108.5513

DESCRIPTION:

XRF measurement at
OCR-RTE-X04.



PHOTOGRAPH 36

DATE: 11/19/2022

LOCATION:

OCR-RTE-X05

35.6215, -108.5502

DESCRIPTION:

XRF measurement at
OCR-RTE-X05.



PHOTOGRAPH 37

DATE: 11/19/2022

LOCATION:

OCR-RTE-X06

35.6214, -108.5491

DESCRIPTION:

XRF measurement at
OCR-RTE-X06.



PHOTOGRAPH 38

DATE: 11/19/2022

LOCATION:

OCR-RTE-X07

35.6215, -108.5481

DESCRIPTION:

XRF measurement at
OCR-RTE-X07.



PHOTOGRAPH 39

DATE: 11/19/2022

LOCATION:

OCR-RTE-X08

35.6215, -108.5469

DESCRIPTION:

XRF measurement at
OCR-RTE-X08.



PHOTOGRAPH 40

DATE: 11/19/2022

LOCATION:

OCR-RTE-X09

35.6215, -108.5458

DESCRIPTION:

XRF measurement at
OCR-RTE-X09.



PHOTOGRAPH 41

DATE: 11/19/2022

LOCATION:

OCR-RTE-X10

35.6215, -108.5447

DESCRIPTION:

XRF measurement at
OCR-RTE-X10.



PHOTOGRAPH 42

DATE: 11/19/2022

LOCATION:

OCR-RTE-X11

35.6215, -108.5436

DESCRIPTION:

XRF measurement at
OCR-RTE-X11.



PHOTOGRAPH 43

DATE: 11/19/2022

LOCATION:

OCR-RTE-X12

35.6215, -108.5424

DESCRIPTION:

XRF measurement at
OCR-RTE-X12.



PHOTOGRAPH 44

DATE: 11/19/2022

LOCATION:

OCR-RTNE-X02

35.6227, -108.5542

DESCRIPTION:

XRF measurement at
OCR-RTNE-X02.



PHOTOGRAPH 45

DATE: 11/19/2022

LOCATION:

OCR-RTNE-X05

DESCRIPTION:

XRF measurement at
OCR-RTNE-X05.



PHOTOGRAPH 46

DATE: 11/19/2022

LOCATION:

OCR-RTNE-X06

35.6253, -108.5511

DESCRIPTION:

XRF measurement at
OCR-RTNE-X06.



PHOTOGRAPH 47

DATE: 11/19/2022

LOCATION:

OCR-RTNE-X07

35.6259, -108.5503

DESCRIPTION:

XRF measurement at
OCR-RTNE-X07.



PHOTOGRAPH 48

DATE: 11/18/2022

LOCATION:

OCR-RTNE-X08

35.6265, -108.5496

DESCRIPTION:

XRF measurement at
OCR-RTNE-X08.



PHOTOGRAPH 49

DATE: 11/18/2022

LOCATION:

OCR-RTNE-X09

35.6272, -108.5488

DESCRIPTION:

XRF measurement at
OCR-RTNE-X09.



PHOTOGRAPH 50

DATE: 11/18/2022

LOCATION:

OCR-RTNE-X10

35.6278, -108.5480

DESCRIPTION:

XRF measurement at
OCR-RTNE-X10.



PHOTOGRAPH 51

DATE: 11/19/2022

LOCATION:

OCR-RTNE-X11

35.6285, -108.5472

DESCRIPTION:

XRF measurement at
OCR-RTNE-X11.



PHOTOGRAPH 52

DATE: 11/19/2022

LOCATION:

OCR-RTNE-X12

35.6289, -108.5466

DESCRIPTION:

XRF measurement at
OCR-RTNE-X12.



PHOTOGRAPH 53

DATE: 11/19/2022

LOCATION:

OCR-RTNW-X01

35.6221, -108.5565

DESCRIPTION:

XRF measurement at
OCR-RTNE-X01.



PHOTOGRAPH 54

DATE: 11/19/2022

LOCATION:

OCR-RTNW-X02

35.6227, -108.5573

DESCRIPTION:

XRF measurement at
OCR-RTNW-X02.



PHOTOGRAPH 56

DATE: 11/19/2022

LOCATION:

OCR-RTNW-X03

35.6233, -108.5581

DESCRIPTION:

XRF measurement at
OCR-RTNW-X03.



PHOTOGRAPH 57

DATE: 11/19/2022

LOCATION:

OCR-RTNW-X04

35.6240, -108.5589

DESCRIPTION:

XRF measurement at
OCR-RTNW-X04.



PHOTOGRAPH 58

DATE: 11/19/2022

LOCATION:

OCR-RTNW-X05

35.6246, -108.5597

DESCRIPTION:

XRF measurement at
OCR-RTNW-X05.



PHOTOGRAPH 59

DATE: 11/19/2022

LOCATION:
OCR-RTNW-X07

DESCRIPTION:
XRF measurement at
OCR-RTNW-X07.



PHOTOGRAPH 60

DATE: 11/19/2022

LOCATION:
OCR-RTN-X02
35.6222, -108.5558

DESCRIPTION:
XRF measurement at
OCR-RTN-X02.



PHOTOGRAPH 61

DATE: 11/19/2022

LOCATION:

OCR-RTN-X03

35.6232, -108.5558

DESCRIPTION:

XRF measurement at
OCR-RTN-X03.



PHOTOGRAPH 62

DATE: 11/19/2022

LOCATION:

OCR-RTN-X04

35.6241, -108.5558

DESCRIPTION:

XRF measurement at
OCR-RTN-X04.



PHOTOGRAPH 63

DATE: 11/19/2022

LOCATION:

OCR-RTN-X06

35.6259, -108.5558

DESCRIPTION:

XRF measurement at
OCR-RTN-X06.



PHOTOGRAPH 64

DATE: 11/19/2022

LOCATION:

OCR-RTN-X07

35.6264, -108.5559

DESCRIPTION:

XRF measurement at
OCR-RTN-X07.



PHOTOGRAPH 65

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X02

35.6203, -108.5543

DESCRIPTION:

XRF measurement at
OCR-RTSE-X02.



PHOTOGRAPH 66

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X03

35.6195, -108.5534

DESCRIPTION:

XRF measurement at
OCR-RTSE-X03.



PHOTOGRAPH 67

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X04

35.6189, -108.5526

DESCRIPTION:

XRF measurement at
OCR-RTSE-X04.



PHOTOGRAPH 68

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X05

35.6183, -108.5518

DESCRIPTION:

XRF measurement at
OCR-RTSE-X05.



PHOTOGRAPH 69

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X06

35.6176, -108.5510

DESCRIPTION:

XRF measurement at
OCR-RTSE-X06.



PHOTOGRAPH 70

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X07

35.6170, -108.5503

DESCRIPTION:

XRF measurement at
OCR-RTSE-X07.



PHOTOGRAPH 71

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X08

35.6164, -108.5494

DESCRIPTION:

XRF measurement at
OCR-RTSE-X08.



PHOTOGRAPH 72

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X09

35.6157, -108.5487

DESCRIPTION:

XRF measurement at
OCR-RTSE-X09.



PHOTOGRAPH 73

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X10

35.6151, -108.5479

DESCRIPTION:

XRF measurement at
OCR-RTSE-X10.



PHOTOGRAPH 74

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X11

35.6145, -108.5471

DESCRIPTION:

XRF measurement at
OCR-RTSE-X11.



PHOTOGRAPH 75

DATE: 11/19/2022

LOCATION:

OCR-RTSE-X12

35.6138, -108.5462

DESCRIPTION:

XRF measurement at
OCR-RTSE-X12.



PHOTOGRAPH 76

DATE: 11/19/2022

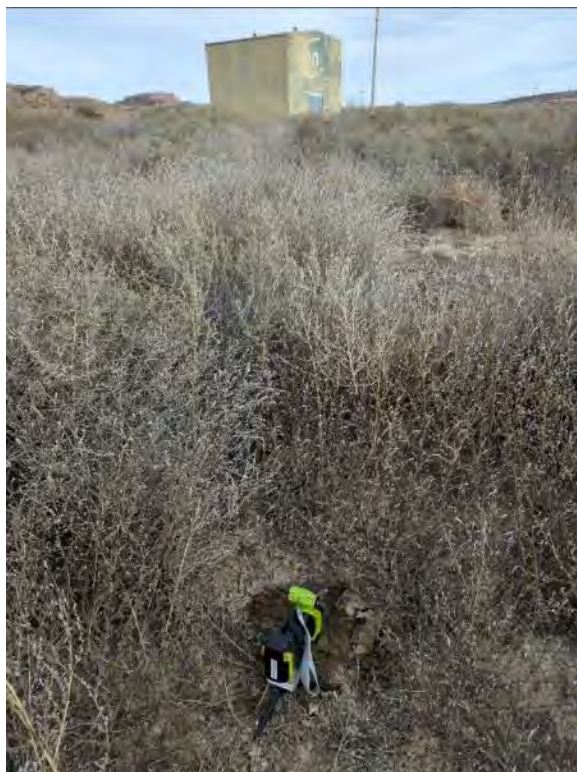
LOCATION:

OCR-RTSW-X01

35.6208, -108.5550

DESCRIPTION:

XRF measurement at
OCR-RTSW-X01.



PHOTOGRAPH 77

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X04

35.6189, -108.5589

DESCRIPTION:

XRF measurement at
OCR-RTSW-X04.



PHOTOGRAPH 78

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X05

35.6182, -108.5597

DESCRIPTION:

XRF measurement at
OCR-RTSW-X05.



PHOTOGRAPH 79

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X06

35.6176, -108.5604

DESCRIPTION:

XRF measurement at
OCR-RTSW-X06.



PHOTOGRAPH 80

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X07

35.6169, -108.5612

DESCRIPTION:

XRF measurement at
OCR-RTSW-X07.



PHOTOGRAPH 81

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X08

35.6163, -108.5620

DESCRIPTION:

XRF measurement at
OCR-RTSW-X08.



PHOTOGRAPH 82

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X09

35.6156, -108.5627

DESCRIPTION:

XRF measurement at
OCR-RTSW-X09.



PHOTOGRAPH 83

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X10

35.6150, -108.5635

DESCRIPTION:

XRF measurement at
OCR-RTSW-X10.



PHOTOGRAPH 84

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X11

35.6144, -108.5642

DESCRIPTION:

XRF measurement at
OCR-RTSW-X11.



PHOTOGRAPH 85

DATE: 11/18/2022

LOCATION:

OCR-RTSW-X12

35.6137, -108.5651

DESCRIPTION:

XRF measurement at
OCR-RTSW-X12.



PHOTOGRAPH 86

DATE: 11/19/2022

LOCATION:

OCR-RTS-X01

35.6205, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X01.



PHOTOGRAPH 87

DATE: 11/19/2022

LOCATION:

OCR-RTS-X02

35.6196, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X02.



PHOTOGRAPH 88

DATE: 11/19/2022

LOCATION:

OCR-RTS-X03

35.6187, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X03.



PHOTOGRAPH 88

DATE: 11/19/2022

LOCATION:

OCR-RTS-X04

35.6178, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X04.



PHOTOGRAPH 89

DATE: 11/19/2022

LOCATION:

OCR-RTS-X05

35.6169, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X05.



PHOTOGRAPH 90

DATE: 11/19/2022

LOCATION:

OCR-RTS-X06

35.6160, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X06.



PHOTOGRAPH 91

DATE: 11/19/2022

LOCATION:

OCR-RTS-X07

35.6151, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X07.



PHOTOGRAPH 92

DATE: 11/19/2022

LOCATION:

OCR-RTS-X08

35.6142, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X08.



PHOTOGRAPH 93

DATE: 11/19/2022

LOCATION:

OCR-RTS-X09

35.6133, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X09.



PHOTOGRAPH 94

DATE: 11/19/2022

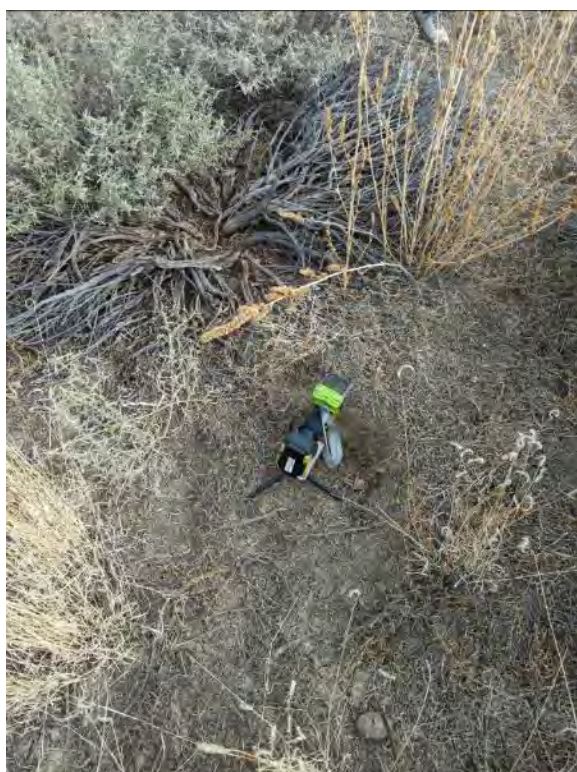
LOCATION:

OCR-RTS-X10

35.6124, -108.5557

DESCRIPTION:

XRF measurement at
OCR-RTS-X10.



PHOTOGRAPH 95

DATE: 11/18/2022

LOCATION:

OCR-RTW-X01

35.6214, -108.5569

DESCRIPTION:

XRF measurement at
OCR-RTW-X01.



PHOTOGRAPH 96

DATE: 11/18/2022

LOCATION:

OCR-RTW-X02

35.6214, -108.5580

DESCRIPTION:

XRF measurement at
OCR-RTW-X02.



PHOTOGRAPH 97

DATE: 11/18/2022

LOCATION:

OCR-RTW-X03

35.6214, -108.5591

DESCRIPTION:

XRF measurement at
OCR-RTW-X03.



PHOTOGRAPH 98

DATE: 11/18/2022

LOCATION:

OCR-RTW-X04

35.6214, -108.5602

DESCRIPTION:

XRF measurement at
OCR-RTW-X04.



PHOTOGRAPH 99

DATE: 11/18/2022

LOCATION:

OCR-RTW-X05

35.6214, -108.5613

DESCRIPTION:

XRF measurement at
OCR-RTW-X05.



PHOTOGRAPH 100

DATE: 11/18/2022

LOCATION:

OCR-RTW-X06
35.6214, -108.5624

DESCRIPTION:

XRF measurement at
OCR-RTW-X06.



PHOTOGRAPH 101

DATE: 11/18/2022

LOCATION:

OCR-RTW-X07
35.6214, -108.5635

DESCRIPTION:

XRF measurement at
OCR-RTW-X07.



PHOTOGRAPH 102

DATE: 11/18/2022

LOCATION:

OCR-RTW-X08

35.6214, -108.5645

DESCRIPTION:

XRF measurement at
OCR-RTW-X08.



PHOTOGRAPH 103

DATE: 11/18/2022

LOCATION:

OCR-RTW-X09

35.6214, -108.5657

DESCRIPTION:

XRF measurement at
OCR-RTW-X09.

APPENDIX A-4: OTHER PHOTOS

The following photographs were taken during RAES Task Order 0035 in November 2022.



PHOTOGRAPH 1

DATE: 11/15/2022

LOCATION:

35.6258, -108.5494

DESCRIPTION:

Old, abandoned cars and other debris in arroyo.



PHOTOGRAPH 2

DATE: 11/17/2022

LOCATION:

35.6205, -108.5525

DESCRIPTION:

Ore rock identified on berm.



PHOTOGRAPH 3

DATE: 11/14/2022

LOCATION:

35.6245, -108.5505

DESCRIPTION:

Underground access.



PHOTOGRAPH 4

DATE: 11/17/2022

LOCATION:

35.62062, -108.5570

DESCRIPTION:

Berm with elevated
gamma readings,
>75,000 cpm.



PHOTOGRAPH 5

DATE: 11/17/2022

LOCATION:
35.62062, -108.5570

DESCRIPTION:
Berm with elevated
gamma readings,
>75,000 cpm

APPENDIX B

GAMMA VERIFICATION AND VALIDATION REPORT

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**OCRM Removal Assessment
Appendix B
Gamma Verification and Validation Report**

**Response, Assessment, and Evaluation Services
Contract No. EP-S9-17-03
Task Order 0035**

August 25, 2023

**Submitted to
U.S. Environmental Protection Agency**

**Submitted by
Tetra Tech, Inc.
1999 Harrison Street, Suite 500
Oakland, CA 94612**



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ATTACHMENTS

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Attachment B-2: Detector and Meter Serial Numbers and Dates of Use

Attachment B-3: Raw Gamma Measurement Files (Electronic)

Attachment B-4: Gamma QA/QC Procedures

Attachment B-5: Calibration Certificates

Attachment B-6: Daily Function Check Forms

Attachment B-7: Excluded Gamma Data (Electronic)

Attachment B-8: Final Gamma Dataset (Electronic)

ACRONYMS AND ABBREVIATIONS

μCi	Microcurie
ags	Above ground surface
ANSI	American National Standards Institute
BSA	Background study area
cpm	Counts per minute
Cs-137	Cesium-137
Detectors	Gamma Radiation Detection Instrumentation
GIS	Geographic Information System
GPS	Global Positioning System
HDOP	Horizontal dilution of position
HPIC	High-pressure ionization chamber
IL	Investigation level
MARLAP	<i>Multi-Agency Radiological Laboratory Analytical Protocols Manual</i>
MARSSIM	<i>Multi-Agency Radiation Survey and Site Investigation Manual</i>
NaI	Sodium iodide
OCRM	Old Church Rock Mine
QA	Quality assurance
QC	Quality control
Ra-226	Radium-226
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and Analysis Plan
SOP	Standard operating procedure
Tetra Tech	Tetra Tech, Inc.
USEPA	U.S. Environmental Protection Agency
VDOP	Vertical dilution of position



1.0 INTRODUCTION

Appendix B to the Old Church Rock Mine (OCRM) Removal Assessment Report (hereafter referred to as the main report) presents the data validation and verification methods and results of the 2022 field investigation in-field gamma radiation surveys at OCRM in New Mexico. Tetra Tech Inc. (Tetra Tech) adhered to quality assurance (QA) and quality control (QC) procedures regarding in-field gamma measurements in accordance with the U.S. Environmental Protection Agency (USEPA) approved Removal Assessment Sampling and Analysis Plan (SAP) (Tetra Tech 2022). QA includes qualitative factors that provide confidence in results, while QC involves quantitative field evidence that supports validity of results. Tetra Tech uses data quality indicators as recommended in the *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARSSIM) (USEPA 2000) and the *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP) (USEPA 2004) to ensure acquisition of data by use of reliable gamma radiation detection instrumentation (detectors), and that those data meet quality requirements for their intended end use.

2.0 OVERVIEW OF IN FIELD GAMMA RADIATION SURVEYS

This section provides overviews data quality needs that detectors must satisfy.

2.1 GAMMA RADIATION DETECTION INSTRUMENTATION

Gamma radiation surveys proceeded by use of Ludlum Model 44-10 2- by 2-inch sodium iodide (NaI) detectors, each coupled to either a Ludlum Model 3000 or Ludlum Model 2221r ratemeter/scaler set in ratemeter mode. The ratemeter/scalers were coupled with a Juniper Mesa 2 field computer and the sub-meter accurate Geode GNS2 Global Positioning System (GPS) receiver. The NaI detector was positioned 1 meter above ground surface (ags). Gamma radiation surveys occurred at a rate of approximately 1 meter per second. Gamma count rate measurements and associated geospatial coordinates were recorded every second.

High-pressure ionization chamber (HPIC) surveys were performed by use of a Reuter-Stokes RS-S131-200-ER000 HPIC. Data collected by the HPIC are stored internally where the data can be transferred to a computer for viewing. HPIC surveys were conducted at static locations at a height of 1 meter ags for a duration of 10 minutes.

Table B-1 lists NaI detector and datalogger types for each detector setup during field work, and the corresponding serial number for each.

Table B-1. Gamma Radiation Detection Instrumentation Used during Field Investigation

Instrument Name	Description	System ID	NaI Detector		Datalogger	
			Model	Serial Number	Model	Serial Number
Orange Detector	Juniper Geode/Mesa 2	44	Ludlum 44-10	PR355810	Ludlum 3000	25018543
Red Detector	Juniper Geode/Mesa 2	33	Ludlum 44-10	PR406319	Ludlum 3000	25020102
Blue Detector	Juniper Geode/Mesa 2	26	Ludlum 44-10	PR150857	Ludlum 3000	25016973
Green Detector	Juniper Geode/Mesa 2	38	Ludlum 44-10	PR295014	Ludlum 3000	25017006
Yellow Detector	Juniper Geode/Mesa 2	5	Ludlum 44-10	PR355771	Ludlum 3000	25018610
Black Detector	Juniper Geode/Mesa 2	1	Ludlum 44-10	PR399729	Ludlum 2221	254783
White Detector	Juniper Geode/Mesa 2	14	Ludlum 44-10	PR375296	Ludlum 2221	117357
Instrument Name	Description	System ID	Model		Serial Number	
-	HPIC	-	Reuter-Stokes RS-S131-200-ER000		1001321	

Notes:

HPIC High-pressure ionization chamber

NaI Sodium iodide

2.2 SURVEYS PERFORMED

The OCRM 2022 field investigation was designed to acquire scoping level data in conformance to Standard Operating Procedure (SOP) No. 002, “Performing a GPS-Based Gamma Radiation Survey” included as [Attachment B-1](#). Scoping level data aided development of assumptions pertaining to design of an upcoming characterization level data investigation. QA/QC requirements are more stringent for characterization level data; however, detectors were assessed according to both characterization level and scoping level QC Criteria as discussed in [Section 4.0](#). Areas investigated during gamma radiation survey activities were as follows:

- The fenced area
- The area adjacent to and northeast of the site
- The area adjacent to and east and southeast of the site across State Route 566
- The unnamed arroyo adjacent to the site
- Haul roads including State Route 566 and Blackrock Road
- Residential yards near the site.

Presence of windblown contamination from waste piles on the site is also possible, and therefore radial surveys originating from the center of the site were conducted in eight Cardinal directions. In areas adjacent to the fenced portion of the site where stepout investigations were necessary, gamma radiation survey investigation levels (IL) determined from the background study areas (BSA) per Section 4.1 of the main report were referenced to determine when surface contamination had been laterally delineated. [Table B-2](#) lists gamma scan surveys conducted and instrumentation used.

Table B-2. Gamma Scan Surveys Performed and Instrumentation Used

Gamma Survey	Orange Detector	Red Detector	Blue Detector	Green Detector	Yellow Detector	Black Detector	White Detector
Lateral Delineation (Includes main site, homesite, drainage, and road surveys)	X	X	X	X	X	X	
Radial Scans	X		X	X			
Background Study Areas (BSAs)		X		X			
Gamma-Radium and Exposure Rate Correlation Plots ²		X					
Static Soil Sampling							X
Static BSA Soils							X

[Attachment B-2](#) provides the detector and meter serial numbers and dates of use at the site. Also included within [Attachment B-2](#) are the file names created for each gamma scan as well as the users who performed the gamma scans. [Attachment B-3](#) includes the raw gamma survey data outputs from each device for all useable gamma survey data.

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

This radiological survey project incorporated data QA/QC protocols developed to achieve guidelines established by MARSSIM (USEPA 2000). In general, QA includes qualitative factors that provide confidence in results, while QC involves quantitative field evidence that supports validity of results. Data quality indicators as recommended in MARSSIM (USEPA 2000) and MARLAP (USEPA 2004) were used to ensure reliability and sufficient quality of acquired data. [Attachment B-4](#) presents the QA/QC procedures for gamma radiation surveys. This section discusses QA/QC methods and results.

3.1 DETECTOR CALIBRATION

An important QA protocol for in-field gamma radiation surveys is detector calibration. All detectors used in the gamma radiation surveys had been calibrated in accordance with the *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* (American National Standards Institute [ANSI] 1997). Calibration of a detector is required (1) prior to initial use, (2) at least annually, and (3) after any scheduled or unscheduled maintenance or repair that may affect its operation. Recalibration is not necessary after general maintenance of detectors, such as cleaning, painting, and changing of buttons.

All detectors utilized during field work had been factory-calibrated within the previous 12 months and no detector underwent maintenance between the time of calibration and time of use. Copies of factory calibration documentation for all detectors used during the survey are in [Attachment B-5](#).

3.2 PRE- AND POST-SURVEY QUALITY CONTROL AND RESULTS

This subsection summarizes methods and results of QC analyses of detectors used during the gamma radiation survey. The QC protocol involved pre-survey and post-survey QC checks, and daily function QC checks. The purpose of these QC analyses is to show the comparability of the detectors and that the functionality of the instruments did not change over the course of the fieldwork. QC data measurements were recorded from all detectors used during the survey. See [Section 4.2.1](#) for a discussion of data validation.

3.2.1 Pre-Survey and Post-Survey Quality Control Methodology and Quality Control Criteria

Each detector anticipated for use during the gamma radiation survey underwent pre-survey and post-survey QC checks at an indoor location. The purpose of these measurements was to quantify consistency of readings among detectors under controlled conditions with consistent geometry and location before (pre-survey) and after (post-survey) removal assessment field activities. For both the pre-survey and post-survey, 1,000 background counts (no source) and 1,000 Cesium-137 (Cs-137) counts were collected with each detector. The exception to this was the white detector which collected 951 pre-survey background counts. Pre-survey QC checks of all seven detectors occurred during November 10 and 11, 2022. Post-survey QC checks of all seven detectors occurred on November 28, 2022. All QC checks took place in the Tetra Tech Fort Collins, Colorado office, with a setup similar to that shown on [Figure B-1](#).

The following four steps were necessary for the pre-survey QC checks, and the four associated QC Criteria must have been met to allow use of a detector for gamma surveys:

- **QC Criterion 1:** The mean of all background measurements and all Cs-137 source measurements is calculated. Then the mean of all detector-specific background measurements and Cs-137 measurements is calculated. The relative percent difference (RPD) between mean detector-specific measurements and the mean measurements from all detectors is then calculated. For each detector, this RPD must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow its use in scoping level gamma surveys.
- **QC Criterion 2:** For each detector, the RPD is calculated between the mean background and the mean background of the detector that deviates the most from the detector being tested. The RPD is calculated again between the mean Cs-137 measurement. The RPD must be less than 10 percent for use of a detector for characterization level and scoping level gamma surveys.
- **QC Criteria 3:** The Relative Standard Deviation (RSD) is calculated for the mean background and Cs-137 source measurements for each detector. The RSD must be less than 5 percent for use of a detector in characterization level gamma surveys, or 10 percent for use of a detector in scoping level gamma surveys. RSD is also known as the coefficient of variation, but herein exclusively will be referred to as RSD.
- **QC Criterion 4:** Pre-survey measurements are plotted on a histogram and inspected to ensure they follow a normal distribution curve. First the normal Q-Q probability of the pre-survey and post-survey background and Cs-137 source measurements is plotted. Normal-fitted frequency histograms of the pre-survey and post-survey background and Cs-137 source measurements then are plotted. A side-by-side analysis of pre-survey and post-survey measurements on a histogram allows an inspection of the normality of the distribution. Following are the qualitative characteristics evaluated for whether a detector's measurements are normal:
 - a. Middle/highest point on histogram is the only identifiable peak.
 - b. Peak of the normal curve aligns with the peak point of the histogram.
 - c. Slopes of normal probability plots look approximately equal.

If any detectors deviate from these QC criteria, they will be re-evaluated by repetition of the 1,000 background and Cs-137 source measurements. If the deviations from QC criteria are repeatable, the detector will be sent back to the vendor for replacement. Detectors that meet the QC criteria can be used for either characterization level or scoping level gamma surveys, based upon the specific QC criteria they meet.

Upon successful completion of planned gamma surveys, a set of identical measurements in the same laboratory setting, hereafter referred to as post-survey measurements, will occur. Post-survey measurements will be completed by application of the same procedures as for the pre-survey measurements, including uses of the same location, Cs-137 (or equivalent source), and geometry. Following completion of the post-survey measurements, QC criteria 1 through 4 will

again be evaluated. In addition to the four pre-survey criteria, the following two criteria will be evaluated during post-survey QC checks:

- **QC Criterion 5:** The RPD between the mean pre-survey background gamma count rate and the mean post-survey background gamma count rate measurement should not exceed 5 percent for characterization data and 10 percent for scoping data.
- **QC Criterion 6:** The RPD between the mean pre-survey Cs-137 source gamma count rate and the mean post-survey Cs-137 source gamma count rate measurement should not exceed 5 percent for characterization data and 10 percent for scoping data.

Any detector deviating from these post-survey QC criteria will be re-evaluated by repetition of the 1,000 background and Cs-137 source measurements. If deviations from the QC criteria are repeatable, the gamma survey data collected from the detector(s) deviating from the QC criteria will be compared to data from other detectors and possibly removed from the final dataset.

Figure B-1 shows the setup for a pre-survey QC background check.

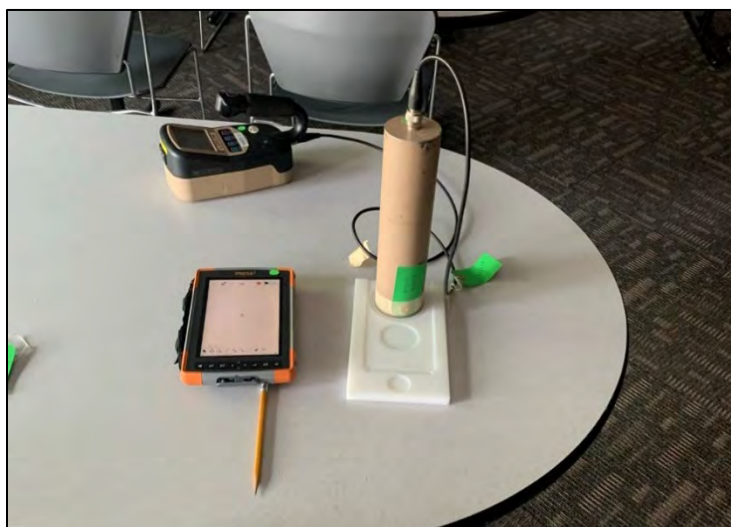


Figure B-1. Photograph of Pre-Survey QC Background Check

3.2.2 Pre-Survey Comparability Results

Table B-3 summarizes statistics of pre-survey QC measurements by each detector. The RPD between the mean of all detectors addresses QC Criterion 1, the RPD between the mean of individual detectors addresses QC Criterion 2, and the RSD addresses QC Criterion 3. All detectors passed QC Criteria 1 through 3 for scoping level data. QC Criterion 4 is addressed in Section 4.2.1.

Figure B-2 and Figure B-3 show interval plots of the mean of pre-survey background measurements and Cs-137 source measurements, respectively, for each detector. The mean of each detector is plotted as a point within plotted lines representing the mean of all detectors' measurements, a difference from the mean of 5 percent, and a difference from the mean of 10 percent.



Table B-3. Summary Statistics of Pre-Survey QC Background and Cs-137 Source Calculations

Pre-Survey Background Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	RPD Between Mean of All Instruments
Orange Detector	1,000	15,125	15,100	590	3.9%	9.0%	3.5%
Red Detector	1,000	15,163	15,200	581	3.8%	8.8%	3.3%
Blue Detector	1,000	16,226	16,200	589	3.6%	7.0%	3.5%
Green Detector	1,000	15,702	15,700	989	6.3%	5.3%	0.2%
Yellow Detector	1,000	15,600	15,600	581	3.7%	5.9%	0.5%
Black Detector	1,000	16,555	16,399	830	5.0%	9.0%	5.6%
White Detector	951	15,339	15,316	648	4.2%	7.6%	2.1%
Pre-Survey Cs-137 Source Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	Instrument RPD From Mean of All Instruments
Orange Detector	1,000	28,764	28,800	817	2.8%	3.8%	1.4%
Red Detector	1,000	29,215	29,200	774	2.6%	2.2%	0.1%
Blue Detector	1,000	29,265	29,300	742	2.5%	2.1%	0.3%
Green Detector	1,000	28,646	28,600	1,306	4.6%	4.2%	1.8%
Yellow Detector	1,000	29,091	29,100	768	2.6%	2.6%	0.3%
Black Detector	1,000	29,406	29,447	1,173	4.0%	2.6%	0.8%
White Detector	1,000	29,870	29,874	789	2.6%	4.2%	2.4%

Notes:

¹ RPD was calculated between the two instruments with the greatest difference in average cpm.

cpm Counts per minute

Cs-137 Cesium-137

QC Quality control

RPD Relative percentage deviation

RSD Relative standard deviation

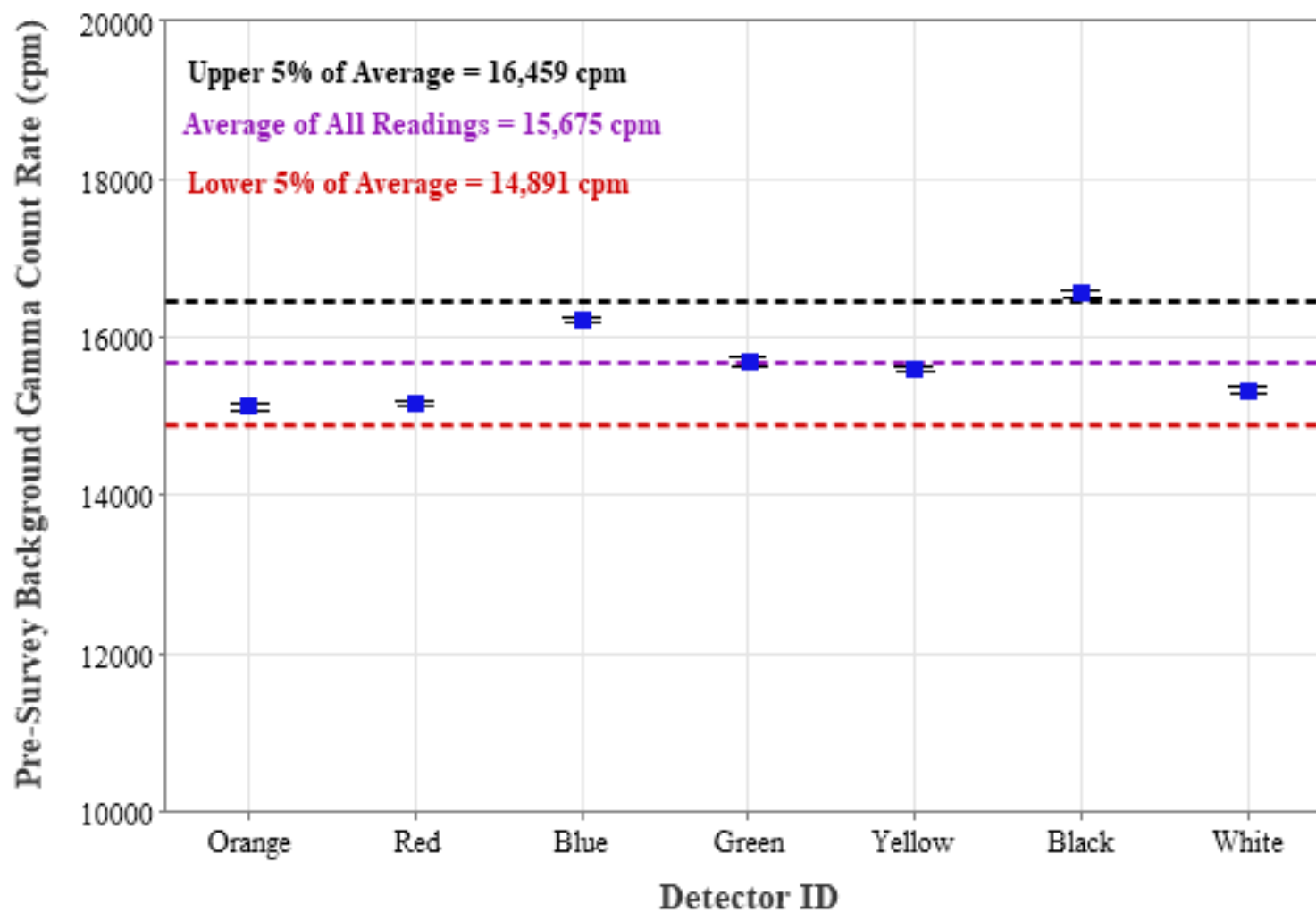


Figure B-2. Interval Plot of Pre-Survey Background Measurements by Detector

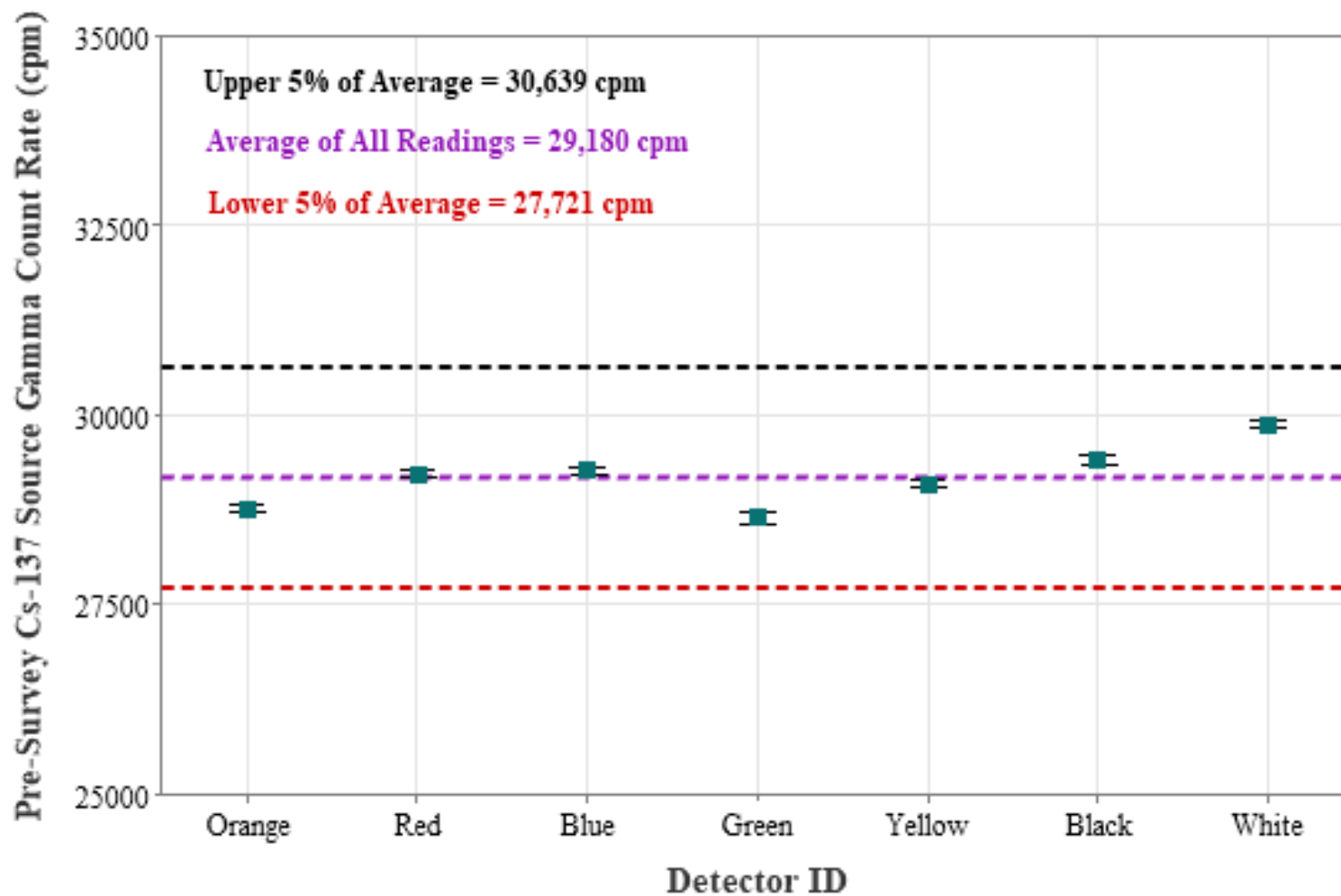


Figure B-3. Interval Plot of Pre-Survey Cs-137 Source Measurements by Detector

3.2.3 Post-Survey Comparability Results

Table B-4 summarizes statistics of post-survey QC measurements for each detector. The RPD between the mean of all detectors addresses QC Criterion 1, the RPD between the mean of individual detectors addresses QC Criterion 2, and the RSD addresses QC Criterion 3. All detectors passed QC Criteria 1 through 3 for scoping level data. QC Criterion 4 is addressed in Section 4.2.1.

Figure B-4 and Figure B-5 show interval plots of the mean of post-survey background measurements and Cs-137 source measurements, respectively, for each detector. The mean of measurements for each detector is plotted as a point within plotted lines representing the mean of all detectors measurements, a difference from the mean of 5 percent, and a difference from the mean of 10 percent.

Table B-4. Summary Statistics of Post-Survey QC Background and Cs-137 Source Calculations

Post-Survey Background Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	RPD Between Mean of All Instruments
Orange Detector	1,000	15,502	15,500	589	3.8%	5.3%	0.9%
Red Detector	1,000	15,797	15,800	554	3.5%	7.1%	1.0%
Blue Detector	1,000	16,219	16,200	590	3.6%	9.8%	3.7%
Green Detector	1,000	14,709	14,700	942	6.4%	9.8%	6.0%
Yellow Detector	1,000	15,659	15,700	562	3.6%	6.3%	0.1%
Black Detector	1,000	16,207	16,177	665	4.1%	9.7%	3.6%
White Detector	1,000	15,424	15,373	686	4.4%	5.0%	1.4%
Post-Survey Cs-137 Source Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	RPD Between Mean of All Instruments
Orange Detector	1,000	28,853	28,900	830	2.9%	5.2%	1.6%
Red Detector	1,000	28,823	28,800	755	2.6%	5.3%	1.7%
Blue Detector	1,000	29,976	29,900	776	2.6%	4.8%	2.2%
Green Detector	1,000	28,573	28,500	782	2.7%	6.1%	2.5%
Yellow Detector	1,000	29,324	29,400	1,346	4.6%	3.6%	0.0%
Black Detector	1,000	30,386	30,386	841	2.8%	6.1%	3.6%
White Detector	1,000	29,279	29,272	815	2.8%	3.7%	0.1%

Notes:

¹ RPD was calculated between the two instruments with the greatest difference in average cpm.

cpm Counts per minute

Cs-137 Cesium-137

QC Quality control

RPD Relative percentage deviation

RSD Relative standard deviation

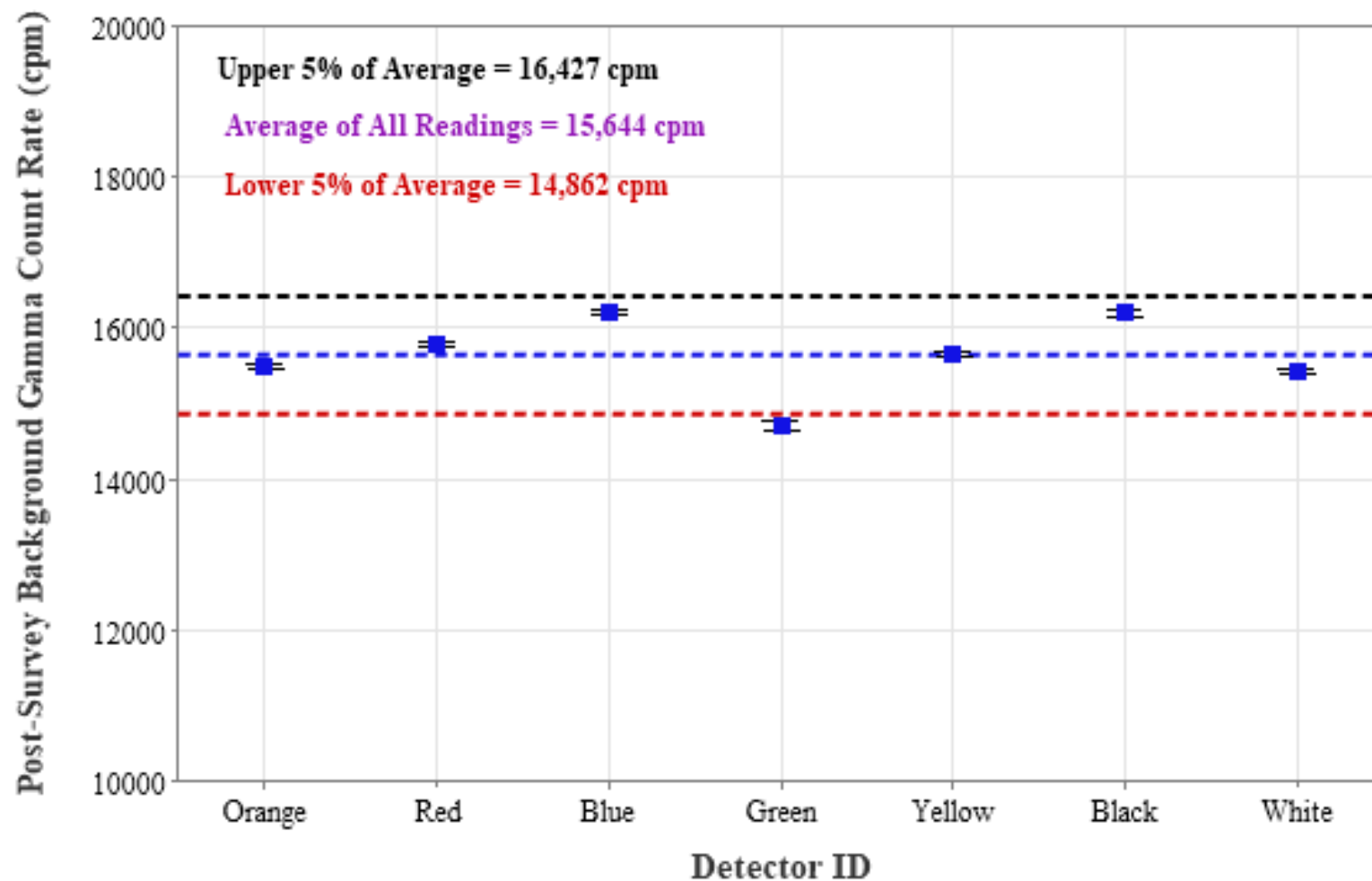


Figure B-4. Interval Plot of Post-Survey Background Measurements by Detector

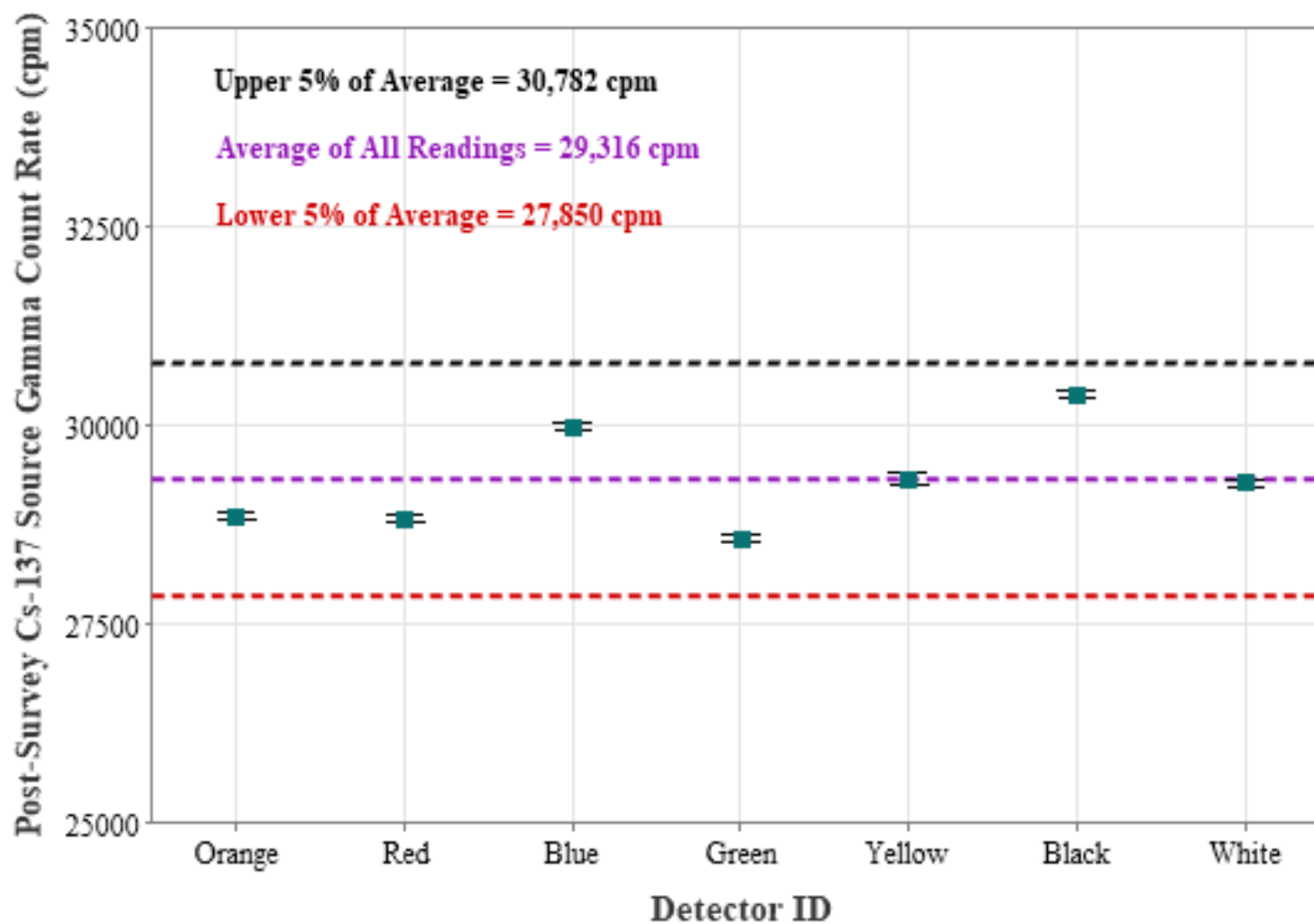


Figure B-5. Interval Plot of Post-Survey Cs-137 Source Measurements by Detector

3.2.4 Pre-Survey and Post-Survey Comparison and Distribution Analysis

Table B-5 summarizes statistics comparing pre-survey and post-survey QC measurements for each detector. The RPD of means for the background mean comparison addresses QC Criterion 5, and the RPD of means for the Cs-137 source mean comparison addresses QC Criterion 6. All detectors passed QC Criteria 5 and 6 for scoping level data.

Figure B-6 through Figure B-33 show normal probability plots, and normal-fitted frequency histograms with a normal distribution fitted curve showing pre-survey and post-survey QC measurements for each of the seven detectors. A qualitative analysis of each normal probability plot and histogram was completed.

Normal probability plots were developed displaying pre-survey and post-survey background QC measurements, and pre-survey and post-survey Cs-137 QC measurements side by side. The normal probability plots were found to contain the majority of data within the three normality prediction curves, thus demonstrating normality. Most data falling outside of the normality prediction curves can be attributed to bin sizes of the histograms. This is well within expected measurement deviation from normality for detectors, and acceptable for the use of all detectors except for the white detector. Analysis of the white detector and black detector pre-survey background measurements found that both detectors tend in frequency toward measurements below the mean; however, it was decided that each detector is acceptable for scoping level data acquisition.

Histograms were developed displaying pre-survey and post-survey background QC measurements, and pre-survey and post-survey Cs-137 QC measurements side by side. A normal distribution fitted curve was transposed over the plotted QC measurements allowing comparison of QC measurements with a normal distribution. It was found that QC measurements were substantially contained within the normal distribution fitted curve, and typically fell outside of the curve only when displays showed an exaggerated number of readings because of the size of bins used. This is well within expected measurement deviation from normality for detectors, and acceptable for use of detectors.



Table B-5. Intra-Detector Comparison of Pre-Survey and Post-Survey QC Background and Cs-137 Source Statistics

Background Mean Comparison			
Instrument Name	Pre-Survey Mean (cpm)	Post-Survey Mean (cpm)	RPD of Means (%)
Orange System	15,125	15,502	2.5%
Red System	15,163	15,797	4.1%
Blue System	16,226	16,219	0.0%
Green System	15,702	14,709	6.5%
Yellow System	15,600	15,659	0.4%
Black System	16,555	16,207	2.1%
White System	15,339	15,424	0.5%
Cs-137 Source Mean Comparison			
Instrument Name	Pre-Survey Mean (cpm)	Post-Survey Mean (cpm)	RPD of Means (%)
Orange System	28,764	28,853	0.3%
Red System	29,215	28,823	1.4%
Blue System	29,265	29,976	2.4%
Green System	28,646	28,573	0.3%
Yellow System	29,091	29,324	0.8%
Black System	29,406	30,386	3.3%
White System	29,870	29,279	2.0%

Notes:

cpm Counts per minute

RPD Relative percent difference

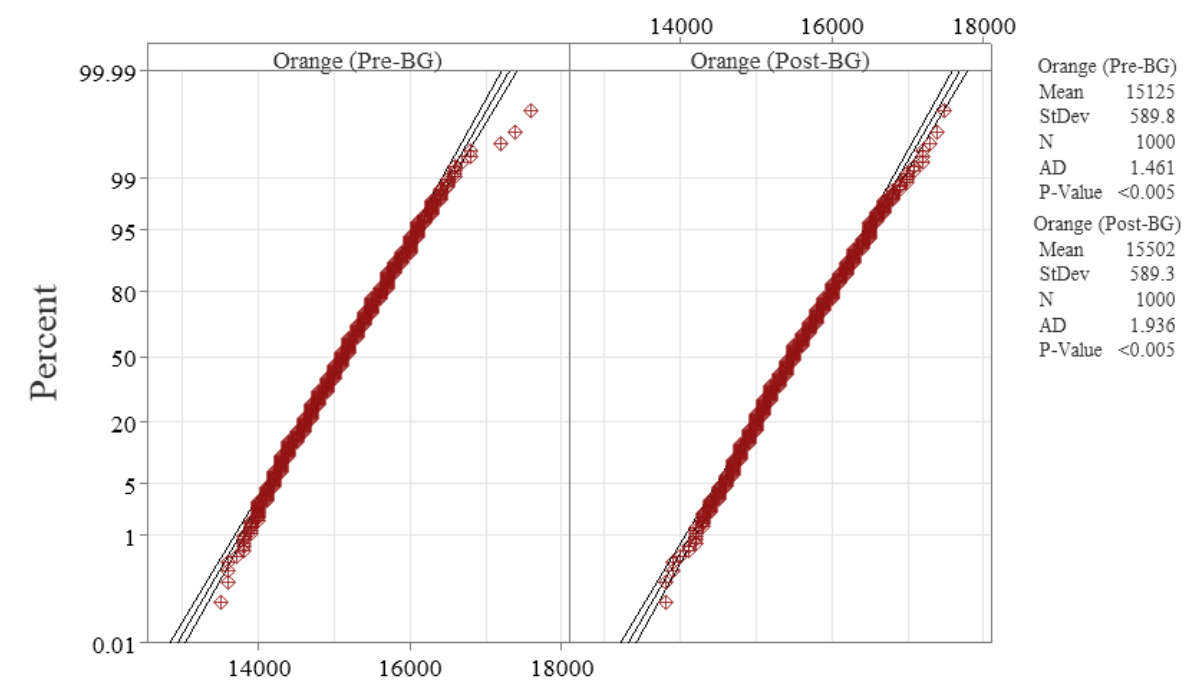


Figure B-6. Normal Probability Plot of Orange Detector Pre- and Post-Survey Background Measurements

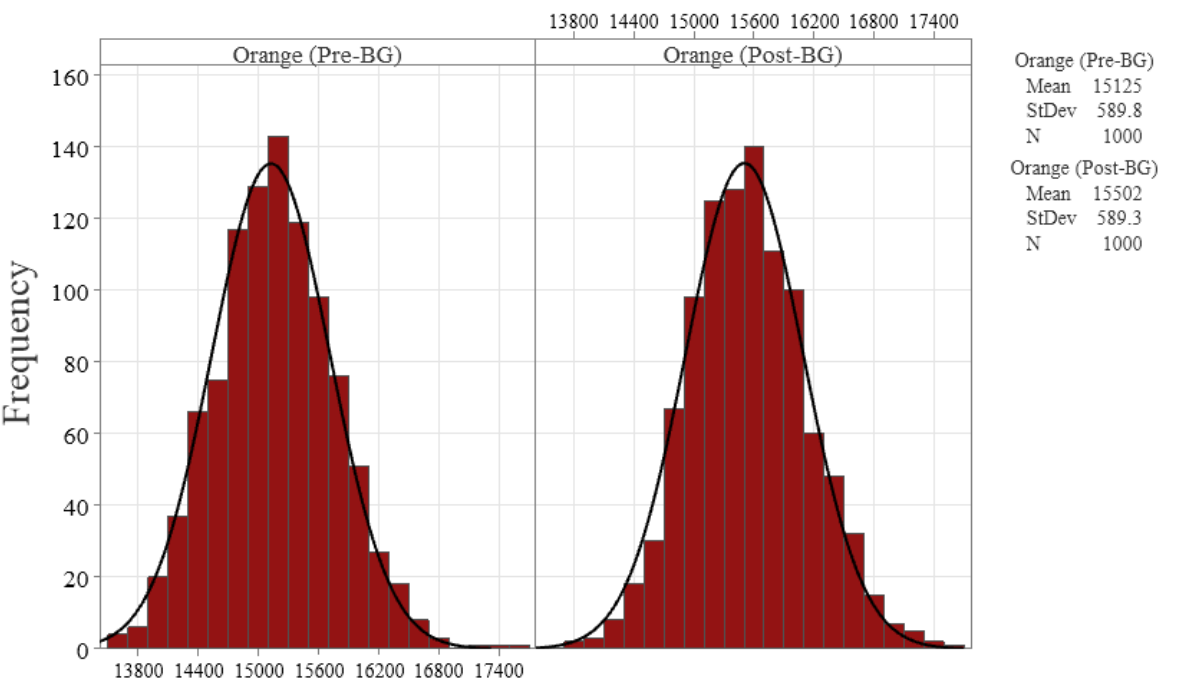


Figure B-7. Normal-Fitted Frequency Histogram of the Orange Detector Pre- and Post-Survey Background Measurements

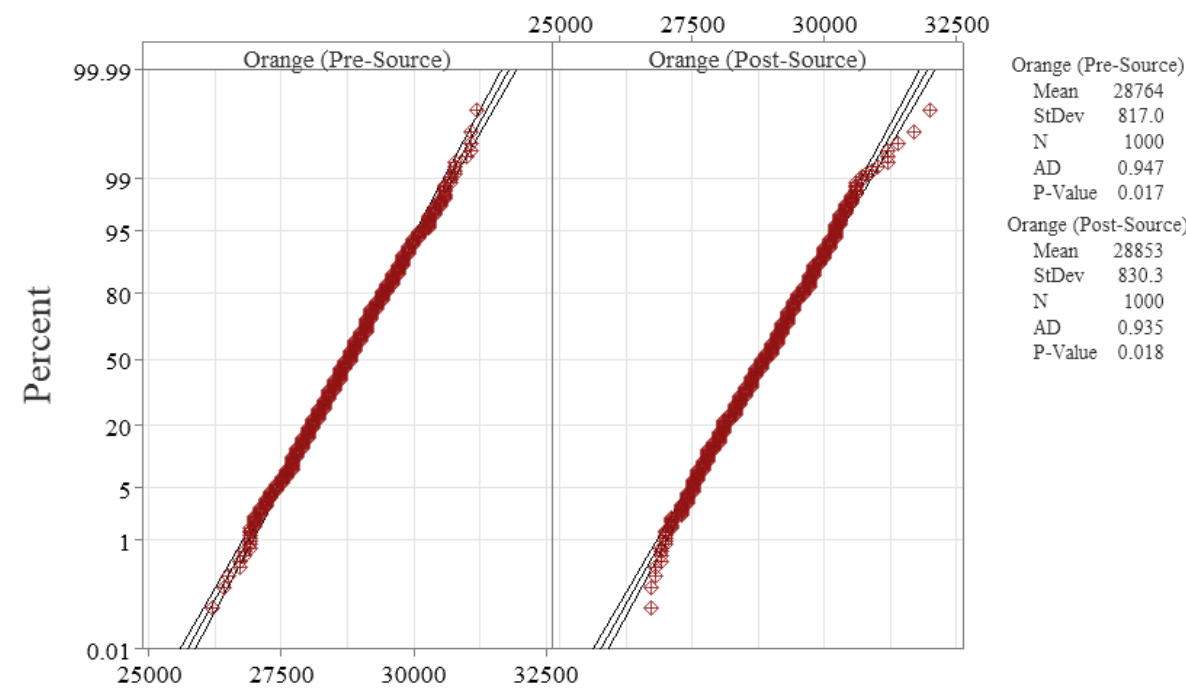


Figure B-8. Normal Probability Plot of Orange Detector Pre- and Post-Survey Cs-137 Source Measurements

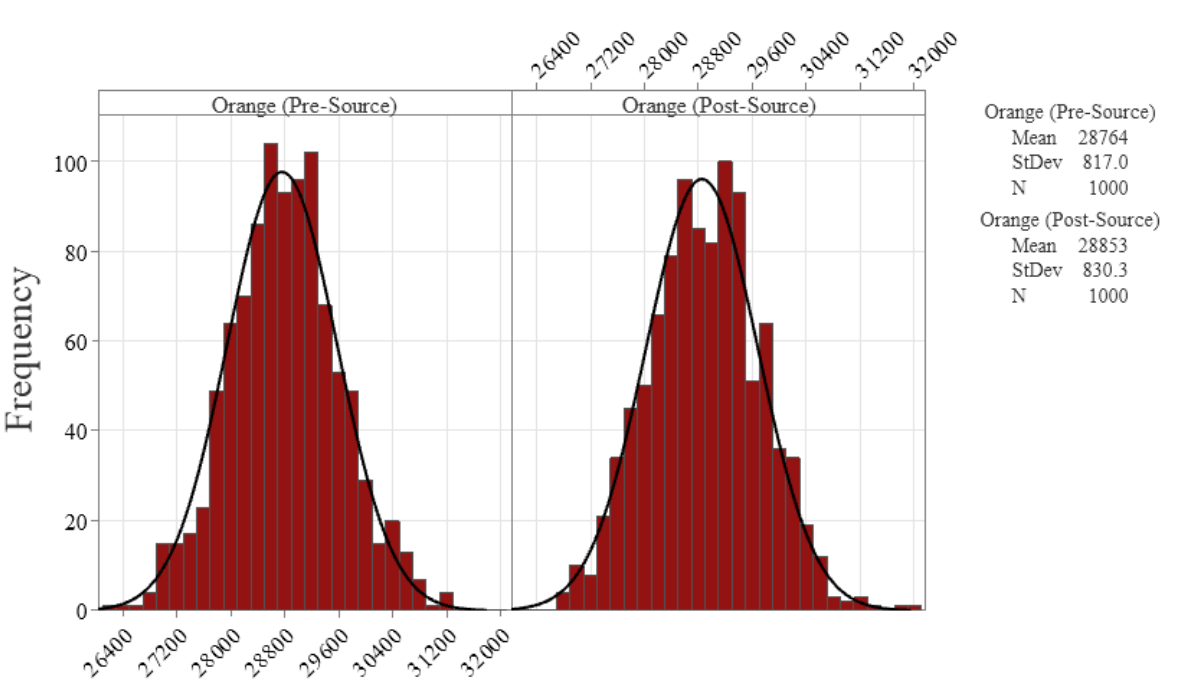


Figure B-9. Normal-Fitted Frequency Histogram of the Orange Detector Pre- and Post-Survey Cs-137 Source Measurements

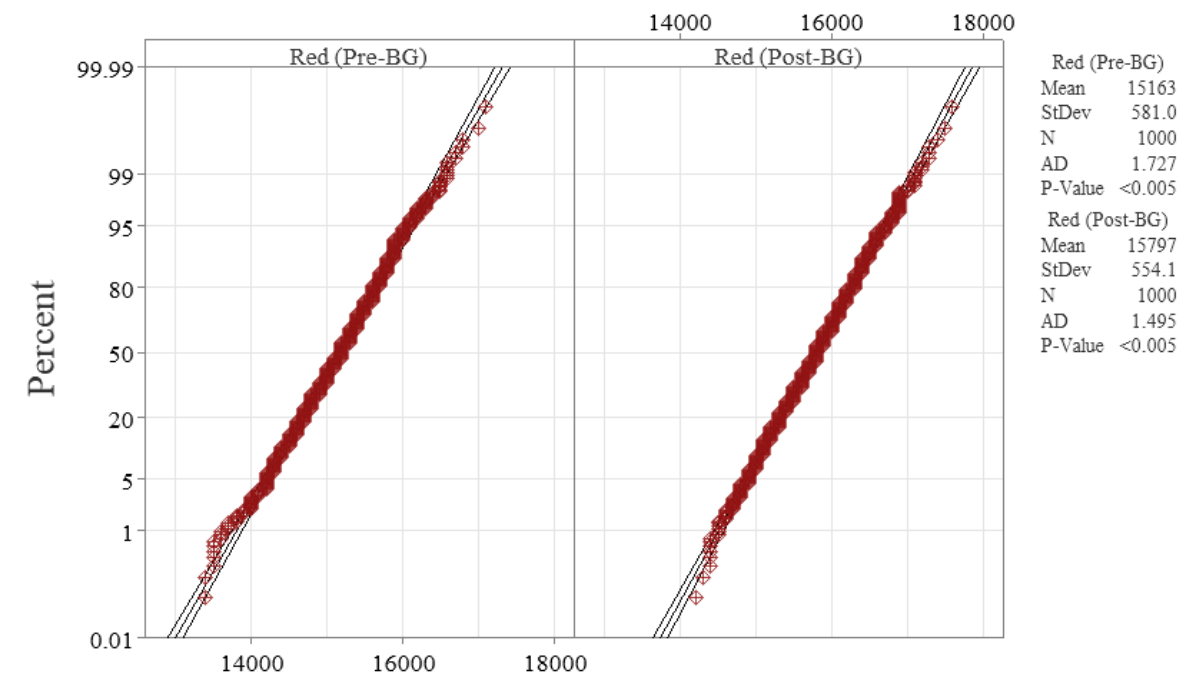


Figure B-10. Normal Probability Plot of Red Detector Pre- and Post-Survey Background Measurements

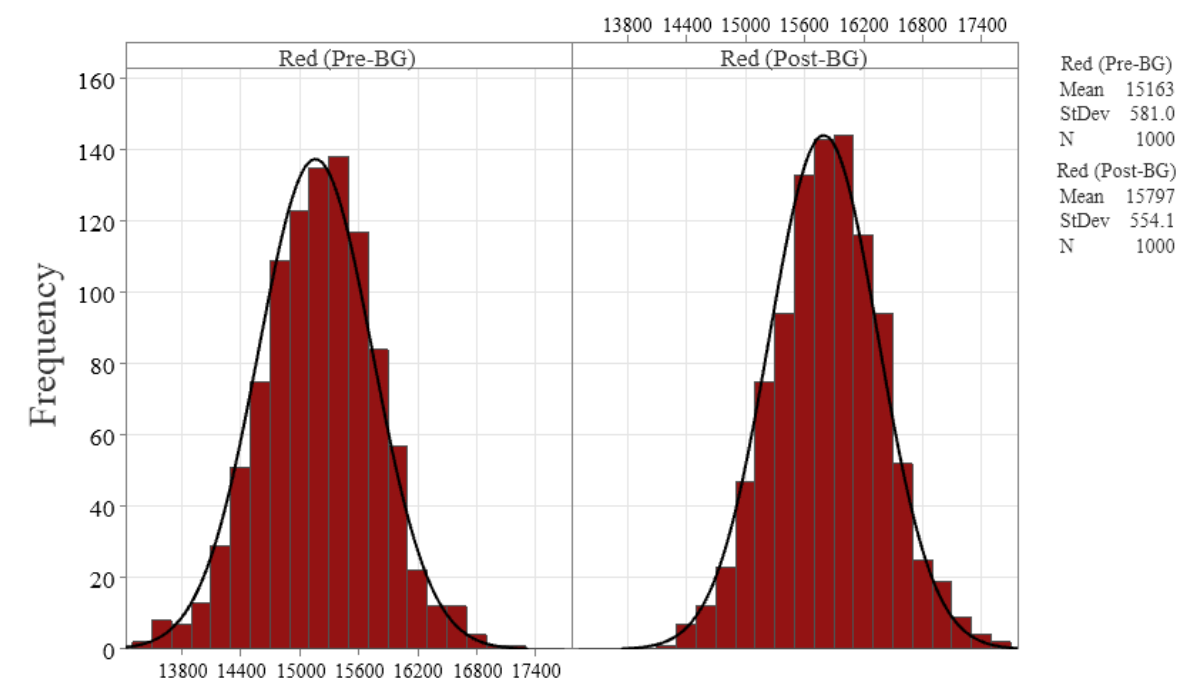


Figure B-11. Normal-Fitted Frequency Histogram of the Red Detector Pre- and Post-Survey Background Measurements

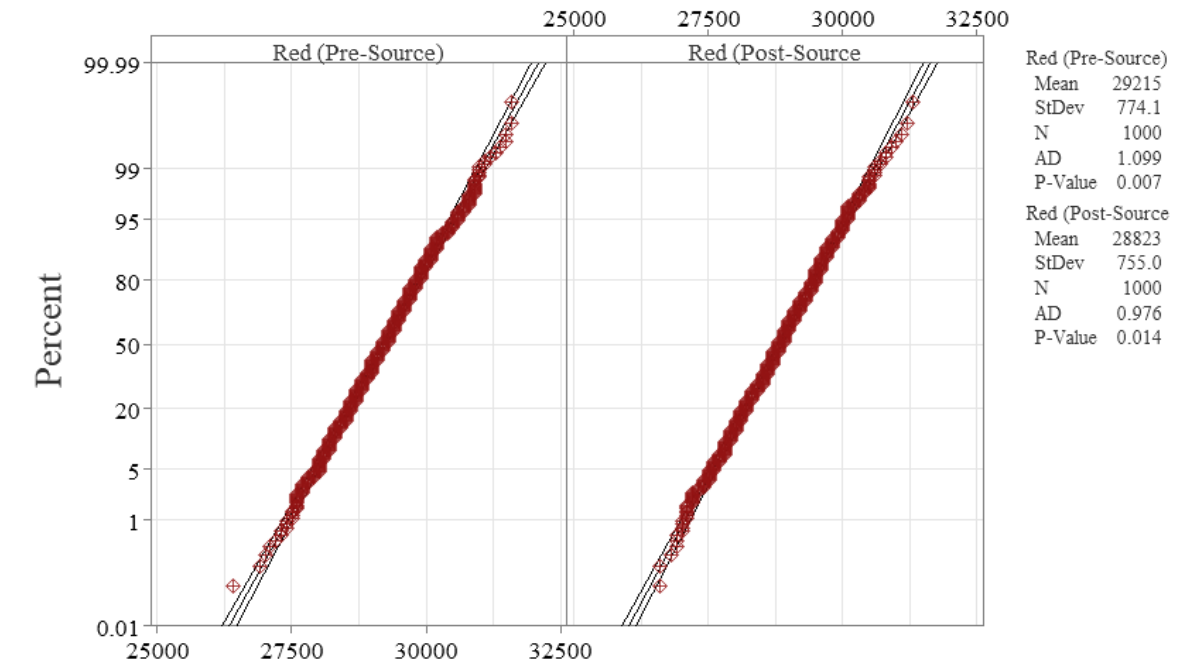


Figure B-12. Normal Probability Plot of Red Detector Pre- and Post-Survey Cs-137 Source Measurements

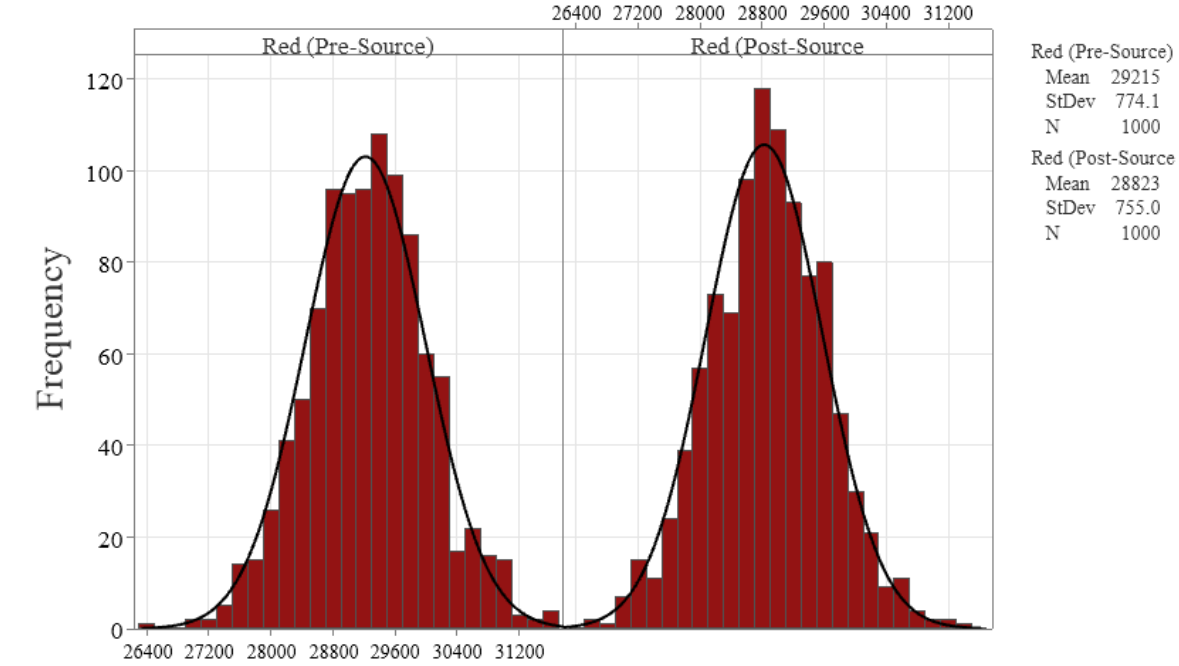


Figure B-13. Normal-Fitted Frequency Histogram of the Red Detector Pre- and Post-Survey Cs-137 Source Measurements

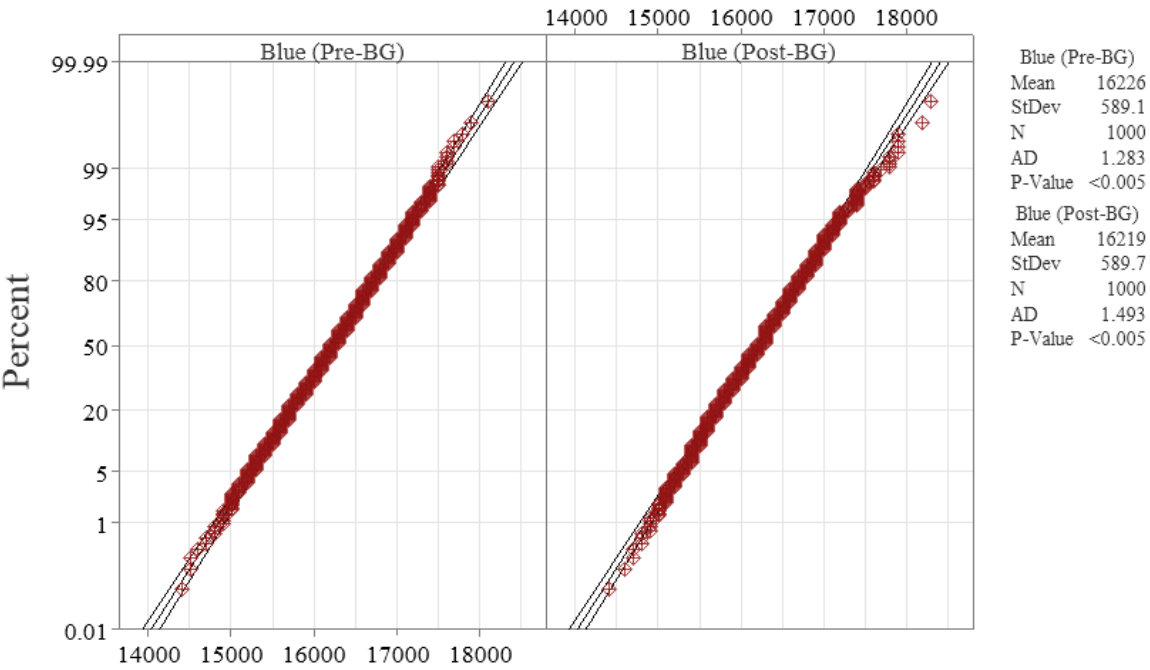


Figure B-14. Normal Probability Plot of Blue Detector Pre- and Post-Survey Background Measurements

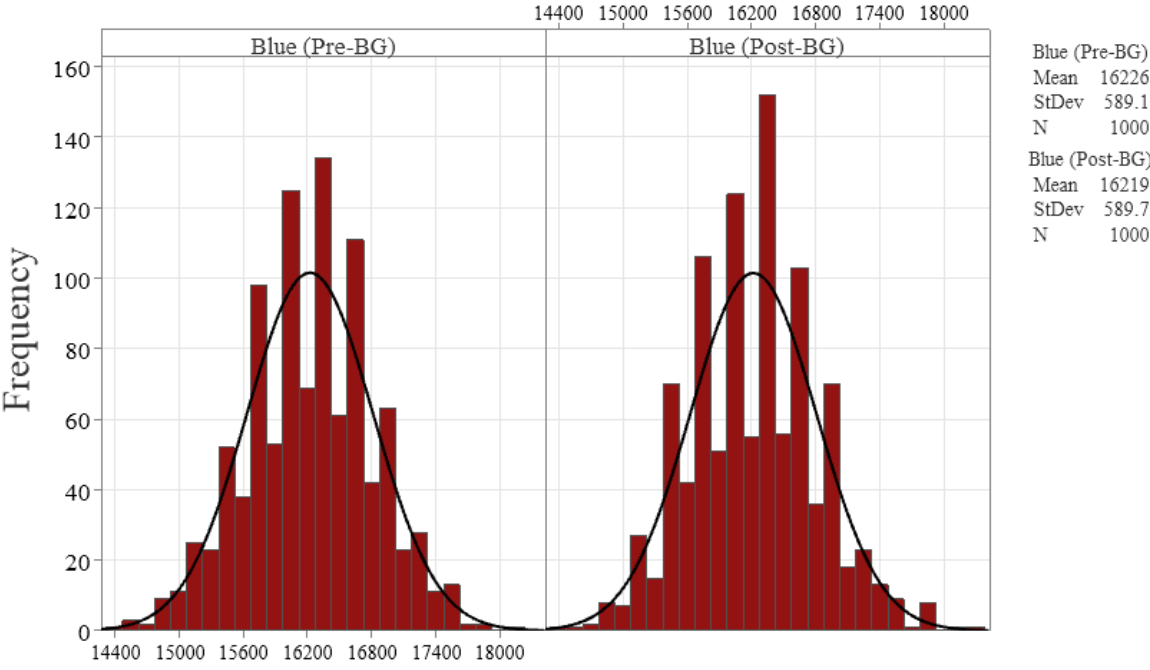


Figure B-15. Normal-Fitted Frequency Histogram of the Blue Detector Pre- and Post-Survey Background Measurements

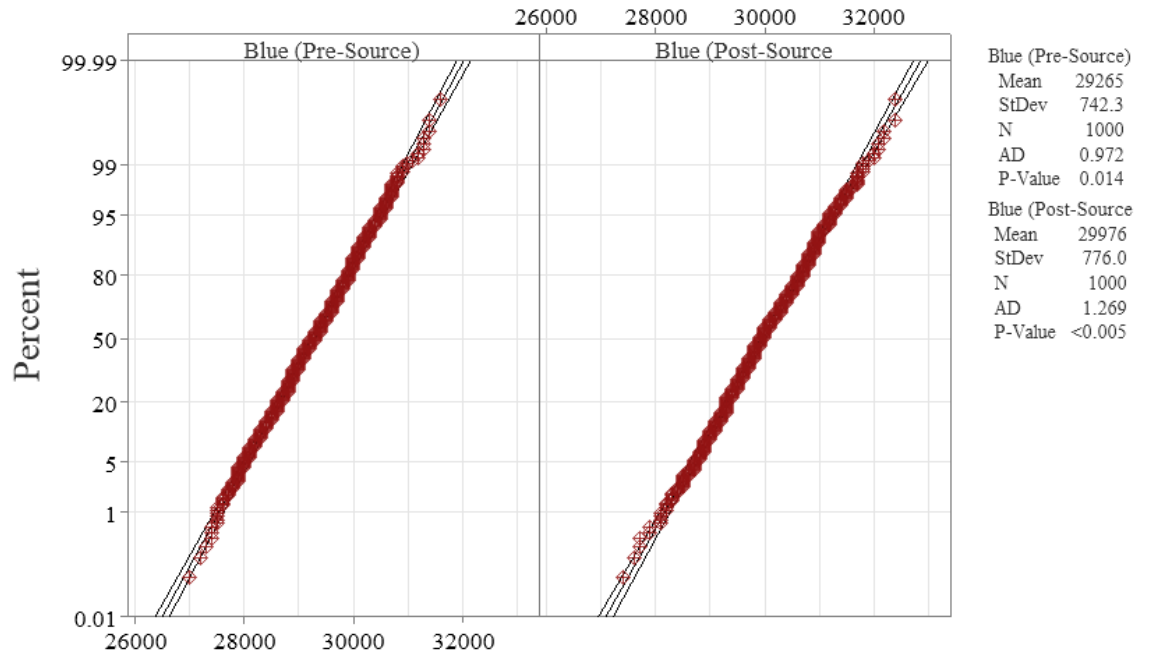


Figure B-16. Normal Probability Plot of Blue Detector Pre- and Post-Survey Cs-137 Source Measurements

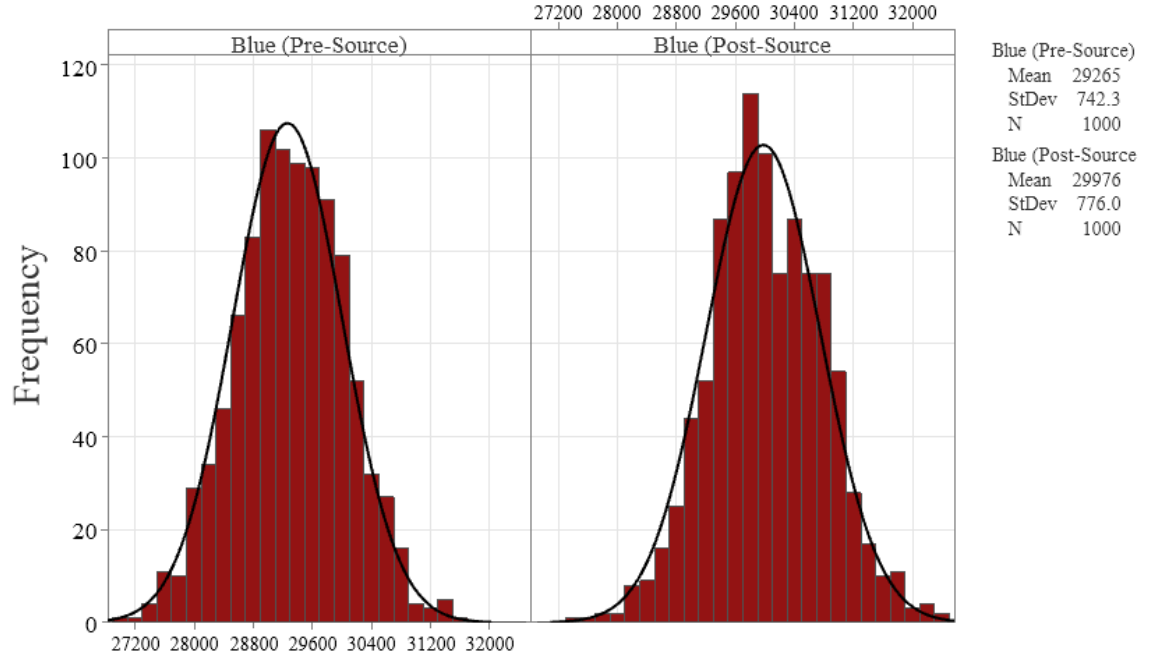


Figure B-17. Normal-Fitted Frequency Histogram of the Blue Detector Pre- and Post-Survey Cs-137 Source Measurements

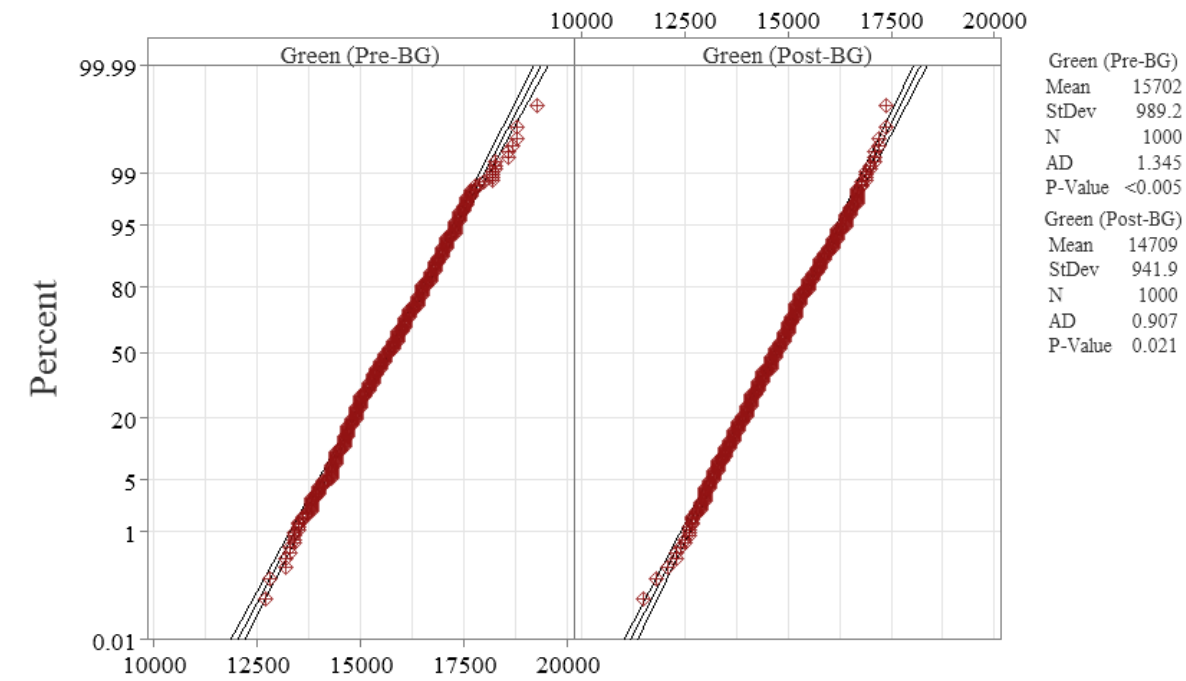


Figure B-18. Normal Probability Plot of Green Detector Pre- and Post-Survey Background Measurements

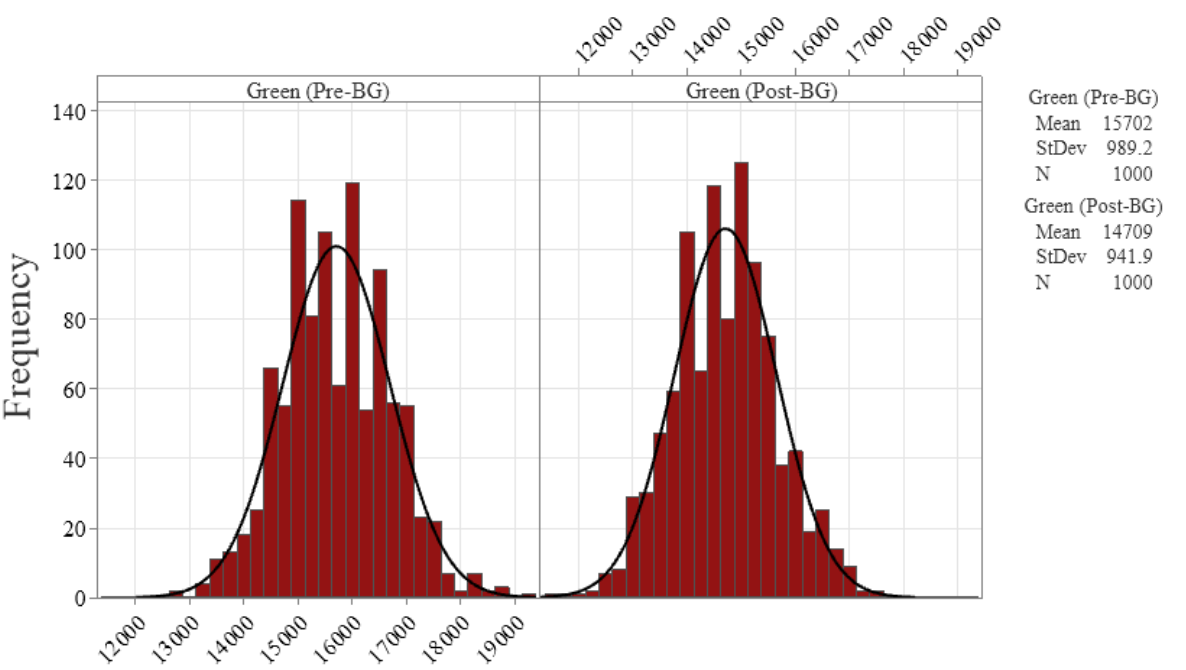


Figure B-19. Normal-Fitted Frequency Histogram of the Green Detector Pre- and Post-Survey Background Measurements

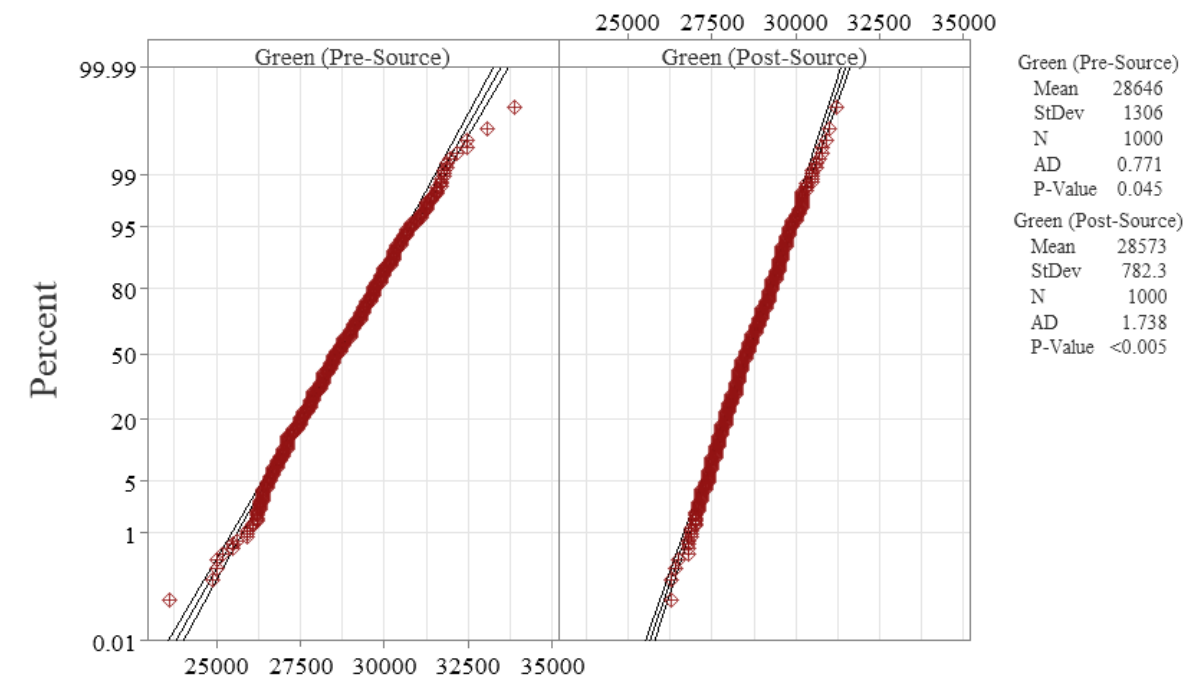


Figure B-20. Normal Probability Plot of Green Detector Pre- and Post-Survey Cs-137 Source Measurements

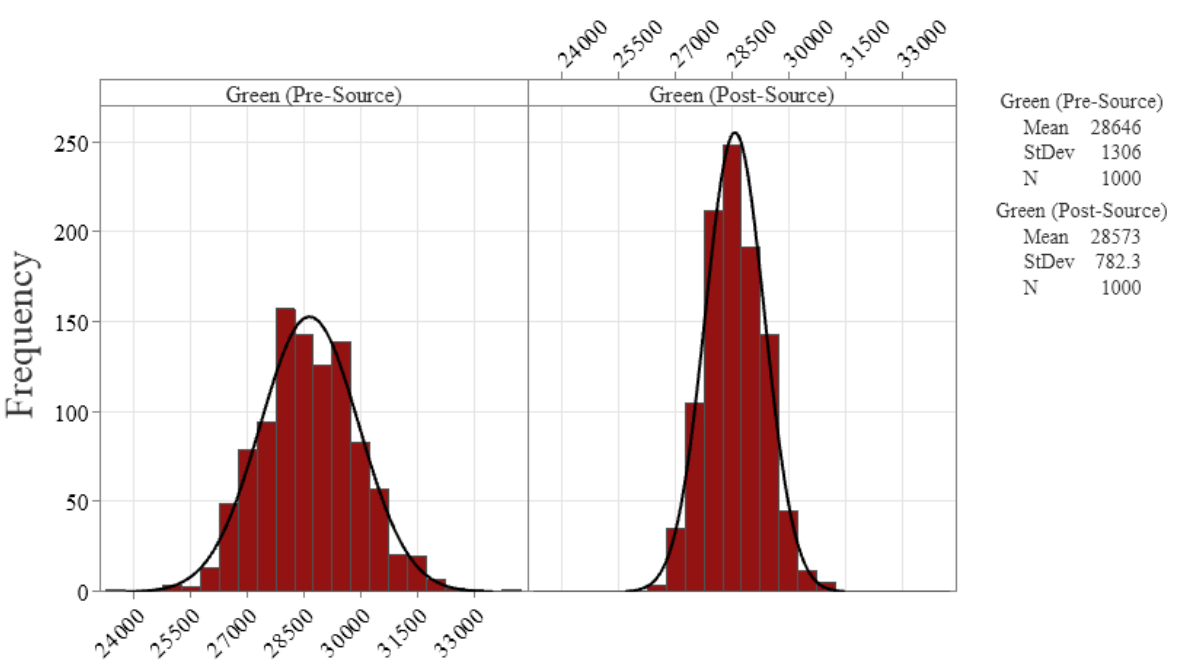


Figure B-21. Normal-Fitted Frequency Histogram of the Green Detector Pre- and Post-Survey Cs-137 Source Measurements

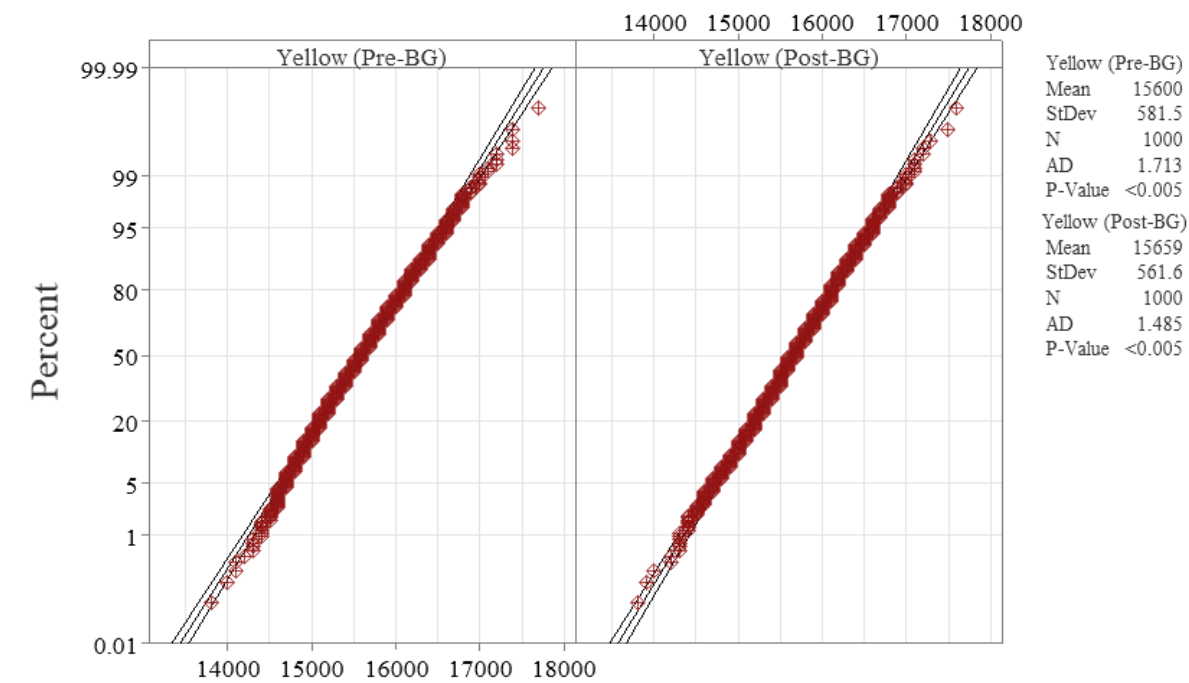


Figure B-22. Normal Probability Plot of Yellow Detector Pre- and Post-Survey Background Measurements

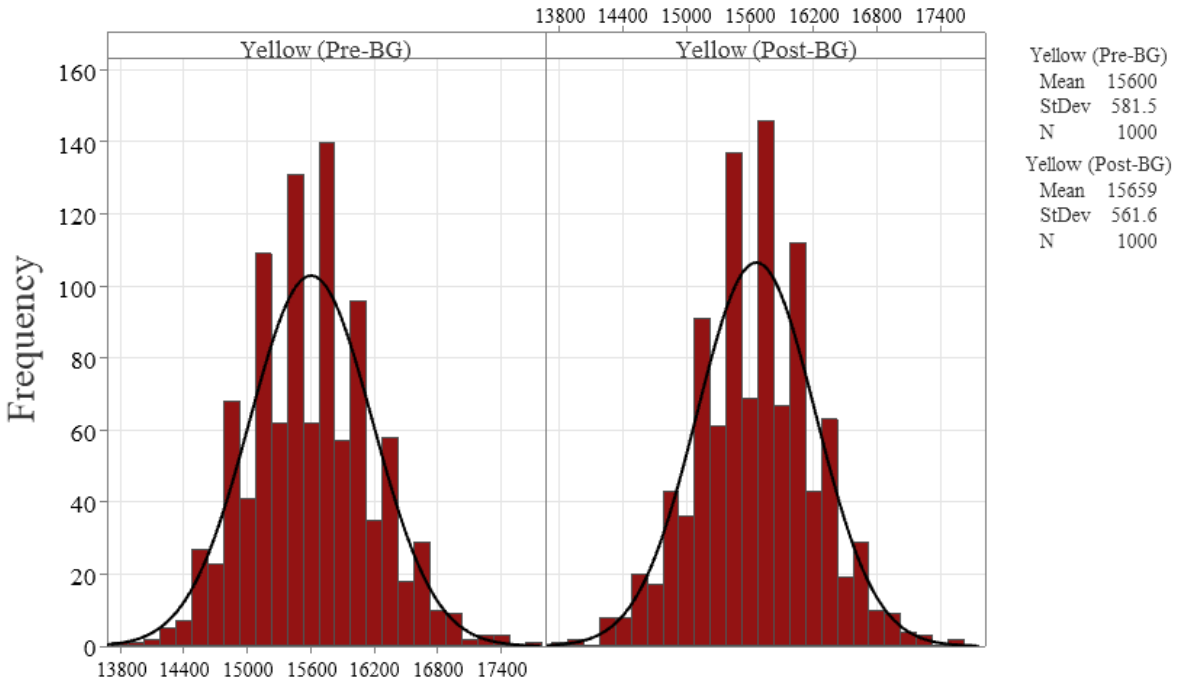


Figure B-23. Normal-Fitted Frequency Histogram of the Yellow Detector Pre- and Post-Survey Background Measurements

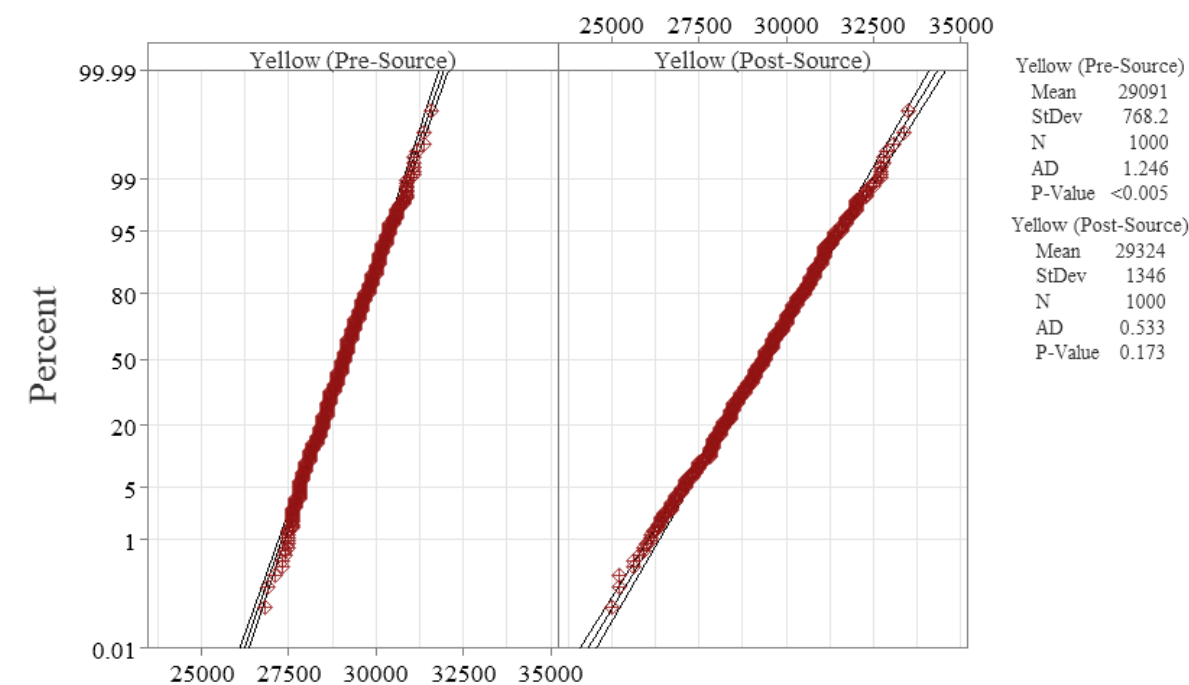


Figure B-24. Normal Probability Plot of Yellow Detector Pre- and Post-Survey Cs-137 Source Measurements

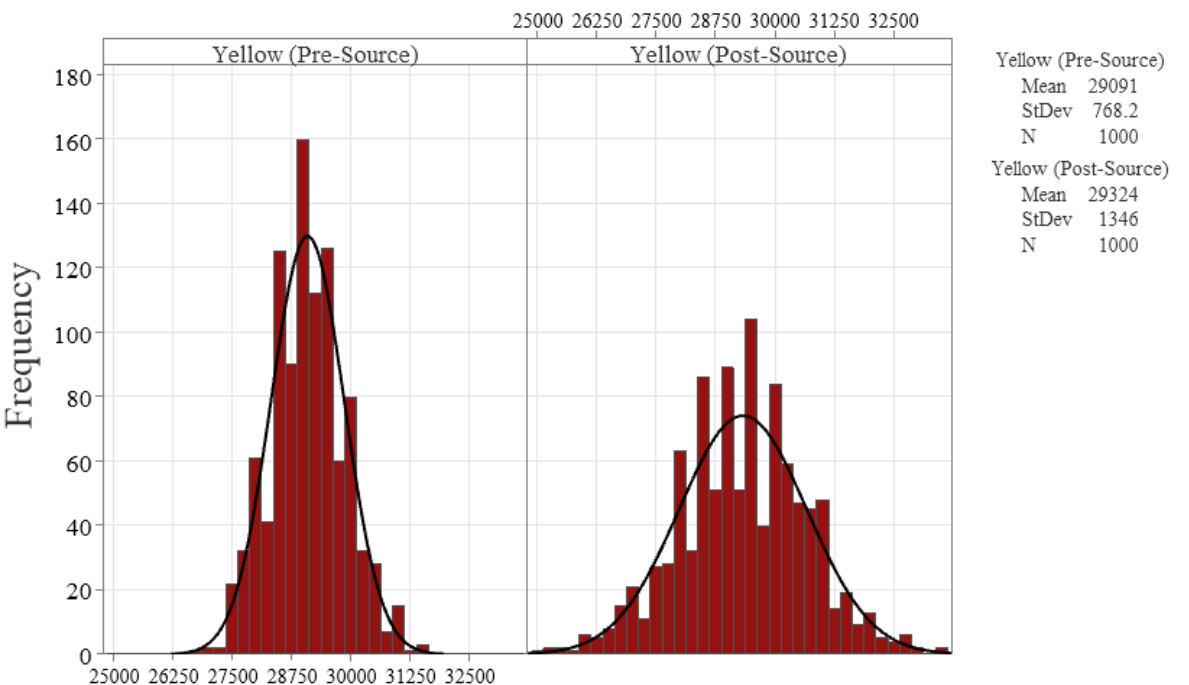


Figure B-25. Normal-Fitted Frequency Histogram of the Yellow Detector Pre- and Post-Survey Cs-137 Source Measurements

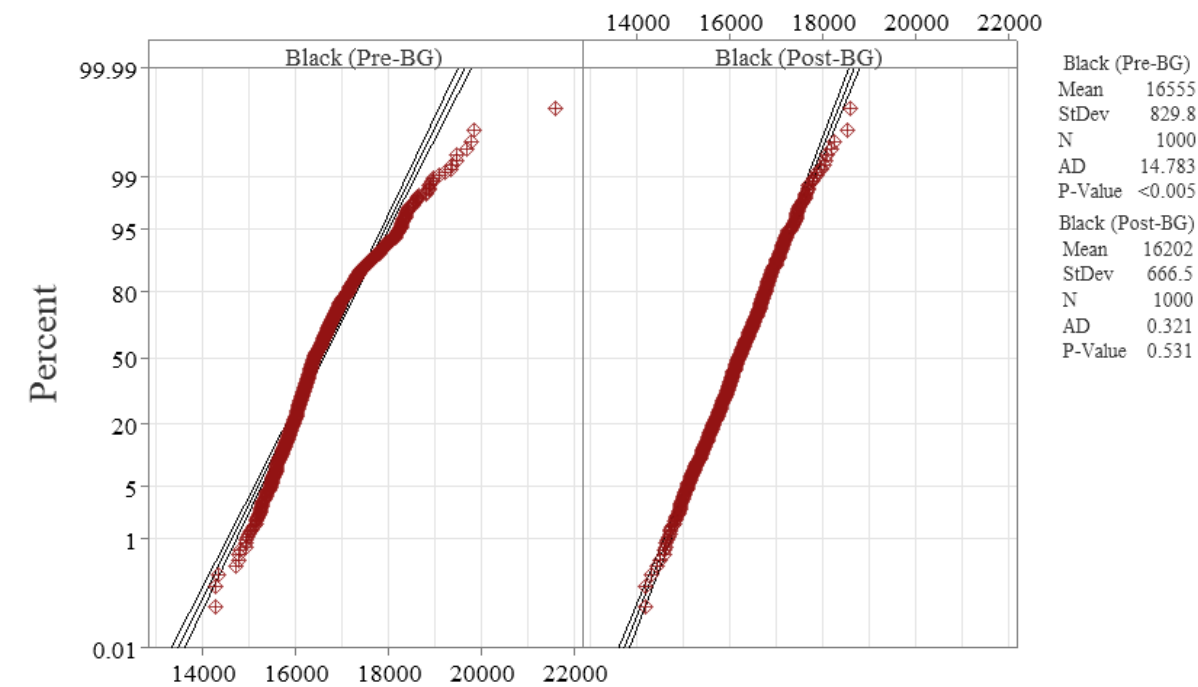


Figure B-26. Normal Probability Plot of Black Detector Pre- and Post-Survey Background Measurements

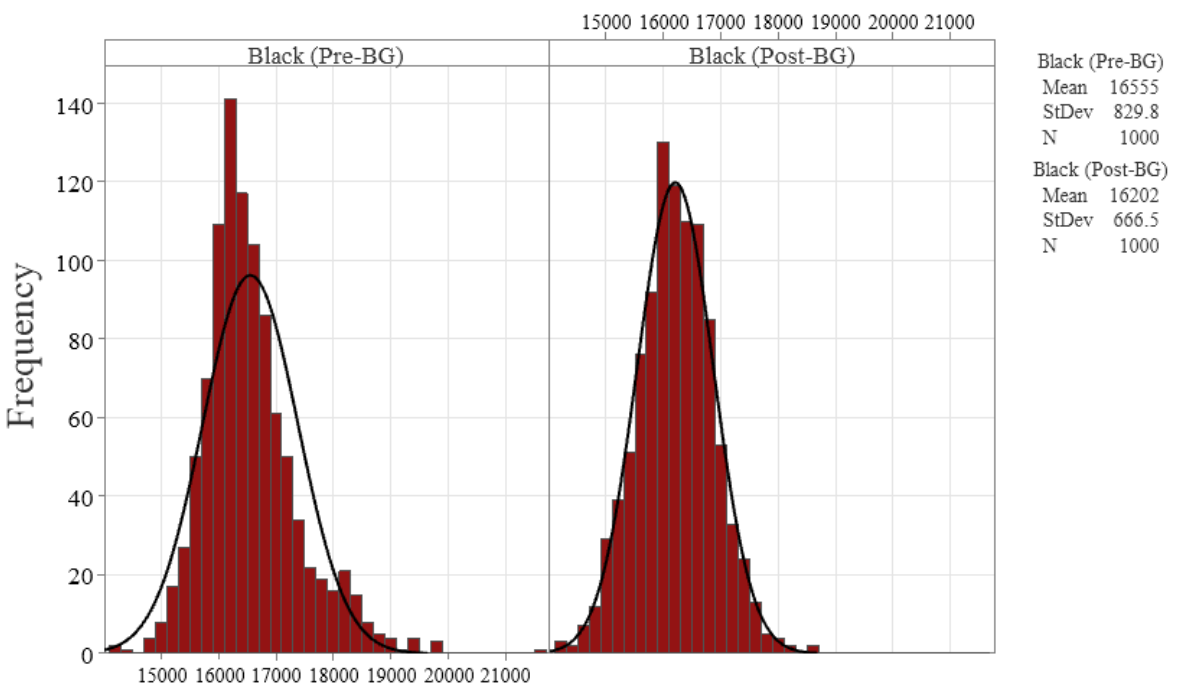


Figure B-27. Normal-Fitted Frequency Histogram of the Black Detector Pre- and Post-Survey Background Measurement

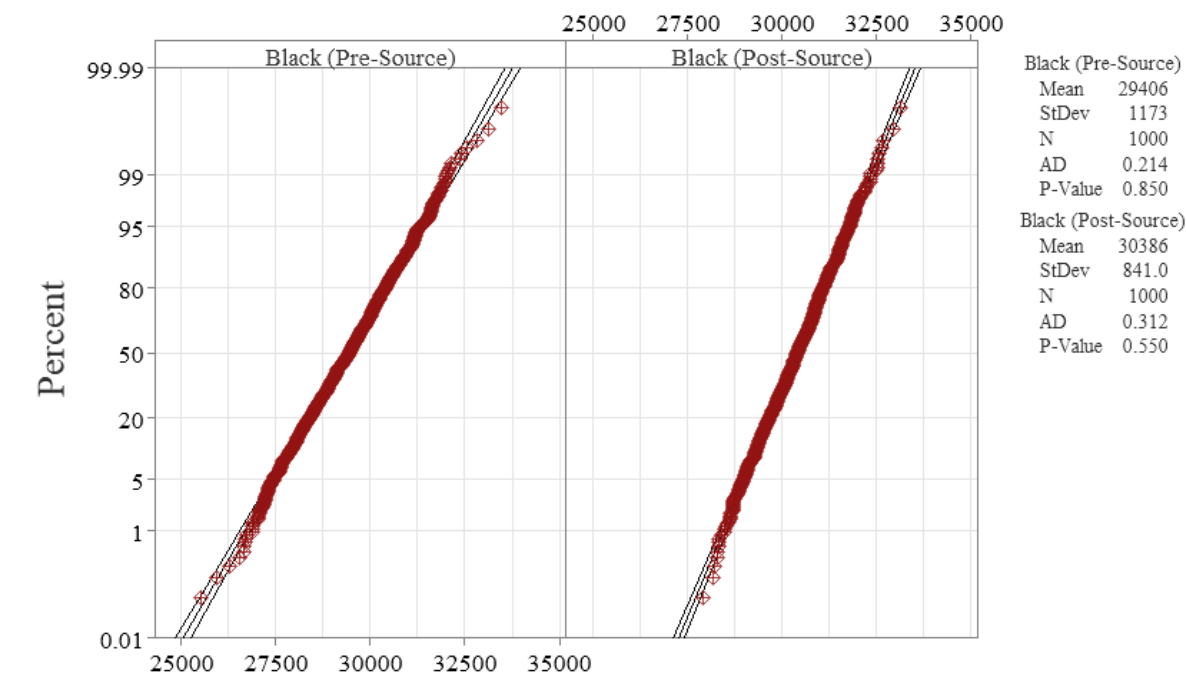


Figure B-28. Normal Probability Plot of Black Detector Pre- and Post-Survey Cs-137 Source Measurements

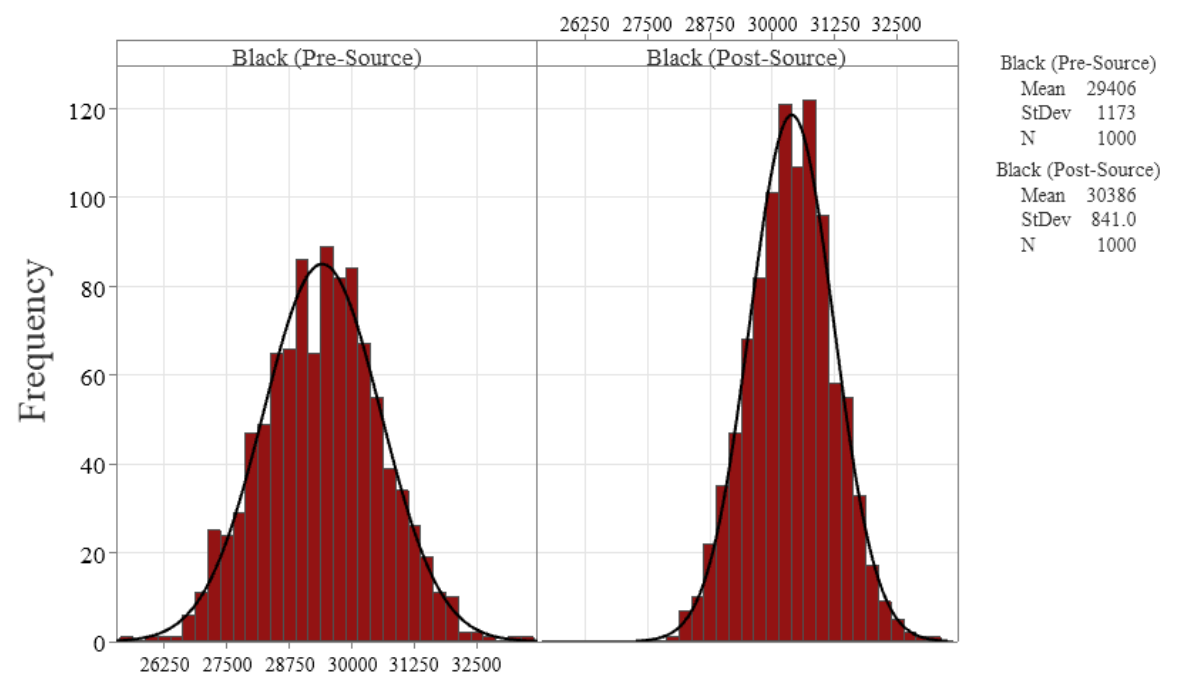


Figure B-29. Normal-Fitted Frequency Histogram of the Black Detector Pre- and Post-Survey Cs-137 Source Measurements

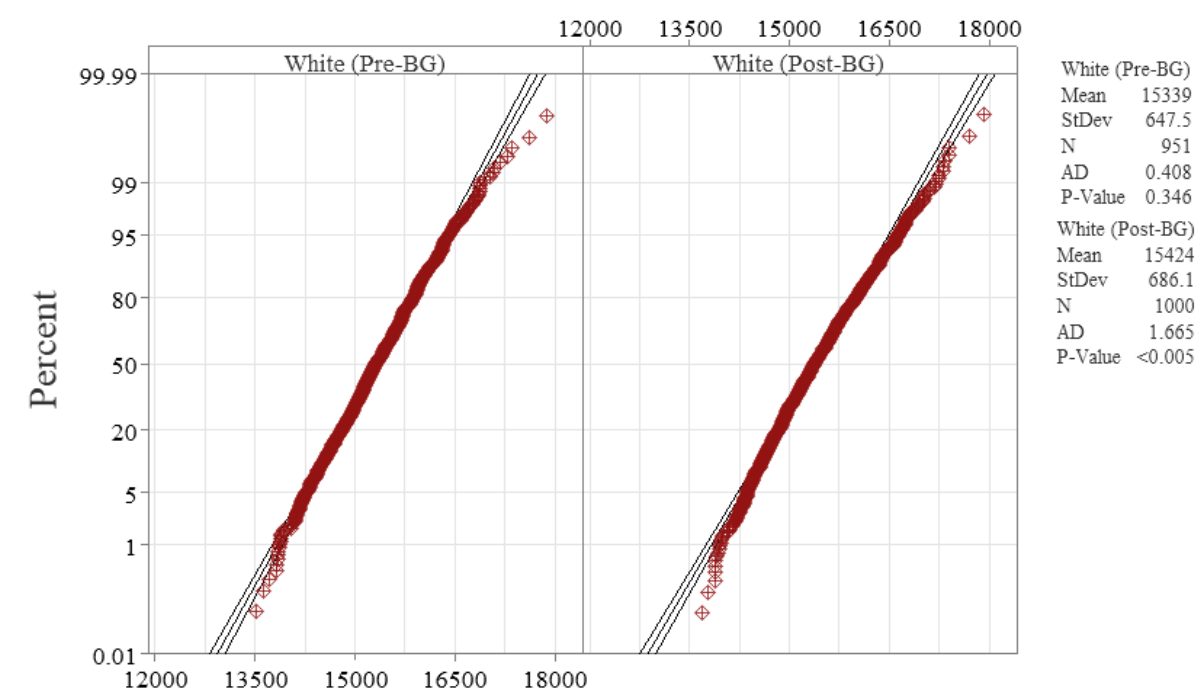


Figure B-30. Normal Probability Plot of White Detector Pre- and Post-Survey Background Measurements

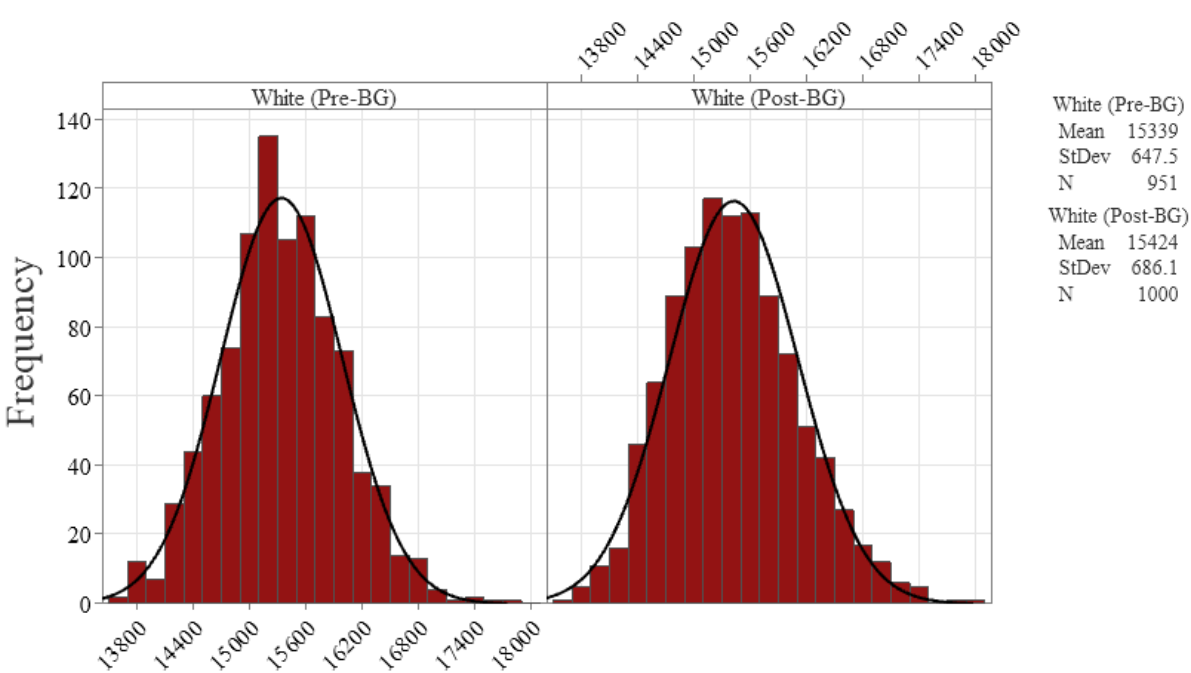


Figure B-31. Normal-Fitted Frequency Histogram of the White Detector Pre- and Post-Survey Background Measurements

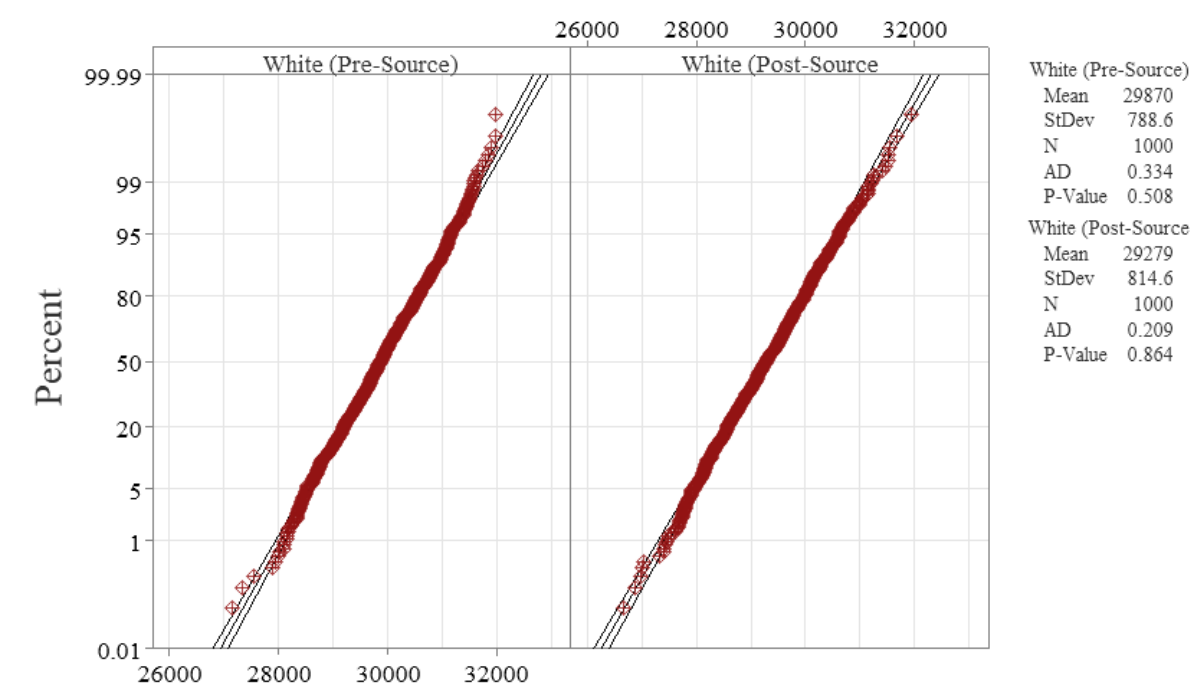


Figure B-32. Normal Probability Plot of White Detector Pre- and Post-Survey Cs-137 Source Measurements

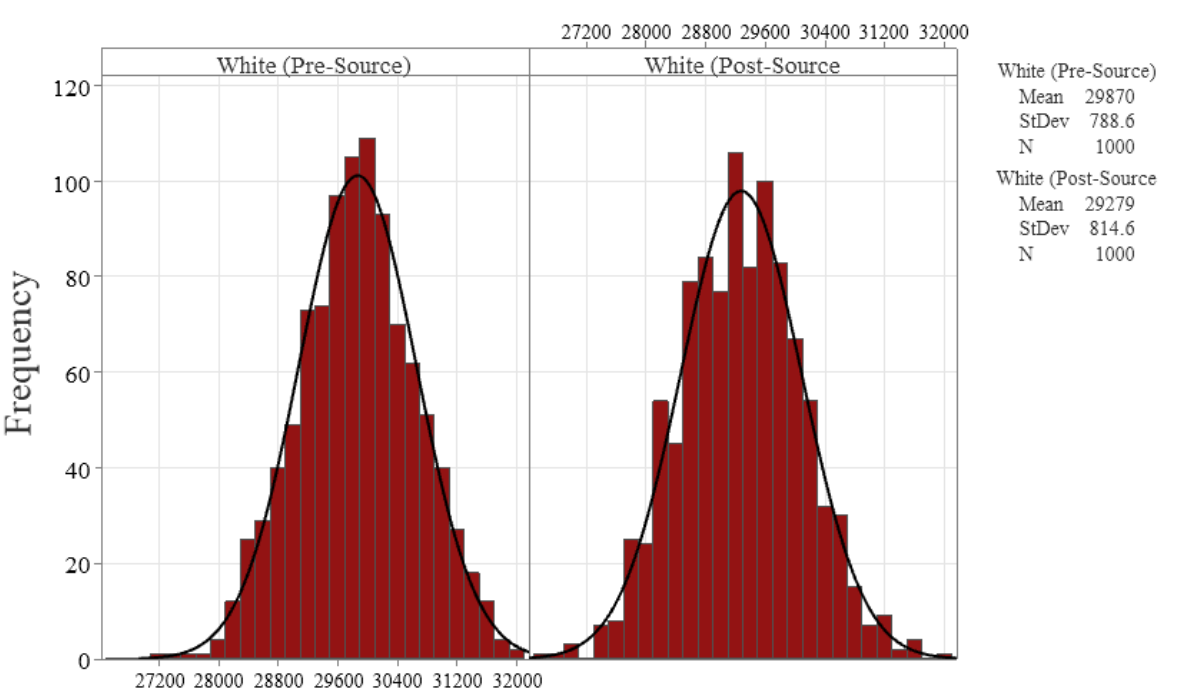


Figure B-33. Normal-Fitted Frequency Histogram of the White Detector Pre- and Post-Survey Cs-137 Source Measurements



3.3 DAILY FUNCTION QUALITY CONTROL AND RESULTS

Under the QC program, factory-calibrated detectors must also meet on-site daily function QC checks. Daily function QC checks are measurements to verify detector performance each time a detector is used (USEPA 2000). These checks occurred at a pre-determined background reference area not impacted by site activities. For this project, daily function QC checks were performed in Gallup, New Mexico, within Room 214 of the Gallup IHG Hotel. Field test strips for detectors were not used during this project. [Attachment B-6](#) includes the daily function check forms used to document daily function QC checks.

The following three steps must occur during daily function QC checks, and the three associated QC Criteria must be met each day after use of a detector to collect characterization or scoping level data:

- **Daily QC Criterion 1:** Daily function QC checks consist of collecting 60 background and 60 Cs-137 source measurements from each detector used during daily survey activities. The mean of the 60 background and the mean of the 60 Cs-137 source measurements is then calculated. These QC measurements should be performed at the same location each day, or at a location as similar as possible to the previous daily function check location if unforeseen circumstances preclude function checks at the same location as the previous day. These steps constitute Daily QC Criterion 1.
- **Daily QC Criterion 2:** For each detector, the difference between the respective means of the 60 Cs-137 source data and 60 background measurements is then calculated. This difference is called the daily net count. Daily net count for each detector then is compared to the mean of the pre-survey net counts. Any detector with a daily function QC measurement result falling outside 20 percent of the mean of pre-survey QC net measurements will require investigation. A detector exceeding control limits on any QC check may be replaced with a pre-qualified spare detector and flagged for evaluation, repair, and recalibration.
- **Daily QC Criterion 3:** For normally distributed data, 99 percent of all measurements are expected to fall within 3 standard deviations from the mean. Any detector with a QC measurement result falling outside 3 standard deviations from the mean of all daily QC measurements requires investigation. A detector exceeding control limits on any QC function check (background, field strip, or source) will be replaced with a pre-qualified spare detector and sent back to the manufacturer for evaluation, repair, and recalibration.

During the OCRM investigation, QC measurements, including a background check and Cs-137 source check, were performed once daily for each detector used for gamma surveys, satisfying daily QC Criterion 1. [Table B-6](#) lists daily function QC check results for each detector. The mean of the daily net counts was compared to the mean of the pre-survey net counts, and no mean of daily net counts was found to exceed the mean of the pre-survey net counts by more than 20 percent, satisfying Criterion 2. The daily mean counts were compared to the mean counts for all days beginning on day 3 for Cs-137 source counts, background counts, and net counts. No daily background or Cs-137 source measurement mean was found to be more than 3 standard deviations from the mean counts for all days. A data validation discussion of daily QC checks is in [Section 4.2.2](#).



Figure B-34 is a QC chart of daily QC background measurements. Average background measurements are displayed on a line accompanied on both sides by lines representing three standard deviations above and below the mean of all daily background measurements.

Figure B-35 is a QC chart for the daily QC Cs-137 source measurements. Average Cs-137 source measurements are displayed on a line accompanied on both sides by lines representing 3 standard deviations above and below the mean for all daily Cs-137 source measurements.



Date	Orange			Red			Blue			Green			Yellow			Black			White ¹		
	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)
11/14/2022	17,659	5,059	12,600	17,595	5,235	12,360	18,314	5,325	12,989	17,738	5,191	12,547	17,441	5,174	12,267	18,314	5,325	12,989	18,577	5,793	12,784
11/15/2022	17,671	5,180	12,491	17,719	5,300	12,419	18,280	5,547	12,733	17,869	5,143	12,726	17,761	4,941	12,820	18,280	5,547	12,733	17,603	6,119	11,484
11/16/2022	17,241	5,019	12,222	17,970	5,088	12,882	18,051	5,455	12,596	17,926	5,132	12,794	17,585	5,285	12,300	18,051	5,455	12,596	18,299	6,025	12,274
11/17/2022	17,880	5,461	12,419	17,495	5,325	12,170	18,784	5,915	12,869	18,162	5,276	12,886	17,770	5,302	12,468	18,784	5,915	12,869	18,703	6,611	12,092
11/18/2022	18,129	5,045	13,084	17,772	5,805	11,967	18,345	5,508	12,837	17,955	6,005	11,950	17,658	5,308	12,350	18,345	5,508	12,837	18,736	6,713	12,023
11/19/2022	17,652	5,242	12,410	17,926	5,694	12,232	18,577	5,768	12,809	17,500	5,494	12,006	17,614	5,645	11,969	18,577	5,768	12,809	-	-	-
11/20/2022	18,213	5,896	12,317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	17,778	5,272	12,506	17,746	5,408	12,338	18,392	5,586	12,806	17,858	5,374	12,485	17,638	5,276	12,362	18,392	5,586	12,806	18,384	6,252	12,131
Standard Deviation (cpm)	330	315	282	184	279	310	255	216	133	223	337	408	123	228	279	255	216	133	469	394	469
Counts Within 3 Standard Deviations of Mean (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RSD	2%	6%	2%	1%	5%	3%	1%	4%	1%	1%	6%	3%	1%	4%	2%	1%	4%	1%	3%	6%	4%

Notes:
¹ White QC attributed to 11/15/2022 actually performed the morning of 11/16/2022 prior to fieldwork
- Instrument not used
cpm Counts per minute
Cs-137 Cesium-137
QC Quality control
RSD Relative standard deviation

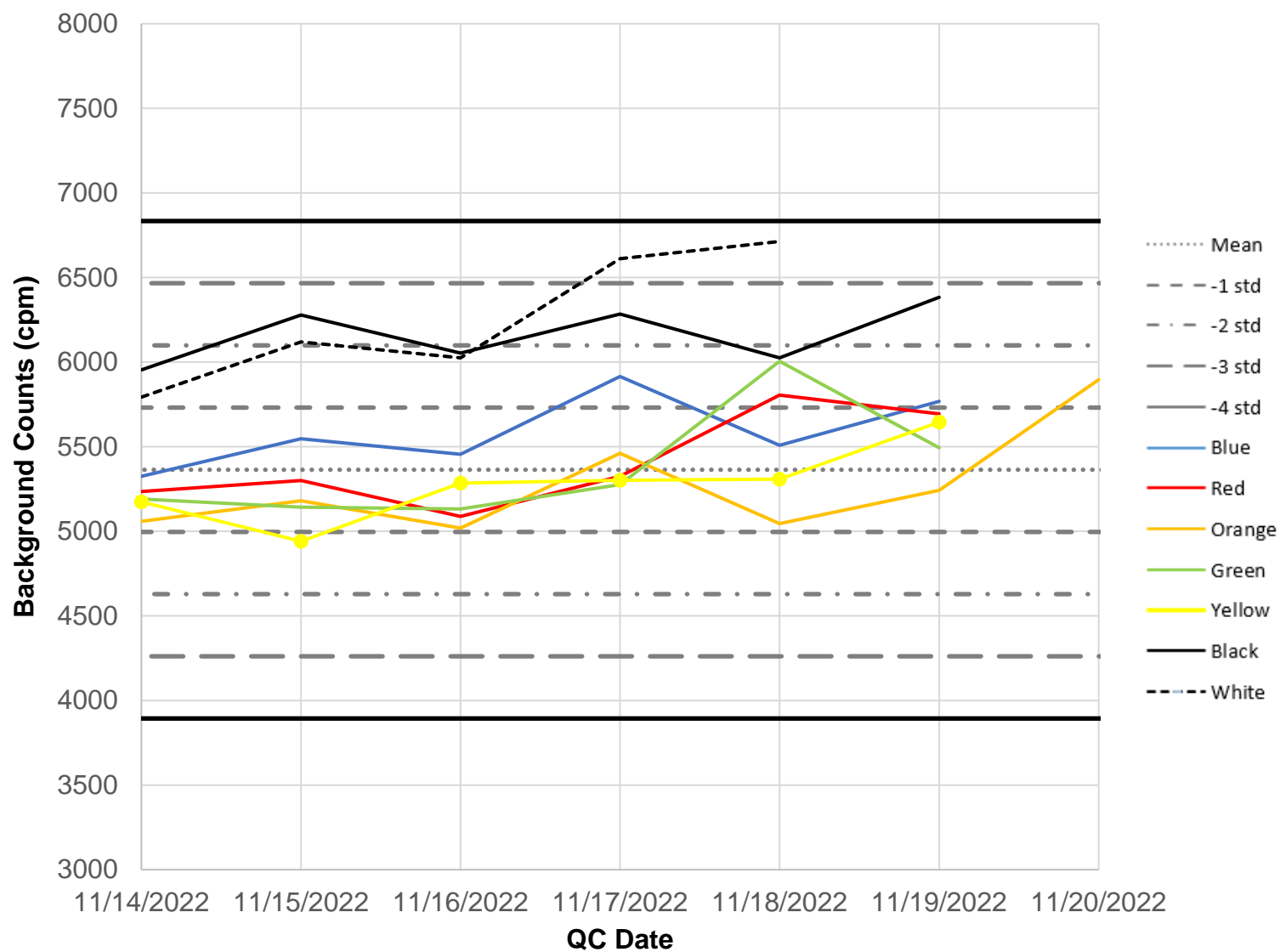


Figure B-34. Daily QC Check Control Chart – Background Measurements

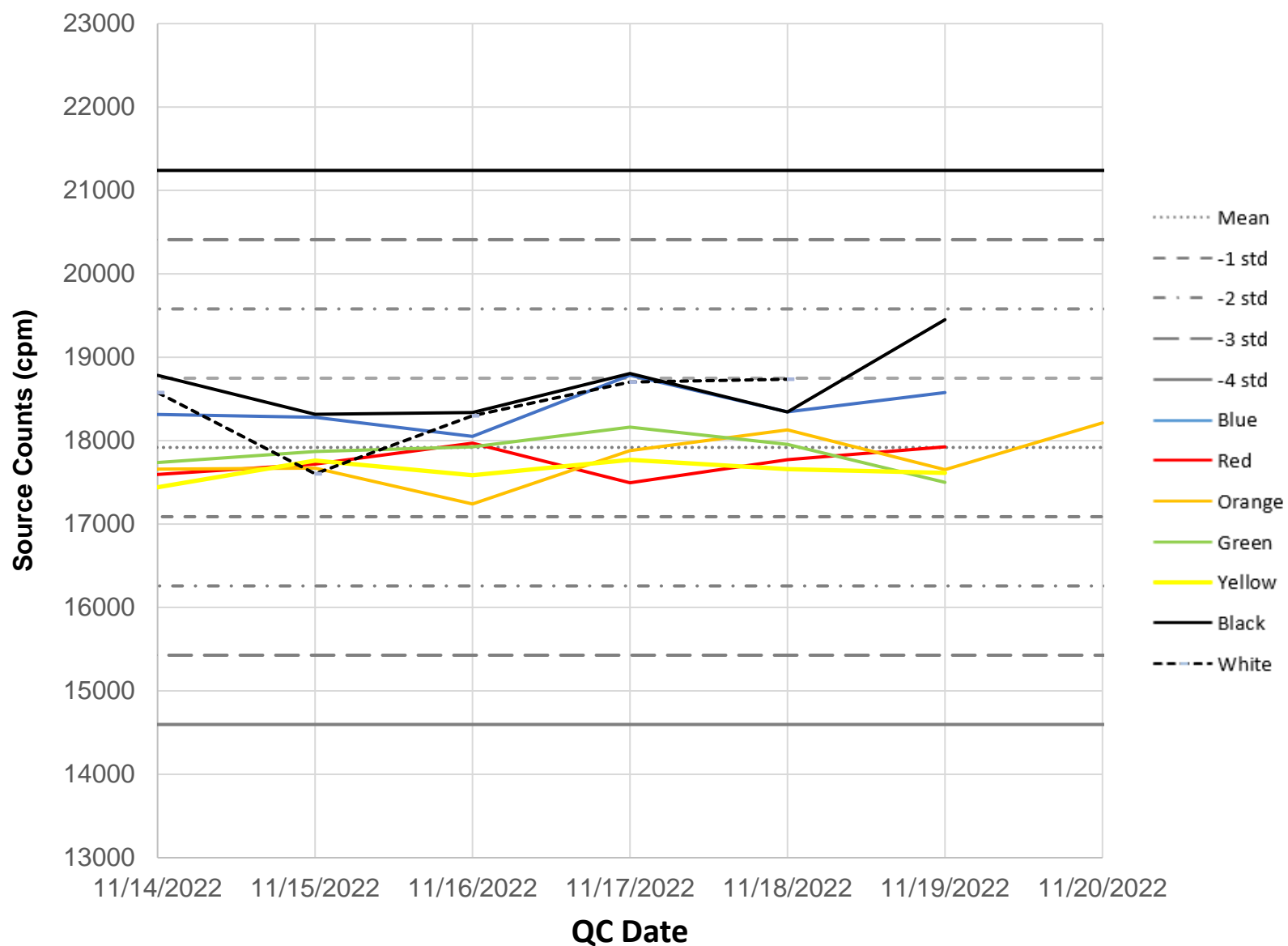


Figure B-35. Daily QC Check Control Chart – Cs-137 Source Measurements

4.0 VALIDATION AND VERIFICATION OF INSTRUMENT OPERATION

This section discusses validation and verification of the in-field gamma radiation surveys.

4.1 CALCULATIONS

The following calculations are used to assess precision or comparability. Precision is an indicator of repeatability and reproducibility and can be assessed by evaluating primary and duplicate measurements or datasets. Comparability refers to how well detectors compare to each other so they can be interchanged in the field. The data validation methods used to evaluate the precision or comparability are RSD and RPD.

The RSD was used for evaluation of pre-survey and post-survey gamma exposure rate measurements and daily QC checks. The RSD of the sample mean is used to assess method precision. The equation for calculating RSD is:

$$RSD = \frac{\sigma}{\mu} \times 100$$

where:

RSD	=	relative standard deviation for the precision measurement of gamma radiation counts per minute (cpm)
σ	=	standard deviation of gamma radiation cpm
μ	=	mean concentration of gamma radiation cpm

The RPD was used for pre-survey and post-survey gamma exposure rate measurements. RPD was calculated for detectors with the greatest difference in mean gamma radiation cpm, giving the highest possible RPD for each detector. The equation for RPD is:

$$RPD(\%) = \frac{|S - D|}{\frac{(S + D)}{2}} \times 100$$

where:

RPD	=	relative percent difference between detectors mean gamma radiation cpm
S	=	value of the first detectors mean gamma radiation cpm
D	=	value of the detector with the greatest difference in mean gamma radiation cpm from the first detector's mean gamma radiation cpm

4.2 VALIDATION

Validation of in-field data involves a technical review comparing QC data with established quality criteria to ensure adequacy of data for intended use. The primary validation provided here involves pre-survey and post-survey QC checks in the office, and daily function QC checks in the field.

4.2.1 Pre-Survey and Post-Survey Validation

Methods and results of pre-survey and post-survey QC checks are in [Section 3.2.1](#). The OCRM investigation is a scoping level gamma survey, and detectors were compared according to these specific criteria. Data validation project quality criteria for pre-survey and post-survey are as follows:

- **QC Criterion 1:** The RPD between each detector and the detector with the greatest difference in mean background measurements must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow use of a detector in scoping level gamma surveys. **This was achieved.**
- **QC Criterion 2:** The RPD between each detector and the detector with the greatest difference in mean Cs-137 measurements must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow use of a detector in scoping level gamma surveys. **This was achieved.**
- **QC Criterion 3:** The RSD of an individual detector's background and Cs-137 source measurements must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow use of a detector in scoping level gamma surveys. **This was achieved.**
- **QC Criterion 4:** Each individual detector's background and Cs-137 source measurements must be normally distributed. **This was achieved.**
 - a. Middle/highest point on histogram is the only identifiable peak. **This was achieved.**
 - b. Peak of the normal curve aligns with the peak point of the histogram. **This was achieved except for the white detector and black detector.** It was found that pre-survey background measurements by the white detector were skewed slightly to the left of the normal curve, and that pre-survey and post-survey background measurements by the black detector were skewed slightly to the left of the normal curve. However, neither detector's background measurements were far enough outside of the normal curve to disqualify them from scoping level gamma surveys.
 - c. Slopes of normal probability plots look approximately equal. **This was achieved.**
- **QC Criterion 5:** The RPD between each detector's mean pre-survey background gamma count rate and the mean post-survey background gamma count rate measurement must not exceed 5 percent for characterization data and 10 percent for scoping data. **This was achieved.**
- **QC Criterion 6:** The RPD between each detector's mean pre-survey Cs-137 source gamma count rate and the mean post-survey Cs-137 source gamma count rate measurement must not exceed 5 percent for characterization data and 10 percent for scoping data. **This was achieved.**

[Table B-7](#) and [Table B-8](#) summarize the Pre-Survey QC Criteria and Post-Survey QC Criteria, respectively. Each table lists specific QC criteria and whether the detectors passed those QC criteria. **All project QC requirements for scoping level data were achieved for pre-survey and post-survey measurements.**



Table B-7. Pre-Survey QC Criteria

Instrument Name	Pre-Survey QC Criteria						
	Criterion 1	Criterion 1	Criterion 2	Criterion 2	Criterion 3	Criterion 3	Criterion 4
	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Background	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Cs-137	RPD Between Detector Mean Background and Detector with Greatest Difference in Mean Background is less than 10%	RPD Between Detector Mean Cs-137 Source Measurements Compared to the Instrument with the Greatest Difference in Mean Cs-137 Source Measurements is less than 10%	RSD of Background Measurements is less than 10%	RSD of Cs-137 Source Measurements is less than 10%	Normal Distribution of Background and Cs-137 Source Measurements
Orange Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Red Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blue Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Green Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yellow Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Black Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
White Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
cpm Counts per minute
RPD Relative percent difference
RSD Relative standard deviation



Table B-8. Post-Survey QC Criteria

Instrument Name	Post-Survey QC Criteria								
	Criterion 1	Criterion 1	Criterion 2	Criterion 2	Criterion 3	Criterion 3	Criterion 4	Criterion 5	Criterion 6
	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Background	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Cs-137	RPD Between Detector Mean Background and Detector with Greatest Difference in Mean Background is less than 10%	RPD Between Detector Mean Cs-137 Source Measurements Compared to the Instrument with the Greatest Difference in Mean Cs-137 Source Measurements is less than 10%	RSD of Background Measurements is less than 10%	RSD of Cs-137 Source Measurements is less than 10%	Normal Distribution of Background and Cs-137 Source Measurements	RPD of Pre- and Post-Survey Background Measurements are Less Than 10%	RPD of Pre- and Post-Survey Cs-137 Source Measurements are Less Than 10%
Orange Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Red Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blue Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Green Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yellow Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Black Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
White Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
cpm Counts per minute
RPD Relative percent difference
RSD Relative standard deviation

4.2.2 Daily QC Checks

The goal of the daily function QC checks is to ensure the detectors were working properly during field surveys. QC criteria and results of the daily function QC checks are presented in [Section 3.0](#). The QC charts show that data points for background and Cs-137 source checks were all within the project quality criteria limits. [Table B-9](#) lists results of daily function QC checks.

Table B-9. Daily QC Criteria

Instrument Name	Daily QC Criteria				
	Criterion 1	Criterion 2	Criterion 3	Criterion 3	Criterion 3
	Daily Function QC Checks Were Completed Daily After Survey Activities	Mean of Net Measurements Within 20% of Pre-Survey Mean	Background Measurements Within 3 Standard Deviations of Total Daily QC Mean	Cs-137 Source Measurements Within 3 Standard Deviations of Total Daily QC Mean	Net Measurements Within 3 Standard Deviations of Total Daily QC Mean
Orange Detector	Yes	Yes	Yes	Yes	Yes
Red Detector	Yes	Yes	Yes	Yes	Yes
Blue Detector	Yes	Yes	Yes	Yes	Yes
Green Detector	Yes	Yes	Yes	Yes	Yes
Yellow Detector	Yes	Yes	Yes	Yes	Yes
Black Detector	Yes	Yes	Yes	Yes	Yes
White Detector	Yes	Yes	Yes	Yes	Yes

4.3 VERIFICATION

Data verification of in-field gamma radiation survey data is the process for evaluating completeness, correctness, consistency, and compliance of a data package against the SAP. In this context, “completeness” means all required hard-copy and electronic deliverables are present. For in-field gamma radiation survey compliance verification, the primary evaluation involves completeness of gamma radiation surveys performed during the 2021 field investigation. A number of documents pertaining to the in-field gamma radiation survey compliance verification evaluation are as follows:

- A photographic log of the in-field gamma radiation surveys is in [Appendix A](#) to the main report.
- A detailed methodology regarding the gamma-radium correlation study is presented as the Gamma Correlation Report in [Appendix E](#) to the main report.



- The scanned field forms relating to in-field gamma radiation surveys are included as [Appendix F](#) to the main report.

5.0 VALIDATION AND VERIFICATION OF FIELD SURVEY DATA

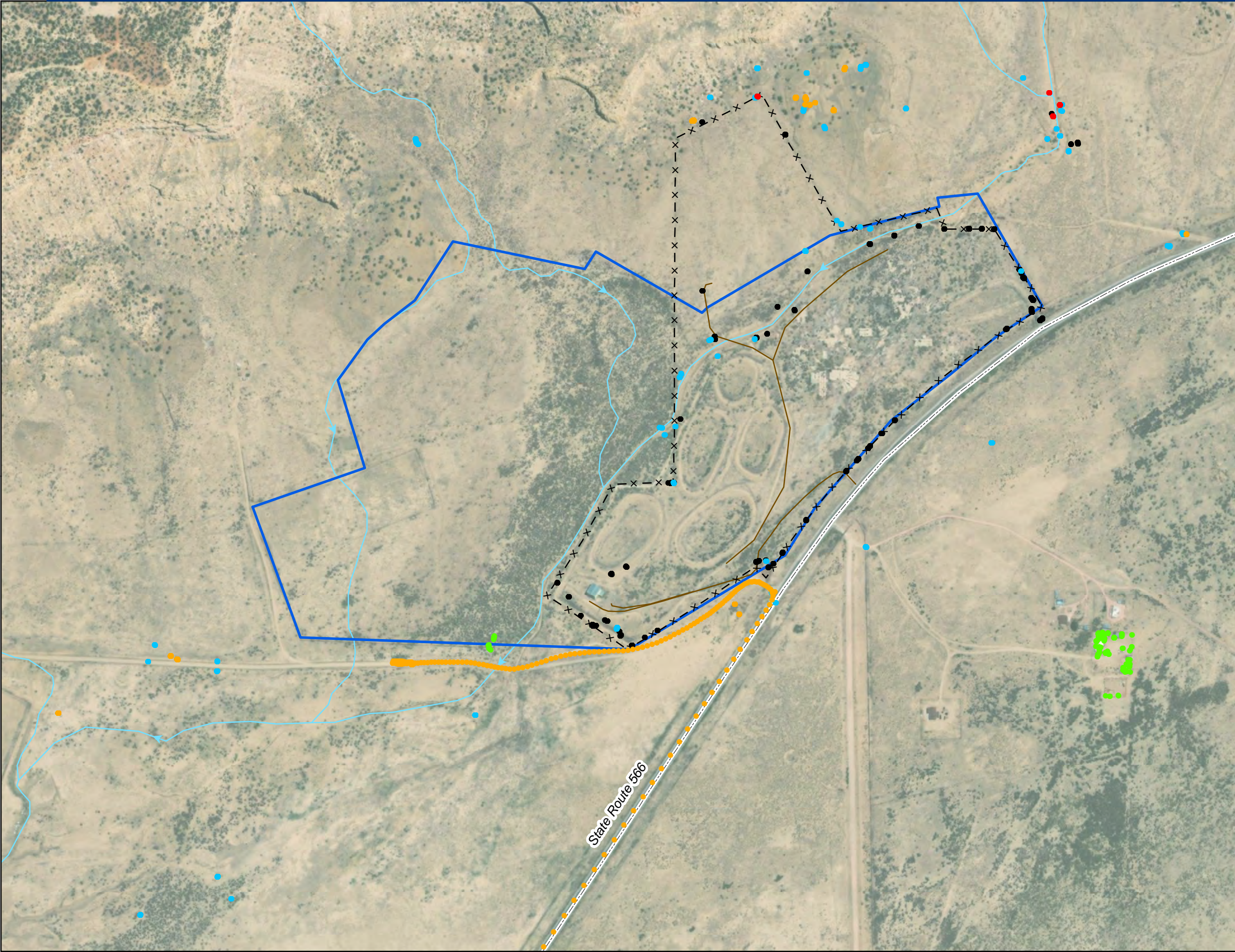
The objective of validating gamma survey data is to ensure all gamma survey data are screened for erroneous readings. Following collection of survey data, Geographic Information System (GIS) or other appropriate software shall be used to evaluate data quality associated with gamma levels, GPS accuracy, and survey indicators by:

- Screening for erroneous values including abnormally high or low gamma values, spikes in data indicating a cable issue, zeros indicating a malfunctioning detector or cable, and distribution.
- Evaluating quality of GPS data through verification of horizontal dilution of position (HDOP) and vertical dilution of position (VDOP), number of satellites, and visual inspection of the data to capture signal reflection.
- Evaluating user performance characteristics including surveyor speed and coverage through spot checking of data.

The following attachments are provided to support validation and verification of field survey data:

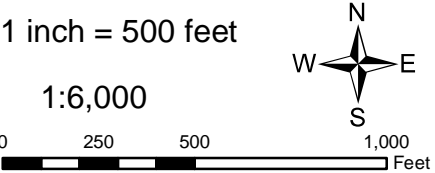
- [Attachment B-2](#) – Detector and Meter Serial Numbers and Dates of Use
- [Attachment B-3](#) – Gamma Survey MetaData (.gsf)
- [Attachment B-7](#) – Excluded Gamma Survey Data (.shp)
- [Attachment B-8](#) – Final Gamma Survey Data (.shp)

[Figure B-36](#) shows excluded gamma data. [Figure B-37](#) shows the final data set color coded to instrument identification. [Table B-10](#) summarizes data excluded from the final dataset, including date acquired, impacted data file, number of datapoints removed, justification for removal, and user. All data summarized in [Table B-10](#) are included in a SHP file as [Attachment B-7](#). The final gamma survey dataset, which comprises all data from [Attachment B-3](#) minus any excluded data, is included in a SHP file as [Attachment B-8](#). SHP files can be viewed in ESRI ArcMap, QGIS, or similar software.



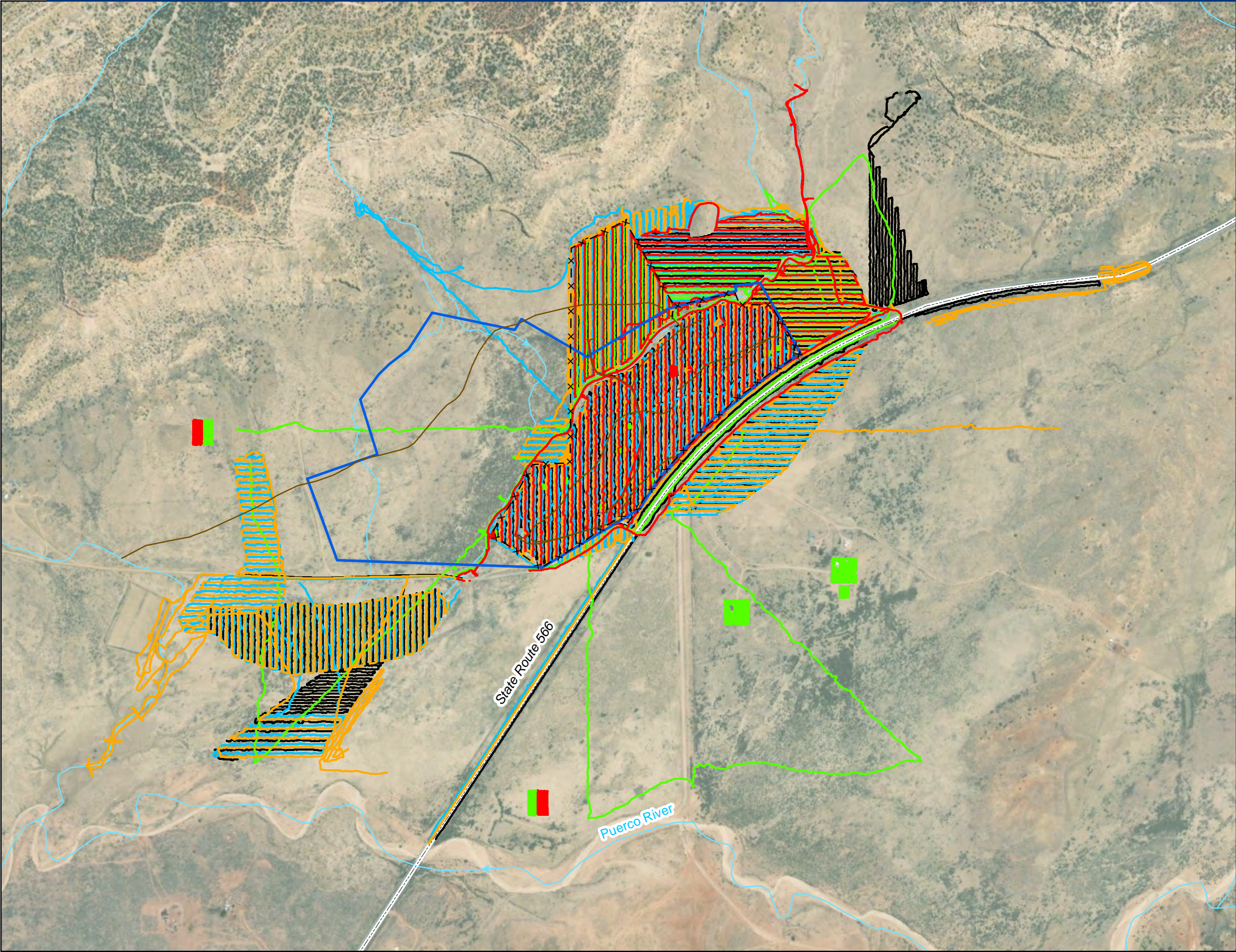
- Excluded Gamma Data¹**
- Black Detector
 - Blue Detector
 - Green Detector
 - Orange Detector
 - Red Detector
 - 2007 USEPA Navajo AUM Atlas Polygon
- Site Features**
- × — Fenced Boundary
 - Drill Road - Fall 2022
 - Community Road
 - Surface Water Pathway

Notes:
¹An additional 970 data points not shown were recorded during demobilization to nightly lodging.
AUM Abandoned uranium mine



OLD CHURCH ROCK MINE
EXCLUDED GAMMA DATA
COLOR CODED TO INSTRUMENT ID

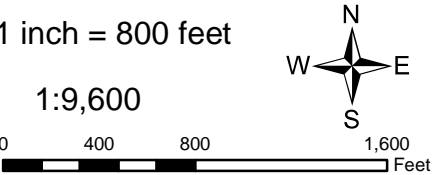
Prepared For: U.S. EPA Region 9	Prepared By:
	 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: B-36



- Final Gamma Dataset**
- Black Detector
 - Blue Detector
 - Green Detector
 - Orange Detector
 - Red Detector
 - ▭ AUM Site Boundary

- Site Features**
- × — Fenced Boundary
 - Facility Road
 - Community Road
 - Surface Water Pathway

Notes:
¹An additional 970 data points not shown were recorded during demobilization to nightly lodging.
AUM Abandoned uranium mine



OLD CHURCH ROCK MINE
FINAL GAMMA DATASET
COLOR CODED TO INSTRUMENT ID

Prepared For: U.S. EPA Region 9 	Prepared By: TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/17/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: B-37

Table B-10. Data Exclusion Log

Date	Affected Dataset	Initial Records	Records Removed	Reason for Exclusion	User (Initials)
11/14/2022	111422-085300-26-blue-OCRM-MB	12982	138	Cluster of datapoints	MB
11/14/2022	111422-090424-1_black ocrm sk	15420	1991	Cluster of datapoints	SK
11/15/2022	111522-125725-33-red-ocrm-sk	11830	177	Cluster of datapoints	SK
11/16/2022	111622-101449-1-Black-OCRM-SC	9843	196	Cluster of datapoints	SC
11/16/2022	111622-103133-26-blue-OCRM-MB	13012	735	Cluster of datapoints	MB
11/18/2022	111822-094244-38-green-ocrm-mq	8058	157	GPS VDOP/HDOP	MQ
11/18/2022	111822-093922-26-blue-OCRM-MB	14775	150	Cluster of datapoints	MB
11/19/2022	111922-090705-44-Orange-OCRM-CP	19681	1803	Gamma survey meter left on during demobilization	CP
11/19/2022	111922-090705-44-Orange-OCRM-CP	19681	769	Cluster of datapoints	CP
11/19/2022	111922-093915-26-Blue-OCRM-MB	17538	586	Cluster of datapoints	MB

Notes:

GPS Global Positioning System

VDOP Vertical dilution of precision

HDOP Horizontal dilution of precision



6.0 REFERENCES

American National Standards Institute (ANSI). 1997. “American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.”

Tetra Tech, Inc. (Tetra Tech). 2022. “OCRM Removal Assessment Sampling and Analysis Plan.” Response, Assessment, and Evaluation Services. Contract No. EP-S9-17-02. Task Order 0035.

U.S. Environmental Protection Agency (USEPA). 2000. *Multi-Agency Radiation Survey and Site Investigation Manual*. August.

USEPA. 2004. *Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)*. July.

**ATTACHMENT B-1: SOP NO. 002 “PERFORMING A GPS-BASED
GAMMA RADIATION SURVEY”**

Environmental Standard Operating Procedure

**SOP No. 002
Performing a GPS-Based Gamma
Radiation Survey**



Tetra Tech, Inc.

Environmental Restoration Group, Inc.



February 2018



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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for performing a gamma radiation survey using a survey meter and gamma radiation detector coupled to a global positioning system (GPS).

A radiation survey is often performed to provide a spatially representative radiological condition of an area. By combining the radiological survey instruments to a GPS unit the survey data and associated positions can be logged in electronic format for use in GIS. Depending upon the goals of the survey and the terrain or the survey area a GPS-based radiological survey may be performed with the system setup carried by the surveyor (backpack) or setup for use on a vehicle (push cart, utility terrain vehicle, and truck).

To perform a project related GPS-based radiological survey personnel must be recognized on their ERG Training Qualification Form as qualified to perform this procedure.

2.0 PRECAUTIONS

The following precautions will be observed during GPS-based radiation survey:

- The radiation protection plan (Attachment D-6 in Appendix D) will be followed.

3.0 EQUIPMENT AND MATERIALS

The following equipment is required for performing a GPS-based radiological survey:

- GPS survey system of mapping grade or better (sub-meter accuracy) – Juniper Systems Mesa2 and Geode, Trimble ProXRT, ProXH, or similar with data logger/controller.
- Gamma radiological survey instruments with RS-232 data output or Bluetooth output – Ludlum Model 2221 ratemeter/scaler or Ludlum Model 4612 counter matched with a Ludlum Model 44-10 (2-inch by 2-inch NaI), Model 44-20 (3-inch by 3-inch NaI), Field Instrument for Detection of Low Energy Radiation (FIDLER) detector, or similar radiation detector.
- Radiological check source – Use a cesium 137 (Cs-137) or americium 241 (Am-241) source for typical function check of a high-energy gamma detector or low-energy gamma detector such as a FIDLER, respectively. Check sources used are depend on the goal of the survey. While the sources listed above are for typical function checks, they are not required to be NIST-traceable. NOTE: Select check sources that will provide a minimum accumulation of 5,000 gross counts during the counting interval, typically one minute.
- All appropriate cables, including GPS antenna cable as necessary, RS-232 cable from meter to GPS data logger, C-cables from meter to detector, and others as necessary.
- Detector rack to hold multiple detectors at set height above ground surface, as necessary when performing a survey using a push cart, UTV, or truck.

4.0 PROCEDURE

The following procedures will be used for performing a GPS-based gamma radiation survey.



4.1 SETUP

Setup the survey system hardware by assembling the GPS backpack or detector rack (push cart, UTV, and truck), as appropriate. Connect cabling and/or Bluetooth connection(s) between GPS units, antennas, ratemeter/scaler/counters, detectors, and data loggers or controller, as necessary. Use sufficient cabling such that it will be safe and secure from damage or unintended disconnection. If performing a vehicle survey, mount rack to vehicle and attach detectors to rack. The GPS data loggers or controllers are typically setup to record the external sensor (ratemeter/scaler/counter) output with associated position every one second.

4.2 FUNCTION CHECK

Perform function check of the radiological survey instrument(s) per the safe work practices for Operational Checkout of Single-Channel Detector with Meter in the radiation protection plan or Operational Checkout of a Single-Channel Detector Array with Ludlum Model 4612 provided in the radiation protection program, whichever is applicable, before and after each day of use.

4.3 SURVEY

- SURVEY FILE NAME – Open a new survey file and give it a unique file name indicative of the survey. The file name could include the survey date and/or time, the surveyor initials, and/or the site name. NOTE: The default Trimble Terrasync naming format is RmmddhhA; where a file name begins with the letter R (rover), followed by the date and hour, and ends with a letter signifying the order the file was created within the hour (A: first, B: second, etc.). When multiple dataloggers are used the surveyor should add their initials and/or a description (R/L; right/left, 1: first, etc.) to the end of the file.
- WHEN SURVEYING –
 1. Turn the ratemeter/scaler/counter on prior to beginning a survey file. NOTE: the unit is not turned on prior to opening a survey file the initial recorded gamma count rate records will be low.
 2. Begin and end a survey data file at a point/location where it is desirable to collect data. Do not start a survey file when near the function check source.
 3. Close the survey file upon completion of the survey. If taking a break create a new survey file upon resuming the survey.
- SURVEY DESIGN - Perform the survey by either walking (backpack), pushing (push cart), or driving (UTV or truck) the survey equipment following the survey design, typically provided in a work plan. The survey design depends on the goal of the survey and the equipment and should take into account the radiation detector type and model, survey scan speed, detector spacing, and height of detector above ground during the survey. Some of these design parameters may be depend on the terrain of the survey area.
 1. DETECTOR – Choose a detector that is appropriate to meet the goals and/or requirements of the survey. For middle to high-energy gamma emitting radiation it is common to use the Model 44-10, Model 44-20, or similar detector. For low-energy emitting radiation a FIDLER detector may be more suitable. If surveying in an area where gamma shine is an issue, then

use of a detector shield may be appropriate. The project work plan will typically prescribe the type of detector to be used.

2. **SURVEY SCAN SPEED** – Use the designed survey scan speed or choose a range that is appropriate to meet the goals and/or requirements of the survey. A survey scan speed that is too fast may not allow for a detector to be present over a localized area of elevated gamma count rates long enough to adequately represent the conditions. For an area believed to have homogenous gamma count rates a slower survey scan speed may be unnecessary and inefficient. The project work plan will typically prescribe the survey scan speed.
3. **DETECTOR SPACING** – Attempt to cover the survey area adequately with an appropriate detector spacing to meet the goals and/or requirements of the survey. If surveying over an area known to have homogenous gamma count rates, then a wider/farther apart detector spacing may be appropriate. When surveying over an area where radiological conditions are unknown or known to have small localized areas of elevated readings, then a tighter/closer detector spacing may be warranted. A combination of detector spacing may also be appropriate; tighter detector spacing in areas of elevated readings and wider spacing in areas of homogenous readings. The project work plan will typically prescribe the detector spacing.
4. **DETECTOR HEIGHT** – The detector height above ground should be chosen to meet the goals and/or requirements of the survey. Attempt to maintain the same detector height throughout the survey. The project work plan will typically prescribe the detector height.

4.4 DATA PROCESSING AND REVIEW

Upon completion of a GPS-based radiological survey download the data from the datalogger(s) or controller and convert into usable format, typically a GIS shapefile format. Process and review the data in accordance with SOP No. 006 Validation and Verification of Gamma Survey Data. Resurvey areas where data is unexplainably missing, corrupt, or there is reason to believe the results are in error.

**ATTACHMENT B-2: DETECTOR AND METER SERIAL NUMBERS
AND DATES OF USE**

Ludlum Meter SN	Ludlum Meter Model	Ludlum Model 44-10 SN	Event	Event Color	Dates Used	User	GSF Filename / PDF Fieldform
254783	2221	PR399729	OCRM	Black	11/14/2022	SK	111422-090424-1_black ocrm sk.gsf
			Section 32/33		11/15/2022	SK	111522-095015-1-black-s32-33-sk.gsf
			OCRM		11/16/2022	SC	111622-101449-1-Black-OCRM-SC.gsf
			Section 32/33		11/17/2022	SK	111722-094631-1-black-32-33-sk.gsf 111722-014501-1-black-32-33-sk 2.gsf 111722-014834-1-black-32-33-sk 3.gsf
			OCRM		11/18/2022	BB	111822-094029-1_Black_BSB_OCRM.gsf
			OCRM		11/19/2022	BB	111922-101237-1_Black_BSB_OCRM.gsf
25016973	3000	PR150857	OCRM	Blue	11/14/2022	MB	111422-085300-26-blue-OCRM-MB.gsf
			Section 32/33		11/15/2022	MB	111522-094949-26-blue-s32-33-MB.gsf
			OCRM		11/16/2022	MB	111622-103133-26-blue-OCRM-MB.gsf
			Section 32/33		11/17/2022	MB	111722-095815-26-Blue-32-33-MB.gsf
			OCRM		11/18/2022	MB	111822-093922-26-blue-OCRM-MB.gsf
			OCRM		11/19/2022	MB	111922-093915-26-Blue-OCRM-MB.gsf
25020102	3000	PR406319	OCRM	Red	11/14/2022	SC	111222-112652-33-Red-OCRM-SC.gsf
			OCRM		11/15/2022	MQ	111522-111852-33-red-ocrm-mq.gsf
			OCRM		11/16/2022	SK	111622-125725-33-red-ocrm-sk.gsf
			Section 32/33		11/17/2022	MC	111722-122949-33_Red_MEC_3233.gsf
			Section 32/33		11/18/2022	SK	111722-011412-33corrplors.gsf
			OCRM		11/19/2022	SK	111722-115125-33-ocrmcorr.gsf 111822-042536-33-ocrm-ablation.gsf
25018543	3000	PR355810	OCRM	Orange	11/14/2022	CP	111422-085312-44-orange-OCRM-CP.gsf
			Section 32/33		11/15/2022	CP	111522-021533-44-Orange-S 32 33-CP.gsf 111522-092757-44-Orange-Section 32 33-CP.gsf
			OCRM		11/16/2022	CP	111622-094515-44-Orange-OCRM-CP.gsf
			Section 32/33		11/17/2022	CP	111722-091731-44-Orange-S 32 33-CP.gsf
			OCRM		11/18/2022	CP	111822-084955-44-Orange-OCRM-CP
			OCRM		11/19/2022	CP	111922-090705-44-Orange-OCRM-CP.gsf
			OCRM		11/20/2022	MQ	112022-084804-44-orange-ocrm-mq.gsf
25017006	3000	PR295014	OCRM	Yellow	11/14/2022	AM	111422-085423-5-yellow-OCRM-AM.gsf
			Section 32/33		11/15/2022	AM	111522-093836-5-yellow-sec3132-AM.gsf
			OCRM		11/16/2022	AM	111622-095723-5-yellow-OCRM-AM.gsf
			Section 32/33		11/17/2022	AM	111722-100303-5-yellow-3233-AM.gsf

Ludlum Meter SN	Ludlum Meter Model	Ludlum Model 44-10 SN	Event	Event Color	Dates Used	User	GSF Filename / PDF Fieldform
			OCRM		11/18/2022	AM	111822-094124-5-yellow-OCRM-AM.gsf
			OCRM		11/19/2022	AM	111922-090833-5-yellow-OCRM-AM.gsf
25018610	3000	PR355771	Section 32/33	Green	11/14/2022	BB	111422-020554-38_BSA2Test.gsf 111422-022515-38_3233_BSA2_4real.gsf 111422-031420-38_3233_CorrPlot_BSA2.gsf 111422-040819-38_3233_OCRM_corrPlot.gsf 111422-103712-38_3233BSA1.gsf 111422-103838-38_3233_BSA1.gsf 111422-115707-38_3233_BSA2.gsf
			OCRM		11/15/2022	BB	111522-085557-38_Green_BSB__OCRM.gsf
			OCRM		11/16/2022	BB	111622-101416-38_Green_BSB_OCRM.gsf
			Section 32/33		11/17/2022	BB	111722-101512-38_Green_BSB_3233.gsf
			OCRM		11/18/2022	MQ	111822-094244-38-green-ocrm-mq.gsf
			OCRM		11/19/2022	MQ	111922-093927-38-green-ocrm-mq.gsf
117357	2221	PR375296	Section 32/33	White	11/14/2022	JH/MC	2022_11_14_BSA1_BSA2_SoilSampling.pdf
			Section 32/33		11/15/2022	JH/MC	2022_11_15_BSA2_MainSite_SoilSampling.pdf
			OCRM		11/16/2022	JH/MC	2022_11_16_BSA2_Ponds_SoilSampling.pdf
			Section 32/33		11/17/2022	JH/MC	2022_11_17_MainSite_SoilSampling.pdf
			OCRM		11/18/2022	JH/MC	2022_11_17_MainSite_SoilSampling.pdf

Notes:

SK Sean Kit
SC Seth Crank
BB Braden Belliveau
MB Molly Baron
MQ Marcus Quinlan
MC Margaret Carolan
CP Christine Phillips
AM Anya Mikheicheva
OCRM Old Church Rock Mine

**ATTACHMENT B-3: RAW GAMMA MEASUREMENT FILES
(ELECTRONIC)**

ATTACHMENT B-4: GAMMA QA/QC PROCEDURES

samples to laboratories for definitive measurement of contamination. The fallible and definitive datasets will be strategically collected to allow for the statistical analysis and correlation of both datasets. This correlation of high-density fallible data with lower-density definitive data allows for the definition of a mathematical relationship between the two datasets. The fallible dataset can then be mathematically corrected to provide statistically defensible, laboratory-like results with near 100 percent coverage of the target population. This sampling approach is based on well-accepted methodology such as the double sampling approach (Gilbert 1987). Statistical approaches to correlating fallible and definitive datasets are also well-defined and accepted (Gilbert 1987; USEPA 2002a). The double sampling approach is defined as requiring strong linear correlation between the fallible and definitive datasets (Gilbert 1987). The nature of the relationship between fallible and definitive datasets that will be collected under TO 0001 is not yet known and experience indicates that relationships could be linear, logarithmic, or power-based. As a result, Tetra Tech is referring to this sampling approach as “paired sampling” in this SAP/QAPP.

Tetra Tech will use this paired sampling strategy for both gamma radiation and metals contamination investigations. The specific methods that will be used to implement the paired sampling strategy, as well as the methods used to accomplish the remaining primary Baseline Study goals are detailed in the sections below.

4.1.1.1 *Gamma Radiation Surveys*

Tetra Tech will perform GPS-based gamma radiation surveys (gamma surveys) of the land areas at each investigation area as part of the Baseline Study, including background reference areas and mine claim areas and roads and drainages that extend hydraulically (or by wind) downgradient from the mine claims, and will expand the surveys to the areal limits of contamination defined by an investigation level for Ra-226. Tetra Tech has tailored its gamma survey approach to provide near-comprehensive assessment of the target population of surface soil. Gamma survey measurements represent the fallible dataset within the paired sampling approach and will be mathematically related to both analytical results for radioactive COPCs (most notably Ra-226), and exposure rate measurements collected using a high-pressure ionization chamber (HPIC).

The purpose of performing GPS-based gamma surveys is to:

- Define the areal extent of TENORM;
- Help establish a basis from which the subsurface can be investigated;
- Establish a basis that can be used to predict Ra-226 concentrations across a site; and
- Establish a basis that can be used to predict exposure rates across a site

The use of GPS-based radiation survey systems has become a mature method for characterizing the spatial distribution of gamma radiation due to NORM in soils (Adsleya and others 2004; Johnson and others 2006; Meyer and others 2005; Vitkus and Bailey 2007; Whicker and others 2008). Furthermore, these types of systems are well-suited to outdoor gamma radiation surveys in terms of cost, portability, coverage, durability, and high sensitivity to terrestrial sources of low-level gamma radiation (Whicker and others 2015).

The gamma radiation surveys will be performed using Ludlum Model 44-10 (or equivalent) 2-inch by 2-inch NaI detectors each coupled to a Ludlum Model 2221 (or equivalent) ratemeter/scaler set in ratemeter mode. For this project, Tetra Tech plans to utilize these detectors coupled to an ERG Model 105 GPS (or equivalent). The ERG Model 105 GPS consists of a Juniper Mesa 2 field computer and geode GPS receiver (or equivalent). The surveys will be conducted on foot at approximately 3 feet per second along 2-meter transects. The detectors will be positioned at 1 meter above ground surface. The “field of view” of the sodium iodide detector in this configuration (2-meter transects and 1-meter height) provides 100 percent coverage of land areas.

Gamma count rate measurements and associated geospatial coordinates will be made and recorded every one second. The output will be converted to exposure rates in microroentgens per hour ($\mu\text{R/hr}$) using a correction factor published by Ludlum Measurements for the Ludlum Model 44-10 (or equivalent), after which the measurements will be correlated to an energy independent HPIC (see Section 4.1.1.3).

All Ludlum Model 44-10/2221 (or equivalent) instrument systems used in the gamma surveys will be calibrated in accordance with “American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments” (ANSI, 1997), RPP SOP 002: Calibration of a Radiological Survey Meter, and RPP SOP 001: Calibration of a Radiological Survey Detector. Calibration of the detection systems is required prior to their initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect their operation. General maintenance of the detection systems, such as cleaning, painting, and changing buttons, does not require that they be calibrated. The instruments will be function-checked daily, before at the end of each work day in accordance with RPP SOP No. 009: Operational Checkout of Single Detector with Meter. The SOPs mentioned in this subsection are attached in Attachment C-1 to this SAP/QAPP, and a summary of instrument calibration and functional checks is provided in Table C-9.

Table C-9. Gamma Radiation Survey Equipment Summary

Equipment	Use/Calibration Summary	Relevant SOP No.
Ludlum 2221/ Ludlum 44-10 (or equivalent)	<p>Use: Ludlum 2221 ratemeter/scaler instruments will be paired with Ludlum 44-10 NaI detectors or similar to measure surface gamma radiation. This detection system will be paired with a GPS unit and data logger to record gamma survey results in real-time.</p> <p>Calibration: Each system (Ludlum 2221/44-10 pair or equivalent) will be calibrated at least annually. Calibration will also be performed following any maintenance or repair that could affect functionality.</p> <p>Functional Checks: Checks are performed on each system each day that they are used. One check is performed prior to use, and one check when all measurement activities have been completed for the day. Checks utilize a standardized source, and net results (source less background counts) must be within $\pm 20\%$ of the results established as part of ongoing control charting.</p>	RPP SOP 001 RPP SOP 002 RPP SOP 009

Table C-9. Gamma Radiation Survey Equipment Summary

Equipment	Use/Calibration Summary	Relevant SOP No.
ERG Model 105 GPS	Use: The ERG Model 105 GPS system will be used to pair radiation instruments with GPS units to simultaneously record gamma measurements with geospatial locations. The system uses a handheld tablet computer to collect and display survey results in real-time and protect the data from manipulation. Calibration: NA Functional Checks: NA	NA

Notes:

ERG	Environmental Restoration Group, Inc.
GPS	Global positioning system
NA	Not applicable
NaI	Sodium iodide
RPP	Radiological protection plan
SOP	Standard operating procedure

There will be slight variations to the data collection methodology described above during the assessments of roads and drainages.

- **Roads:** GPS-based gamma surveys will be performed on access/hauling roads to a distance of 0.25 mile from investigation areas. Gamma surveys will use the methodology described above, resulting in 100 percent survey coverage.
- **Drainages:** GPS-based gamma surveys will be performed along drainages near sites to a distance of 1 mile downstream from investigation areas, or until the first junction with another drainage channel. Gamma surveys will use the methodology described above, but may be prevented from reaching 100 percent survey coverage because of rough terrain or the presence of standing/running water in the drainages.

The measurements collected from each site will be used to:

- Estimate the areal extent of TENORM on land surfaces and identify anomalies in site conditions;
- Determine provisional areas that field personnel can use to select plots for the correlation studies described in Section 4.1.1.2;
- Predict Ra-226 concentrations and energy independent exposure rates across the sites (see Sections 4.1.1.2 and 4.1.1.3 for descriptions of these activities);
- Evaluate the scan MDC for the Ludlum Model 44-10 (or equivalent) sodium iodide detector, which is addressed in Section 3.2.1 of the SAP/QAPP.

The gamma measurements at a particular site will be processed after they have been collected by (1) overlaying 100 m² grids across the site, (2) estimating the average of the gamma measurements within each grid, (3) comparing these averages to ILs, and (4) stopping or guiding additional surveys as follows:

- If the gamma measurements made in the survey area, particularly along the perimeter of a survey area, are below the corresponding investigation level (IL), then the area will be considered accurate or defined, the survey complete, and sufficient information at that point will be available to estimate the lateral extent of TENORM. The information garnered from the XRF surveys described in Section 4.1.1.4 of this SAP/QAPP also will be considered in this decision.
- If the gamma and XRF surveys indicate clusters of point values above their ILs within drainages or other migration pathways, then the survey areas will be extended.

4.1.1.2 Gamma-Radium Correlation Study

Gamma count rates depend on a variety of conditions including the type of instruments, the configuration of the instruments (for example, height above ground surface [ags]), soil moisture, and instrument settings. If the gamma measurements are not related to a common parameter (such as concentrations of Ra-226 in soil or exposure rates), their comparison to data collected under different conditions using different equipment can be considered erroneous.

Tetra Tech will avoid this potential issue by performing two types of correlation studies to establish site-specific and regionally applicable statistical relationships between (1) gamma exposure rates as measured by the Ludlum 44-10 (or equivalent) and Ra-226 concentrations in surface soil, and (2) gamma count rates measured using a Ludlum 44-10 (or equivalent) and exposure rates measured using an HPIC. This section focuses on the gamma – Ra-226 correlation study; for additional details on the gamma – exposure rate correlation study, see Section 4.1.1.3.

The purpose of the gamma-radium correlation study is to translate the relatively high-density gamma measurements to more meaningful predicted concentrations of Ra-226. Predicted concentrations of Ra-226 are more useful for estimating volumes of TENORM that may require removal during future remediation activities.

Tetra Tech will correlate gamma count rates to concentrations of Ra-226 in surface soil and sediment according to the framework in SOP No. 001 (Attachment C-1 to this SAP/QAPP). Using the following method, Tetra Tech will:

- Select correlation study areas for a subset or individual AUM sites exhibiting gamma measurements that envelop likely future decision points, such as potential cleanup levels for Ra-226 in surface soils. Gamma measurements that represent relatively high concentrations of Ra-226 in surface soils — on the order of greater than 20 pCi/g — will be removed in a remedial action. Thus, the predicted concentrations of Ra-226 at such levels need not be known for the volume estimate.
- Establish 10-meter by 10-meter (100 m²) study plots in the areas, the number and location of which will be based on the discussion above and as determined by field personnel if the gamma measurements are relatively homogeneous. A minimum of 10 study plots will be established at AUM sites. A minimum of two study plots will be established at Target sites (primarily as a result of the smaller size of Target sites). During assessments of roads, correlation plots will be established only if there are field

ATTACHMENT B-5: CALIBRATION CERTIFICATES



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:	117357
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR375296

☒ 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 ☒ 60-inch ☐ Other:
☒ Geotropism ☒ Audio Check
☒ Meter Zeroed ☒ Battery Check
 Source Distance: ☐ Contact ☒ 6 inches ☐ Other: Threshold: 10 mV Barometric Pressure: 24.43 inches Hg
 Source Geometry: ☒ Side ☐ Below ☐ Other: Window: Temperature: 72 °F
 Pulser: Ludlum 500-1 sn 201932 Multimeter: n/a Relative Humidity: 20 %
 Instrument found within tolerance: ☒ Yes ☐ No

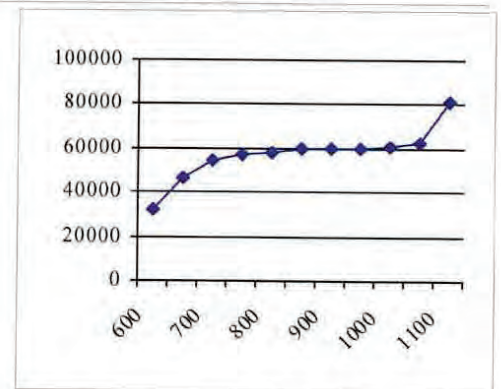
Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	400211	400
x 1000	100	100	100		100
x 100	400	400	400	40024	400
x 100	100	100	100		100
x 10	400	400	400	4003	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

Count Time (min): 1.0

High Voltage Source Counts Background Counts Net Counts

600	31976	2659	29317
650	46352	5358	40994
700	54384	7883	46501
750	56700	8686	48014
800	58342	9103	49239
850	59497	9225	50272
900	59506	9159	50347
950	59868	9268	50600
1000	60388	9494	50894
1050	62062	9977	52085
1100	80810	12312	68498

Voltage Plateau



Recommended HV (VDC) 1,000

Additional Comments:

Source 1 Cs-137 sn:4097-03 5.2μCi (1/4/12) button

Total Efficiency: n/a 4π Efficiency: n/a

Source 2

Total Efficiency: n/a 4π Efficiency: n/a

NOTE: The total efficiency provided is calculated per ISO-7503/NUREG 1575 (MARSSIM): Total Efficiency = Instrument Efficiency × Source Efficiency; where Instrument Efficiency is calculated as net counts ÷ source 2π emission rate. The 4π efficiency is calculated as net counts ÷ source 4π activity. The provided efficiencies are radionuclide specific and are calculated using source counts and background counts at the recommended operating HV. The provided efficiencies are for general information purposes only and are not intended to replace user efficiency calculation method or results.

Calibrated By:

Calibration Date: 9/21/22

Calibration Due: 9/21/23

Reviewed By:

Date: 9/22/22



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:	254783
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR391729

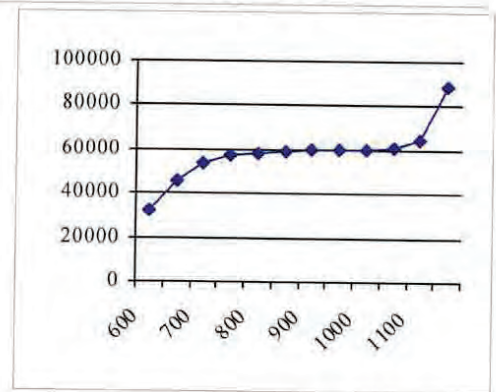
<input checked="" type="checkbox"/> Mechanical Check	<input checked="" type="checkbox"/> THR/WIN Operation	HV Check (+/- 2.5%):	<input checked="" type="checkbox"/> 500 V	<input checked="" type="checkbox"/> 1000 V	<input checked="" type="checkbox"/> 1500 V
<input checked="" type="checkbox"/> F/S Response Check	<input checked="" type="checkbox"/> Reset Check	Cable Length:	<input type="checkbox"/> 39-inch	<input checked="" type="checkbox"/> 60-inch	<input type="checkbox"/> Other:
<input checked="" type="checkbox"/> Geotropism	<input checked="" type="checkbox"/> Audio Check	Barometric Pressure:	24.43	inches Hg	
<input checked="" type="checkbox"/> Meter Zeroed	<input checked="" type="checkbox"/> Battery Check	Threshold:	10 mV	Temperature:	73 °F
Source Distance:	<input type="checkbox"/> Contact	<input checked="" type="checkbox"/> 6 inches	<input type="checkbox"/> Other:	Window:	
Source Geometry:	<input checked="" type="checkbox"/> Side	<input type="checkbox"/> Below	<input type="checkbox"/> Other:	Relative Humidity:	20 %
Pulser	Ludlum 500-1 sn 201932	Multimeter	n/a	Instrument found within tolerance:	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	400176	400
x 1000	100	100	100		100
x 100	400	400	400	40020	400
x 100	100	100	100		100
x 10	400	400	400	4003	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

Count Time (min): 1.0

High Voltage	Source Counts	Background Counts	Net Counts
600	31799	2484	29315
650	45343	5141	40202
700	53544	7752	45792
750	56804	8512	48292
800	58443	9036	49407
850	59284	9223	50061
900	59755	9194	50561
950	60156	9415	50741
1000	60185	9485	50700
1050	60968	9683	51285
1100	63926	10483	53443
1150	88037	12858	75179

Voltage Plateau



Recommended HV (VDC) 1,000

Additional Comments:

Source 1 Cs-137 sn:4097-03 5.2μCi (1/4/12) button

Total Efficiency: n/a 4π Efficiency: n/a

Source 2

Total Efficiency: n/a 4π Efficiency: n/a

NOTE: The total efficiency provided is calculated per ISO-7503/NUREG 1575 (MARSSIM): Total Efficiency = Instrument Efficiency × Source Efficiency; where Instrument Efficiency is calculated as net counts ÷ source 2π emission rate. The 4π efficiency is calculated as net counts ÷ source 4π activity. The provided efficiencies are radionuclide specific and are calculated using source counts and background counts at the recommended operating HV. The provided efficiencies are for general information purposes only and are not intended to replace user efficiency calculation method or results.

Calibrated By: 

Calibration Date: 9/21/22 Calibration Due: 9/21/23

Reviewed By: 

Date: 9/22/22



Designer and Manufacturer
of
Scientific and Industrial
Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.

501 Oak Street
325-235-5494

Sweetwater, TX 79556, U.S.A.



CERT # 4084.01

Customer ENVIRONMENTAL RESTORATION GROUP

ORDER NO. 20415684/519368

Mfg. Ludlum Measurements, Inc. Model 3000

Serial No. 25017006

Mfg. Ludlum Measurements, Inc. Model 44-10

Serial No. PR295014

Cal. Date 26-Jan-22 Cal Due Date 26-Jan-23 Cal. Interval 1 Year Meterface 44-10 R

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 16 % Alt 712.9 mm Hg

☐ New Instrument ☐ Instrument Received ☐ Within Toler. +10% ☒ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity

☒ F/S Resp. ck. ☒ Reset ck. ☐ Window Operation ☐ Geotropism

☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) 4.4 VDC

☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 950 V Input Sens. 10 mV Det. Oper. 950 V at 10 mV Threshold Dial Ratio = mV

☒ HV Readout (2 points) Ref./Inst. 500 / 495 V Ref./Inst. 1500 / 1511 V

COMMENTS:

Deadtime: 6.5 µSec Overload checked but not set.

Calibration Constant: 531 e+8 Pulser calibration RATEMETER READOUT performed without deadtime.

Primary Units: R/hr Pulser calibration SCALER READOUT reflects 6 second count.

Primary Units Alarm: 5 mR/hr Calibrated using 5' C-cable.

Secondary Units: cpm

Secondary Units Alarm: 999 kcpm

Firmware: 5LC-N30.4382

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	5 mR/hr	4.15 mR/hr	4.50 mR/hr				
Digital	1 mR/hr	986 µR/hr	1.02				
	800 µR/hr	789	811 µR/hr				
	200 µR/hr	193	199				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading. Gamma uncertainty within 5.0% of reading. Neutron uncertainty within 7.0% of reading. Count rate uncertainty within 5.4% of reading

Digital Readout	REFERENCE	INSTRUMENT	INSTRUMENT	Scaler	REFERENCE	INSTRUMENT	INSTRUMENT
	CAL. POINT	RECEIVED	METER READING		CAL. POINT	RECEIVED	METER READING
	800K cpm	799 kcpm	799 kcpm		800K cpm	79.9K	79.9K
	200K cpm	199	199		200K cpm	19.9K	19.9K
	80K cpm	79.9	79.9		80K cpm	7.99K	7.99K
	20K cpm	19.9	19.9		20K cpm	2.00K	2.00K
	8K cpm	7.99	7.99		8K cpm	799	799
	2K cpm	1.99	1.99		2K cpm	200	200
	800 cpm	800 cpm	800 cpm		800 cpm	80	80
	200 cpm	201	201		200 cpm	20	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.

All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.

Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2.

The calibration system conforms to the requirements of ANSI/NCCL Z540-1-1994 and ANSI N323AB-2013

ISO/IEC 17025:2017(E)

State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☒ G112 ☒ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ☐ Beta S/N ☒ Other Am241(0.66µCi)

☒ m 500 S/N 251106 ☐ Oscilloscope S/N ☒ Multimeter S/N 15060230

Calibrator James McBeth

Title Calibrator

Date 26JAN22

QC'd By

Title Final QC

Date 26. Jan. 22

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

FORM C3000 01/22/2020

Page 1 of 2

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test
Only ☐ Failed:

Order #: 20415684/519368

Channel(s)

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10

Serial No.: PR295014

Instrument: Model 3000

Serial No.: 25017006

BKG Time: 6

Distance: Surface

Selected HV: 950

Date: Wednesday, January 26, 2022

Notes:

Signature:

James M. Burt

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

0.66 μ Ci

6

γ

High Voltage

Background

Am241

Reading

Reading

650

490

1,482

700

534

10,315

750

525

11,600

800

525

12,008

850

531

12,118

900

527

12,165

- 950

561

12,198

1000

590

12,116

1050

514

12,049

1100

529

12,197

1150

584

12,287

1200

656

12,682

1250

1,153

13,525

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25017006
1/26/2022 3:28:14 PM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25017006
Device Real Time Clock Day	26
Device Real Time Clock Hour	15
Device Real Time Clock Minutes	27
Device Real Time Clock Month	1
Device Real Time Clock Seconds	56
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	4
Device Backlight Threshold	1
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	120
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	100
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	1
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.342
Device 1 Channel 1 RawCnt	4654586

Device Calibration

Device Calibration High Voltage Slope	41
Device Calibration High Voltage Offset	-58
Device Calibration Channel [1] Pulse Threshold Offset	-31

Detector 1

Detector [1] Serial Number	PR295014
Detector [1] Model	44-10
Detector [1] High Voltage	950
Detector [1] Overload	100
Detector [1] Count Time	60
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	0
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	R/h
Detector [1] Unit [1] Rate Min Exponet	-6
Detector [1] Unit [1] Rate Max Value	0.007
Detector [1] Unit [1] Scaler Unit Type	R
Detector [1] Unit [1] Scaler Min Exponet	-6
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0.005
Detector [1] Unit [1] Scaler Alarm [1]	0
Detector [1] Unit [1] Scaler Alarm [2]	0
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	cpm
Detector [1] Unit [2] Rate Min Exponet	0
Detector [1] Unit [2] Rate Max Value	999000
Detector [1] Unit [2] Scaler Unit Type	counts
Detector [1] Unit [2] Scaler Min Exponet	0
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	999000
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	6.5
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	0
Detector [1] Channel [1] Calibration Constant	5.31E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0

Customer **ENVIRONMENTAL RESTORATION GROUP**
ORDER NO. **20421033/523055**

Mfg. **Ludlum Measurements, Inc.** Model **3000** Serial No. **25016973**
Mfg. **Ludlum Measurements, Inc.** Model **44-10** Serial No. **PR150851**
Cal. Date **16-Apr-22** Cal Due Date **16-Apr-23** Cal. Interval **1 Year** Meterface **44-10**

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. **74** °F RH **33** % Alt **701.0** mm Hg
☐ New Instrument ☐ Instrument Received ☐ Within Toler. $\pm 10\%$ ☒ $10-20\%$ ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments
☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☒ F/S Resp. ck ☒ Reset ck. ☐ Window Operation ☐ Geotropism
☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) **4.4** VDC
☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set **1100** V Input Sens. **10** mV Det. Oper. **1100** V at **10** mV Threshold **14.9** mV
☒ HV Readout (2 points) Ref./Inst. **500** / **497** V Ref./Inst. **1500** / **1505** V

COMMENTS:

Deadtime: 9.8 μ Sec
Cal Constant: 503e+8
Primary Units Alarm: 00.00 mR/hr
Secondary Units Alert: 00.00 kcpm
Firmware: 5LC-N42.4885

Calibrated using 5' C-cable.
Overload checked but not set.
Pulser calibration "RATEMETER READOUT" performed without deadtime.
Pulser calibration "SCALER READOUT" reflects 6 second count.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	5 mR/hr	4.38 mR/hr	5.16 mR/hr				
Digital	1 mR/hr	961 μR/hr	1.03 mR/hr				
	800 μ R/hr	773	823 μR/hr				
	200 μ R/hr	196	202 μR/hr				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

REFERENCE	INSTRUMENT	INSTRUMENT	REFERENCE	INSTRUMENT	INSTRUMENT
CAL. POINT	RECEIVED	METER READING	CAL. POINT	RECEIVED	METER READING
Digital Readout	800K cpm	797 kcpm	Scaler	800K cpm	79.7 k
	200K cpm	198		200K cpm	19.9 k
	80K cpm	79.7		80K cpm	7.97 k
	20K cpm	19.9		20K cpm	1.99 k
	8K cpm	7.98		8K cpm	798
	2K cpm	1.99		2K cpm	199
	800 cpm	800 cpm		800 cpm	80
	200 cpm	200 cpm		200 cpm	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors. Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2. ISO/IEC 17025:2017(E) State of Texas Calibration License No. LO-1963 The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☒ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N _____ ☐ Beta S/N _____ ☐ Other _____
☒ m 500 S/N **247891** ☐ Oscilloscope S/N _____ ☒ Multimeter S/N **17500076**

Calibrator **Scot VanAllen** Title **Calibrator** Date **16 APR 22**
QC'd By **Jeremy Thompson** Title **Final QC** Date **17 APR 23**

Order #: 20421033/523055

Customer: Environmental Restoration Group

Detector: 44-10

Serial No.: PR150851

Instrument: Model 3000

Serial No.: 25016973

BKG Time: 6

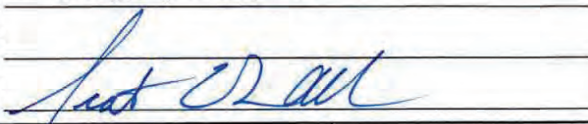
Distance: Surface

Selected HV: 1100

Date: Saturday, April 16, 2022

Notes:

Signature:



Channel(s)

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

n/a

0.79 μ Ci

6

γ

High Voltage

Background

Am241: n/a

Reading

Reading

500

63

101

550

132

199

600

245

409

650

328

664

700

421

1,419

750

432

9,564

800

421

10,524

850

474

11,247

900

470

11,421

950

407

11,475

1000

463

11,626

1050

432

11,681

1100

421

11,828

1150

426

11,764

1200

468

11,714

1250

558

11,770

1300

846

12,431

1350

1,546

14,264

Dev

Mdl	Model 3000
SN	25016973
Aud Lvl	Single
Conv R To Sv	0.0106
Fw	5LC- N42.4885
LB	0
Rate Reset Btn	Off
Setup Prtct	Normal
Sleep	0
Temp	49
V Bat	6.33

AuxCom

Crypto En	Off
Enable	On
Mode	LMI Direct
Write Prtct	Off

AutoMode

Interval	1
----------	---

Pwr

Auto Off Tm	0
Mode	On At Boot

BklThr

Sensitivity	Low
-------------	-----

High

Light Turn Off	100
Light Turn On	0

Low

Light Turn Off	120
Light Turn On	0

Cnt

Audio Mode	Off
Display Mode	Timer

Ext 1

Act Det Mem	0
----------------	---

Ch 1

Cal Raw Cnt	16450
Raw Cnt	10916632

Meas

Cur	25.7992
-----	---------

RTC

Day	16
-----	----

Hr	8
Mins	42
Mo	4
Sec	9
Yr	2022

DetMem 1

Mdl	44-10
SN	PR150851
Aud Sigma	Off
Count Tm	60
HV	1100
Op Mode	Rate/Max/ Count
Over Cur	100

Ch 1

CPS Offset	0
DTC 1	9.8E-06
DTC 2	0
Eff	15
LO Cnt Tm	60
R Cal Const	5.03E+10
Thr	0.01

Response

Rate	Slow
Time	3

Unit 1**Count**

Alrm 1	0
Alrm 2	0
Min Exp	000E-6
Unit	R

Rate

Alrm 1	0
Alrm 2	0
Max Val	999000
Min Exp	000E0
Unit	cpm

Unit 2**Count**

Alrm 1	0
Alrm 2	0
Min Exp	000E0
Unit	counts

Rate

Alrm 1	0
Alrm 2	0
Max Val	999
Min Exp	000E-6
Unit	R/h

LOG

ENABLE	0
MODE	1
NOTES	
USER	

AUTO

TM	60
----	----

NUM

MAX	1000
REC	0

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.

501 Oak Street
325-235-5494

Sweetwater, TX 79556, U.S.A.



CERT # 4084.01

Customer ENVIRONMENTAL RESTORATION GROUP

ORDER NO. 20425713/526297

Mfg. Ludlum Measurements, Inc. Model 3000

Serial No. 25018543

Mfg. Ludlum Measurements, Inc. Model 44-10

Serial No. *PR 355810*

Cal. Date	28-Jun-22	Cal Due Date	28-Jun-23	Cal. Interval	1 Year	Meterface	44-10 R
-----------	-----------	--------------	-----------	---------------	--------	-----------	---------

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 23 % Alt 703.8 mm Hg

☒ New Instrument Instrument Received ☒ Within Toler. $\pm 10\%$ ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity☒ F/S Resp. ck ☒ Reset ck. ☐ Window Operation ☐ Geotropism

☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) 4.4 VDC

☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set	900	V	Input Sens.	28	mV	Det. Oper.	900	V at	28	mV	Threshold Dial Ratio	=	mV
---------------------	-----	---	-------------	----	----	------------	-----	------	----	----	----------------------	---	----

✓ HV Readout (2 points)	Ref./Inst.	500	1	503	V	Ref./Inst.	1500	1	1498	V
-------------------------	------------	-----	---	-----	---	------------	------	---	------	---

COMMENTS:

Deadtime: 10μsec Calibrated using 5' C Cable

Cal Constant: 514 e+08 Alarms disabled

Primary Units: R/hr Overload checked but not set

Secondary Units: CPM Pulser Calibration RATEMETER READOUT performed without deadtime

Firmware: 4382N30 Pulser Calibration SCALER READOUT reflects 6 second count

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	4mR/hr	3.92 mR/hr	3.84 mR/hr				
Digital	1mR/hr	1.02 |	1.09 |				
Digital	800µr/hr	811 µr/hr	820 µr/hr				
Digital	200µr/hr	201 |	267 |				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 3.4% of reading							
Digital Readout	REFERENCE	INSTRUMENT	INSTRUMENT	Scaler	REFERENCE	INSTRUMENT	INSTRUMENT
	CAL. POINT	RECEIVED	METER READING		CAL. POINT	RECEIVED	METER READING
	800K cpm	803 Kcpm	803 Kcpm		800K cpm	804 Kcpm	804 Kcpm
	200K cpm	200	200		200K cpm	200	200
	80K cpm	80.2	80.2		80K cpm	80.4	80.4
	20K cpm	20.0	20.0		20K cpm	20.0	20.0
	8K cpm	8.04	8.04		8K cpm	8.04	8.04
	2K cpm	1.99	1.99		2K cpm	2.00	2.00
	800 cpm	817 Cpm	817 Cpm		800 cpm	805 Cpm	805 Cpm
	200 cpm	216	216		200 cpm	201	201

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ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☒ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 ☐ Neutron Am-241 Be ☐ T-304 ☐ Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N _____ ☐ Beta S/N _____ ☒ Other Am 241 - (0.81 Nci)

☒ m 500 S/N 57883 ☐ Oscilloscope S/N ☒ Multimeter S/N 55140005

Calibrator Christopher Galindo Christopher Galindo Title Calibrator/ Technician Date 28 Jun 22

QC'd By Reha 11 Title Final QC Date 28 Jun 22

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

FORM C3000 01/22/2020

Page 1 of 5

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test
Only ☐ Failed:

Order #: 20425713/526297

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10 Serial No.: PR355810

Instrument: Model 3000 Serial No.: 25018543

BKG Count 6 seconds

Time:

Distance: SURFACE

Date: Tuesday, June 28, 2022

Notes:

Signature:

Christopher Garindo

Channel(s)

Name

Threshold

Channel: 1

10 mV

Source(s)

Name

ID

Activity

Count Time (Sec.)

Am241

E504

0.81 μ Ci

6

High Voltage	Background	Am241 (0.81 μ Ci)
700	380	11254
750	429	12795
800	437	13305
850	442	13212
900	441	13239
950	409	13284
1000	438	13347
1050	487	13577
1100	599	14159

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25018543
6/28/2022 10:55:31 AM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25018543
Device Real Time Clock Day	28
Device Real Time Clock Hour	8
Device Real Time Clock Minutes	19
Device Real Time Clock Month	6
Device Real Time Clock Seconds	5
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	6
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	0
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	0
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	1
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	1
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.23
Device 1 Channel 1 RawCnt	22536

Device Calibration

Device Calibration High Voltage Slope	45
Device Calibration High Voltage Offset	-57
Device Calibration Channel [1] Pulse Threshold Offset	6

Detector 1

Detector [1] Serial Number	PR355810
Detector [1] Model	44-10
Detector [1] High Voltage	900
Detector [1] Overload	100
Detector [1] Count Time	6
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	0
Detector [1] Response Time	4
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	cpm
Detector [1] Unit [1] Rate Min Exponet	-2
Detector [1] Unit [1] Rate Max Value	999000
Detector [1] Unit [1] Scaler Unit Type	R
Detector [1] Unit [1] Scaler Min Exponet	-2
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0
Detector [1] Unit [1] Scaler Alarm [1]	0
Detector [1] Unit [1] Scaler Alarm [2]	0
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	R/h
Detector [1] Unit [2] Rate Min Exponet	-8
Detector [1] Unit [2] Rate Max Value	999
Detector [1] Unit [2] Scaler Unit Type	counts
Detector [1] Unit [2] Scaler Min Exponet	-6
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	0
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	10
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	5.14E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0

	Model Number	Serial Number
Detector	44-10	PR355810
Instrument	Model 3000	25018543

	Field	Count Rate
Low	200 μ R/hr	16368 counts in 6 seconds
High	4 mR/hr	209695 counts in 6 seconds

	Constant
Calibration Constant	514e08 C/R
Dead Time Constant	10 μ Sec.
Dead Time Second Order Constant	000e00



CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.

501 Oak Street
325-235-5494

Sweetwater, TX 79556, U.S.A.

Customer ENVIRONMENTAL RESTORATION GROUP

ORDER NO. 20421956/523693

Mfg. Ludlum Measurements, Inc. Model 3000

Serial No. 25020102

Mfg. Ludlum Measurements, Inc. Model 44-10

Serial No. PR406319

Cal. Date 25-Apr-22 Cal Due Date 25-Apr-23 Cal. Interval 1 Year Meterface 44-10 Ra

Check mark ☒ Applies to applicable instr. and/or detector IAW mfg. spec. T. 74 °F RH 40 % Alt 707.6 mm Hg

☐ New Instrument ☐ Instrument Received ☒ Within Toler. +/-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☒ Other-See comments

☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity

☒ F/S Resp. ck. ☒ Reset ck. ☐ Window Operation ☐ Geotropism

☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) 4.4 VDC

☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 750 V Input Sens. 10 mV Det. Oper. 750 V at 10 mV Threshold Dial Ratio = mV

☒ HV Readout (2 points) Ref./Inst. 500 / 498 V Ref./Inst. 1500 / 1524 V

COMMENTS:
Deadtime: 8.1 µSec Unable to take as found readings with 44-10 due to first time calibration to 3000.
Calibration Constant: 570 e+8 Calibrated using 5' C-cable.
Primary Units: cpm Overload checked but not set.
Secondary Units: R/hr Pulser calibration performed without deadtime.
Firmware: 5LC-N30.4382 Pulser calibration SCALER READOUT reflects 6 second count.
Alarms disabled.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	4 mR/hr	N/A	3.99 mR/hr				
Digital	2 mR/hr		1.99				
	1 mR/hr		1.01				
	500 µR/hr		502 µR/hr				
	200 µR/hr		194				
	100 µR/hr		94				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading							
Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	Scaler	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
	800K cpm	800 kcpm	800 kcpm		800K cpm	80.0K	80.0K
	200K cpm	200	200		200K cpm	20.0K	20.0K
	80K cpm	80.0	80.0		80K cpm	8.00K	8.00K
	20K cpm	20.0	20.0		20K cpm	2.00K	2.00K
	8K cpm	8.00	8.00		8K cpm	801	801
	2K cpm	2.00	2.00		2K cpm	200	200
	800 cpm	799 cpm	799 cpm		800 cpm	80	80
	200 cpm	201	201		200 cpm	20	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.
All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.
Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2.
The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

State of Texas Calibration License No. LO-1983

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☒ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ☐ Beta S/N ☒ Other Am241(0.66µCi)
☒ m 500 S/N 251106 ☐ Oscilloscope S/N ☒ Multimeter S/N 15060230

Calibrator James McBeth James McBeth Title Calibrator Date 25 APR 22
QC'd By Rick H Title Final QC Date 25 Apr 22

Order #: 20421956/523693

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10 Serial No.: PR406319

Instrument: Model 3000 Serial No.: 25020102

BKG Time: 6

Distance: Surface

Selected HV: 750

Date: Monday, April 25, 2022

Notes: Performed using 5' cable.

Signature: *James M. B. A.*

Channel(s)

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

0.66 μ Ci

6

γ

High Voltage

Background

Am241

Reading

Reading

550

413

3,284

600

399

10,836

650

408

12,218

700

424

12,231

-750

394

12,247

800

429

12,350

850

433

12,290

900

439

12,342

950

628

12,900

1000

1,433

13,859

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25020102
4/25/2022 7:43:22 AM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25020102
Device Real Time Clock Day	25
Device Real Time Clock Hour	7
Device Real Time Clock Minutes	43
Device Real Time Clock Month	4
Device Real Time Clock Seconds	13
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	6
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	40
Device Backlight Threshold Low Turn Off	120
Device Backlight Threshold High Turn On	17
Device Backlight Threshold High Turn Off	100
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	0
Device Auxiliary Auto Power Down	1
Device Auxiliary Write Protect	1
Device Auxiliary Encryption Enabled	1
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.422
Device 1 Channel 1 RawCnt	1325430

Device Calibration

Device Calibration High Voltage Slope	56
Device Calibration High Voltage Offset	-67
Device Calibration Channel [1] Pulse Threshold Offset	4

Detector 1

Detector [1] Serial Number	PR406319
Detector [1] Model	44-10
Detector [1] High Voltage	750
Detector [1] Overload	100
Detector [1] Count Time	60
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	1
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	cpm
Detector [1] Unit [1] Rate Min Exponet	0
Detector [1] Unit [1] Rate Max Value	999000
Detector [1] Unit [1] Scaler Unit Type	counts
Detector [1] Unit [1] Scaler Min Exponet	0
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0
Detector [1] Unit [1] Scaler Alarm [1]	0
Detector [1] Unit [1] Scaler Alarm [2]	0
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	R/h
Detector [1] Unit [2] Rate Min Exponet	-6
Detector [1] Unit [2] Rate Max Value	0.007
Detector [1] Unit [2] Scaler Unit Type	R
Detector [1] Unit [2] Scaler Min Exponet	-6
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	0
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	8.1
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	5.7E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0

Customer

ENVIRONMENTAL RESTORATION GROUP

ORDER NO.

20421242/523218

Mfg.

Ludlum Measurements, Inc.

Model

3000

Serial No.

25018610

Mfg.

Ludlum Measurements, Inc.

Model

44-10

Serial No.

PR355771

Cal. Date

14-Apr-22

Cal Due Date

14-Apr-23

Cal. Interval

1 Year

Meterface

44-10 Ra

Check mark

☒ applies to applicable instr. and/or detector IAW mfg. spec.

T.

74

°F

RH

23

%

Alt

707.9

mm Hg

☐ New Instrument

☐ Instrument Received

☐ Within Toler. +-10%

☒ 10-20%

☐ Out of Tol.

☐ Requiring Repair

☐ Other-See comments

☒ Mechanical ck.

☐ Meter Zeroed

☐ Background Subtract

☐ Input Sens. Linearity

☒ F/S Resp. ck

☒ Reset ck.

☐ Window Operation

☐ Geotropism

☒ Audio ck.

☒ Alarm Setting ck.

☒ Batt. ck. (Min. Volt)

4.4

VDC

☒ Calibrated in accordance with LMI SOP 14.8

☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set

850

V

Input Sens.

10

mV

Det. Oper.

850

V

at

10

mV

Threshold

Dial Ratio

=

mV

☒ HV Readout (2 points)

Ref./Inst.

500

/

496

V

Ref./Inst.

1500

/

1506

V

COMMENTS:

Deadtime: 9.1 µSec

Calibrated using 5' C-cable.

Calibration Constant: 584 e+8

Overload checked but not set.

Primary Units: cpm

Alarms disabled.

Secondary Units: R/hr

Pulser calibration performed without deadtime.

Firmware: 5LC-N30.4382

Pulser calibration SCALER READOUT reflects 6 second count.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	4 mR/hr	4.52 mR/hr	4.00 mR/hr				
Digital	2 mR/hr	2.28	2.07				
	1 mR/hr	1.12	1.02				
	500 µR/hr	542 µR/hr	498 µR/hr				
	200 µR/hr	206	191				
	100 µR/hr	101	94				

Range(s) Calibrated Electronically

REFERENCE	INSTRUMENT	INSTRUMENT	REFERENCE	INSTRUMENT	INSTRUMENT
CAL. POINT	RECEIVED	METER READING	CAL. POINT	RECEIVED	METER READING
Digital Readout	800K cpm	800K cpm	Scaler	800K cpm	80.0K
	200K cpm	200		200K cpm	20.0K
	80K cpm	80.0		80K cpm	8.00K
	20K cpm	20.0		20K cpm	2.00K
	8K cpm	8.00		8K cpm	800
	2K cpm	1.99		2K cpm	200
	800 cpm	799 cpm		800 cpm	80
	200 cpm	201		200 cpm	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors. Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013.

ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521

☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☒ Y982

☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N

☐ Beta S/N

☒ Other

Am241(0.66µCi)

☒ m 500 S/N

251106

☐ Oscilloscope S/N

☒ Multimeter S/N

15060230

Calibrator

James McBeth

Title

Calibrator

Date

14 APR 22

QC'd By

Jeremy Thompson

Title

Final QC

Date

14-Apr-22

Order #: 20421242/523218

Channel(s)

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10

Serial No.: PR355771

Instrument: Model 3000

Serial No.: 25018610

BKG Time: 6

Distance: Surface

Selected HV: 850

Date: Thursday, April 14, 2022

Notes: Performed using 5' cable.

Signature: James M. B. P.

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

0.66 μ Ci

6

γ

High Voltage	Background	Am241
	Reading	Reading
650	501	9,755
700	539	11,227
750	533	12,151
800	537	12,041
- 850	557	12,089
900	560	12,239
950	596	12,060
1000	650	12,098
1050	807	12,641
1100	1,561	13,894

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25018610
4/14/2022 10:27:33 AM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25018610
Device Real Time Clock Day	14
Device Real Time Clock Hour	10
Device Real Time Clock Minutes	27
Device Real Time Clock Month	4
Device Real Time Clock Seconds	24
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	1
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	0
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	0
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	1
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	1
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.382
Device 1 Channel 1 RawCnt	2962040

Device Calibration

Device Calibration High Voltage Slope	35
Device Calibration High Voltage Offset	-55
Device Calibration Channel [1] Pulse Threshold Offset	-1

Detector 1

Detector [1] Serial Number	PR355771
Detector [1] Model	44-10
Detector [1] High Voltage	850
Detector [1] Overload	100
Detector [1] Count Time	60
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	1
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	cpm
Detector [1] Unit [1] Rate Min Exponent	0
Detector [1] Unit [1] Rate Max Value	999000
Detector [1] Unit [1] Scaler Unit Type	counts
Detector [1] Unit [1] Scaler Min Exponent	0
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0
Detector [1] Unit [1] Scaler Alarm [1]	999000
Detector [1] Unit [1] Scaler Alarm [2]	999000
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	R/h
Detector [1] Unit [2] Rate Min Exponent	-6
Detector [1] Unit [2] Rate Max Value	999
Detector [1] Unit [2] Scaler Unit Type	R
Detector [1] Unit [2] Scaler Min Exponent	-6
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	0
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	9.1
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	5.84E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0



Environmental Restoration Group, Inc.
8809 Washington NE, Suite #150
Albuquerque, NM 87113

office: (505) 298-4224
fax: (505) 797-1404
web: www.ERGOffice.com

Company Name: Tetra Tech

Order Number: 5233

Contact Name:

P.O. or Reference Number: 1144750 25

Contact Telephone:

Date Ordered: 11/3/2022

Shipping Method: n/a

Date Shipped: 11/10/2022

Shipping Number: ERG FedEx Number

Date of Delivery: 11/10/2022

Ship To Information:

Billing Address:

Tetra Tech

Tetra Tech - Oakland
Accounts Payable
1999 Harrison St.
Ste 500
Oakland, CA 94612

Equipment Enclosed:

Instrument	Serial Number	Tested
MSA Escort ELF Lapel Air Sampler	A2-32572	<input type="checkbox"/>
GE Energy HPIC	1001321	<input type="checkbox"/>

Special Instructions:

None

Note:

(a) By accepting and using ERG rental equipment, the Renter indemnifies and holds harmless ERG against any and all claims, actions, proceedings, costs, expenses, damages, and liabilities (including attorney's fees and costs) arising out of Renter's use of equipment.



K&S Associates, Inc.
1926 Elm Tree Drive Nashville, Tennessee 37210-3718
Voice: 615-883-9760 (800-522-2325) Fax: 615-871-0856 kslab.com

Attached are stickers for instruments

April 26, 2022	Reuter-Stokes Chamber Calibration				Test Number	M220839
Mfor: Reuter-Stokes	BEAM				DOSE RATE	CALIBRATION COEFF.
Mod: RS-S131-200-ER00	Cs-137	(11mCi)	0.22mR/h	Nx =	1.00	mR/h/rdg
Ser: 1001321	Cs-137	(11mCi)	0.08mR/h	Nx =	1.01	mR/h/rdg
AION: NA	Cs-137	(11mCi)	0.012mR/h	Nx =	1.00	mR/h/rdg
Serial number away	Cs-137	(11mCi)	0.015mR/h	Nx =	1.00	mR/h/rdg
from source	Cs-137	(20 Ci)	50mR/h	Nx =	1.01	mR/h/rdg
"True" background	Cs-137	(20 Ci)	80mR/h	Nx =	1.01	mR/h/rdg
exposure rate of 6.7						
Batt: 8.02 V; K&S	Bias:	401.3V	ERG			
Environment: Temp: 23						



K&S Associates, Inc.
1925 Elm Tree Drive
Nashville, TN 37211-2718
615-523-2325 Fax 615-523-1856



ACCREDITED COSMETIC CALIBRATION LABORATORY

CALIBRATION REPORT

SUBMITTED BY: ERG
855 Washington Street Northeast
Suite 151
Albuquerque, NM 87102

INSTRUMENT: Fisher Baker 75-117-201-2000 #101121

REPORT NUMBER: 21878

RECEIVED DATE: April 14, 2022

TEST NUMBERS: 102020

REPORT ISSUE DATE: May 13, 2022

Inventory Statement

The instrument received is identified with a unique label of 1.0% tolerance according to the NIST requirements. The instrument received after the date of the report is the same as the instrument.

Traceability Statement

1.1.1. The instrument received is identified with a unique label of 1.0% tolerance according to the NIST requirements. The instrument received after the date of the report is the same as the instrument.

1.1.2. The instrument received is identified with a unique label of 1.0% tolerance according to the NIST requirements. The instrument received after the date of the report is the same as the instrument.

The calibration results stated herein are valid under the conditions and parameters specified in this report.

A calibration certificate was performed on the 1.0% tolerance of 1925 Elm Tree Drive Nashville, TN 37211.

Conformance Statement and Decision Rule

When a measurement is performed, the tolerance is 1.0% tolerance according to the NIST requirements. The instrument received after the date of the report is the same as the instrument. The instrument received after the date of the report is the same as the instrument.



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



CALIBRATION CERTIFICATE

Calibration Date: 4/26/2022 Report Number: 221918 Test Number: M220839

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 17025:2017.

Sensor Type: 100 R/h

Serial Number: 1001321

Average Calibration Coefficient for the range of 0.012 mR/h – 0.22 mR/h*:

1.00 mR/"mR" reading
(Measured at 4 points)

Calibration Coefficient for the 50.0 mR/h point*:

1.01 mR/"mR" reading

Calibration Coefficient for the 80.0 mR/h point*:

1.01 mR/"mR" reading

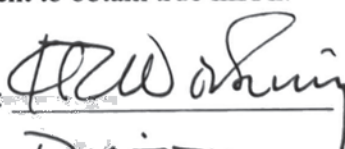
Found Sensitivity: -2.206e-8

*Multiply the reading in **mR/h** by the Calibration Coefficient to obtain true **mR/h**.

Calibrated By:


Jeremy Gossman
Title: **Calibration Technician**

Reviewed By:


Title: **DIRECTOR**

Log: M87



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



AS FOUND DATA
Reuter-Stokes Chamber Calibration

April 26, 2022

Test Number M220839

CHAMBER:

Mfgr: Reuter Stokes
Model: RS-S131-200-ER0000
Serial: 1001321

SUBMITTED BY:

ERG

Albuquerque, NM

ORIENTATION/CONDITIONS:

ATMOSPHERIC COMMUNICATION: SEALED

Serial number away from source

"True" background exposure rate of 6.7 uR/h, instrument reading was 7.23 uR/h

The calibration result(s) stated herein are valid under the conditions and parameters specified in this report.

POLARIZING POTENTIAL: 401.3V

LEAKAGE: Negligible

BEAM QUALITY				CALIBRATION		
BEAM		EXPOSURE RATE		COEFFICIENT	UNCERT	LOG
CsEn220	(11mCi)	0.22mR/h	$N_x =$	1.00 mR/h/rdg	11% M87	
CsEn80	(11mCi)	0.08mR/h	$N_x =$	1.01 mR/h/rdg	11%	
CsEnv12	(1mCi)	0.012mR/h	$N_x =$	1.00 mR/h/rdg	11%	
CsEnv15	(1mCi)	0.015mR/h	$N_x =$	1.00 mR/h/rdg	11%	
Cs199m	(20 Ci)	50mR/h	$N_x =$	1.01 mR/h/rdg	8%	
Cs252m	(20 Ci)	80mR/h	$N_x =$	1.01 mR/h/rdg	8%	

Comments Batt: 8.02 V; K&S Environment: Temp: 23 deg C, RH: 41%, Press: 758 mmHg

Report Number: 221918

Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25

Sensitivity Found: -2.206×10^{-8}

Calibrated By Jeremy Gossman
Title: Calibration Technician

Reviewed By: [Signature]
Title: Director

Checked By: [Signature] **Prepared By:** [Signature]

Form RSS



Test Number: M220839

Report Number: 221918

Appendix I

Pressurized Ion Chambers & Reuter-Stokes Units

CALIBRATION COEFFICIENTS:

EXPOSURE CALIBRATION COEFFICIENTS_{X(N)}

R/RDG: Roentgen/reading calibration coefficients apply to the chamber-electrometer-readout system as a unit, with scales, switch settings and output mode specified. To obtain the exposure in Roentgens at the reference point*, in the absence of the chamber, the calibration coefficient is applied directly to the instrument reading corrected for temperature and pressure:

$$\text{Exposure} = \text{RDG} \cdot \text{R/RDG}$$

R/C: Roentgen/Coulomb calibration coefficients apply to the ion chamber alone. To obtain the exposure in Roentgens at the reference point*, in the absence of the chamber, an appropriately calibrated (Coulomb/reading) electrometer must be used.

$$\text{Exposure} = \text{RDG} \cdot \text{R/C} \cdot \text{C/RDG}$$

where C/RDG = calibration coefficient of electrometer

If the unit has been adjusted during the calibration, a separate data page is provided to show the calibration coefficients as found before adjustment.

* The reference point is the center of the radiation field at the appropriate distance for the dose rate shown on the calibration data page.

ENVIRONMENTAL CONDITIONS:

The background radiation level in the Environmental Laboratory is continuously monitored using a pressurized ion chamber calibrated by or directly traceable to the National Institute for Standards and Technology (NIST).

The typical background rate is between six and seven micro-Roentgen per hour. Background spectrums are periodically measured with an HP Ge detector and compared to previous spectrums. The prevailing background is reported at the time of calibration.

The room scatter at each calibration position has been evaluated and found to be negligible.



CALIBRATION CONDITIONS:

The calibration is performed using a collimated Cesium-137 source calibrated with an ion chamber calibrated by NIST. Periodically, the working ion chamber is compared to an pressurized ion chamber calibrated by the National Physical Laboratory of the United Kingdom and an Exradin ion chamber calibrated by NIST.

Biannually, K&S participates in a Proficiency Test conducted by NIST and supervised by the Health Physics Society's Laboratory Accreditation Policy Committee.

The calibration distance from the source to the instrument center, ambient conditions and other physical data are stated on each calibration page.

UNCERTAINTY:

The best combined expanded uncertainty with a coverage factor $k=2$ of the reference exposure or air kerma is 11%. This value is twice the quadratic sum of the laboratory uncertainty and the uncertainty stated by NIST for the calibration of the transfer standards used by K&S. It is believed to have the approximate significance of the 95% confidence limit.

SHADOW SHIELD CALIBRATION METHOD:

In some cases a customer may specifically request the use of the shadow shield calibration method of calibration. The shadow shield method of calibration of an instrument is an older method used to calibrate an instrument with a source that was calibrated for activity content or dose rate by NIST or a secondary laboratory in open air. It consists of an initial measurement at a distance from a calibrated source and then placing a shield between the source and the instrument that shields only the instrument in order to measure room scatter. Subtracting the room scatter component from the initial measurement provides the net reading of the instrument from the calibrated source. When this method is used, it is noted on the page with the calibration coefficient.

Present day methods with collimated sources standardized with NIST traceable instruments are equivalent to the shadow shield method and less labor intensive. They involve a replacement technique using a NIST traceable instrument to calibrate a collimated source at a specific distance and then placing the instrument at the same position to calculate the calibration coefficient. Room scatter is initially investigated to ensure that it is below an acceptable level within a specified range of operation. However, since the collimated source almost totally eliminates room scatter and since both the calibration standard and the instrument being calibrated see the same contribution from scatter, the scatter components cancel in the calculation of the calibration coefficient.

ATTACHMENT B-6: DAILY FUNCTION CHECK FORMS



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
1809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	3000
Serial No.:	25618543
Cal. Due Date:	6/28/2023

DETECTOR	
Manufacturer:	Ludlum
Model:	44-80
Serial No.:	PR355810
Cal. Due Date:	6/28/2023

Comments:
Orange
Scaler Count Time:
Distance To Source:

Source: 172 Cs-137

Serial No.: 1122

Activity: 1 ^{uCi} cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery V	High Voltage V	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1705	5.73	900	10	17,659	5,059	12,600	AM	
11/15/22	1733	5.45	900	10	17,671	5,180	12,491	AM	
11/16/22	1637	5.41	900	10	17,241	5,019	12,222	AM	
11/17/22	1717	5.17	900	10	17,880	5,461	12,419	AM	
11/18/22	1547	5.19	900	10	18,129	5,045	13,084	AM	
11/19/22	1714	5.20	900	10	17,652	5,242	12,410	AM	
11/20/22	1344	5.77	900	10	18213	5,896	12317	ma	Battery swap

Reviewed by: _____

Review Date: _____



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:	3000
Serial No.:	25020102
Cal. Due Date:	4/25/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR406319
Cal. Due Date:	4/25/23

Comments:
Red
Scaler Count Time:
Distance To Source:

Source: CS-137

Serial No.: 1122

Activity: 1 uCi
Emission Rate: 1 cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14	1740	5.52	750	10	17,959	5,235	12,724	sc	
11/15	1551	5.67	750	10	17,719	5,300	12,419	MQ	
11/16	1730	5.41	750	10	17,470	5,088	12,382	sc	
11/17/22	1737	5.52	750	10	17,495	5,325	12,170	AM	
11/18/22	1634	5.22	750	10	17,772	5,805	11,967	AM	
11/19/22	1737	5.31	750	10	17,926	5,694	12,232	AM	

Reviewed by: _____

Review Date: _____



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
4809 Washington St. NE, Suite 150
Albuquerque, NM 87111
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	3000
Serial No.:	25016973
Cal. Due Date:	4/16/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 156857
Cal. Due Date:	

Comments:
Blue
Scaler Count Time:
Distance To Source:

Source: Cs-137

Serial No.: 1122

Activity: 1 uCi
Emission Rate: cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC 201 B.

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1705	5.86	1,100	10	18,314	5,325	12,989	AM	
11/15/22	1647	5.71	1,100	10	18,280	5,547	12,733	AM	
11/16/22	1648	5.55	1,100	10	18,051	5,455	12,596	AM	
11/17/22	1739	5.59	1,100	10	18,784	5,915	12,869	AM	
11/18/22	1546	5.43	1,100	10	18,345	5,508	12,837	AM	
11/19/22	1715	5.30	1,100	10	18,577	5,768	12,809	AM	

Reviewed by: _____

Review Date: _____



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:	3000
Serial No.:	25017006
Cal. Due Date:	1/26/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	426422 PR 295014
Cal. Due Date:	1/26/23

Comments:
Green
Scaler Count Time:
Distance To Source:

Source: Cs-137

Serial No.: 1122

Activity: ICi
Emission Rate: 1 cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B.

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1752	5.93	950	10	17738	5191	12547	BSB	
11/15/22	1553	5.89	950	10	17869	5143	12726	BSB	
11/16/22	1630	5.58	950	10	17,926	5,132	12,794	AM	
11/17/22	1731	5.63	950	10	18,162	5,276	12,886	AM	
11/18/22	1632	5.29	950	10	17,955	6,005	11,950	AM	
11/19/22	1716	5.26	950	10	17,500	5,494	12,006	AM	

Reviewed by: _____

Review Date: _____



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:	3000
Serial No.:	25018610
Cal. Due Date:	4/25/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 355771
Cal. Due Date:	4/25/23

Comments:
Yellow
Scaler Count Time:
Distance To Source:

Source: Cs-137

Serial No.: 1122

Activity: 1 ^{uCi} cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1705	5.63	850	10	17,441	5,174	12,267	AM	
11/15/22	1730	5.72	850	10	17,761	4,941	12,820	AM	
11/16/22	1630	5.52	850	10	17,585	5,285	12,300	AM	
11/17/22	1717	5.60	850	10	17,770	5,302	12,468	AM	
11/18/22	1545	5.31	850	10	17,658	5,308	12,350	AM	
11/19/22	1713	5.24	850	10	17,614	5,645	11,969	AM	

Reviewed by: _____

Review Date: _____



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.:	254783
Cal. Due Date:	

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR399720
Cal. Due Date:	

Comments:
Black
Scaler Count Time:
Distance To Source:

Source: C5-137

Serial No.: 1122

Activity: 1 ^{uCi}
Emission Rate: cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B.

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1723	5.7	1080	181	18,783	5,954	12,829	AM	
11/15/22	1425				18,316	6,278	12,038	AM	
11/16/22	1649	5.5	1079	180	18,337	6,053	12,284	AM	
11/17/22	1736	5.2	1079	180	18,805	6,486		AM	
11/17/22	1751	5.2	1079	180	18,805	6,284	12,521	AM	
11/18/22	1550	5.1	1017	118	18,349	6,025	12,324	AM	
11/19/22	1738	5.2	1104	205	19,450	6,383	13,067	AM	

Reviewed by: _____

Review Date: _____



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.:	117357
Cal. Due Date:	10/5/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR375296
Cal. Due Date:	10/5/23

Comments:
White
Scaler Count Time:
Distance To Source:

Source: Cs-137 Serial No.: 1122 Activity: 1 uCi Emission Rate: 1 cpm/emissions Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B.

Acceptable Upper Net Counts:
Acceptable Lower Net Counts:

Total Efficiency (E _t):
MDA (dpm/100-cm ²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14	2113	5.7	901	100	18,577	5793	12784	MR	
11/14	1551				17603	6119			
11/16/22	0746	5.8	901	100	17603	6119	11484	ASB	
11/16/22	1650	5.7	903	101	18,299	6,025	12,274	AM	
11/17/22	1757	5.7	905	101	18,703	6,611	12,092	AM	
11/18/22	1630	5.7	903	101	18,736	6,713	12,023	AM	

Reviewed by: _____

Review Date: _____

ATTACHMENT B-7: EXCLUDED GAMMA DATA (ELECTRONIC)

ATTACHMENT B-8: FINAL GAMMA DATASET (ELECTRONIC)

APPENDIX C

XRF VERIFICATION AND VALIDATION REPORT

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**OCRM Removal Assessment
Appendix C
XRF Verification and Validation Report**

Response, Assessment, and Evaluation Services

Contract No. EP-S9-17-03

Task Order 0035

August 25, 2023

**Submitted to
U.S. Environmental Protection Agency**

**Submitted by
Tetra Tech, Inc.
1999 Harrison Street, Suite 500
Oakland, CA 94612**



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ATTACHMENTS

Attachment C-1: Instrument Calibration Sheets
Attachment C-2: Certified Reference Material
Attachment C-3: XRF (Electronic)



ACRONYMS AND ABBREVIATIONS

CRM	Certified reference material
OCRM	Old Church Rock Mine
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
SAP	Sampling and analysis plan
Tetra Tech	Tetra Tech, Inc.
XRF	X-ray fluorescence
USEPA	U.S. Environmental Protection Agency



1.0 INTRODUCTION

This document presents the quality assurance (QA), quality control (QC), and verification methods and results of the in situ X-ray fluorescence (XRF) surveys performed during the 2022 field investigation at the Old Church Rock Mine (OCRM) in New Mexico. This document is included as Appendix C of the OCRM removal assessment report.

QA includes qualitative factors that provide confidence in the results while QC involves quantitative field evidence that supports the validity of results. During the in situ XRF surveys at OCRM, Tetra Tech, Inc. (Tetra Tech) adhered to the QA/QC procedures for collecting in situ XRF measurements in the U.S. Environmental Protection Agency (USEPA)-approved removal assessment sampling and analysis plan (SAP) (Tetra Tech 2022). To assess the validity of the data collected, Tetra Tech used the data quality indicators described in Appendix B of the 2018 removal site evaluation report (Tetra Tech 2018).

2.0 OVERVIEW OF THE IN SITU X-RAY FLUORESCENCE SURVEYS

This section provides an overview of the in situ XRF surveys performed at OCRM during the 2022 field investigation.

2.1 X-RAY FLUORESCENCE INSTRUMENTATION

XRF survey measurements were performed using a Niton XL5 XRF with a soil guard installed over the primary window of the instrument. XRF measurements were collected using an XRF filter setting in seconds of 60s:0s:0s (Main:High:Low). [Table C-1](#) summarizes the individual instruments used during the removal assessments and dates of use.

Table C-1. XRF Instrumentation Used During Field Investigation

Manufacturer	Model	Serial Number	Dates of Use
Niton	XL5	X500940	11/16/2022
			11/17/2022
			11/18/2022
			11/19/2022

Note:

XRF X-ray fluorescence

2.2 SURVEYS PERFORMED

The XRF surveys were intended to collect screening-level data. Screening-level data were used to support soil sample collection and estimate the extent of metal contamination at the site. Areas at OCRM investigated during XRF survey activities were:

- The fenced area
- The adjacent area to the southeast across State Route 566
- The background study area

In addition to these areas, XRF measurements were also collected along radial transects in cardinal and ordinal directions originating from the center of the site.

XRF surveys were conducted following the methodology described in Section 4.1.2.3 of the removal assessment SAP (Tetra Tech 2022).

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

This section presents the QA/QC methods and results.

3.1 QUALITY ASSURANCE

An important QA protocol for in-field XRF surveys involves instrument calibration. All XRF instruments used for screening data collection purposes during fieldwork were factory calibrated within the previous 12 months. Copies of factory calibration documentation for all detectors used during the survey are provided in [Attachment C-1](#).

3.2 QUALITY CONTROL

This subsection summarizes the methods and results of the QC analyses performed for those detectors that were used during the XRF surveys. One detector was used for screening. The QC protocol involved pre-trip baseline and daily function QC checks. The purpose of these QC analyses was to quantify the consistency of the instrument's response to a known source for instrument consistency and functionality during the course of the fieldwork. QC data measurements were recorded for all detectors that were used during the survey.

An explanation of the QC methods for the detectors, including results of the QC checks, data validation and categorization, and duplicate error analysis, are presented in the following subsections.

3.2.1 Pre-Trip Baseline Quality Control Checks

Pre-trip baseline QC checks were collected at an indoor location for each detector that could be potentially used during the XRF survey. The purpose of these measurements was to quantify the response of the instrument to sources. A total of 12 60s:0s:0s counts were collected on a certified reference material (CRM), provided to Tetra Tech by USEPA, with known concentrations of copper, uranium, and vanadium. The baseline checks then served as a reference to compare daily function checks. The pre-trip baseline QC check was performed on November 14, 2022. The CRM used for the pre-trip baseline QC check is DC73319a. A copy of the elemental composition of the CRM is included in [Attachment C-2](#).

The results of the baseline measurements are summarized in [Table C-2](#), including the mean and standard deviation baseline response for copper, uranium, and vanadium. The mean and standard deviation can be used to assess the daily function checks.

Table C-2. XRF Baseline Response

Date	XRF Serial Number	Run Number	Analyte Results (ppm)		
			Copper	Uranium	Vanadium
11/14/2022	X500940	918	37.7	8.1	64.4
		919	37.0	6.9	93.5
		920	36.1	5.3	65.0
		921	35.6	6.9	53.9
		922	33.1	4.8	50.6
		923	35.8	8.0	72.1
		924	34.2	6.2	81.2
		925	38.2	5.5	65.5
		926	33.8	8.6	61.7
		927	32.5	6.3	46.5
		928	33.1	7.2	62.3
		929	36.5	5.9	58.4
Baseline Average:			35.3	6.6	64.6
Baseline Standard Deviation			1.9	1.2	13.0

Notes:

Run number 919 was excluded from the baseline response dataset as its measurement duration was too short.

Exclusion of datapoints from the XRF dataset is discussed in [Section 3.2.3.2](#).

ppm Parts per million

XRF X-ray fluorescence

3.2.2 Daily Function Quality Control Checks

Under the QC program, factory-calibrated instruments must also meet onsite field test criteria. Daily instrument function checks are measurements performed to verify instrument performance each time an instrument is used. The instrument function checks consist of collecting five 60s:0s:0s measurements on a CRM with the instrument used to conduct XRF surveys. For this project, the field checks were performed in Gallup, New Mexico, within room 214 of the Gallup Holiday Inn Express.

For normally distributed data, 99 percent of all measurements are expected to fall within ± 3 standard deviations from the mean. Any instrument with a QC measurement result falling outside ± 3 standard deviations from the mean of all QC measurements on the field check control chart required investigation. A detector exceeding control limits on any QC function check would be replaced with a spare detector and sent back to the manufacturer for evaluation, repair, and recalibration.

The daily QC checks for each instrument are summarized in [Table C-3](#). A QC chart for the daily QC background measurements, including the initial baseline QC measurements, is provided in [Figure C-1](#), [Figure C-2](#), and [Figure C-3](#) for copper, uranium, and vanadium, respectively.

The average of each daily function check for each analyte (copper, uranium, and vanadium) was within one standard deviation of the baseline mean with no error bar exceeding two standard deviations of the measured baseline response mean.



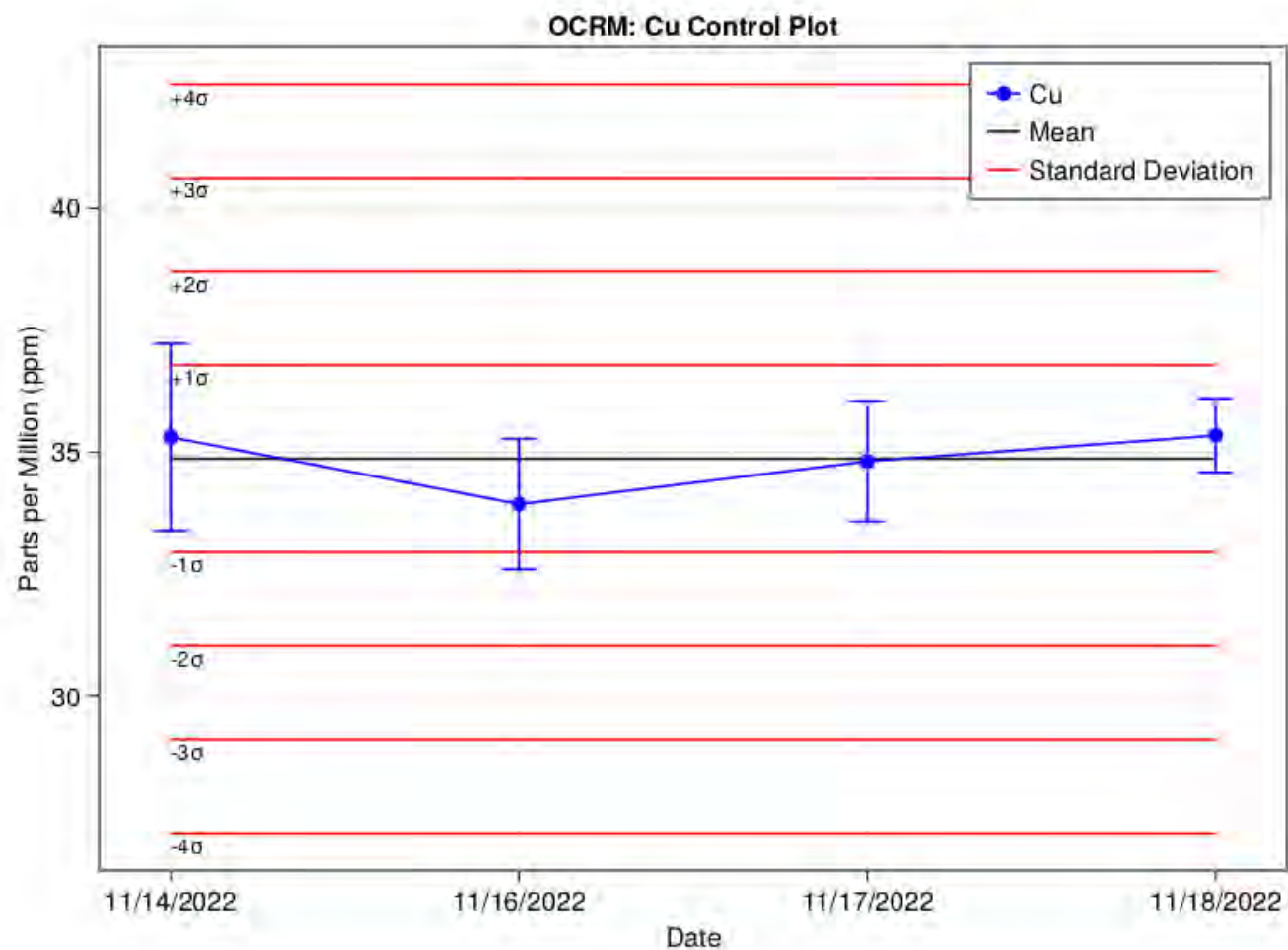
Table C-3. Daily Function Check Results

Date	XRF Serial Number	Run Number	Analyte Results (ppm)		
			Copper	Uranium	Vanadium
11/16/2022	X500940	979	35.1	9.8	86.5
	X500940	980	33.0	9.0	62.8
	X500940	981	36.3	8.5	72.0
	X500940	982	33.5	7.2	75.3
	X500940	983	34.6	5.5	75.9
	X500940	984	33.3	6.3	55.1
	X500940	985	32.1	9.6	71.1
	X500940	986	33.5	7.9	66.9
Daily Average:			33.9	8.0	70.7
11/17/2022	X500940	1031	35.8	6.5	76.7
	X500940	1032	34.8	7.7	58.0
	X500940	1033	35.6	7.2	73.8
	X500940	1034	33.1	6.5	51.0
Daily Average:			34.8	7.0	64.9
11/18/2022	X500940	1057	34.6	8.3	69.8
	X500940	1058	36.3	7.3	57.4
	X500940	1059	34.7	9.0	51.7
	X500940	1060	35.9	6.5	69.0
	X500940	1061	35.2	6.9	75.0
Daily Average:			35.3	7.6	64.6

Notes:

ppm Parts per million

XRF X-ray fluorescence



Notes:
Cu Copper
OCRM Old Church Rock Mine
ppm Parts per million

Figure C-1. X500940 XRF Daily Function Check Control Chart - Copper

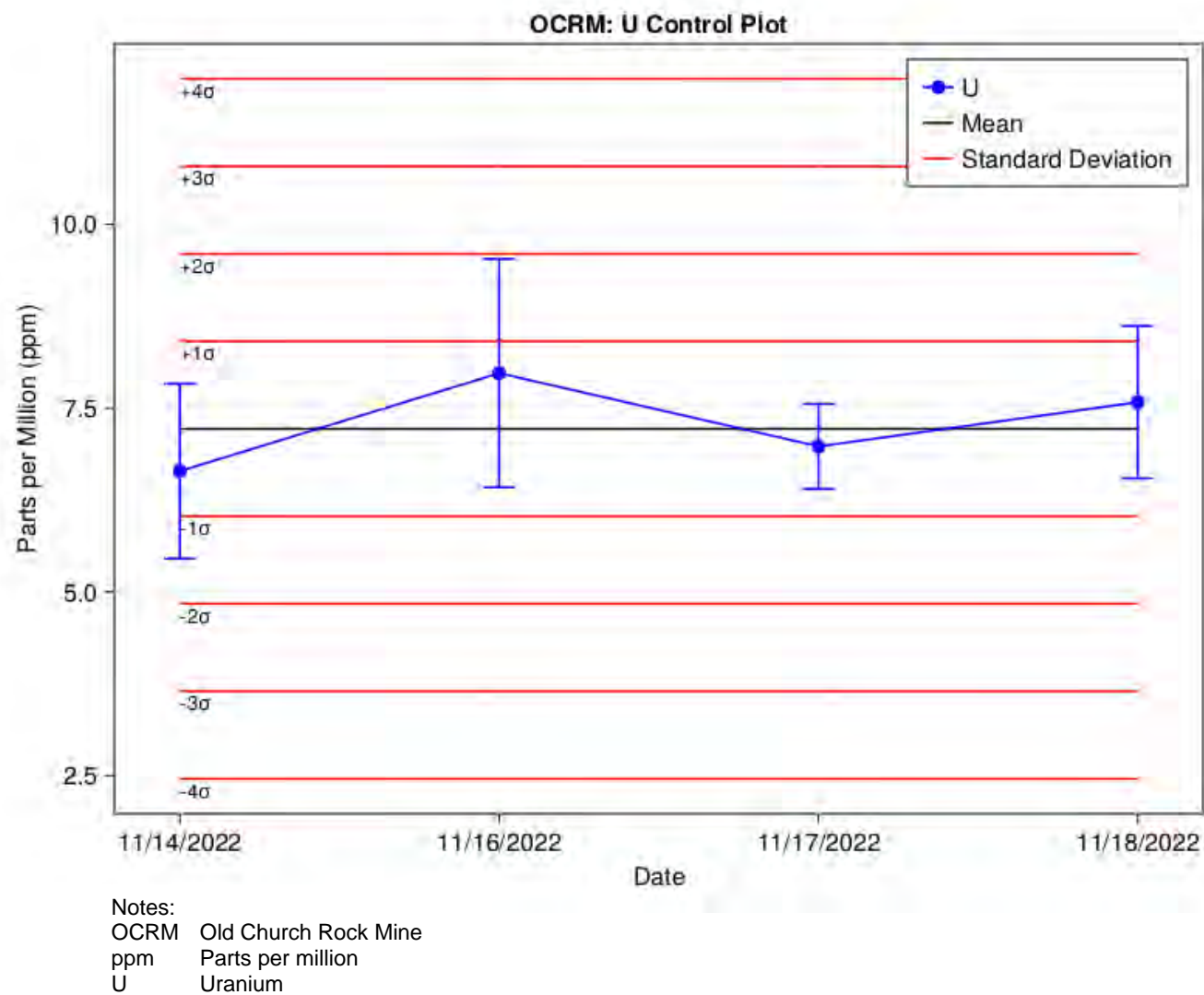


Figure C-2. X500940 XRF Daily Function Check Control Chart - Uranium

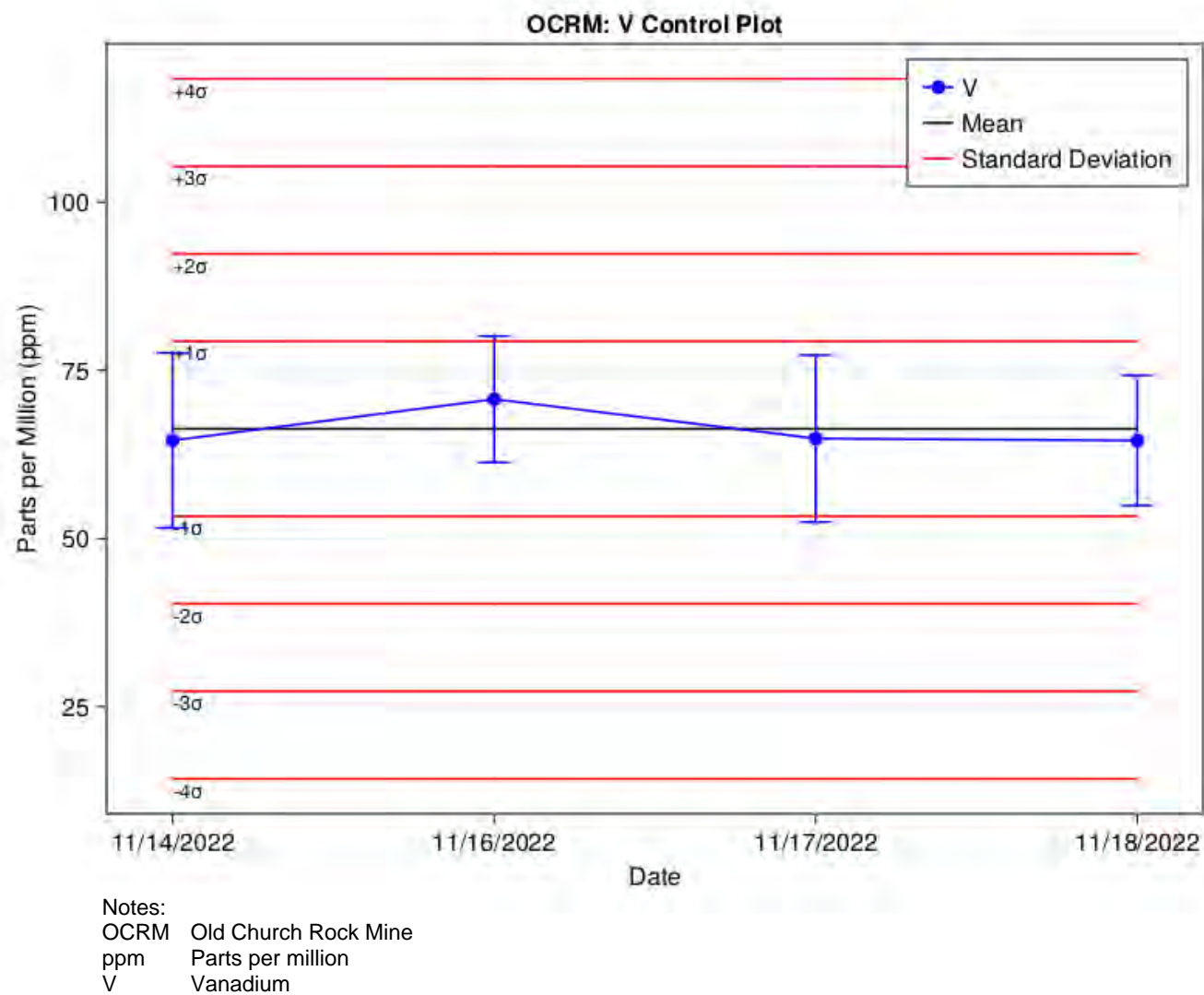


Figure C-3. X500940 XRF Daily Function Check Control Chart - Vanadium

3.2.3 Validating and Categorizing Data

A total of 206 XRF measurements were stored in the instrument's memory as part of the removal assessment. The raw export of the XRF data is included in [Attachment C-3](#). The following subsections detail the methods to clean up the data.

3.2.3.1 *Categorization*

Each measurement collected can be categorized into one of the following categories:

- **System Check:** An internal check the instrument completes on a daily basis on startup.
- **QC-Baseline:** Initial baseline response measurements on a CRM to compare with daily function checks.
- **QC:** Function check measurements on a CRM to compare with the baseline response.
- **In Situ:** A 60s:0s:0s measurement collected in the field to assess analytes at the site.
- **In Situ-QC:** Identical to an in situ measurement except with an associated duplicate pair.
- **Duplicate:** A 60s:0s:0s measurement collected in the field immediately after an in situ measurement was collected to assess precision of the instrument.
- **Miscellaneous:** Measurements collected that do not correspond to any activities identified in the SAP (such as accidental trigger pulls or operator curiosity).

3.2.3.2 *Data Exclusion*

Once categorized, several factors may disqualify a measurement from being included in the final dataset. Examples of disqualifying factors include:

- Measurement interrupted before intended duration of 60 seconds could be completed.
- Measurement not collected at appropriate location.
- Miscellaneous measurement taken in field that is not a part of the SAP.

A total of 13 of the 206 measurements were excluded from the final dataset. One QC-baseline, nine miscellaneous, and two in situ measurements were excluded because the measurement duration was too short. One in situ measurement was excluded because its results were not part of the scope of the project. The list of measurements excluded and associated justifications are included in [Attachment C-3](#).

3.2.3.3 *Sample Identification Correction*

Once the dataset is properly categorized with disqualified measurements excluded, the sample IDs that are stored in the instrument must be verified against other sources of record to confirm that the XRF operator logged the correct sample ID in the correct location. Checking sample IDs can be accomplished by comparing the recorded sample ID to the handwritten fieldnotes or completing a cross comparison with the timestamps and IDs of samples logged in ArcGIS Field

Maps. Fieldnotes documenting the XRF sample collection are included in Appendix F of the main report.

Samples identified as duplicates will have an “A” appended to the end of the sample name. Sample IDs for measurements categorized as system checks, QC-baseline, and QC do not need to have sample IDs corrected.

The final dataset with categorization, original and corrected sample IDs, and justifications for sample ID changes is included in [Attachment C-3](#).

3.2.4 Duplicate Error Analysis

Duplicate in situ measurements were collected at a minimum frequency of 1:20. To assess accuracy of the instrument, the relative percent difference (RPD) between the primary and duplicate measurement was calculated for a total of eight pairs. Based on Table B-3 of Appendix B and the 2018 removal site evaluation report (Tetra Tech 2018), a RPD of ≤ 30 percent is required for the data to be used as definitive data and a RPD of ≤ 50 percent is required for the data to be used as either quantitative or qualitative screening data.

[Table C-4](#) summarizes the findings of the duplicate error analysis.

Table C-4. XRF Duplicate Error Analysis

Location ID	Date	Primary Run #	Duplicate Run #	Copper			Uranium			Vanadium		
				Primary (ppm)	Duplicate (ppm)	RPD	Primary (ppm)	Duplicate (ppm)	RPD	Primary (ppm)	Duplicate (ppm)	RPD
OCRM-B02-X08	11/16/2022	938	939	10.7	9.8	9%	3.3	3.5	5%	72.3	80.7	11%
OCRM-B02-X20	11/16/2022	947	948	9.4	7.5	22%	3.4	4.1	20%	63.1	80.7	25%
OCRM-B02-X25	11/16/2022	957	958	10.1	9.4	8%	3.4	3.1	8%	68.6	65.0	5%
OCRM-X29	11/17/2022	1011	1012	6.2	5.0	20%	21.1	21.3	1%	<LOD	<LOD	-
OCRM-RTW-X09	11/18/2022	1052	1053	9.3	9.1	1%	3.6	2.6	30%	<LOD	<LOD	-
OCRM-RTE-X04	11/19/2022	1081	1082	5.9	2.7	73%	3.0	2.9	3%	66.4	49.5	29%
OCRM-RTNW-X07	11/19/2022	1098	1099	8.1	9.1	12%	1.4	1.7	20%	<LOD	<LOD	-
OCRM-RTN-X05	11/19/2022	1121	1122	9.2	7.6	20%	4.4	4.4	0%	<LOD	<LOD	-

Notes:

- Not applicable
<LOD Less than the limit of detection
ppm Parts per million
RDP Relative percent difference
XRF X-ray fluorescence



4.0 REFERENCES

Tetra Tech, Inc (Tetra Tech). 2018. “Appendix B, X-Ray Fluorescence Data Evaluation Report.” Response, Assessment, and Evaluation Services. Contract No. EP-S9-17-02. Task Order 0001

Tetra Tech. 2022. “Old Church Rock Mine Removal Assessment Sampling and Analysis Plan.” Response, Assessment, and Evaluation Services. Contract No. EP-S9-17-02. Task Order 0035.

ATTACHMENT C-1: INSTRUMENT CALIBRATION SHEETS

Serial Number: X500940
 Resolution: 153.911 143.059

 Model: Niton XL5 Standard
 Escalate: 7.417 7.429

 Software: 1.7.2.7548
 Spot Size: 8mm

 Date of Q.C.: 8/2/2022
 Inspector: AS

30 second analysis time Main Filter only, 3 analysis each

Pure Fe

	Low	High	Measured	Err	OK
Bi			0.000	0.0019	<LOD
Pb			0.022	0.0128	
Au			0.003	0.0009	
Re			0.000		OK
W			0.000	0.0060	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0032	<LOD
Sn			0.000	0.0031	<LOD
Cd			0.000	0.0028	<LOD
Ag			0.000	0.0033	<LOD
Pd			0.000	0.0036	<LOD
Ru			0.000	0.0007	<LOD
Mo			0.000	0.0005	<LOD
Nb			0.001	0.0004	
Zr			0.000	0.0005	<LOD
Y			0.000	0.0003	<LOD
Se			0.000	0.0007	<LOD
Zn			0.000	0.0025	<LOD
Cu			0.000	0.0042	<LOD
Ni			0.000	0.0167	<LOD
Co			0.041	0.0521	<LOD
Fe	99.5	100	99.957	0.0665	OK
Mn			0.000	0.0117	<LOD
Cr			0.000	0.0125	<LOD
V			0.008	0.0164	<LOD
Ti			0.016	0.0246	<LOD
Al (Bal)			0.000	0.0000	OK
LEC			0.000		

Pure Ta

	Low	High	Measured	Err	OK
			0.000	0.0035	<LOD
			0.000		OK
			0.000	0.0000	<LOD
			0.023	0.0216	<LOD
			0.000	0.0948	<LOD
99	100		99.989	0.1784	OK
			0.000	0.0882	<LOD
			0.000	0.0092	<LOD
			0.000	0.0070	<LOD
			0.000	0.0075	<LOD
			0.000	0.0055	<LOD
			0.000	0.0083	<LOD
			0.000	0.0062	<LOD
			0.000	0.0016	<LOD
			0.005	0.0020	
			0.000	0.0013	<LOD
			0.001	0.0014	<LOD
			0.000	0.0008	<LOD
			0.000	0.0229	<LOD
			0.000		OK
			0.000		OK
			0.000	0.0122	<LOD
			0.000	0.0271	<LOD
			0.000	0.0171	<LOD
			0.000	0.0226	<LOD
			0.000	0.0316	<LOD
			0.000	0.0512	<LOD
			0.000	0.0914	<LOD
			0.000	0.0000	OK

Pure Sn

	Low	High	Measured	Err	OK
Bi			0.008	0.0042	
Pb			0.000	0.0045	<LOD
Au			0.000	0.0032	<LOD
Re			0.000		OK
W			0.000	0.0153	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0215	<LOD
Sb			0.024	0.0235	<LOD
Sn	99	100	99.930	0.4077	OK
Cd			0.000	0.0170	<LOD
Ag			0.000	0.0089	<LOD
Pd			0.000	0.0074	<LOD
Ru			0.000	0.0019	<LOD
Mo			0.000	0.0012	<LOD
Nb			0.000	0.0011	<LOD
Zr			0.000	0.0015	<LOD
Y			0.000	0.0009	<LOD
Se			0.000	0.0026	<LOD
Zn			0.000	0.0094	<LOD
Cu			0.012	0.0147	<LOD
Ni			0.000	0.0155	<LOD
Co			0.000	0.0223	<LOD
Fe			0.000	0.0369	<LOD
Mn			0.000	0.0604	<LOD
Cr			0.000	0.0833	<LOD
V			0.168	0.1469	<LOD
Ti			0.000	0.3602	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC			0.000		

Pure Cu

	Low	High	Measured	Err	OK
			0.003	0.0021	
			0.000	0.0024	<LOD
			0.000	0.0058	<LOD
			0.000		OK
			0.000	0.0175	<LOD
			0.000		OK
			0.000		OK
			0.000	0.0074	<LOD
			0.000	0.0053	<LOD
			0.000	0.0061	<LOD
			0.000	0.0052	<LOD
			0.000	0.0058	<LOD
			0.000	0.0055	<LOD
			0.002	0.0015	<LOD
			0.001	0.0010	<LOD
			0.000	0.0009	<LOD
			0.000	0.0015	<LOD
			0.000	0.0004	<LOD
			0.000	0.0037	<LOD
			0.000	0.0206	<LOD
99.5	100		99.995	0.0817	OK
			0.000	0.0105	<LOD
			0.000	0.0110	<LOD
			0.01	0.0091	<LOD
			0.000	0.0150	<LOD
			0.000	0.0211	<LOD
			0.000	0.0318	<LOD
			0.000	0.0582	<LOD
			0.000	0.0000	<LOD
			0.000		

Pure Ni
Pure Ti

	Low	High	Measured	Err	OK
Bi			0.004	0.0021	
Pb			0.000	0.0027	<LOD
Au			0.000	0.0028	<LOD
Re			0.000		OK
W			0.000	0.2372	<LOD
Ta			0.000		OK
Hf			0.000		OK
Te			0.000	0.0000	<LOD
Sb			0.000	0.0047	<LOD
Sn			0.000	0.0051	<LOD
Cd			0.000	0.0039	<LOD
Ag			0.000	0.0047	<LOD
Pd			0.000	0.0057	<LOD
Ru			0.000	0.0013	<LOD
Mo			0.000	0.0008	<LOD
Nb			0.001	0.0005	
Zr			0.000	0.0002	<LOD
Y			0.000	0.0014	<LOD
Se			0.000	0.0061	<LOD
Zn			0.000	0.0253	<LOD
Cu			0.000	0.0283	<LOD
Ni	99.5	100	99.996	0.2889	OK
Co			0.000	0.0102	<LOD
Fe			0.004	0.0099	<LOD
Mn			0.000	0.0138	<LOD
Cr			0.000	0.0166	<LOD
V			0.000	0.0282	<LOD
Ti			0.000	0.0599	<LOD
Al (Bal)			0.000	0.0000	<LOD
LEC			0.000		

	Low	High	Measured	Err	OK
			0.001	0.0005	
			0.001	0.0005	
			0.000	0.0011	<LOD
			0.000		OK
			0.000	0.0000	<LOD
			0.000		OK
			0.000		OK
			0.000	0.0024	<LOD
			0.000	0.0018	<LOD
			0.000	0.0017	<LOD
			0.000	0.0015	<LOD
			0.000	0.0019	<LOD
			0.000	0.0019	<LOD
			0.000	0.0003	<LOD
			0.000	0.0002	<LOD
			0.000	0.0002	<LOD
			0.000	0.0001	<LOD
			0.000	0.0003	<LOD
			0.000	0.0012	<LOD
			0.000	0.0019	<LOD
			0.000	0.0019	<LOD
			0.004	0.0032	<LOD
			0.000	0.0057	<LOD
			0.000	0.0110	<LOD
			0.000	0.0342	<LOD
			0.092	0.0487	
99.5	100		99.942	0.0627	OK
			0.000	0.0000	<LOD
			0.000		

	20Cb3		IARM 25C		180-509	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0008	<LOD
Pb				0.000	0.0017	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.08			0.228	0.0940	
Ta	0.004			0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.004	0.0037	<LOD
Sn	0.01	0.000	0.020	0.013	0.0030	OK
Cd				0.000	0.0032	<LOD
Ag				0.031	0.0245	<LOD
Pd				0.000	0.0034	<LOD
Ru				0.002	0.0018	<LOD
Mo	2.26	2.034	2.486	2.195	0.0089	OK
Nb	0.58	0.48	0.68	0.569	0.0040	OK
Zr				0.000	0.0005	<LOD
Y				0.000	0.0003	<LOD
Se				0.000	0.0032	<LOD
Zn				0.000	0.0106	<LOD
Cu	3.51	3.264	3.756	3.488	0.0343	OK
Ni	33.30	31.635	34.965	33.012	0.1142	OK
Co	0.091	0.020	0.250	0.168	0.0376	OK
Fe	38.80	36.860	40.740	38.404	0.0720	OK
Mn	0.90	0.400	1.400	0.919	0.0328	OK
Cr	19.97	19.371	20.569	20.260	0.0536	OK
V	0.095	0.035	0.180	0.132	0.0132	OK
Ti	0.003			0.015	0.0165	<LOD
Al (Bal)	0.019			0.000	0.00	<LOD
LEC		0.50	0.50	0.50	#N/A	OK

	Stellite 6B		IARM 95B		180-502	
	Certified	Low	High	Measured	Err	
				0.000	0.0008	<LOD
				0.000		OK
				0.000	0.0000	<LOD
				0.000	0.0105	
	3.42	3.112	3.728	3.433	0.0498	OK
				0.000	0.0231	<LOD
				0.000	0.0485	<LOD
				0.000	0.0000	<LOD
				0.005	0.0029	
				0.011	0.0026	
				0.004	0.0030	<LOD
				0.037	0.0260	<LOD
				0.000	0.0031	<LOD
				0.000	0.0010	<LOD
	0.83	0.697	0.963	0.833	0.0045	OK
	0.002			0.001	0.0005	
	0.002			0.001	0.0004	<LOD
				0.000	0.0004	<LOD
				0.000	0.0034	<LOD
				0.000		OK
	0.01			0.000		OK
	2.25	1.913	2.588	2.259	0.0366	OK
	60.90	58.50	62.50	59.998	0.1053	OK
	1.10	0.990	1.210	1.104	0.0228	OK
	0.99	0.891	1.089	0.994	0.0294	OK
	28.90	28.467	29.334	29.009	0.0597	OK
	0.002			0.031	0.0111	
	0.004			0.043	0.0148	
	0.07			0.000	0.00	<LOD
		2.25	2.25	2.250	#N/A	OK

	CDA 836		IARM 86C		180-510	
	Certified	Low	High	Measured	Err	
Bi	0.01			0.054	0.0099	
Pb	5.03	4.68	5.38	5.019	0.0420	OK

	1.25Cr 0.5 Mo		IARM 35H		195-019	
	Certified	Low	High	Measured	Err	
				0.000	0.0018	<LOD
	0.0009			0.013	0.0082	

Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.000	0.0378	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0083	<LOD
Sb	0.143	0.122	0.164	0.130	0.0073	OK
Sn	4.37	3.452	5.288	4.230	0.0249	OK
Cd				0.000	0.0054	<LOD
Ag	0.02			0.029	0.0056	
Pd				0.000	0.0053	<LOD
Ru				0.000	0.0017	<LOD
Mo				0.000	0.0011	<LOD
Nb				0.000	0.0009	<LOD
Zr				0.000	0.0019	<LOD
Y				0.019	0.0135	<LOD
Se				0.000	0.0051	<LOD
Zn	5.38	4.788	5.972	5.382	0.0349	OK
Cu	84.6	82.49	86.72	84.588	0.0855	OK
Ni	0.27	0.100	0.400	0.269	0.0105	OK
Co				0.006	0.0090	<LOD
Fe	0.24	0.200	0.280	0.247	0.0095	OK
Mn	0.002			0.000	0.0219	<LOD
Cr				0.000	0.0222	<LOD
V				0.017	0.0346	<LOD
Ti				0.051	0.0545	<LOD
Al (Bal)	0.002			0.000	0.00	<LOD
LEC						

				0.005	0.0025	
				0.000		OK
0.004				0.000	0.0028	<LOD
				0.000		OK
				0.000		OK
				0.000	0.0000	<LOD
0.002				0.000	0.0035	<LOD
0.002				0.004	0.0034	<LOD
				0.000	0.0029	<LOD
				0.008	0.0053	<LOD
				0.000	0.0041	<LOD
				0.000	0.0011	<LOD
0.47	0.455	0.525		0.486	0.0037	OK
0.002				0.000	0.0005	<LOD
0.001				0.000	0.0004	<LOD
				0.000	0.0003	<LOD
				0.000	0.0008	<LOD
				0.003	0.0025	<LOD
0.033	0.018	0.048		0.034	0.0053	OK
0.071				0.075	0.0208	
0.004				0.000	0.0452	<LOD
96.96	95.506	98.414		96.961	0.0661	OK
0.56	0.392	0.728		0.569	0.0182	OK
1.11	0.999	1.221		1.092	0.0144	OK
0.004				0.010	0.0134	<LOD
0.0016				0.012	0.0287	<LOD
0.028				0.000	0.00	<LOD
	0.75	0.75		0.750	#N/A	OK

	Hast X			IARM 69C			180-511		
	Certified	Low	High	Measured	Err		Certified	Low	High
Bi				0.000	0.0016	<LOD			
Pb				0.000	0.0025	<LOD			
Au				0.000	0.0000	<LOD			
Re				0.000		OK			
W	0.62	0.320	0.920	0.719	0.1534	OK			
Ta	0.003			0.000		OK			
Hf				0.000		OK			
Te				0.000	0.0000	<LOD			
Sb				0.000	0.0051	<LOD			
Sn	0.002			0.000	0.0044	<LOD			
Cd				0.000	0.0045	<LOD			
Ag				0.026	0.0162				
Pd				0.000	0.0050	<LOD			
Ru				0.004	0.0032	<LOD			
Mo	8.30	7.719	8.881	8.307	0.0316	OK			
Nb	0.09	0.030	0.150	0.074	0.0021	OK			
Zr	0.004			0.002	0.0009				
Y				0.000	0.0005	<LOD			
Se				0.000	0.0057	<LOD			
Zn				0.000	0.0180	<LOD			
Cu				0.055	0.0277				
Ni	48.80	46.85	50.75	48.295	0.1786	OK			
Co	1.11	0.944	1.300	1.184	0.0391	OK			
Fe	18.30	17.39	19.22	18.315	0.0662	OK			
Mn	0.47	0.353	0.588	0.470	0.0366	OK			
Cr	21.60	20.74	22.60	21.984	0.0706	OK			
V	0.03			0.056	0.0163				
Ti	0.02			0.036	0.0368	<LOD			
Al (Bal)	0.12			0.00	0.00	<LOD			
LEC		0.50	0.50	0.50		OK			

	Tool steel M2			BS 32C			180-492		
	Certified	Low	High	Measured	Err		Certified	Low	High
				0.000	0.0007	<LOD			
				0.000	0.0028	<LOD			
				0.000	0.0000	<LOD			
				0.000		OK			
	6.30	6.00	7.00	6.559	0.0705	OK			
				0.000		OK			
				0.000		OK			
				0.000	0.0000	<LOD			
				0.000	0.0042	<LOD			
0.01				0.007	0.0038				
				0.000	0.0037	<LOD			
				0.025	0.0198	<LOD			
				0.000	0.0042	<LOD			
				0.000	0.0027	<LOD			
	4.85	4.61	5.15	4.852	0.0159	OK			
				0.000	0.0010	<LOD			
				0.000	0.0007	<LOD			
				0.000	0.0004	<LOD			
				0.000	0.0057	<LOD			
				0.000	0.0162	<LOD			
	0.13	0.104	0.156	0.124	0.0109	OK			
	0.35	0.250	0.420	0.310	0.0176	OK			
	0.31	0.200	0.403	0.283	0.0464	OK			
	80.59	78.59	82.59	80.176	0.0946	OK			
	0.29	0.24	0.36	0.301	0.0242	OK			
	3.98	3.59	4.42	4.095	0.0329	OK			
	2.03	1.57	2.46	2.010	0.0330	OK			
				0.032	0.0278	<LOD			
0.02				0.00	0.00	<LOD			
	1.24	1.24	1.24			OK			

	SS321			IARM 6D			180-512		
	Certified	Low	High	Measured	Err		Certified	Low	High
Bi				0.000	0.0003	<LOD			
Pb				0.000	0.0013	<LOD			
Au				0.000	0.0000	<LOD			
Re				0.000		OK			

	Ti 6-2-4-2			IARM 177C			180-503		
	Certified	Low	High	Measured	Err		Certified	Low	High
				0.000	0.0013	<LOD			
				0.000	0.0015	<LOD			
				0.000	0.0027	<LOD			
				0.000		OK			

W	0.09	0.060	0.200	0.158	0.0400	OK
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.003	0.0041	<LOD
Sn	0.013	0.010	0.025	0.021	0.0025	OK
Cd				0.003	0.0027	<LOD
Ag				0.032	0.0239	<LOD
Pd				0.000	0.0037	<LOD
Ru				0.001	0.0008	<LOD
Mo	0.358	0.29	0.44	0.358	0.0026	OK
Nb	0.039	0.01	0.06	0.039	0.0009	OK
Zr	0.002			0.000	0.0004	<LOD
Y				0.000	0.0003	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0046	<LOD
Cu	0.302	0.15	0.5	0.332	0.0141	OK
Ni	9.42	9	9.8	9.293	0.0536	OK
Co	0.182	0.140	0.300	0.231	0.0412	OK
Fe	69.40	68	70	68.921	0.0832	OK
Mn	1.52	1.25	1.85	1.580	0.0339	OK
Cr	17.45	17.1	18	17.721	0.0443	OK
V	0.128	0.100	0.200	0.168	0.0120	OK
Ti	0.63	0.43	0.83	0.644	0.0213	OK
Al (Bal)	0.11			0.00	0.00	<LOD
LEC				0.50	#N/A	OK

			0.000	0.0000	<LOD
			0.000		OK
			0.000		OK
			0.000	0.0042	<LOD
			0.000	0.0034	<LOD
2.02	1.919	2.121	2.023	0.0121	OK
			0.000	0.0030	<LOD
			0.007	0.0059	<LOD
			0.000	0.0034	<LOD
			0.000	0.0014	<LOD
1.96	1.764	2.156	1.960	0.0088	OK
			0.001	0.0009	<LOD
3.99	3.75	4.23	3.990	0.0157	OK
			0.000	0.0007	<LOD
			0.000	0.0008	<LOD
			0.000	0.0022	<LOD
0.003			0.000	0.0038	<LOD
0.011			0.008	0.0057	<LOD
			0.000	0.0070	<LOD
0.033	0.010	0.040	0.018	0.0118	
0.0015			0.000	0.0206	<LOD
			0.000	0.0616	<LOD
0.02			0.000	0.1016	<LOD
85.72	84.01	87.43	85.996	0.1163	OK
6.02			0.00	0.00	<LOD
			6.0	#N/A	OK

	AA7075		ALC 7075 AF		180-505	
	Certified	Low	High	Measured	Err	
Bi	0.007	0.001	0.020	0.007	0.0005	OK
Pb	0.0073	0.001	0.020	0.007	0.0005	OK
Au				0.000	0.0000	<LOD
Re				0.000		OK
W				0.034	0.0248	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0013	<LOD
Sb				0.002	0.0017	<LOD
Sn	0.014	0.007	0.024	0.015	0.0009	OK
Cd				0.002	0.0012	<LOD
Ag				0.007	0.0052	<LOD
Pd				0.000	0.0014	<LOD
Ru				0.000	0.0003	<LOD
Mo				0.000	0.0001	<LOD
Nb				0.000	0.0001	<LOD
Zr	0.0024	0.0014	0.0034	0.0025	0.0002	OK
Y				0.000	0.0001	<LOD
Se				0.000	0.0002	<LOD
Zn	5.75	5.578	5.923	5.772	0.0115	OK
Cu	1.750	1.663	1.838	1.757	0.0080	OK
Ni	0.027	0.0070	0.0470	0.026	0.0015	OK
Co				0.000	0.0026	<LOD
Fe	0.17	0.136	0.204	0.169	0.0050	OK
Mn	0.031	0.015	0.050	0.037	0.0053	OK
Cr	0.22	0.187	0.253	0.224	0.0105	OK
V	0.020			0.050	0.0148	
Ti	0.092	0.000	0.250	0.143	0.0296	OK
Al (Bal)	91.7	89.8268	93.4932	91.75	0.08	OK
LEC						

15s Main Filter and 30s Low Filter

	1.25Cr 0.5Mo		IARM35H		195-019	
	Provisional	Low	High	Measured	Err	
Bi				0.000	0.0018	<LOD
Pb	0.001			0.013	0.0082	
Au				0.005	0.0026	
Re				0.000		OK

	Tool steel T-1		IARM 48C		195-152	
	Certified	Low	High	Measured	Err	
				0.000	0.0005	<LOD
				0.000	0.0030	<LOD
				0.000	0.0000	<LOD
				0.000		OK

W	0.004			0.000	0.0028	<LOD
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb	0.002			0.000	0.0035	<LOD
Sn	0.002			0.004	0.0034	<LOD
Cd				0.000	0.0029	<LOD
Ag				0.008	0.0053	<LOD
Pd				0.000	0.0041	<LOD
Ru				0.000	0.0011	<LOD
Mo	0.47	0.430	0.530	0.488	0.0037	OK
Nb	0.002			0.000	0.0005	<LOD
Zr	0.001			0.000	0.0004	<LOD
Y				0.000	0.0003	<LOD
Se				0.000	0.0008	<LOD
Zn				0.003	0.0025	<LOD
Cu	0.032	0.012	0.052	0.034	0.0053	OK
Ni	0.071			0.075	0.0209	
Co	0.004			0.000	0.0452	<LOD
Fe	96.96	95.990	97.930	96.951	0.0540	OK
Mn	0.56	0.48	0.64	0.571	0.0183	OK
Cr	1.11	1.00	1.22	1.109	0.0053	OK
V	0.004			0.000	0.0014	<LOD
Ti	0.002			0.000	0.0015	<LOD
Al (Bal)	0.028			0.00	0.00	<LOD
LEC	0.75			0.750		OK

17.50	16.63	18.38	17.348	0.0783	OK
			0.000		OK
			0.000		OK
			0.000	0.0000	<LOD
			0.010	0.0033	
0.012			0.029	0.0032	
			0.004	0.0034	<LOD
			0.060	0.0034	
			0.000	0.0041	<LOD
			0.003	0.0016	
0.17	0.140	0.190	0.160	0.0020	OK
0.005	0.001	0.010	0.004	0.0005	OK
			0.002	0.0005	
			0.000	0.0001	<LOD
			0.000	0.0080	<LOD
			0.000	0.0212	<LOD
0.13	0.09	0.180	0.102	0.0116	OK
0.204	0.1	0.24	0.164	0.0157	
0.22	0.12	0.32	0.200	0.0401	
74.5	73.383	75.618	74.758	0.0928	OK
0.39	0.30	0.500	0.431	0.0228	OK
4.24	3.90	4.75	4.444	0.0312	OK
1.27	1.14	1.40	1.259	0.0076	OK
0.006			0.002	0.0025	<LOD
0.017			0.00	0.00	<LOD
1.025			1.025		OK

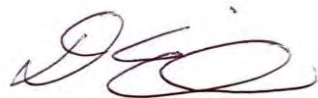
	Custom 455		IARM16B		195-142	
	Certified	Low	High	Measured	Err	
Bi				0.000	0.0007	<LOD
Pb				0.002	0.0020	<LOD
Au				0.000	0.0000	<LOD
Re				0.000		OK
W	0.011			0.077	0.0392	
Ta				0.000		OK
Hf				0.000		OK
Te				0.000	0.0000	<LOD
Sb				0.006	0.0039	<LOD
Sn	0.004			0.010	0.0025	
Cd				0.003	0.0025	<LOD
Ag				0.034	0.0227	<LOD
Pd				0.000	0.0037	<LOD
Ru				0.002	0.0012	<LOD
Mo	0.016	0.010	0.022	0.015	0.0007	OK
Nb	0.25	0.225	0.275	0.257	0.0024	OK
Zr				0.001	0.0005	<LOD
Y				0.000	0.0003	<LOD
Se				0.000	0.0014	<LOD
Zn				0.000	0.0054	<LOD
Cu	2.23	2.119	2.342	2.223	0.0260	OK
Ni	8.28	7.866	8.694	8.236	0.0527	OK
Co	0.027			0.091	0.0405	
Fe	76.4	72.580	80.220	76.299	0.0366	OK
Mn	0.026			0.094	0.0254	
Cr	11.44	10.868	12.012	11.476	0.0366	OK
V	0.067			0.057	0.0038	
Ti	1.11	1.055	1.166	1.105	0.0081	OK
Al (Bal)	0.062			0.000	0.00	<LOD

AA7075	ALC 7075 AF			180-505	
Certified	Low	High	Measured	Err	
0.007	0.000	0.150	0.007	0.0005	OK
0.0073	0.001	0.020	0.007	0.0005	OK
			0.000	0.0000	<LOD
			0.000		OK
			0.034	0.0247	<LOD
			0.000		OK
			0.000		OK
			0.000	0.0013	<LOD
			0.002	0.0017	<LOD
0.014	0.007	0.025	0.015	0.0009	OK
			0.002	0.0012	<LOD
			0.007	0.0052	<LOD
			0.000	0.0014	<LOD
			0.000	0.0003	<LOD
			0.000	0.0001	<LOD
			0.000	0.0001	<LOD
0.0024	0.0004	0.0044	0.002	0.0002	OK
			0.000	0.0001	<LOD
			0.000	0.0002	<LOD
5.75	5.578	5.923	5.773	0.0113	OK
1.750	1.663	1.838	1.758	0.0080	OK
0.027	0.0070	0.0470	0.026	0.0015	OK
			0.000	0.0431	<LOD
0.17	0.136	0.204	0.169	0.0050	OK
0.031	0.016	0.050	0.037	0.0053	OK
0.22	0.1	0.4	0.221	0.0028	OK
0.020			0.044	0.0015	
0.092	0.072	0.112	0.092	0.0020	OK
91.7	89.8268	93.4932	91.804	0.01	OK

This certificate is issued in accordance with Thermo Fisher Scientific factory specifications.
 The measurements were found to be within specification limits at the time of manufacture and calibration.

Samples used for factory calibrations are either certified reference standards (CRM) or reference samples (RM), when available.
 Certificates of Analysis (CoA) are available on request

Signed:

A handwritten signature in black ink, appearing to read 'DEVEN ERICKSON', with a stylized, cursive script.

Deven Erickson

ATTACHMENT C-2: CERTIFIED REFERENCE MATERIAL

Soil

Art. ID NCS DC73319a
Unit 70 g
Deliverydetails No Dangerous Good /not restricted

Text/Information	Analyte/Parameter	CAS number	Concentration/Value	Unit	Method	Source
	Silver (Ag)	[7440-22-4]	0,81 ± 0,04	µg/g		
	Arsenic (As)	[7440-38-2]	33 ± 3	µg/g		
	Boron (B)	[7440-42-8]	69 ± 4	µg/g		
	Barium (Ba)	[7440-39-3]	700 ± 40	µg/g		
	Beryllium (Be)	[7440-41-7]	3,3 ± 0,3	µg/g		
	Bismuth (Bi)	[7440-69-9]	1,4 ± 0,2	µg/g		
	Bromine (Br)	[7726-95-6]	4,1 ± 0,6	µg/g		
	Cadmium (Cd)	[7440-43-9]	2,5 ± 0,2	µg/g		
	Cerium (Ce)	[7440-45-1]	71 ± 5	µg/g		
	Chlorine (Cl)	[7782-50-5]	~87	µg/g		
	Cobalt (Co)	[7440-48-4]	10,3 ± 0,6	µg/g		
	Chromium (Cr)	[7440-47-3]	44 ± 3	µg/g		
	Caesium (Cs)	[7440-46-2]	7,2 ± 0,5	µg/g		
	Copper (Cu)	[7440-50-8]	42 ± 5	µg/g		
	Dysprosium (Dy)	[7429-91-6]	6,0 ± 0,5	µg/g		
	Erbium (Er)	[7440-52-0]	3,8 ± 0,4	µg/g		
	Europium (Eu)	[7440-53-1]	0,89 ± 0,08	µg/g		
	Fluorine (F)	[7782-41-4]	513 ± 21	µg/g		
	Gallium (Ga)	[7440-55-3]	18,1 ± 1,4	µg/g		
	Gadolinium (Gd)	[7440-54-2]	5,5 ± 0,4	µg/g		
	Germanium (Ge)	[7440-56-4]	1,3 ± 0,2	µg/g		
	Hafnium (Hf)	[7440-58-6]	6,5 ± 0,5	µg/g		
	Mercury (Hg)	[7439-97-6]	0,31 ± 0,03	µg/g		
	Holmium (Ho)	[7440-60-0]	1,3 ± 0,2	µg/g		
	Iodine (I)	[7553-56-2]	2,0 ± 0,2	µg/g		
	Indium (In)	[7440-74-6]	0,12 ± 0,02	µg/g		
	Lanthanum (La)	[7439-91-0]	39 ± 2	µg/g		
	Lithium (Li)	[7439-93-2]	28 ± 2	µg/g		
	Lutetium (Lu)	[7439-94-3]	0,57 ± 0,06	µg/g		
	Manganese (Mn)	[7439-96-5]	0,131 ± 0,006	%		
	Molybdenum (Mo)	[7439-98-7]	2,0 ± 0,2	µg/g		

Nitrogen (N)	[7727-37-9]	0,32 ± 0,03	%
Niobium (Nb)	[7440-03-1]	15,3 ± 1,4	µg/g
Neodymium (Nd)	[7440-00-8]	30,8 ± 1,3	µg/g
Nickel (Ni)	[7440-02-0]	16,9 ± 1,5	µg/g
Phosphorus (P)	[7723-14-0]	0,23 ± 0,02	%
Lead (Pb)	[7439-92-1]	339 ± 12	µg/g
Praseodymium (Pr)	[7440-10-0]	8,5 ± 0,7	µg/g
Rubidium (Rb)	[7440-17-7]	137 ± 9	µg/g
Sulfur (S)	[7704-34-9]	726 ± 94	µg/g
Antimony (Sb)	[7440-36-0]	2,4 ± 0,3	µg/g
Scandium (Sc)	[7440-20-2]	8,3 ± 0,3	µg/g
Selenium (Se)	[7782-49-2]	~0,22	µg/g
Samarium (Sm)	[7440-19-9]	5,9 ± 0,4	µg/g
Tin (Sn)	[7440-31-5]	9,8 ± 1,1	µg/g
Strontium (Sr)	[7440-24-6]	192 ± 9	µg/g
Tantalum (Ta)	[7440-25-7]	1,3 ± 0,1	µg/g
Terbium (Tb)	[7440-27-9]	0,98 ± 0,09	µg/g
Tellurium (Te)	[13494-80-9]	~0,06	µg/g
Thorium (Th)	[7440-29-1]	13,1 ± 0,9	µg/g
Titanium (Ti)	[7440-32-6]	0,326 ± 0,009	%
Thallium (Tl)	[7440-28-0]	1,2 ± 0,1	µg/g
Thulium (Tm)	[7440-30-4]	0,61 ± 0,06	µg/g
Uranium (U)	[7440-61-1]	6,0 ± 0,3	µg/g
Vanadium (V)	[7440-62-2]	61 ± 4	µg/g
Tungsten (W)	[7440-33-7]	3,5 ± 0,5	µg/g
Yttrium (Y)	[7440-65-5]	38 ± 3	µg/g
Ytterbium (Yb)	[7440-64-4]	3,8 ± 0,4	µg/g
Zinc (Zn)	[7440-66-6]	475 ± 30	µg/g
Zirconium (Zr)	[7440-67-7]	218 ± 10	µg/g
SiO ₂		56,60 ± 0,46	%
Al ₂ O ₃		12,92 ± 0,21	%
TFe ₂ O ₃		4,41 ± 0,20	%
FeO		~2,25	%
CaO		2,78 ± 0,11	%
MgO	[1309-48-4]	1,17 ± 0,04	%
Na ₂ O		1,65 ± 0,07	%
K ₂ O		2,85 ± 0,08	%
H ₂ O+		~4,3	%

Corg	~6,8	%
TC	7,87 ± 0,26	%
Loss on Ignition (LOI)	15,82 ± 0,64	%

ATTACHMENT C-3: XRF (ELECTRONIC)

- XRF Raw Data Output
- Excluded XRF Measurements
- Final XRF Dataset

APPENDIX D

SOIL DATA QUALITY REPORT

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**OCRM Removal Assessment
Appendix D
Soil Verification Report**

Response, Assessment, and Evaluation Services

Contract No. EP-S9-17-03

Task Order 0035

August 25, 2023

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

1999 Harrison Street, Suite 500

Oakland, CA 94612





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ATTACHMENTS

Attachment D-1: OCRM Removal Assessment SAP Excerpts
Attachment D-2: Chain-of-Custody Forms
Attachment D-3: Laboratory Data Verification Reports

ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
bgs	Below ground surface
COC	Chain of custody
DER	Duplicate error ratio
EB	Equipment blank
g	Gram
GEL	GEL Laboratories, LLC
HNO ₃	Nitric acid
ICPMS ID	Inductively Coupled Plasma Mass Spectrometry Identification
J	Estimated value
LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
LOD	Limit of detection
LOQ	Limit of quantitation
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MS	Matrix spike
MSD	Matrix spike duplicate
OCRM	Old Church Rock Mine
QA	Quality assurance
QC	Quality control
RAES	Response, Assessment, and Evaluation Services
RPD	Relative percent difference
SAP	Sampling and Analysis Plan
SWB	Surface water blank
Tetra Tech	Tetra Tech, Inc.
TPU	Total propagated uncertainty
U	Analyte not detected at concentration exceeding limit of detection
USEPA	U.S. Environmental Protection Agency



1.0 INTRODUCTION

Appendix D to the Old Church Rock Mine (OCRM) Removal Assessment Report (hereafter referred to as the main report) presents the soil verification methods applied during the 2022 field investigation soil sampling efforts at OCRM in New Mexico. Tetra Tech, Inc. (Tetra Tech) adhered to the procedures and methodologies regarding soil sampling in accordance with the U.S. Environmental Protection Agency (USEPA) approved Removal Assessment Sampling and Analysis Plan (SAP) (Tetra Tech 2022).

2.0 OVERVIEW OF SURFACE SOIL SAMPLING

This section overviews surface soil sampling activities during the OCRM removal assessment. Discrete surface soil sampling was part of the following investigations:

- Background Investigation
- Ion Exchange Building and Ponds Sampling
- Gamma-Guided Sampling

Discrete surface soil sampling proceeded according to the methods described in Section 4.1.2.2 of the SAP (Tetra Tech 2022), included in Attachment D1. Surface soil samples (250 grams [g] each) were collected by use of a hand trowel within 0 to 3 inches below ground surface (bgs) and placed into plastic ziploc sample bags. Each sample was labeled with a unique sample ID, date, time, and the sampler's name/initials.

Composite surface soil sampling was part of the gamma-radium correlation study, and conformed to the methodology in Section 4.1.2.4 of the SAP, included in Attachment D1. Composite surface soil samples were collected by use of a hand trowel within 0 to 3 inches bgs, and were homogenized in a stainless steel bowl to make a single composite sample of at least 250 g. Each single composite sample was put into a plastic ziploc sample bag and labeled with a unique sample ID, date, time, and the sampler's initials.

Table D1 summarizes surface soil sampling activities during the removal assessment, including dates of sampling and numbers of samples collected. Photographs of samples collected are in Appendix A to the main report.

Table D-1. Summary of Surface Soil Sampling Activities

Date	Investigation	Sample Type	Sampling and Analysis Plan Procedure Section	Number of Samples Collected	Number of Duplicates Collected
11/16/2022	Background Study Area	Grab	4.1.1.2	30	2
11/16/2022	Ion Exchange & Ponds	Grab	4.1.1.2	10	0
11/17/2022	Gamma-Guided	Grab	4.1.1.2	30	2
11/19/2022	Gamma-Radium Correlation	Composite	4.1.2.4	15	1

3.0 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

This sections presents the QA/QC methods applied during the removal assessment, and results.

3.1 DECONTAMINATION

Upon collection of a surface sample, the equipment used to collect the sample was decontaminated per the decontamination procedures in Section 4.5 of the OCRM Removal Assessment SAP (Tetra Tech 2022), which included the following steps:

1. Removal of gross contamination by use of a dry paper towel or a paper towel and distilled water as necessary.
2. Secondary decontamination by application of a Liquinox solution and paper towel or scrub brush.
3. Equipment drying with a clean paper towel or placement of the equipment on aluminum foil to allow air drying.

Rinsate/equipment blank (EB) samples were collected by running source water over the equipment into a liquid sample bottle containing nitric acid (HNO₃) preservative. A source water blank (SWB) also was collected by pouring source water directly into a similar liquid sample bottle containing HNO₃ preservative. EB and SWB samples were given unique sample IDs and submitted for laboratory analysis.

To demonstrate that decontamination efforts were successful in mitigating cross-contamination, results for copper, uranium, and vanadium from each EB sample were compared to SWB sample results. Table D2 summarizes the comparisons of results. No EB result exceeded an SWB result significantly, as all sample results were near the detection limit of the instrumentation.

Table D-2. EB/SWB Result Comparison

Sample ID	Type	Copper		Uranium		Vanadium	
		Result (µg/L)	Qualifier	Result (µg/L)	Qualifier	Result (µg/L)	Qualifier
SWB-01-111422	SWB	0.3	U	0.067	U	4.99	J
EB-01-111422	EB	0.3	U	0.067	U	4.35	J
EB-01-111522	EB	0.718	J	0.112	J	4.32	J
EB-01-111622	EB	0.751	J	0.067	U	3.3	U
EB-01-111722	EB	0.3	U	0.067	U	3.3	U
EB-02-111722	EB	0.406	B	0.067	U	3.3	U

Notes:

No common laboratory contaminant was detected at concentration exceeding its limit of quantitation (LOQ).

µg/L Micrograms per liter

B Target analyte was detected at concentration exceeding ½ its limit of detection (LOD) and exceeding 1/10 its concentration in any sample.

EB Equipment blank

J Indicates an estimated value. Result exceeded detection limit, but was less than the reporting limit—or analyte recovery in the matrix spike (MS) or matrix spike duplicate (MSD) was outside of specified acceptance criteria.

SWB Source water blank

U Target analyte not detected at concentration exceeding limit of detection.

3.2 DUPLICATES

Soil duplicates were collected at a minimum frequency of one per 20 soil samples. Of the 90 samples collected, five were duplicates. To assess accuracy of the sampling methods, relative percent differences (RPD) between results for a select number of analytes from each duplicate pair were determined to cover the three analytical methods applied:

- Copper (Cu) via SW6020B (Inductively Coupled Plasma Mass Spectrometry [ICPMS])
- Uranium (U) metal via SW6020B (ICPMS)
- Vanadium (V) via SW6020B (ICPMS)
- Radium (Ra)-226 via EH300 (Gamma Spectrometry)
- Potassium (K)-40 via EH300 (Gamma Spectrometry)
- U-238 via HASL 300 (Alpha Spectrometry) (Only one duplicate pair was analyzed via HASL 300.)

The highest RPD between two duplicate pairs was 17 percent.

Regarding radionuclides assessed via gamma or alpha spectrometry, the duplicate error ratio (DER) also was calculated. Per the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) (2004), the DER was calculated according to the following relationship between primary and duplicate sample results:

$$DER = \frac{|C_{primary} - C_{duplicate}|}{2\sigma_{primary} + 2\sigma_{duplicate}}$$

where:

DER	Duplicate error ratio
$C_{primary}$	Analyte concentration in the primary sample
$C_{duplicate}$	Analyte concentration in the duplicate sample
$\sigma_{primary}$	Total propagated error of the primary sample
$\sigma_{duplicate}$	Total propagated error of the duplicate sample

Per MARLAP, a DER was acceptable if it did not exceed 2.13. Results with DERs above 2.13 percent resulted in “J” qualifications.

The highest DER between duplicate pairs was 0.22. No additional qualifiers were necessary.

Table D3 summarizes RPDs and DERs between the duplicate pairs.



Table D-3. Surface Soil Duplicate Error Analysis

Date	Primary ID	Duplicate ID	Analytical Method: SW6020B								
			Copper			Uranium			Vanadium		
			Primary (mg/kg)	Duplicate (mg/kg)	RPD	Primary (mg/kg)	Duplicate (mg/kg)	RPD	Primary (mg/kg)	Duplicate (mg/kg)	RPD
11/16/2022	OCRM-B02-SS10-01-111622	OCRM-B02-SS10-02-111622	14.7	14.2	3%	1.19	1.13	5%	26.7	26	3%
11/16/2022	OCRM-B02-SS20-01-111622	OCRM-B02-SS20-02-111622	11.8	11.2	5%	1.11	1.04	7%	23.8	23	3%
11/17/2022	OCRM-SS12-01-111722	OCRM-SS12-02-111722	4.89	5.34	9%	48.4	46.9	3%	29.3	30.5	4%
11/17/2022	OCRM-SS28-01-111722	OCRM-SS28-02-111722	5.6	5.76	3%	81.1	95.2	16%	62.9	65.3	4%
11/19/2022	OCRM-CORR01-01-111922	OCRM-CORR01-02-111922	11.9	11	8%	1.43	1.36	5%	19.5	19	3%

Date	Primary ID	Duplicate ID	Analytical Method: EH300						Analytical Method: EH300						Analytical Method: HASL 300					
			Radium-226						Potassium-40						Uranium-238					
			Primary (pCi/g)	Primary TPU (pCi/g)	Duplicate (pCi/g)	Duplicate TPU (pCi/g)	RPD	DER	Primary (pCi/g)	Primary TPU (pCi/g)	Duplicate (pCi/g)	Duplicate TPU (pCi/g)	RPD	DER	Primary	Primary TPU	Duplicate	Duplicate TPU	RPD	DER
11/16/2022	OCRM-B02-SS10-01-111622	OCRM-B02-SS10-02-111622	1.66	0.276	1.67	0.301	1%	0.01	20	2.77	20.1	2.81	1%	0.01	-	-	-	-	-	-
11/16/2022	OCRM-B02-SS20-01-111622	OCRM-B02-SS20-02-111622	1.13	0.263	1.34	0.222	17%	0.22	20.3	2.82	19.5	2.56	17%	0.07	-	-	-	-	-	-
11/17/2022	OCRM-SS12-01-111722	OCRM-SS12-02-111722	50.6	4.87	54.5	4.63	7%	0.21	18.7	3.5	17.5	3.35	7%	0.09	-	-	-	-	-	-
11/17/2022	OCRM-SS28-01-111722	OCRM-SS28-02-111722	201	17.3	196	16	3%	0.08	20.7	5.99	18.6	4.52	3%	0.10	-	-	-	-	-	-
11/19/2022	OCRM-CORR01-01-111922	OCRM-CORR01-02-111922	1.51	0.19	1.66	0.209	9%	0.19	22	2.38	21.8	2.37	9%	0.02	1.39 (pCi/g)	0.629 (pCi/g)	1.25 (pCi/g)	0.547 (pCi/g)	11%	0.06

Notes:
DER Duplicate error analysis
EH300 Gamma Spectrometry
HASL 300 Alpha Spectrometry
ID Identification
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram
RPD Relative percent difference
SW6020B Inductively Coupled Plasma - Mass Spectrometry
TPU Total propagated uncertainty

3.3 CHAIN OF CUSTODY

Chain-of-custody (COC) forms were generated during the field investigation to trace each sample collected through analysis and final disposition while ensuring sample integrity—in conformance to the methodology described in Section 4.4.2 of the SAP. A summary of COCs is in Table D4. All COCs are in Attachment D2.

Table D-4. Summary of COC Forms

COC Number	Sample IDs
RAES35-0001	OCRM-B02-SS01-01-111622, OCRM-B02-SS02-01-111622, OCRM-B02-SS03-01-111622, OCRM-B02-SS04-01-111622, OCRM-B02-SS05-01-111622, OCRM-B02-SS06-01-111622, OCRM-B02-SS07-01-111622, OCRM-B02-SS08-01-111622, OCRM-B02-SS09-01-111622, OCRM-B02-SS10-01-111622, OCRM-B02-SS10-02-111622, OCRM-B02-SS11-01-111622, OCRM-B02-SS12-01-111622, OCRM-B02-SS13-01-111622, OCRM-B02-SS14-01-111622, OCRM-B02-SS15-01-111622, OCRM-B02-SS18-01-111622, OCRM-B02-SS19-01-111622, OCRM-B02-SS20-01-111622, OCRM-B02-SS20-02-111622
RAES35-0002	OCRM-B02-SS16-01-111622, OCRM-B02-SS17-01-111622, OCRM-B02-SS21-01-111622, OCRM-B02-SS22-01-111622, OCRM-B02-SS23-01-111622, OCRM-B02-SS24-01-111622, OCRM-B02-SS25-01-111622, OCRM-B02-SS26-01-111622, OCRM-B02-SS27-01-111622, OCRM-B02-SS28-01-111622, OCRM-B02-SS29-02-111622, OCRM-B02-SS30-01-111622, OCRM-SS3099-01-111622, OCRM-SS2738-01-111622, OCRM-SS2679-01-111622, OCRM-SS2217-01-111622
RAES35-0003	OCRM-SS2225-01-111622, OCRM-SS1804-01-111622, OCRM-SS02-01-111722, OCRM-SS05-01-111722, OCRM-SS06-01-111722, OCRM-SS07-01-111722, OCRM-SS08-01-111722, OCRM-SS09-01-111722, OCRM-SS10-01-111722, OCRM-SS11-01-111722, OCRM-SS12-01-111722, OCRM-SS12-02-111722, OCRM-SS13-01-111722, OCRM-SS16-01-111722, OCRM-SS18-01-111722, OCRM-SS20-01-111722, OCRM-SS23-01-111722, OCRM-SS25-01-111722, EB-01-111622
RAES35-0004	OCRM-SS19-01-111722, OCRM-SS21-01-111722, OCRM-SS24-01-111722, OCRM-SS26-01-111722, OCRM-SS27-01-111722, OCRM-SS28-01-111722, OCRM-SS28-02-111722, OCRM-SS29-01-111722, OCRM-SS30-01-111722, OCRM-SS31-01-111722, OCRM-SS32-01-111722, OCRM-SS34-01-111722, OCRM-SS35-01-111722, OCRM-SS36-01-111722, OCRM-RTSW-XS05-01-111822, EB-02-111722
RAES35-0005	OCRM-CORR01-01-111922, OCRM-CORR01-02-111922, OCRM-CORR02-01-111922, OCRM-CORR03-01-111922, OCRM-CORR04-01-111922, OCRM-CORR05-01-111922, OCRM-CORR06-01-111922, OCRM-CORR07-01-111922, OCRM-CORR08-01-111922, OCRM-CORR09-01-111922, OCRM-CORR10-01-111922, OCRM-CORR11-01-111922, OCRM-CORR12-01-111922, OCRM-CORR13-01-111922, OCRM-CORR14-01-111922, OCRM-CORR15-01-111922
RAES35-0006	OCRM-SS2975-01-111622, OCRM-SS3006-01-111622, OCRM-SS2946A-01-111622, OCRM-SS2946B-01-111622

Note:

COC Chain of custody



4.0 LABORATORY DATA VERIFICATION REPORTS

GEL Laboratories, LLC (GEL) was the USEPA-approved laboratory under the RAES contract to analyze soil samples. The Level IV data package GEL provided to Tetra Tech included the following data elements:

- COC form
- Sample preservation, storage, and holding times
- Method and field blank contamination
- Surrogate spikes
- Matrix spikes/matrix spike duplicates (MS/MSD)
- Laboratory control samples (LCS)/laboratory control sample duplicates (LCSD).

Each data element listed above was verified in all data packages received from GEL. GEL's report categorized each data element as "Useable," "Rejected," or "NA." A description of impacted data with specific samples and analytical parameters is provided when appropriate.

Results of the data element verification are summarized in Data Verification Reports, included as Attachment D3. None of the 12 Data Verification Reports was rejected.



5.0 REFERENCES

Tetra Tech, Inc (Tetra Tech). 2022. “Old Church Rock Mine Removal Assessment Sampling and Analysis Plan.” Response, Assessment, and Evaluation Services. Contract No. EP-S9-17-02. Task Order 0035.

U.S. Environmental Protection Agency (USEPA). 2004. *Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual*. EPA 402-B-04-001A. July.

**ATTACHMENT D-1: OCRM REMOVAL ASSESSMENT SAP
EXCERPTS**



Each sample container will be labeled to ensure sample integrity from collection through analysis and final disposition. Labels will be written in indelible ink on labels provided by the laboratory. The label for the samples will include the following information:

- Sample name
- Sample collection date and time
- Sampler initials

Each sampling team will maintain a physical field logbook or collect notes on project-specific field forms or in electronic format. Logbooks will be used for any sampling activities that do not have a dedicated field form. Logbook entries will summarize field activities (SOP 024-2). Logbooks will be used to record all relevant sampling information in the event of malfunctioning digital data capture equipment.

4.4.2 Chain of Custody

Samples collected during the field investigation must be traceable from the point of collection through analysis and final disposition to ensure sample integrity. Sample integrity helps ensure the legal defensibility of the analytical data and subsequent conclusions. The project team will use standard USEPA procedures and software (such as Sampling and Laboratory Results Data Management Architecture [SCRIBE]) to identify, track, monitor, and maintain sample chain-of-custody records. Chain-of-custody records will establish the documentation necessary to trace sample possession from collection through analysis and final disposition. Each person retaining custody at any time throughout the sample history is responsible for maintaining proper documentation and control measures. A sample is under a person's custody if it:

- Is in that person's possession
- Is in that person's view after being in his or her possession
- Is in that person's possession and he or she places it in a secured location
- Is placed by that person in a designated secure area

Field staff will follow the sample and document control procedures, sample and evidence identification procedures, field records requirements and procedures, and chain-of-custody procedures outlined in the Contract Laboratory Program Guidance for Field Samplers (USEPA 2014). Samples will be packaged, screened for radioactivity, and labeled for shipment in compliance with U.S. Department of Transportation and International Air Transport Association dangerous goods regulations. Any additional requirements stipulated by the overnight carrier will be followed.

Chain-of-custody forms will be signed in ink by the samplers and the individual relinquishing custody. Field staff will then follow the sample packaging and shipment procedures summarized



below and captured in SOP 019-7 to ensure that samples arrive at the laboratory with the chain of custody intact.

- Immediately after samples are collected, sample containers will be labeled with the appropriate identifiers and clear tape will be placed over the labels to prevent smearing.
- Samples will be placed in the appropriate containers and then in a cooler. If sample preservation methods require the samples to be kept cool, the cooler will contain double sealed bags of ice and will be maintained at 4 degrees Celsius. The cooler will remain in a secured area or in view of the sampler until it is properly sealed for shipment to the laboratory. The only samples that require cooling will be samples collected for toxicity characteristic leaching procedure analysis because of mercury. No other samples require refrigeration.
- Before shipping, the chain-of-custody forms, airbills, and all other relevant documents will be completed. Chain-of-custody forms will be sealed in plastic bags and taped to the inside of the cooler lid. Cushioning material, such as bubble-wrap, will be placed in the cooler.
- A temperature blank consisting of a jar or vial containing water will be included in every cooler containing water samples that will be analyzed for mercury. Temperature blanks will be used by the laboratory to determine the cooler temperature at the time samples are received.
- The shipping cooler will then be sealed with tape and custody seals in a manner that will indicate whether the cooler was opened. The preferred procedure includes placing custody seals diagonally at opposite corners of the cooler. The custody seals will be covered with clear plastic tape or strapping tape.
- The outside surface of the shipping cooler will be cleaned and scanned to ensure that no field-related contamination is present on outside surfaces and that the overall activity measured and documented is appropriate for the handling and shipping method.

The field sampler is personally responsible for the care and custody of the samples until they are transferred to other field staff or dispatched to an overnight carrier or directly to a laboratory. As few people as possible should handle the samples to prevent loss, breakage, or potential contamination. When transferring possession of the samples, the individuals relinquishing and receiving the samples must sign, date, and note the time of transfer on the chain-of-custody form. Commercial carriers are not required to sign off on the chain-of-custody form as long as the form is sealed inside the sample cooler and the custody seals remain intact.

Custody procedures must be followed in the laboratory from sample receipt until the sample is discarded. The laboratory should designate a specific person as the sample custodian with an alternate designated to act in the custodian's absence. The custodian will receive incoming samples and indicate receipt by signing the accompanying custody forms and retaining copies of the signed forms as permanent records. Once the sample transfer process is complete, the laboratory is responsible for maintaining internal logbooks, laboratory tracking reports, and other records necessary to maintain custody throughout sample preparation and analysis.

The laboratory sample custodian will record pertinent information concerning the sample, including the persons delivering and receiving the sample, the date and time received, the method by which the sample was transmitted to the laboratory, the sample condition at the time of receipt (sealed, unsealed, or broken container; temperature; or other relevant remarks), the sample identification number, and any unique laboratory identification number associated with the sample. This information should be entered into a computerized laboratory information management system.

The laboratory must provide a secure storage area restricted to authorized personnel for all samples. The custodian will ensure that samples that are heat or light sensitive, are radioactive, have other unusual physical characteristics, or require special handling are properly stored and maintained before analysis. Only the custodian can distribute samples to laboratory personnel authorized to conduct the required analyses. Laboratory analytical personnel are responsible for the care and custody of the sample when it is received. These personnel must be prepared to testify that the sample was in their custody at all times from the moment they received it from the custodian until the time that the analyses were completed.

At the completion of the sample analysis, any unused portion of the sample, together with identifying labels, must be returned to the custodian. The returned tagged sample should be retained in secure storage until the custodian receives permission to dispose of the sample. Sample disposal will occur only on the order of the laboratory director in consultation with USEPA or Tetra Tech, when it is certain that the information is no longer required, or when the samples have deteriorated. Likewise, tags and laboratory records will be maintained until the information is no longer required and final disposition is ordered by the laboratory director in consultation with USEPA or Tetra Tech.

4.5 DECONTAMINATION PROCEDURES

Non-disposable equipment used in the field will be decontaminated between samples in accordance with SOP 002-4 using wet decontamination procedures. The most commonly employed decontamination method for reusable equipment includes:

- Removal of gross contamination using a dry paper towel or a paper towel and distilled water as necessary
- Secondary decontamination using a Liquinox solution and paper towel or scrub brush
- Equipment drying with a clean paper towel or setting it out on aluminum foil to allow for air drying

Fluids generated during equipment decontamination will not need to be containerized and will be discharged directly to the surface within known contaminated areas to allow for evaporation. Personnel decontamination will proceed in accordance with the procedures outlined in the HASP and RPP contained in [Appendix A](#).

4. Place the sample into a labeled and decontaminated sample container and record the sample collection information on the soil sampling form. At a minimum, the label should include the sample location or sample number, date and time, and sampler(s) name or initials.
5. Before collecting any additional samples or leaving a sample location, sufficiently decontaminate the sampling and mixing equipment.
6. Before leaving the sample location, record the position using a GPS or mark it with pin flags and close off the sample opening(s) with bentonite and, if approved, excess sample material and surrounding materials will be returned to the dug hole to backfill.

4.1.2.3 X-Ray Fluorescence Field Surveys Methods

XRF surveys will be performed using Niton XL5 (or equivalent) instruments. The surveys will be conducted with a soil guard in place protecting the instrument's X-ray window from soil and debris. The XRF instruments will be set to a scan time of 60 seconds for the low filter, 0 seconds for the medium filter, and 60 seconds for the high filter. A summary of the XRF survey equipment is included in [Table 9](#). Surveys will be conducted every 100 meters along radial gamma surveys. XRF measurements will identify or confirm locations to collect laboratory soil samples in areas of high gamma exposure. XRF surveys may also be conducted to collect qualitative metals results in areas such as residences.

The following protocol will be used for XRF measurements:

1. Because measurement can be impacted by elevated soil moisture levels, field staff will stop XRF measurement during persistent precipitation events. Field staff will use professional judgment to resume measurements. If the soil is visibly moist and the soil moisture is estimated to be greater than 30 percent at 0 to 3 inches below ground surface (bgs), field staff will wait at least 8 hours and then confirm acceptable soil moisture before resuming work.
2. At each XRF measurement location, the soil will be cleared of surface debris and visually assessed for signs of moisture. XRF analysis requires no signs of visible moisture (USEPA 2017). The XRF analyzer will then be placed directly against the soil for measurement, and a single XRF measurement will be collected at each location. An additional measurement will be made at locations selected for field duplicate analysis, resulting in a total of two measurements at those locations. XRF measurements will be collected in accordance with USEPA SW-846 Method 6200.
3. Each XRF location will be named alphanumerically with a unique ID.

4.1.2.4 Gamma-Radium Correlation Study Method

Gamma count rates will be correlated to concentrations of Ra-226 in surface soil and sediment using the following method:

1. Following completion of the delineation of gamma radiation levels, the data will be analyzed to identify areas exhibiting gamma measurements that envelop likely future decision points, such as potential cleanup levels for Ra-226 in surface soils.

2. A minimum of 10 study plots will be established at OCRM. The nominal size of each plot will be 100 m² or less; to the extent possible, each correlation plot will be selected in an area with reasonably homogeneous gamma readings near the target radiation level (that is, exhibiting characteristics of a uniform, normal, or lognormal distribution).
3. A GPS-based gamma radiation survey will be performed in the 100 m² study plots using one of the same detectors (if possible), survey speed, and geometry as described in [Section 4.1.2.1](#). The transect spacing will be reduced to 1 meter in this case.
4. A composite surface soil or sediment sample will be collected in each study plot composed of nine grab samples collected from 0 to 3 inches bgs and homogenized and composited into a single sample in the field for laboratory analysis.
5. The gamma correlation samples will be submitted to a fixed laboratory for analysis of total metals (including total uranium) by USEPA SW-846 Method 6020 (inductively coupled plasma mass spectroscopy), radionuclides (uranium-238 [via protactinium-234m], thorium-232 [via actinium-228], Ra-226, and potassium-40) by USEPA Method 901.1 (gamma spectroscopy), and isotopic thorium and uranium by American Society for Testing and Materials International D3972 (alpha spectroscopy). A summary of laboratory analyses for the gamma-radium correlation study is included in [Table 10](#).
6. A regression analysis of the paired average gamma measurements and Ra-226 concentrations in each plot will be performed to develop a statistically valid relationship between the two parameters.
7. The gamma measurements obtained in the gamma radiation survey will be converted to predicted Ra-226 concentrations using the relationship determined above.
8. Maps of the predicted Ra-226 concentrations will be produced that include raw and grid-averaged estimates of Ra-226. In addition, validated and interpolated maps using geostatistical methods may be provided.

4.1.2.5 *Gamma-Exposure Rate Correlation Study Method*

In addition to the gamma radiation survey, a cross-calibration will be conducted with a HPIC exposure rate measurement system. Calibration with a HPIC is necessary because the NaI thallium-laced detector systems exhibit energy-dependent response characteristics normalized to the cesium-137 0.662 million electronvolt photon. This energy response is never truly constant, and any given instrument can read somewhat different from the true exposure or dose rate, depending on the makeup of the energy spectrum at a site and the energy spectrum of the radionuclide sources used to calibrate the instrument (NRC 1994). The true exposure rate total from all radionuclide and cosmic contributions will be checked independently with the HPIC. HPIC measurements will be strategically collected to span a large range of gamma survey results to allow for a robust correlation. A summary of exposure rate equipment is presented in [Table 11](#).



4.1.1.6 Site Mapping

During field tasks at OCRM, observations of site features will be recorded to be included in maps and reports. Areas of damaged fence lines will be noted for repair by a contractor.

4.1.2 Methodologies

The following subsections describe the field sampling methodologies to be used during the sampling events described in [Section 4.1.1](#).

4.1.2.1 Gamma Radiation Survey Methods

The gamma radiation surveys will be performed using Ludlum Model 44-10 (or equivalent) 2-inch by 2-inch NaI detectors coupled to Ludlum Model 2221 (or equivalent) ratemeters/scalers set in ratemeter mode. For this project, these detectors will be coupled with an Environmental Restoration Group, Inc. (ERG) Model 105 GPS (or equivalent). The ERG Model 105 GPS consists of a Juniper Mesa 2 field computer and sub-meter accurate geode GPS receiver (or equivalent). A summary of gamma radiation survey equipment is presented in [Table 8](#). The surveys will be conducted on foot at approximately 3 feet per second along 4-meter transects at ORCM. Higher-density gamma scan transects may be performed as determined in the field. BSAs and residential areas will be scanned with 2-meter transects. Correlation plots will be scanned with <1-meter transects and will be conducted with both collimated and uncollimated NaI detectors. The detectors will be positioned at 1 meter ags. Consistent with recommendations in NUREG-5849 (NRC 1992), the gamma measurements will be processed after they have been collected by (1) overlaying 100-m² grids across OCRM, (2) estimating the average of the gamma measurements within each grid, and (3) comparing these averages to ILs. Additional areas may be surveyed as step-outs if the grid-averaged gamma values are above ILs.

4.1.2.2 Soil and Sediment Sampling Methods

Surface soil and sediment samples will be collected across OCRM from locations determined by the highest gamma radiation levels measured during the gamma delineation survey. A total of forty 250-gram soil samples will be collected from a depth of 0 to 3 inches.

Soil samples will be collecting using the following steps:

1. Clear debris, loose brush, and any excess vegetation or rock from sample locations.
2. Using a decontaminated sampler, collect the soil sample to the prescribed depth for the sample. If the sampler encounters refusal (that is, the sampler cannot be advanced to full sample depth), adjust the sample location to another location as near as practical to achieve successful sample collection. If a sample cannot be collected at the location, note "Refusal" in the logbook or field form.
3. Confirm the sample is equally representative of the range of depth. If multiple soil samples are collected from the same location and depth interval to achieve sufficient sample mass for analysis, either submit all of the collected soil for analysis or, using a mixing bucket or bowl, homogenize the collected soil into a single representative sample of sufficient mass for laboratory analysis.

4. Place the sample into a labeled and decontaminated sample container and record the sample collection information on the soil sampling form. At a minimum, the label should include the sample location or sample number, date and time, and sampler(s) name or initials.
5. Before collecting any additional samples or leaving a sample location, sufficiently decontaminate the sampling and mixing equipment.
6. Before leaving the sample location, record the position using a GPS or mark it with pin flags and close off the sample opening(s) with bentonite and, if approved, excess sample material and surrounding materials will be returned to the dug hole to backfill.

4.1.2.3 X-Ray Fluorescence Field Surveys Methods

XRF surveys will be performed using Niton XL5 (or equivalent) instruments. The surveys will be conducted with a soil guard in place protecting the instrument's X-ray window from soil and debris. The XRF instruments will be set to a scan time of 60 seconds for the low filter, 0 seconds for the medium filter, and 60 seconds for the high filter. A summary of the XRF survey equipment is included in [Table 9](#). Surveys will be conducted every 100 meters along radial gamma surveys. XRF measurements will identify or confirm locations to collect laboratory soil samples in areas of high gamma exposure. XRF surveys may also be conducted to collect qualitative metals results in areas such as residences.

The following protocol will be used for XRF measurements:

1. Because measurement can be impacted by elevated soil moisture levels, field staff will stop XRF measurement during persistent precipitation events. Field staff will use professional judgment to resume measurements. If the soil is visibly moist and the soil moisture is estimated to be greater than 30 percent at 0 to 3 inches below ground surface (bgs), field staff will wait at least 8 hours and then confirm acceptable soil moisture before resuming work.
2. At each XRF measurement location, the soil will be cleared of surface debris and visually assessed for signs of moisture. XRF analysis requires no signs of visible moisture (USEPA 2017). The XRF analyzer will then be placed directly against the soil for measurement, and a single XRF measurement will be collected at each location. An additional measurement will be made at locations selected for field duplicate analysis, resulting in a total of two measurements at those locations. XRF measurements will be collected in accordance with USEPA SW-846 Method 6200.
3. Each XRF location will be named alphanumerically with a unique ID.

4.1.2.4 Gamma-Radium Correlation Study Method

Gamma count rates will be correlated to concentrations of Ra-226 in surface soil and sediment using the following method:

1. Following completion of the delineation of gamma radiation levels, the data will be analyzed to identify areas exhibiting gamma measurements that envelop likely future decision points, such as potential cleanup levels for Ra-226 in surface soils.

ATTACHMENT D-2: CHAIN-OF-CUSTODY FORMS

601828

Tetra Tech

1999 Harrison Street, Suite 500

Oakland, CA 94612

Date Shipped: 11/20/2022

CHAIN OF CUSTODY RECORD

Event: RAES TO 35 OCRM Removal Assessment

Contact Name: Mike Dahquist 510-302-6310

Project Code: 103Z5440035 03.06

No: RAES35-0001

Lab: GEL Laboratories LLC - Charleston

Lab Phone: 843-769-7379

PO: RAES-005, TO 35, BOA 1150779

Lab #	Sample #	Matrix	Sample Date	Sample Time	Analyses	Analytical Method	Container	MS/MSD
	OCRM-B02-SS01-01-111622	Soil	11/16/2022	10:34	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	Y
	OCRM-B02-SS02-01-111622	Soil	11/16/2022	10:42	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS03-01-111622	Soil	11/16/2022	10:48	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS04-01-111622	Soil	11/16/2022	10:53	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS05-01-111622	Soil	11/16/2022	10:58	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS10-01-111622	Soil	11/16/2022	11:05	Metals, Ra-226, K-40, Isotopic U, Isotopic Th	6020, 901.1, ASTM 3972	1 quart bag	
	OCRM-B02-SS10-02-111622	Soil	11/16/2022	11:06	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS09-01-111622	Soil	11/16/2022	11:11	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS08-01-111622	Soil	11/16/2022	11:16	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS07-01-111622	Soil	11/16/2022	11:20	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS06-01-111622	Soil	11/16/2022	11:25	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS11-01-111622	Soil	11/16/2022	11:31	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS12-01-111622	Soil	11/16/2022	11:34	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS13-01-111622	Soil	11/16/2022	11:39	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS14-01-111622	Soil	11/16/2022	11:44	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS15-01-111622	Soil	11/16/2022	11:49	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS20-01-111622	Soil	11/16/2022	11:54	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS20-02-111622	Soil	11/16/2022	11:54	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS19-01-111622	Soil	11/16/2022	12:03	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS18-01-111622	Soil	11/16/2022	12:07	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	

Special Instructions: Use EDD NAUM v4.1. Send results to RAESANLY@tetrattech.com and marcus.quinlan@tetrattech.com. Please refer to PO for special instructions.

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
1 cooler 20 soil samples	Margaret Carolan Tetra Tech, Inc. Margaret Carolan	11/21/2022 12:00 pm	M. [Signature] GEL	11-22-22 0930	

601838

Tetra Tech

1999 Harrison Street, Suite 500

Oakland, CA 94612

Date Shipped: 11/20/2022

CHAIN OF CUSTODY RECORD

Event: RAES TO 35 OCRM Removal Assessment

Contact Name: Mike Dahlquist 510-302-6310

Project Code: 103Z5440035 03.06

No: RAES35-0002

Lab: GEL Laboratories LLC - Charleston

Lab Phone: 843-769-7379

PO: RAES-005, TO 35, BOA 1150779

Lab #	Sample #	Matrix	Sample Date	Sample Time	Analyses	Analytical Method	Container	MS/MSD
	OCRM-B02-SS17-01-111622	Soil	11/16/2022	12:11	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS16-01-111622	Soil	11/16/2022	12:16	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS21-01-111622	Soil	11/16/2022	12:21	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS22-01-111622	Soil	11/16/2022	12:26	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS23-01-111622	Soil	11/16/2022	12:30	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS24-01-111622	Soil	11/16/2022	12:37	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	Y
	OCRM-B02-SS25-01-111622	Soil	11/16/2022	12:42	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS30-01-111622	Soil	11/16/2022	12:48	Metals, Ra-226, K-40, Isotopic U, Isotopic Th	6020,901.1,ASTM 3972	1 quart bag	
	OCRM-B02-SS29-01-111622	Soil	11/16/2022	12:53	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS28-01-111622	Soil	11/16/2022	12:57	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS27-01-111622	Soil	11/16/2022	13:01	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS26-01-111622	Soil	11/16/2022	13:06	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS25-01-111622	Soil	11/16/2022	13:06	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS24-01-111622	Soil	11/16/2022	13:06	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS23-01-111622	Soil	11/16/2022	13:06	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-B02-SS22-01-111622	Soil	11/16/2022	13:06	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS3099-01-111622	Soil	11/16/2022	15:03	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS2738-01-111622	Soil	11/16/2022	15:13	Metals, Ra-226, K-40, Isotopic U, Isotopic Th	6020,901.1,ASTM 3972	1 quart bag	
	OCRM-SS2679-01-111622	Soil	11/16/2022	15:21	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS2217-01-111622	Soil	11/16/2022	15:28	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	

Special Instructions: Use EDD NAUM v4.1. Send results to RAESANLY@tetratech.com and marcus.quinlan@tetratech.com. Please refer to PO for special instructions.

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
1 cooler 16 soil samples	Margaret Carolan Tetra Tech, Inc. Margaret Carolan	11/21/2022 12:00 pm	M. [Signature] GEL	11-22-22 0930	

601842

Tetra Tech

1999 Harrison Street, Suite 500

Oakland, CA 94612

Date Shipped: 11/20/2022

CHAIN OF CUSTODY RECORD

Event: RAES TO 35 OCRM Removal Assessment

Contact Name: Mike Dahquist 510-302-6310

Project Code: 103Z5440035 03.06

No: RAES35-0003

Lab: GEL Laboratories LLC - Charleston

Lab Phone: 843-769-7379

PO: RAES-005, TO 35, BOA 1150779

Lab #	Sample #	Matrix	Sample Date	Sample Time	Analyses	Analytical Method	Container	MS/MSD
	OCRM-SS2225-01-111622	Soil	11/16/2022	15:35	Metals, Ra-226, K-40, Isotopic U, Isotopic Th	6020,901.1,ASTM 3972	1 quart bag	
	OCRM-SS1804-01-111622	Soil	11/16/2022	15:44	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	EB-01-111622	Water	11/16/2022	17:40	Metals, Ra-226, K-40	6020, 903.1	1x1L poly and 1x250mL HNO3 poly	
	OCRM-SS02-01-111722	Soil	11/17/2022	09:24	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS17-01-111722	Soil	11/17/2022	09:43	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS10-01-111722	Soil	11/17/2022	09:57	Metals, Ra-226, K-40, Isotopic U, Isotopic Th	6020,901.1,ASTM 3972	1 quart bag	
	OCRM-SS13-01-111722	Soil	11/17/2022	10:06	Metals, Ra-226, K-40,	6020, 901.1	1 quart bag	
	OCRM-SS11-01-111722	Soil	11/17/2022	10:17	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS09-01-111722	Soil	11/17/2022	10:27	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS06-01-111722	Soil	11/17/2022	10:41	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS05-01-111722	Soil	11/17/2022	10:49	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS07-01-111722	Soil	11/17/2022	10:59	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS08-01-111722	Soil	11/17/2022	11:08	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS12-01-111722	Soil	11/17/2022	11:21	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS12-02-111722	Soil	11/17/2022	11:21	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	Y
	OCRM-SS16-01-111722	Soil	11/17/2022	11:31	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS18-01-111722	Soil	11/17/2022	11:36	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS25-01-111722	Soil	11/17/2022	11:42	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS20-01-111722	Soil	11/17/2022	11:47	Metals, Ra-226, K-40, Isotopic U, Isotopic Th	6020,901.1,ASTM 3972	1 quart bag	
	OCRM-SS23-01-111722	Soil	11/17/2022	11:52	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	

Special Instructions: Use EDD NAUM v4.1. Send results to RAESANLY@tetratech.com and marcus.quinlan@tetratech.com. Please refer to PO for special instructions.

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
1 cooler 20 samples	Margaret Carlson Tetra Tech Inc Margaret Carlson	11/21/2022 12:00 PM	M. [Signature] GEL	11-22-22 0930	

601849

Tetra Tech

1999 Harrison Street, Suite 500

Oakland, CA 94612

Date Shipped: 11/20/2022

CHAIN OF CUSTODY RECORD

Event: RAES TO 35 OCRM Removal Assessment

Contact Name: Mike Dahquist 510-302-6310

Project Code: 103Z5440035 03.06

No: RAES35-0004

Lab: GEL Laboratories LLC - Charleston

Lab Phone: 843-769-7379

PO: RAES-005, TO 35, BOA 1150779

Lab #	Sample #	Matrix	Sample Date	Sample Time	Analyses	Analytical Method	Container	MS/MSD
	OCRM-SS26-01-111722	Soil	11/17/2022	11:58	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS27-01-111722	Soil	11/17/2022	12:04	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS24-01-111722	Soil	11/17/2022	12:09	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS35-01-111722	Soil	11/17/2022	13:05	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS32-01-111722	Soil	11/17/2022	13:11	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS31-01-111722	Soil	11/17/2022	13:17	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS30-01-111722	Soil	11/17/2022	13:25	Metals, Ra-226, K-40, Isotopic U, Isotopic Th	6020, 901.1, ASTM 3792	1 quart bag	
	OCRM-SS29-01-111722	Soil	11/17/2022	13:31	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS34-01-111722	Soil	11/17/2022	13:37	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS36-01-111722	Soil	11/17/2022	13:53	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS28-01-111722	Soil	11/17/2022	14:13	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS28-02-111722	Soil	11/17/2022	14:14	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS19-01-111722	Soil	11/17/2022	14:26	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	OCRM-SS21-01-111722	Soil	11/17/2022	14:38	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	
	EB-02-111722	Water	11/17/2022	18:35	Metals, Ra-226, K-40	6020, 903.1	1x1L poly and 1x250mL HNO3 poly	
	OCRM-RTSW-XS05-01-111822	Soil	11/18/2022	13:43	Metals, Ra-226, K-40	6020, 901.1	1 quart bag	Y

Special Instructions: Use EDD NAUM v4.1. Send results to RAESANLY@tetratech.com and marcus.quinlan@tetratech.com. Please refer to PO for special instructions.

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

Items/Reason	Relinquished by (Signature and Organization)	Date/Time	Received by (Signature and Organization)	Date/Time	Sample Condition Upon Receipt
1 cooler 16 samples	Margaret Carlson Tetra Tech Inc <i>Margaret Carlson</i>	11/21/2022 12:00pm	<i>M. [Signature]</i> GEL	11-22-22 0930	

Tetra Tech

1999 Harrison Street, Suite 500

Oakland, CA 94612

DateShipped: 11/20/2022

CHAIN OF CUSTODY RECORD

Event: RAES TO 35 OCRM Removal Assessment

Contact Name: Mike Dahquist 510-302-5310

Project Code: 103Z5440035 03.06

No: RAES35-0005

Lab: GEL Laboratories LLC - Charleston

Lab Phone: 843-769-7379

PO: RAES-005, TO 35, BOA 1150779

[illegible]

Special Instructions: Use EDD NAUM v4.1. Send results to RAESANLY@tetratech.com and marcus.quinlan@tetratech.com. Please refer to PO for special instructions.

SAMPLES TRANSFERRED FROM

CHAIN OF CUSTODY #

[illegible]

1999 Harrison Street, Suite 500
Oakland, CA 94612
DateShipped: 12/5/2022

CHAIN OF CUSTODY RECORD

Event: RAES TO 35 OCRM Removal Assessment
Contact Name: Mike Dahlquist 510-302-6310
Project Code: 103Z5440035 03.05

No: RAES35-0006

Lab: GEL Laboratories LLC - Charleston
Lab Phone: 843-769-7379
PO: RAES-005, TO 35, BOA 1150779

[illegible]

Special Instructions: Use EDD NAUM v4.1. Send results to RAESANLY@tetrattech.com and marcus.quinlan@tetrattech.com. Please refer to PO for special instructions.

SAMPLES TRANSFERRED FROM
CHAIN OF CUSTODY #

[illegible]

ATTACHMENT D-3: LABORATORY DATA VERIFICATION REPORTS

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 601828

Sample Designations/Names (ID): OCRM-B02-SS01-01-111622, OCRM-B02-SS02-01-111622, OCRM-B02-SS03-01-111622, OCRM-B02-SS04-01-111622, OCRM-B02-SS05-01-111622, OCRM-B02-SS10-01-111622, OCRM-B02-SS10-02-111622, OCRM-B02-SS09-01-111622, OCRM-B02-SS08-01-111622, OCRM-B02-SS07-01-111622, OCRM-B02-SS06-01-111622, OCRM-B02-SS11-01-111622, OCRM-B02-SS12-01-111622, OCRM-B02-SS13-01-111622, OCRM-B02-SS14-01-111622, OCRM-B02-SS15-01-111622, OCRM-B02-SS20-01-111622, OCRM-B02-SS20-02-111622, OCRM-B02-SS19-01-111622, and OCRM-B02-SS18-01-111622

Matrix: Soil
Analytical Parameters: Metals by EPA 6010D/6020B

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			Antimony was detected in preparation blank 1205253411, however, as this analyte was not detected in any associated field samples, no qualification of data was necessary.
Surrogate spikes			X	

Matrix spikes/matrix spike duplicates (MS/MSD)	X			Recoveries for molybdenum and vanadium are outside QC limits in MS/MSD for Metals by EPA 6020 that was prepared from sample OCRM-B02-SS01-01-111622. Laboratory flagged these analytes in all associated samples with an "N".
Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			All recoveries are within limits.
Other	X			Laboratory qualified results between MDL and PQL as estimated with a "B" flag.
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality. There may be high bias associated with vanadium and a low bias associated with molybdenum, however, the laboratory also noted possible matrix interference as contributing to the matrix spike failures.				

Notes:

LCS Laboratory control sample
 LCSD Laboratory control sample duplicate
 MDL Method detection limit
 MS Matrix spike
 MSD Matrix spike duplicate
 NA Not applicable
 PQL Practical quantitation limit
 QC Quality control
 SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 601835

Sample Designations/Names (ID): OCRM-B02-SS01-01-111622, OCRM-B02-SS02-01-111622, OCRM-B02-SS03-01-111622, OCRM-B02-SS04-01-111622, OCRM-B02-SS05-01-111622, OCRM-B02-SS10-01-111622, OCRM-B02-SS10-02-111622, OCRM-B02-SS09-01-111622, OCRM-B02-SS08-01-111622, OCRM-B02-SS07-01-111622, OCRM-B02-SS06-01-111622, OCRM-B02-SS11-01-111622, OCRM-B02-SS12-01-111622, OCRM-B02-SS13-01-111622, OCRM-B02-SS14-01-111622, OCRM-B02-SS15-01-111622, OCRM-B02-SS20-01-111622, OCRM-B02-SS20-02-111622, OCRM-B02-SS19-01-111622, and OCRM-B02-SS18-01-111622

Matrix: Soil

Analytical Parameters: Gamma Spec by DOE HASL 300, 4.5.2.3/Ga-01-R
Alpha Spec by DOE EML HASL 300, U-02-RC Modified
Alpha Spec by DOE EML HASL 300, Th-01-RC Modified

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			Thorium-230 was detected in preparation blank 1205261131, however, the value was less than the RDL.
Surrogate spikes			X	
Matrix spikes/matrix spike duplicates (MS/MSD)			X	

Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			All recoveries are within limits.
Other	X			
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality.				

Notes:

LCS Laboratory control sample
 LCSD Laboratory control sample duplicate
 MS Matrix spike
 MSD Matrix spike duplicate
 NA Not applicable
 PQL Practical quantitation limit
 QC Quality control
 RDL Required detection limit
 SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist
Date: 2/3/2023
Site Name/Job Number: RAES TO35 – Old Church Rock Mine
Laboratory: GEL
Data Package or SDG Number: 601838

Sample Designations/Names (ID): OCRM-B02-SS17-01-111622, OCRM-B02-SS16-01-111622,
OCRM-B02-SS21-01-111622, OCRM-B02-SS22-01-111622, OCRM-B02-SS23-01-111622,
OCRM-B02-SS24-01-111622, OCRM-B02-SS25-02-111622, OCRM-B02-SS30-01-111622,
OCRM-B02-SS29-01-111622, OCRM-B02-SS28-01-111622, OCRM-B02-SS27-01-111622,
OCRM-B02-SS26-01-111622, OCRM-SS3099-01-111622, OCRM-SS2738-01-111622,
OCRM-SS2679-01-111622, and OCRM-SS2217-01-111622

Matrix: Soil
Analytical Parameters: Metals by EPA 6010D/6020B

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			
Surrogate spikes			X	
Matrix spikes/matrix spike duplicates (MS/MSD)	X			Recoveries for molybdenum are outside QC limits in MS/MSD for Metals by EPA 6020 that was prepared from sample OCRM-B02-SS17-01-111622. Laboratory flagged these analytes in all associated samples with an “N”.

Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			All recoveries are within limits.
Other	X			Laboratory qualified results between MDL and PQL as estimated with a “B” flag.
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality. There may be low bias associated with molybdenum, however, the laboratory also noted possible matrix interference as contributing to the matrix spike failures.				

Notes:

EPA United States Environmental Protection Agency
LCS Laboratory control sample
LCSD Laboratory control sample duplicate
MDL Method detection limit
MS Matrix spike
MSD Matrix spike duplicate
NA Not applicable
PQL Practical quantitation limit
QC Quality control
SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 601840

Sample Designations/Names (ID): OCRM-B02-SS17-01-111622, OCRM-B02-SS16-01-111622, OCRM-B02-SS21-01-111622, OCRM-B02-SS22-01-111622, OCRM-B02-SS23-01-111622, OCRM-B02-SS24-01-111622, OCRM-B02-SS25-02-111622, OCRM-B02-SS30-01-111622, OCRM-B02-SS29-01-111622, OCRM-B02-SS28-01-111622, OCRM-B02-SS27-01-111622, OCRM-B02-SS26-01-111622, OCRM-SS3099-01-111622, OCRM-SS2738-01-111622, OCRM-SS2679-01-111622, and OCRM-SS2217-01-111622

Matrix: Soil

Analytical Parameters: Gamma Spec by DOE HASL 300, 4.5.2.3/Ga-01-R
Alpha Spec by DOE EML HASL 300, U-02-RC Modified
Alpha Spec by DOE EML HASL 300, Th-01-RC Modified

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			Thorium-230 was detected in preparation blank 1205261131, however, the value was less than the RDL.
Surrogate spikes			X	
Matrix spikes/matrix spike duplicates (MS/MSD)			X	

Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			All recoveries are within limits.
Other	X			
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality.				

Notes:

LCS Laboratory control sample
 LCSD Laboratory control sample duplicate
 MS Matrix spike
 MSD Matrix spike duplicate
 NA Not applicable
 PQL Practical quantitation limit
 QC Quality control
 RDL Required detection limit
 SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 601842

Sample Designations/Names (ID): OCRM-SS2225-01-111622, OCRM-SS1804-01-111622, EB-01-111622, OCRM-SS02-01-111722, OCRM-SS17-01-111722, OCRM-SS10-01-111722, OCRM-SS13-01-111722, OCRM-SS11-01-111722, OCRM-SS09-01-111722, OCRM-SS06-01-111722, OCRM-SS05-01-111722, OCRM-SS07-01-111722, OCRM-SS08-01-111722, OCRM-SS12-02-111722, OCRM-SS12-01-111722, OCRM-SS16-01-111722, OCRM-SS18-01-111722, OCRM-SS25-01-111722, OCRM-SS20-01-111722, and OCRM-SS23-01-111722

Matrix: Soil
Analytical Parameters: Metals by EPA 6010D/6020B

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			Aluminum, barium, calcium, copper, iron, magnesium, and manganese were detected in equipment rinsate blank EB-01-111622, but these analytes were detected in associated samples at values greater than ten times their concentrations in the equipment blank.
Surrogate spikes			X	

Matrix spikes/matrix spike duplicates (MS/MSD)	X			Recoveries for chromium and lithium are outside QC limits in MS/MSD for Metals by EPA 6020 that was prepared from sample OCRM-SS2225-01-111622. Laboratory flagged these analytes in all associated samples with an “N”.
Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			All recoveries are within limits.
Other	X			Laboratory qualified results between MDL and PQL as estimated with a “B” flag.
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality. There may be high bias associated with chromium and lithium, however, the laboratory also noted possible matrix interference as contributing to the matrix spike failures.				

Notes:

EPA	United States Environmental Protection Agency
LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
MDL	Method detection limit
MS	Matrix spike
MSD	Matrix spike duplicate
NA	Not applicable
PQL	Practical quantitation limit
QC	Quality control
SDG	Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist
Date: 2/3/2023
Site Name/Job Number: RAES TO35 – Old Church Rock Mine
Laboratory: GEL
Data Package or SDG Number: 601847

Sample Designations/Names (ID): OCRM-SS2225-01-111622, OCRM-SS1804-01-111622,
 EB-01-111622, OCRM-SS02-01-111722, OCRM-SS17-01-111722, OCRM-SS10-01-111722,
 OCRM-SS13-01-111722, OCRM-SS11-01-111722, OCRM-SS09-01-111722,
 OCRM-SS06-01-111722, OCRM-SS05-01-111722, OCRM-SS07-01-111722,
 OCRM-SS08-01-111722, OCRM-SS12-02-111722, OCRM-SS12-01-111722,
 OCRM-SS16-01-111722, OCRM-SS18-01-111722, OCRM-SS25-01-111722
 OCRM-SS20-01-111722, and OCRM-SS23-01-111722

Matrix: Soil, Water (Equipment Blank)
Analytical Parameters: Gamma Spec by DOE HASL 300, 4.5.2.3/Ga-01-R
 Alpha Spec by DOE EML HASL 300, U-02-RC Modified
 Alpha Spec by DOE EML HASL 300, Th-01-RC Modified

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			Thorium-230 was detected in preparation blank 1205261131, however, the value was less than the RDL.
Surrogate spikes			X	
Matrix spikes/matrix spike duplicates (MS/MSD)			X	

Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			High RPD in duplicate samples for Thorium-230, Uranium 235/236, and Potassium-40; however, all relative error ratios were within QC limits.
Other	X			
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality.				

Notes:

LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
MS	Matrix spike
MSD	Matrix spike duplicate
NA	Not applicable
QC	Quality control
RDL	Required detection limit
RPD	Relative percent difference
SDG	Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 601849

Sample Designations/Names (ID): OCRM-SS26-01-111722, OCRM-SS27-01-111722,
OCRM-SS24-01-111722, OCRM-SS35-01-111722, OCRM-SS32-01-111722,
OCRM-SS31-01-111722, OCRM-SS30-01-111722, OCRM-SS29-01-111722,
OCRM-SS34-01-111722, OCRM-SS36-01-111722, OCRM-SS28-01-111722,
OCRM-SS28-02-111722, OCRM-SS19-01-111722, OCRM-SS21-01-111722,
EB-02-111722, and OCRM-RTSW-XS05-01-111822

Matrix: Soil, Water (Equipment Blank)

Analytical Parameters: Metals by EPA 6010D/6020B

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			Barium and copper were detected in equipment rinsate blank EB-02-111722, but these analytes were detected in associated samples at values greater than ten times their concentrations in the equipment blank.
Surrogate spikes			X	

Matrix spikes/matrix spike duplicates (MS/MSD)	X			Recoveries for selenium are outside QC limits in MS/MSD that was prepared from sample OCRM-SS26-01-111722. Laboratory flagged this analyte in all associated samples with an "N".
Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			
Other	X			Laboratory qualified results between MDL and PQL as estimated with a "B" flag.
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality. There may be low bias associated with selenium, however, the laboratory also noted possible matrix interference as contributing to the matrix spike failure.				

Notes:

EB Equipment blank
LCS Laboratory control sample
LCSD Laboratory control sample duplicate
MDL Method detection limit
MS Matrix spike
MSD Matrix spike duplicate
NA Not applicable
PQL Practical quantitation limit
QC Quality control
SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 601851

Sample Designations/Names (ID): OCRM-SS26-01-111722, OCRM-SS27-01-111722,
OCRM-SS24-01-111722, OCRM-SS35-01-111722, OCRM-SS32-01-111722,
OCRM-SS31-01-111722, OCRM-SS30-01-111722, OCRM-SS29-01-111722,
OCRM-SS34-01-111722, OCRM-SS36-01-111722, OCRM-SS28-01-111722,
OCRM-SS28-02-111722, OCRM-SS19-01-111722, OCRM-SS21-01-111722,
EB-02-111722, and OCRM-RTSW-XS05-01-111822

Matrix: Soil, Water (Equipment Blank)

Analytical Parameters: Gamma Spec by DOE HASL 300, 4.5.2.3/Ga-01-R
Alpha Spec by DOE EML HASL 300, U-02-RC Modified
Alpha Spec by DOE EML HASL 300, Th-01-RC Modified

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			
Surrogate spikes			X	
Matrix spikes/matrix spike duplicates (MS/MSD)			X	

Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			High RPD in duplicate sample OCRM-SS26-01-111722 for Potassium-40; however, relative error ratio was within QC limits.
Other	X			
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality.				

Notes:

LCS Laboratory control sample
 LCSD Laboratory control sample duplicate
 MS Matrix spike
 MSD Matrix spike duplicate
 NA Not applicable
 QC Quality control
 RPD Relative percent difference
 SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist
Date: 2/3/2023
Site Name/Job Number: RAES TO35 – Old Church Rock Mine
Laboratory: GEL
Data Package or SDG Number: 602061

Sample Designations/Names (ID): OCRM-CORR02-01-111922, OCRM-CORR01-02-111922,
OCRM-CORR01-01-111922, OCRM-CORR03-01-111922, OCRM-CORR04-01-111922,
OCRM-CORR05-01-111922, OCRM-CORR06-01-111922, OCRM-CORR07-01-111922,
OCRM-CORR08-01-111922, OCRM-CORR09-01-111922, OCRM-CORR10-01-111922,
OCRM-CORR11-01-111922, OCRM-CORR12-01-111922, OCRM-CORR13-01-111922,
OCRM-CORR14-01-111922, and OCRM-CORR15-01-111922

Matrix: Soil
Analytical Parameters: Metals by EPA 6010D/6020B

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			
Surrogate spikes			X	

Matrix spikes/matrix spike duplicates (MS/MSD)	X			Recoveries for copper and molybdenum are outside QC limits in MS/MSD prepared from sample OCRM-CORR12-01-111922. Laboratory flagged these analytes in all associated samples with an "N".
Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			
Other	X			Laboratory qualified results between MDL and PQL as estimated with a "B" flag.
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality. There may be low bias associated with copper and molybdenum, however, the laboratory also noted possible matrix interference as contributing to the matrix spike failures.				

Notes:

LCS Laboratory control sample
 LCSD Laboratory control sample duplicate
 MDL Method detection limit
 MS Matrix spike
 MSD Matrix spike duplicate
 NA Not applicable
 PQL Practical quantitation limit
 QC Quality control
 SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 602063

Sample Designations/Names (ID): OCRM-CORR02-01-111922, OCRM-CORR01-02-111922,
OCRM-CORR01-01-111922, OCRM-CORR03-01-111922, OCRM-CORR04-01-111922,
OCRM-CORR05-01-111922, OCRM-CORR06-01-111922, OCRM-CORR07-01-111922,
OCRM-CORR08-01-111922, OCRM-CORR09-01-111922, OCRM-CORR10-01-111922,
OCRM-CORR11-01-111922, OCRM-CORR12-01-111922, OCRM-CORR13-01-111922,
OCRM-CORR14-01-111922, and OCRM-CORR15-01-111922

Matrix: Soil

Analytical Parameters: Gamma Spec by DOE HASL 300, 4.5.2.3/Ga-01-R
Alpha Spec by DOE EML HASL 300, U-02-RC Modified
Alpha Spec by DOE EML HASL 300, Th-01-RC Modified

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			
Surrogate spikes			X	
Matrix spikes/matrix spike duplicates (MS/MSD)			X	

Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			High RPD in duplicate sample OCRM-CORR12-01-111922 for Potassium-40 and Thorium-232; however, all relative error ratios were within QC limits.
Other	X			
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality.				

Notes:

LCS Laboratory control sample
LCSD Laboratory control sample duplicate
MS Matrix spike
MSD Matrix spike duplicate
NA Not applicable
QC Quality control
RPD Relative percent difference
SDG Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 603278

Sample Designations/Names (ID): OCRM-SS2975-01-111622, OCRM-SS3006-01-111622,
OCRM-SS2946A-01-111622, and OCRM-SS2946B-01-111622

Matrix: Soil

Analytical Parameters: Metals by EPA 6010D/6020B, PCBs by EPA 8082A

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			
Surrogate spikes	X			
Matrix spikes/matrix spike duplicates (MS/MSD)	X			Recoveries for chromium, uranium, vanadium and copper and RPDs for calcium are outside QC limits in MS/MSD prepared from sample OCRM-SS2946A-01-111622. Laboratory flagged these analytes in all associated samples with an “N”.
Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			

Other	X			Laboratory qualified results between MDL and PQL as estimated with a “B” flag.
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality. There may be high bias associated with chromium, uranium, vanadium, and copper, however, the laboratory also noted possible matrix interference as contributing to the matrix spike failures.				

Notes:

LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
MDL	Method detection limit
MS	Matrix spike
MSD	Matrix spike duplicate
NA	Not applicable
PQL	Practical quantitation limit
QC	Quality control
RPD	Relative percent difference
SDG	Sample delivery group

**LABORATORY
DATA VERIFICATION REPORT**

Prepared by: Mike Dahlquist

Date: 2/3/2023

Site Name/Job Number: RAES TO35 – Old Church Rock Mine

Laboratory: GEL

Data Package or SDG Number: 603279

Sample Designations/Names (ID): OCRM-SS2975-01-111622, OCRM-SS3006-01-111622,
OCRM-SS2946A-01-111622, and OCRM-SS2946B-01-111622

Matrix: Soil

Analytical Parameters: Gamma Spec by DOE HASL 300, 4.5.2.3/Ga-01-R
Alpha Spec by DOE EML HASL 300, U-02-RC Modified
Alpha Spec by DOE EML HASL 300, Th-01-RC Modified

Data Package Element	Usable	Rejected	NA	Description of Affected Data (note specific samples and analytical parameters affected)
Chain-of-custody form	X			
Data package completeness	X			
Sample preservation, storage, and holding times	X			
Method and field blank contamination	X			
Surrogate spikes			X	
Matrix spikes/matrix spike duplicates (MS/MSD)			X	
Laboratory control samples/laboratory control sample duplicates (LCS/LCSD)	X			High RPD in duplicate sample OCRM-SS2946A-01-111622 for Uranium-238; however, all relative error ratios were within QC limits.

Other	X			
Summary: Aside from those noted above, there are no QC failures and the data can be considered of high quality.				

Notes:

LCS Laboratory control sample
 LCSD Laboratory control sample duplicate
 MS Matrix spike
 MSD Matrix spike duplicate
 NA Not applicable
 QC Quality control
 RPD Relative percent difference
 SDG Sample delivery group

APPENDIX E

GAMMA-RADIUM CORRELATION REPORT

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**OCRM Removal Assessment
Appendix E
Gamma-Radium Correlation Report**

**Response, Assessment, and Evaluation Services
Contract No. EP-S9-17-03
Task Order 00035**

August 25, 2023

**Submitted to
U.S. Environmental Protection Agency**

**Submitted by
Tetra Tech, Inc.
1999 Harrison Street, Suite 500
Oakland, CA 94612**



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ATTACHMENTS

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Attachment E-4: Correlation Plot Statistics – Shielded Gamma

Attachment E-5: Correlation Plot Statistics – Exposure Rate



ACRONYMS AND ABBREVIATIONS

$\mu\text{R/hr}$	Microroentgens per hour
ags	Above ground surface
AUM	Abandoned Uranium Mine
bgs	Below ground surface
BTV	Background threshold value
CAS	Chemical Abstracts Service
cpm	Counts per minute
Energy Fuels	Energy Fuels Resources, Inc.
HPIC	High-Pressure Ionization Chamber
ID	Identification
K-40	Potassium-40
m^2	Square meter
MARLAP	<i>Multi-Agency Radiological Laboratory Analytical Protocols Manual</i>
MARSSIM	<i>Multi-Agency Radiological Site Survey Investigation Manual</i>
mg/kg	Milligram per kilogram
NAD	North American Datum
NaI	Sodium iodide
NORM	Naturally Occurring Radioactive Materials
NRC	United States Nuclear Regulatory Commission
OCRM	Old Church Rock Mine
pCi/g	Picocuries per gram
QA	Quality Assurance
QC	Quality Control
R^2	Coefficient of Variance
Ra-226	Radium-226
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SOP	Standard operating procedure



ACRONYMS AND ABBREVIATIONS (CONTINUED)

Tetra Tech	Tetra Tech, Inc.
Th-232	Thorium-232

USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency



EXECUTIVE SUMMARY

This report presents methodology and results of utilizing gamma radiation survey data as surrogate measurements of radium-226 (Ra-226) within surface soils of the Old Church Rock Mine (OCRM) site (the site). Ra-226 is a risk driver at abandoned uranium mines (AUM), and ability to understand the geospatial distribution of this radionuclide is important for cleanup decisions at a site. Within this report, Tetra Tech, Inc. (Tetra Tech) presents different models for predicting Ra-226 in surface soils using gamma radiation survey data. A strong gamma-radium model is useful for estimating cleanup and/or removal volumes, allows use of gamma radiation survey data as a real-time remedial survey tool for conducting mine cleanup operations, and can serve as a tool for verification purposes post-cleanup to support the final status survey.



1.0 INTRODUCTION

This Appendix B to the Old Church Rock Mine Removal Assessment Report (hereafter referred to as the main report) presents methodology, results, and data interpretation of the gamma-radium soil correlation study at Old Church Rock Mine (OCRM) within the Navajo Nation (the site).

1.1 PURPOSE

There is potential for a release, or a significant threat of a release at the site, based on results from this and previous investigations. Currently no documented action memorandum exists, and no current cleanup levels have been established for the site; however, radium-226 (Ra-226) is likely considered to be a risk driver at the site. Therefore, quantitation of the geospatial distribution of Ra-226 within the surface soils of the site is an important goal.

A relationship between gamma exposure rates and gamma emitting radionuclides exists at every site, but because of numerous manufacturing, geological, and geographic factors, as well as Natural Occurring Radioactive Material (NORM) such as thorium and potassium, a generalized relationship does not exist—thus need for development of a site-specific relationship. Upon development of a site-specific correlation, field staff will be able to readily estimate concentrations of gamma-emitting radionuclides, particularly Ra-226, by using handheld survey instrumentation (e.g., sodium iodide [NaI] scintillators), which are substantially less expensive, quicker, and enable coverage of greater area than alternative soil characterization methods such as laboratory analysis of soil samples.

No site-specific gamma-radium correlation study has been performed at the site to date. The purpose of the 2022 gamma-radium correlation study at the site was to determine the site-specific relationship between gamma radiation levels and Ra-226 soil concentrations.

1.2 BACKGROUND

Using gamma radiation to estimate radionuclides is a common approach at sites contaminated with windblown uranium tailings (such as at former uranium mills) and at abandoned uranium mines (Abelquist 2014; USEPA 2000; Johnson, Meyer, and Vidyasagar 2006; Whicker and others 2008). Attempts have been made to develop relationships between gamma exposure rate and soil Ra-226 concentrations, so that the less expensive gamma data—easily collected over large areas—can be used to predict Ra-226 concentrations in soil for remedial action. From as early as 1985 (Thomas and Kinnison 1985), this has been a common strategy at sites contaminated with windblown contamination near uranium tailings piles.

The principal method for accurately determining concentration of Ra-226 in soil or any given material typically is by way of gamma spectral analysis, which can be time consuming and costly. Analytical soil sampling is the only way to measure Ra-226 accurately, but is very costly, and return of results from a laboratory can take over a month because of sampling requirements for analyses for the daughter products (at least for the preferred gamma spectral analysis method). Analytical soil sampling likely always will occur to identify and confirm efficacy of cleanup actions at the site; however, one goal is to utilize gamma radiation survey data as a primary screening or indicator tool for effectively identifying whether the site has been

remediated or needs further remediation. Therefore, it is important to determine if a strong gamma-radium relationship exists at the site so that site-specific conversion and/or correlation factors can be established.

The correlation factor developed between gamma measurements and Ra-226 may provide the basis of an economical and effective method for estimating Ra-226 concentration over the entire site (Energy Fuels Resources, Inc. [Energy Fuels] 2014). Currently, no formal guidance or methodology for performing gamma-radium correlation studies or specifics on developing correlation factors are available within the primary U.S. agency guidance documents such as *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (USEPA 2000) or *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP) (USEPA 2004). Literature from Johnson, Meyer, and Vidyasagar (2006) and Whicker and others (2008) presented methodology for performing correlations and developing these types of correlation factors, referred to here as a “gamma-radium correlation,” at uranium mills and uranium mines in the Western United States.

Tetra Tech has performed gamma-radium correlation studies at different uranium sites following approaches or variations of approaches from Johnson, Meyer, and Vidyasagar (2006) and Whicker and others (2008). Some examples include the previous project-wide correlation study at Riley Pass (Tetra Tech 2013, 2017b, 2019a; and United States Department of Agriculture [USDA] 2016). Additional correlation studies include those at the Red Bluff Uranium Mine in the Tonto National Forest (Tetra Tech 2017a) and at the Northern Agency Tronox Mines in the Navajo Nation (Tetra Tech 2019b), among others.

The intent of the gamma-radium correlation study during the 2022 field investigation at the site was to determine if a strong relationship exists between gamma radiation levels and soil Ra-226 concentrations and, if possible, develop statistical correlations that may be useful to estimate approximate soil Ra-226 concentrations across the entire site based on gamma survey results; the latter achievement would aid remediation design, remedial action surveys, and/or final verifications. The study was designed with an aim to incorporate lessons learned from the previous studies cited, and to improve data acquisition techniques and data evaluation approaches for the site. Some lessons learned include: (1) how to better identify and address outliers in gamma-radium correlation data pairs, and how to prevent those from occurring in the field; (2) the importance of utilizing data around the cleanup level and not data too far outside of range; and (3) not to use logarithmic regression models for gamma-radium conversion factors.

Quality assurance and quality control (QA/QC) was a priority throughout data collection and analysis tasks completed in support of the gamma-radium correlation. Specific QA/QC procedures were implemented to both minimize and evaluate potential sources of inaccuracy during sample collection and analysis. QA/QC procedures were designed to consider relevant guidance from USEPA, as well as MARSSIM and MARLAP. Data quality for in-field gamma measurements is presented in “Gamma Validation and Verification Report” (Appendix B to the main report). A detailed photographic log of gamma-radium correlation field activities is in Appendix A to the main report.

2.0 METHODS

This section discusses methodology of the gamma-radium correlation study during the 2022 field investigation of the site.

2.1 PLOT SELECTION

A “plot” refers to a “soil correlaton plot” or “sampling plot,” which is an area of land, selected by the lead radiation expert, to be (1) scanned for radiation, and (2) sampled via collections of composite soil samples for analyses for metals and radionuclide data. Data from the plots are used in the correlation study typically through linear or non-linear regression or multiple linear regression. Plot selection is crucial for a meaningful and successful correlation. Careful planning during plot selection is likely to be far more beneficial to the quality of the correlation results than other factors. As part of the plot selection process, Tetra Tech conducted a desktop study in the field during the initial stages of the 2022 field investigation utilizing already collected gamma walkover data. The goal was to identify ideal plot locations. An ideal set of correlation plots have the following characteristics:

- Plots contain a *homogenous* gamma radiation level and soil radionuclide concentrations, i.e., the gamma radiation field typically follows a normal, lognormal, or uniform parametric distribution.
- Plot shapes are typically square or rectangular.
- Plots should be located in a relatively flat area and generally be free of dense vegetation or uneven terrain.
- Plot size should generally be no smaller than 25 square meters (m^2) and no larger than 200 m^2 in surface area.
- A minimum of 10 plots per correlation study is recommended, but the higher the number of plots selected, the more statistically sound the correlation will become.
- Gamma levels and soil concentrations across the range of plots selected will encompass a wide range ideally bounding the cleanup level for the site with regards to soil Ra-226 concentrations. Gamma levels and soil Ra-226 concentrations should be approximately evenly spaced across this range.

Initial correlation plots were selected by use of gamma radiation survey data collected in the field during November 2022. Plots were identified by the radiation team lead and were preliminarily scanned to determine if they would be appropriate for further analysis. Once the plots were determined to be suitable locations, the field team scanned them with backpack scan systems on November 19, 2022, led by the radiation expert. Plots were then altered, moved, or kept in place, as necessary in the field, for the gamma-radium correlation study.

Table E-1 lists sampling information regarding each of the final soil correlation plot locations including field sample ID, laboratory sample number, sample date, sample time, geospatial coordinates, vertical elevation, and surface area of each plot. The plots ranged in size from 87 to 145 m^2 . The following Figure E-1 is a map showing soil correlation plot locations. Once the final



plots were selected, gamma scanning followed according to methods described in the next subsection.

Table E-1. Summary Information of Gamma-Radium Correlation Plots

Sample ID	Date	Northing (US Feet)	Easting (US Feet)	Surface Area of Correlation Plot (m ²)
OCRM-CORR01	11/19/2022	1,680,715	2,505,848	122
OCRM-CORR02	11/19/2022	1,680,755	2,506,291	114
OCRM-CORR03	11/19/2022	1,682,941	2,510,034	121
OCRM-CORR04	11/19/2022	1,682,864	2,509,924	109
OCRM-CORR05	11/19/2022	1,682,946	2,509,889	117
OCRM-CORR06	11/19/2022	1,680,563	2,506,350	123
OCRM-CORR07	11/19/2022	1,681,821	2,507,996	112
OCRM-CORR08	11/19/2022	1,681,873	2,508,192	101
OCRM-CORR09	11/19/2022	1,682,219	2,508,421	127
OCRM-CORR10	11/19/2022	1,682,131	2,508,640	89
OCRM-CORR11	11/19/2022	1,681,876	2,508,913	87
OCRM-CORR12	11/19/2022	1,682,332	2,508,717	113
OCRM-CORR13	11/19/2022	1,682,671	2,508,653	145
OCRM-CORR14	11/19/2022	1,682,600	2,508,589	141
OCRM-CORR15	11/19/2022	1,683,228	2,509,247	98

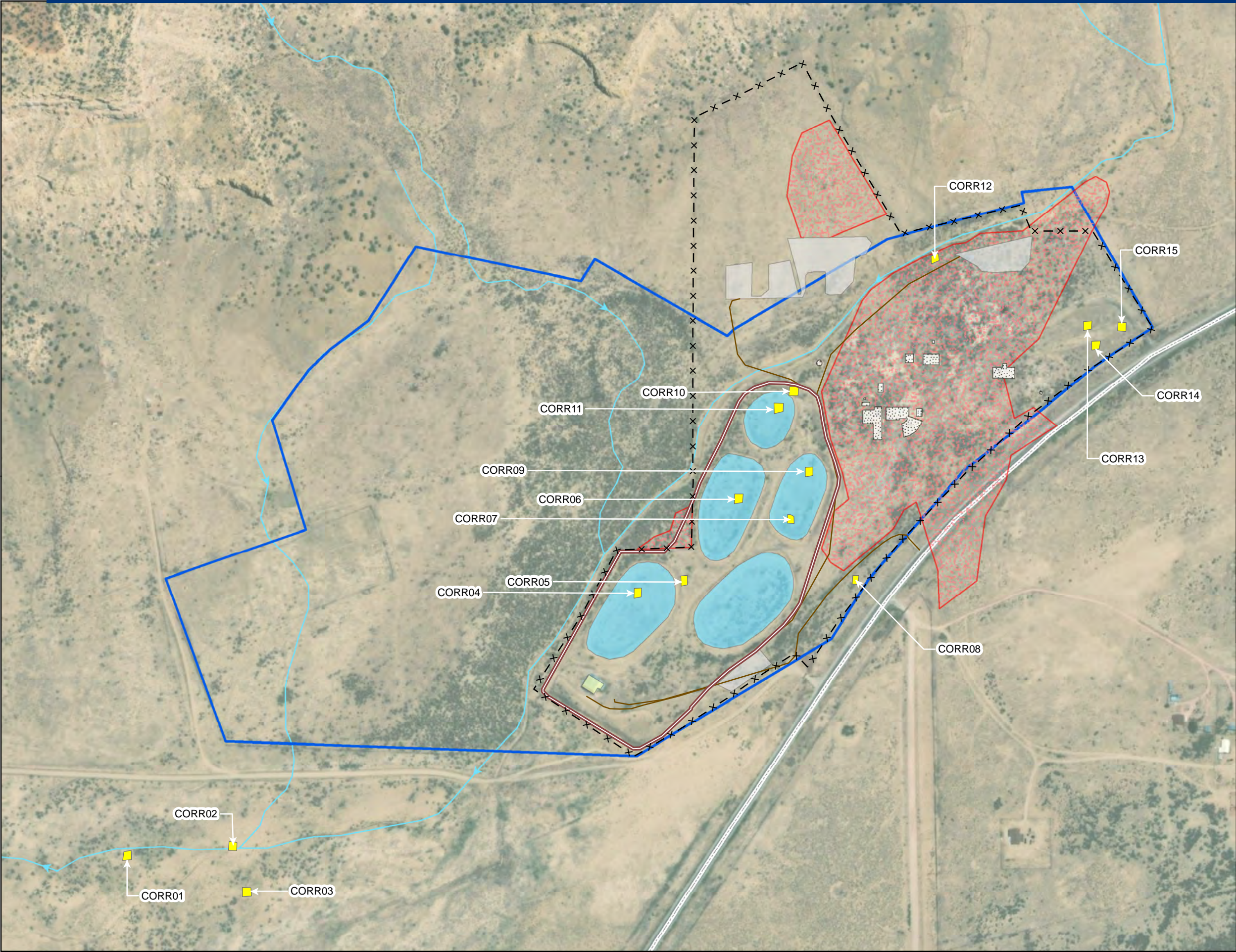
Notes:

Spatial coordinates are in NAD 1983 New Mexico West FIPS 4001 (US Feet), and represent centroid of the plot.

m² Square meter

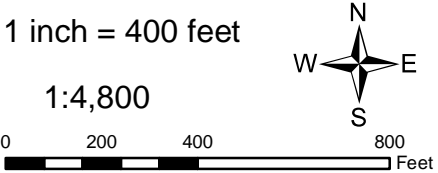
NAD North American Datum

US United States



- Correlation Plot
 - 2007 USEPA Navajo AUM Atlas Polygon
- Features**
- Berm
 - Fenced Boundary
 - Drill Road - Fall 2022
 - Concrete Pad
 - Former Pond
 - Ion Exchange Building
 - Laydown Areas - Fall 2022
 - Approximate Waste Disposal Area
 - Community Road
 - Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AUM Abandoned uranium mine



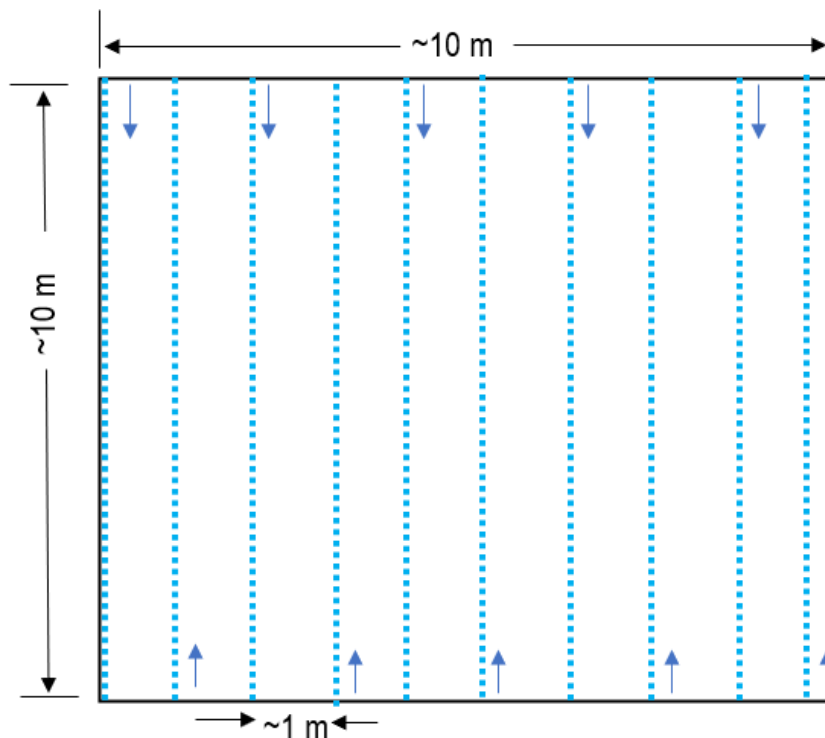
OLD CHURCH ROCK MINE
2022 CORRELATION STUDY
PLOT LOCATIONS

Prepared For: U.S. EPA Region 9	Prepared By:
	 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: E-1

2.2 WALKOVER GAMMA SCANNING

After initial selection of plots from the desktop study, an initial scan in the field ensued to determine if the plot boundaries required adjustment based on the measured gamma radiation field, and to see if these were appropriate plots (i.e., met the criteria specified in [Section 2.1](#)). Once the plots were confirmed to meet the appropriate criteria set forth in [Section 2.1](#), high-density gamma radiation scanning (unshielded and shielded) was performed inside of the plot.

Gamma radiation scanning (walkover gamma scanning) occurred at a high density (1-meter transect spacing) within the boundary of the selected correlation plot. Prior to scanning, the field team had placed pin flags at corners of the correlation plot. Gamma scanning proceeded across the plot in a pattern similar to that shown on [Figure E-2](#). On this figure, the arrows represent the direction of scanning (scan lines are shown as blue dashed dots). Scanning was performed in either horizontal or vertical directions at approximately 1-meter transect spacing. Unshielded scanning occurred initially across the plot at a 1-meter height above ground surface (ags) followed by a lower height (1-foot) shielded scan involving application of a lead collimator. An engineering diagram of the lead shield (collimator) used for this study is in [Attachment E-1](#). One of the radiation instruments used for the soil correlation gamma radiation survey was the same as used for ground-based gamma radiation surveys. For this study, field staff used mobile scanning systems with Ludlum Model 44-10 (2- by 2-inch) sodium iodide (NaI) gamma scintillation detectors coupled to Ludlum Model 3000 ratemeters/scalers set in ratemeter mode. The detectors were coupled to ERG Model 105 Global Positioning System (GPS) units. The ERG Model 105 GPS unit consists of a Juniper Mesa 2 field computer and geode GPS receiver.



**Figure E-2. Grid Scanning Pattern for Soil Correlation Plot
(Blue Dashed Lines Indicate Scanning Data)**

2.3 STATIC GAMMA COUNT RATE

Following the walkover scanning, a pin flag was placed in the approximate centroid of the soil correlation plot. By use of the same radiation detection system, a 1-meter ags, static 60-second gamma count rate measurement occurred at the plot centroid. The 60-second average and standard deviation were recorded in the field logbook. Only an unshielded static measurement was taken for this project (not an accompanying shielded measurement).

2.4 GAMMA EXPOSURE RATE

Following the gamma radiation survey of the plot and measurement of the 60-second static gamma count rate, a high-pressure ionization chamber (HPIC) was placed in the approximate centroid of the soil correlation plot. For the exposure-rate correlation, an HPIC (GE Reuter-Stokes RSDetection, RS-S131-200) was used to take energy-independent measurements of exposure rates in accordance with Standard Operating Procedure (SOP) 003: Making Exposure Rate Measurements Using a HPIC (included as [Attachment E-2](#)). At each measurement location, gamma exposure rate measurements occurred at 1-minute integrated intervals over a duration of at least 10 minutes. The HPIC gamma exposure rate representing a grid is the average of the 1-minute integrated measurements, excluding the first minute of data acquisition during which the HPIC exhibits a startup pulse. The HPIC was centered within the correlation plot area at 1 meter ags. A single, project-wide correlation was determined. [Figure E-3](#) shows a photograph of the HPIC placement in a soil correlation plot.



Figure E-3. Photograph of HPIC Placement in Correlation Plot

2.5 SOIL CORRELATION COMPOSITE SAMPLING

Soil sampling followed completion of gamma scanning within the correlation plot. Grid based, nine-point composite samples of surface soil (0 to 6 inches below ground surface [bgs]) were collected and homogenized into a single sample to be sent for laboratory analysis. Soil sampling proceeded with collection of nine aliquot samples, each within a depth of 0 to 6 inches bgs, followed in turn by compositing the aliquots and then homogenizing them in a stainless steel bowl; removing organic matter, large rocks, and debris; and placing the composite soil sample into a plastic bag to be submitted for laboratory analysis. [Figure E-4](#) is a conceptual image of the soil sampling pattern followed at each grid: ideally the nine-aliquot samples are equally spaced across the correlation plot and adjusted as necessary to fit the final shape of the correlation plot. Sample locations in irregularly shaped correlation plots were distributed evenly across the area of the plot. Typically, the first team member selected the nine-aliquot samples and used a shovel or pickaxe to loosen the soil while the second team member collected the aliquot using a stainless steel shovel and placed it into a stainless steel bowl where the soil subsequently was homogenized. Soil samples were analyzed by GEL Laboratories LLC in Charleston, South Carolina, for Ra-226, thorium-232 (Th-232), and potassium-40 (K-40) via United States Environmental Protection Agency (USEPA) Method 901.1, and for other analytes listed in [Table E-2](#).

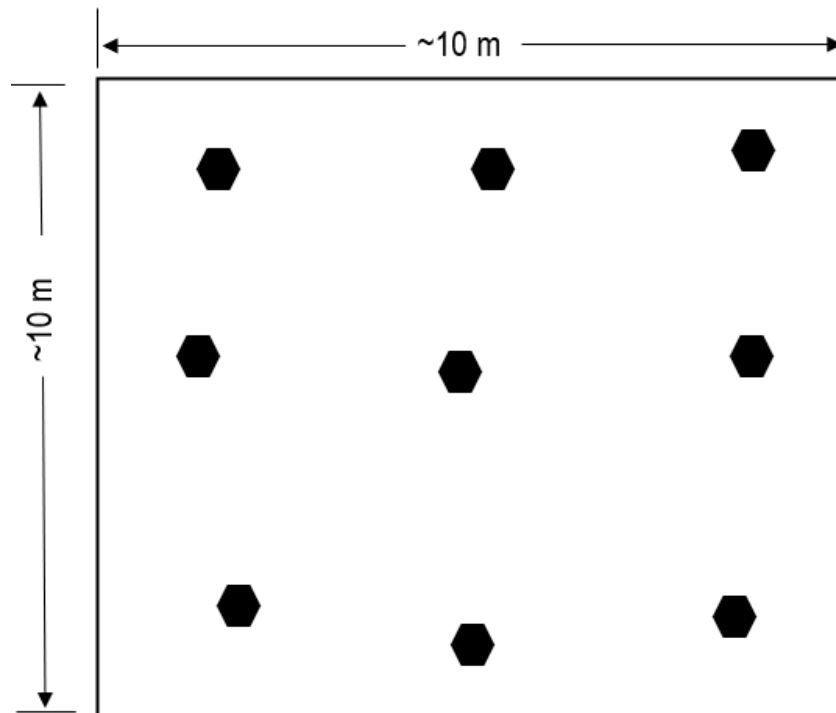


Figure E-4. Example Composite Soil Sampling Pattern within Correlation Plot (Black Hexagons represent aliquot samples collected within 0 to 6 inches bgs)

**Table E-2. Summary of Laboratory Analyses of Correlation Soil Samples**

Analytical Parameter	Abbreviation	CAS Number	Laboratory Method
Actinium-228	Ac-228	14331-83-0	EPA 901.1
Potassium-40	K-40	13966-00-2	EPA 901.1
Radium-226	Ra-226	13982-63-3	EPA 901.1
Thorium-228	Th-228	14274-82-9	HASL 300
Thorium-230	Th-230	14269-63-7	HASL 300
Thorium-232	Th-232	7440-63-7	HASL 300
Uranium-234	U-234	13966-29-5	HASL 300
Uranium-235	U-235	15117-96-1	HASL 300
Uranium-238	U-238	7440-61-1	HASL 300
Arsenic	As	7440-38-2	EPA SW-846 6020B
Thorium	Th	7440-29-1	EPA SW-846 6020B
Uranium	U	7440-61-1	EPA SW-846 6020B

Notes:

CAS

EPA 901.1

HASL 300

EPA SW-846 6020B

Chemical Abstracts Service

Gamma Spectrometry

Alpha Spectrometry

Inductively Coupled Plasma – Mass Spectrometry

3.0 DATA RESULTS AND QUALIFIERS

The following subsections present and discuss data obtained from soil correlation plots.

3.1 OVERVIEW

This section presents data acquired in the field within soil correlation plots, and a method for identifying potentially non-idealized soil correlation plots. The previous section presented methods and various data collected within the soil correlation plots, as part of the gamma-radium correlation study. In total, types of acquired data fell into five primary categories:

- Unshielded gamma count rate walkover data (1 meter ags)
- Shielded gamma count rate walkover data (1 foot ags)
- Static 1-meter ags gamma count rate (60-second average) in plot centroid
- Gamma exposure rate measured at 1 meter ags in plot centroid by use of HPIC
- Laboratory analytical data (radionuclides and metals).

[Section 2.1](#) presented an idealized situation of data from plots meeting specified criteria. Tetra Tech has developed a series of assessment metrics, some quantitative and some qualitative, useful to ascertain how well individual soil correlation plots meet the criteria. These metrics are used to “qualify” a correlation plot based on the criteria, based on evidence that the soil correlation plot may not be idealized (may not truly be homogenous). [Table E-3](#) summarizes the different potential qualifiers that may be applied to datasets. Applications of qualifiers to any soil correlation plots could provide suitable justification for a potential outlier exclusion analysis. Notably, in all cases, Tetra Tech evaluates the data with and without outliers, but typically removes only outliers deemed justifiable for removal.

All metrics identified in [Table E-3](#) are from datasets collected in the field. In theory, it is possible to analyze this information once the soil correlation plots have been scanned and to eliminate or add soil correlation plots based on findings. However, for some projects, this can be limited by budget, field schedule, or other constraints. It is strongly recommended to evaluate this information in the field and so no qualifiers are applied to any soil correlation plots (which rarely happens).

The following subsections present data distinguished by data types, and describes analysis appropriate for determination of qualifiers. The qualifiers are useful for model development.

Table E-3. Summary of Qualifiers for Soil Correlation Plot Data

Criterion	Data Type	Qualifier
RSD of plot data is > 10%	Unshielded Correlation Data Only	A
If the RPD between the mean and median of plot data is > 1.0%		B
Visual analysis of probability plots; any deviations from normal or lognormal		C
RSD of shielded plot data is > 20%	Shielded Correlation Data Only	D
If the RPD between the mean and median of plot data is > 2%		E
Visual analysis of probability plots; any deviations from normal or lognormal		F
The ratio of unshielded to shielded is > 5.0	Unshielded/Shielded	G
Visual outliers observed in the regression		H
RSD of static gamma count rate data is > 10%	Static Gamma Count Rate	I
The ratio of walkover to static < 0.90 or > 1.10	Walkover/Static Unshielded	J
Visual outliers observed in the regression		K
RSD of HPIC plot data is > 5%	HPIC Data Only	L
If the RPD between the mean and median of HPIC plot data is > 1%		M
Visual outliers observed in the regression	HPIC/Static Unshielded	N
Field observations – uneven terrain, heterogenous soil etc.	Field Logbook	O

Notes:

HPIC High-pressure ionization chamber
 RPD Relative percent difference (also can be equated to the coefficient of variation)
 RSD Relative standard deviation



3.2 WALKOVER GAMMA SCANNING (UNSHIELDED)

[Table E-4](#) lists summary statistics of the walkover unshielded gamma scanning data, per soil correlation plot. Average unshielded gamma count rate ranged between 11,474 cpm (OCRM-CORR03) and 37,722 cpm (OCRM-CORR13). The RSD ranged between 3.3 percent (OCRM-CORR07) and 9.8 percent (OCRM-CORR12); all plots were within the qualifying limits for RSD criteria. The Relative Percent Difference (RPD) between the mean and median of the correlation plot ranged from 0.1 percent (OCRM-CORR01) to 3.5 percent (OCRM-CORR12), with three plots exceeding the qualifying limit.

The qualifying criteria listed in [Table E-3](#) were applied to qualify the soil correlation plots based on unshielded walkover scanning results, and the summary of these results is in [Table E-5](#). One correlation plot (OCRM-CORR06) had at least one qualifier, one correlation plot had two qualifiers (OCRM-CORR08), and one correlation plot (OCRM-CORR12) had all three of the possible unshielded walkover qualifiers. [Attachment E-3](#) presents summary statistics and graphical analysis of the raw unshielded gamma count rate data in every soil correlation plot, including individual value plot, box plot, violin plot, probability plot, and histograms.

3.3 WALKOVER GAMMA SCANNING (SHIELDED)

[Table E-6](#) lists summary statistics of the walkover shielded gamma scanning data, per soil correlation plot. Average shielded gamma count rate ranged between 3,036 cpm (OCRM-CORR03) and 8,344 cpm (OCRM-CORR13), which matched the unshielded results. The RSD ranged between 3.4 percent (OCRM-CORR11) and 8.7 percent (OCRM-CORR12); all plots were within the qualifying limits for RSD criteria. The RPD between the mean and median of the correlation plot ranged from 0.05 percent (OCRM-CORR13) to 2.01 percent (OCRM-CORR14), with one plot (OCRM-CORR14) exceeding the qualifying limit.

The qualifying criteria listed in [Table E-3](#) were applied to qualify the soil correlation plots based on shielded walkover scanning results, and the summary of these results is in [Table E-7](#). Only one correlation plot (OCRM-CORR14) had at least one qualifier. [Attachment E-4](#) presents summary statistics and graphical analysis of the raw shielded gamma count rate data in every soil correlation plot, including individual value plot, box plot, violin plot, probability plot, and histograms.

3.4 WALKOVER REGRESSION ANALYSIS

An analysis compared the unshielded and shielded gamma count rate walkover data within each soil correlation plot. [Table E-8](#) lists unshielded and shielded average gamma count rate data, and the ratio of unshielded average to shielded average.

Table E-4. Summary Statistics of Unshielded Walkover Scanning Results

Correlation Plot ID	Count (n)	Minimum Unshielded Gamma Count Rate (cpm)	Maximum Unshielded Gamma Count Rate (cpm)	Average Unshielded Gamma Count Rate (cpm)	Standard Deviation (cpm)	Median (cpm)	RSD (%)	RPD of Mean/Median (%)
OCRM-CORR01	93	12,100	14,700	13,392	559	13,400	4.2%	0.1%
OCRM-CORR02	150	10,700	13,300	11,871	466	11,800	3.9%	0.6%
OCRM-CORR03	117	10,500	12,600	11,474	400	11,400	3.5%	0.6%
OCRM-CORR04	113	14,200	17,000	15,643	669	15,600	4.3%	0.3%
OCRM-CORR05	116	15,100	18,500	16,863	738	16,800	4.4%	0.4%
OCRM-CORR06	118	15,100	18,200	16,341	631	16,300	3.9%	0.2%
OCRM-CORR07	116	16,700	19,600	18,046	602	18,100	3.3%	0.3%
OCRM-CORR08	116	16,000	24,000	18,463	1,260	18,200	6.8%	1.4%
OCRM-CORR09	130	18,800	25,400	21,633	1,273	21,600	5.9%	0.2%
OCRM-CORR10	99	21,000	28,100	24,340	1,387	24,400	5.7%	0.2%
OCRM-CORR11	149	16,700	21,800	19,010	904	19,200	4.8%	1.0%
OCRM-CORR12	105	25,800	37,400	30,350	2,960	29,300	9.8%	3.5%
OCRM-CORR13	97	33,100	41,800	37,722	2,146	37,600	5.7%	0.3%
OCRM-CORR14	104	31,400	40,700	35,866	2,181	35,950	6.1%	0.2%
OCRM-CORR15	99	26,600	34,400	30,547	1,527	30,600	5.0%	0.2%

Notes:

Bold font indicates the value is above qualifying criterion for that correlation plot.

cpm Counts per minute

RPD Relative percent difference

RSD Relative standard deviation

Table E-5. Unshielded Walkover Scanning Qualifier Analysis

Correlation Plot ID	Qualifier A, B, or C
OCRM-CORR01	--
OCRM-CORR02	--
OCRM-CORR03	--
OCRM-CORR04	--
OCRM-CORR05	--
OCRM-CORR06	C
OCRM-CORR07	--
OCRM-CORR08	B, C
OCRM-CORR09	--
OCRM-CORR10	--
OCRM-CORR11	--
OCRM-CORR12	B, C
OCRM-CORR13	--
OCRM-CORR14	--
OCRM-CORR15	--

Notes:

--	No qualifier
A	RSD of unshielded correlation plot greater than 10 percent
B	RPD between mean and median of unshielded plot data is greater than 1 percent
C	Visually identified deviations from normal or lognormal for the unshielded correlation plot
RPD	Relative percent difference
RSD	Relative standard deviation

Table E-6. Summary Statistics of Shielded Walkover Scanning Results

Correlation Plot ID	Count (n)	Minimum Shielded Gamma Count Rate (cpm)	Maximum Shielded Gamma Count Rate (cpm)	Average Shielded Gamma Count Rate (cpm)	Standard Deviation (cpm)	Median (cpm)	RSD (%)	RPD of Mean/Median (%)
OCRM-CORR01	83	3,510	4,260	3,965	157	4,000	4.0%	0.88%
OCRM-CORR02	112	3,110	3,680	3,456	128	3,460	3.7%	0.10%
OCRM-CORR03	95	2,570	3,280	3,036	131	3,030	4.3%	0.18%
OCRM-CORR04	102	3,560	4,420	3,851	161	3,815	4.2%	0.94%
OCRM-CORR05	105	4,100	4,930	4,414	167	4,390	3.8%	0.55%
OCRM-CORR06	122	3,720	4,920	4,247	206	4,220	4.9%	0.64%
OCRM-CORR07	98	4,270	5,100	4,594	159	4,580	3.5%	0.30%
OCRM-CORR08	100	3,850	4,950	4,406	192	4,410	4.4%	0.09%
OCRM-CORR09	118	4,550	5,960	5,104	300	5,085	5.9%	0.37%
OCRM-CORR10	96	4,520	5,760	5,186	285	5,180	5.5%	0.12%
OCRM-CORR11	134	4,020	4,860	4,513	155	4,505	3.4%	0.17%
OCRM-CORR12	105	4,860	7,280	5,943	516	5,830	8.7%	1.92%
OCRM-CORR13	76	6,990	9,530	8,344	667	8,340	8.0%	0.05%
OCRM-CORR14	77	7,110	9,870	8,223	705	8,060	8.6%	2.01%
OCRM-CORR15	80	5,980	8,040	6,959	528	6,880	7.6%	1.14%

Notes:

cpm Counts per minute
RPD Relative percent difference
RSD Relative standard deviation

**Table E-7. Unshielded Walkover Scanning Qualifier Analysis**

Correlation Plot ID	Qualifier D, E, or F
OCRM-CORR01	--
OCRM-CORR02	--
OCRM-CORR03	--
OCRM-CORR04	--
OCRM-CORR05	--
OCRM-CORR06	--
OCRM-CORR07	--
OCRM-CORR08	--
OCRM-CORR09	--
OCRM-CORR10	--
OCRM-CORR11	--
OCRM-CORR12	--
OCRM-CORR13	--
OCRM-CORR14	E
OCRM-CORR15	--

Notes:

--	No qualifier
D	RSD of shielded correlation plot greater than 20 percent
E	RPD between mean and median of shielded plot data is greater than 2 percent
F	Visually identified deviations from normal or lognormal for the shielded correlation plot
RPD	Relative percent difference
RSD	Relative standard deviation

Table E-8. Summary of Unshielded and Shielded Average Gamma Count Rate at Soil Correlation Plots

Correlation Plot ID	Unshielded Average Gamma Count Rate (cpm)	Shielded Average Gamma Count Rate (cpm)	Ratio of Unshielded to Shielded
OCRM-CORR01	13,392	3,965	3.4
OCRM-CORR02	11,871	3,456	3.4
OCRM-CORR03	11,474	3,036	3.8
OCRM-CORR04	15,643	3,851	4.1
OCRM-CORR05	16,863	4,414	3.8
OCRM-CORR06	16,341	4,247	3.8
OCRM-CORR07	18,046	4,594	3.9
OCRM-CORR08	18,463	4,406	4.2
OCRM-CORR09	21,633	5,104	4.2
OCRM-CORR10	24,340	5,186	4.7
OCRM-CORR11	19,010	4,513	4.2
OCRM-CORR12	30,350	5,943	5.1
OCRM-CORR13	37,722	8,344	4.5
OCRM-CORR14	35,866	8,223	4.4
OCRM-CORR15	30,547	6,959	4.4

Notes:

Bold font indicates the value is above qualifying criterion for that correlation plot.

cpm Counts per minute

By application of the qualifying criteria listed in [Table E-3](#), the relationship between unshielded and shielded average gamma count rate was used to qualify the soil correlation plots based on that criterion, and the summary of these results is in [Table E-9](#). Only one correlation plot had a “G” qualifier because the ratio of unshielded to shielded average gamma count rate exceeded a value of 5. [Figure E-5](#) shows a linear regression of all soil correlation plot data pairs for unshielded and shielded average gamma count rate. While the Coefficient of Variance (R^2) was high (0.96), three data pairs were identified as visual outliers, and those plots received an “H” qualifier and are shown as red on [Figure E-5](#). When the visual outliers are removed from the dataset, the linear regression results in an increased R^2 (0.99), as shown on [Figure E-6](#).

**Table E-9. Unshielded and Shielded Regression Qualifier Analysis**

Correlation Plot ID	Qualifier G or H
OCRM-CORR01	H
OCRM-CORR02	--
OCRM-CORR03	--
OCRM-CORR04	--
OCRM-CORR05	--
OCRM-CORR06	--
OCRM-CORR07	--
OCRM-CORR08	--
OCRM-CORR09	--
OCRM-CORR10	H
OCRM-CORR11	--
OCRM-CORR12	G, H
OCRM-CORR13	--
OCRM-CORR14	--
OCRM-CORR15	--

Notes:

-- No qualifier

G The ratio of unshielded to shielded is greater than 5

H Visual outliers identified in the regression between unshielded and shielded average gamma count rate

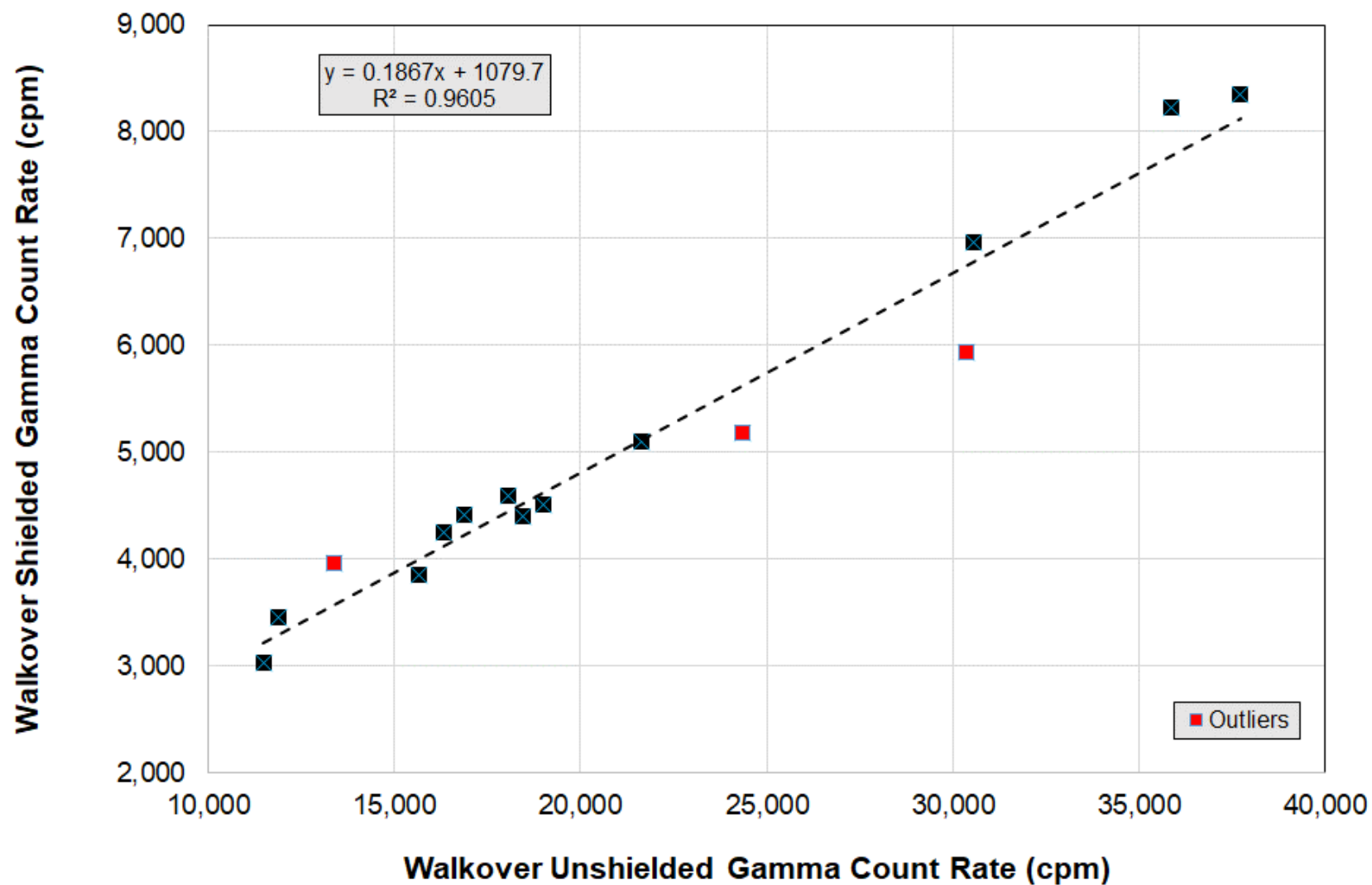


Figure E-5. Unshielded (x-axis) and Shielded (y-axis) Gamma Count Rate Regression Analysis

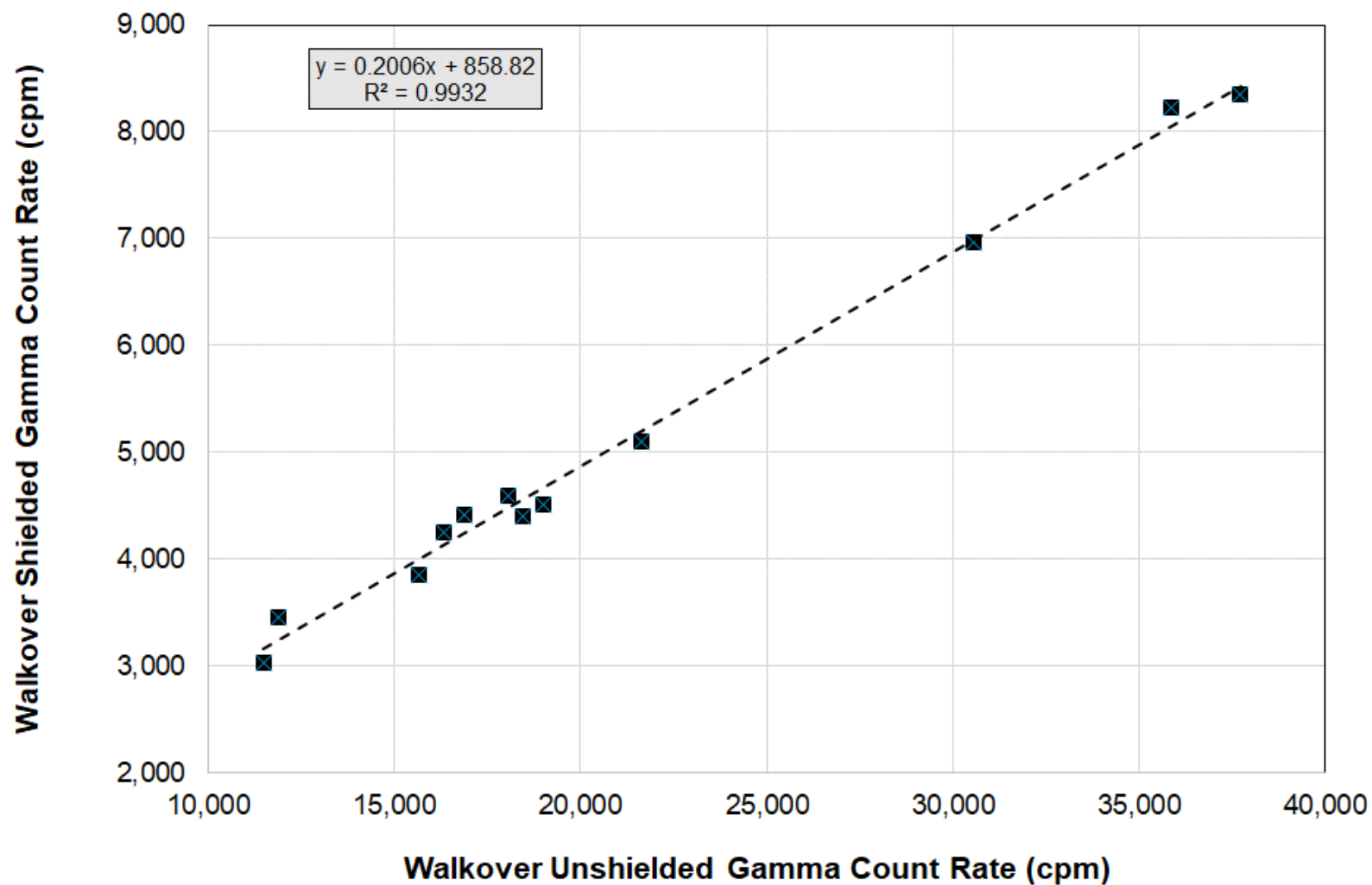


Figure E-6. Unshielded (x-axis) and Shielded (y-axis) Gamma Count Rate Regression Analysis (Outliers Removed)

3.5 STATIC GAMMA COUNT RATE

Table E-10 lists summary statistics of static gamma count rate data (unshielded at 1 meter ags detector height). No associated qualifiers were applied to the RSD (qualifier “I”)—all calculated RSDs were below 10 percent.

Table E-10. Static Gamma Count Rate Data and Qualifiers

Correlation Plot ID	Average Static Gamma Count Rate (cpm)	Standard Deviation (cpm)	Relative Standard Deviation	Qualifier (I)
OCRM-CORR01	14,299	920	6.4%	--
OCRM-CORR02	12,163	930	7.7%	--
OCRM-CORR03	11,313	796	7.0%	--
OCRM-CORR04	15,369	914	5.9%	--
OCRM-CORR05	16,119	1,112	6.9%	--
OCRM-CORR06	16,435	913	5.6%	--
OCRM-CORR07	17,852	1,032	5.8%	--
OCRM-CORR08	17,431	1,046	6.0%	--
OCRM-CORR09	23,286	1,301	5.6%	--
OCRM-CORR10	23,098	1,082	4.7%	--
OCRM-CORR11	18,219	1,063	5.8%	--
OCRM-CORR12	36,408	1,632	4.5%	--
OCRM-CORR13	38,311	1,641	4.3%	--
OCRM-CORR14	34,464	1,269	3.7%	--
OCRM-CORR15	31,050	1,241	4.0%	--

Notes:

-- No qualifier
 cpm Counts per minute
 I RSD of static gamma count rate data is >10 percent
 RSD Relative standard deviation

3.6 UNSHIELDED WALKOVER AND STATIC GAMMA

Table E-11 lists average 1-meter ags unshielded walkover and static gamma count rate data and associated qualifiers. One soil correlation plot (OCRM-CORR12) was qualified based on the ratio criterion. A linear regression between the average unshielded walkover and static gamma count rate data appears on Figure E-7. One soil correlation plot (OCRM-CORR12) was identified as a visual outlier and received a “K” qualifier, identified as red on Figure E-7. The R^2 of the full dataset is 0.96. The visual outlier was removed, and the linear regression was performed again, as shown on Figure E-8— R^2 increased to 0.99.

**Table E-11. Unshielded Walkover and Static Gamma Count Rate and Qualifiers**

Correlation Plot ID	Average Walkover Gamma Count Rate (cpm)	Average Static Gamma Count Rate (cpm)	Ratio of Walkover to Static	Qualifier J or K
OCRM-CORR01	13,392	14,299	0.94	--
OCRM-CORR02	11,871	12,163	0.98	--
OCRM-CORR03	11,474	11,313	1.01	--
OCRM-CORR04	15,643	15,369	1.02	--
OCRM-CORR05	16,863	16,119	1.05	--
OCRM-CORR06	16,341	16,435	0.99	--
OCRM-CORR07	18,046	17,852	1.01	--
OCRM-CORR08	18,463	17,431	1.06	--
OCRM-CORR09	21,633	23,286	0.93	--
OCRM-CORR10	24,340	23,098	1.05	--
OCRM-CORR11	19,010	18,219	1.04	--
OCRM-CORR12	30,350	36,408	0.83	J, K
OCRM-CORR13	37,722	38,311	0.98	--
OCRM-CORR14	35,866	34,464	1.04	--
OCRM-CORR15	30,547	31,050	0.98	--

Notes:

-- No qualifier

cpm Counts per minute

J The ratio of unshielded average walkover to static is <0.90 or >1.10

K Visual outliers identified in regression between unshielded walkover and static average gamma count rate

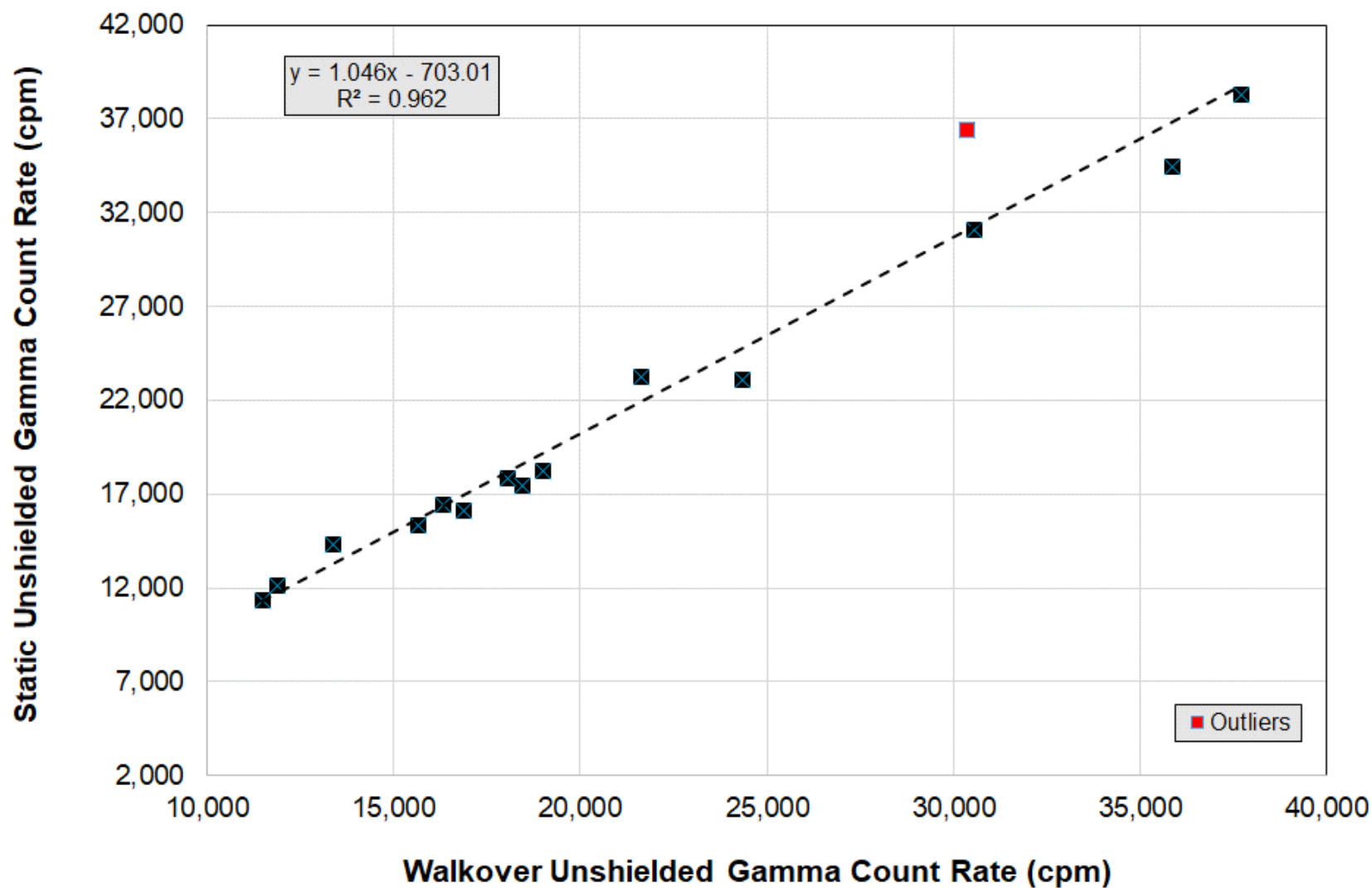


Figure E-7. Unshielded Walkover (x-axis) and Static (y-axis) Gamma Count Rate Regression Analysis

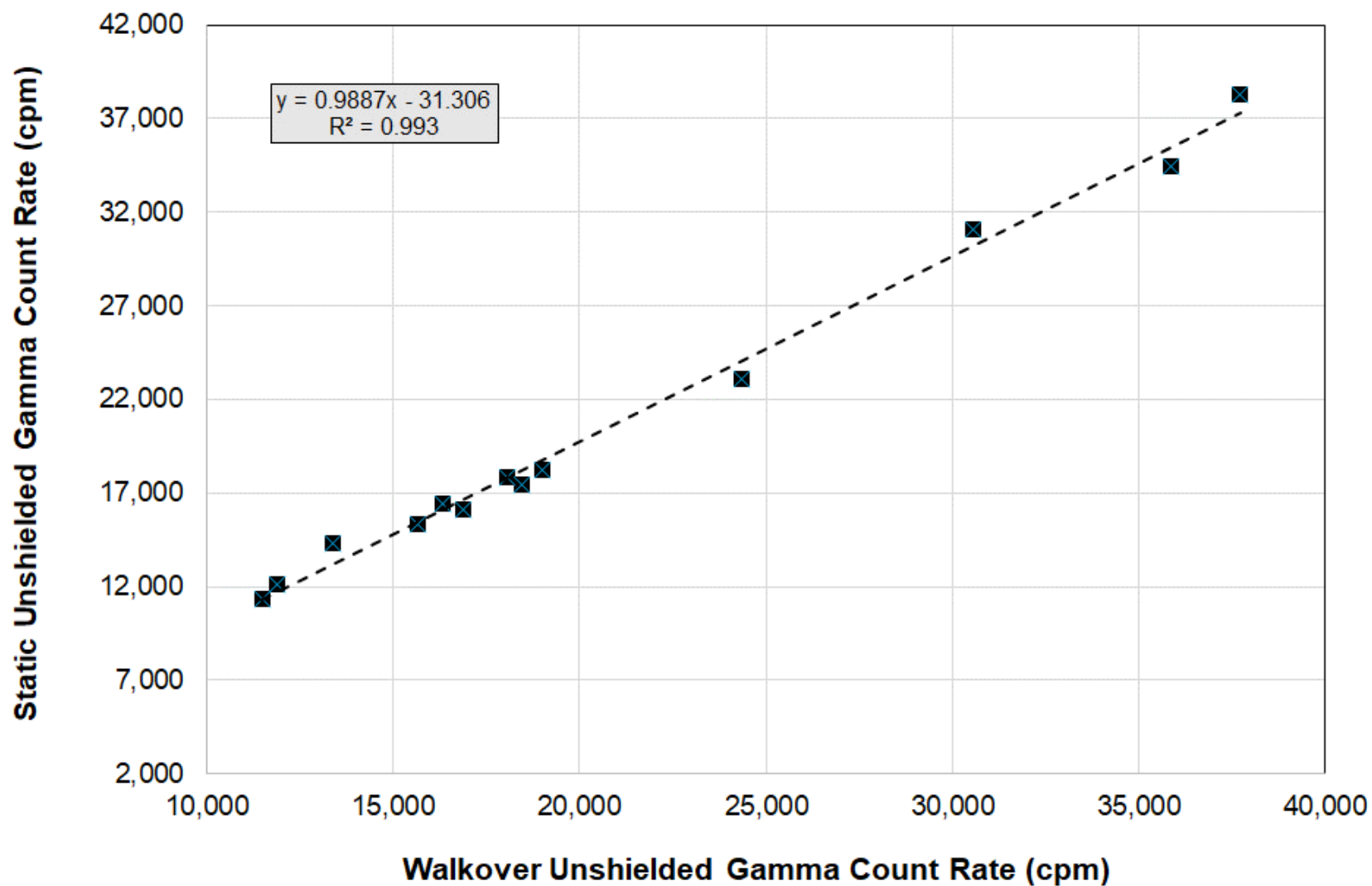


Figure E-8. Unshielded Walkover (x-axis) and Static (y-axis) Gamma Count Rate Regression Analysis (Outlier Removed)

3.7 HIGH-PRESSURE IONIZATION CHAMBER EXPOSURE RATE

Table E-12 lists summary statistics of HPIC exposure rate data collected at soil correlation plots. Measured average gamma exposure rate across all soil correlation plots ranged between 14.6 and 28.7 microrentgens per hour ($\mu\text{R/hr}$). The RSD ranged between 2 and 4 percent; all were below the qualifying criterion of 5 percent. The RPD between the mean and median ranged between 0.1 and 0.5 percent—all below the qualifying criterion of 1 percent. Therefore, no soil correlation plots qualified based on the HPIC exposure rate data. Attachment E-5 presents summary statistics and a graphical analysis of raw exposure rate data in every soil correlation plot, including individual value plot, box plot, violin plot, probability plot, and histograms.

3.8 STATIC GAMMA COUNT RATE VERSUS HPIC EXPOSURE RATE

Table E-13 lists average gamma exposure rates measured by use of the HPIC and 1-meter ags unshielded static gamma count rates. A linear regression on the full dataset appears on Figure E-9. The full dataset linear regression had an R^2 of 0.93. Two identified outliers (OCRM-CORR05 and OCRM-CORR12) are shown on Figure E-9 as red squares. Only OCRM-CORR12 was removed from the dataset, and a linear regression occurred again as shown on Figure E-10, with R^2 increasing from 0.93 to 0.98. While both OCRM-CORR05 and OCRM-CORR12 were qualified, only OCRM-CORR12 was determined to be an influential outlier that would significantly impact estimation of gamma exposure rate.

The final model was developed with the OCRM-CORR12 data pair removed. The final equation to be used for this project for estimating gamma exposure rate from gamma count rate is:

$$\text{Gamma Exposure } \left(\frac{\mu\text{R}}{\text{hr}} \right) = (0.000482 * [\text{Gamma Count Rate (cpm)}]) + 9.724779$$

3.9 SOIL CORRELATION LABORATORY ANALYSIS RESULTS

Table E-14 lists laboratory analytical results for Ra-226, K-40, and thorium.

Table E-12. Summary Statistics of High-Pressure Ionization Chamber Gamma Exposure Rate

Correlation Plot ID	Count (n)	Minimum (μR/hr)	Maximum (μR/hr)	Average (μR/hr)	Standard Deviation (μR/hr)	Median (μR/hr)	RSD (%)	RPD of Mean/Median	Qualifier L or M
OCRM-CORR01	90	15.7	18.4	16.6	0.56	16.6	3%	0.3%	--
OCRM-CORR02	90	15.0	17.6	16.0	0.56	15.9	4%	0.5%	--
OCRM-CORR03	90	13.4	15.9	14.6	0.45	14.5	3%	0.2%	--
OCRM-CORR04	90	15.9	17.8	16.9	0.39	16.9	2%	0.1%	--
OCRM-CORR05	90	17.2	20.3	18.6	0.52	18.6	3%	0.2%	--
OCRM-CORR06	90	16.9	18.6	17.5	0.39	17.5	2%	0.1%	--
OCRM-CORR07	90	17.0	20.1	18.4	0.54	18.4	3%	0.4%	--
OCRM-CORR08	90	16.9	19.7	18.4	0.57	18.4	3%	0.1%	--
OCRM-CORR09	90	19.0	21.8	20.0	0.53	19.9	3%	0.4%	--
OCRM-CORR10	90	19.4	21.8	20.8	0.53	20.8	3%	0.1%	--
OCRM-CORR11	90	17.0	20.2	18.7	0.58	18.6	3%	0.3%	--
OCRM-CORR12	90	21.6	25.3	23.4	0.72	23.5	3%	0.5%	--
OCRM-CORR13	90	26.8	30.5	28.7	0.75	28.8	3%	0.5%	--
OCRM-CORR14	90	24.8	27.8	26.5	0.73	26.5	3%	0.2%	--
OCRM-CORR15	90	22.6	25.6	24.1	0.65	24.0	3%	0.2%	--

Notes:

-- No qualifier
 μR/hr Microrentgens per hour
 HPIC High-pressure ionization chamber
 L If the RSD of HPIC data is >5 percent
 M If the RPD between the mean and median of HPIC data is > 1 percent
 RPD Relative percent difference
 RSD Relative standard deviation

Table E-13. Average Gamma Exposure Rate and Static Gamma Count Rate and Qualifiers

Correlation Plot ID	Average Gamma Exposure Rate (μ R/hr)	Average Static Gamma Count Rate (cpm)	Qualifier (N)
OCRM-CORR01	16.6	14,299	--
OCRM-CORR02	16.0	12,163	--
OCRM-CORR03	14.6	11,313	--
OCRM-CORR04	16.9	15,369	--
OCRM-CORR05	18.6	16,119	N
OCRM-CORR06	17.5	16,435	--
OCRM-CORR07	18.4	17,852	--
OCRM-CORR08	18.4	17,431	--
OCRM-CORR09	20.0	23,286	--
OCRM-CORR10	20.8	23,098	--
OCRM-CORR11	18.7	18,219	--
OCRM-CORR12	23.4	36,408	N
OCRM-CORR13	28.7	38,311	--
OCRM-CORR14	26.5	34,464	--
OCRM-CORR15	24.1	31,050	--

Notes:

-- No qualifier
 μ R/hr Microrentgens per hour
 cpm Counts per minute
 HPIC High-Pressure Ionization Chamber
 N Visual outliers observed in the regression of HPIC/Static

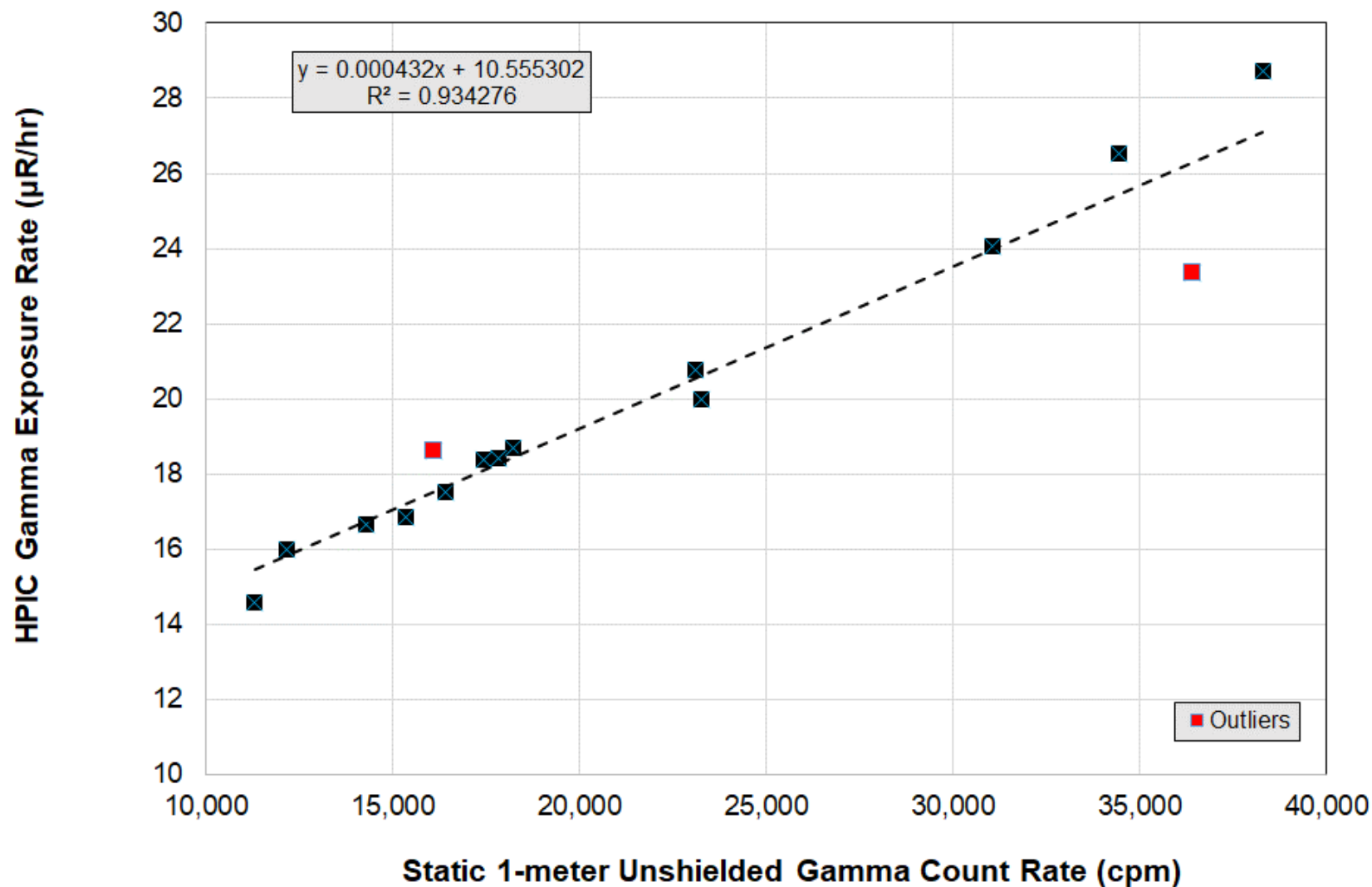


Figure E-9. Static Gamma Count Rate (x-axis) and HPIC Gamma Exposure Rate (y-axis) Linear Regression

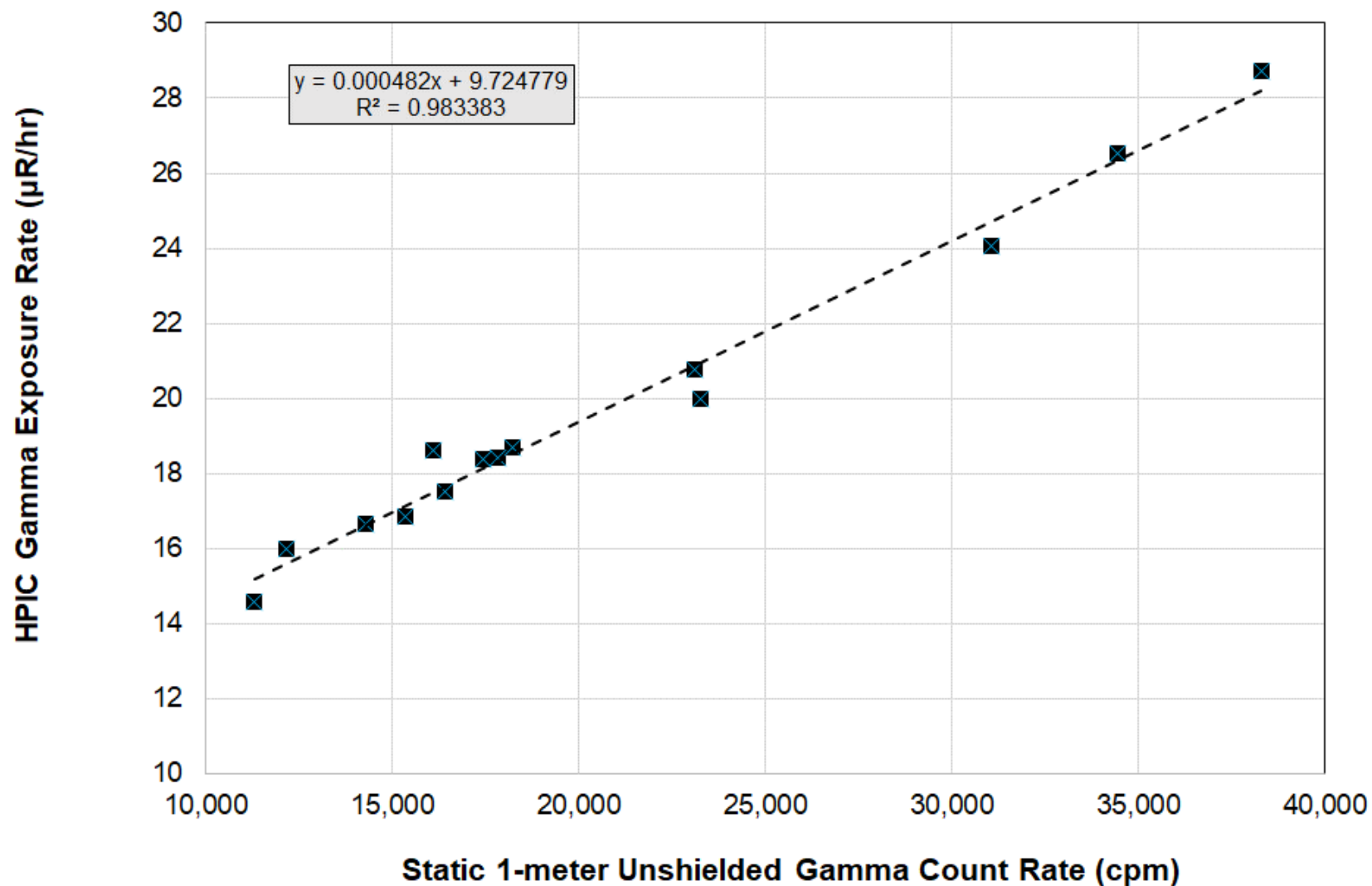


Figure E-10. Static Gamma Count Rate (x-axis) and HPIC Gamma Exposure Rate (y-axis) Linear Regression (Outlier Removed, Final Model Used in Report)

Table E-14. Summary of Select Laboratory Analytes from the Soil Correlation Plots

Sample ID	Radium-226 (pCi/g)	Qualifier	Measurement Uncertainty+/- (pCi/g)	K-40 (pCi/g)	Qualifier	Measurement Uncertainty+/- (pCi/g)	Thorium (mg/kg)	Qualifier
OCRM-CORR01-01-111922	1.51	--	0.19	22.0	--	2.38	8.51	--
OCRM-CORR02-01-111922	1.24	--	0.211	20.6	--	2.61	7.03	--
OCRM-CORR03-01-111922	1.12	--	0.209	16.0	--	2.2	4.29	--
OCRM-CORR04-01-111922	1.95	--	0.253	20.3	--	2.66	7.84	--
OCRM-CORR05-01-111922	3	--	0.35	20.2	--	2.53	8.3	--
OCRM-CORR06-01-111922	3.02	--	0.325	19.8	--	2.44	9.8	--
OCRM-CORR07-01-111922	3.53	--	0.37	19.6	--	2.45	8.24	--
OCRM-CORR08-01-111922	3.45	--	0.361	18.1	--	2.3	6.32	--
OCRM-CORR09-01-111922	2.75	--	0.335	20.9	--	2.67	7.2	--
OCRM-CORR10-01-111922	3.41	--	0.379	18.9	--	2.39	8.23	--
OCRM-CORR11-01-111922	1.6	--	0.215	20.6	--	2.51	7.92	--
OCRM-CORR12-01-111922	2.25	--	0.289	19.7	--	2.56	6.32	--
OCRM-CORR13-01-111922	17	--	1.67	19.6	--	2.74	4.87	--
OCRM-CORR14-01-111922	17.4	--	1.51	18.3	--	2.35	4.86	--
OCRM-CORR15-01-111922	10.7	--	1.04	19.9	--	2.59	5.83	--

Notes:

Qualifiers are based on laboratory reports from GEL

-- No qualifier

K-40 Potassium-40

mg/kg Milligram per kilogram

pCi/g Picocurie per gram

4.0 REGRESSION ANALYSIS

The following subsections discuss regression analysis.

4.1 SUMMARY OF QUALIFIERS

The preceding section presented a step-by-step qualifying analysis based on a number of factors and on criteria listed in [Table E-3](#). The qualifiers were then condensed for each soil correlation plot as listed in [Table E-15](#).

Table E-15. Summary of Final Qualifiers for Soil Correlation Plots

Correlation Plot ID	Final Qualifiers
OCRM-CORR01	H
OCRM-CORR02	--
OCRM-CORR03	--
OCRM-CORR04	--
OCRM-CORR05	N
OCRM-CORR06	C
OCRM-CORR07	--
OCRM-CORR08	B, C
OCRM-CORR09	--
OCRM-CORR10	H
OCRM-CORR11	--
OCRM-CORR12	B, C, G, H, J, K, N
OCRM-CORR13	--
OCRM-CORR14	E
OCRM-CORR15	--

Notes:

- No qualifiers
- A RSD of unshielded correlation plot greater than 10 percent
- B RPD between mean and median of unshielded plot data is greater than 1 percent
- C Visually identified deviations from normal or lognormal for the unshielded correlation plot
- D RSD of shielded correlation plot greater than 20 percent
- E RPD between mean and median of shielded plot data is greater than 2 percent
- F Visually identified deviations from normal or lognormal for the shielded correlation plot
- G The ratio of unshielded to shielded is greater than 5
- H Visual outliers identified in the regression between unshielded and shielded average gamma count rate
- I RSD of static gamma count rate data is >10 percent
- J The ratio of unshielded average walkover to static is <0.90 or >1.10
- K Visual outliers identified in regression between unshielded walkover and static average gamma count rate
- L If the RSD of HPIC data is >5 percent
- M If the RPD between the mean and median of HPIC data is > 1 percent
- N Visual outliers observed in the regression of HPIC/Static
- RSD Relative standard deviation

4.2 UNSHIELDED WALKOVER AND RADIUM-226 RESULTS

[Table E-16](#) lists average unshielded walkover gamma count rate data from and associated Ra-226 soil concentrations within all 15 soil correlation plots.

A linear regression analysis on the full dataset appears on [Figure E-11](#). The R^2 of the full dataset is 0.73. The low R^2 is likely associated with the OCRM-CORR12 outlier identified in a previous subsection. Therefore, a linear regression analysis on the dataset with removal of OCRM-CORR12 appears on [Figure E-12](#)—lowering R^2 to 0.88, which meets the project quality criterion for regression models for gamma-radium correlations.

[Figure E-12](#) shows that while OCRM-CORR12 was an influential outlier, the linear regression line still does not follow the lowest three soil correlation data pairs; therefore, the model may be slightly over predictive at lower concentrations.

Because of likely overprediction by application of the linear regression models, an additional analysis was performed on all data pairs where average gamma count rate was less than 19,000 cpm (which excluded seven data pairs). [Figure E-13](#) shows that the lower range dataset linear regression model yielded a resulting R^2 of 0.934 and extremely good mimic of lower Ra-226 concentrations; however, this model may not predict higher Ra-226 concentrations as accurately because of need to extrapolate to obtain higher estimates of Ra-226.

Table E-16. Average Unshielded Gamma and Ra-226 Soil Concentration

Correlation Plot ID	Average Unshielded Walkover Gamma Count Rate (cpm)	Radium-226 (pCi/g)
OCRM-CORR01	13,392	1.51
OCRM-CORR02	11,871	1.24
OCRM-CORR03	11,474	1.12
OCRM-CORR04	15,643	1.95
OCRM-CORR05	16,863	3
OCRM-CORR06	16,341	3.02
OCRM-CORR07	18,046	3.53
OCRM-CORR08	18,463	3.45
OCRM-CORR09	21,633	2.75
OCRM-CORR10	24,340	3.41
OCRM-CORR11	19,010	1.6
OCRM-CORR12	30,350	2.25
OCRM-CORR13	37,722	17
OCRM-CORR14	35,866	17.4
OCRM-CORR15	30,547	10.7

Notes:

cpm Counts per minute
pCi/g Picocurie per gram

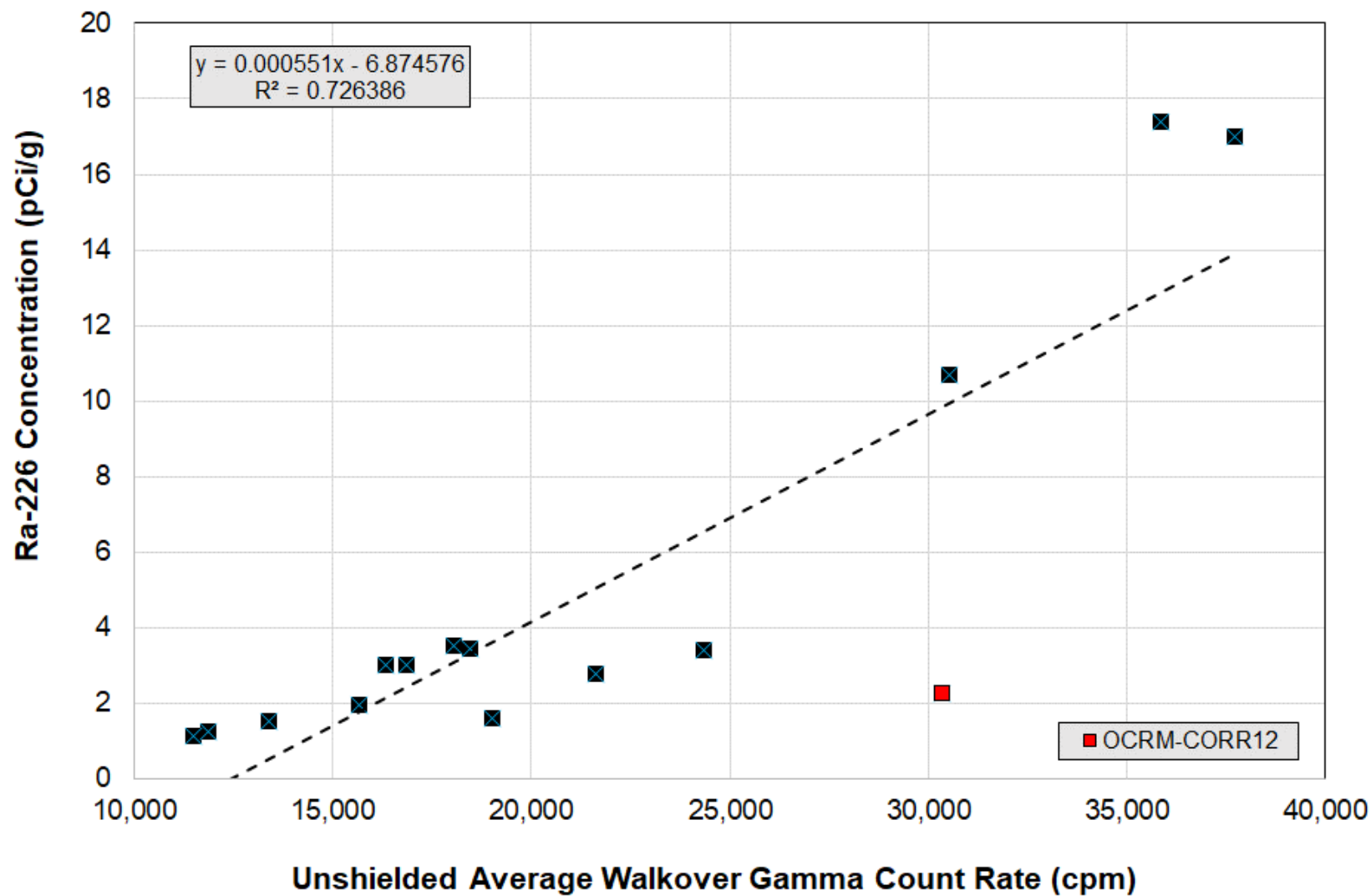


Figure E-11. Linear Regression of Unshielded Walkover Gamma Count Rate and Ra-226 Soil Concentration (Full Dataset)

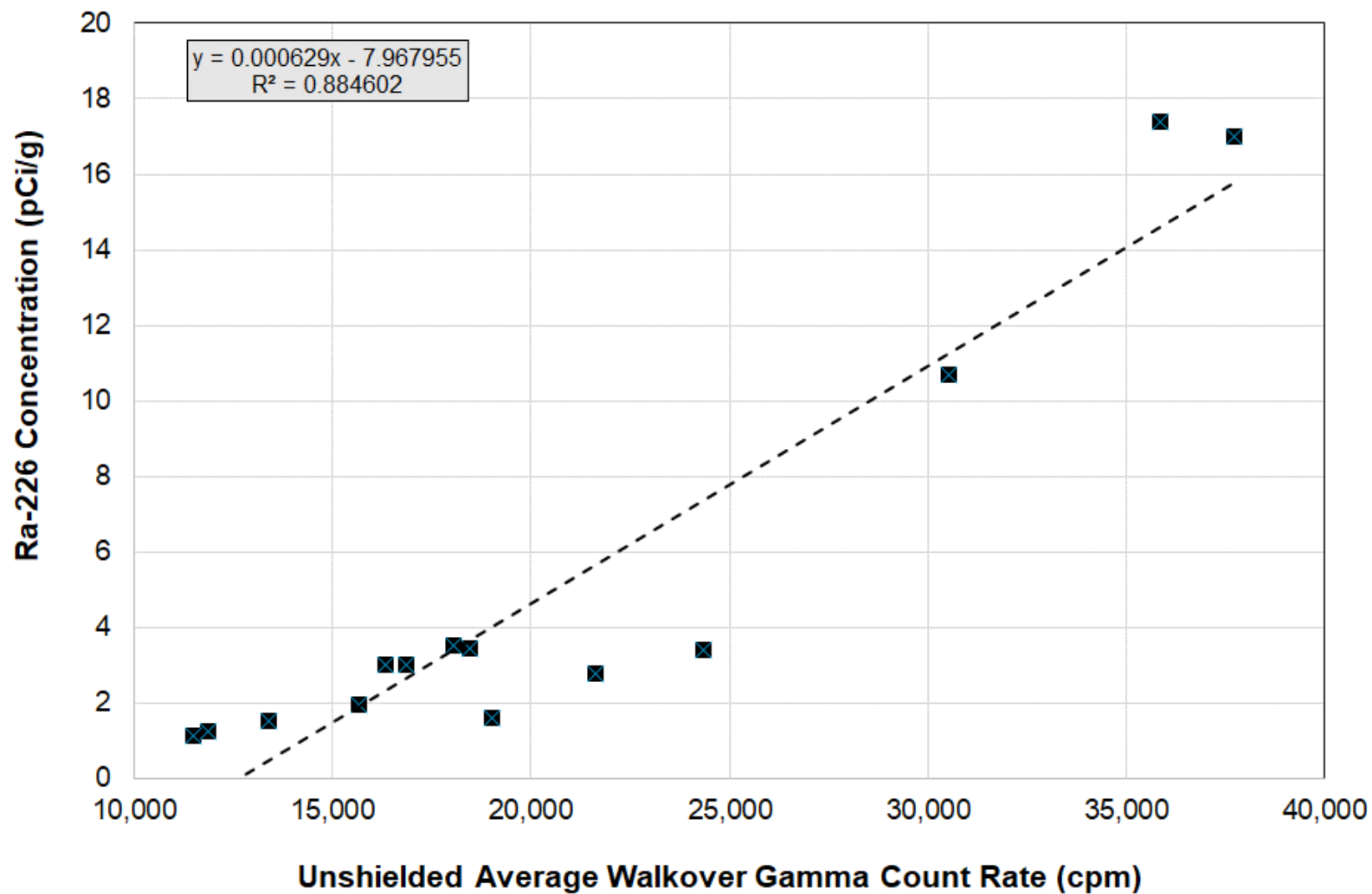


Figure E-12. Linear Regression of Unshielded Walkover Gamma Count Rate and Ra-226 Soil Concentration (OCRM-CORR12 Removed as Outlier)

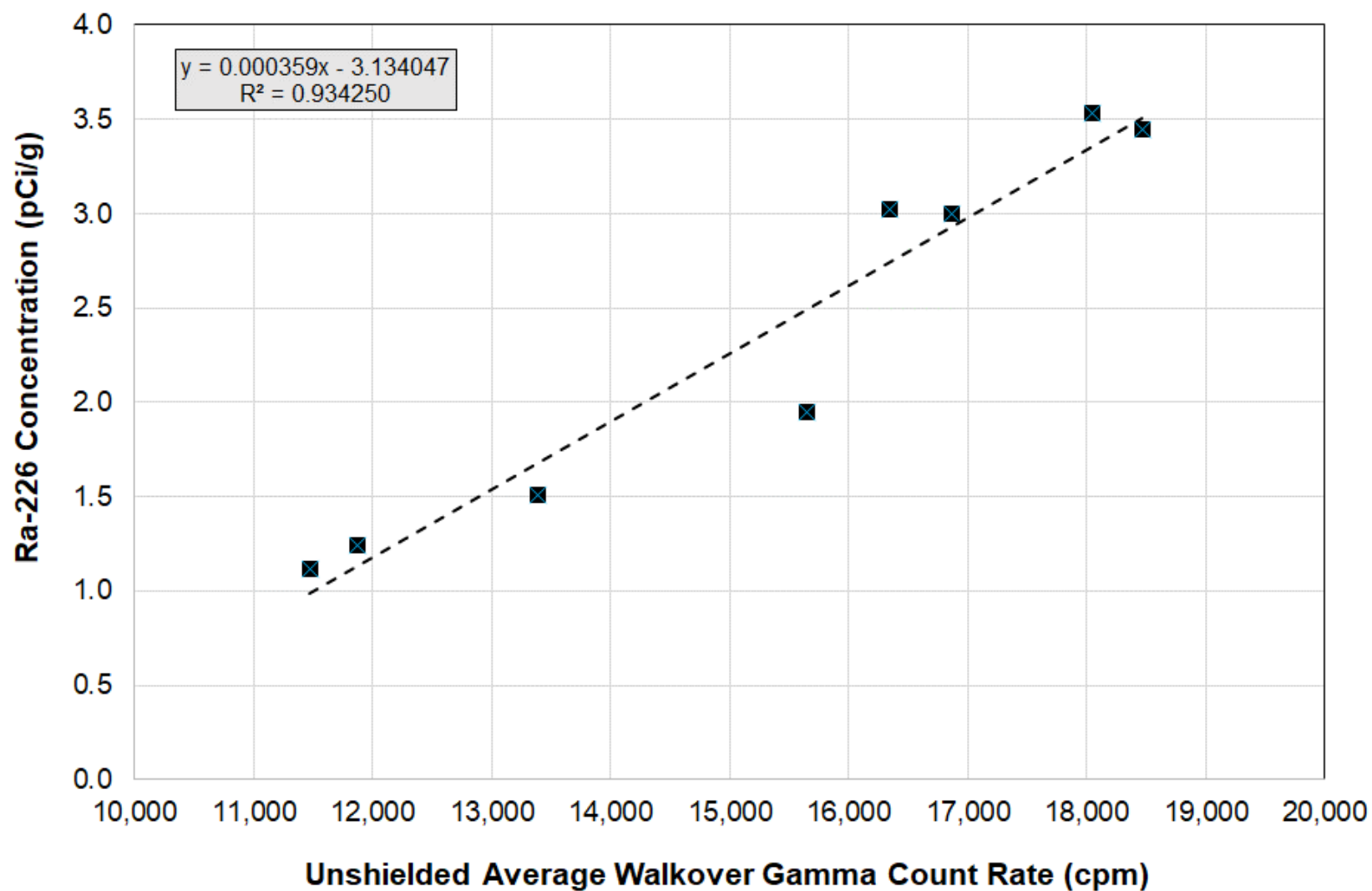


Figure E-13. Linear Regression of Unshielded Walkover Gamma Count Rate and Ra-226 Soil Concentration (Less than 19,000 cpm)



4.3 SHIELDED WALKOVER AND RADIUM-226 RESULTS

In certain instances, during remediation, it may be advantageous to utilize a collimated detection system for remedial action surveys (i.e., guiding remedial or removal action utilizing instrumentation). Therefore, an effort was made to ascertain the relationship between shielded gamma count rate and Ra-226 soil concentration. [Figure E-14](#) shows results of that effort.

The shielded gamma cutoff for 2 pCi/g of Ra-226 using the full dataset is 4,148 cpm, and the R^2 is 0.86. For 10 pCi/g, the shielded gamma cutoff is 6,699. Therefore, if a collimated detection system is to clean up the site for background and for 10 pCi/g, the shielded gamma cutoff to be used should be 4,100 and 6,700 cpm for 2 and 10 pCi/g, respectively.

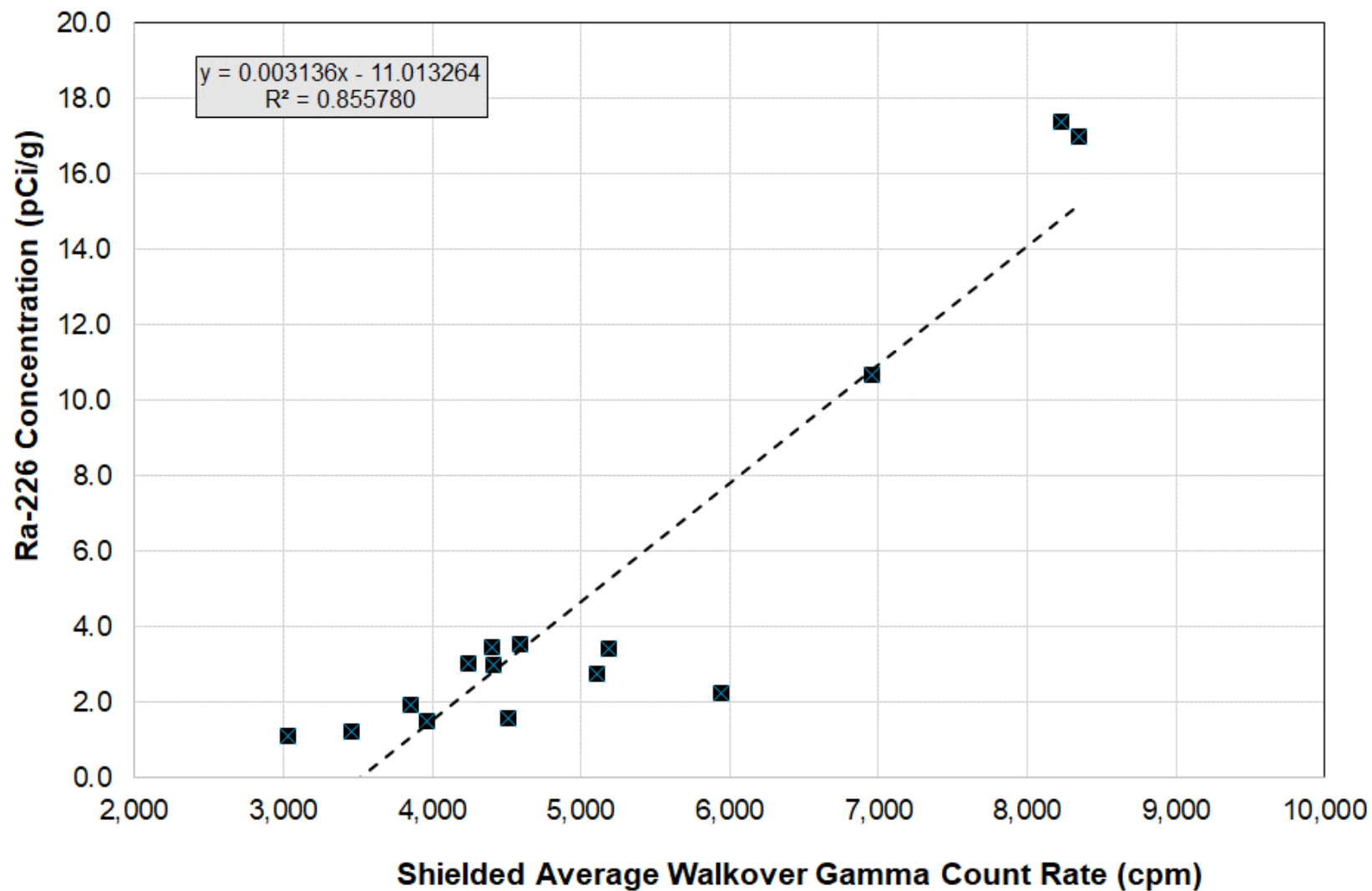


Figure E-14. Shielded Gamma Count Rate versus Ra-226 Soil Concentration (Full Dataset)

5.0 MODEL DEVELOPMENT

5.1 OVERVIEW

The preceding section presented an analysis of model development which lead to a linear correlation between unshielded gamma count rate and Ra-226 soil concentration as well as a linear correlation between unshielded gamma count rate and Ra-226 soil concentrations limited to a range less than 19,000 cpm. Additionally, a model was developed for shielded gamma count rate and Ra-226 soil concentration. The focus of this section is on final models selected for predicting estimated Ra-226 from unshielded gamma count rate data. Two models were selected for final analysis: Model 1 and Model 2, both forms of traditional models (i.e., gamma count rate versus Ra-226 soil concentration). The following subsections present information regarding both models.

These models were applied to the full validated dataset. For further analysis, a kriging boundary was developed across the site where appropriate, and the gamma survey data were buffered within 10 meters of the final kriged boundary. The final kriged boundary surrounded 236 acres. The final dataset used for kriging purposes was reduced from 260,946 to 238,185 measurements.

5.2 MODEL 1: TRADITIONAL LINEAR REGRESSION WITH OCRM-CORR12 EXCLUDED

The following subsections discuss Model 1.

5.2.1 Overview of Model 1

Model 1 is classified as a traditional linear model with one outlier removed (OCRMCORR12). The correlation plot OCRMCORR12 was determined to be an influential outlier with numerous lines of evidence supporting and justifying removal and exclusion of the data pair from the initial correlation model. Therefore, no model was run using OCRMCORR12 from the onset. [Table E-17](#) lists data pairs included in or excluded from Model 1. [Figure E-15](#) depicts the regression analysis that represents Model 1. The following equation was used to convert gamma count rate to Ra-226 for Model 1:

$$^{226}\text{Ra} \left(\frac{\text{pCi}}{\text{g}} \right) = (0.000629 * [\text{Gamma Count Rate (cpm)}]) - 7.967955$$

One issue with Model 1 is that negative values persist at lower gamma count rates. A total of 42,348 of 260,946 measurements were negative after the conversion, or 16 percent of the full dataset. For the dataset used for kriging, a total of 29,028 of 238,185 measurements were classified as negative. Any gamma count rate less than ~12,668 cpm was converted to a negative value. This is a common issue associated with linear regression models; furthermore, linear regression Model 1 evidently does not reflect the lower range of data pairs very well. Nonetheless, a common practice is to evaluate the full dataset in comparison to other models; however, this particular model does exclude the extreme outlier identified during the qualifying selection process (OCRMCORR12).

**Table E-17. Model 1 Traditional Linear Data Pair Inclusion/Exclusion**

Correlation Plot ID	Average Unshielded Walkover Gamma Count Rate (cpm)	Radium-226 (pCi/g)	Final Qualifiers	Model 1 Inclusion
OCRM-CORR01	13,392	1.51	H	Included
OCRM-CORR02	11,871	1.24	--	Included
OCRM-CORR03	11,474	1.12	--	Included
OCRM-CORR04	15,643	1.95	--	Included
OCRM-CORR05	16,863	3	N	Included
OCRM-CORR06	16,341	3.02	C	Included
OCRM-CORR07	18,046	3.53	--	Included
OCRM-CORR08	18,463	3.45	B, C	Included
OCRM-CORR09	21,633	2.75	--	Included
OCRM-CORR10	24,340	3.41	H	Included
OCRM-CORR11	19,010	1.6	--	Included
OCRM-CORR12	30,350	2.25	B, C, G, H, J, K, N	Excluded
OCRM-CORR13	37,722	17	--	Included
OCRM-CORR14	35,866	17.4	E	Included
OCRM-CORR15	30,547	10.7	--	Included

Notes:

-- No qualifier

cpm Counts per minute

pCi/g Picocurie per gram

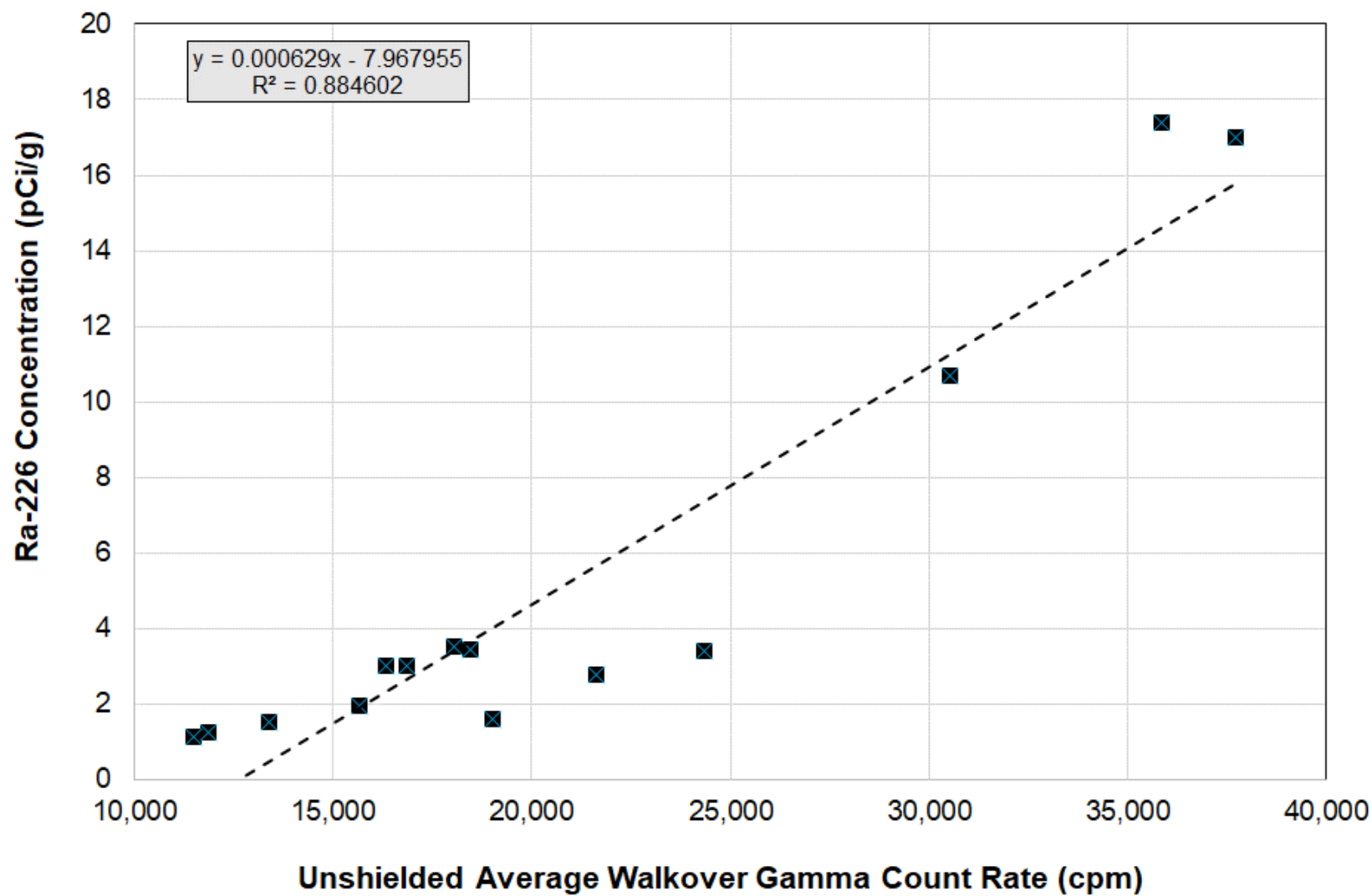


Figure E-15. Gamma-Radium Correlation, Linear Regression – Model 1



Table E-18 lists gamma cutoff values associated with various Ra-226 concentrations as derived from Model 1.

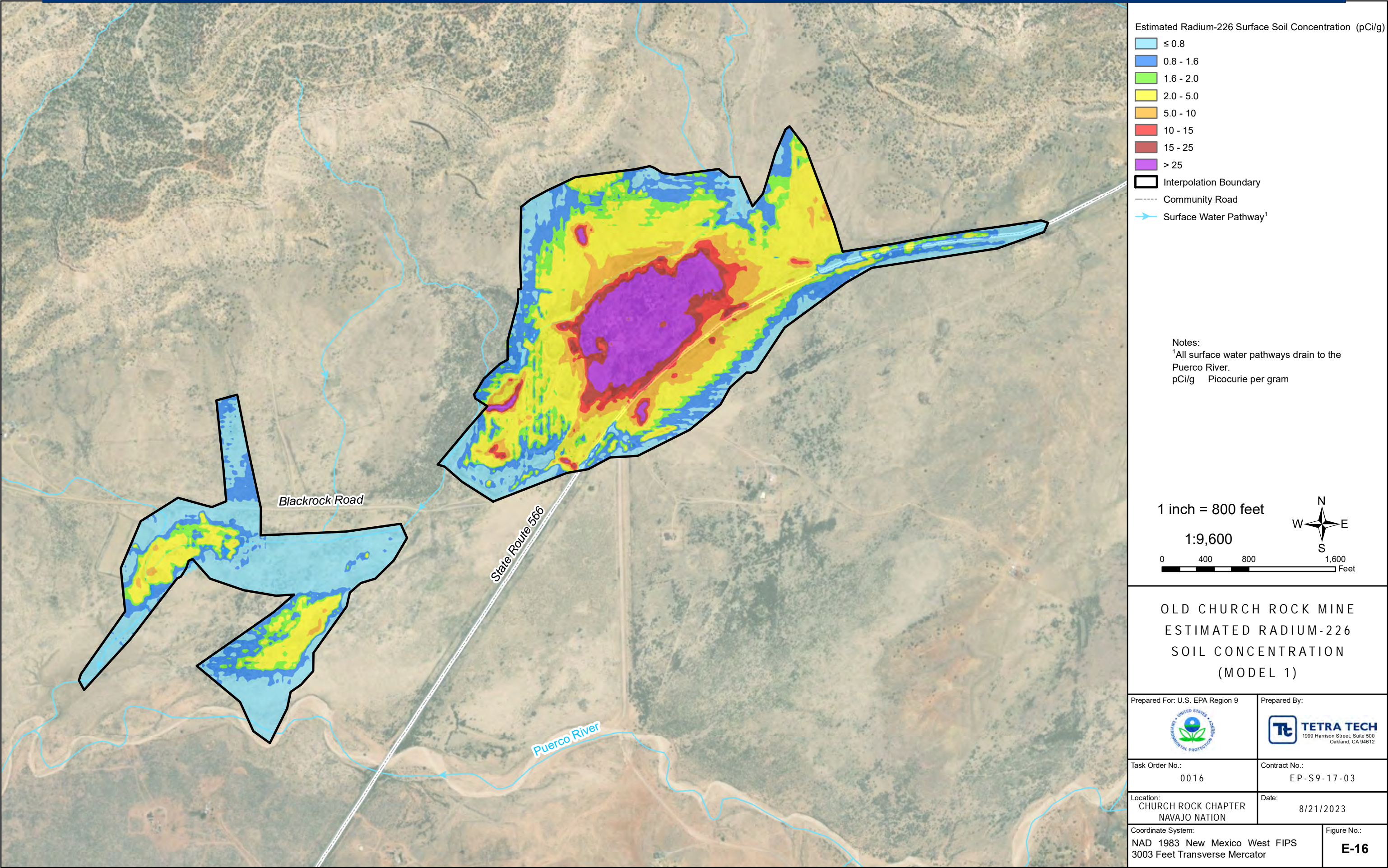
Table E-18. Summary of Model 1 Gamma Cutoff Values

Ra-226 Concentration (pCi/g)	Model 1 Cutoff Value (cpm)
2	15,847
5	20,617
10	28,566
15	36,515
25	52,413

Notes:

cpm Counts per minute
pCi/g Picocurie per gram

Figure E-16 shows an interpolated map of the gamma data collected at the site converted to an estimated Ra-226 concentration in pCi/g by application of Model 1.

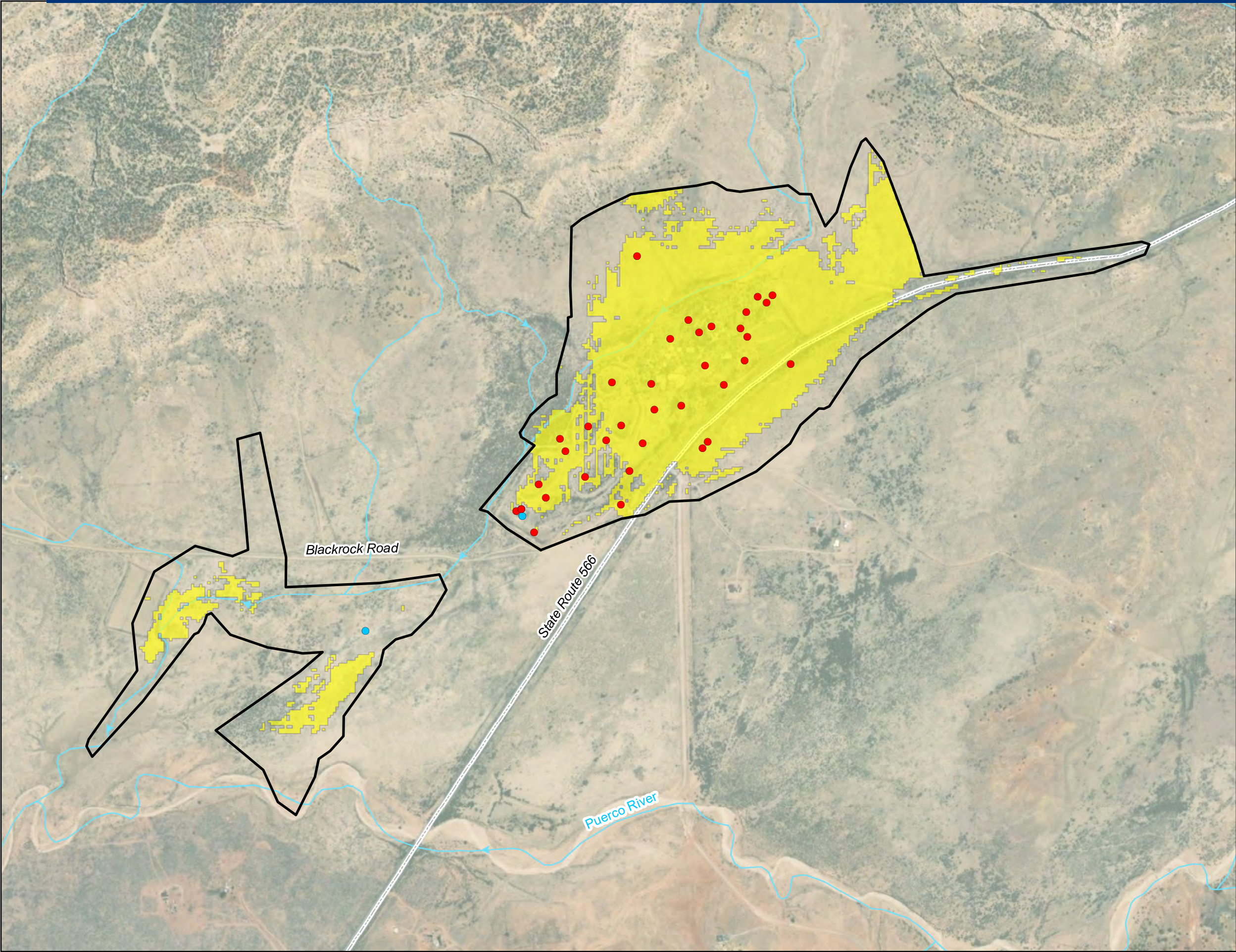


5.2.2 Model 1 Estimated Extent of Ra-226 Contamination

Total areal extent of estimated Ra-226 above 2 pCi/g by application of Model 1 is 125 acres. Both soil samples containing less than 2 pCi/g of Ra-226 were not within that areal extent (100 percent exclusion rate). Thirty-two of the 36 samples containing 2 pCi/g or greater of Ra-226 were within the footprint (89 percent containment rate). [Figure E-17](#) is a visual representation of these results.

Total areal extent of estimated Ra-226 above 5 pCi/g by application of Model 1 is 56 acres. Ten of the 11 soil samples containing less than 5 pCi/g of Ra-226 were outside the 5 pCi/g cleanup extent (91 percent exclusion rate). Twenty-five of the 27 samples containing 5 pCi/g or greater of Ra-226 were within the footprint (93 percent containment rate). [Figure E-18](#) is a visual representation of these results.

Total areal extent of estimated Ra-226 above 15 pCi/g by application of Model 1 is 29 acres. Thirteen of the 14 soil samples containing less than 15 pCi/g of Ra-226 were outside the 15 pCi/g cleanup extent (93 percent exclusion rate). Twenty-one the 24 samples containing 15 pCi/g or greater of Ra-226 were within the footprint (88 percent containment rate). [Figure E-19](#) is a visual representation of these results.



Observed Soil Radium-226 Validation Sample (pCi/g)

- ≤ 2.0
- > 2.0
- Predicted Removal Action Extent (≤ 2.0 pCi/g)
- ▭ Interpolation Boundary
- Community Road
- Surface Water Pathway¹

Notes:

¹All surface water pathways drain to the Puerco River.

pCi/g Picocurie per gram

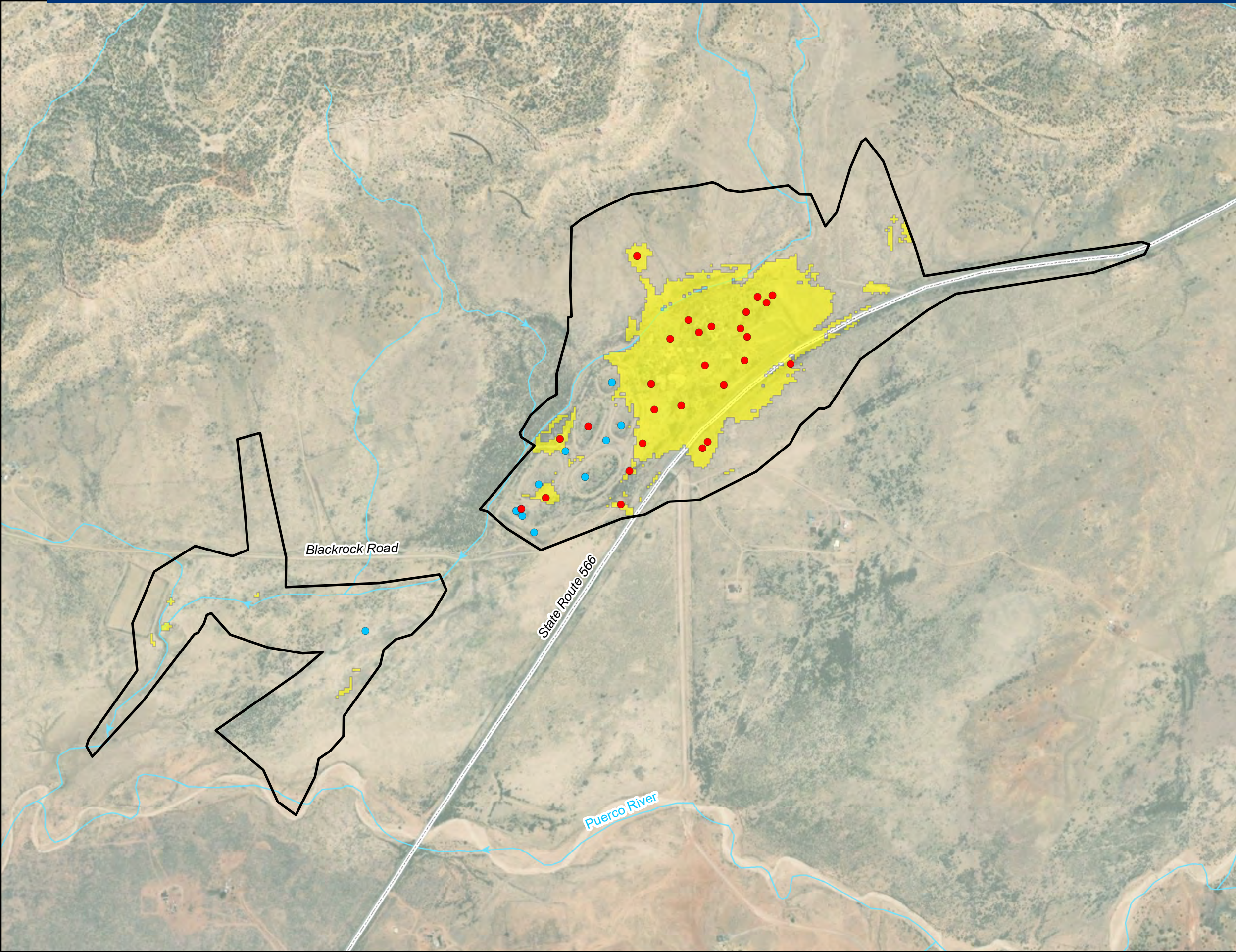
1 inch = 800 feet

1:9,600

0 400 800 1,600 Feet

OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 2 pCi/g (MODEL 1)

Prepared For: U.S. EPA Region 9	Prepared By:
	TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 New Mexico West FIPS 3003 Feet Transverse Mercator	Figure No.: E-17



- Observed Soil Radium-226 Validation Sample (pCi/g)**
- ≤ 5.0
 - > 5.0
 - Predicted Removal Action Extent (≤ 5.0 pCi/g)
 - ▭ Interpolation Boundary
 - Community Road
 - Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
pCi/g Picocurie per gram

1 inch = 800 feet

1:9,600

04008001,600

Feet

W

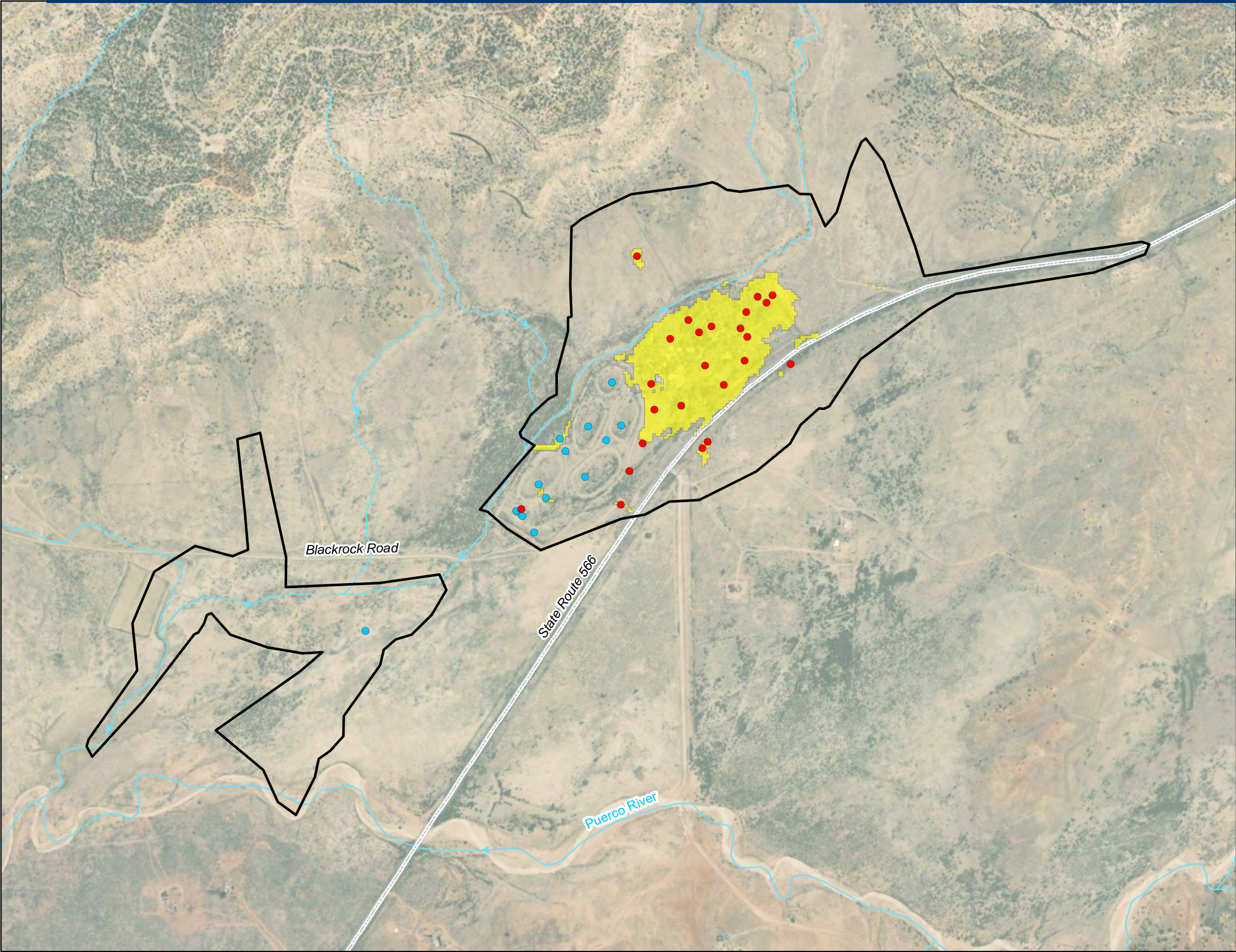
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E

S

OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 5 pCi/g (MODEL 1)

Prepared For: U.S. EPA Region 9		Prepared By:	
		<div>TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612</div>	
Task Order No.: 0016		Contract No.: EP-S9-17-03	
Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 8/21/2023	
Coordinate System: NAD 1983 New Mexico West FIPS 3003 Feet Transverse Mercator			Figure No.: E-18



Observed Soil Radium-226 Validation Sample (pCi/g)

- ≤ 15
- > 15
- Predicted Removal Action Extent (≤ 15.0 pCi/g)
- ▭ Interpolation Boundary
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
pCi/g Picocurie per gram

1 inch = 800 feet
1:9,600

0 400 800 1,600 Feet

N
W — E
S

OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 15 pCi/g (MODEL 1)

Prepared For: U.S. EPA Region 9 	Prepared By: TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 New Mexico West FIPS 3003 Feet Transverse Mercator	Figure No.: E-19

5.3 MODEL 2: TRADITIONAL LINEAR REGRESSION WITH ONLY DATA PAIRS WITH LESS THAN 19,000 CPM INCLUDED

The following subsections discuss Model 2.

5.3.1 Overview of Model 2

Model 2 is classified as a traditional linear model with only data pairs where the average unshielded gamma count rate less than 19,000 cpm was included. [Table E-19](#) lists the data pairs included or excluded for Model 2. [Figure E-20](#) depicts the regression analysis that represents Model 2. The following equation was used to convert gamma count rate to Ra-226 for Model 2:

$$^{226}\text{Ra} \left(\frac{\text{pCi}}{\text{g}} \right) = (0.000359 * [\text{Gamma Count Rate (cpm)}]) - 3.134047$$

Table E-19. Model 2 Traditional Linear Data Pair Inclusion/Exclusion

Correlation Plot ID	Average Unshielded Walkover Gamma Count Rate (cpm)	Radium-226 (pCi/g)	Final Qualifiers	Model 2 Inclusion
OCRM-CORR01	13,392	1.51	H	Included
OCRM-CORR02	11,871	1.24	--	Included
OCRM-CORR03	11,474	1.12	--	Included
OCRM-CORR04	15,643	1.95	--	Included
OCRM-CORR05	16,863	3	N	Included
OCRM-CORR06	16,341	3.02	C	Included
OCRM-CORR07	18,046	3.53	--	Included
OCRM-CORR08	18,463	3.45	B, C	Included
OCRM-CORR09	21,633	2.75	--	Excluded
OCRM-CORR10	24,340	3.41	H	Excluded
OCRM-CORR11	19,010	1.6	--	Excluded
OCRM-CORR12	30,350	2.25	B, C, G, H, J, K, N	Excluded
OCRM-CORR13	37,722	17	--	Excluded
OCRM-CORR14	35,866	17.4	E	Excluded
OCRM-CORR15	30,547	10.7	--	Excluded

Notes:

-- No qualifier
 cpm Counts per minute
 pCi/g Picocurie per gram

The number of negative values resulting from application of Model 2 was significantly less than from application of Model 1. Via Model 2, all data less than ~8,729 cpm is converted to a negative Ra-226 value. This results in 682 of 260,946 measurements being converted to negative Ra-226 values for the full dataset, and 226 of 238,185 measurements converted to negative Ra-226 values from the dataset used for the kriging.

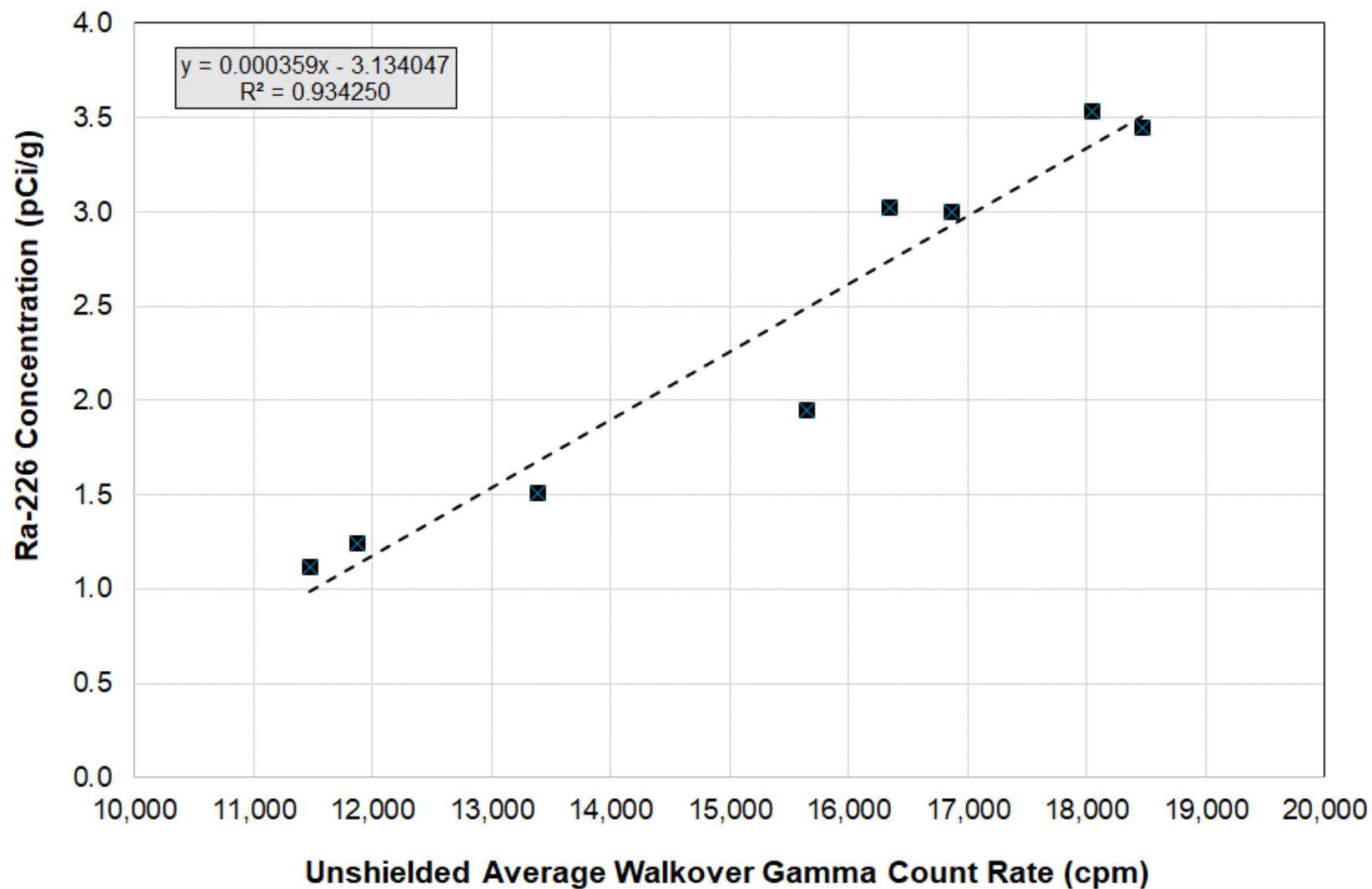


Figure E-20. Gamma-Radium Correlation, Linear Regression – Model 2

Table E-20 lists gamma equivalent values of Ra-226 concentrations as derived from Model 2.

Table E-20. Summary of Model 2 Gamma Cutoff Values

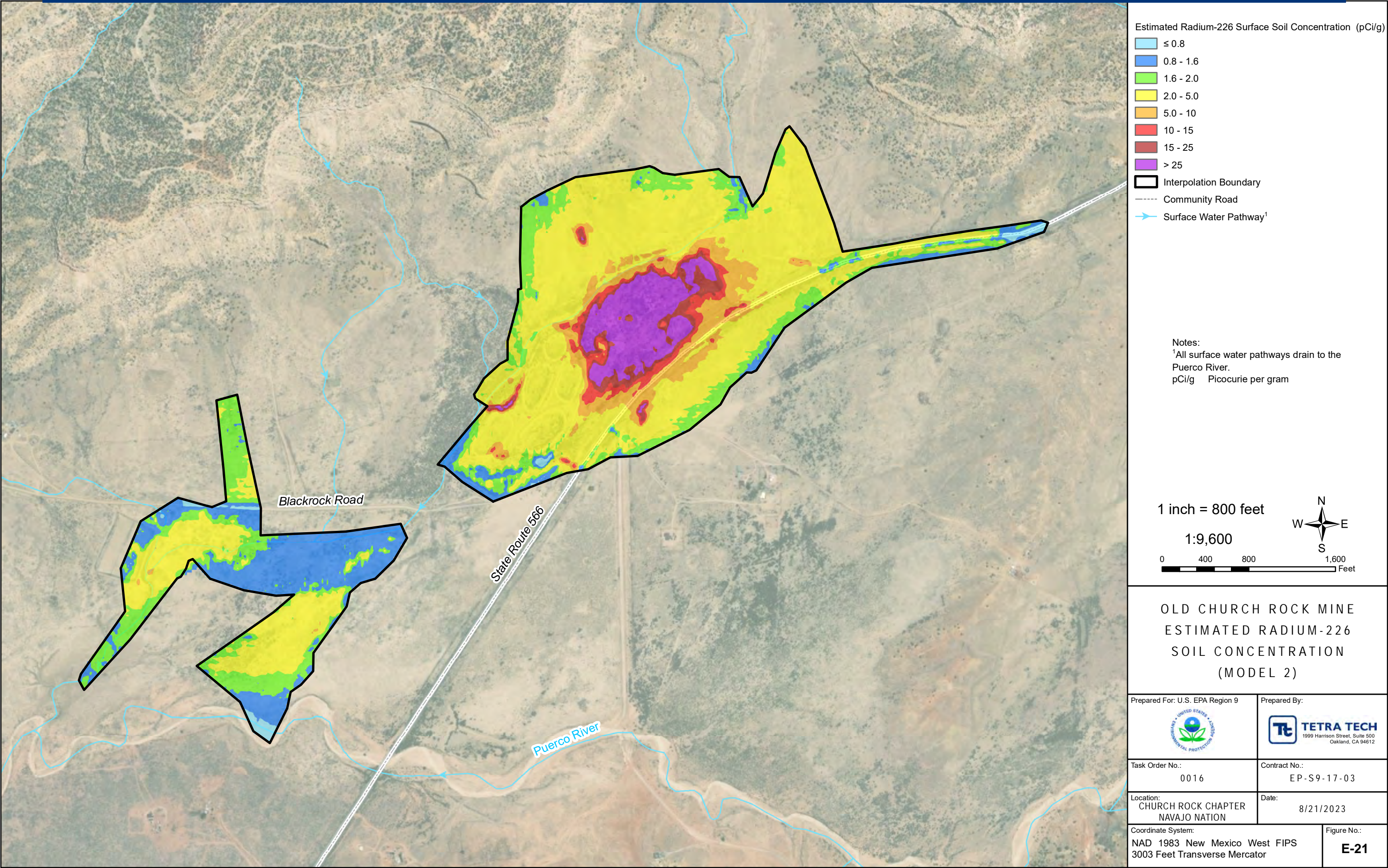
Ra-226 Concentration (pCi/g)	Model 2 Cutoff Value (cpm)
2	14,301
5	22,658
10	36,585
15	50,513
25	78,368

Notes:

cpm Counts per minute

pCi/g Picocuries per gram

Figure E-21 is an interpolated map of the gamma data collected at the site converted to estimated Ra-226 concentrations in pCi/g by application of Model 2.

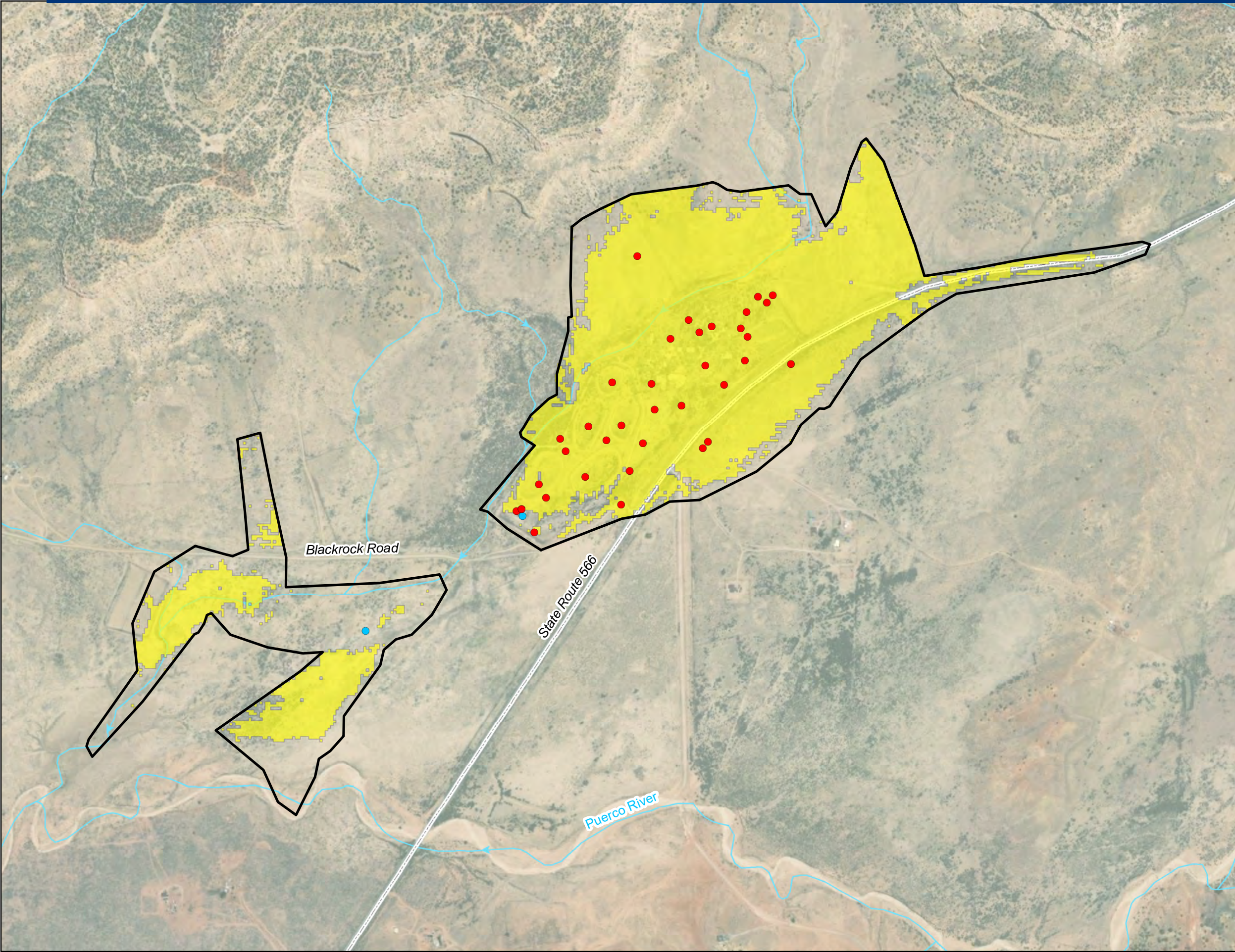


5.3.2 Model 2 Estimated Extent of Ra-226 Contamination

Total areal extent of estimated Ra-226 above 2 pCi/g by application of Model 2 is 171 acres. Both soil samples containing less than 2 pCi/g of Ra-226 were not within the areal extent (100 percent exclusion rate). Thirty-five of the 36 samples containing 2 pCi/g or greater of Ra-226 were within the footprint (97 percent containment rate). [Figure E-22](#) is a visual representation of these results.

Total areal extent of estimated Ra-226 above 5 pCi/g by application of Model 2 is 46 acres. All 11 soil samples containing less than 5 pCi/g of Ra-226 were outside the 5 pCi/g cleanup extent (100 percent exclusion rate). Twenty-four of the 27 samples containing 5 pCi/g or greater of Ra-226 were within the footprint (89 percent containment rate). [Figure E-23](#) is a visual representation of these results.

Total areal extent of estimated Ra-226 above 15 pCi/g by application of Model 2 is 22 acres. Thirteen of the 14 soil samples containing less than 15 pCi/g of Ra-226 were outside the 15 pCi/g cleanup extent (93 percent exclusion rate). Twenty of the 24 samples containing 15 pCi/g or greater of Ra-226 were within the footprint (83 percent containment rate). [Figure E-24](#) is a visual representation of these results.



Observed Soil Radium-226 Validation Sample (pCi/g)

- ≤ 2.0
- > 2.0
- Predicted Removal Action Extent (≤ 2.0 pCi/g)
- ▭ Interpolation Boundary
- Community Road
- Surface Water Pathway¹

Notes:

¹All surface water pathways drain to the Puerco River.

pCi/g Picocurie per gram

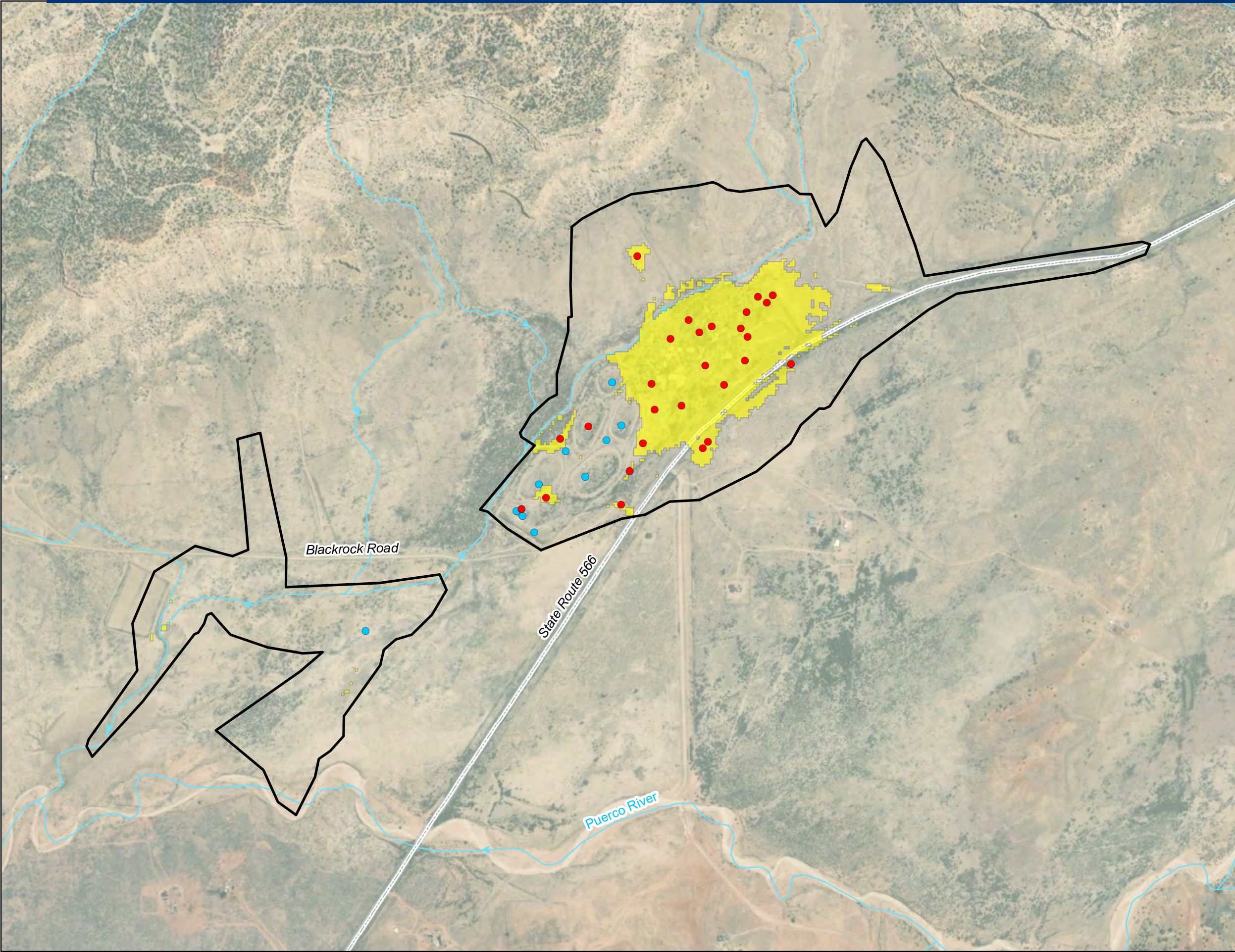
1 inch = 800 feet

1:9,600

0 400 800 1,600 Feet

OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 2 pCi/g (MODEL 2)

Prepared For: U.S. EPA Region 9	Prepared By:
	TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 New Mexico West FIPS 3003 Feet Transverse Mercator	Figure No.: E-22



Observed Soil Radium-226 Validation Sample (pCi/g)

- ≤ 5.0
- > 5.0
- Predicted Removal Action Extent (≤ 5.0 pCi/g)
- ▭ Interpolation Boundary
- Community Road
- Surface Water Pathway¹

Notes:

¹All surface water pathways drain to the Puerco River.

pCi/g Picocurie per gram

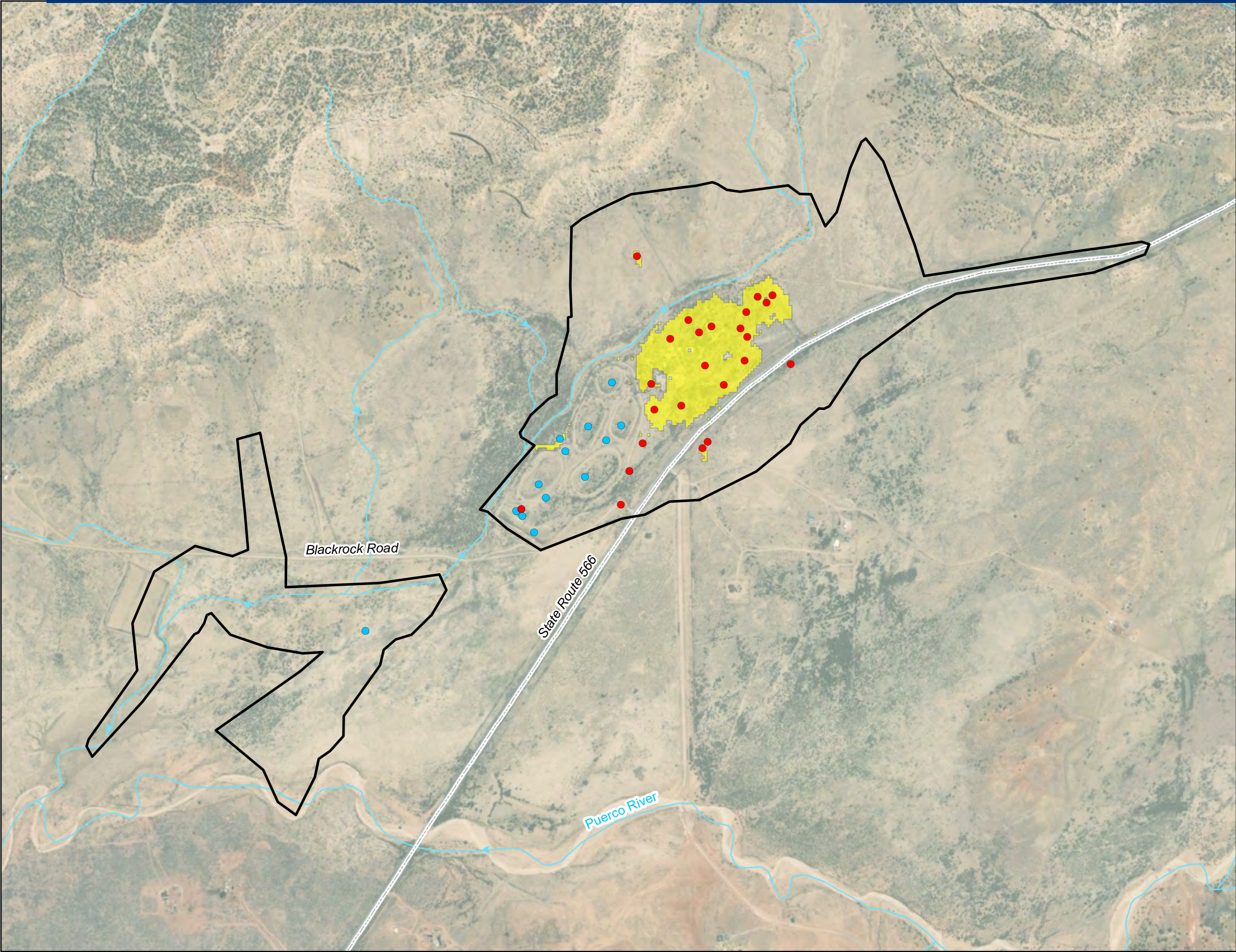
1 inch = 800 feet

1:9,600

0 400 800 1,600 Feet

OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 5 pCi/g (MODEL 2)

Prepared For: U.S. EPA Region 9 	Prepared By: TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
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Observed Soil Radium-226 Validation Sample (pCi/g)

- ≤ 15
- > 15
- Predicted Removal Action Extent (≤ 15.0 pCi/g)
- ▭ Interpolation Boundary
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
pCi/g Picocurie per gram

1 inch = 800 feet
1:9,600

0 400 800 1,600 Feet

OLD CHURCH ROCK MINE
AREAL EXTENT OF
ESTIMATED RADIUM-226
ABOVE 15 pCi/g (MODEL 2)

Prepared For: U.S. EPA Region 9		Prepared By:	
		 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612	
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Location: CHURCH ROCK CHAPTER NAVAJO NATION		Date: 8/21/2023	
Coordinate System: NAD 1983 New Mexico West FIPS 3003 Feet Transverse Mercator			Figure No.: E-24

6.0 MODEL SELECTION

This section discusses determination whether Model 1 or Model 2 is a better fit for future use at the site.

6.1 MODEL COMPARISON ANALYSIS

This section compares Model 1 and Model 2 by analyzing gamma cutoff values and gamma regressions of each, and conducting a containment analysis of each model.

6.1.1 Gamma Cutoff Analysis

Table E-21 lists gamma equivalents for both models at various Ra-226 concentrations that may be useful for future cleanup efforts. Model 2 yields a lower gamma equivalent cutoff value only when estimated Ra-226 concentration is very low (close to background).

Table E-21. Ra-226 Concentration Equivalent Gamma Cutoff Values

Ra-226 Concentration (pCi/g)	Gamma Cutoff Value (cpm)	
	Model 1	Model 2
2	15,847	14,301
5	20,617	22,658
10	28,566	36,585
15	36,515	50,513
25	52,413	78,368

Notes:

cpm Counts per minute
pCi/g Picocurie per gram

6.1.2 Gamma Regression Analysis

Figure E-25 is a plot of both Model 1 and Model 2 regressions on the same axis. Confirming information conveyed in Section 6.1.1, Model 2 is a more conservative model, predicting a higher Ra-226 concentration when the gamma count rate is lower. The intersection point of the two Models is 17,903 cpm, at which both models estimate a Ra-226 concentration of 3.3 pCi/g. Above this point, for any given gamma count rate, Model 1 is more conservative and will estimate a higher Ra-226 concentration.

Visually, Model 1 is more accurate when estimating Ra-226 at higher concentrations. Model 2 on the other hand underpredicts Ra-226 at higher levels. The inverse is true for visual assessment of lower concentrations, with Model 1 estimating negative concentrations of Ra-226 when lab results indicate concentrations in the range of 1 pCi/g.

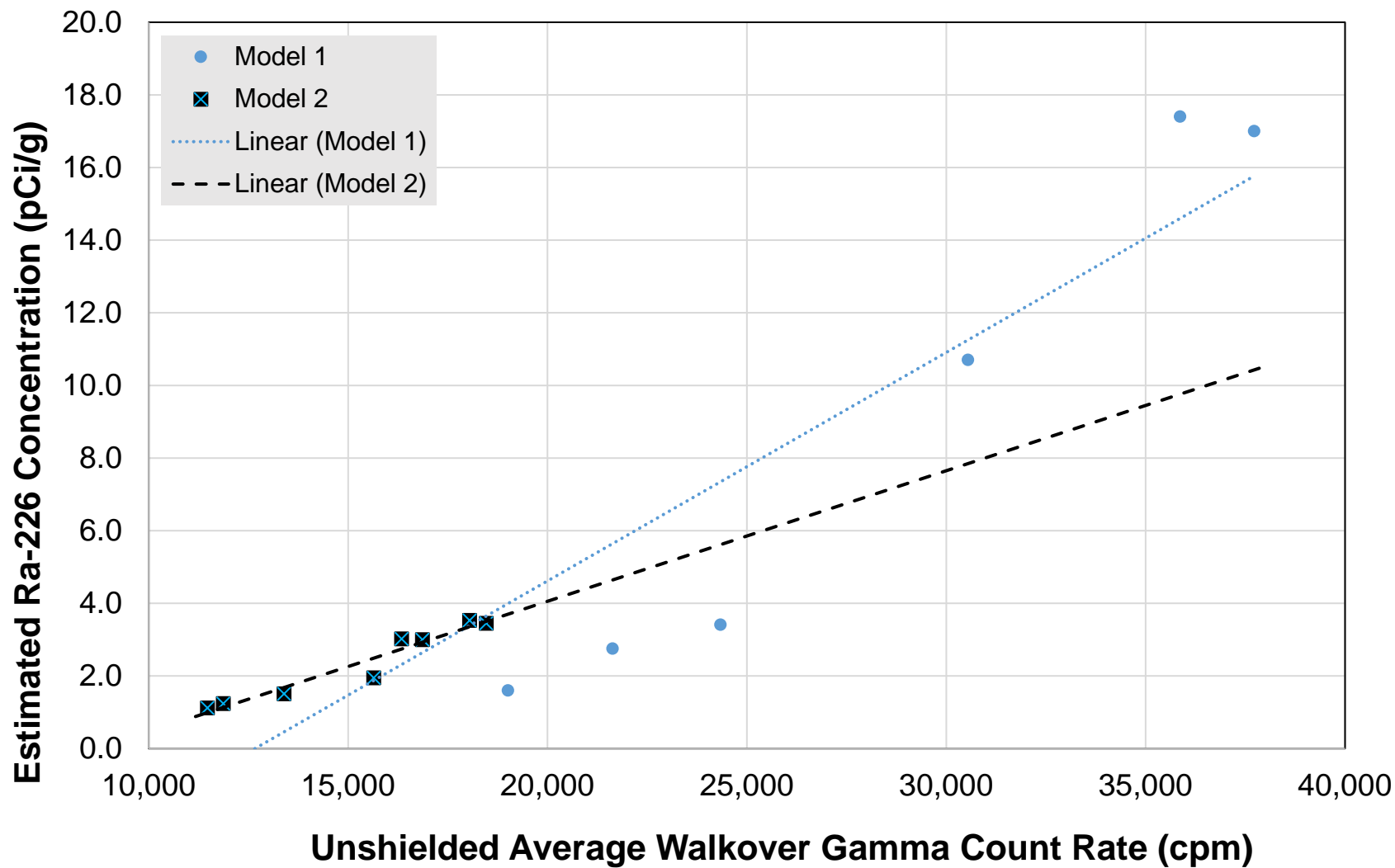


Figure E-25. Gamma-Radium Correlation Model Regression Comparison

6.1.3 Containment Analysis

Separate from the 15 correlation composite samples collected during the OCRM removal assessment, 38 soil samples were collected around the site and analyzed for Ra-226. Each of these samples was collected within an area for which walkover gamma data were available.

[Table E-22](#) through [Table E-24](#) summarize the containment analysis of site soil samples via applications of Model 1 and Model 2, as discussed in [Section 5.2.2](#) and [Section 5.3.2](#), respectively.

Model 2 yielded a greater containment rate of samples exceeding a threshold of 2 pCi/g, with only one sample being improperly contained (97 percent containment rate), whereas Model 1 yielded an 89 percent containment rate. Both Model 1 and Model 2 demonstrated a 100 percent exclusion rate of samples below a threshold of 2 pCi/g.

Model 1 yielded a greater containment rate of samples exceeding thresholds of 5 and 15 pCi/g, with containment rates of 93 percent and 88 percent, respectively. Model 2 yielded containment rates of 89 percent and 83 percent for the same thresholds. Model 2 demonstrated a slightly better exclusion rate of samples lower than 5 pCi/g (100 percent), with Model 1 improperly containing one sample, resulting in an exclusion rate of 93 percent at a threshold of 5 pCi/g. Both Models yielded a 100 percent exclusion rate of samples below a threshold of 15 pCi/g.

Table E-22. Containment Analysis at 2 pCi/g Ra-226

Model	Acres	# ≥ 2.0 pCi/g	# ≥ 2.0 pCi/g Contained	# ≥ 2.0 pCi/g Excluded	Contained %	# < 2.0 pCi/g	# < 2.0 pCi/g Contained	# < 2.0 pCi/g Excluded	Excluded %
Model 1	125	36	32	4	89%	2	0	2	100%
Model 2	171	36	35	1	97%	2	0	2	100%

Notes:

pCi/g Picocurie per gram

Ra-226 Radium-226

Table E-23. Containment Analysis at 5 pCi/g Ra-226

Model	Acres	# ≥ 5.0 pCi/g	# ≥ 5.0 pCi/g Contained	# ≥ 5.0 pCi/g Excluded	Contained %	# < 5.0 pCi/g	# < 5.0 pCi/g Contained	# < 5.0 pCi/g Excluded	Excluded %
Model 1	56	27	25	2	93%	11	1	10	91%
Model 2	46	27	24	3	89%	11	0	11	100%

Notes:

pCi/g Picocurie per gram

Ra-226 Radium-226

Table E-24. Containment Analysis at 15 pCi/g Ra-226

Model	Acres	# ≥ 15.0 pCi/g	# ≥ 15.0 pCi/g Contained	# ≥ 15 pCi/g Excluded	Contained %	# < 15.0 pCi/g	# < 15.0 pCi/g Contained	# < 15.0 pCi/g Excluded	Excluded %
Model 1	29	24	21	3	88%	14	1	13	93%
Model 2	22	24	20	4	83%	14	1	13	93%

Notes:

pCi/g Picocurie per gram

Ra-226 Radium-226

6.2 FINAL SELECTION

Two modeling approaches were considered to predict Ra-226 soil concentrations at the site, described in [Section 5.0](#) and compared in [Section 6.1](#). It is important to carefully consider selection of an appropriate model that better represents actual ground conditions to avoid both potential cost of unnecessary cleanup and potential hazards related to contamination left in place.

Model 2 demonstrated better capabilities than Model 1 of estimating Ra-226 at concentrations closer to background. Model 1 demonstrated better capabilities than Model 2 of estimating Ra-226 at concentrations above background. The two models shared an intersection point of 17,903 cpm, which equates to 3.3 pCi/g Ra-226.

Because both models demonstrate better performance in different regions of Ra-226 concentration, combining both models into a hybrid model would entail advantages of characteristic benefits from both models. To generate a continuous function, the point at which the hybrid model changes regressions should be set to the point at which the two models intersect, which is at 17,903 cpm.

This hybrid model can be implemented such that Model 2 is applied when estimating Ra-226 concentrations lower than 3.3 pCi/g, and Model 1 is applied when estimating Ra-226 concentrations greater than or equal to 3.3 pCi/g.

[Figure E-26](#) is a visual representation of the final hybrid model recommended for the site, including the breakpoint between Model 1 and Model 2.

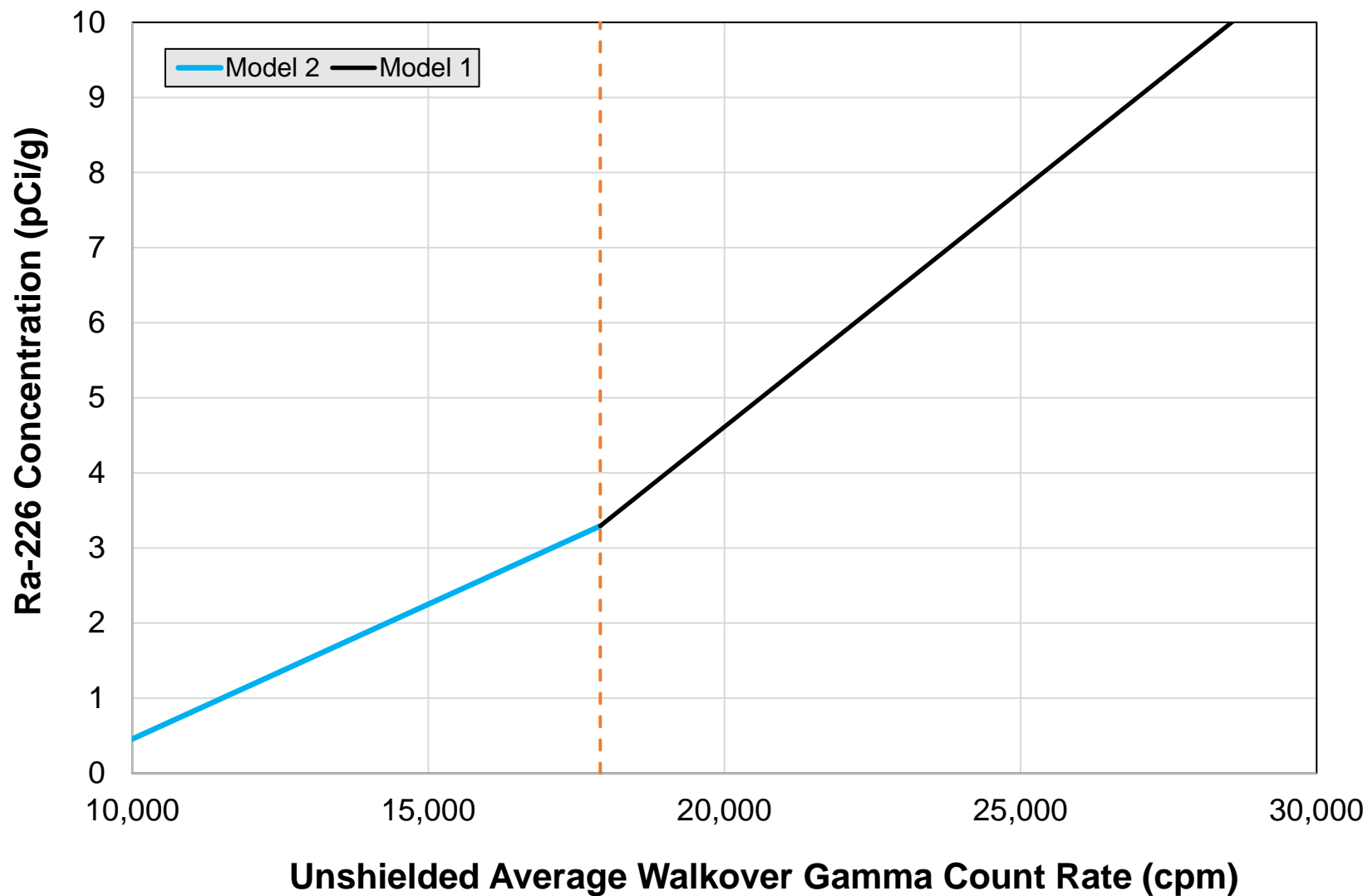


Figure E-26. Final Hybrid Model Selection (Red Dotted Line Shows Break Point Between Model 1 and Model 2)

7.0 CONCLUSIONS

Studies within 15 100-square-meter plots at the site included gamma walkover surveys, static gamma surveys co-located with HPIC surveys, visual observations, and composite soil sampling. One of the correlation plots was not used in development of all correlations.

From the remaining 14 correlation plots at the site, two models were developed correlating raw gamma radiation count measurements to Ra-226 analytical results. These models could be combined into a single hybrid model that changes regressions around the models' intersection point.

- Model 1 ($R^2 = 0.88$) is best used when estimating Ra-226 concentrations in areas of higher gamma radiation (greater than or equal to 17,903 cpm).

$$^{226}\text{Ra} \left(\frac{\text{pCi}}{\text{g}} \right) = (0.000629 * [\text{Gamma Count Rate (cpm)}]) - 7.967955$$

- Model 2 ($R^2 = 0.93$) is best used when estimating Ra-226 concentrations in areas of gamma radiation close to background (less than 17,903 cpm).

$$^{226}\text{Ra} \left(\frac{\text{pCi}}{\text{g}} \right) = (0.000359 * [\text{Gamma Count Rate (cpm)}]) - 3.134047$$

From the remaining 14 correlation plots at the site, a single model was developed correlating raw gamma radiation count measurements to exposure rate measurements ($R^2 = 0.98$).

$$\text{Gamma Exposure} \left(\frac{\mu\text{R}}{\text{hr}} \right) = (0.000482 * [\text{Gamma Count Rate (cpm)}]) + 9.724779$$

Table E-25 summarizes recommended gamma cutoff values by application of the appropriate Model for the given range, along with equivalent exposure rates.

Table E-25. Summary of Ra-226 Estimates

Ra-226 Concentration (pCi/g)	Recommended Gamma-Radium Model	Gamma Cutoff Value (cpm)	Exposure Rate (μR/hr)
2	Model 2	14,301	16.6
3.3	Model 1 & Model 2	17,903	18.4
5	Model 1	20,617	19.7
10	Model 1	28,566	23.5
15	Model 1	36,515	27.3
25	Model 1	52,413	35.0

Notes:

μR/hr Microrentgen per hour

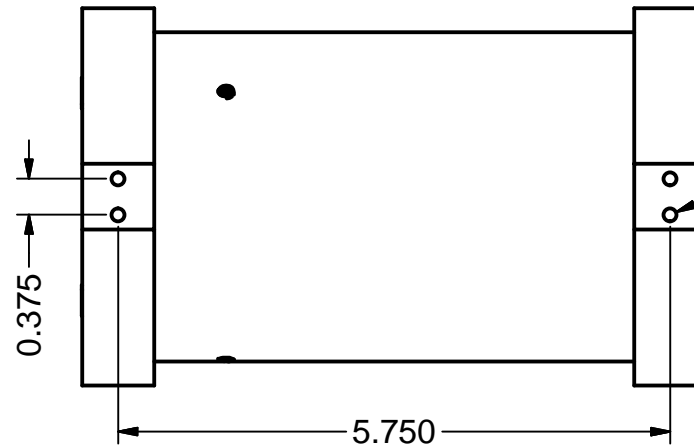
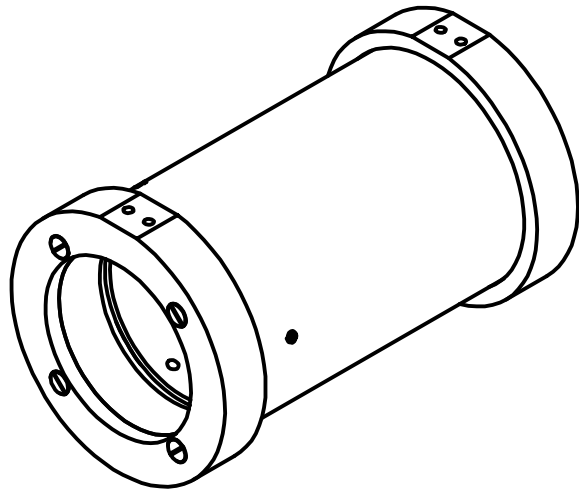
cpm Counts per minute

pCi/g Picocurie per gram

8.0 REFERENCES

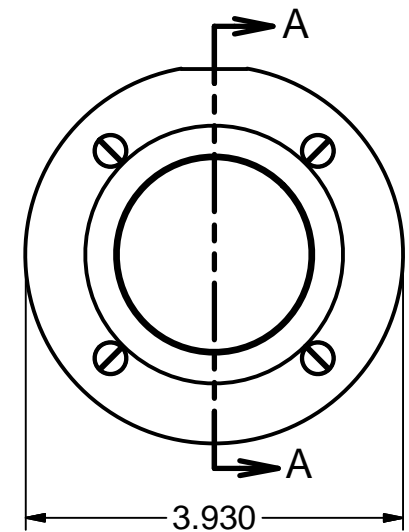
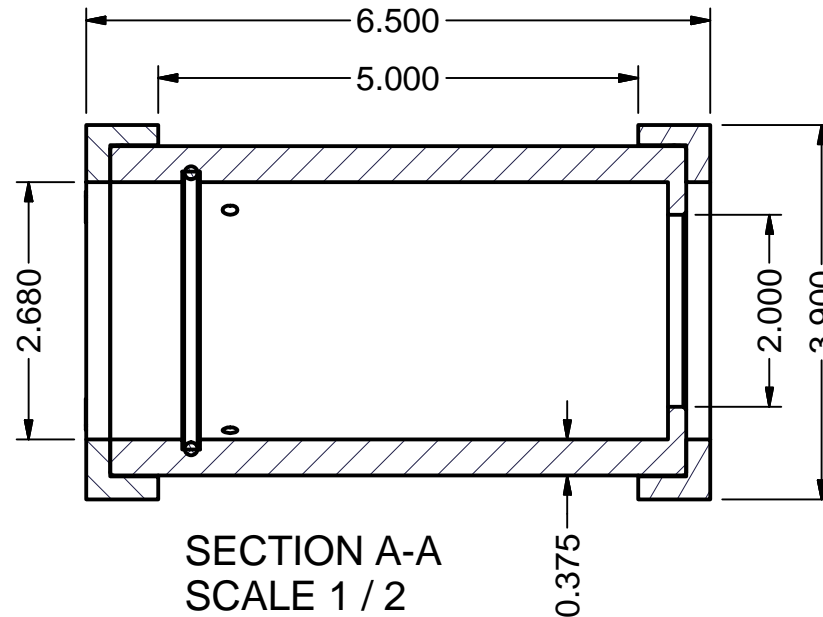
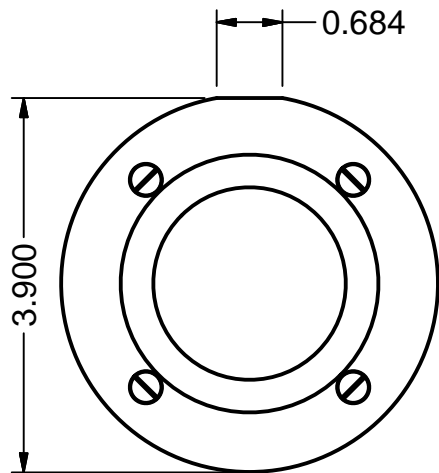
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ATTACHMENT E-1: LUDLUM COLLIMATOR DESIGN



REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	10/10/18	JWI

8-32 UNC X 0.500 DEEP
4 PLACES



NOTES:
 DIMENSIONS SHOWN FOR 3/8" WALL DESIGN
 3/8" WALL DESIGN IS 9.6#
 1/2" WALL DESIGN IS 13.1#

DWN	DATE	CHK	DATE	APP	DATE
JWI	10/10/18				
DWG NUM: 4260-233				SCALE:	
TITLE M 44-10 COLLIMATOR ASSY					
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556		SERIES 260		SHEET 233	

**ATTACHMENT E-2: SOP 003: MAKING AN EXPOSURE RATE
MEASUREMENT USING AN HPIC**

Environmental Standard Operating Procedure

SOP No. 003

**Making Exposure Rate Measurements Using a
High Pressure Ionization Chamber (HPIC)**



Tetra Tech, Inc.

Environmental Restoration Group, Inc.



February 2018



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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for making exposure rate measurements using the GE-Energy Model RS-S131 High Pressure Ionization Chamber (HPIC), or similar.

An HPIC is a highly sensitive and stable detector for measuring gamma radiation exposure rates in air, in the unit milliroentgen per hour (mR/hr). These measurements often are made for comparison to, and/or correlation with, other gamma radiation detectors such as Ludlum Model 44-10 or Model 44-20 gamma scintillators.

To make project-related exposure rate measurements using an HPIC, personnel must be recognized on their ERG Training Qualification Form as qualified to perform this procedure.

2.0 PRECAUTIONS

- For shipping purposes the GE-Energy Model RS-S131 HPIC is considered Dangerous Goods, and must be shipped as such.

3.0 EQUIPMENT AND MATERIALS

The following equipment is required for making exposure rate measurements using a High Pressure Ionization Chamber (HPIC):

- A calibrated GE-Energy Model RSS-131 HPIC, or similar. NOTE: fully charge battery.
- Tripod
- Computer with Model RSS-131 software installed to communicate with HPIC.
- Cables, including USB to RS-232 cable, and others as necessary.

4.0 COMMUNICATION AND SETUP

Setup of the HPIC is an initial one-time step for a project. After setting this up on the computer it will not be necessary to perform again.

4.1 COMMUNICATION

1. Load the Model RS-S131 software on to the computer to be used with HPIC.
2. Connect the round 8-pin connector to COM2 on the HPIC and connect the 9-pin serial connector to COM1 on computer. *NOTE: A Serial to USB adaptor may be needed to make this connection since many computers have no serial port. It may be necessary to setup the Serial to USB adaptor as COM1 in the computer's Device Manager.*
3. Power on the HPIC using the ON/OFF toggle switch.
4. Open the Model RS-S131 Configuration Utility on the computer.
5. To change COM port settings select the **PC** menu, then **Serial Config...** option to open up the **Serial Setup** window. On the left side of the **Serial Setup** window is the **PC COM Port** options; choose



COM1. On the right side of the Serial Setup window is the **RS-S131 COM Port** Options; choose COM4. The **PC Baud rate** should be 9600 and **PC Parity** should be None.

6. When done with these settings click the **OK** button. Refer to the GE-Energy Model RS-S131 User's Manual for additional communication information.

4.2 GENERAL SETTINGS

To change the HPIC general use settings select the **Configuration** menu, then the **General...** option. The general use settings should be **Time Format** equal to mm/dd/yy, and **Radiation Label** equal to mR/hr.

4.3 SENSOR CONFIGURATION

If there is a need to adjust the recording interval of the HPIC measurements then select the **Configuration** menu, then the **Sensors** option to open the **Sensor Configuration** window. In the **Sensor Configuration** window select the **HPIC** tab and input the desired interval in the **Recording interval (sec)** box. *NOTE: The Sensor Configuration window is where the user may confirm that the Conversion factor set matches the unit's calibration sheet.*

5.0 OPERATION

The HPIC will log readings when powered on, regardless of whether it is connected to a computer. You may power the detector on/off as needed between locations.

5.1 MAKE MEASUREMENT

Power on the HPIC using the ON/OFF toggle switch. *NOTE: When the HPIC is powered on the exposure rate readings will be a dip, relative to the actual exposure rate. After approximately one minute the exposure rate readings will stabilize. The HPIC will continue to log exposure rate readings according to the logging settings as set in the Sensor Configuration. The project work plan may prescribe the measurement duration and/or logging interval, but if not then 5-minutes per location and an interval of 6-seconds is typically acceptable.* At each location where an HPIC measurement is made record the date, collection time, approximate measurement duration, and comments (any other pertinent information) in the logbook. When finished with making the measurement, power off the HPIC.

5.2 VIEWING DATA IN REAL TIME

Exposure rate readings can be viewed in real time through the RS-S131 Configuration Utility application. Select the **Online** menu, then the **Sensor Data...** option. The exposure rate in units of mR/hr will be displayed next to HPIC in the Sensor Values window. Another option for viewing data in real time is to select the **Online** menu, then the **Current Data...** option to open the **Current Data** window. When the **Current Data** window opens choose the HPIC in the Sensor drop down box and click the **Get Data** button. *NOTE: The exposure rate in mR/hr will be updated at the interval set in the Sensor Configuration.*

5.3 DOWNLOAD DATA

Upon completion of making measurements the data may be downloaded to the computer. From the **Online** menu select **Upload Sensor Data...** Option to open the Upload window. In the Upload window enter the **Start – Date** and **Time**, and the **End – Date** and **Time** in mm/dd/yyyy and hh:mm format. Do this

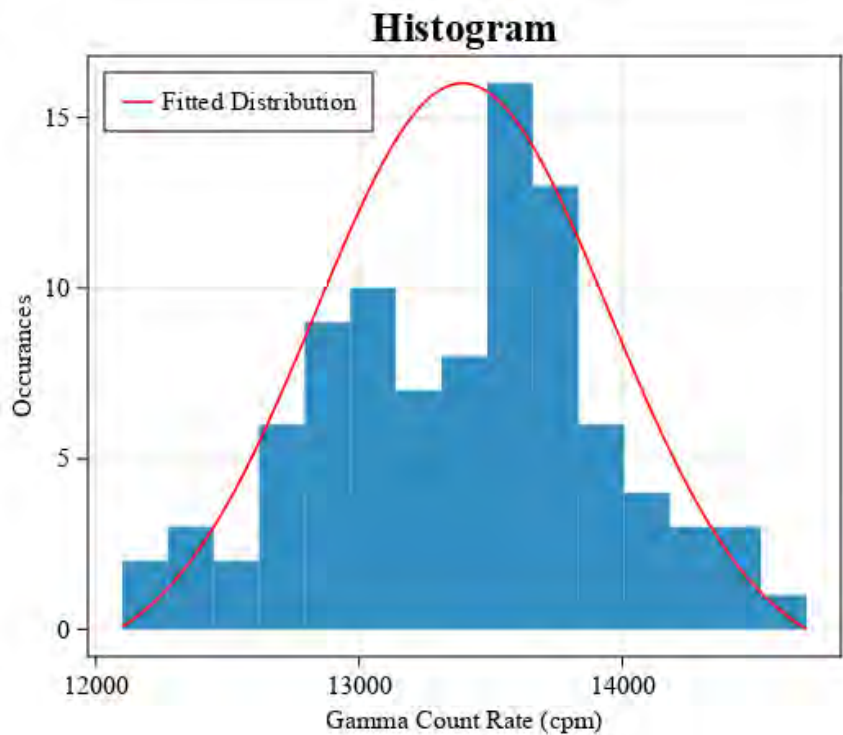
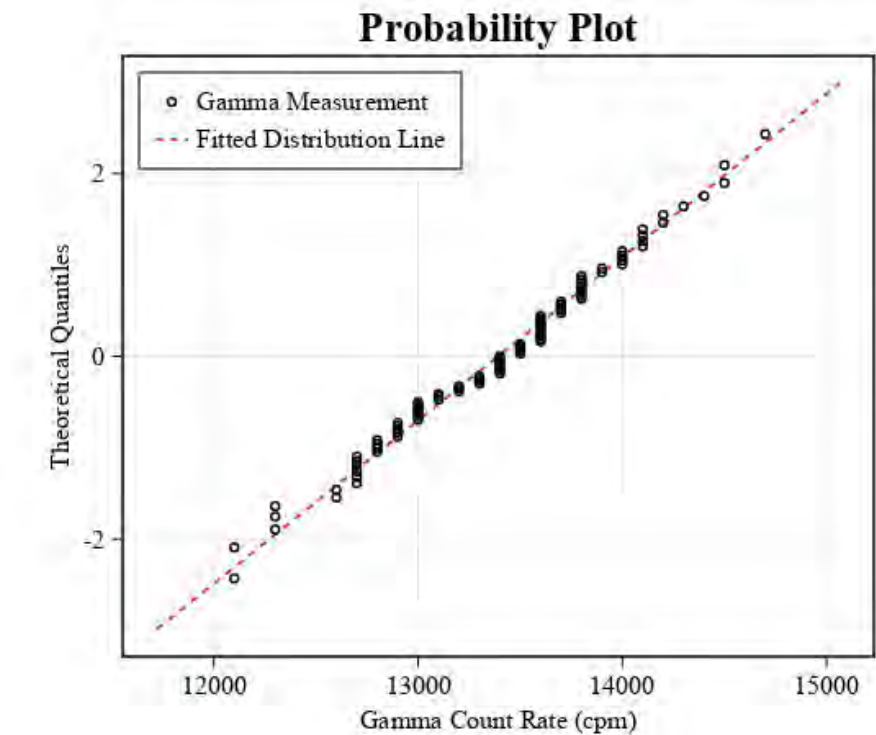
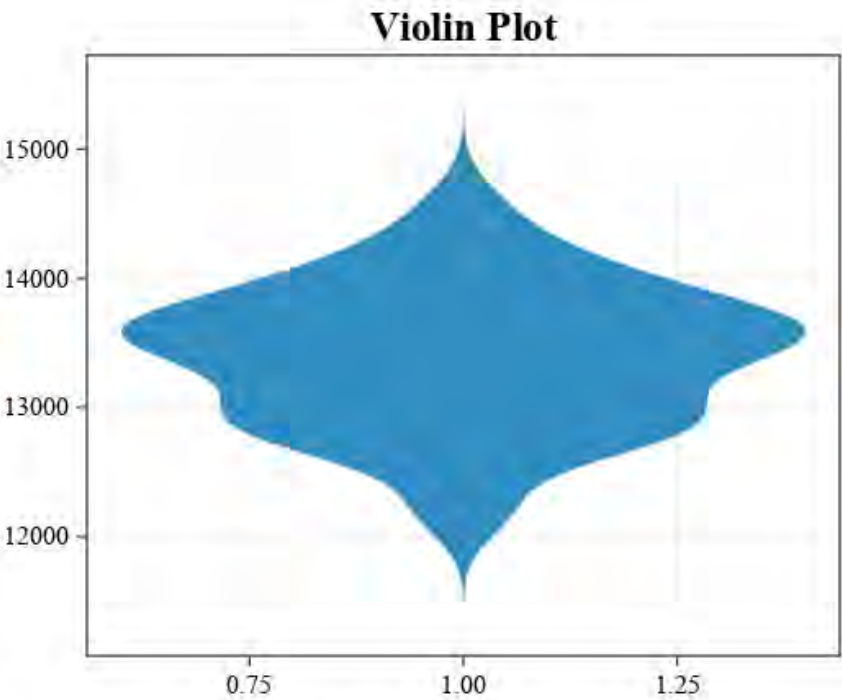
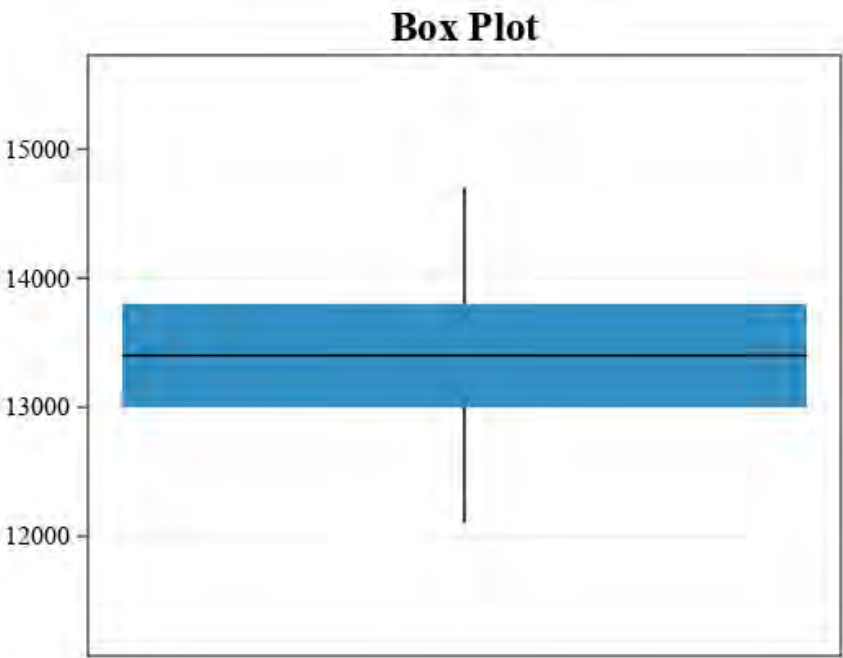
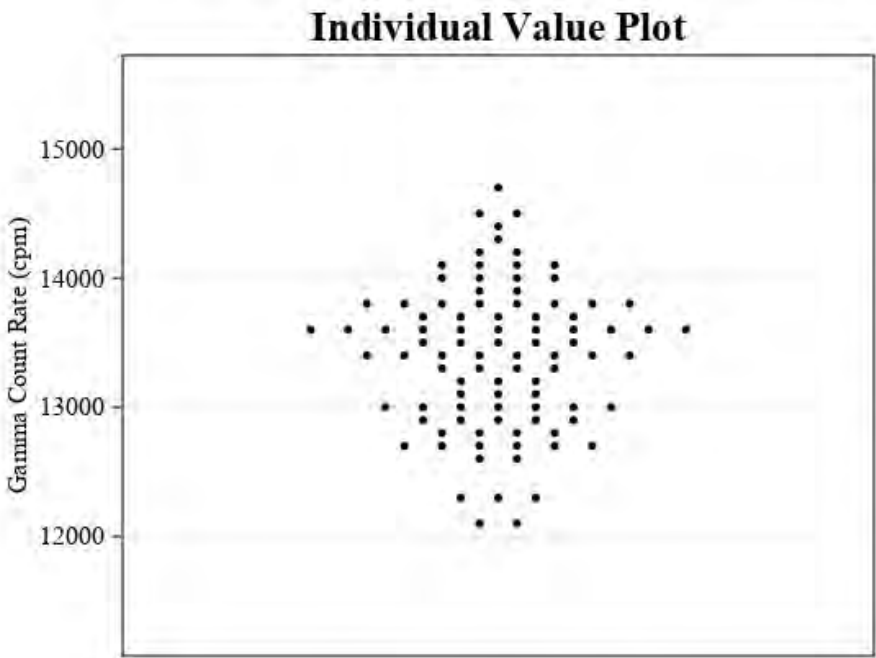


for the period of data to be saved then click the **OK** button. A **Save As** dialog window will open allowing the user to navigate to the location where the file is to be saved. Click on the Save button to save the file.

ATTACHMENT E-3: CORRELATION PLOT STATISTICS – UNSHIELDED GAMMA

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR01 Type: Unshielded

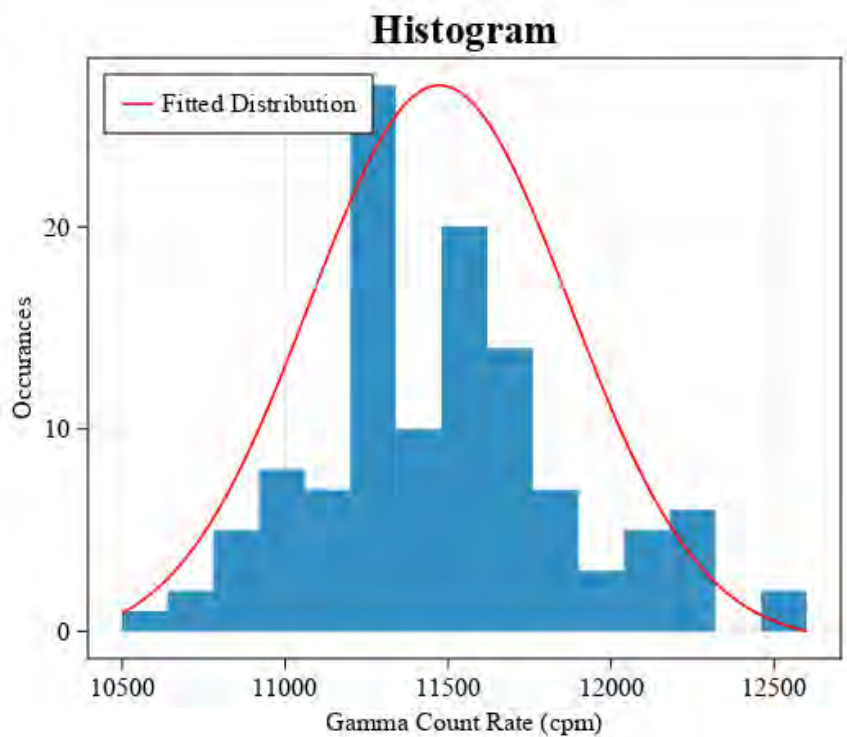
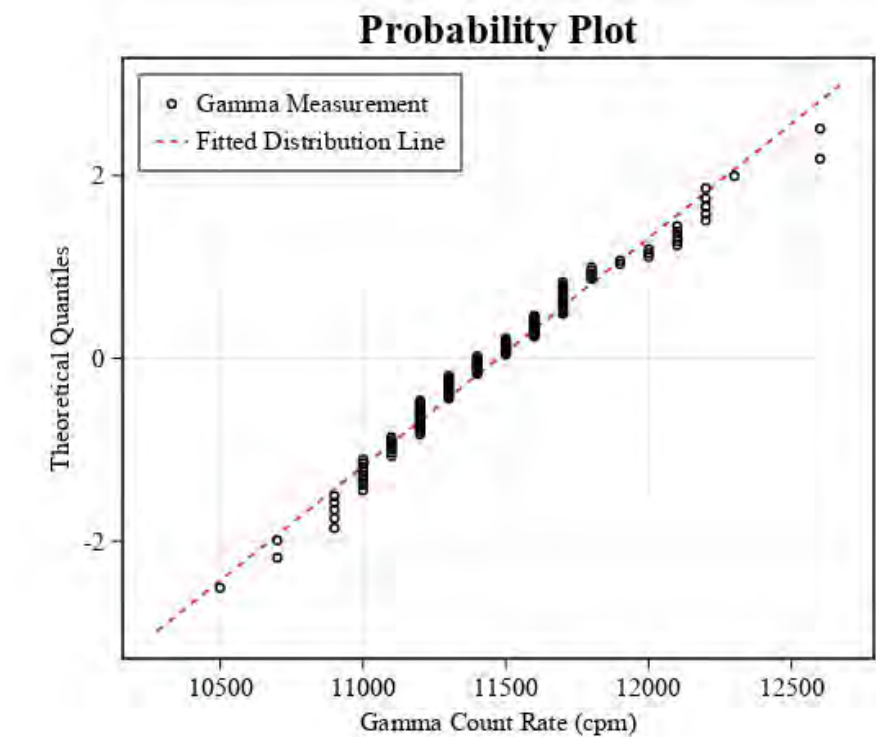
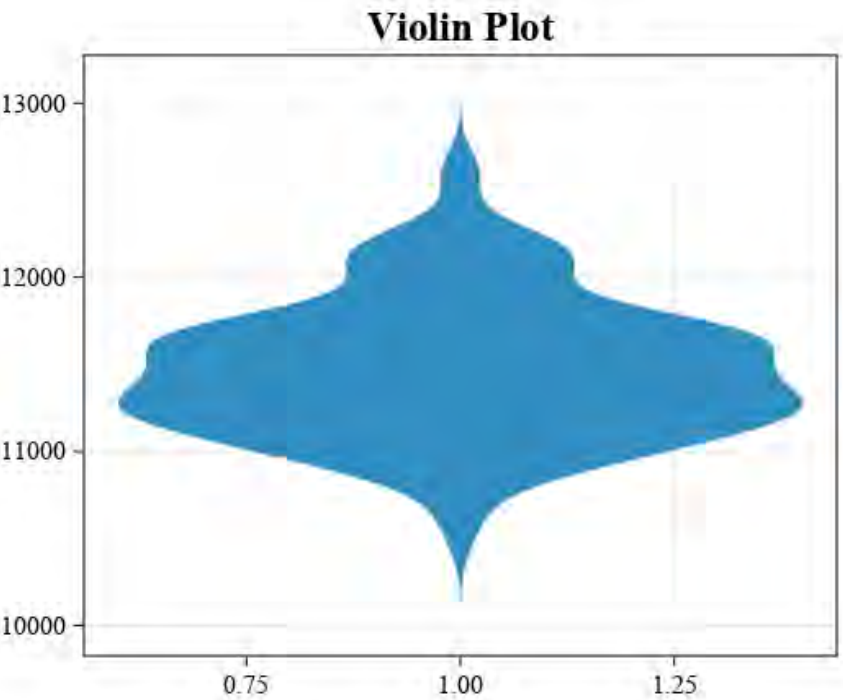
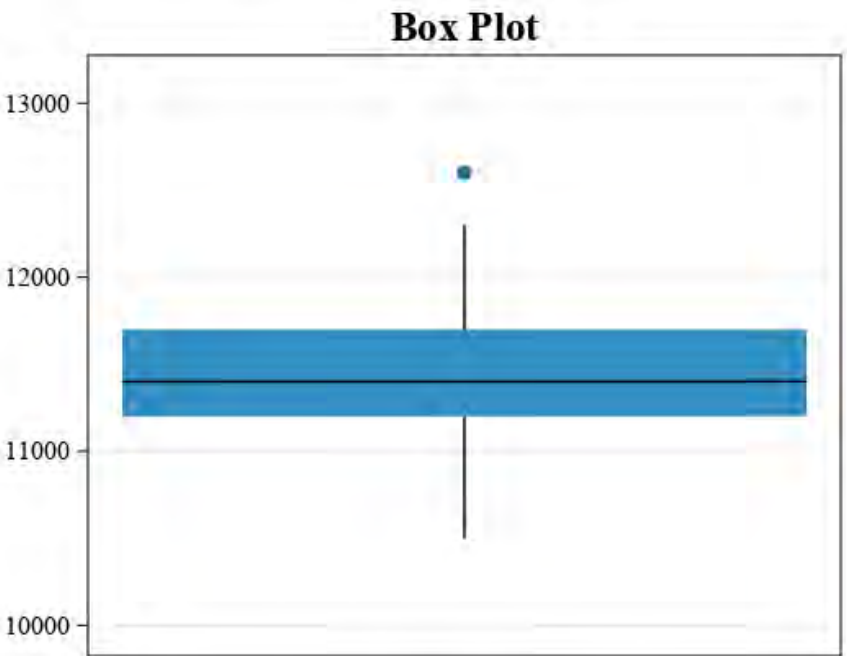
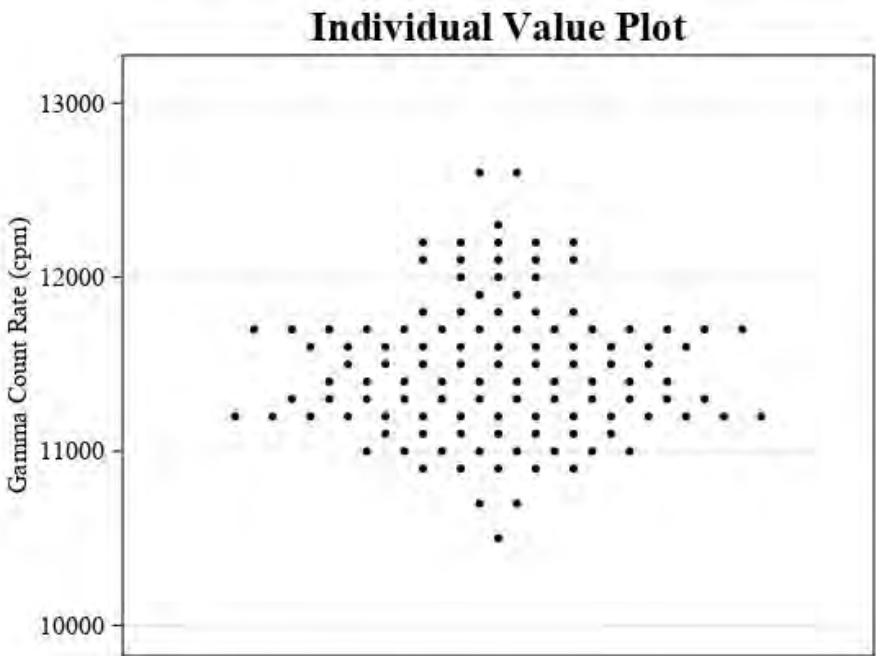


Summary Statistics

Count (n)	93
Minimum (cpm)	12,100
Maximum (cpm)	14,700
Average (cpm)	13,392
Median (cpm)	13,400
Standard Deviation (cpm)	559
Relative Standard Deviation	4.177%
RPD of Mean and Median	0.056%
90th Percentile (cpm)	14,100
95th Percentile (cpm)	14,300
99th Percentile (cpm)	14,700

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR03 Type: Unshielded

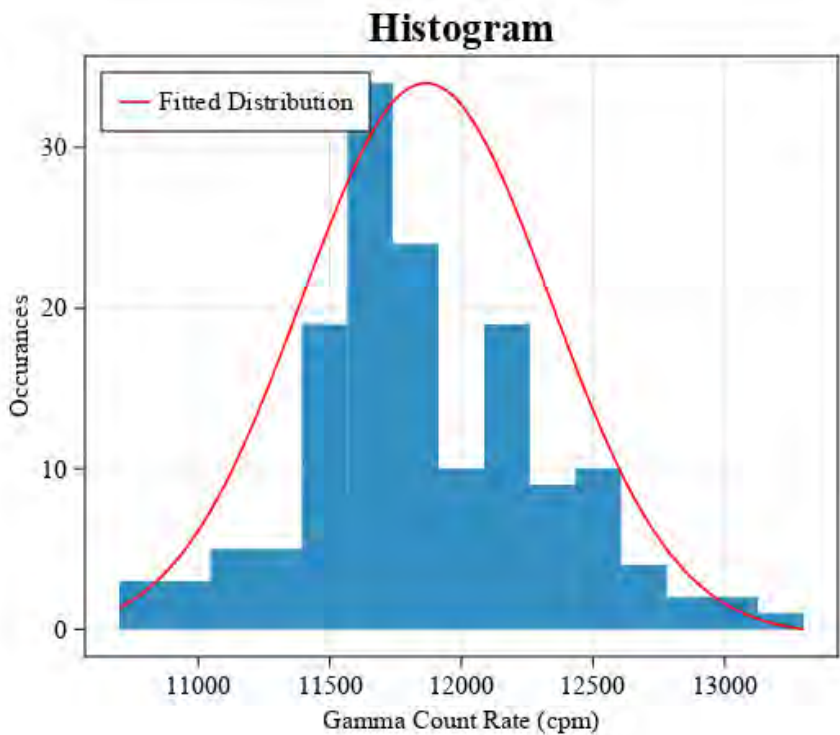
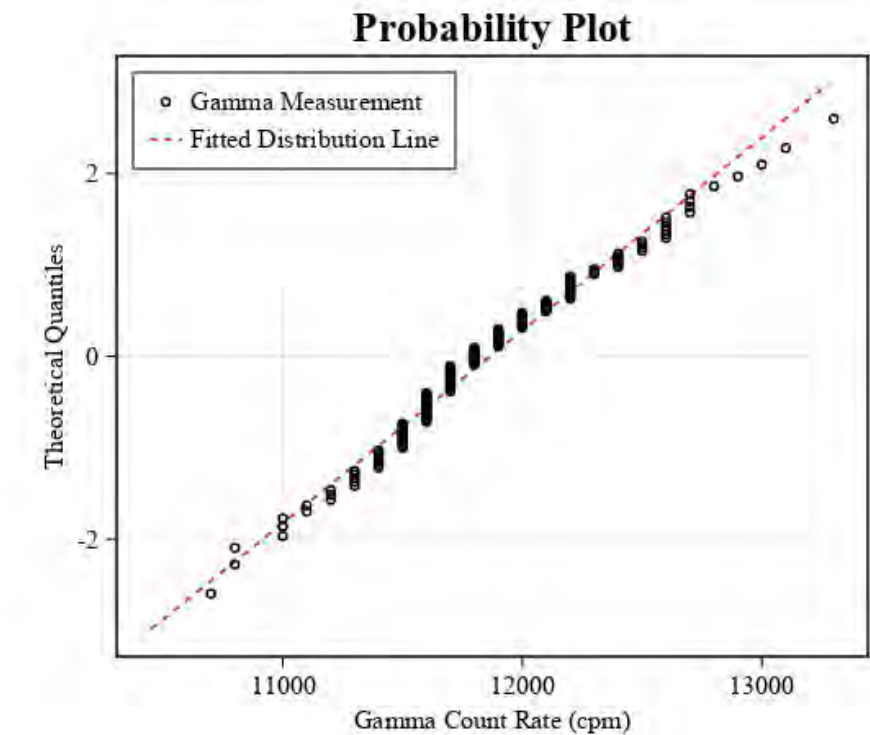
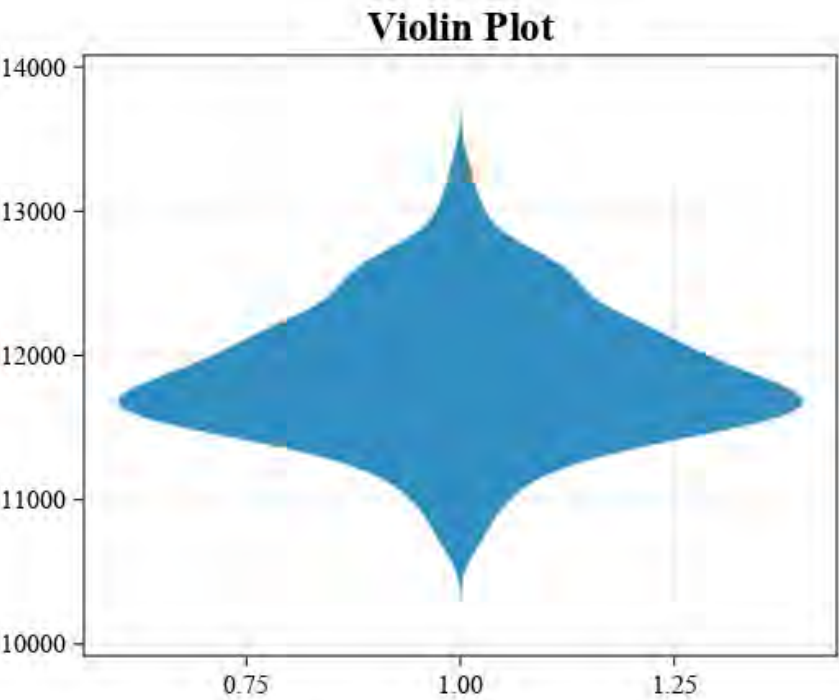
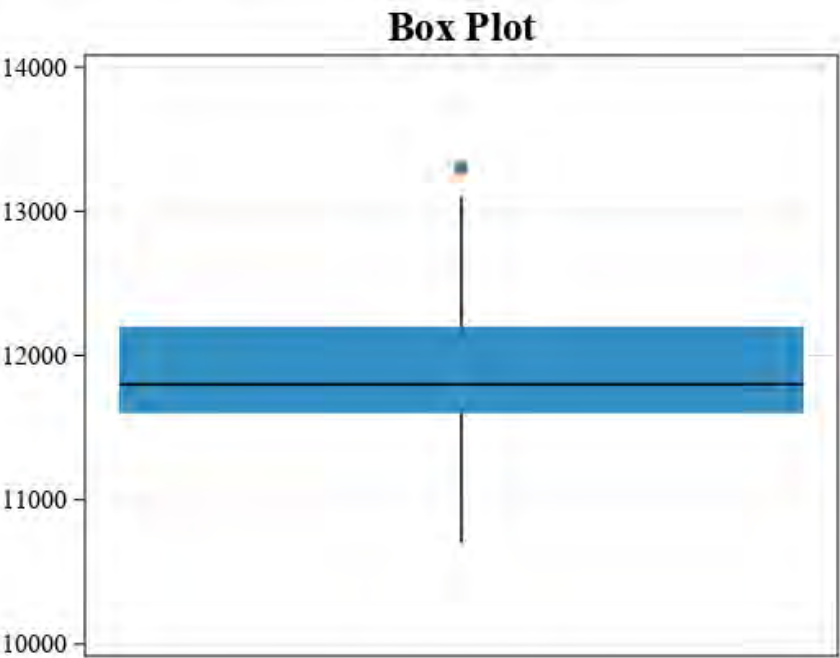
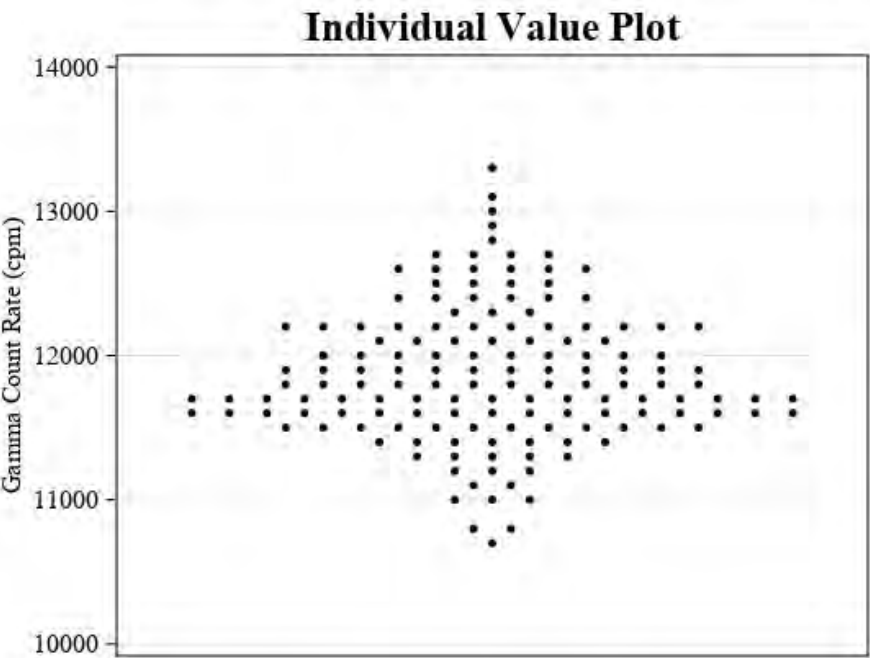


Summary Statistics

Count (n)	117
Minimum (cpm)	10,500
Maximum (cpm)	12,600
Average (cpm)	11,474
Median (cpm)	11,400
Standard Deviation (cpm)	400
Relative Standard Deviation	3.485%
RPD of Mean and Median	0.643%
90th Percentile (cpm)	12,100
95th Percentile (cpm)	12,200
99th Percentile (cpm)	12,600

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR02 Type: Unshielded

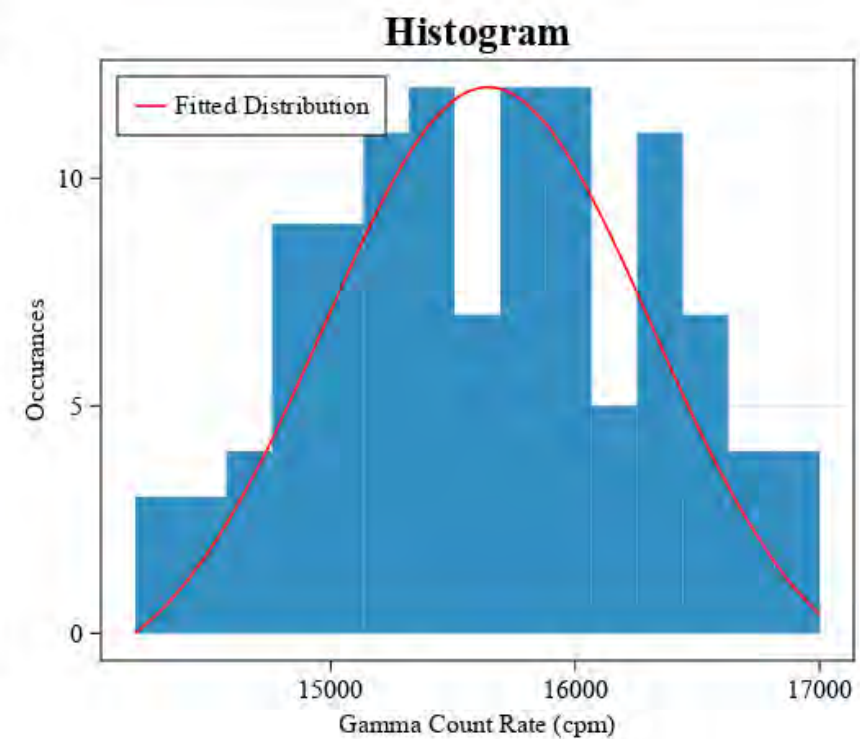
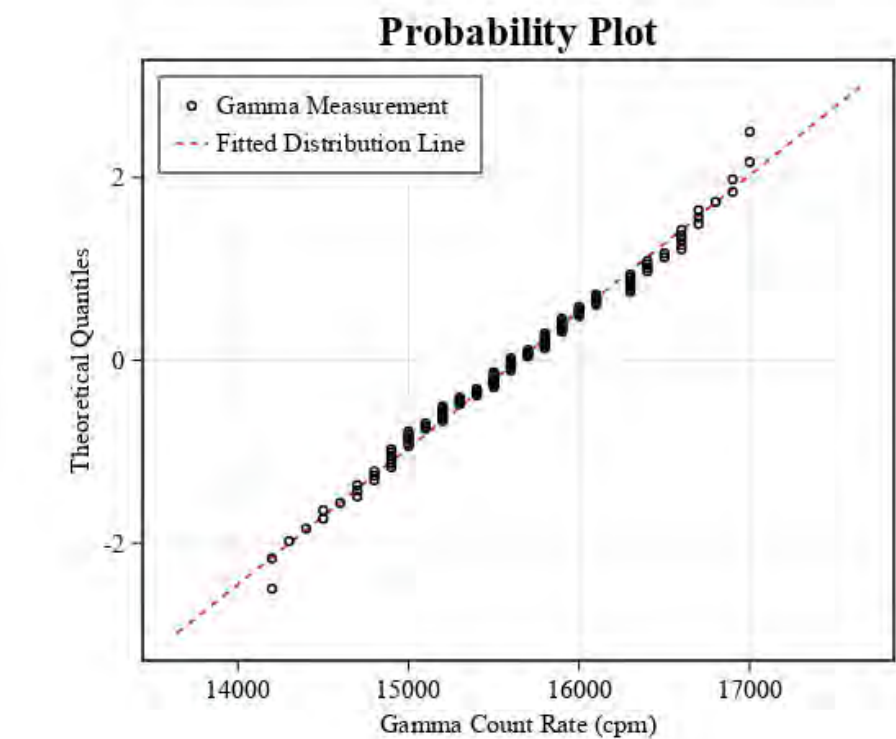
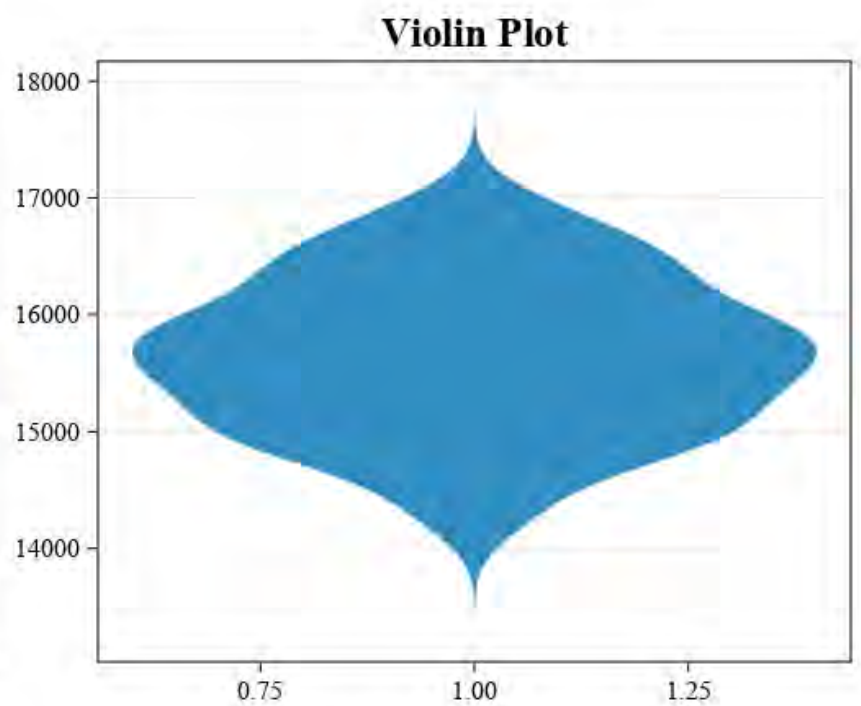
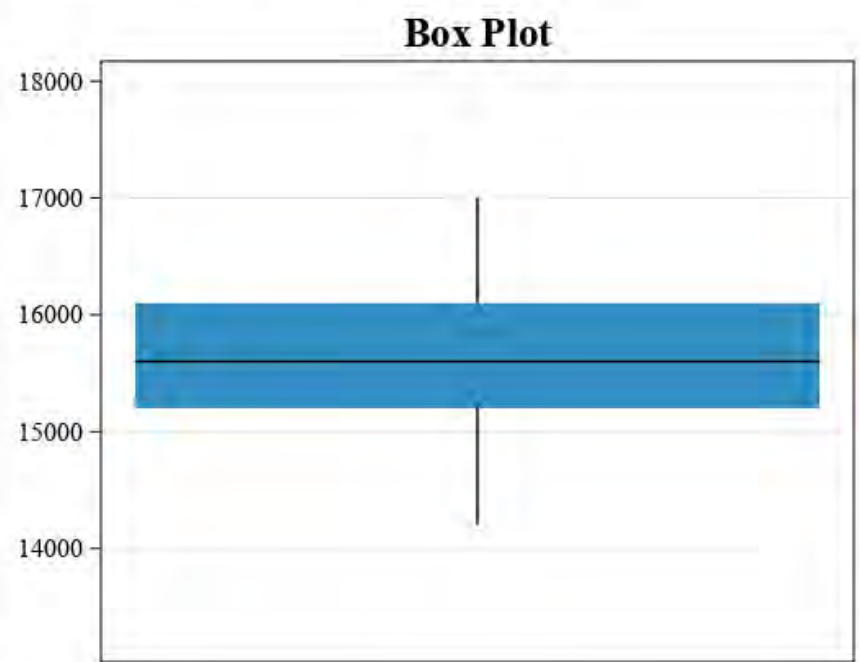
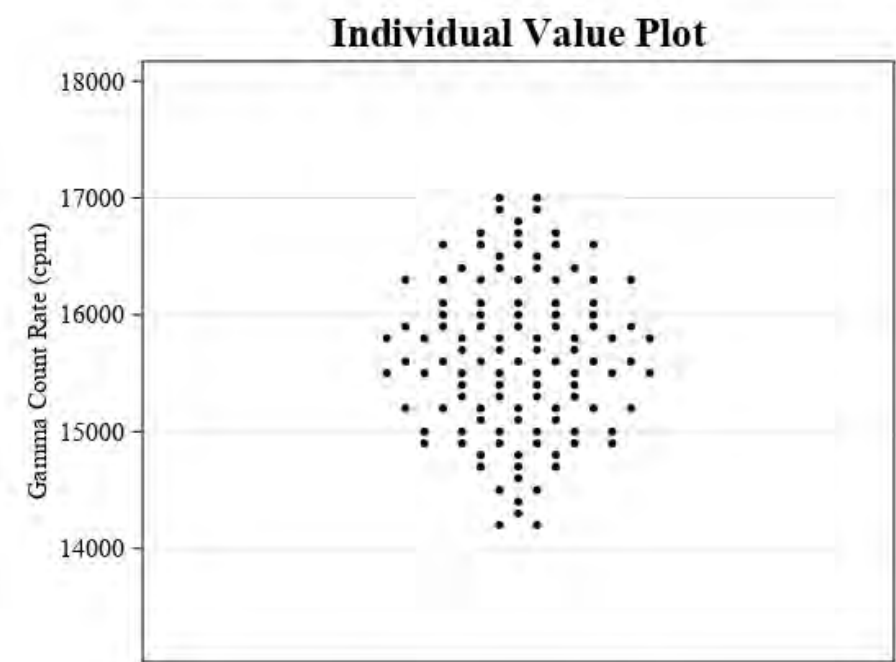


Summary Statistics

Count (n)	150
Minimum (cpm)	10,700
Maximum (cpm)	13,300
Average (cpm)	11,865
Median (cpm)	11,800
Standard Deviation (cpm)	474
Relative Standard Deviation	3.994%
RPD of Mean and Median	0.552%
90th Percentile (cpm)	12,600
95th Percentile (cpm)	12,700
99th Percentile (cpm)	13,100

Summary Statistics - Correlation Plots

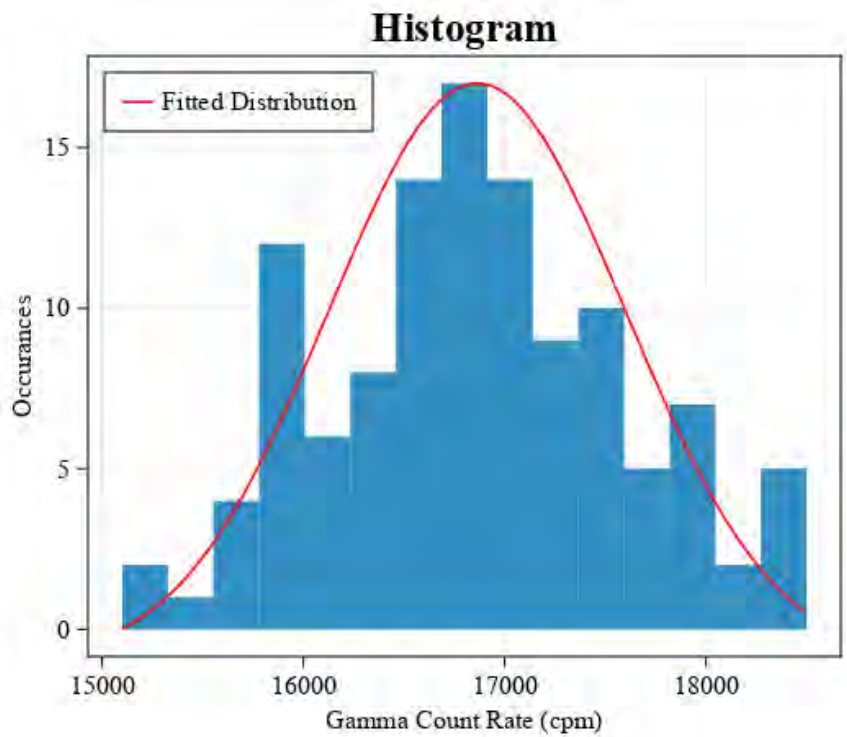
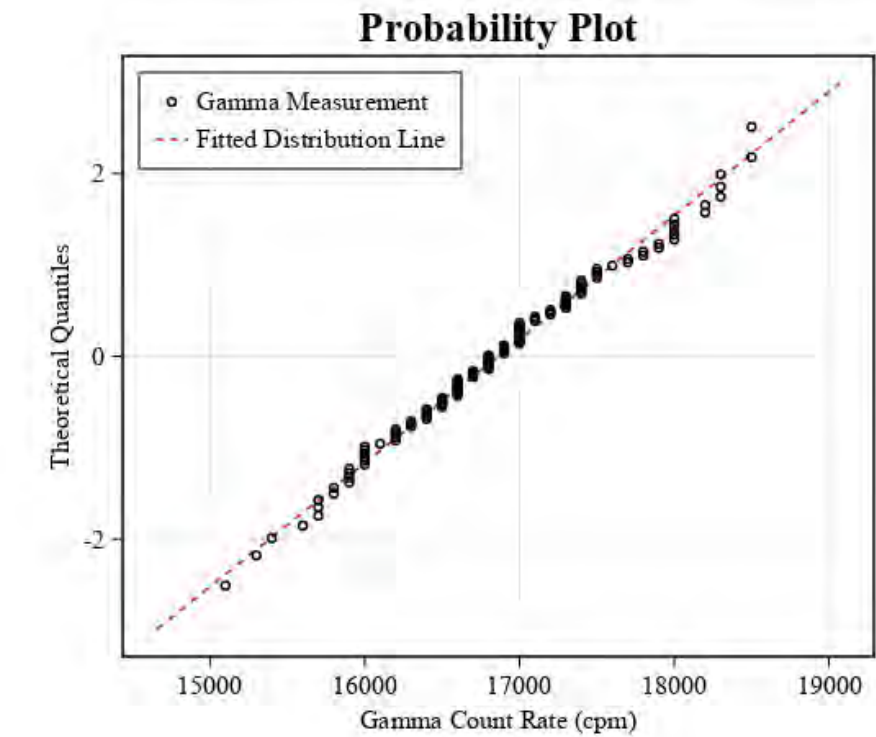
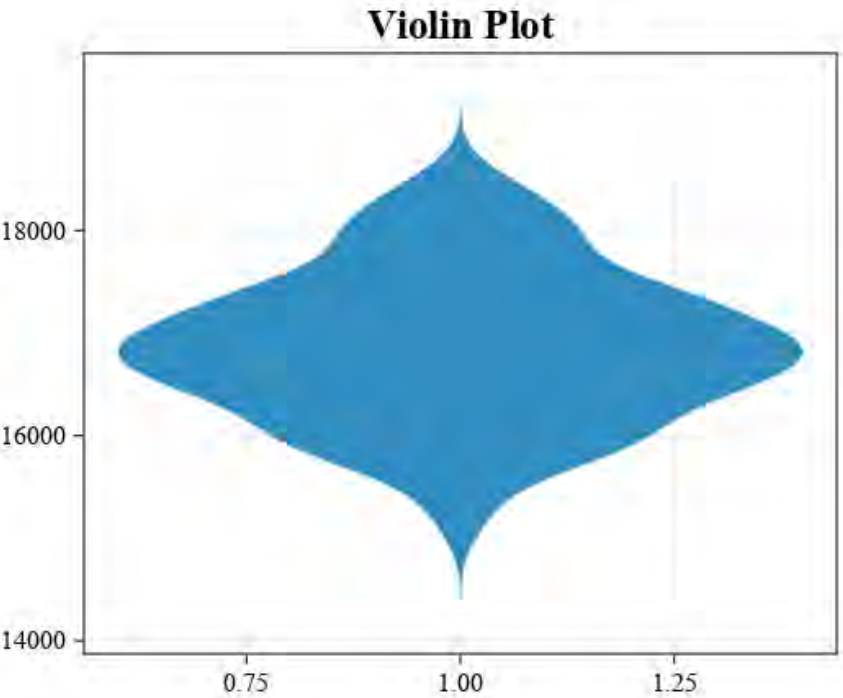
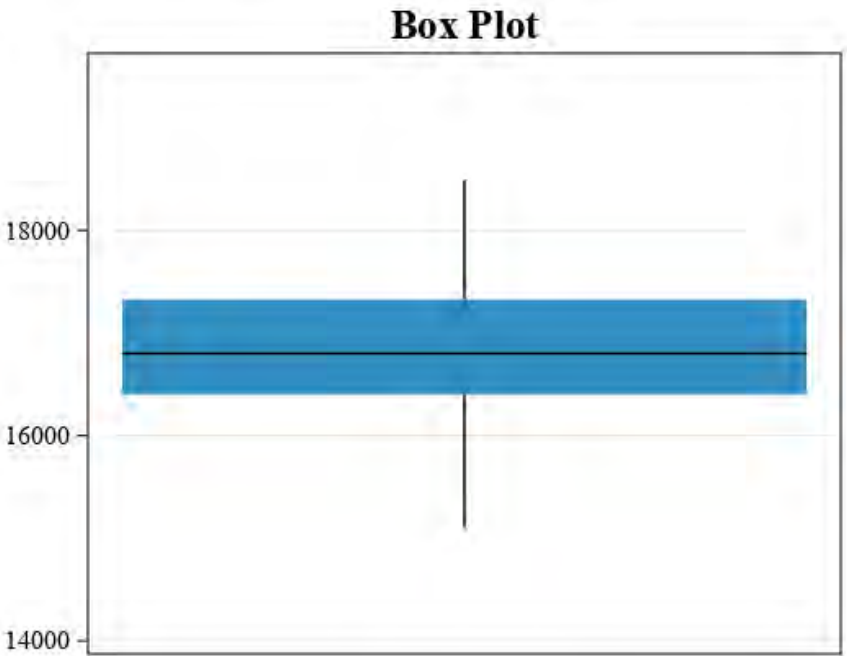
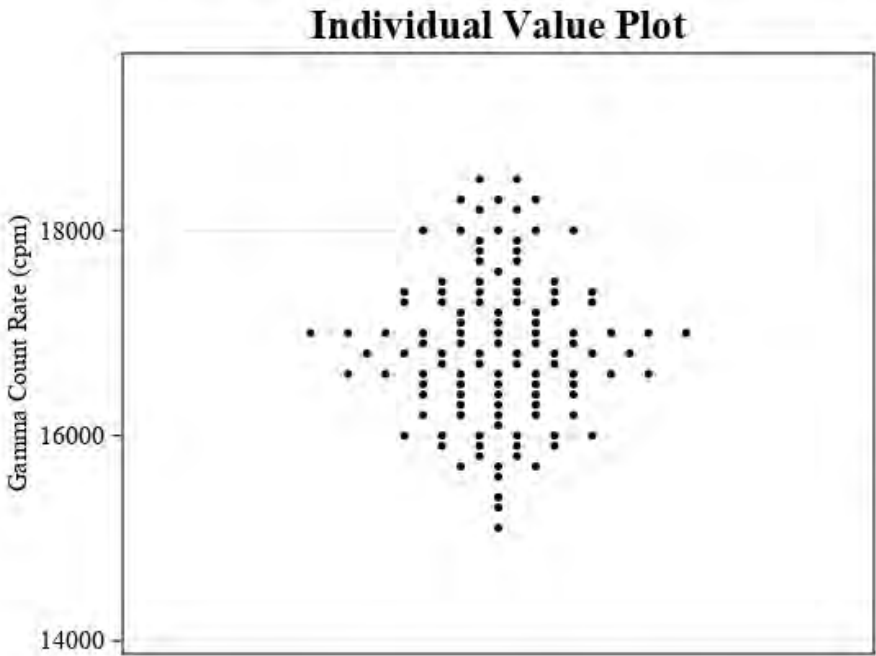
Site: OCRM Plot ID: CORR04 Type: Unshielded



Summary Statistics	
Count (n)	113
Minimum (cpm)	14,200
Maximum (cpm)	17,000
Average (cpm)	15,643
Median (cpm)	15,600
Standard Deviation (cpm)	669
Relative Standard Deviation	4.28%
RPD of Mean and Median	0.278%
90th Percentile (cpm)	16,600
95th Percentile (cpm)	16,700
99th Percentile (cpm)	17,000

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR05 Type: Unshielded

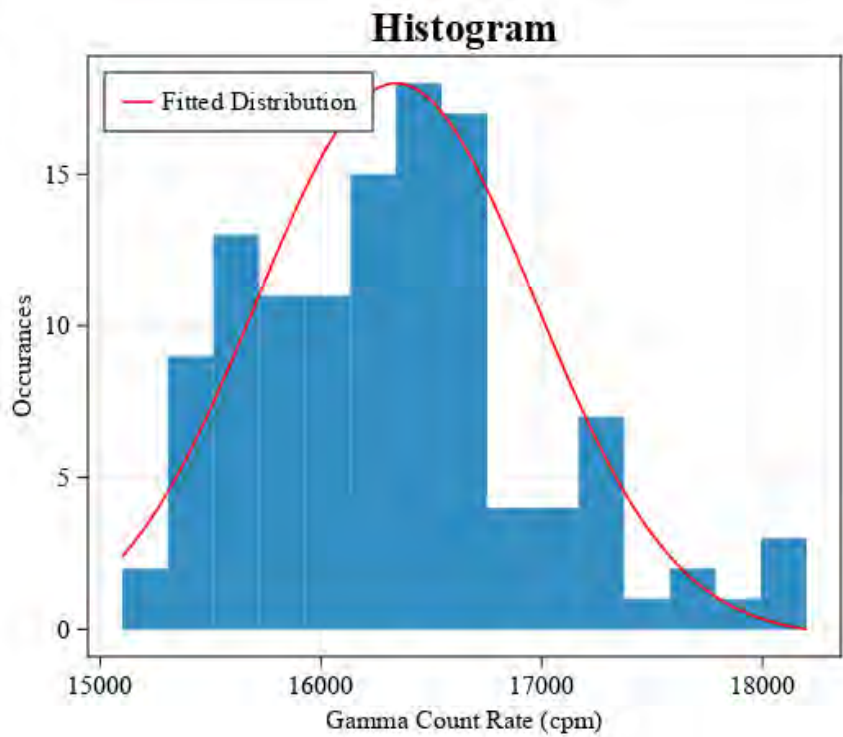
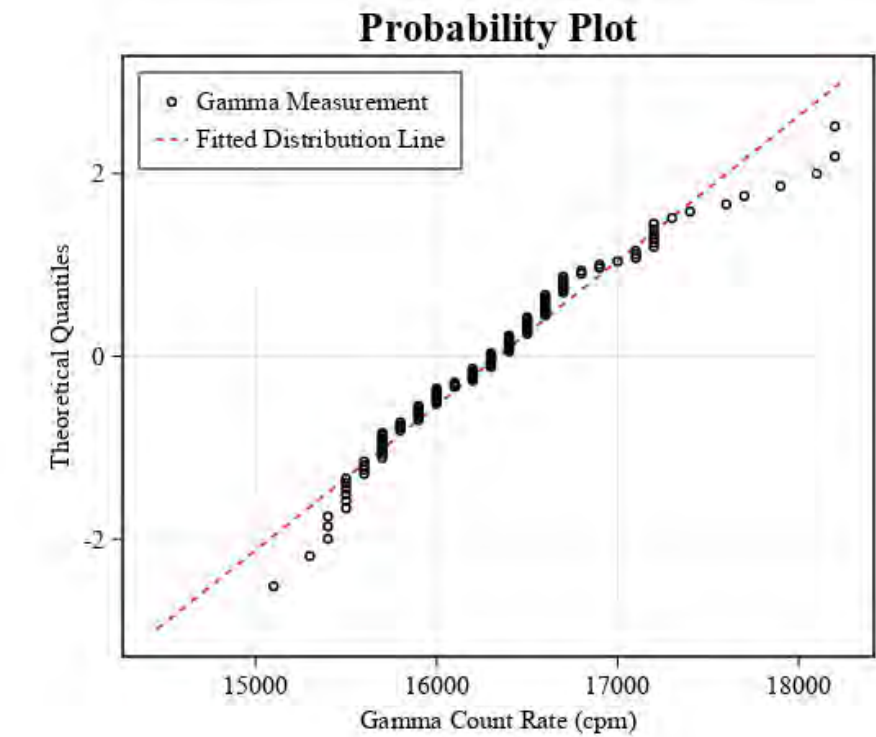
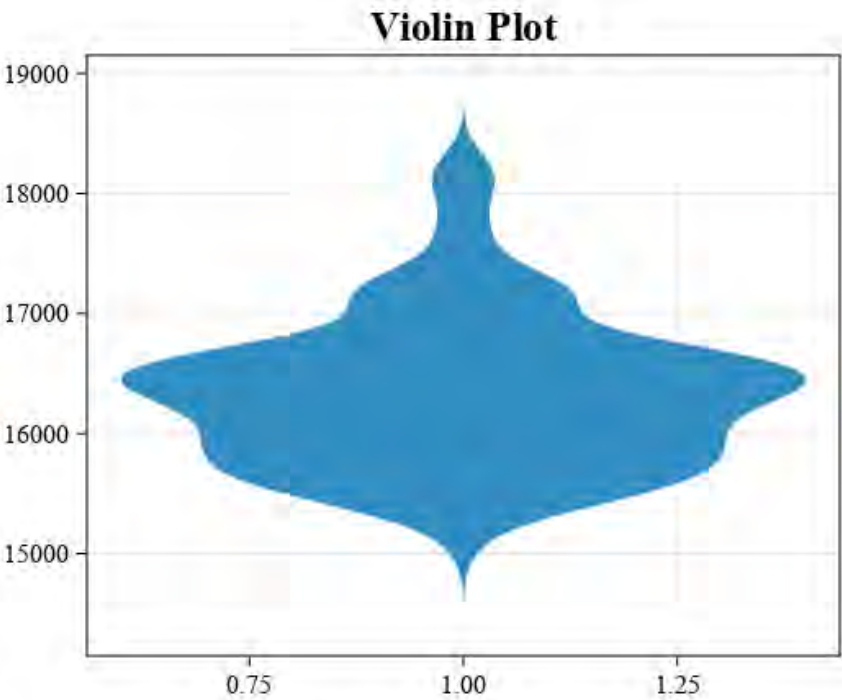
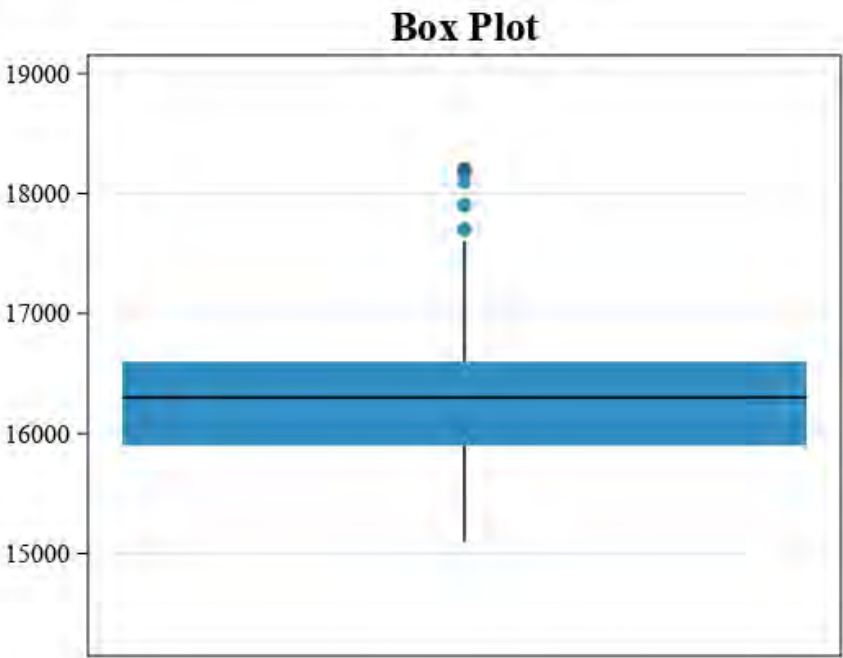
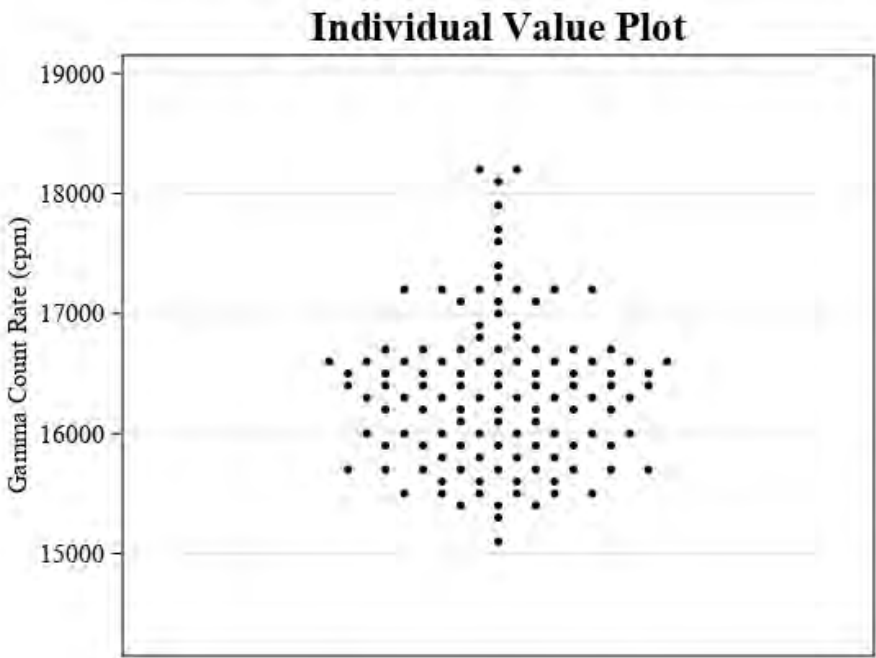


Summary Statistics

Count (n)	116
Minimum (cpm)	15,100
Maximum (cpm)	18,500
Average (cpm)	16,863
Median (cpm)	16,800
Standard Deviation (cpm)	738
Relative Standard Deviation	4.378%
RPD of Mean and Median	0.374%
90th Percentile (cpm)	18,000
95th Percentile (cpm)	18,200
99th Percentile (cpm)	18,500

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR06 Type: Unshielded

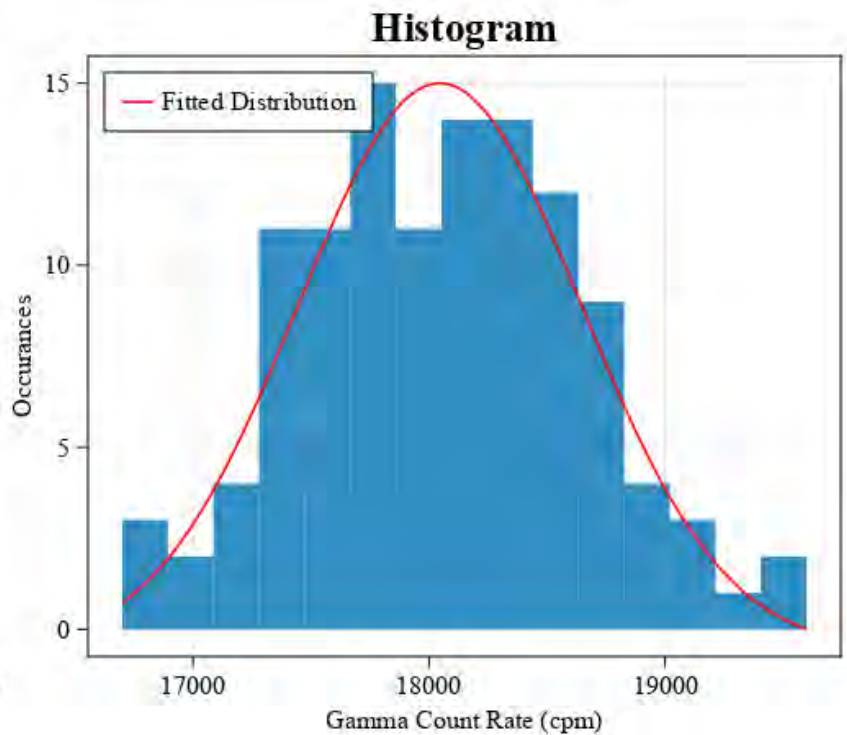
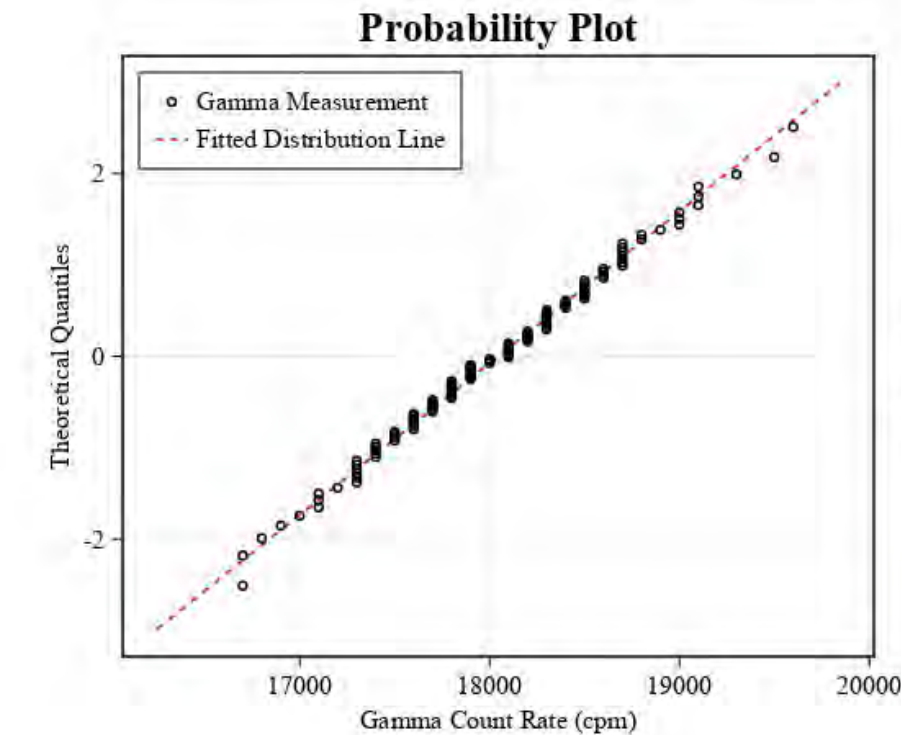
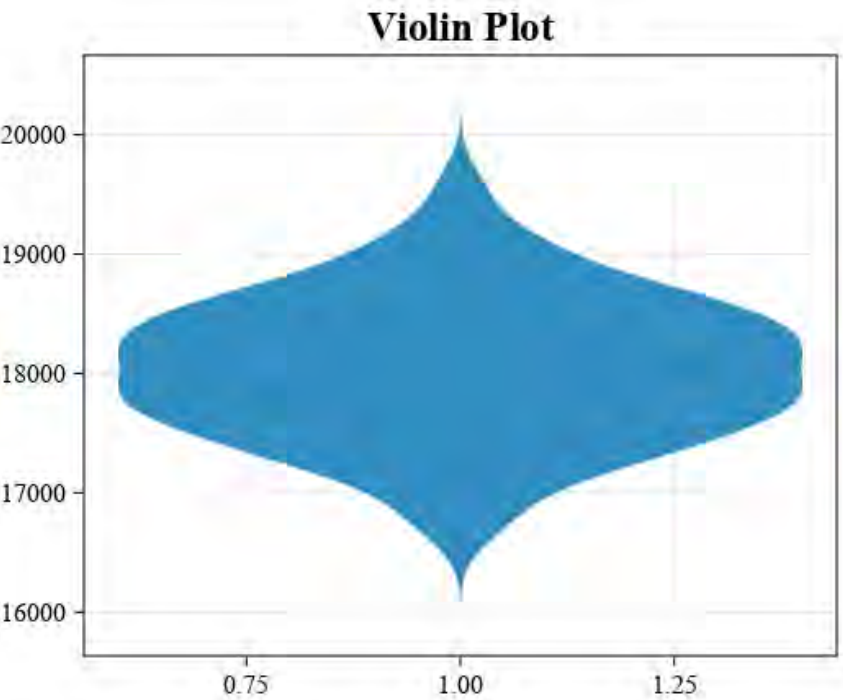
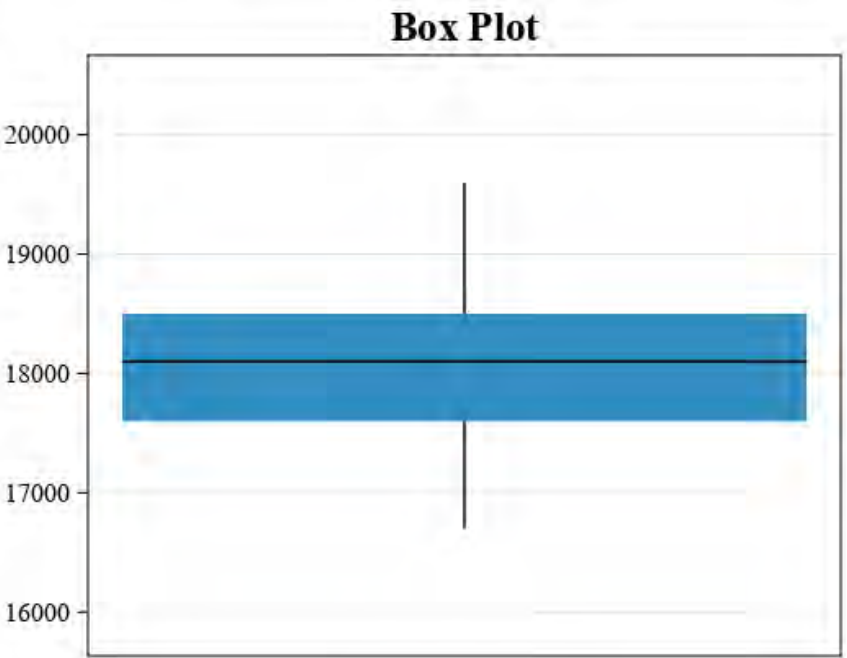
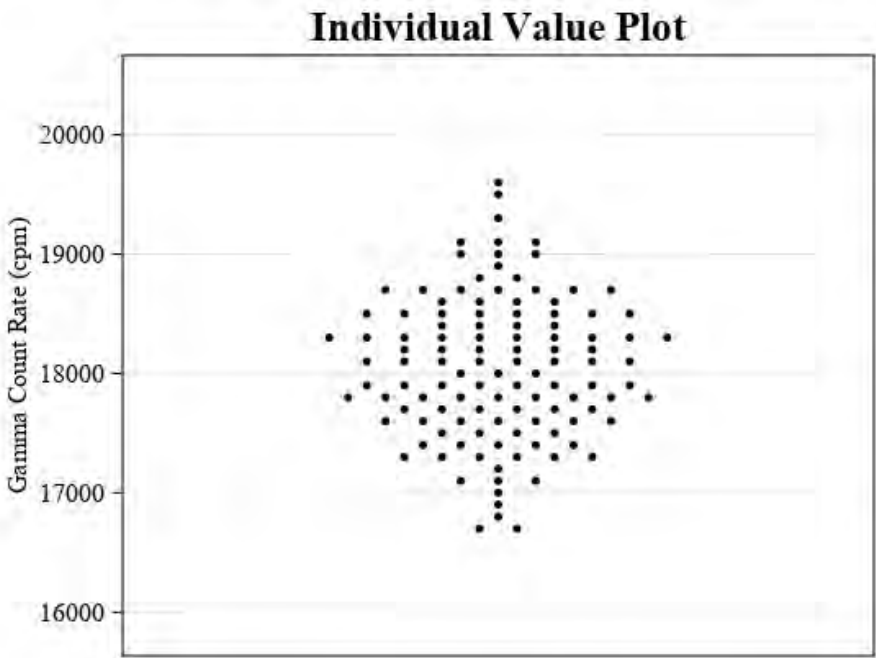


Summary Statistics

Count (n)	118
Minimum (cpm)	15,100
Maximum (cpm)	18,200
Average (cpm)	16,341
Median (cpm)	16,300
Standard Deviation (cpm)	631
Relative Standard Deviation	3.862%
RPD of Mean and Median	0.249%
90th Percentile (cpm)	17,200
95th Percentile (cpm)	17,600
99th Percentile (cpm)	18,200

Summary Statistics - Correlation Plots

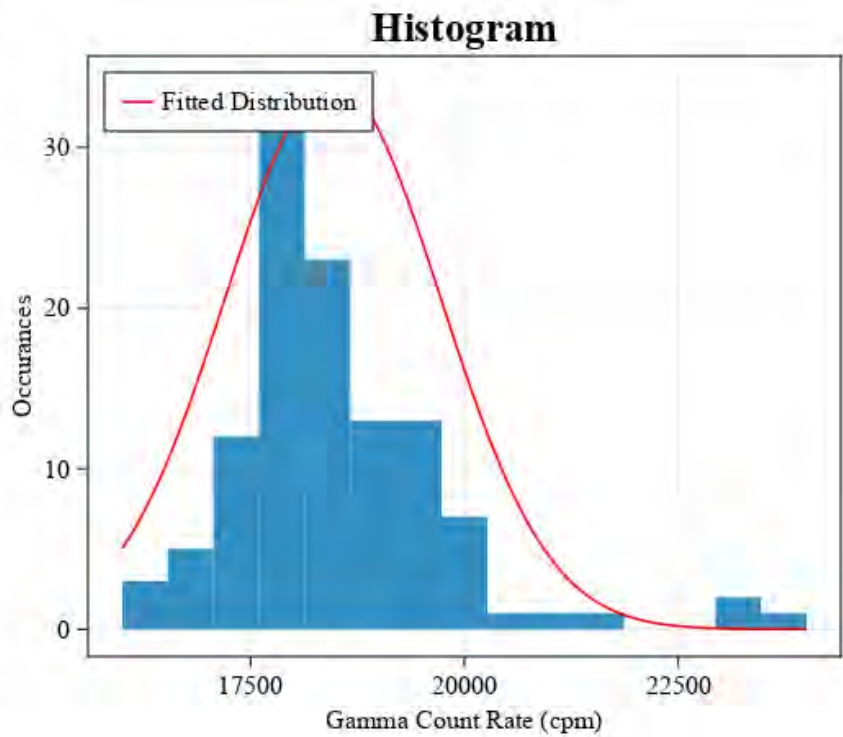
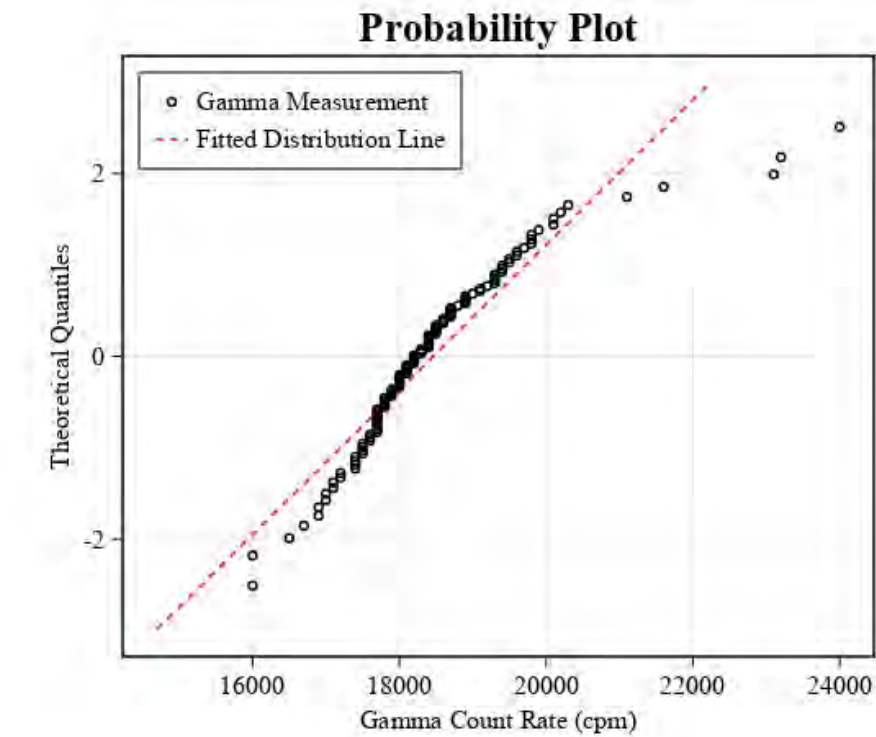
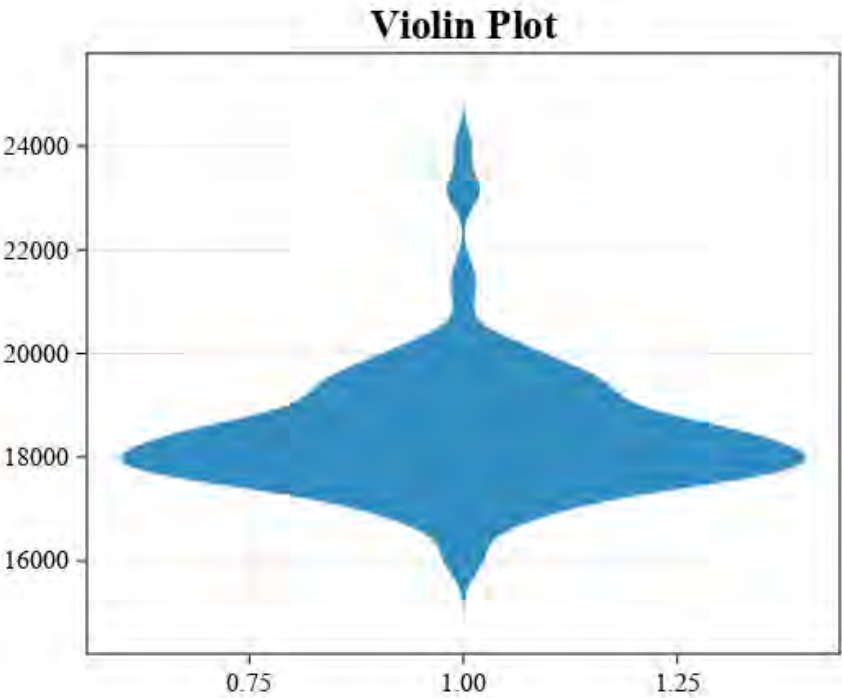
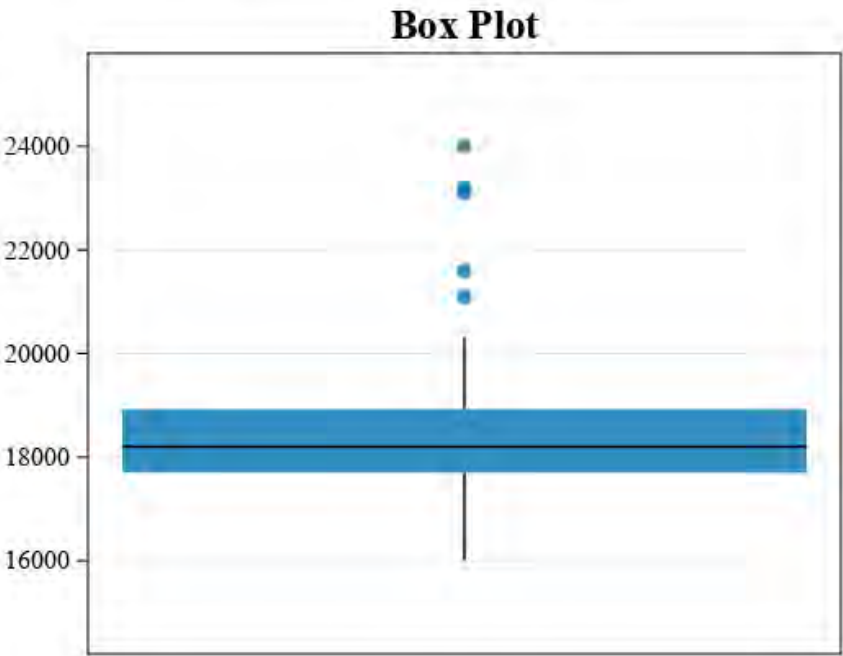
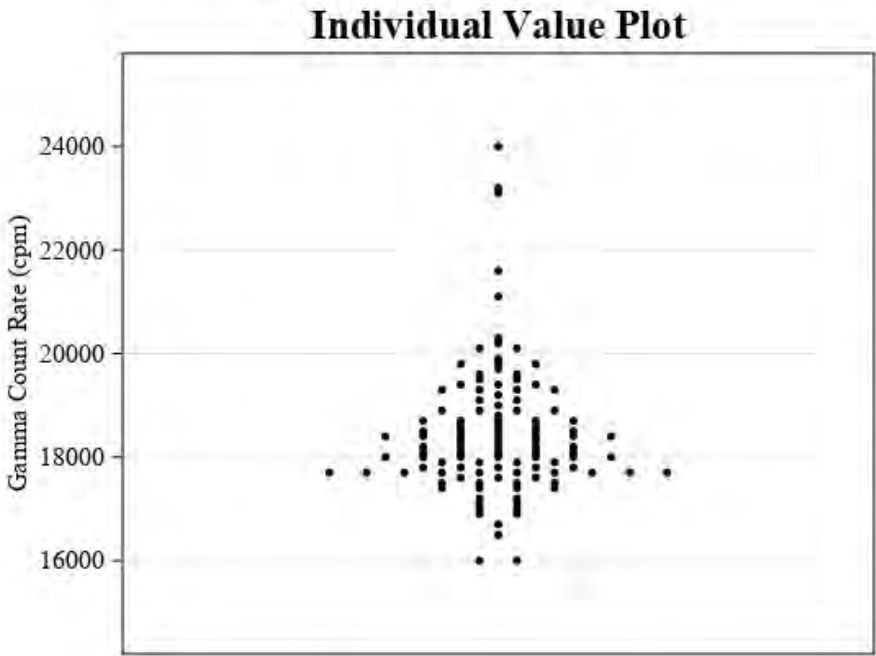
Site: OCRM Plot ID: CORR07 Type: Unshielded



Summary Statistics	
Count (n)	116
Minimum (cpm)	16,700
Maximum (cpm)	19,600
Average (cpm)	18,046
Median (cpm)	18,100
Standard Deviation (cpm)	602
Relative Standard Deviation	3.335%
RPD of Mean and Median	0.301%
90th Percentile (cpm)	18,800
95th Percentile (cpm)	19,100
99th Percentile (cpm)	19,500

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR08 Type: Unshielded

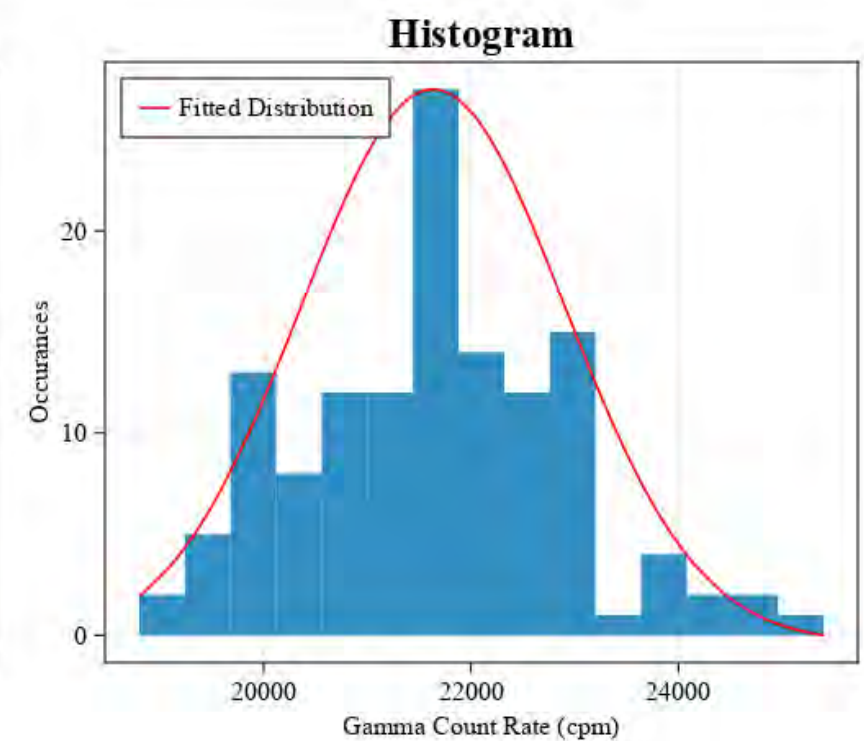
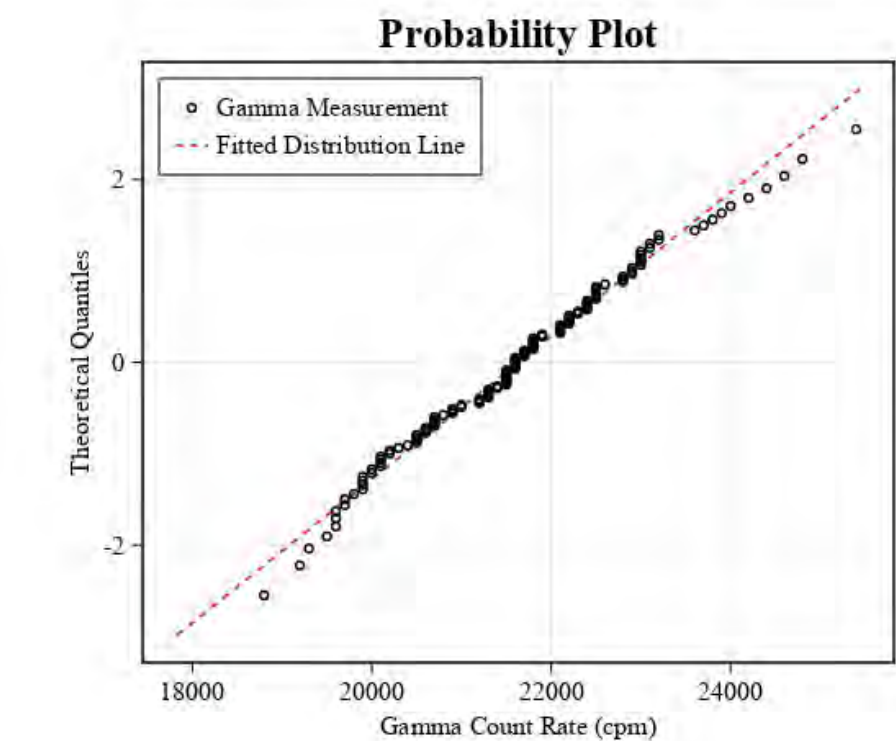
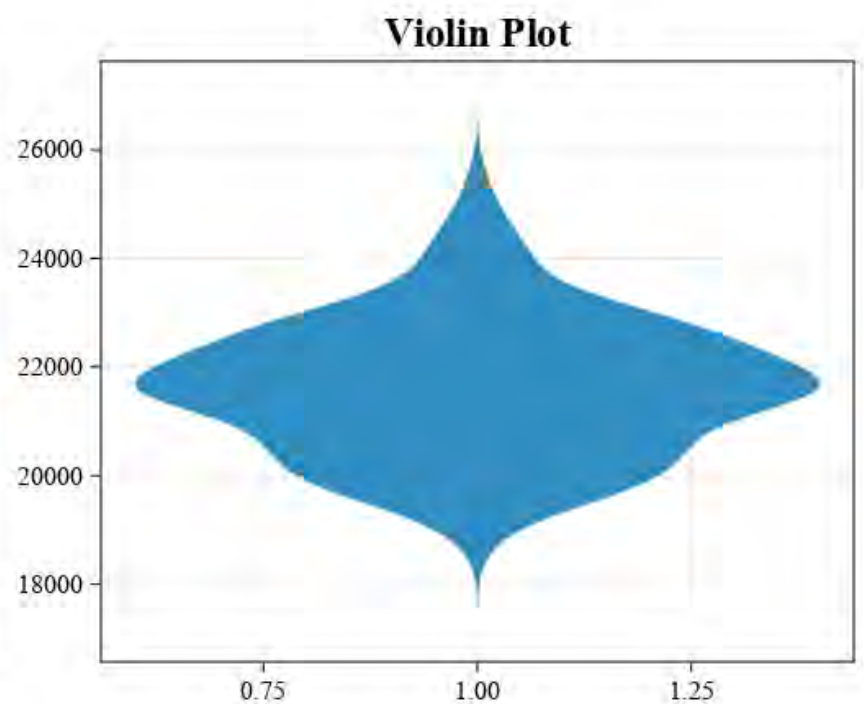
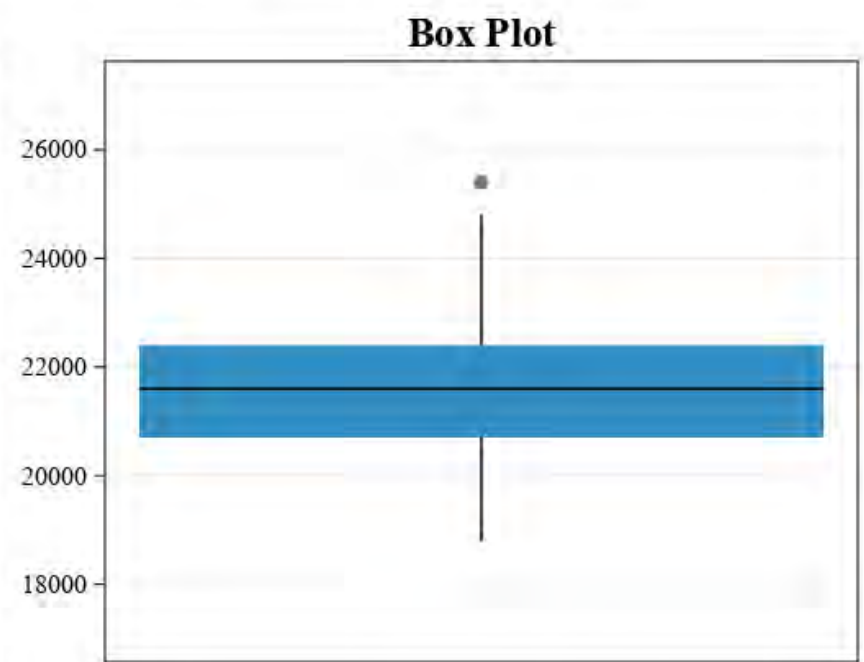
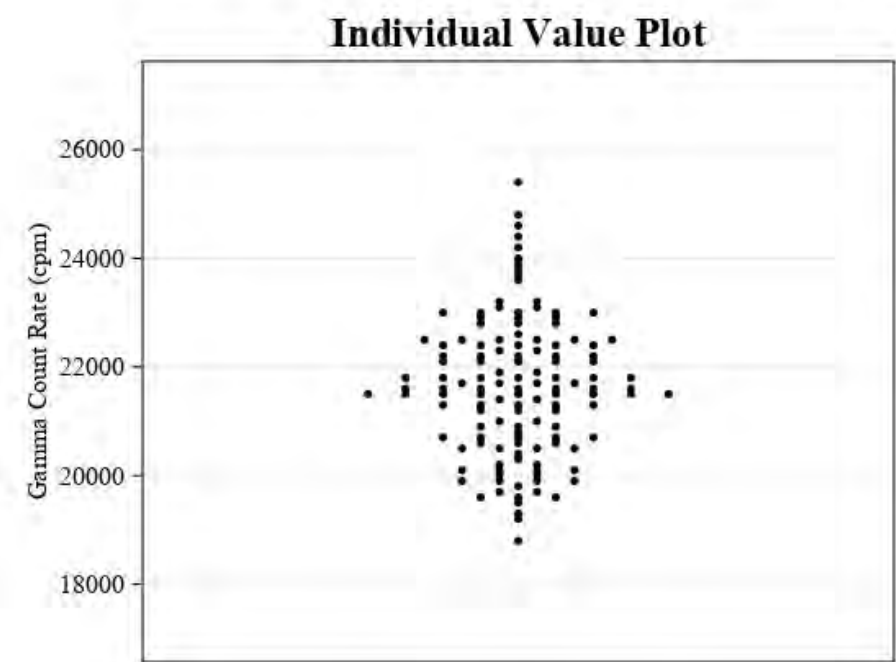


Summary Statistics

Count (n)	116
Minimum (cpm)	16,000
Maximum (cpm)	24,000
Average (cpm)	18,463
Median (cpm)	18,200
Standard Deviation (cpm)	1,260
Relative Standard Deviation	6.826%
RPD of Mean and Median	1.434%
90th Percentile (cpm)	19,800
95th Percentile (cpm)	20,300
99th Percentile (cpm)	23,200

Summary Statistics - Correlation Plots

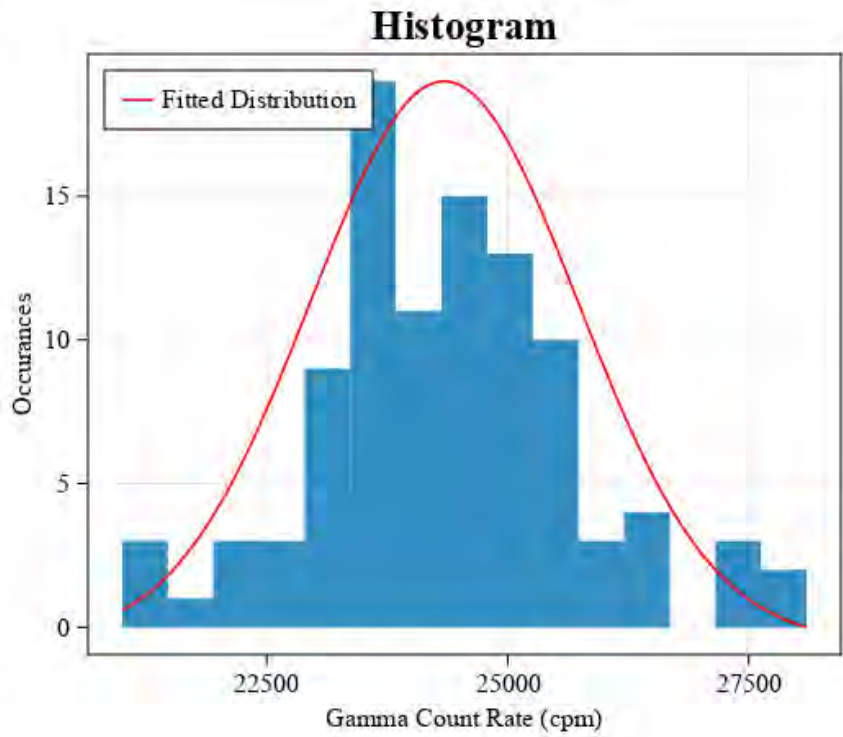
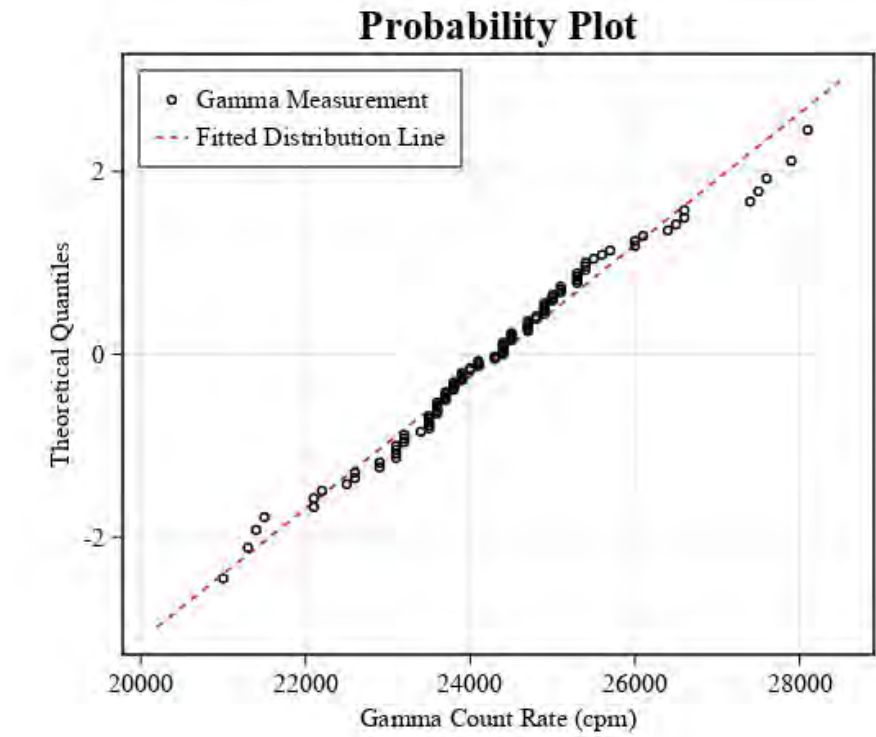
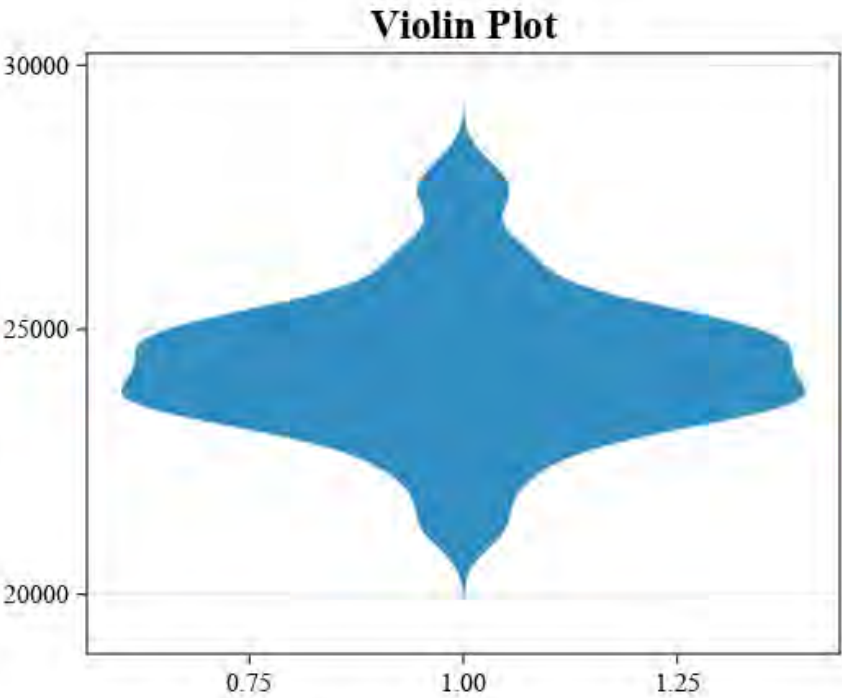
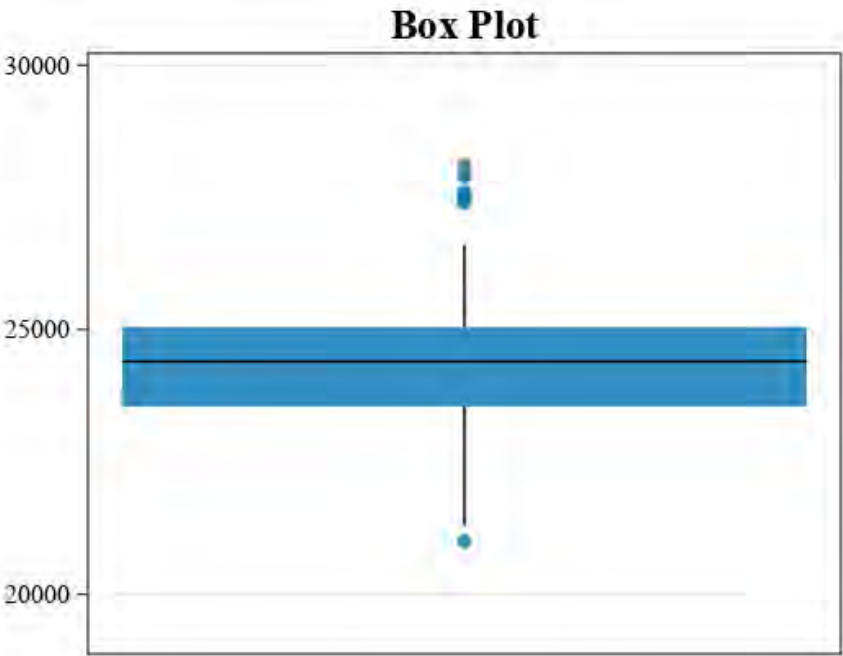
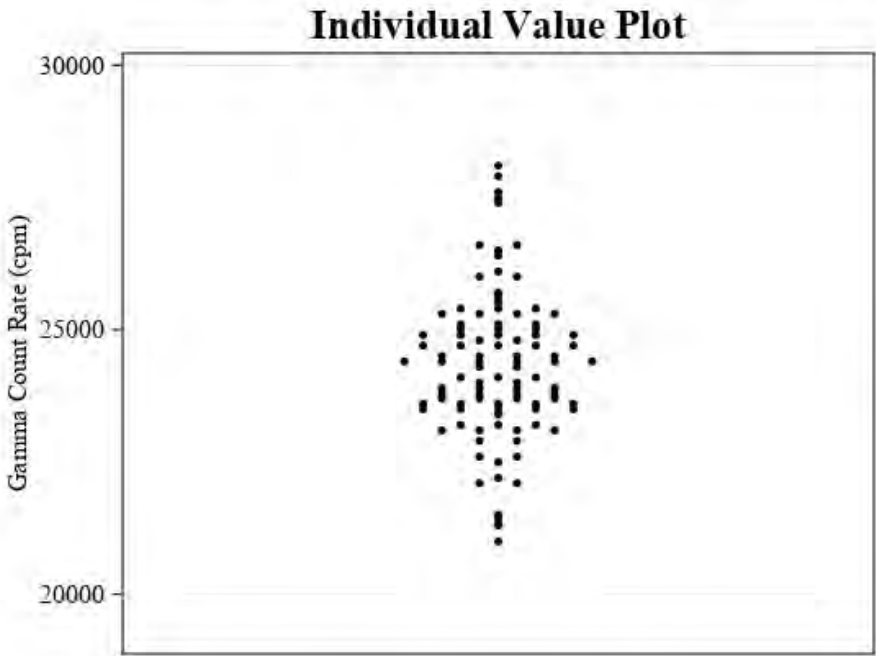
Site: OCRM Plot ID: CORR09 Type: Unshielded



Summary Statistics	
Count (n)	130
Minimum (cpm)	18,800
Maximum (cpm)	25,400
Average (cpm)	21,633
Median (cpm)	21,600
Standard Deviation (cpm)	1,273
Relative Standard Deviation	5.886%
RPD of Mean and Median	0.153%
90th Percentile (cpm)	23,100
95th Percentile (cpm)	23,900
99th Percentile (cpm)	24,800

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR10 Type: Unshielded

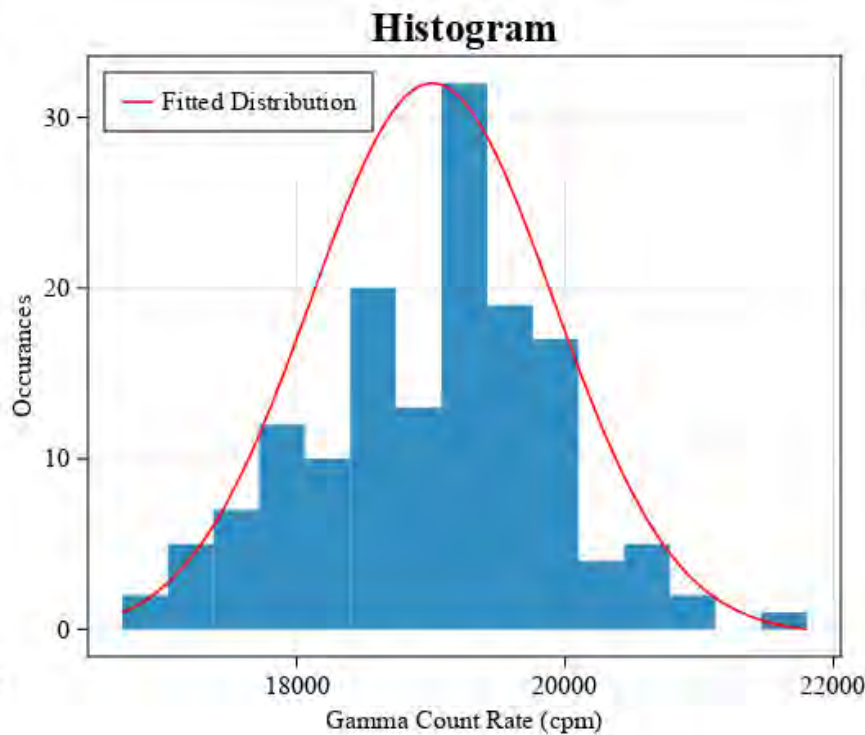
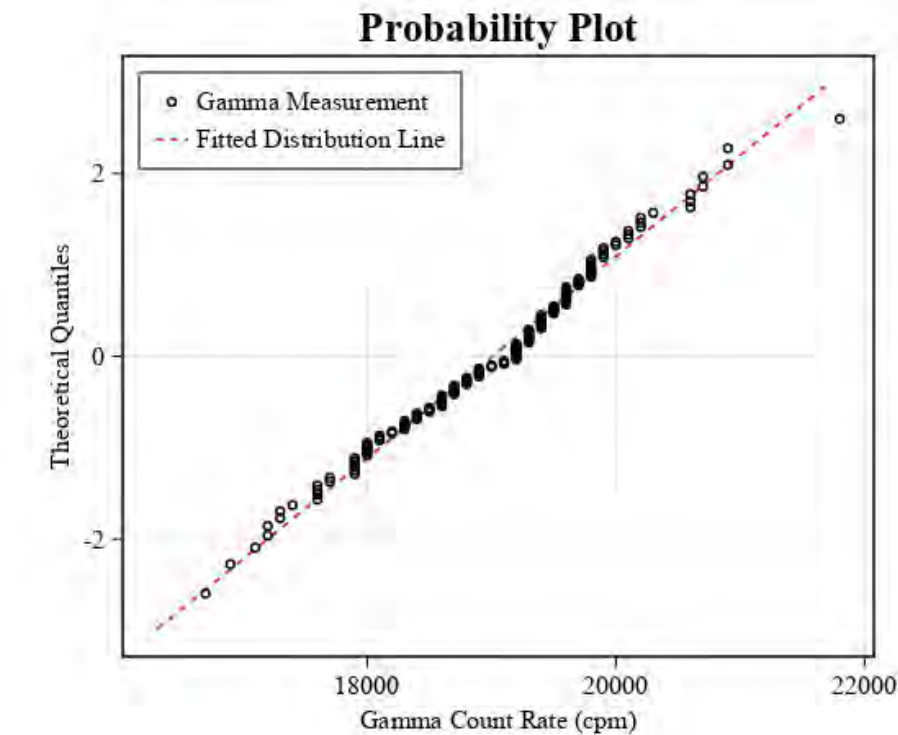
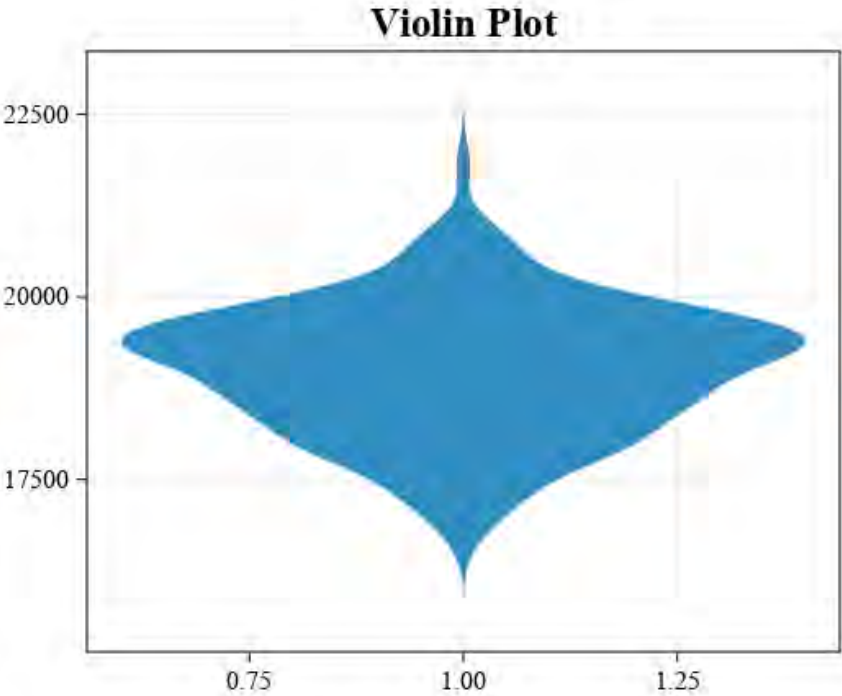
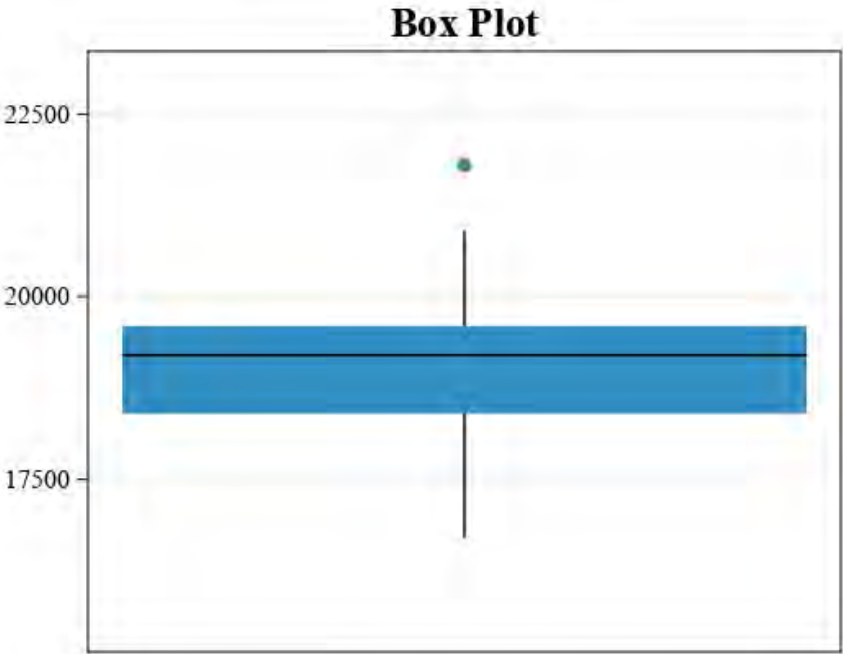
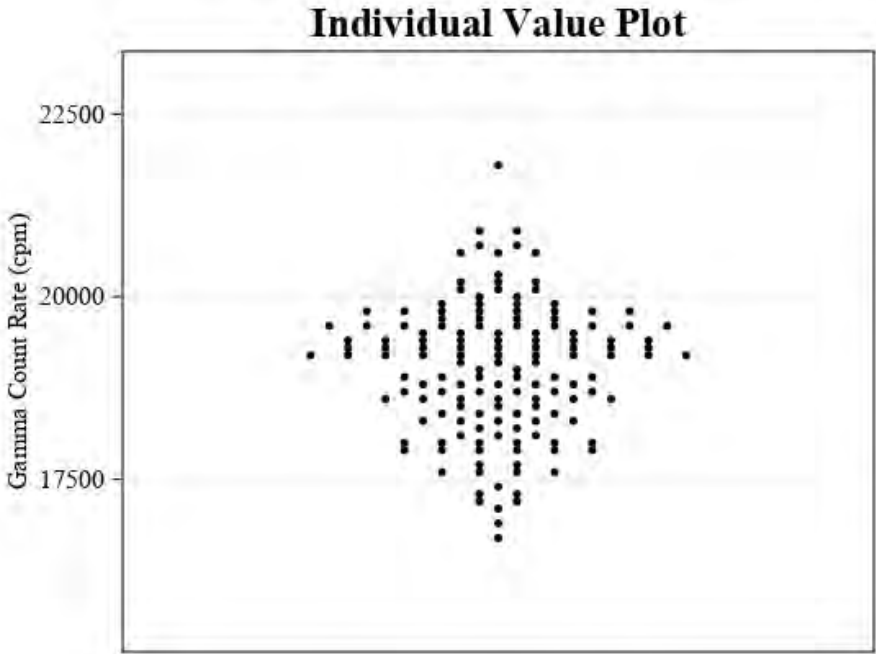


Summary Statistics

Count (n)	99
Minimum (cpm)	21,000
Maximum (cpm)	28,100
Average (cpm)	24,340
Median (cpm)	24,400
Standard Deviation (cpm)	1,387
Relative Standard Deviation	5.7%
RPD of Mean and Median	0.245%
90th Percentile (cpm)	26,100
95th Percentile (cpm)	27,400
99th Percentile (cpm)	28,100

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR11 Type: Unshielded

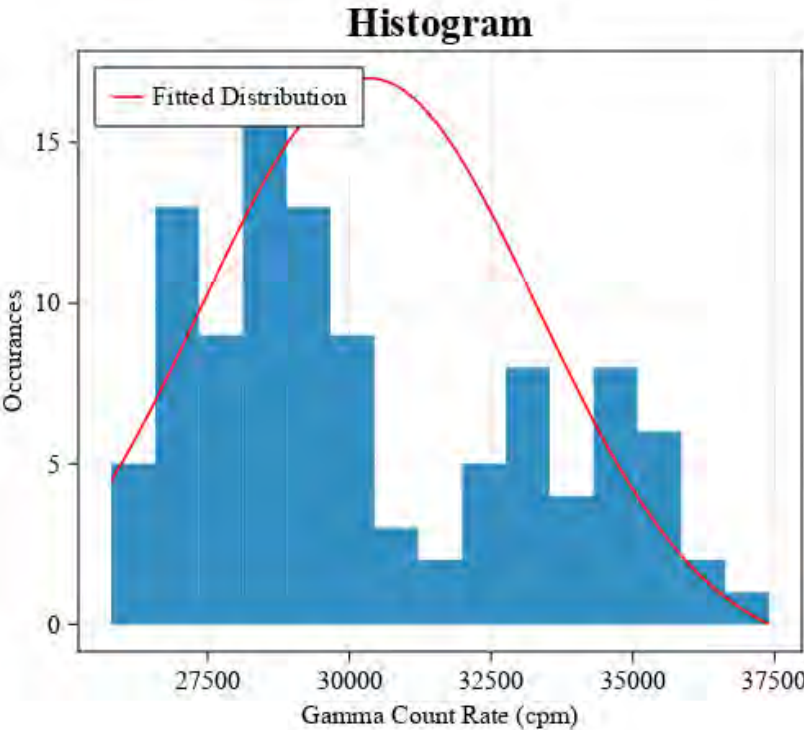
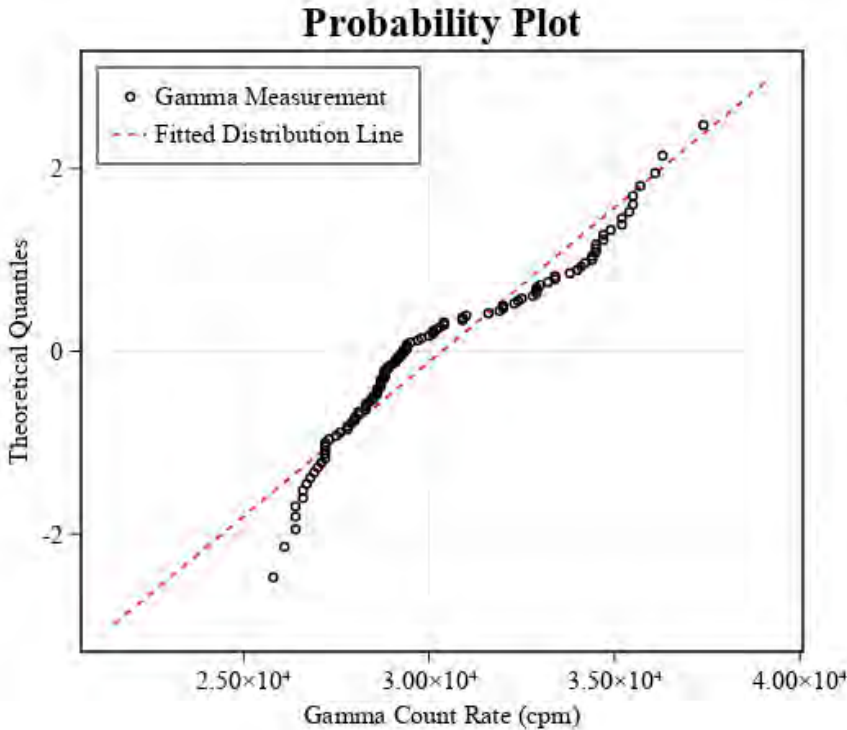
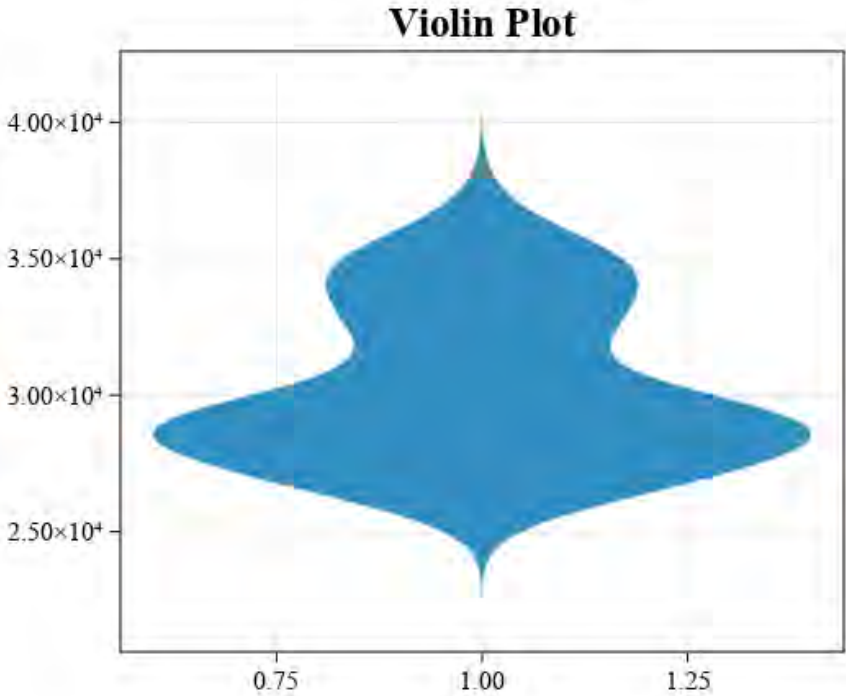
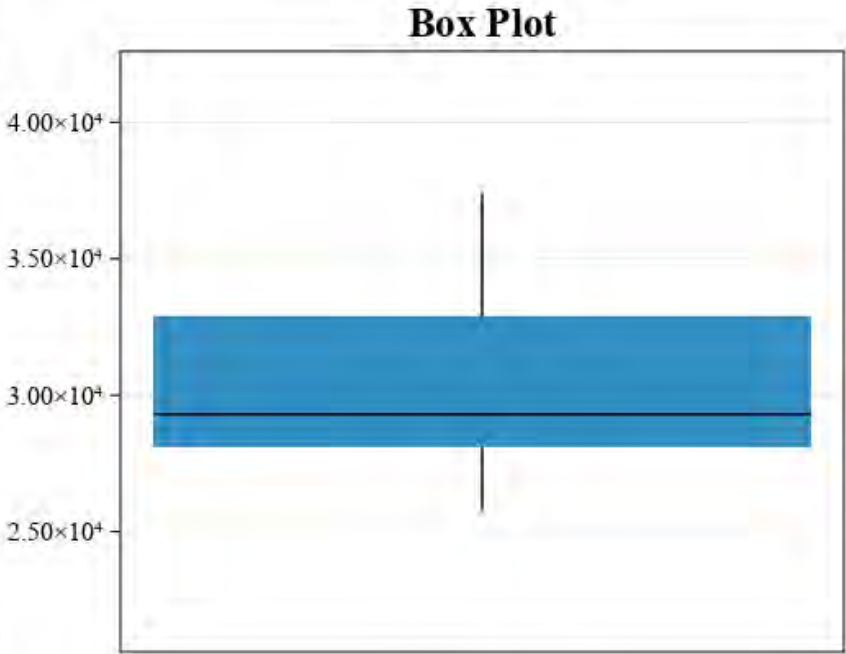
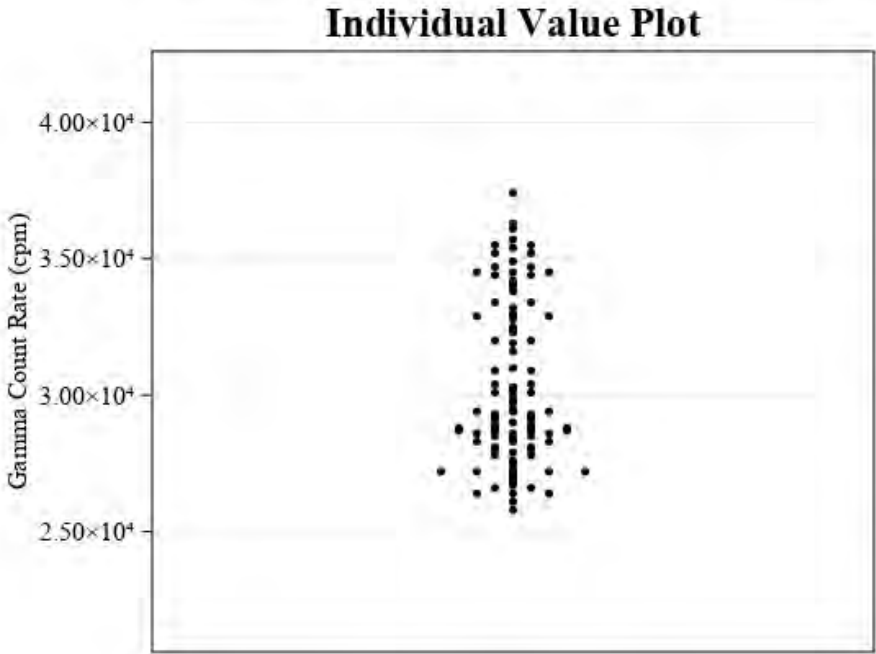


Summary Statistics

Count (n)	149
Minimum (cpm)	16,700
Maximum (cpm)	21,800
Average (cpm)	19,010
Median (cpm)	19,200
Standard Deviation (cpm)	904
Relative Standard Deviation	4.755%
RPD of Mean and Median	0.994%
90th Percentile (cpm)	20,100
95th Percentile (cpm)	20,600
99th Percentile (cpm)	20,900

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR12 Type: Unshielded

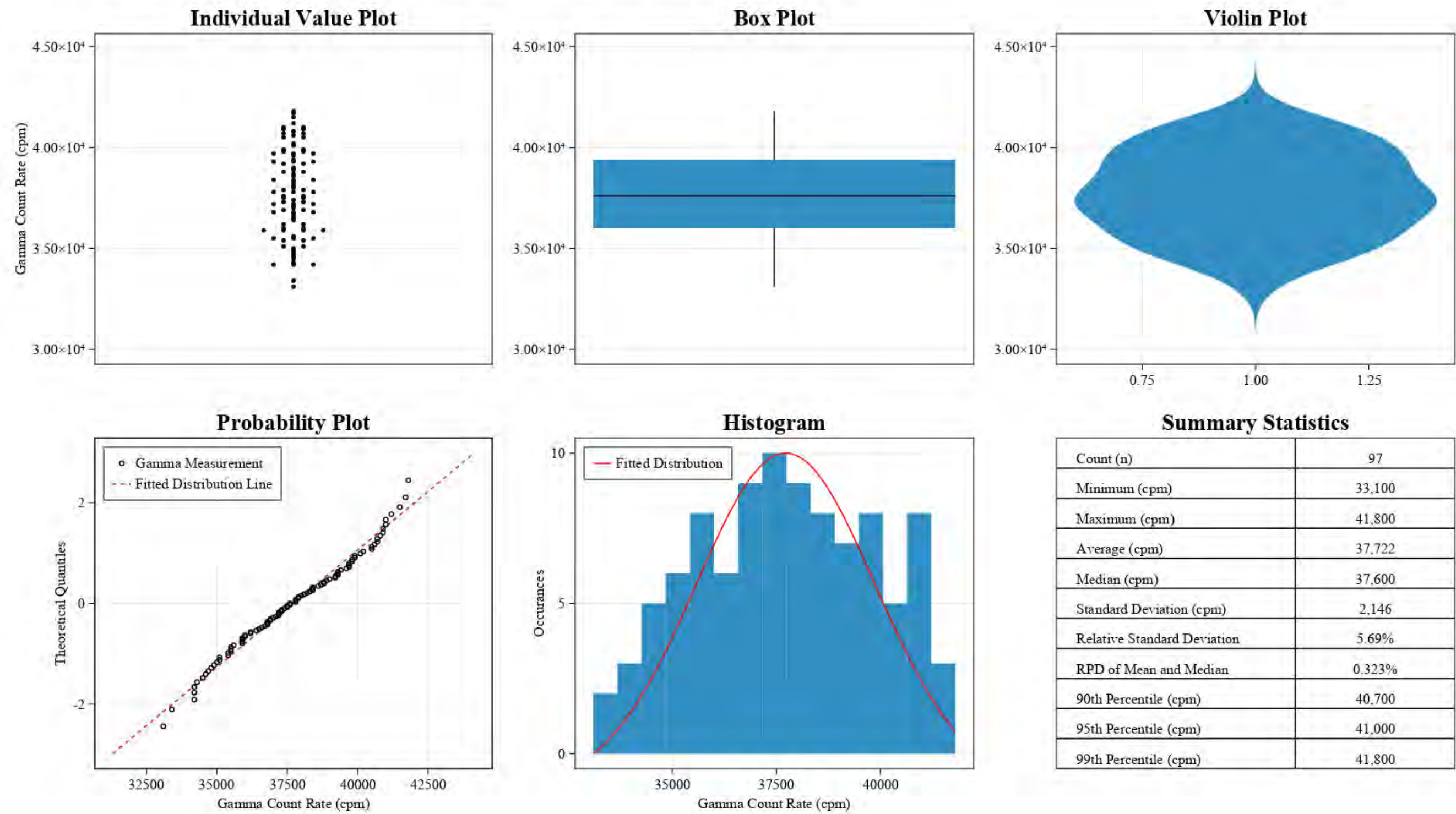


Summary Statistics

Count (n)	105
Minimum (cpm)	25,800
Maximum (cpm)	37,400
Average (cpm)	30,350
Median (cpm)	29,300
Standard Deviation (cpm)	2,960
Relative Standard Deviation	9.754%
RPD of Mean and Median	3.519%
90th Percentile (cpm)	34,700
95th Percentile (cpm)	35,500
99th Percentile (cpm)	36,300

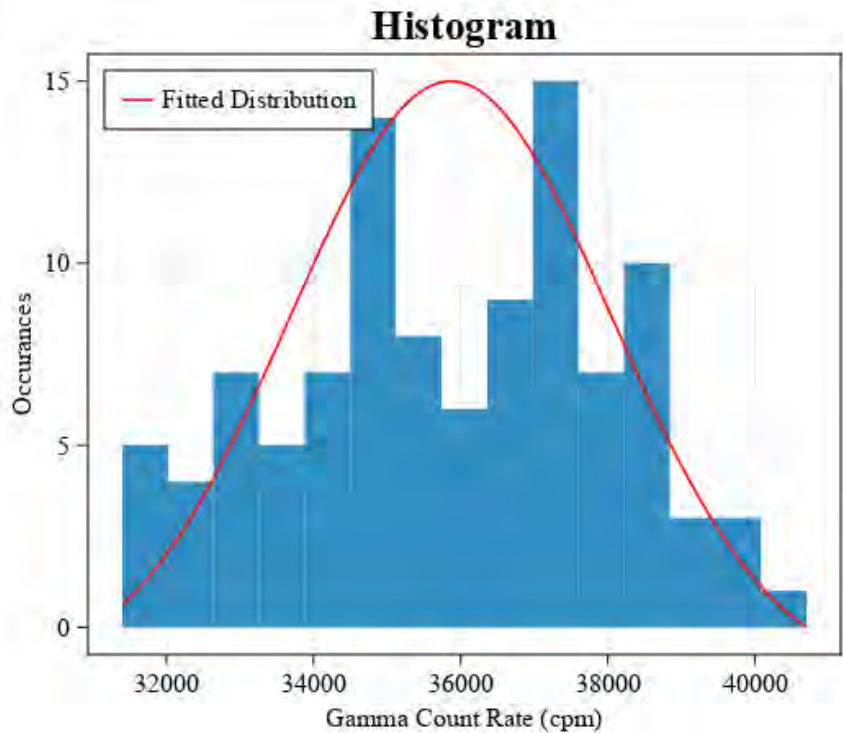
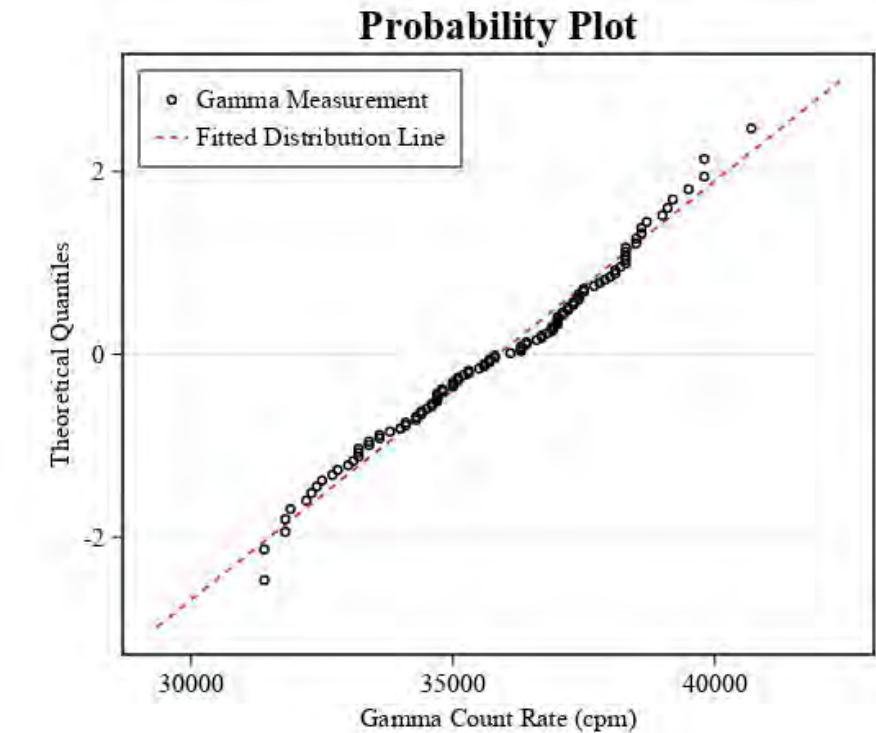
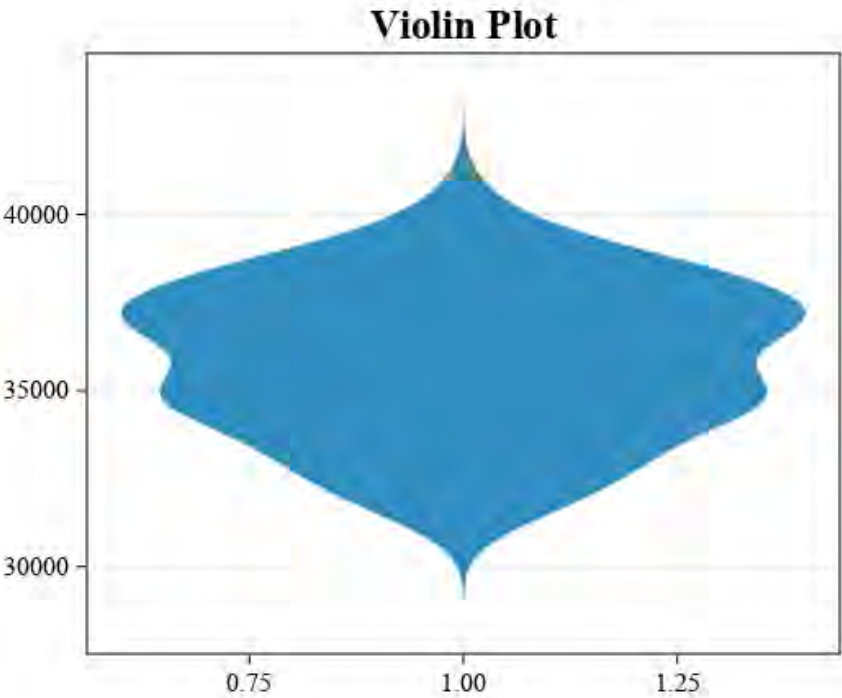
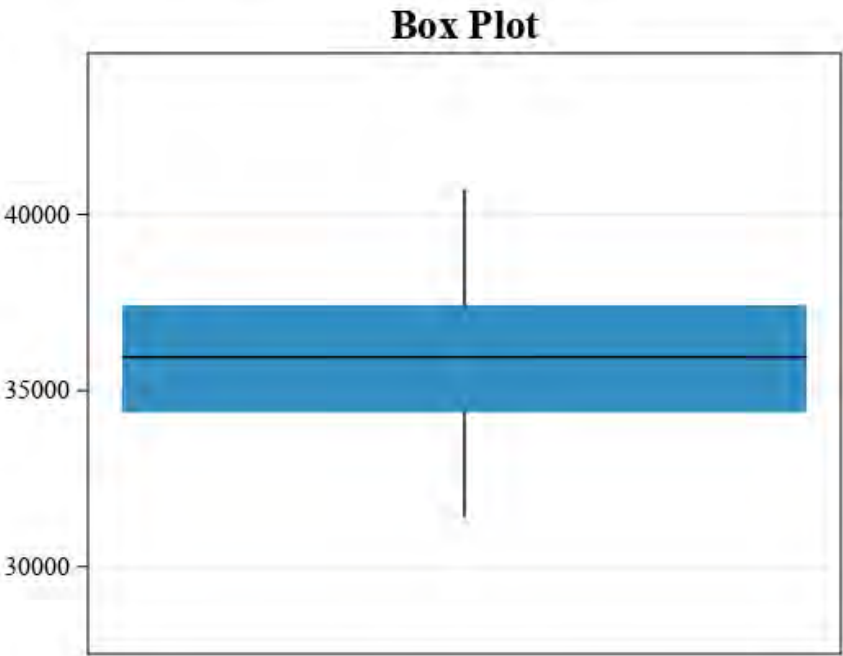
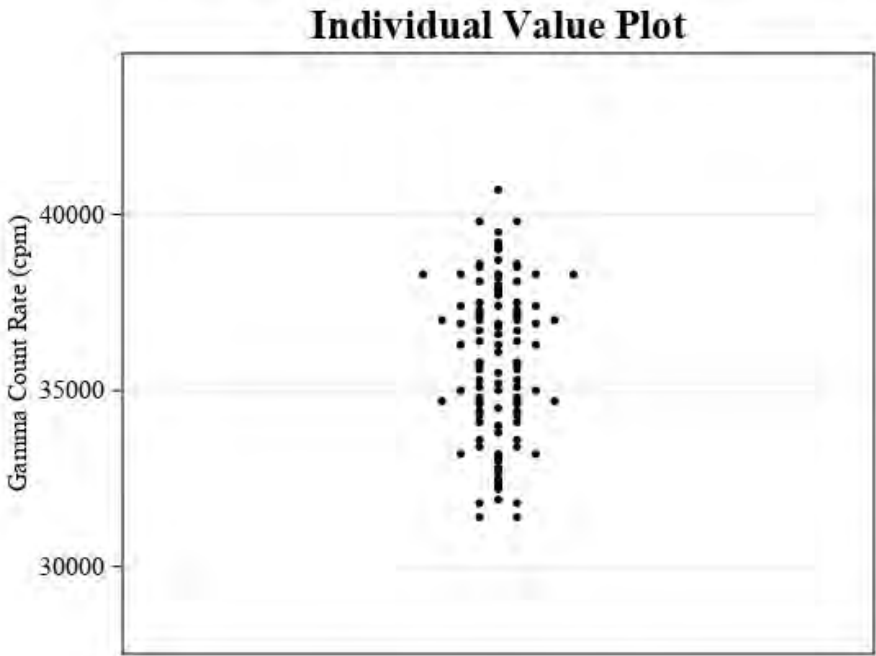
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR13 Type: Unshielded



Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR14 Type: Unshielded

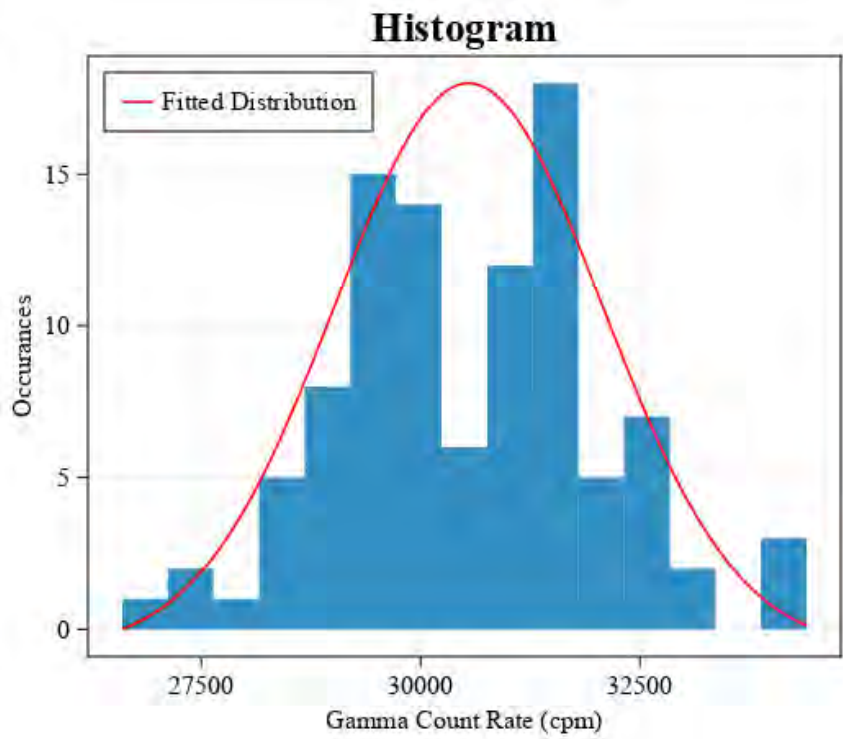
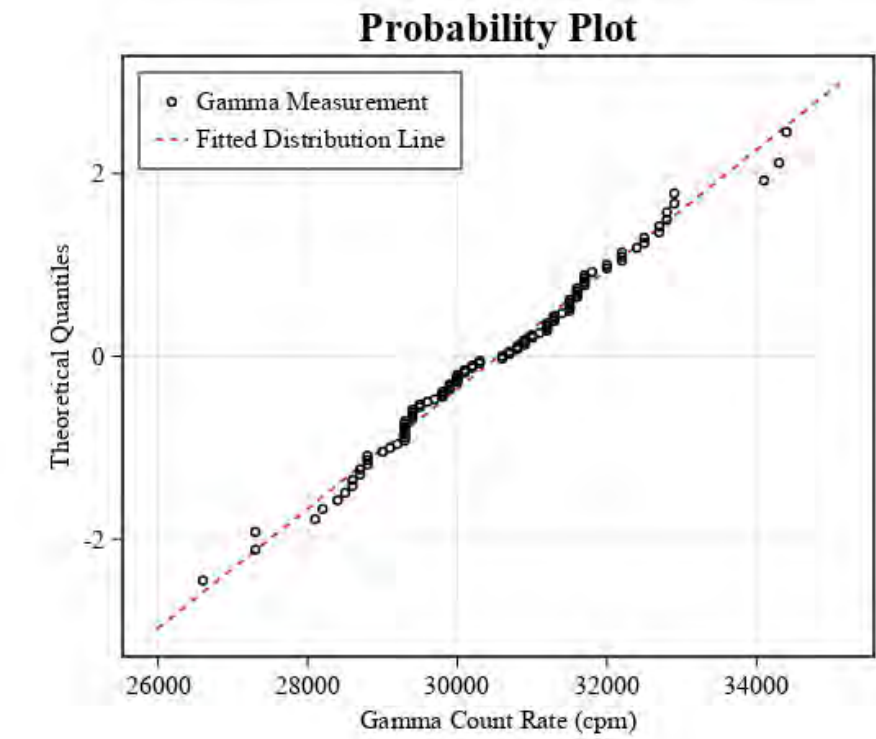
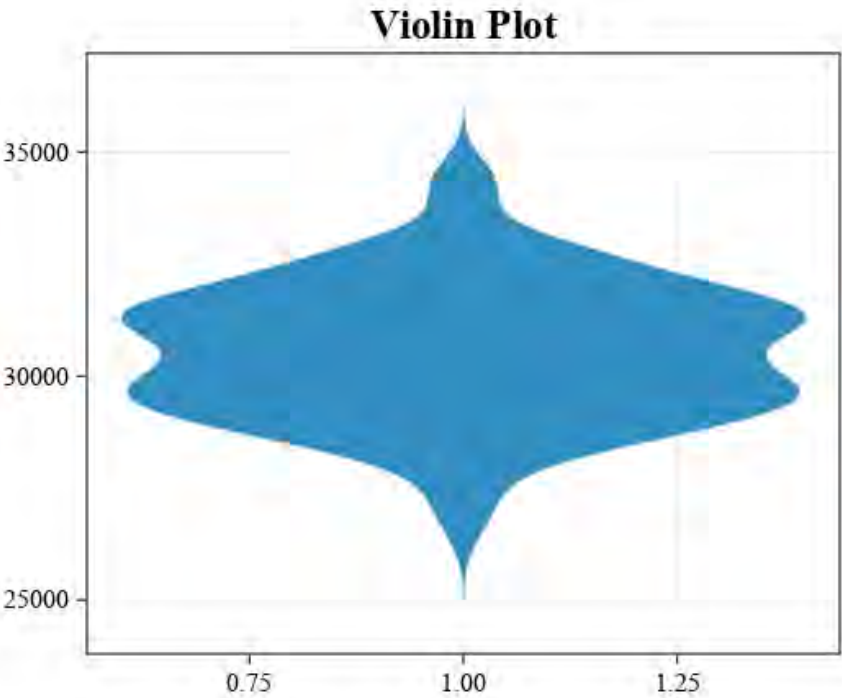
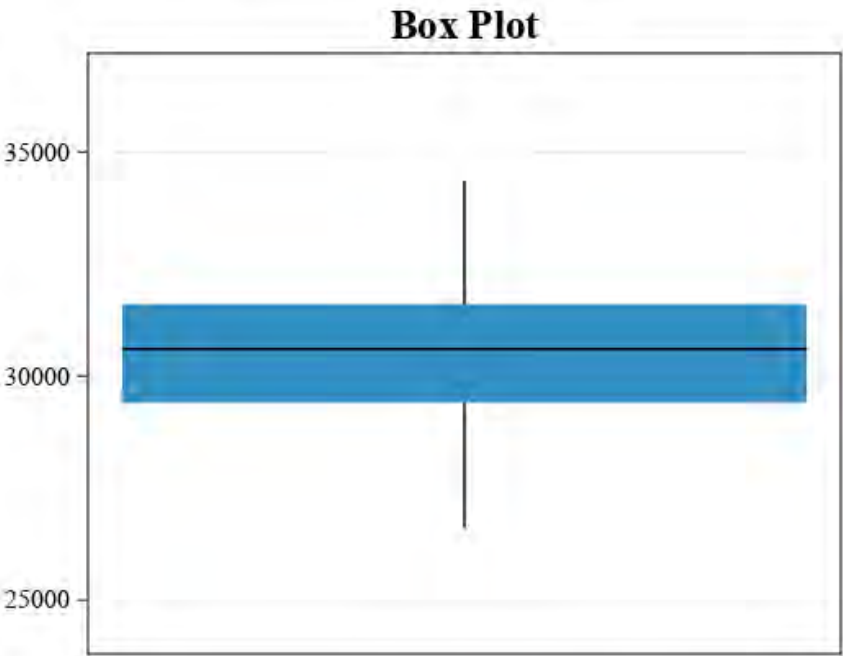
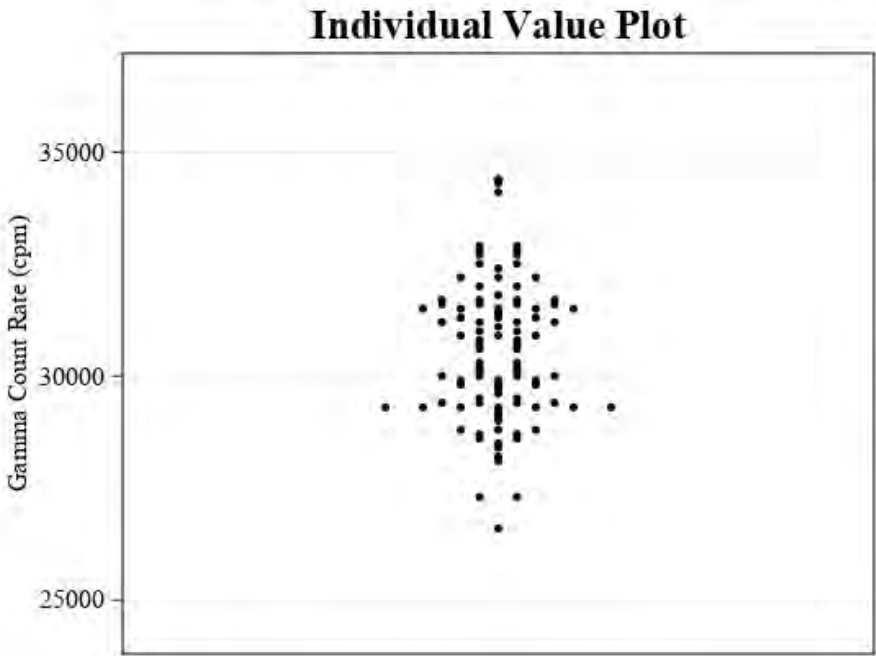


Summary Statistics

Count (n)	104
Minimum (cpm)	31,400
Maximum (cpm)	40,700
Average (cpm)	35,866
Median (cpm)	35,950
Standard Deviation (cpm)	2,181
Relative Standard Deviation	6.082%
RPD of Mean and Median	0.233%
90th Percentile (cpm)	38,500
95th Percentile (cpm)	39,100
99th Percentile (cpm)	39,800

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR15 Type: Unshielded



Summary Statistics

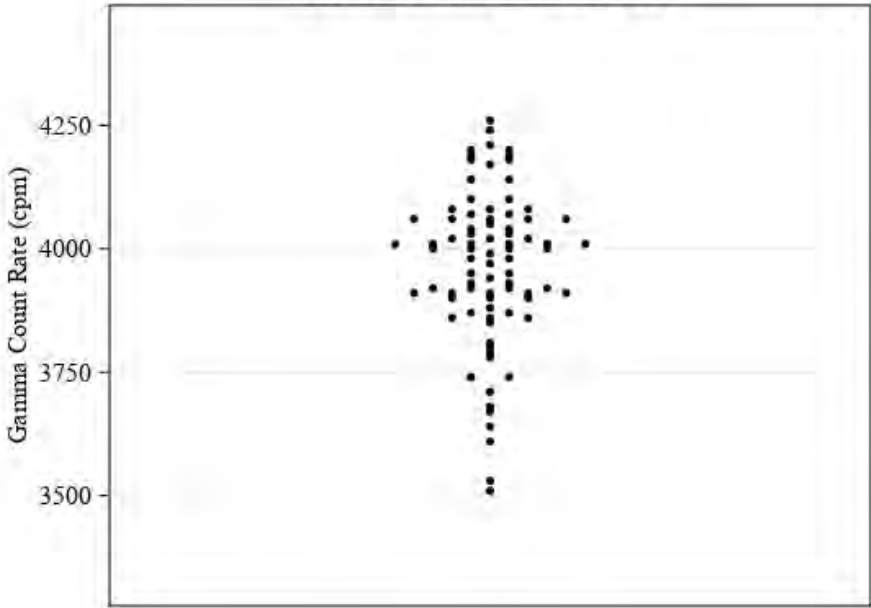
Count (n)	99
Minimum (cpm)	26,600
Maximum (cpm)	34,400
Average (cpm)	30,547
Median (cpm)	30,600
Standard Deviation (cpm)	1,527
Relative Standard Deviation	4.998%
RPD of Mean and Median	0.172%
90th Percentile (cpm)	32,500
95th Percentile (cpm)	32,900
99th Percentile (cpm)	34,400

ATTACHMENT E-4: CORRELATION PLOT STATISTICS – SHIELDED GAMMA

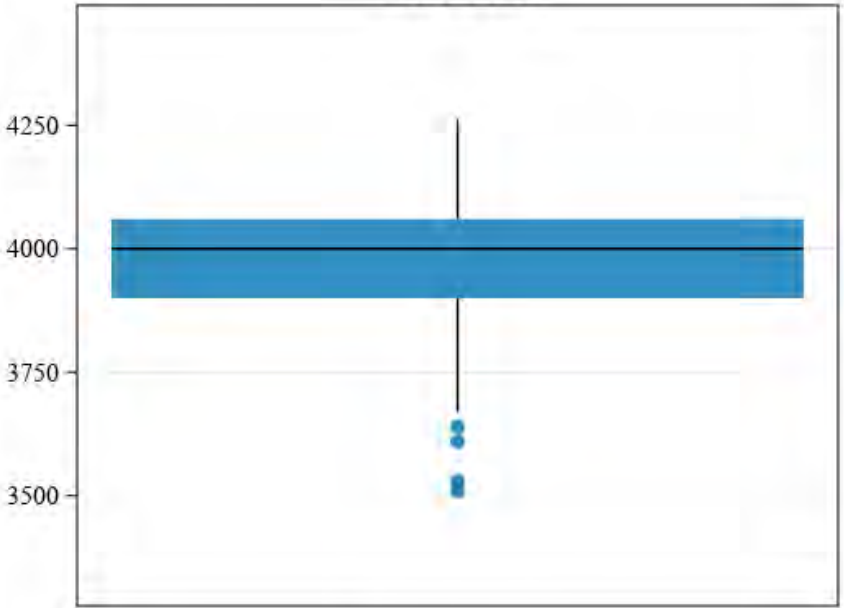
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR01 Type: Shielded

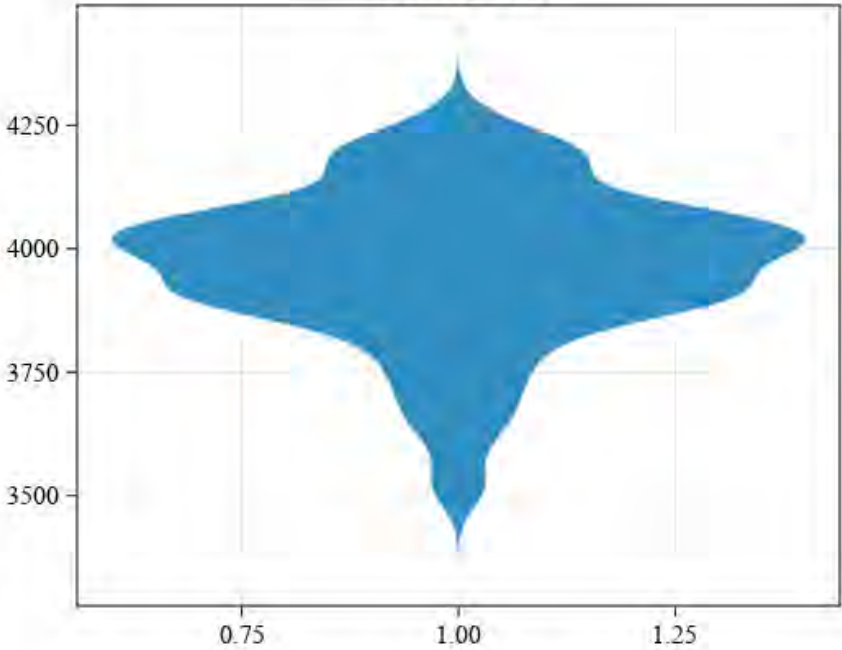
Individual Value Plot



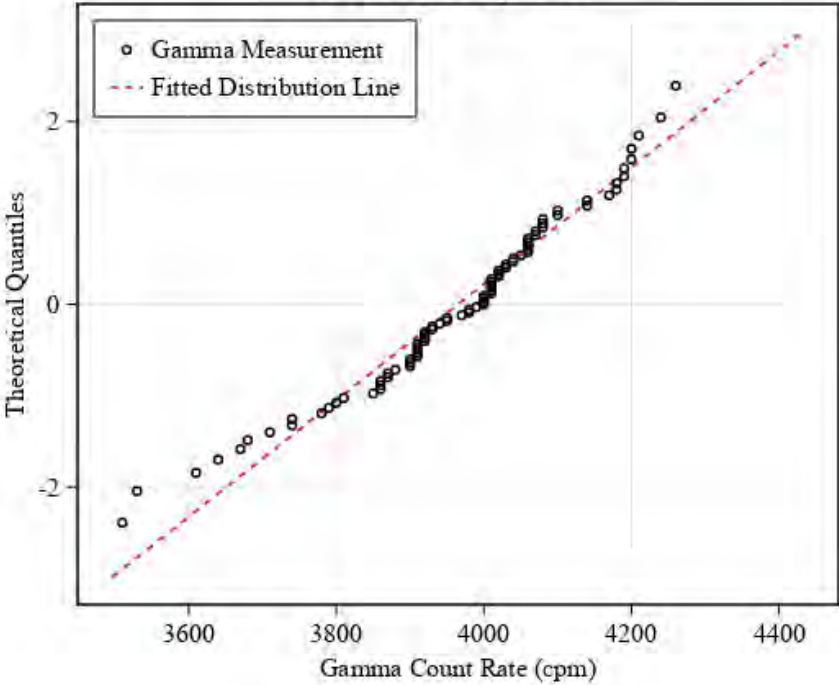
Box Plot



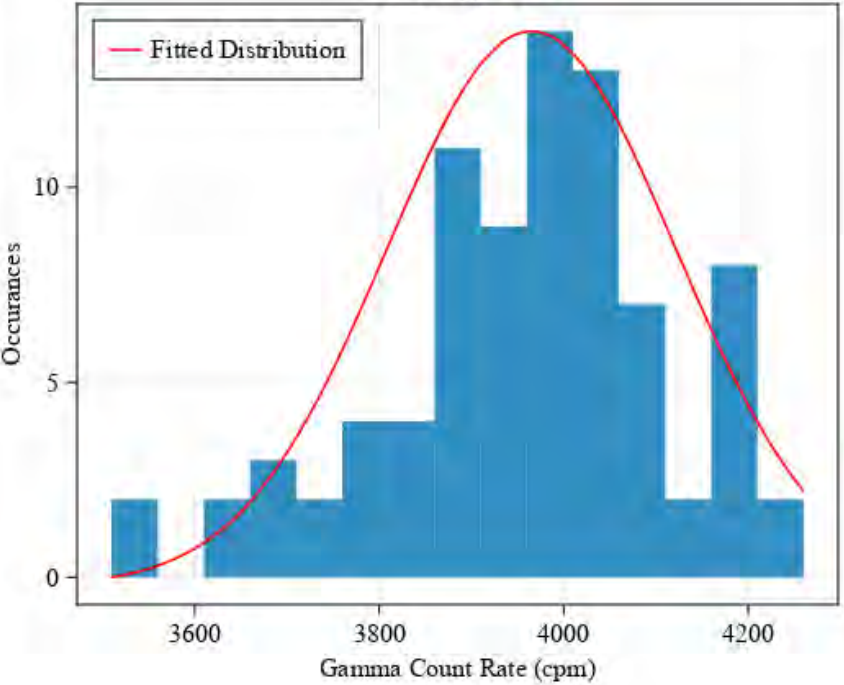
Violin Plot



Probability Plot



Histogram



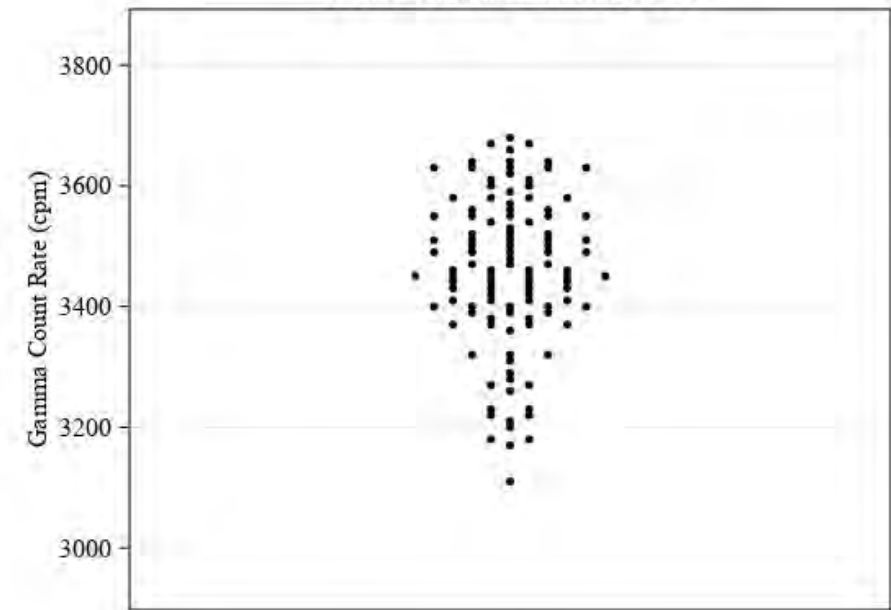
Summary Statistics

Count (n)	83
Minimum (cpm)	3,510
Maximum (cpm)	4,260
Average (cpm)	3,965
Median (cpm)	4,000
Standard Deviation (cpm)	157
Relative Standard Deviation	3.956%
RPD of Mean and Median	0.877%
90th Percentile (cpm)	4,180
95th Percentile (cpm)	4,200
99th Percentile (cpm)	4,260

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR02 Type: Shielded

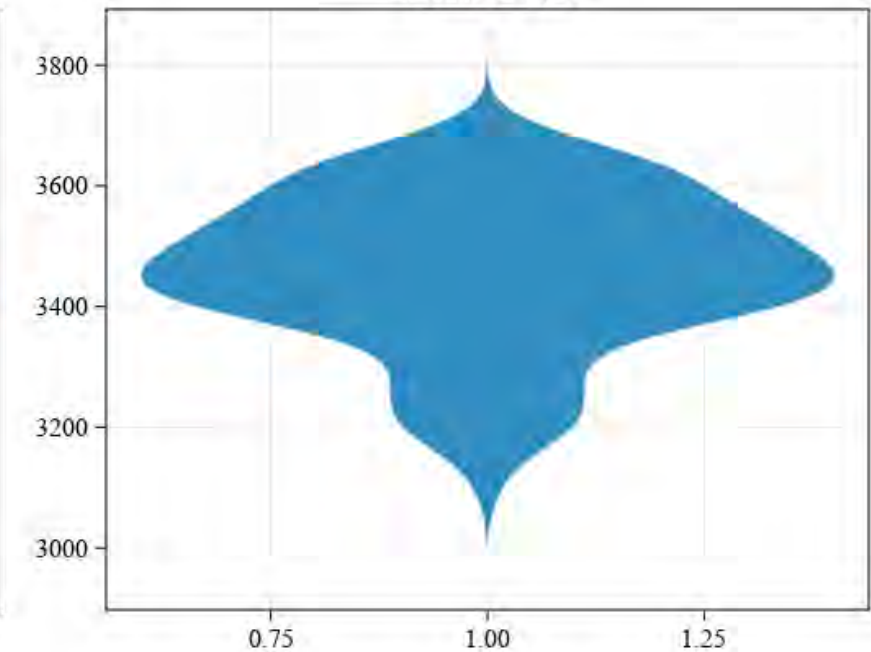
Individual Value Plot



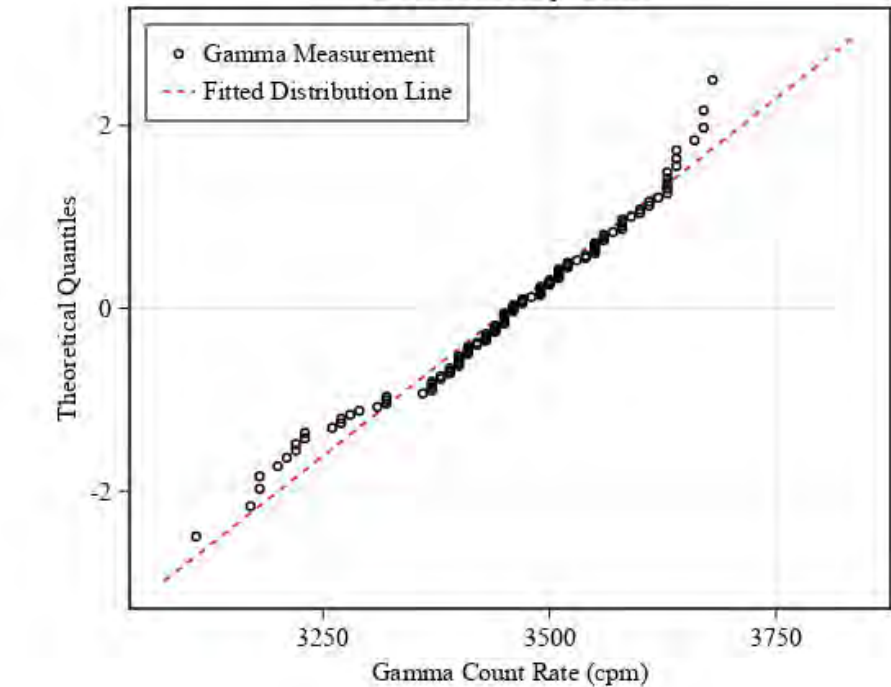
Box Plot



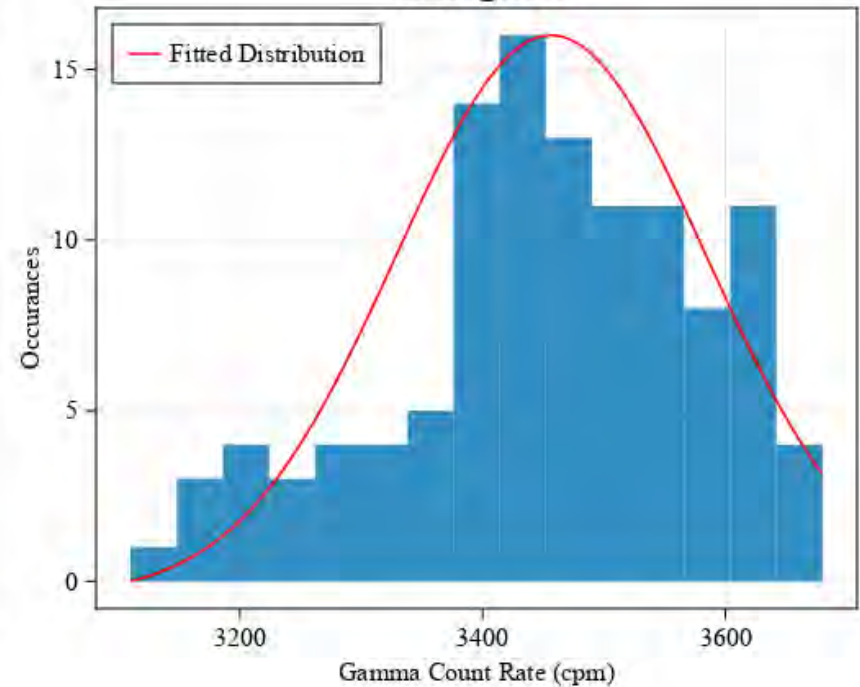
Violin Plot



Probability Plot



Histogram



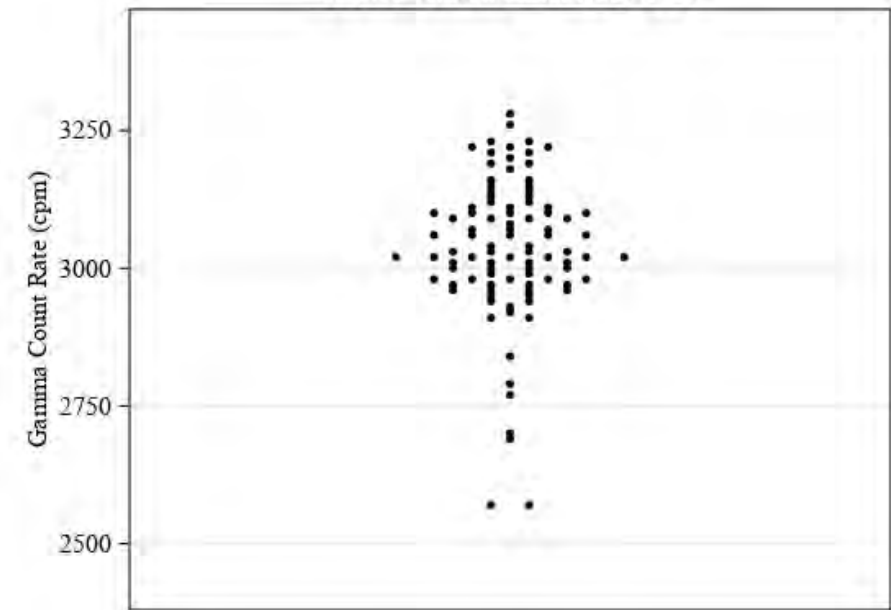
Summary Statistics

Count (n)	112
Minimum (cpm)	3,110
Maximum (cpm)	3,680
Average (cpm)	3,456
Median (cpm)	3,460
Standard Deviation (cpm)	128
Relative Standard Deviation	3.695%
RPD of Mean and Median	0.103%
90th Percentile (cpm)	3,630
95th Percentile (cpm)	3,640
99th Percentile (cpm)	3,670

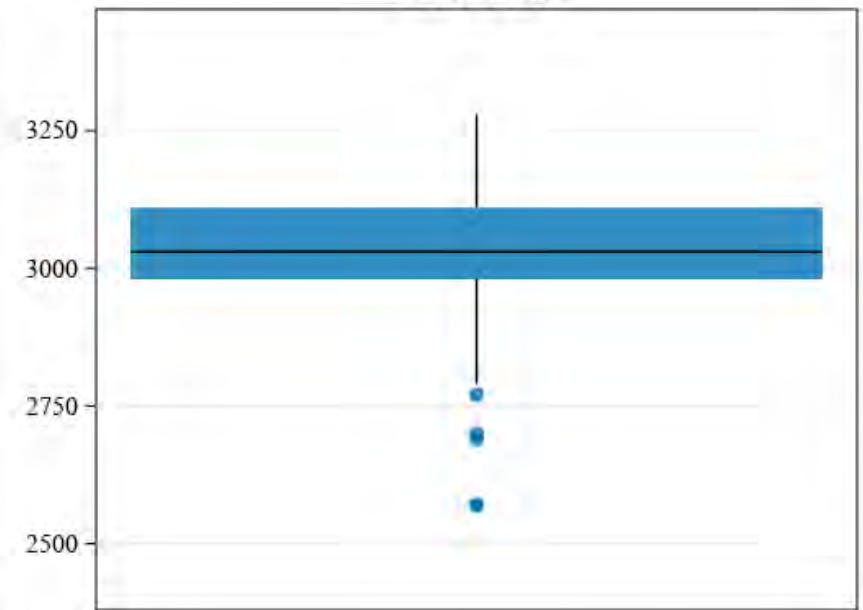
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR03 Type: Shielded

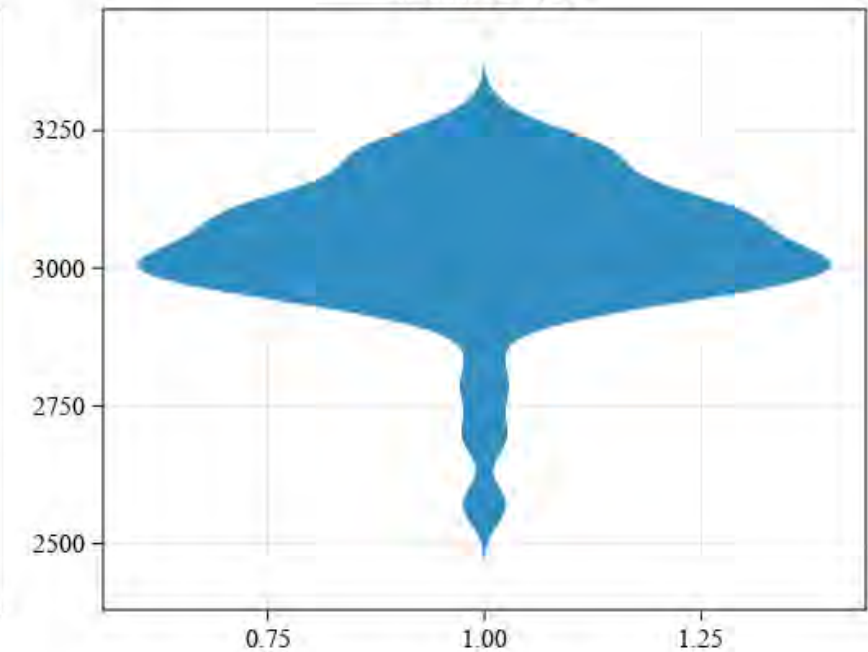
Individual Value Plot



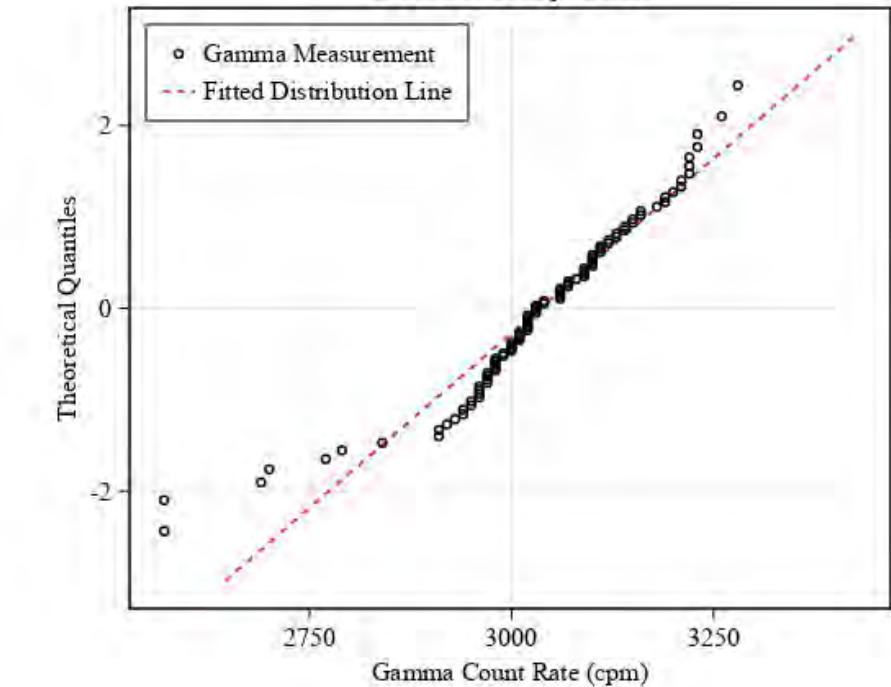
Box Plot



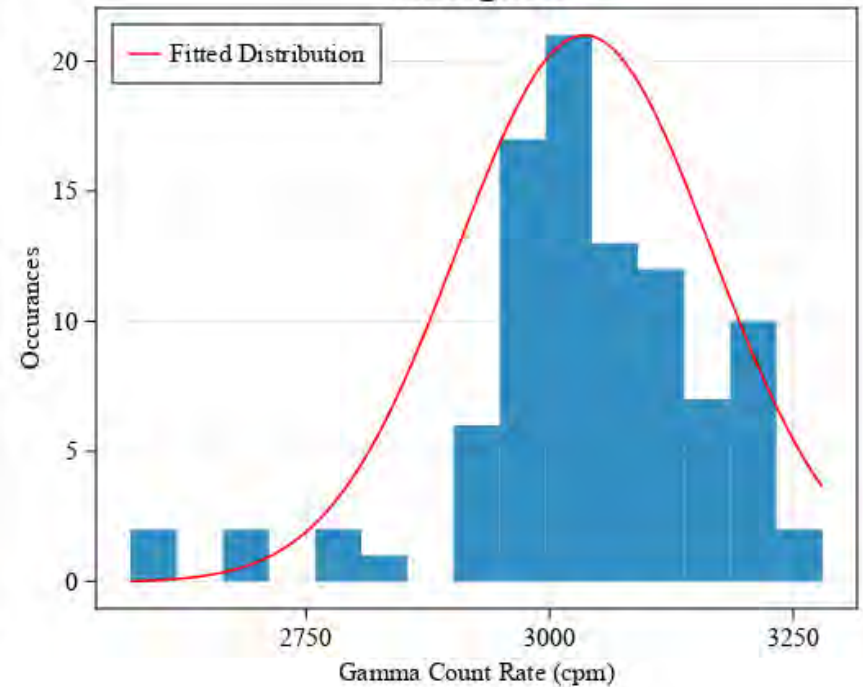
Violin Plot



Probability Plot



Histogram



Summary Statistics

Count (n)	95
Minimum (cpm)	2,570
Maximum (cpm)	3,280
Average (cpm)	3,036
Median (cpm)	3,030
Standard Deviation (cpm)	131
Relative Standard Deviation	4.306%
RPD of Mean and Median	0.184%
90th Percentile (cpm)	3,200
95th Percentile (cpm)	3,220
99th Percentile (cpm)	3,280

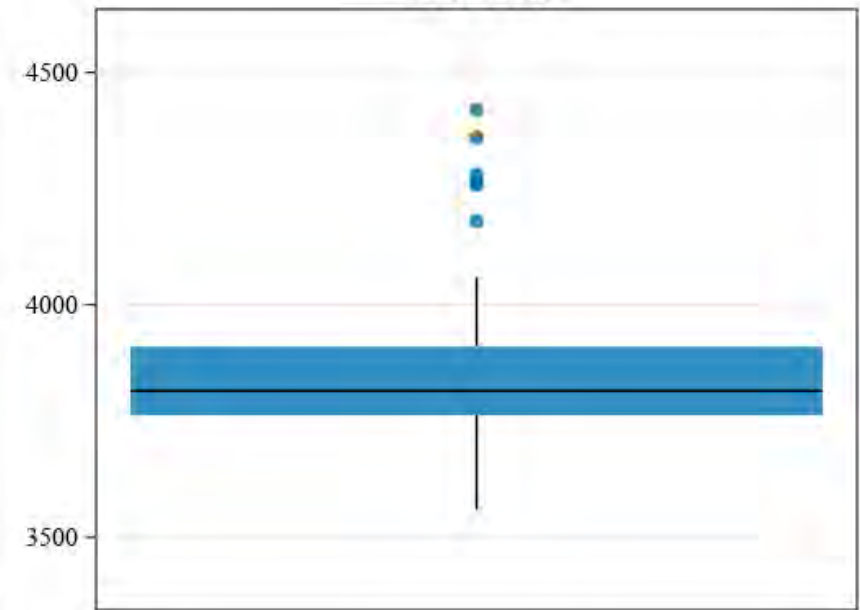
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR04 Type: Shielded

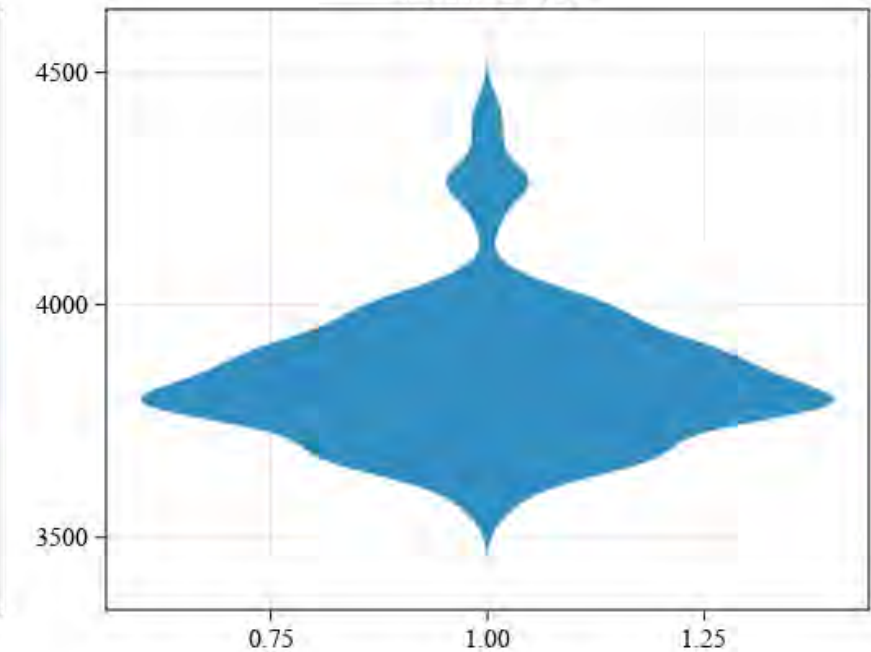
Individual Value Plot



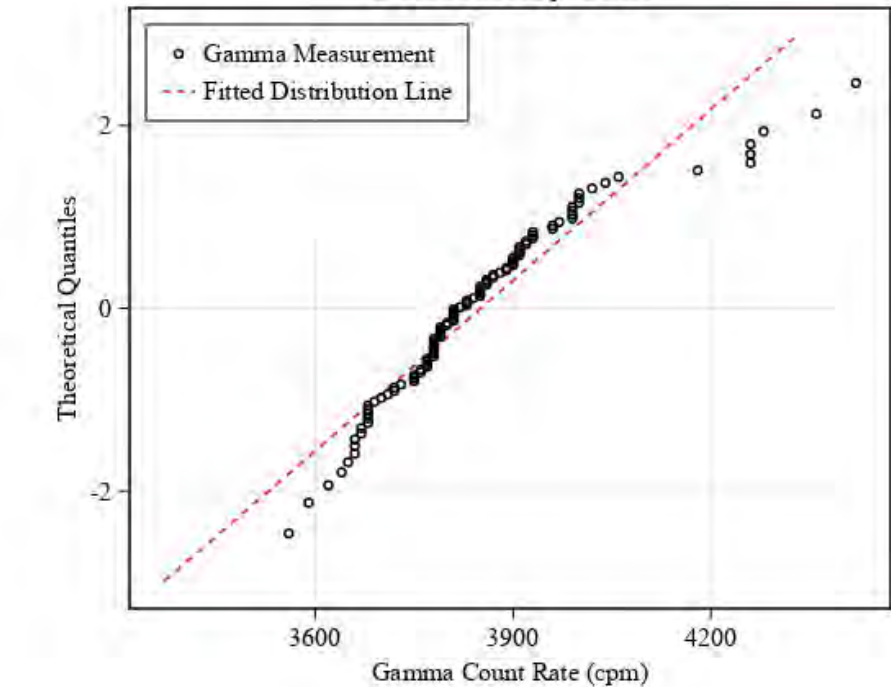
Box Plot



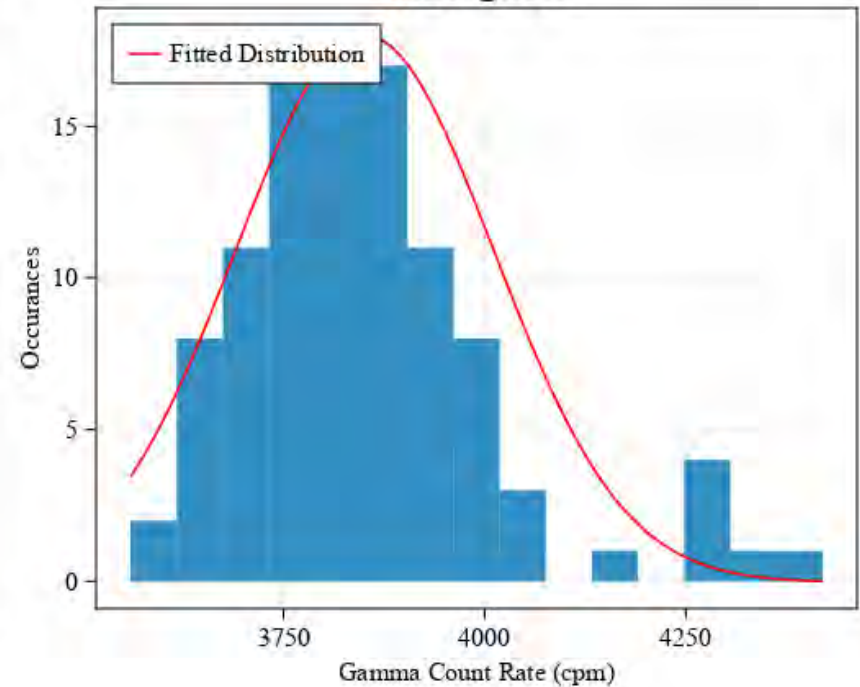
Violin Plot



Probability Plot



Histogram



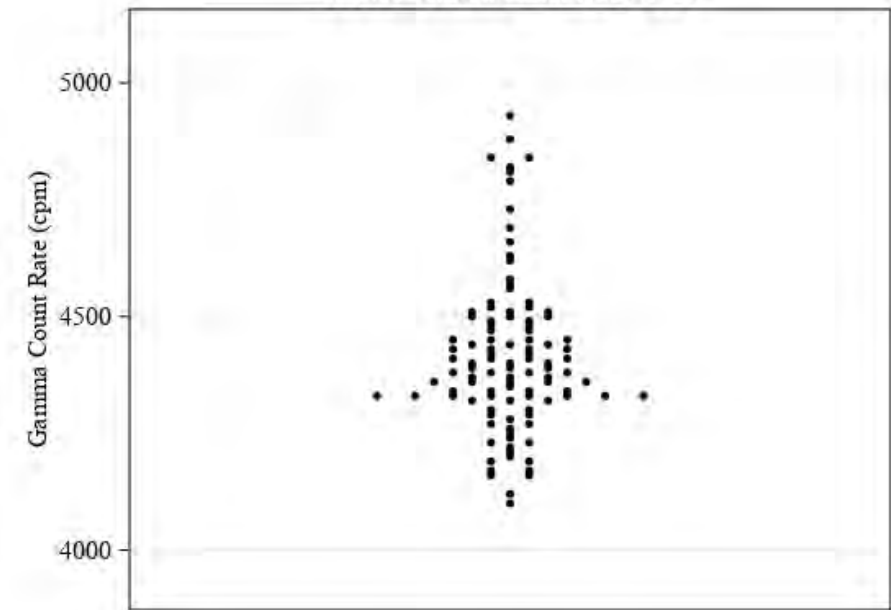
Summary Statistics

Count (n)	102
Minimum (cpm)	3,560
Maximum (cpm)	4,420
Average (cpm)	3,851
Median (cpm)	3,815
Standard Deviation (cpm)	161
Relative Standard Deviation	4.169%
RPD of Mean and Median	0.936%
90th Percentile (cpm)	4,000
95th Percentile (cpm)	4,260
99th Percentile (cpm)	4,360

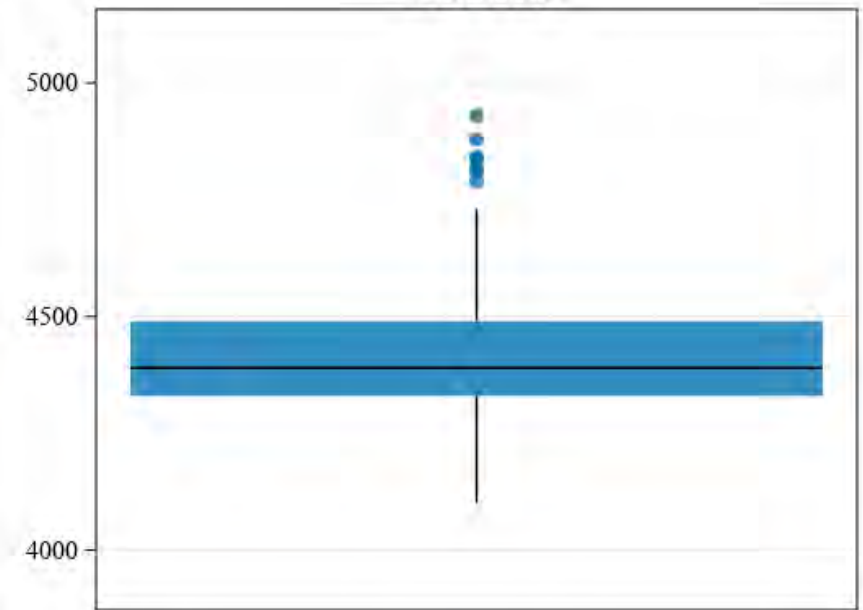
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR05 Type: Shielded

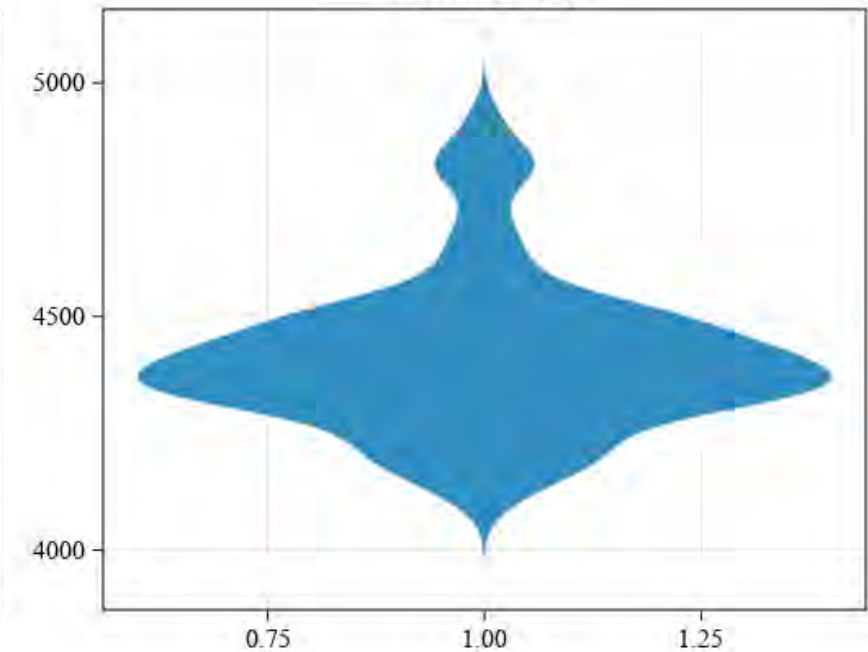
Individual Value Plot



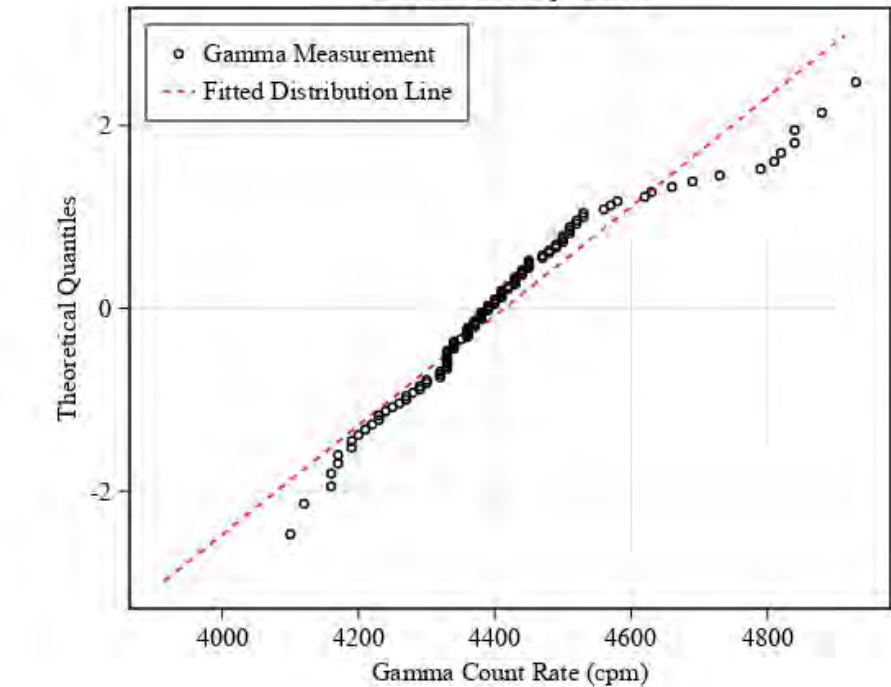
Box Plot



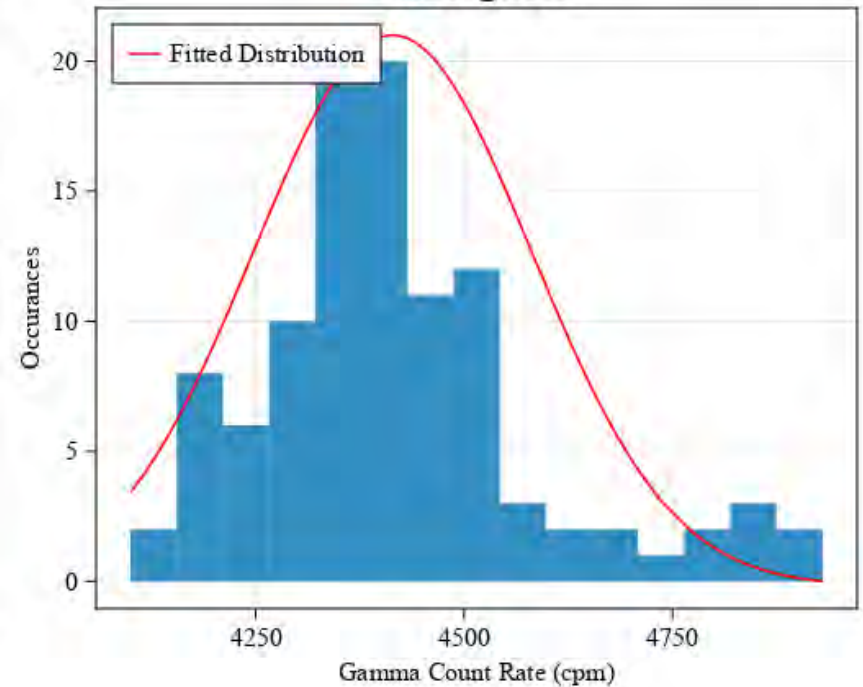
Violin Plot



Probability Plot



Histogram



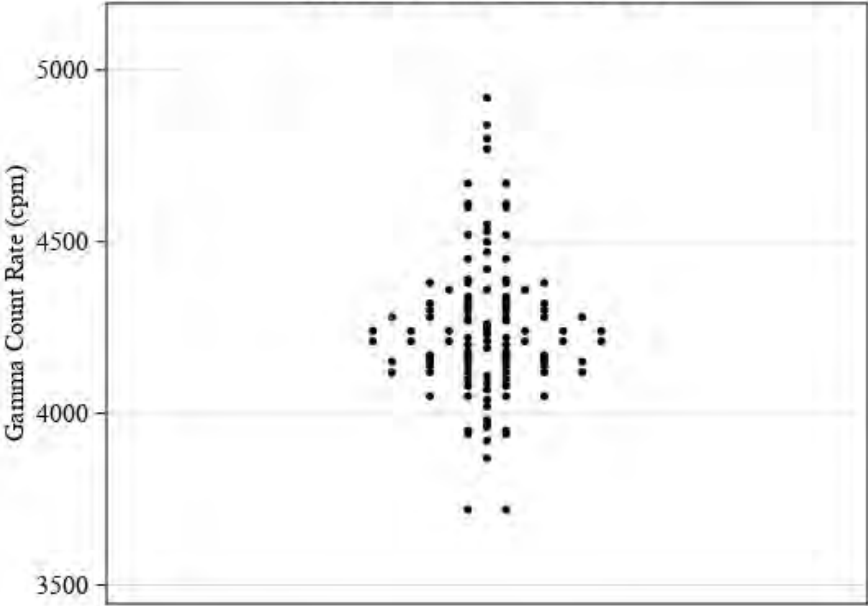
Summary Statistics

Count (n)	105
Minimum (cpm)	4,100
Maximum (cpm)	4,930
Average (cpm)	4,414
Median (cpm)	4,390
Standard Deviation (cpm)	167
Relative Standard Deviation	3.784%
RPD of Mean and Median	0.55%
90th Percentile (cpm)	4,630
95th Percentile (cpm)	4,810
99th Percentile (cpm)	4,880

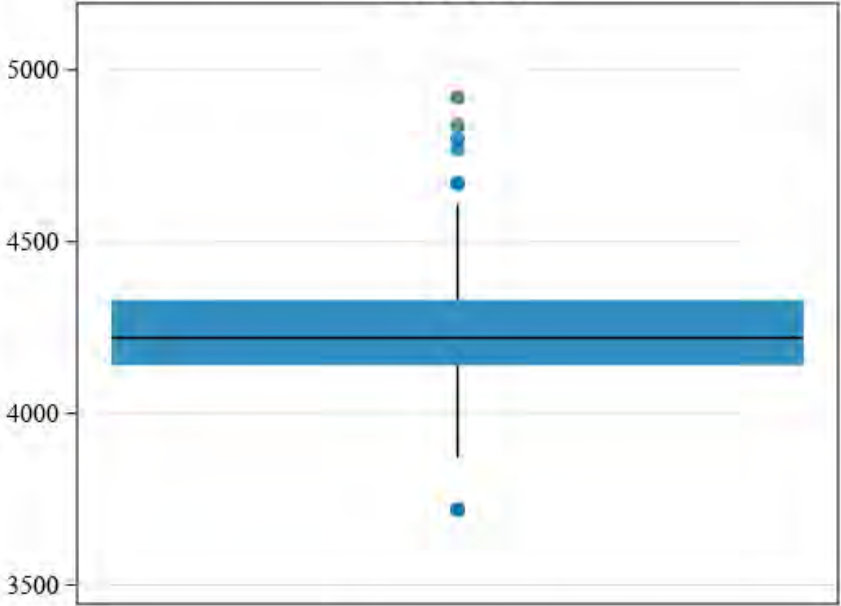
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR06 Type: Shielded

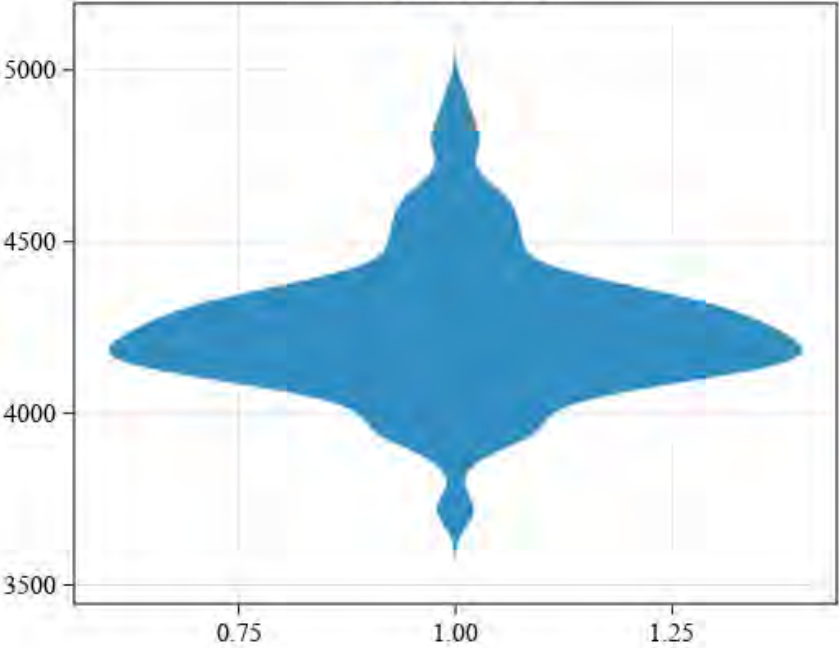
Individual Value Plot



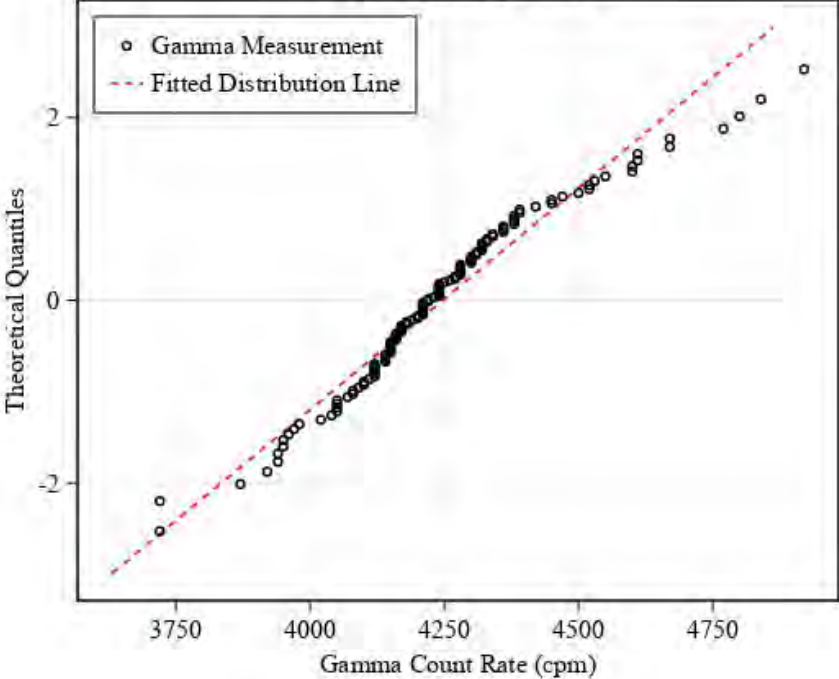
Box Plot



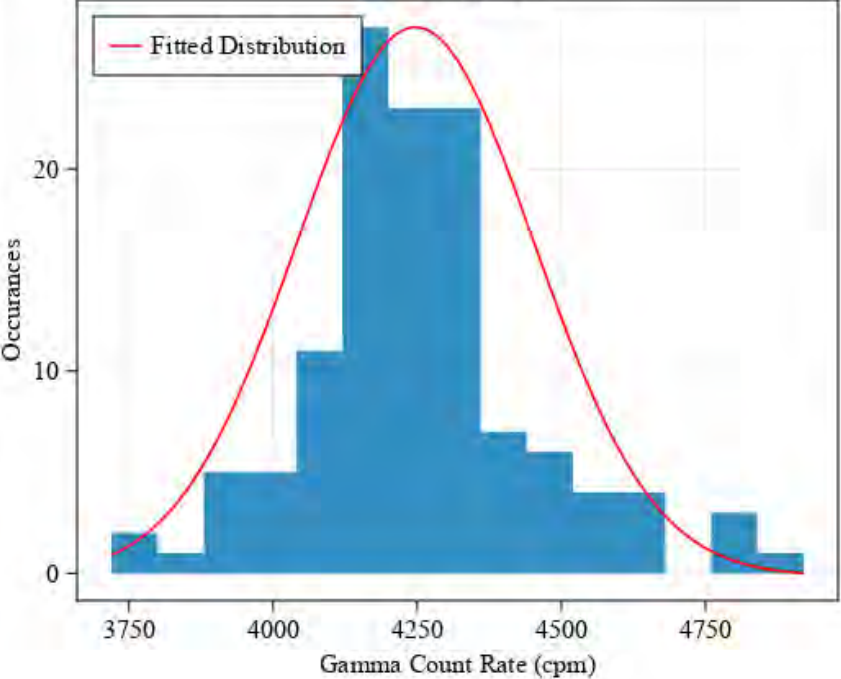
Violin Plot



Probability Plot



Histogram

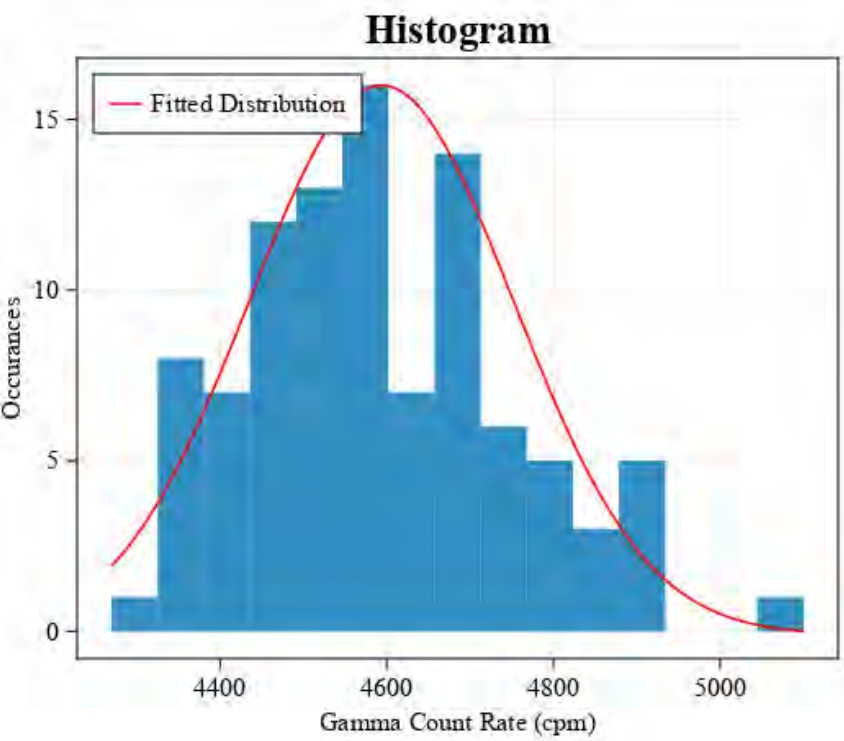
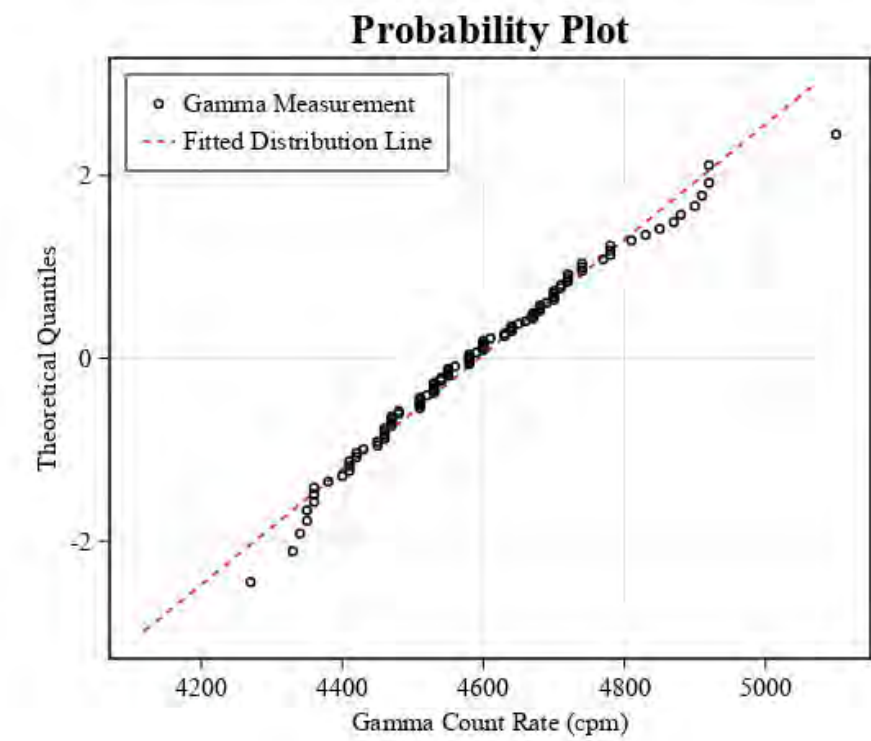
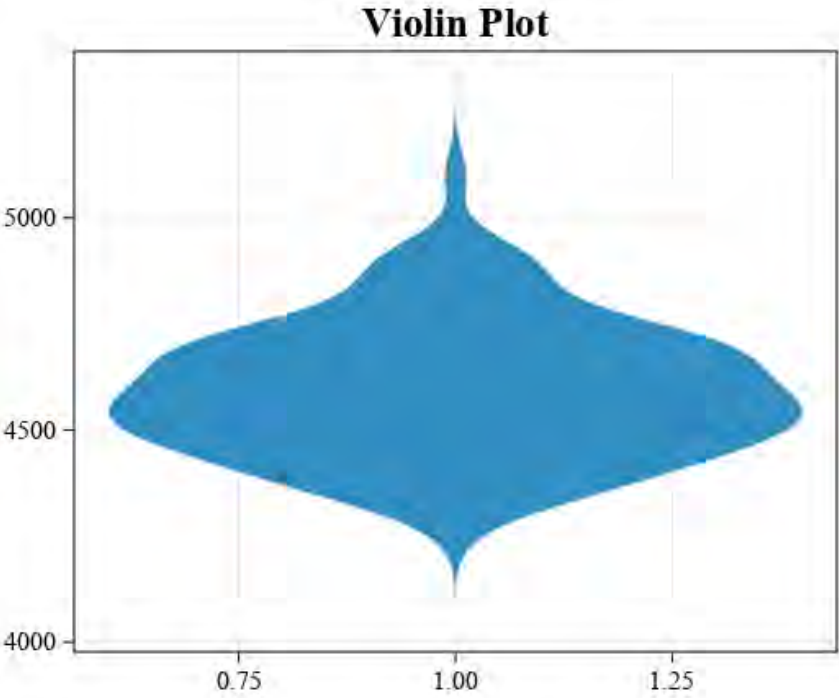
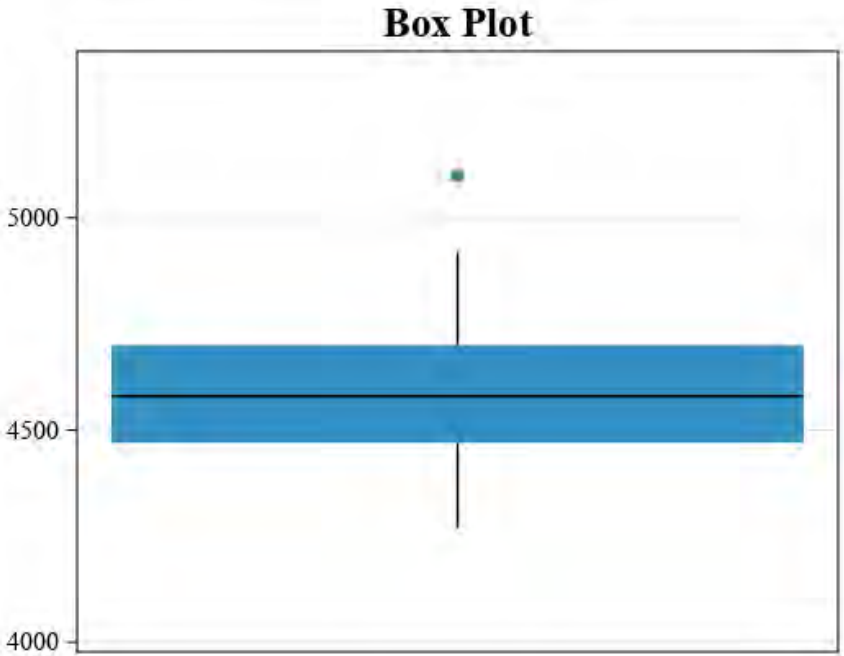
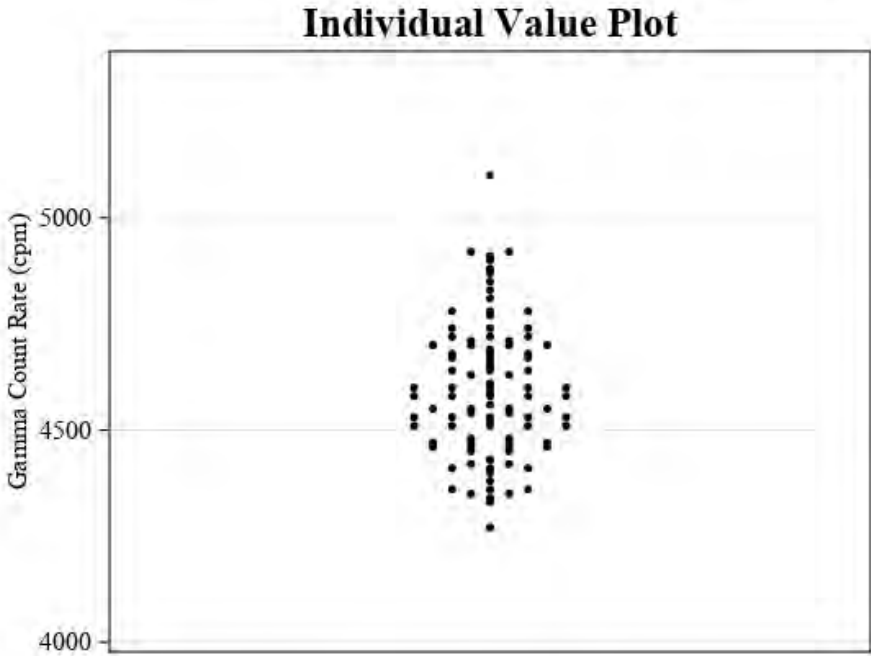


Summary Statistics

Count (n)	122
Minimum (cpm)	3,720
Maximum (cpm)	4,920
Average (cpm)	4,247
Median (cpm)	4,220
Standard Deviation (cpm)	206
Relative Standard Deviation	4.851%
RPD of Mean and Median	0.637%
90th Percentile (cpm)	4,520
95th Percentile (cpm)	4,610
99th Percentile (cpm)	4,840

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR07 Type: Shielded



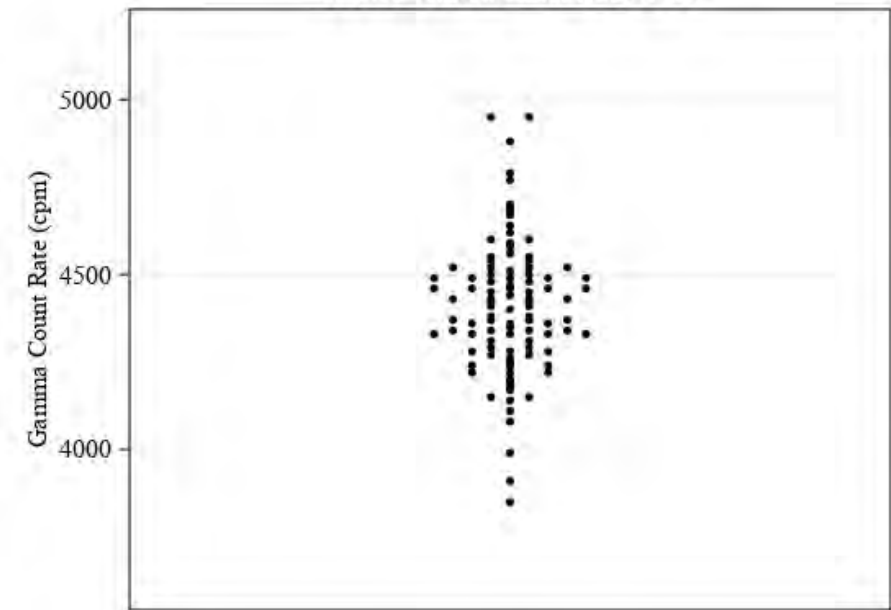
Summary Statistics

Count (n)	98
Minimum (cpm)	4,270
Maximum (cpm)	5,100
Average (cpm)	4,594
Median (cpm)	4,580
Standard Deviation (cpm)	159
Relative Standard Deviation	3.456%
RPD of Mean and Median	0.296%
90th Percentile (cpm)	4,810
95th Percentile (cpm)	4,900
99th Percentile (cpm)	5,100

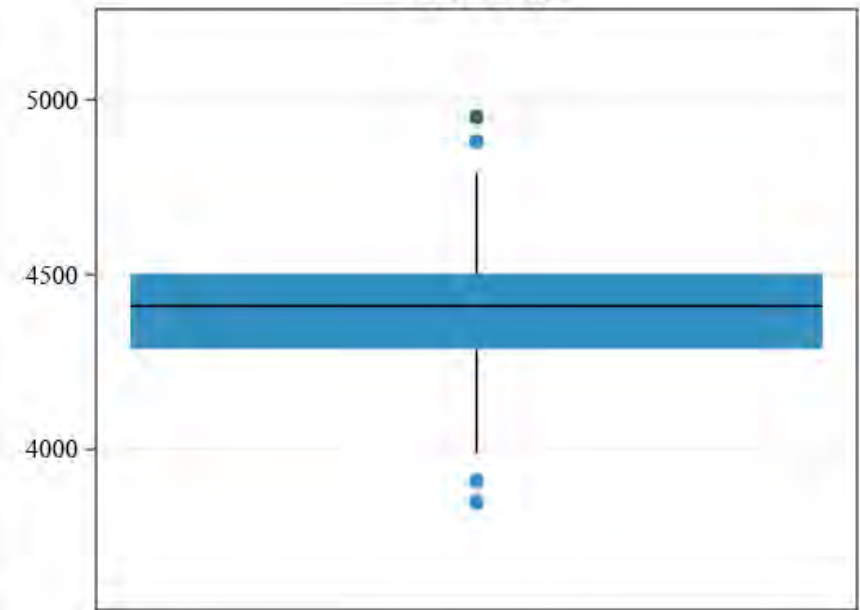
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR08 Type: Shielded

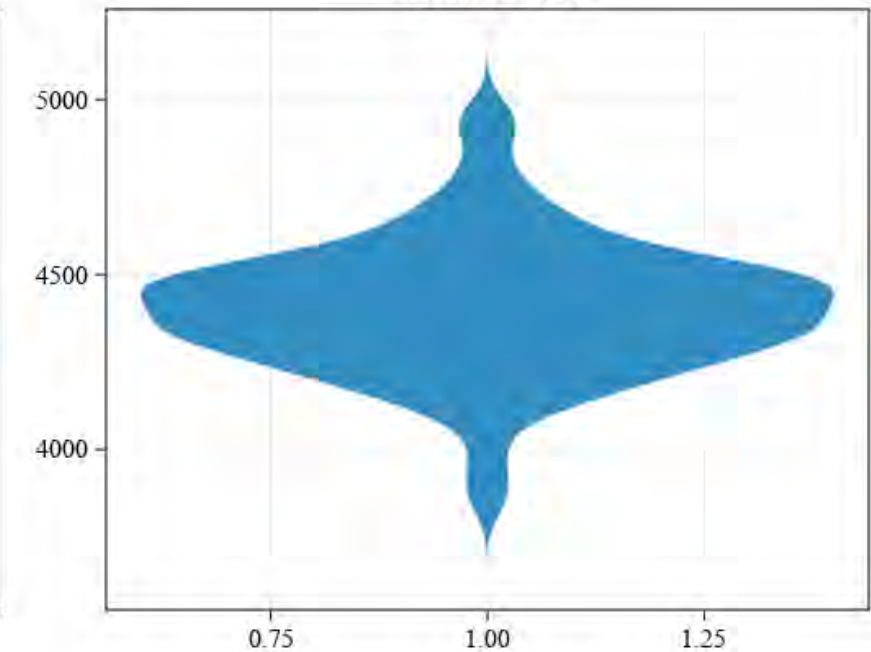
Individual Value Plot



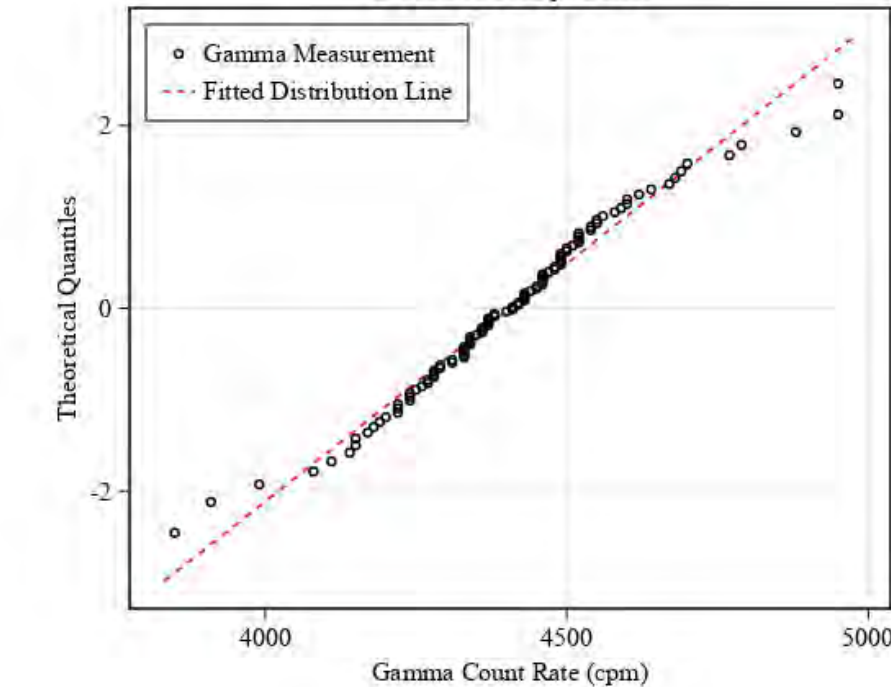
Box Plot



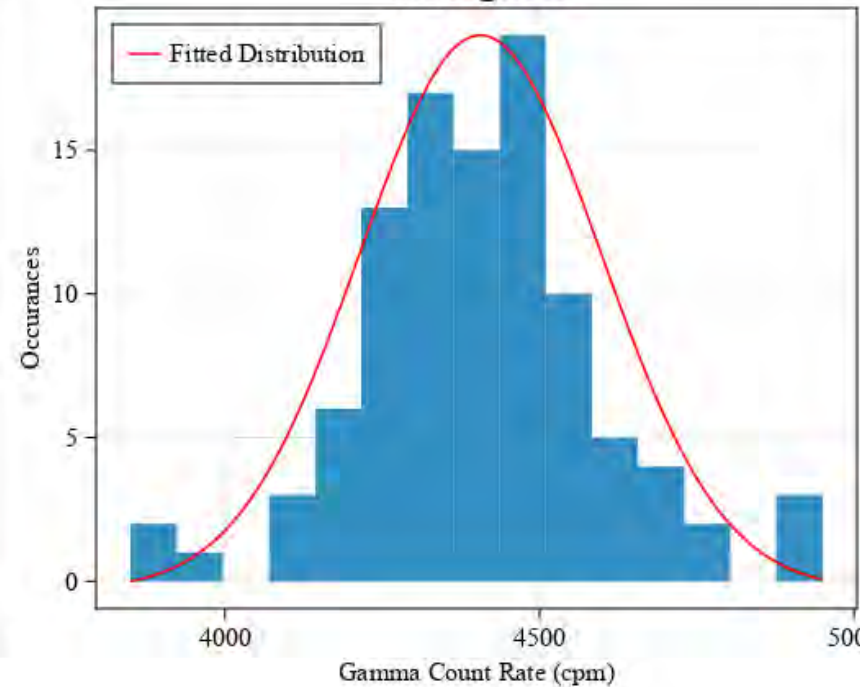
Violin Plot



Probability Plot



Histogram



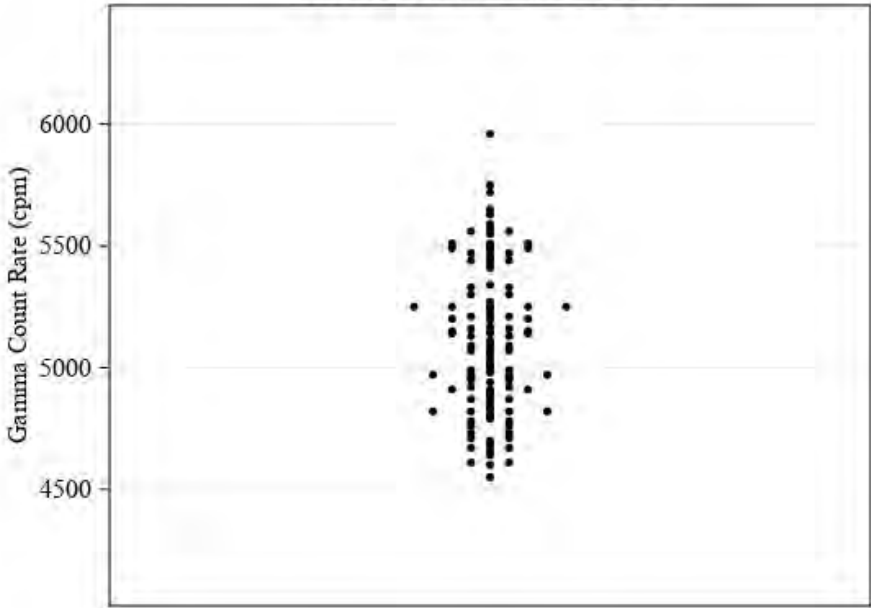
Summary Statistics

Count (n)	100
Minimum (cpm)	3,850
Maximum (cpm)	4,950
Average (cpm)	4,406
Median (cpm)	4,410
Standard Deviation (cpm)	192
Relative Standard Deviation	4.356%
RPD of Mean and Median	0.088%
90th Percentile (cpm)	4,620
95th Percentile (cpm)	4,700
99th Percentile (cpm)	4,950

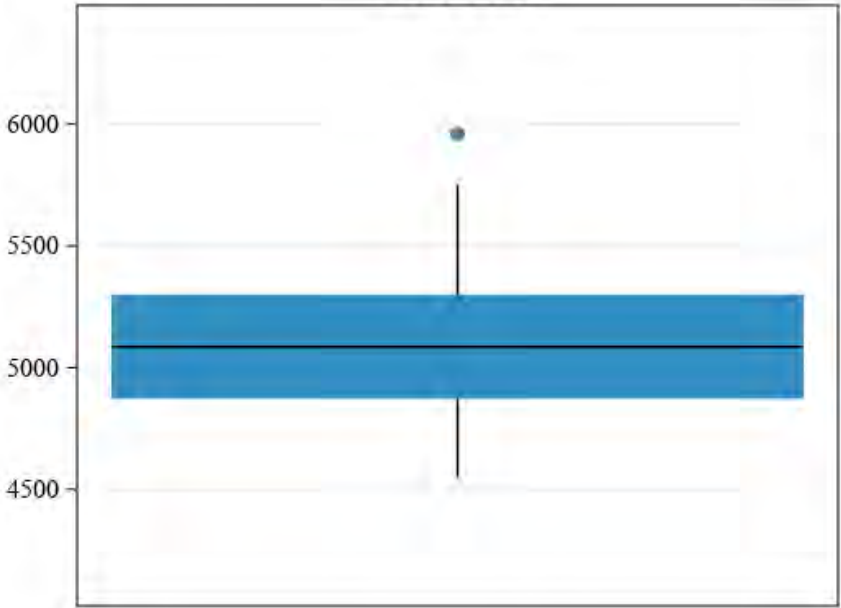
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR09 Type: Shielded

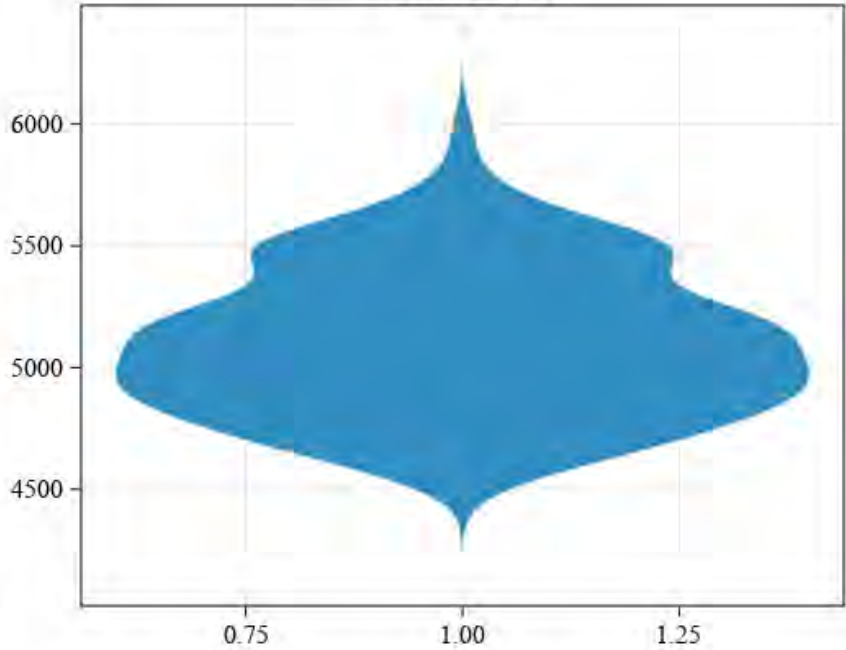
Individual Value Plot



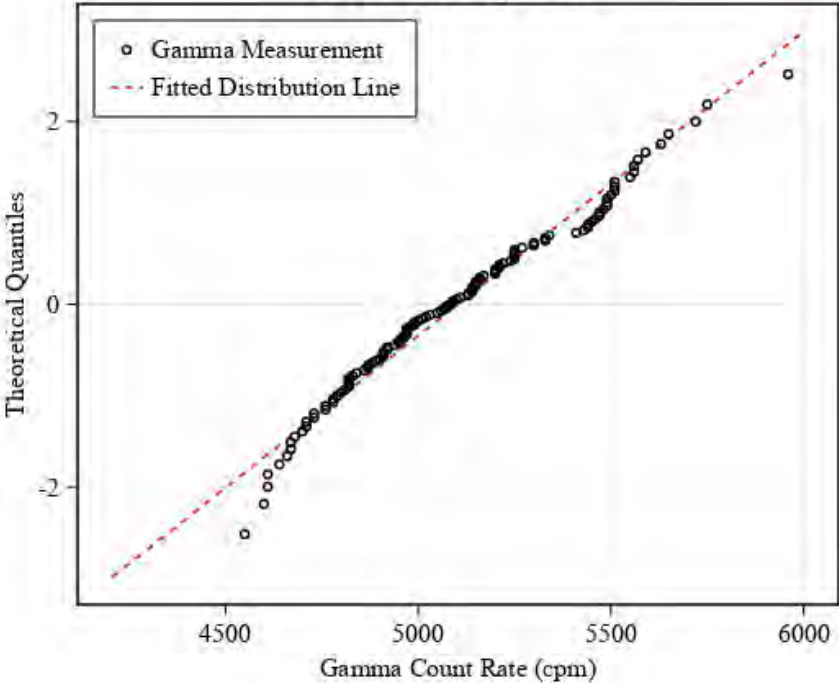
Box Plot



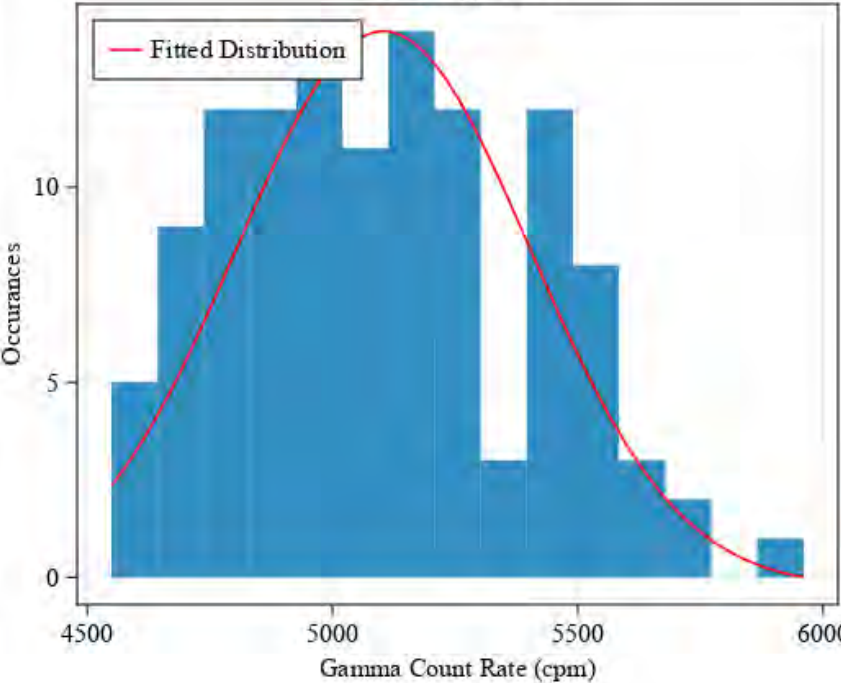
Violin Plot



Probability Plot



Histogram



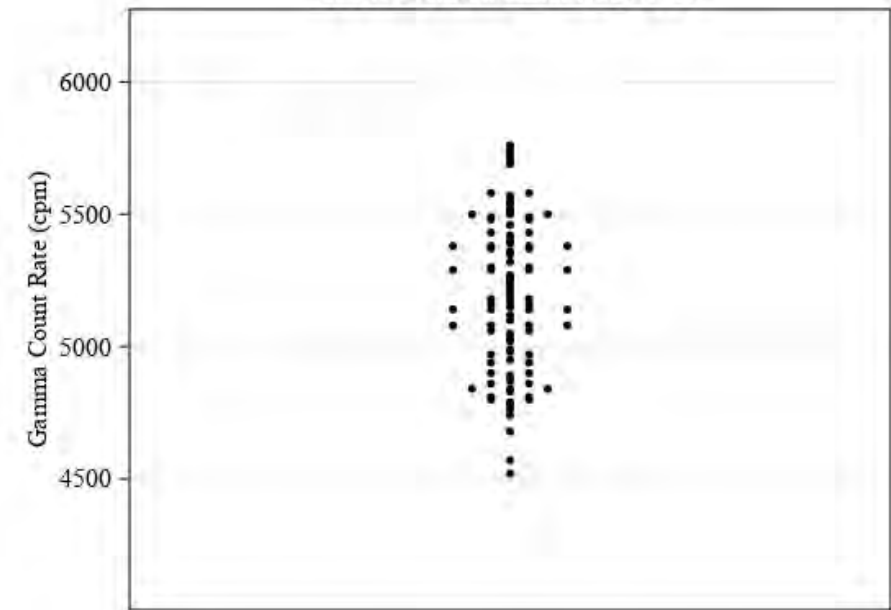
Summary Statistics

Count (n)	118
Minimum (cpm)	4,550
Maximum (cpm)	5,960
Average (cpm)	5,104
Median (cpm)	5,085
Standard Deviation (cpm)	300
Relative Standard Deviation	5.882%
RPD of Mean and Median	0.366%
90th Percentile (cpm)	5,510
95th Percentile (cpm)	5,590
99th Percentile (cpm)	5,750

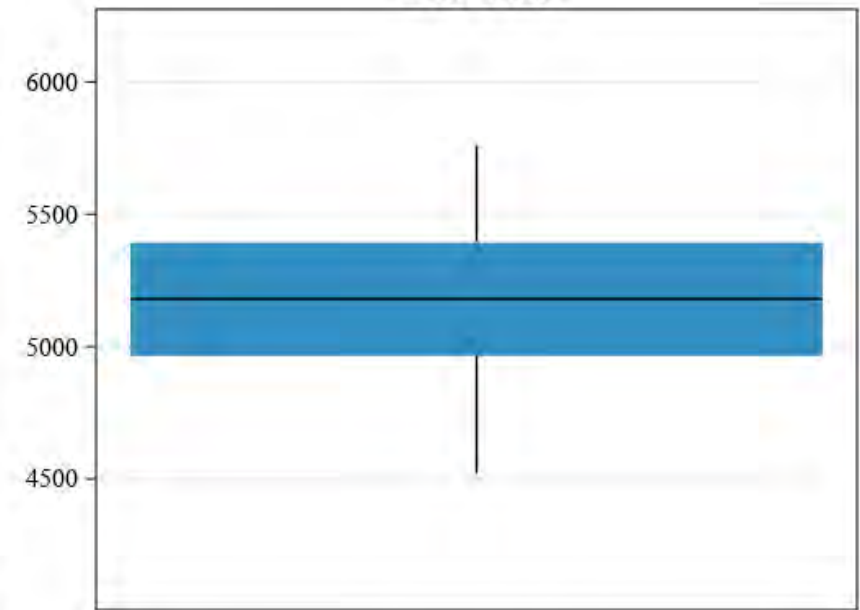
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR10 Type: Shielded

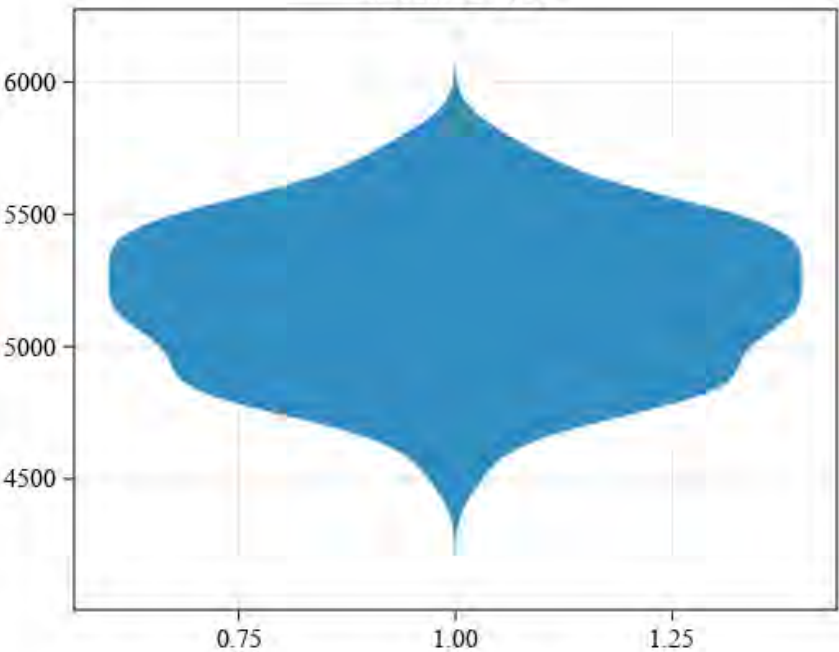
Individual Value Plot



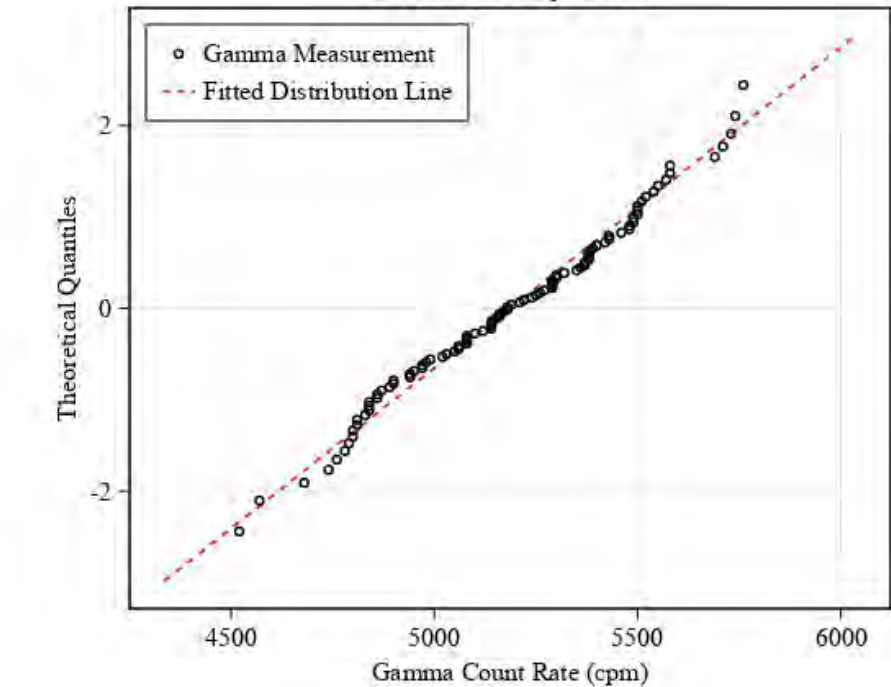
Box Plot



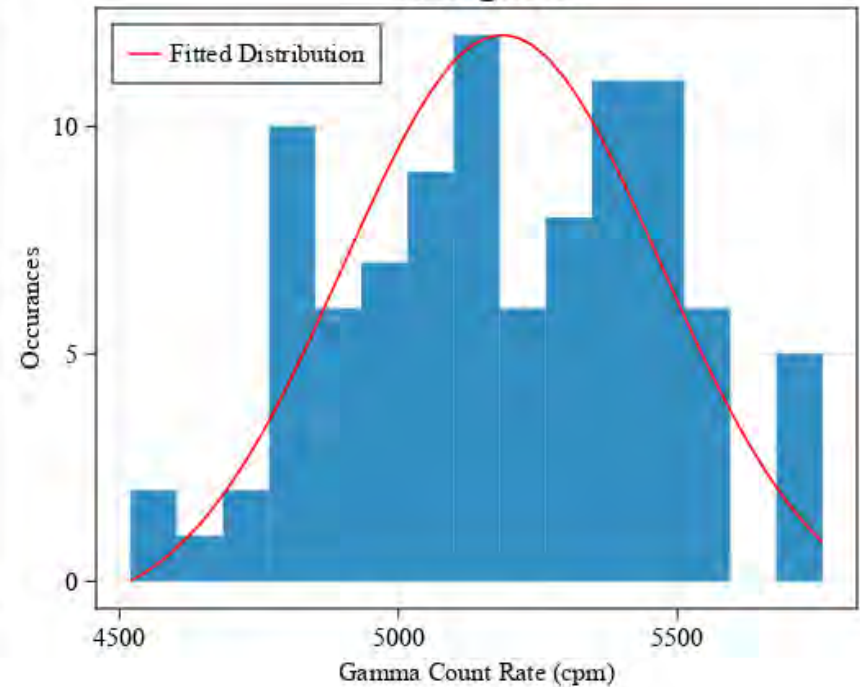
Violin Plot



Probability Plot



Histogram



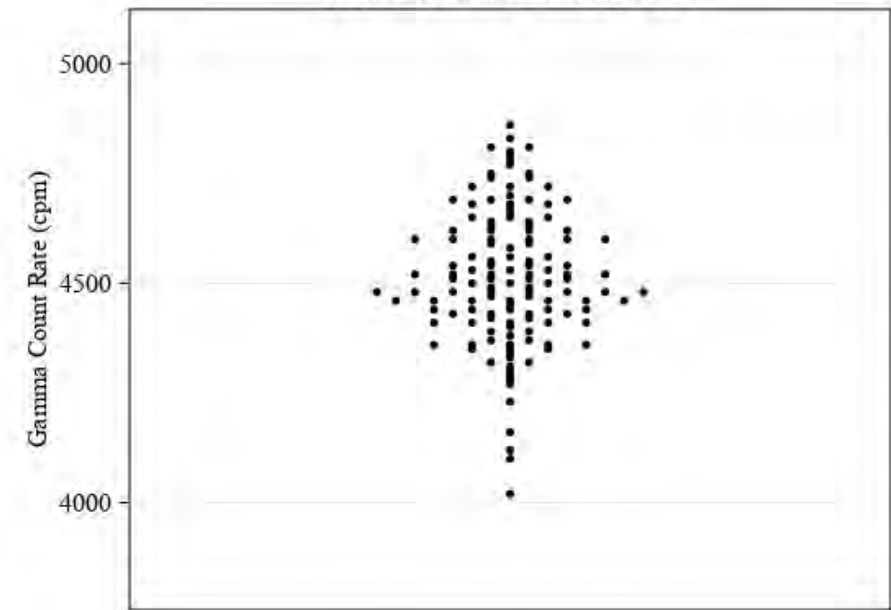
Summary Statistics

Count (n)	96
Minimum (cpm)	4,520
Maximum (cpm)	5,760
Average (cpm)	5,186
Median (cpm)	5,180
Standard Deviation (cpm)	285
Relative Standard Deviation	5.489%
RPD of Mean and Median	0.123%
90th Percentile (cpm)	5,540
95th Percentile (cpm)	5,690
99th Percentile (cpm)	5,760

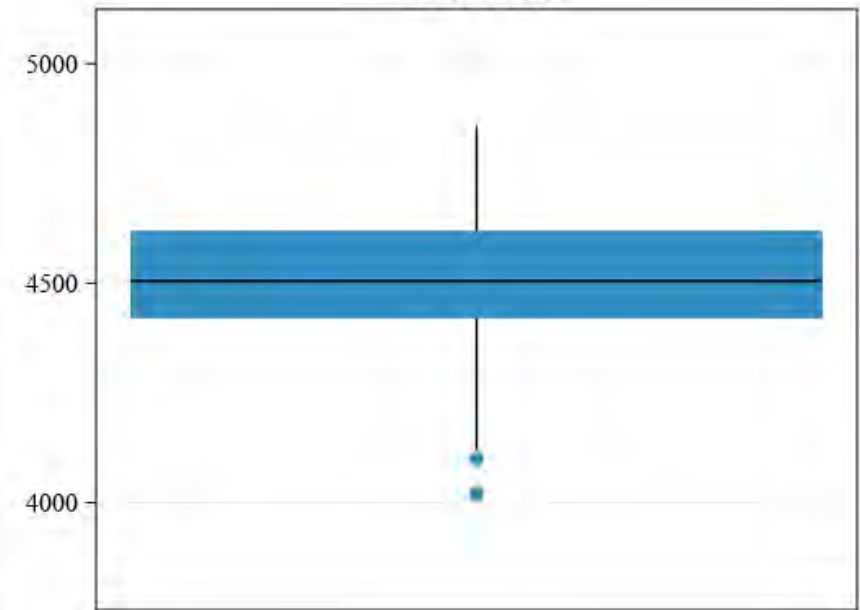
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR11 Type: Shielded

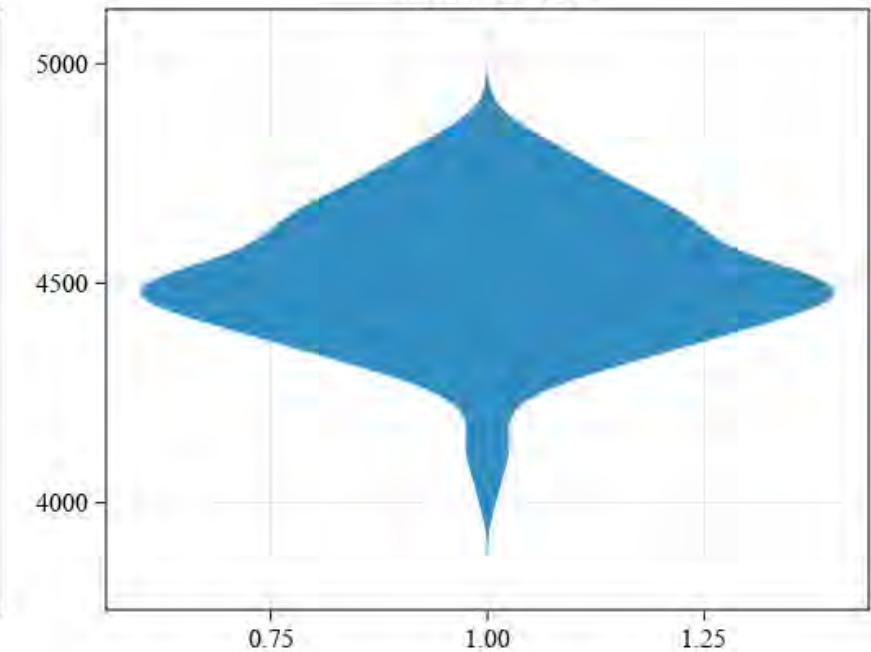
Individual Value Plot



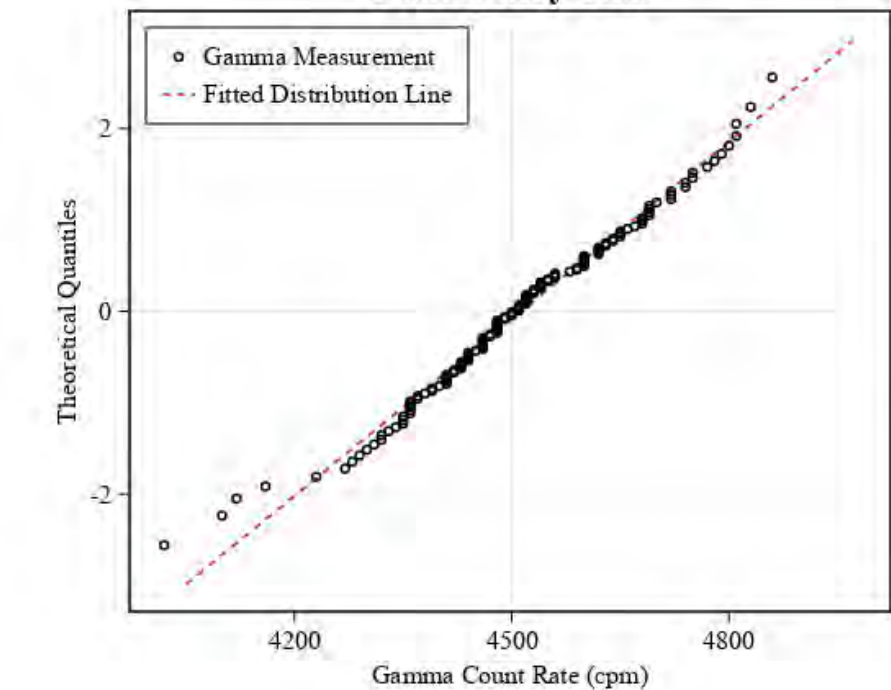
Box Plot



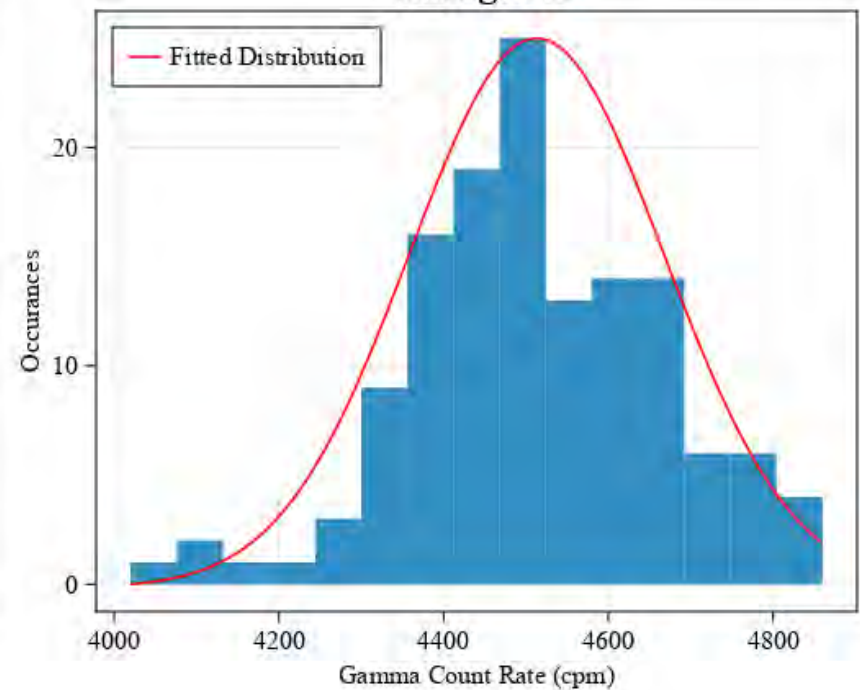
Violin Plot



Probability Plot



Histogram



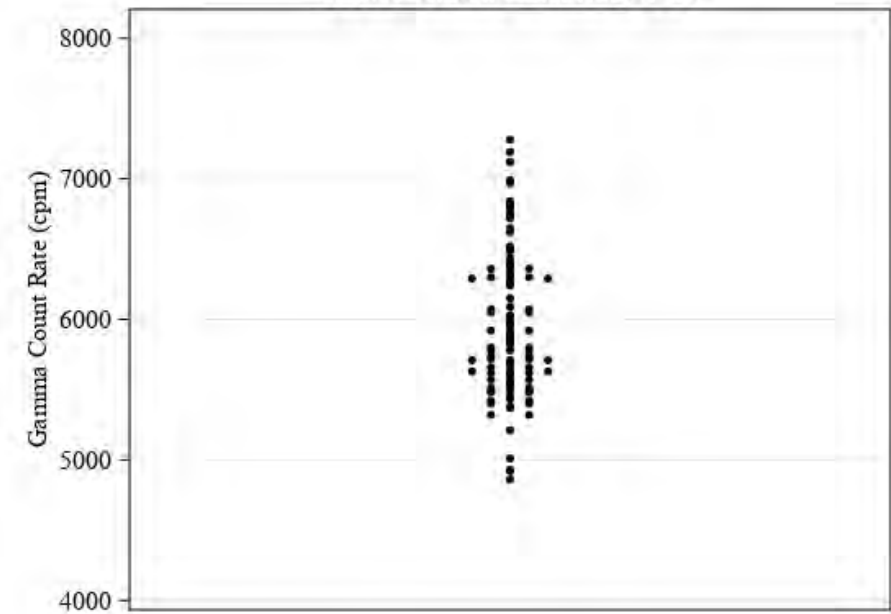
Summary Statistics

Count (n)	134
Minimum (cpm)	4,020
Maximum (cpm)	4,860
Average (cpm)	4,513
Median (cpm)	4,505
Standard Deviation (cpm)	155
Relative Standard Deviation	3.429%
RPD of Mean and Median	0.174%
90th Percentile (cpm)	4,720
95th Percentile (cpm)	4,780
99th Percentile (cpm)	4,830

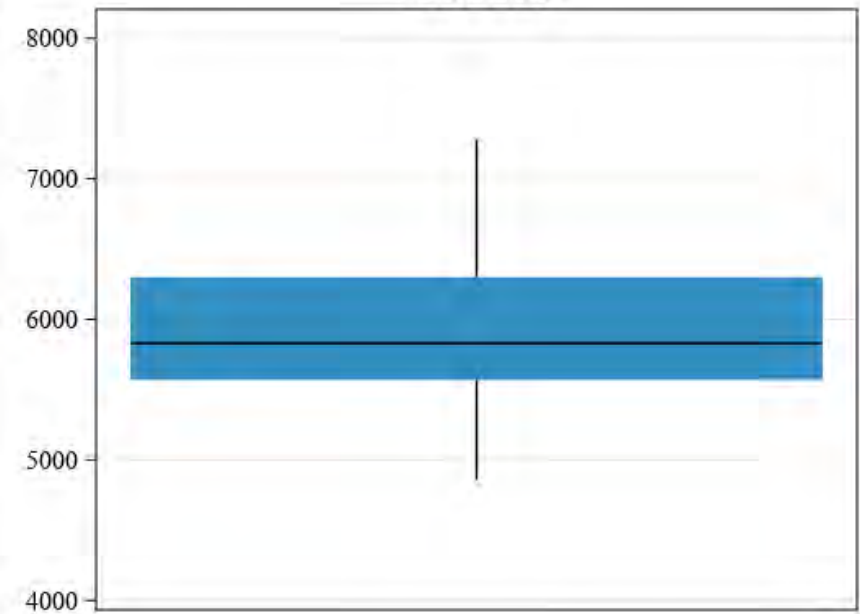
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR12 Type: Shielded

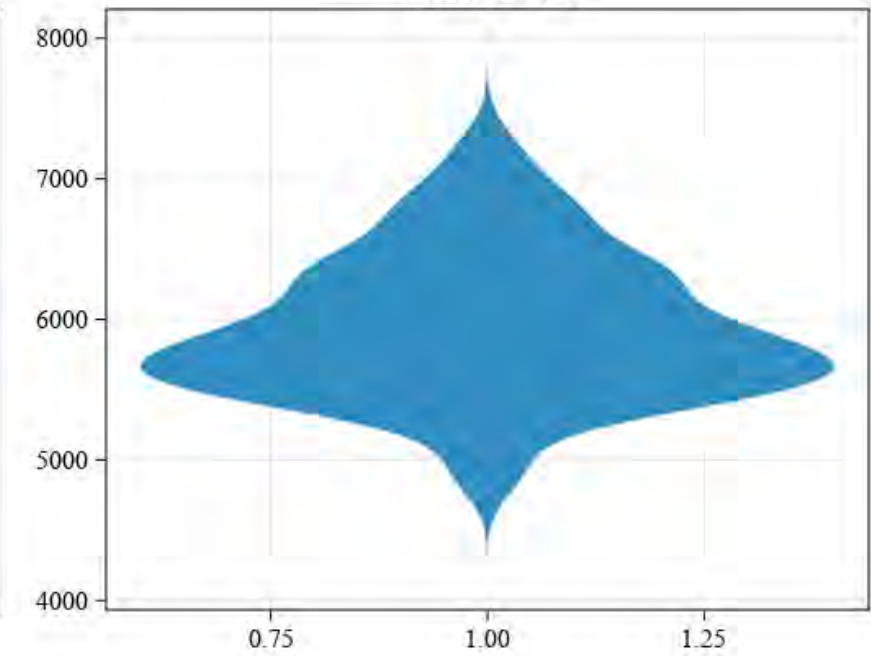
Individual Value Plot



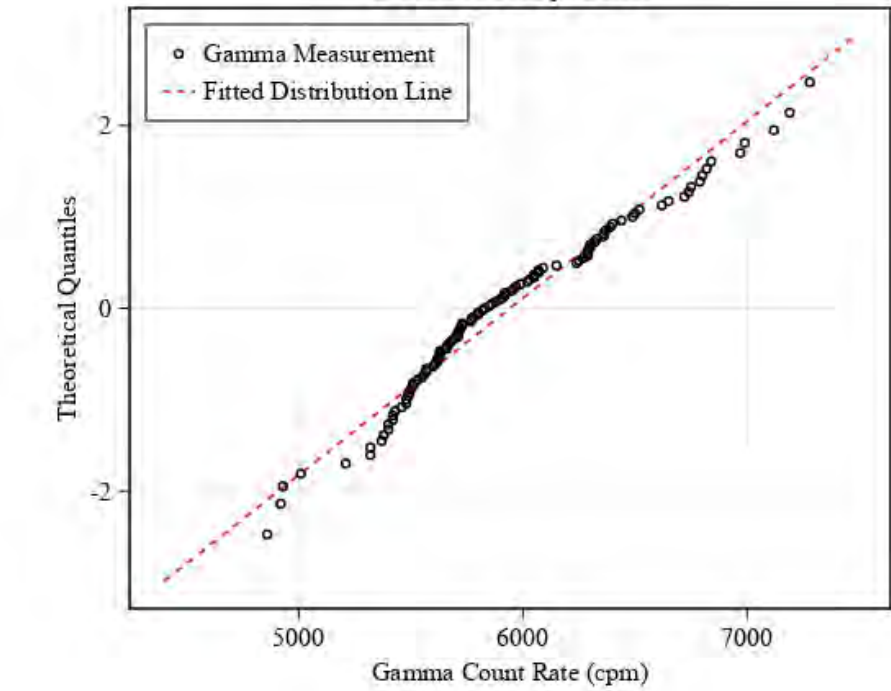
Box Plot



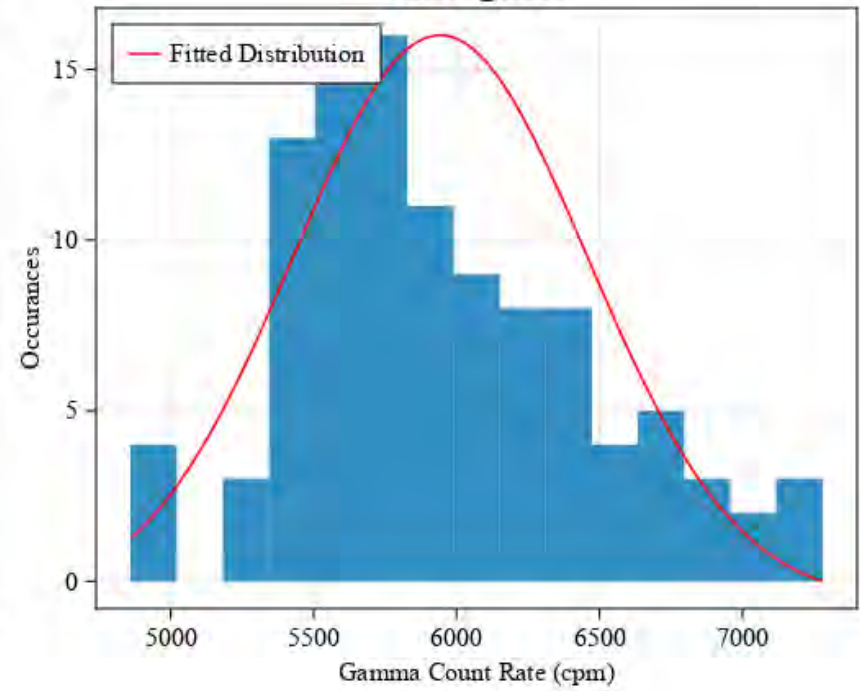
Violin Plot



Probability Plot



Histogram

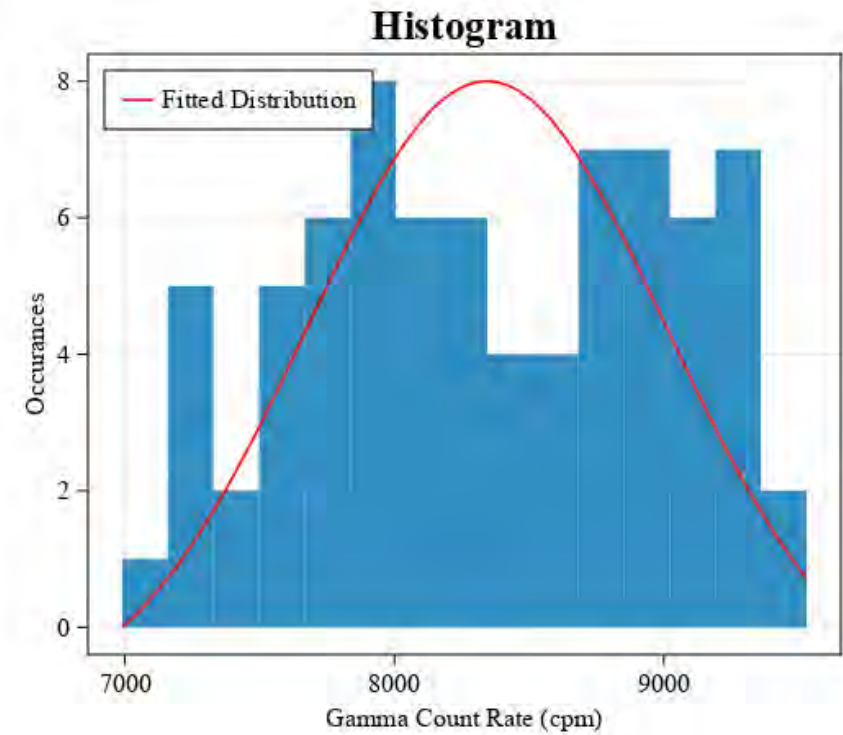
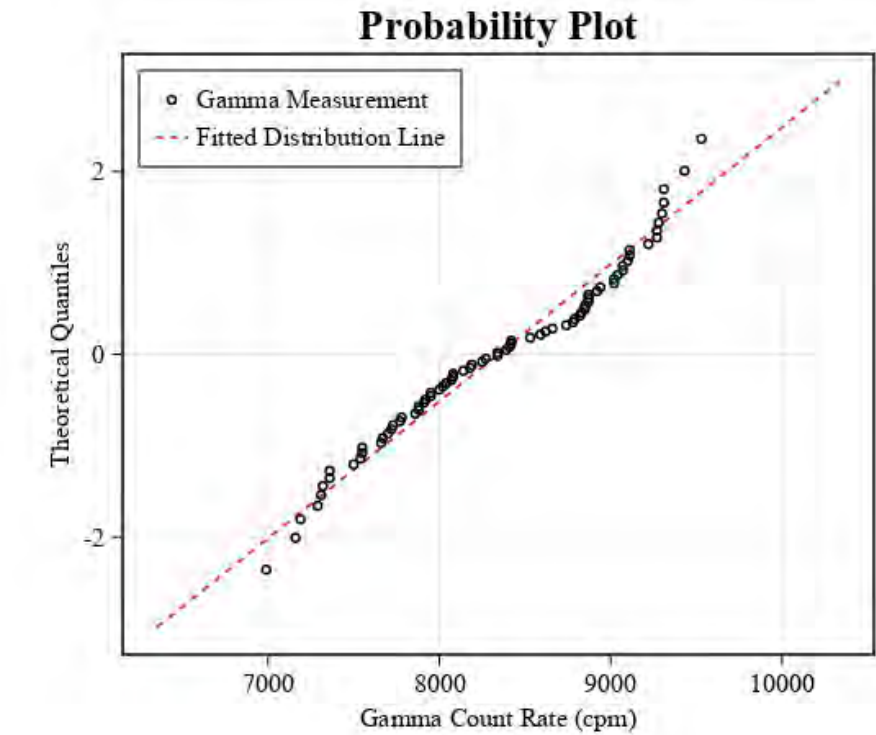
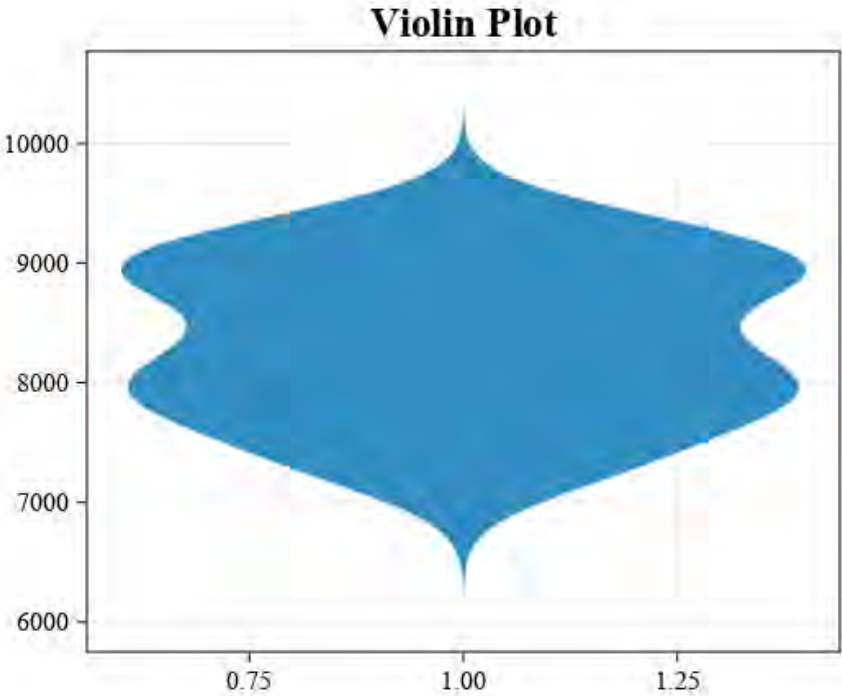
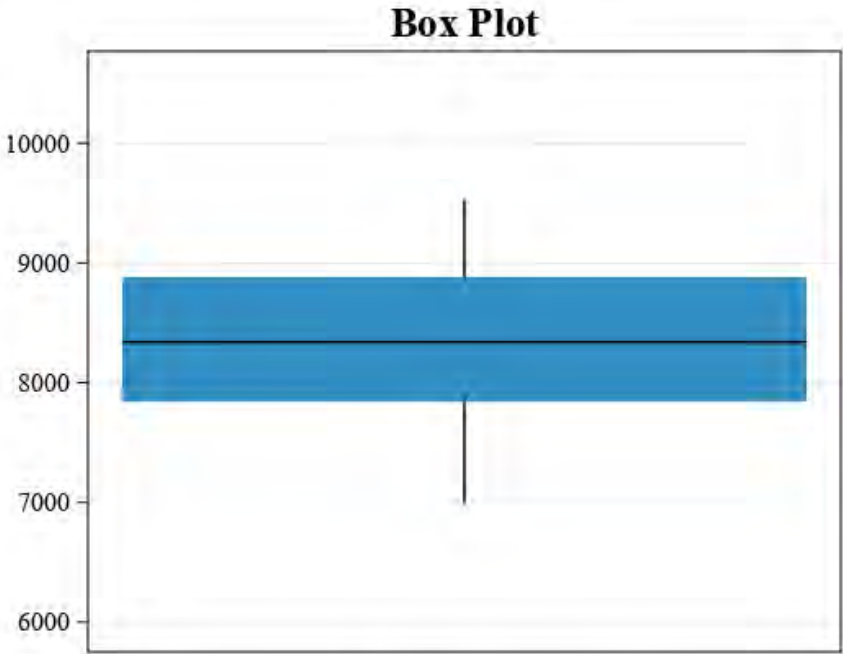
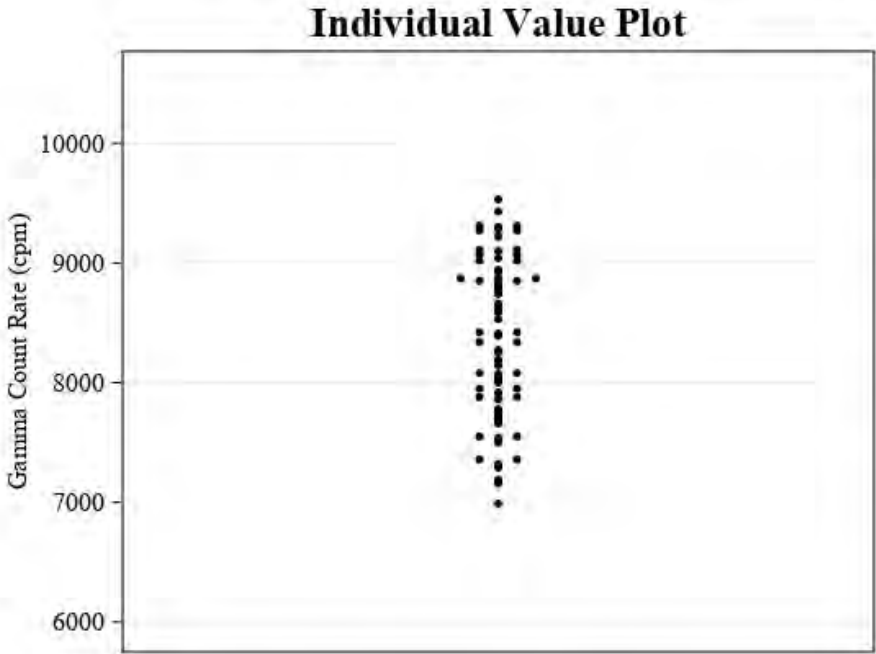


Summary Statistics

Count (n)	105
Minimum (cpm)	4,860
Maximum (cpm)	7,280
Average (cpm)	5,943
Median (cpm)	5,830
Standard Deviation (cpm)	516
Relative Standard Deviation	8.686%
RPD of Mean and Median	1.92%
90th Percentile (cpm)	6,740
95th Percentile (cpm)	6,840
99th Percentile (cpm)	7,190

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR13 Type: Shielded

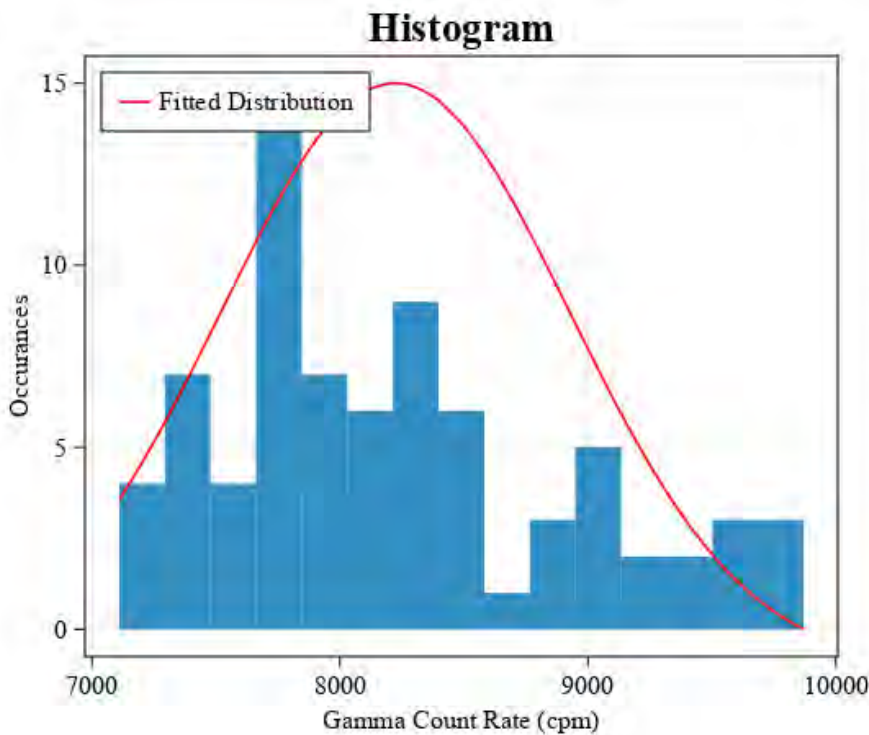
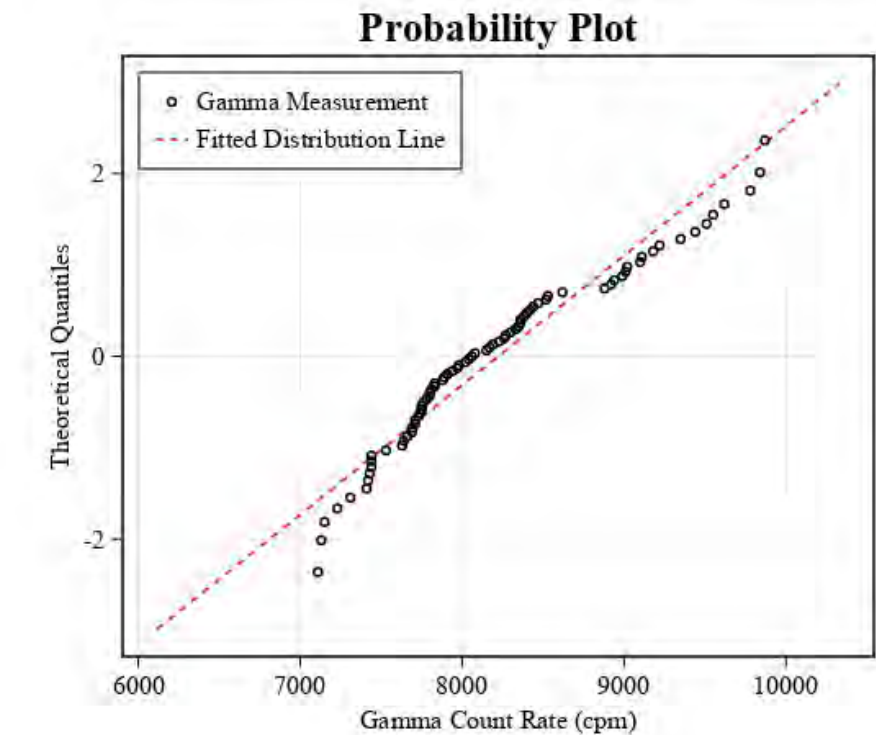
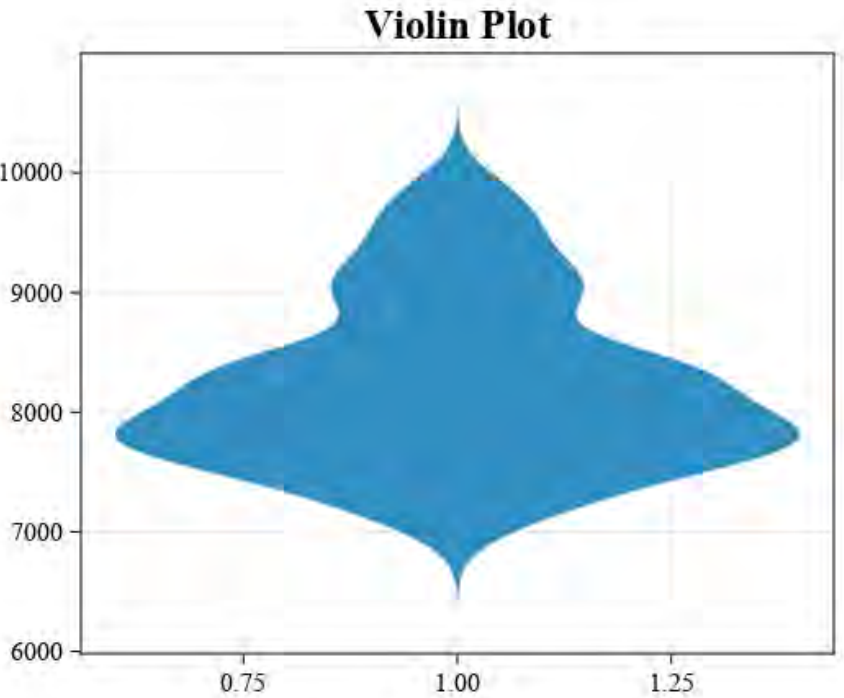
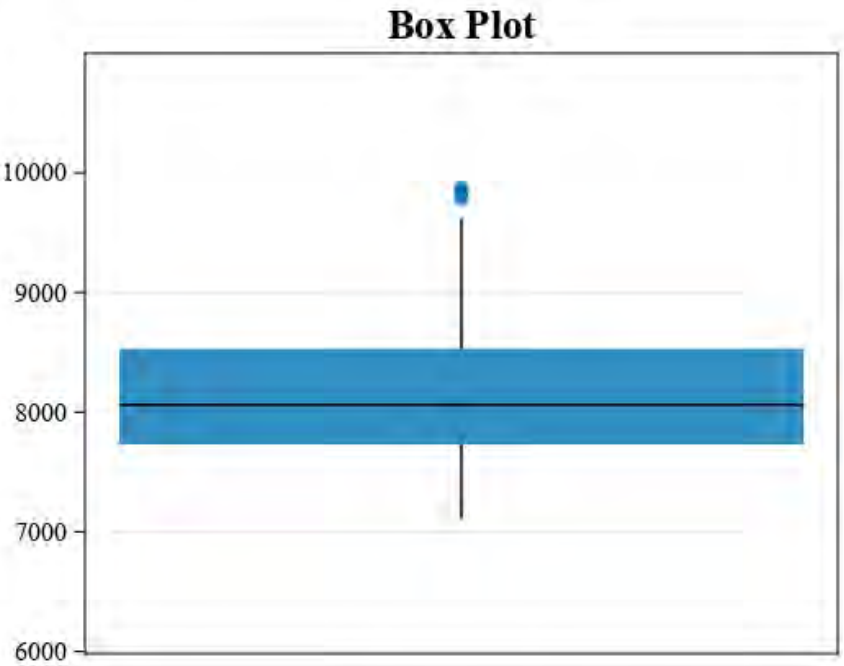
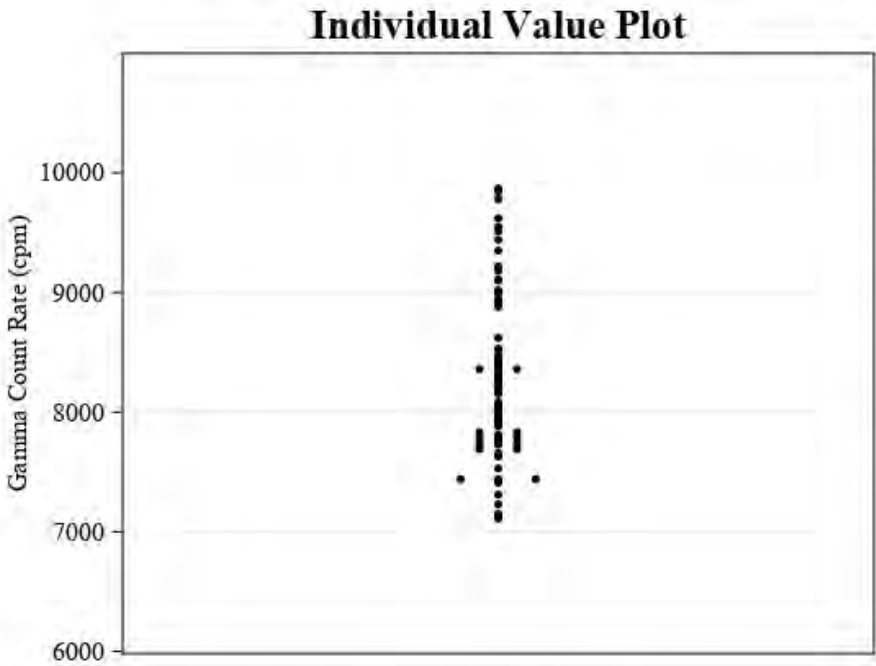


Summary Statistics

Count (n)	76
Minimum (cpm)	6,990
Maximum (cpm)	9,530
Average (cpm)	8,344
Median (cpm)	8,340
Standard Deviation (cpm)	667
Relative Standard Deviation	7.99%
RPD of Mean and Median	0.046%
90th Percentile (cpm)	9,270
95th Percentile (cpm)	9,310
99th Percentile (cpm)	9,530

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR14 Type: Shielded

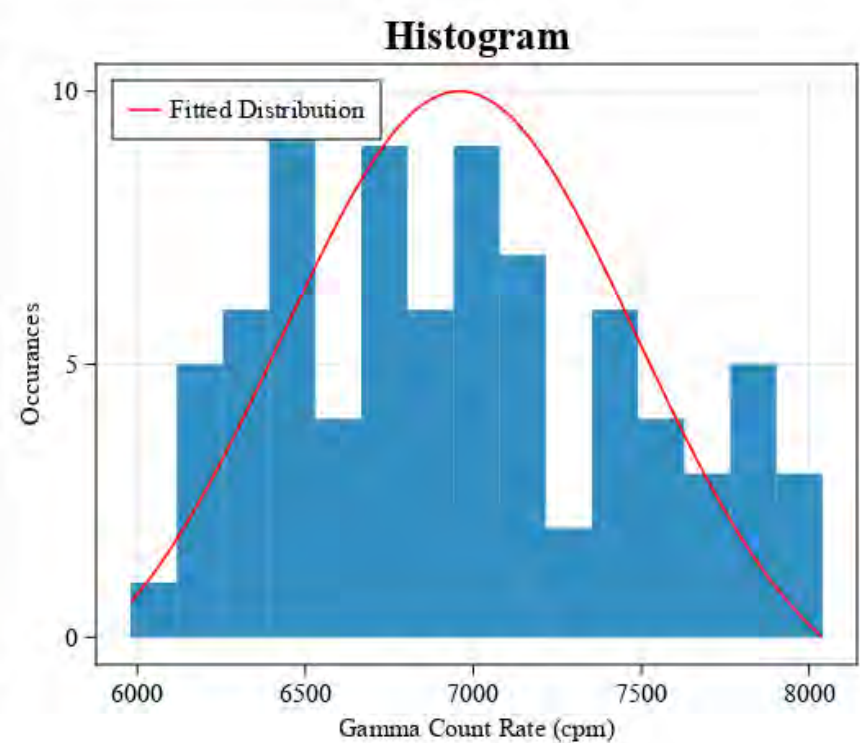
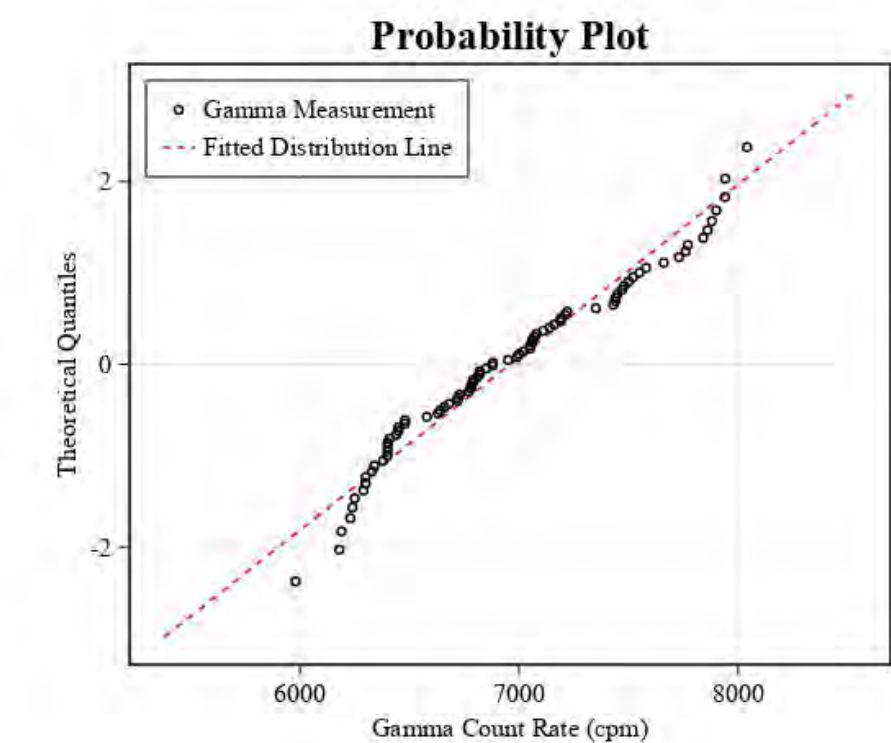
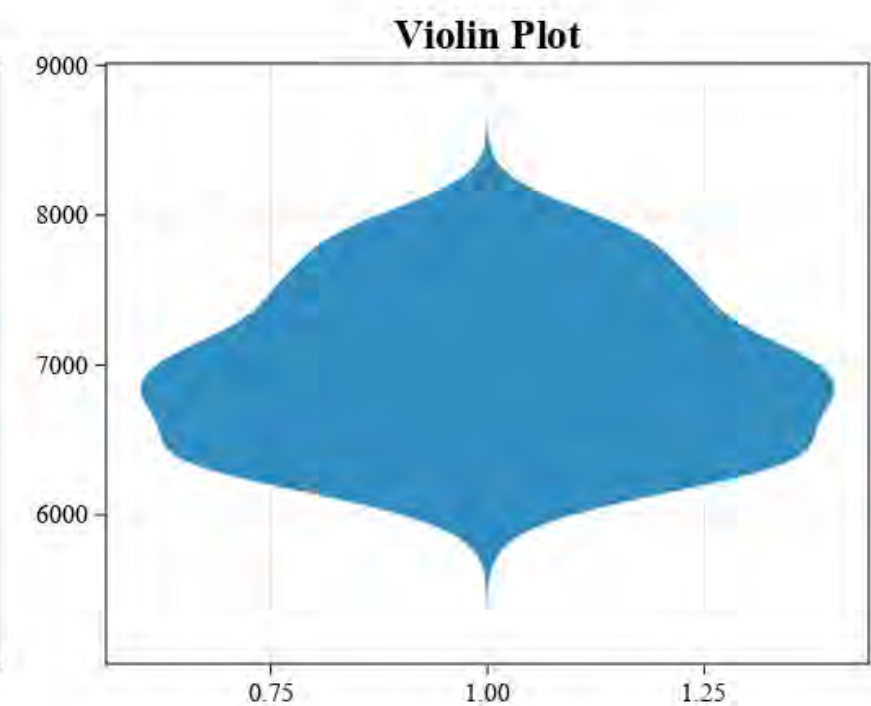
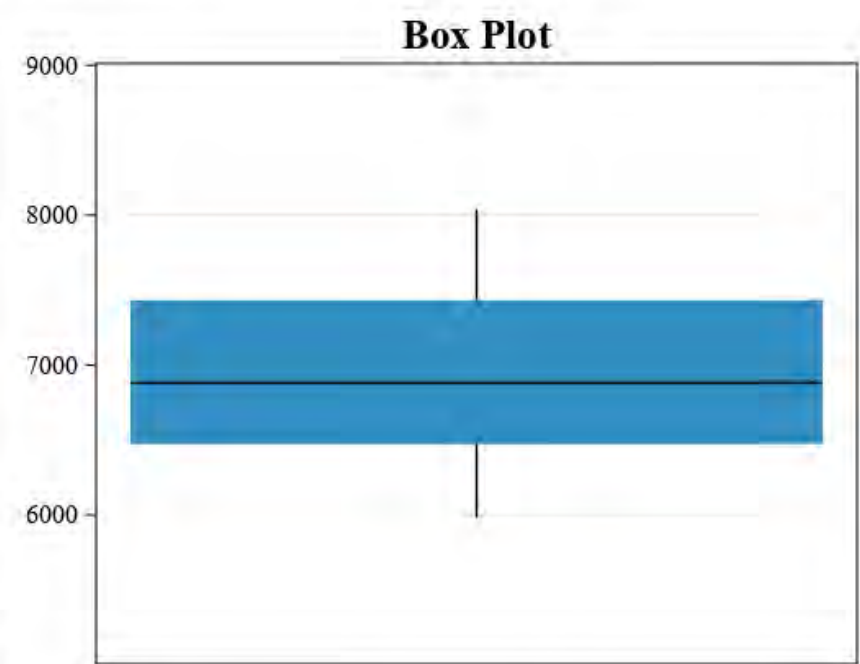
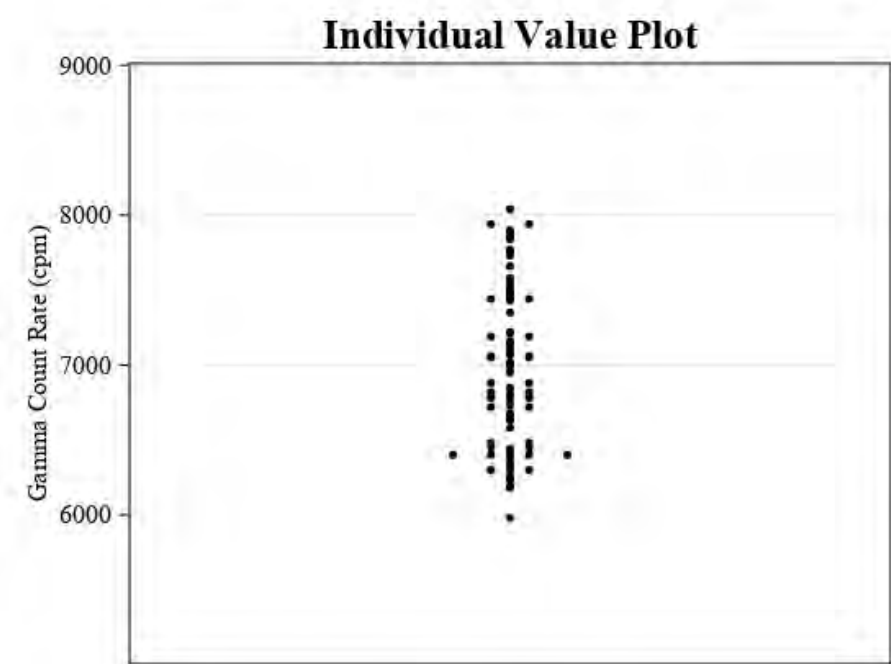


Summary Statistics

Count (n)	77
Minimum (cpm)	7,110
Maximum (cpm)	9,870
Average (cpm)	8,223
Median (cpm)	8,060
Standard Deviation (cpm)	705
Relative Standard Deviation	8.579%
RPD of Mean and Median	2.007%
90th Percentile (cpm)	9,350
95th Percentile (cpm)	9,620
99th Percentile (cpm)	9,870

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR15 Type: Shielded



Summary Statistics

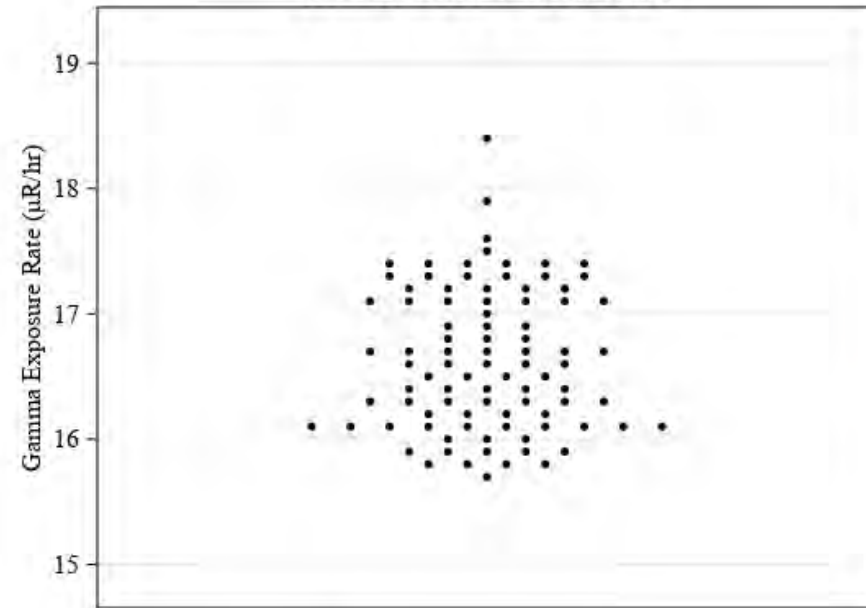
Count (n)	80
Minimum (cpm)	5,980
Maximum (cpm)	8,040
Average (cpm)	6,959
Median (cpm)	6,880
Standard Deviation (cpm)	528
Relative Standard Deviation	7.587%
RPD of Mean and Median	1.143%
90th Percentile (cpm)	7,770
95th Percentile (cpm)	7,900
99th Percentile (cpm)	8,040

ATTACHMENT E-5: CORRELATION PLOT STATISTICS – EXPOSURE RATE

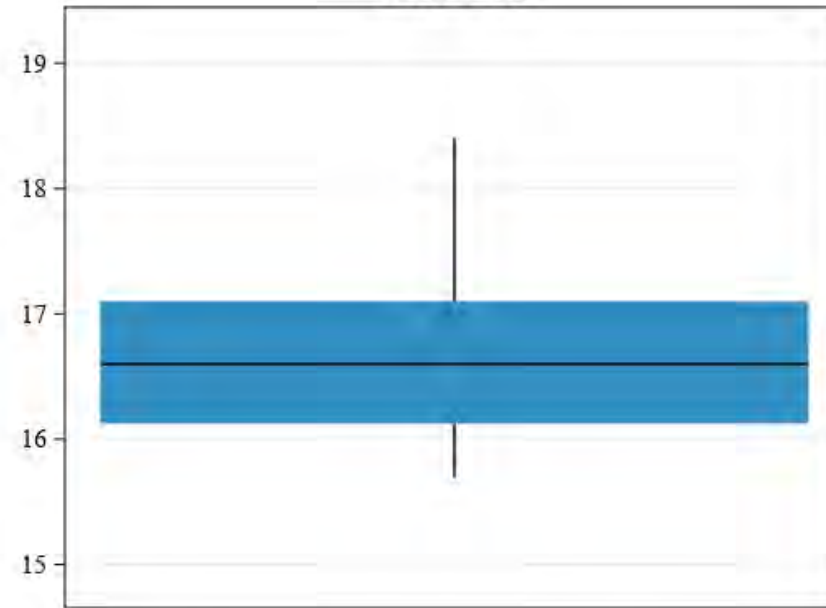
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR01 Type: High Pressure Ionization Chamber

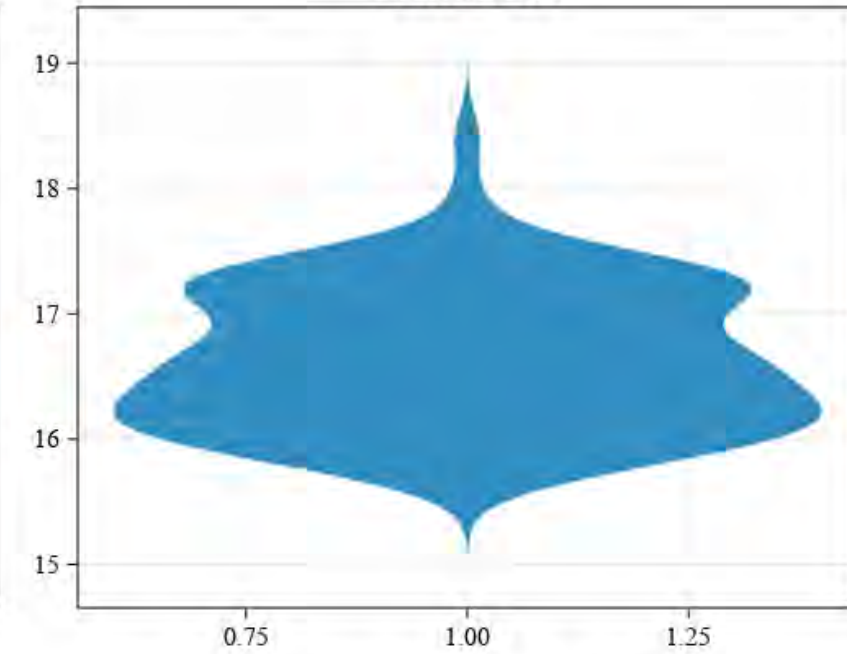
Individual Value Plot



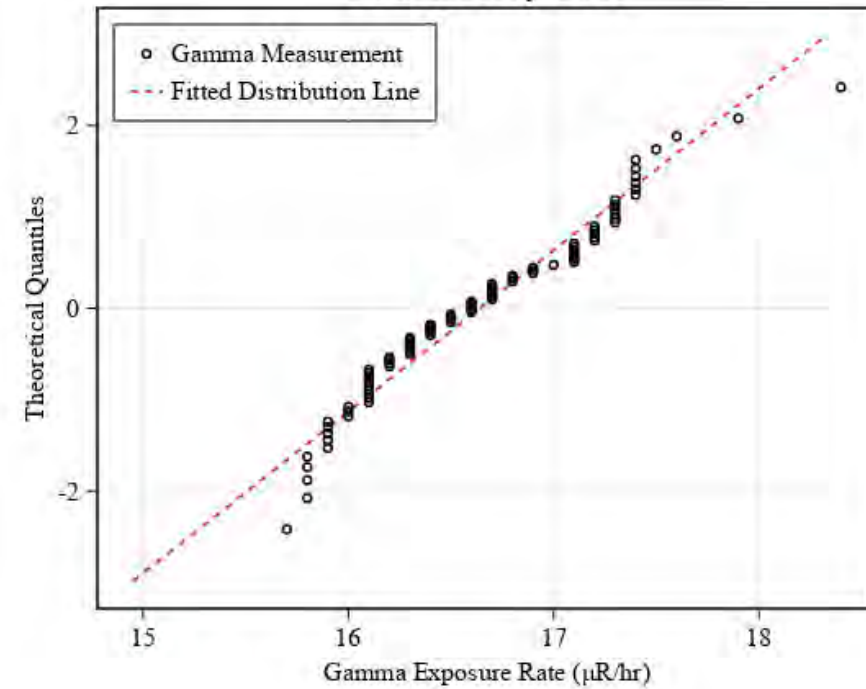
Box Plot



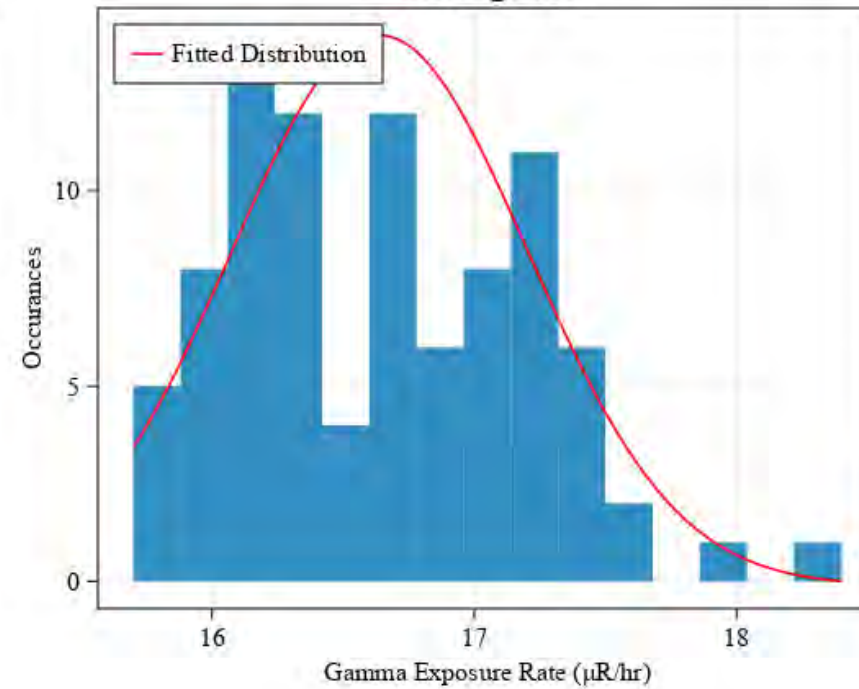
Violin Plot



Probability Plot



Histogram



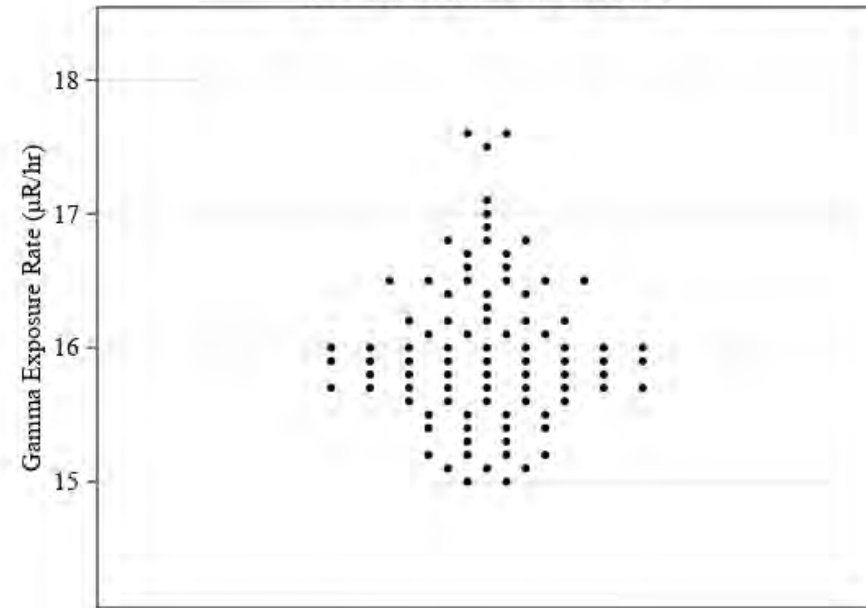
Summary Statistics

Count (n)	90
Minimum (µR/hr)	15.7
Maximum (µR/hr)	18.4
Average (µR/hr)	16.6
Median (µR/hr)	16.6
Standard Deviation (µR/hr)	0.57
Relative Standard Deviation	3.398%
RPD of Mean and Median	0.241%
90th Percentile (µR/hr)	17.4
95th Percentile (µR/hr)	17.4
99th Percentile (µR/hr)	18.4

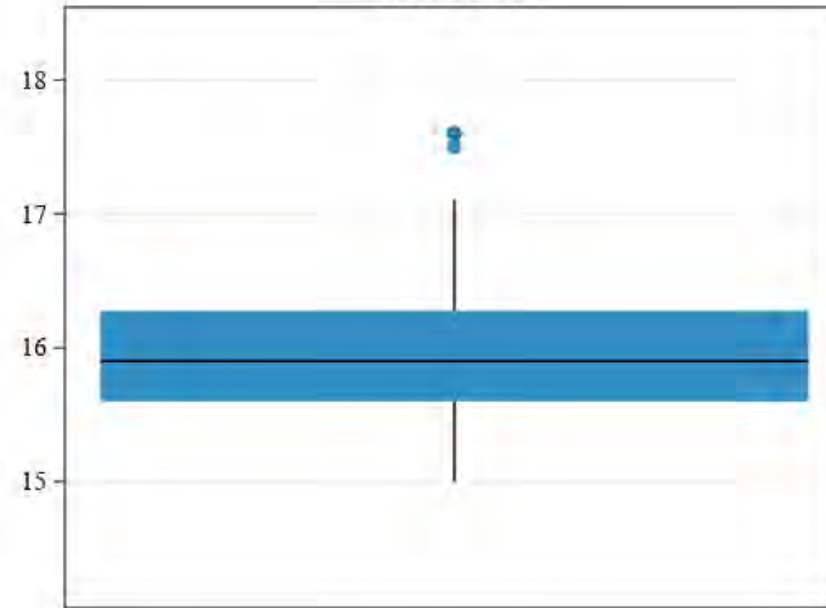
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR02 Type: High Pressure Ionization Chamber

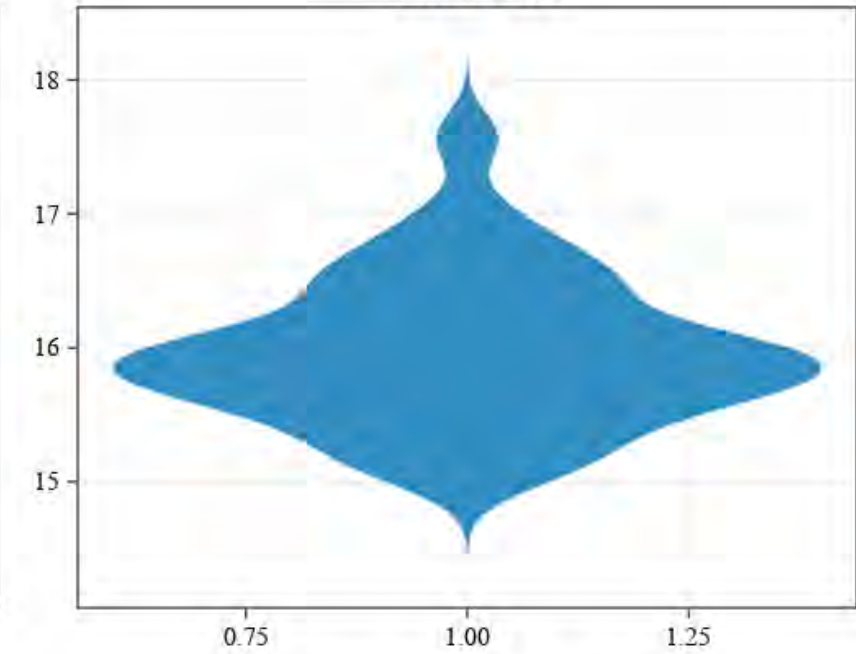
Individual Value Plot



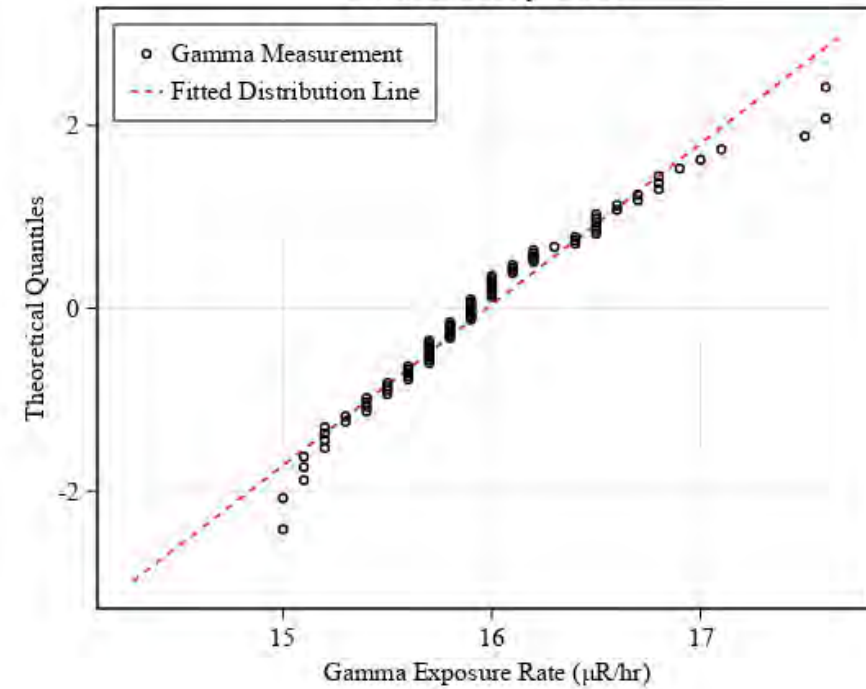
Box Plot



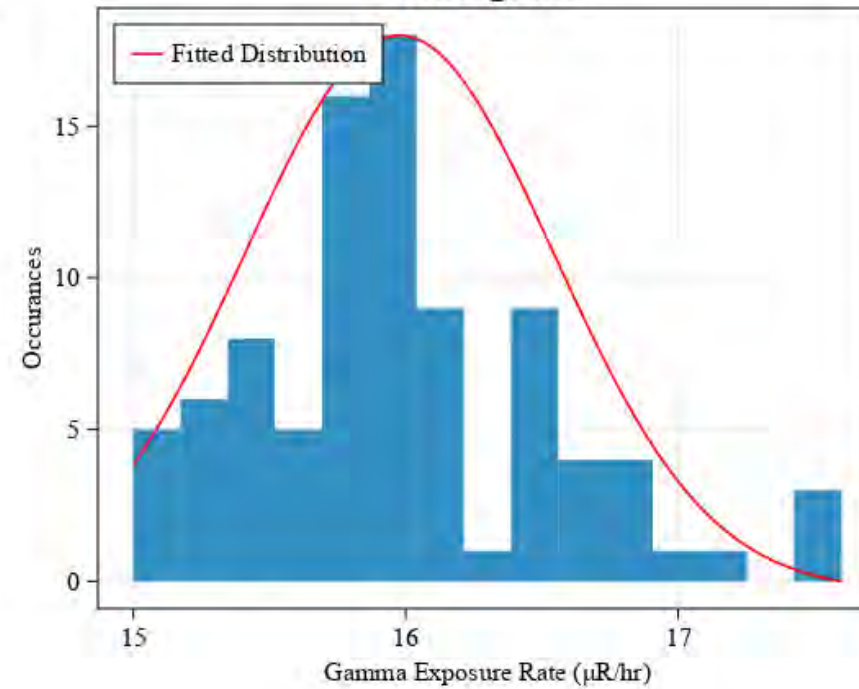
Violin Plot



Probability Plot



Histogram



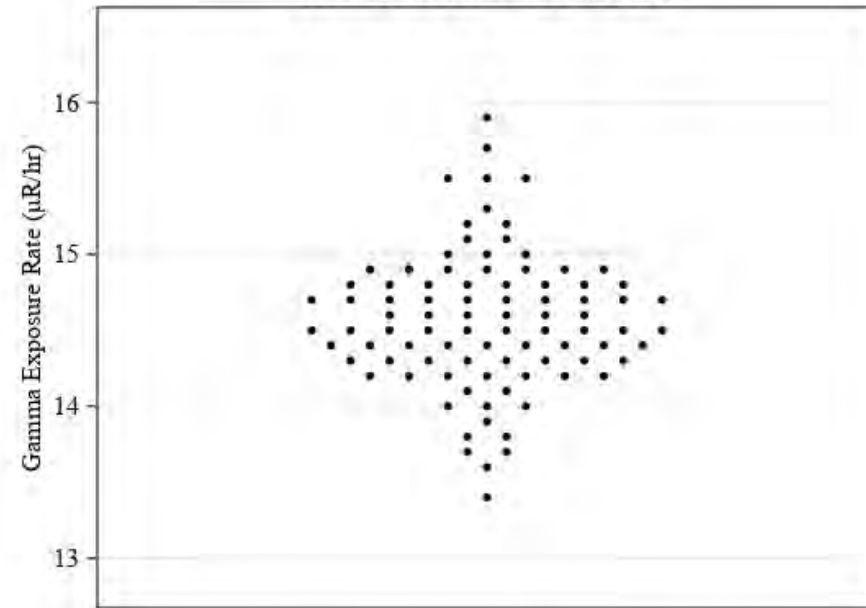
Summary Statistics

Count (n)	90
Minimum (µR/hr)	15.0
Maximum (µR/hr)	17.6
Average (µR/hr)	16.0
Median (µR/hr)	15.9
Standard Deviation (µR/hr)	0.57
Relative Standard Deviation	3.552%
RPD of Mean and Median	0.481%
90th Percentile (µR/hr)	16.7
95th Percentile (µR/hr)	17.0
99th Percentile (µR/hr)	17.6

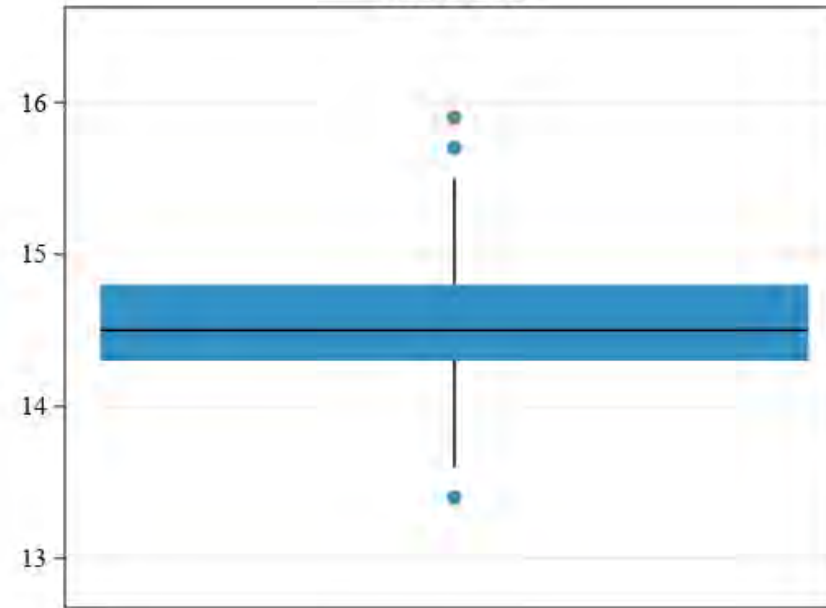
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR03 Type: High Pressure Ionization Chamber

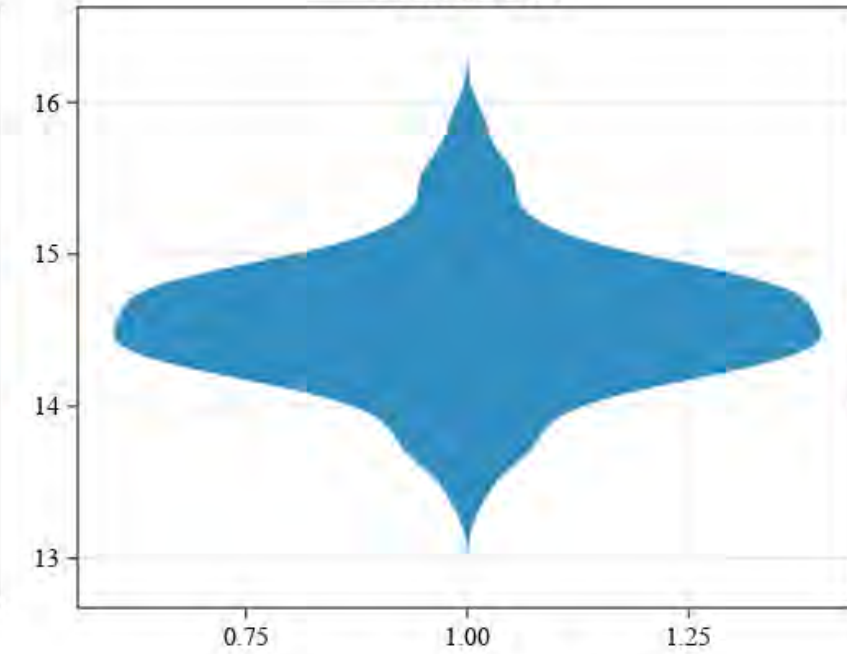
Individual Value Plot



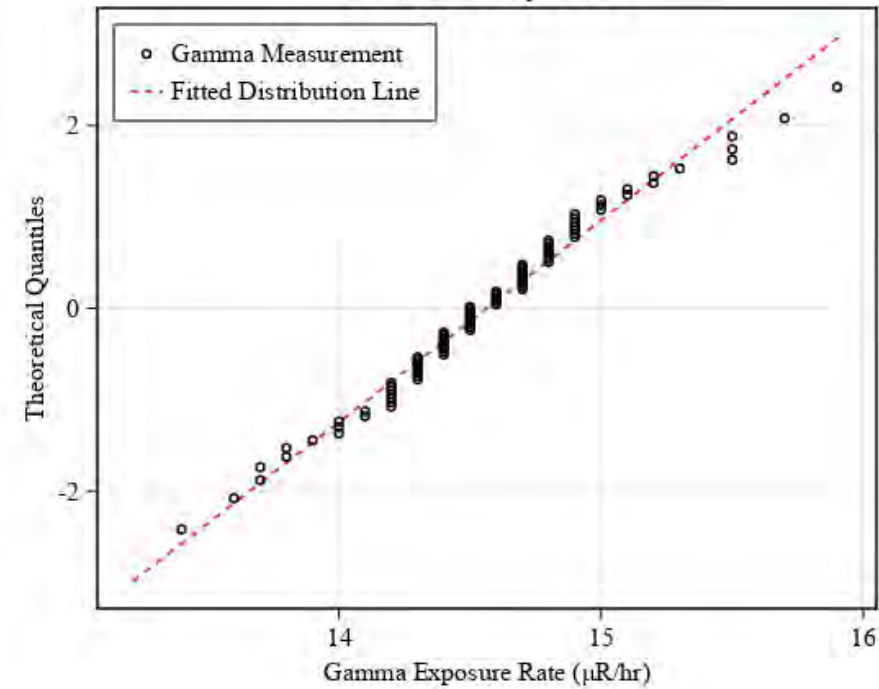
Box Plot



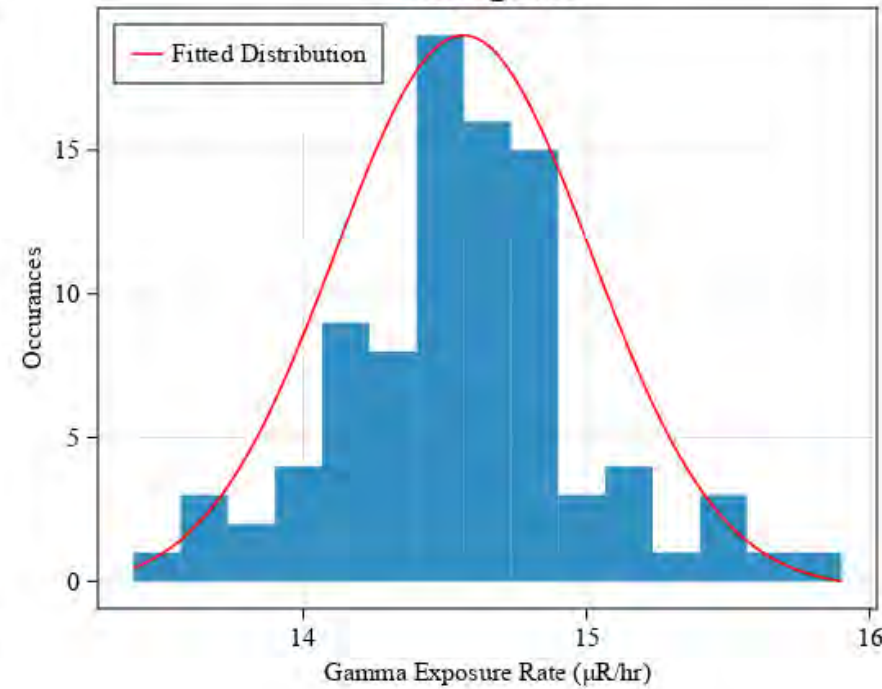
Violin Plot



Probability Plot



Histogram



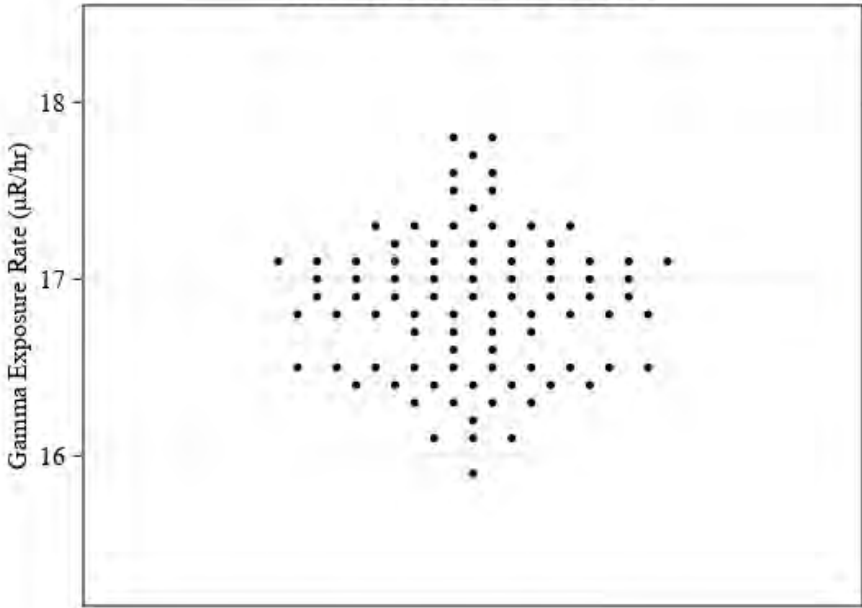
Summary Statistics

Count (n)	90
Minimum (µR/hr)	13.4
Maximum (µR/hr)	15.9
Average (µR/hr)	14.6
Median (µR/hr)	14.5
Standard Deviation (µR/hr)	0.45
Relative Standard Deviation	3.102%
RPD of Mean and Median	0.443%
90th Percentile (µR/hr)	15.1
95th Percentile (µR/hr)	15.5
99th Percentile (µR/hr)	15.9

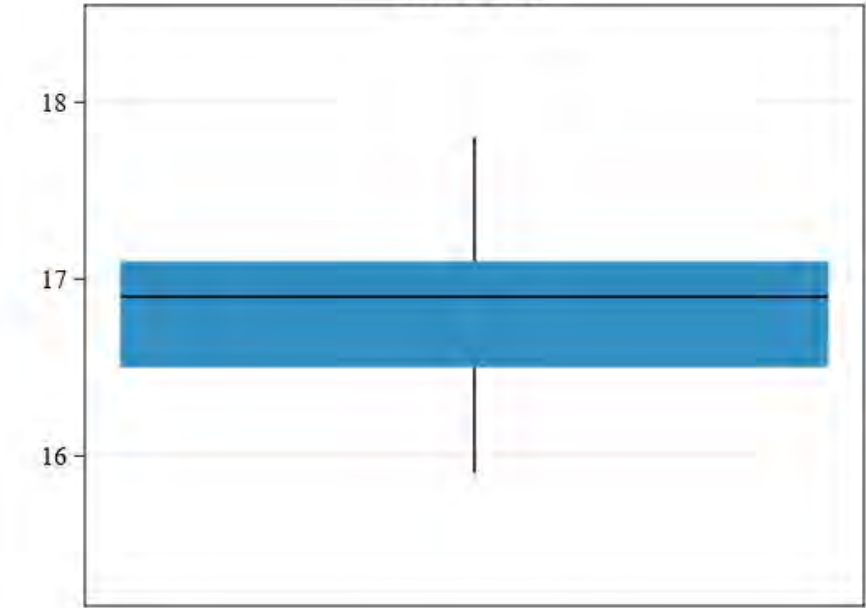
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR04 Type: High Pressure Ionization Chamber

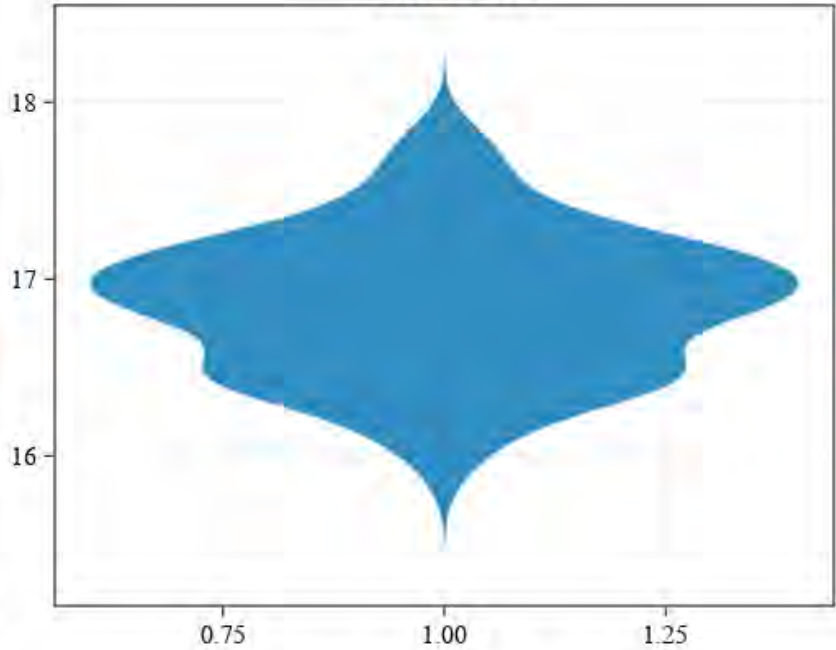
Individual Value Plot



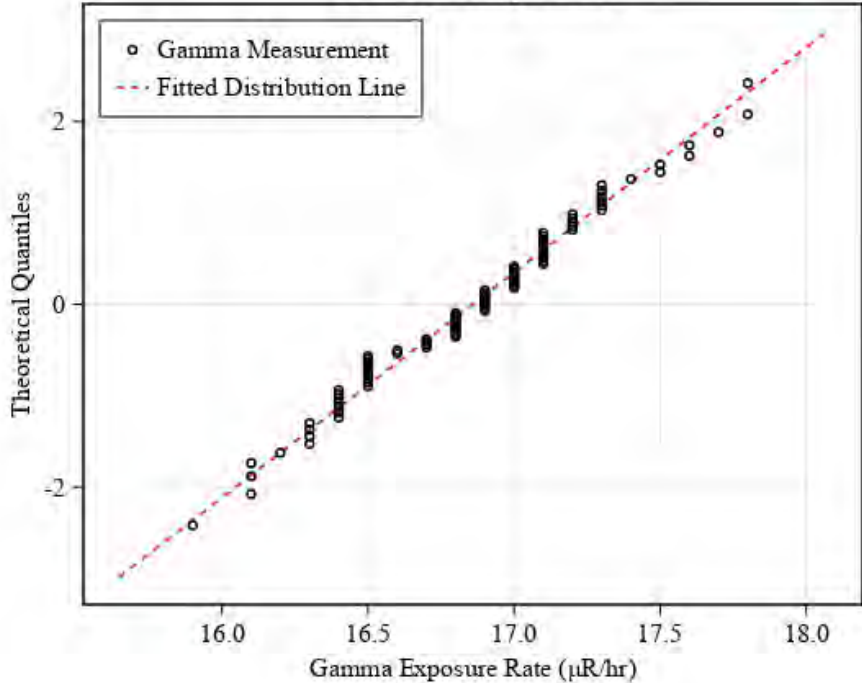
Box Plot



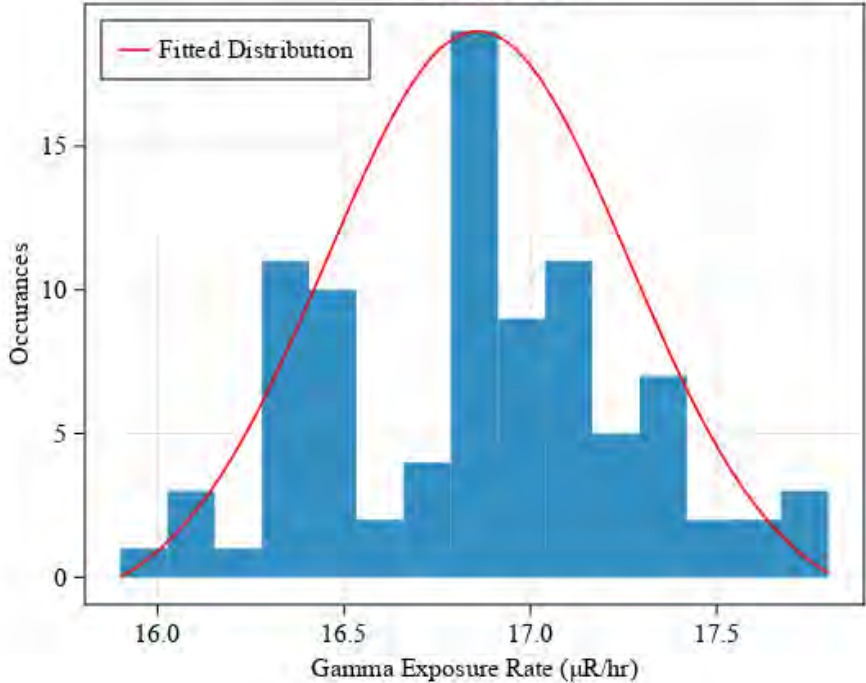
Violin Plot



Probability Plot



Histogram

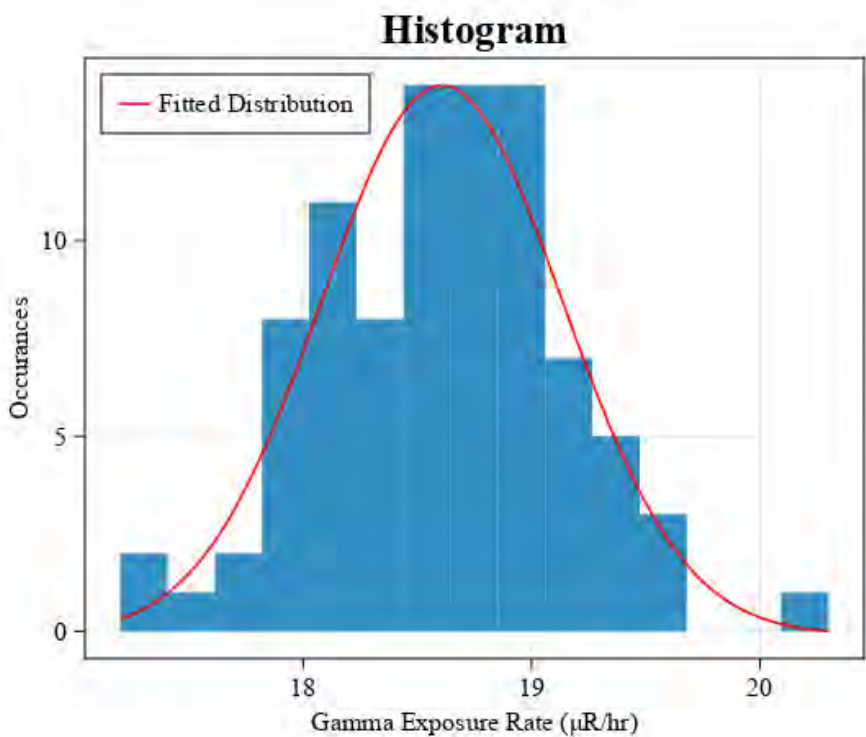
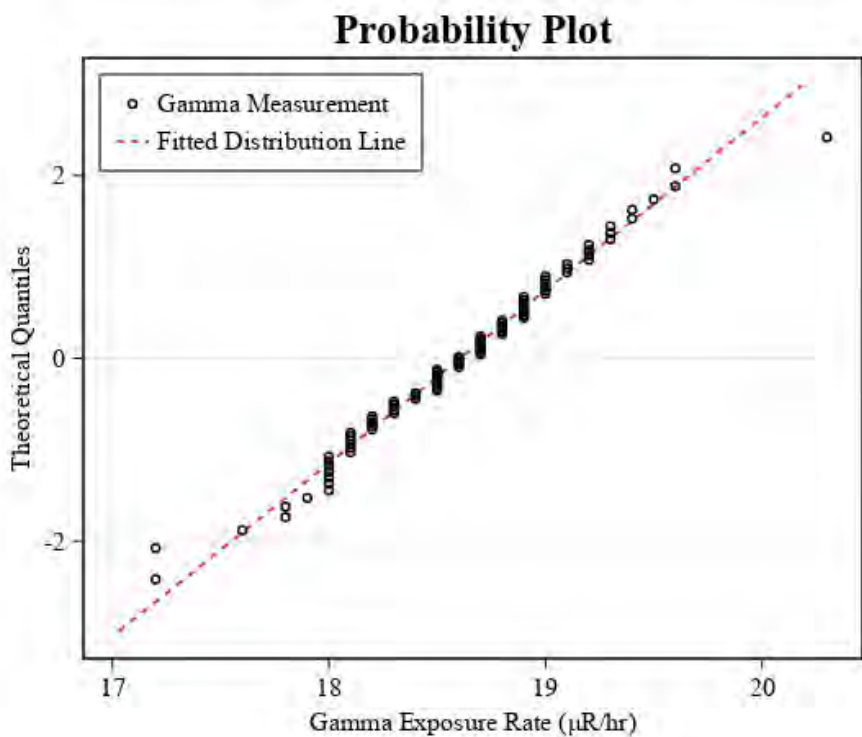
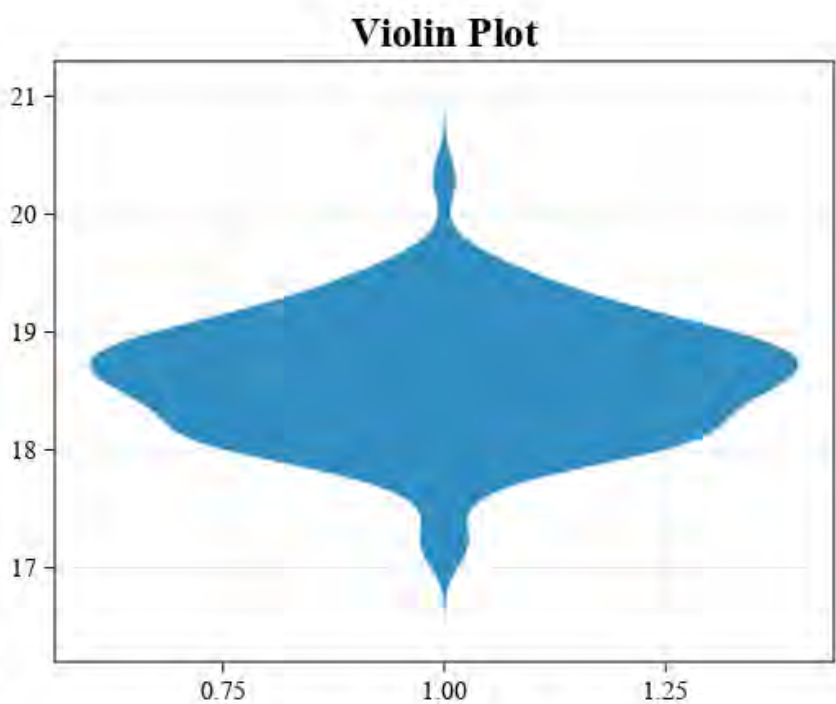
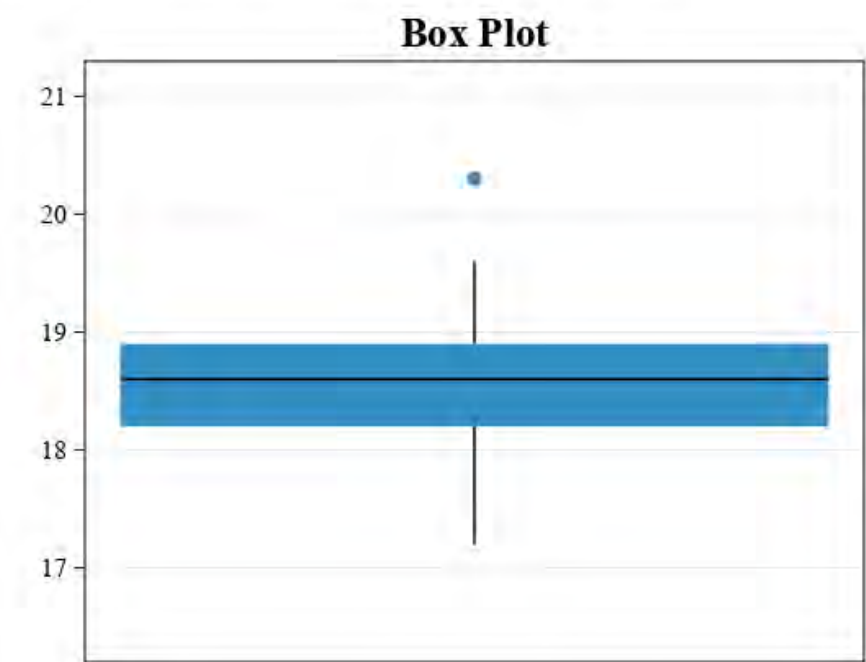
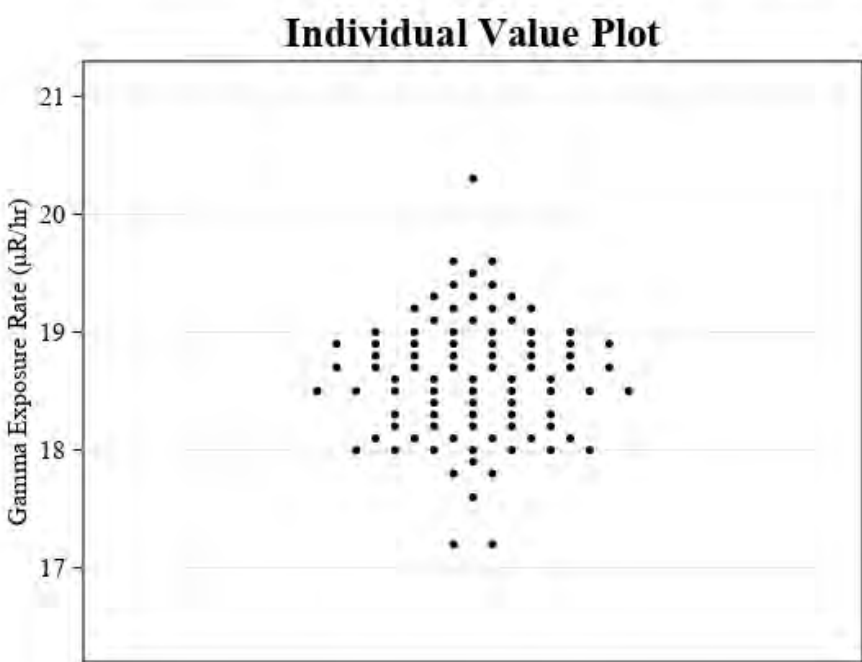


Summary Statistics

Count (n)	90
Minimum (µR/hr)	15.9
Maximum (µR/hr)	17.8
Average (µR/hr)	16.9
Median (µR/hr)	16.9
Standard Deviation (µR/hr)	0.41
Relative Standard Deviation	2.406%
RPD of Mean and Median	0.244%
90th Percentile (µR/hr)	17.3
95th Percentile (µR/hr)	17.6
99th Percentile (µR/hr)	17.8

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR05 Type: High Pressure Ionization Chamber

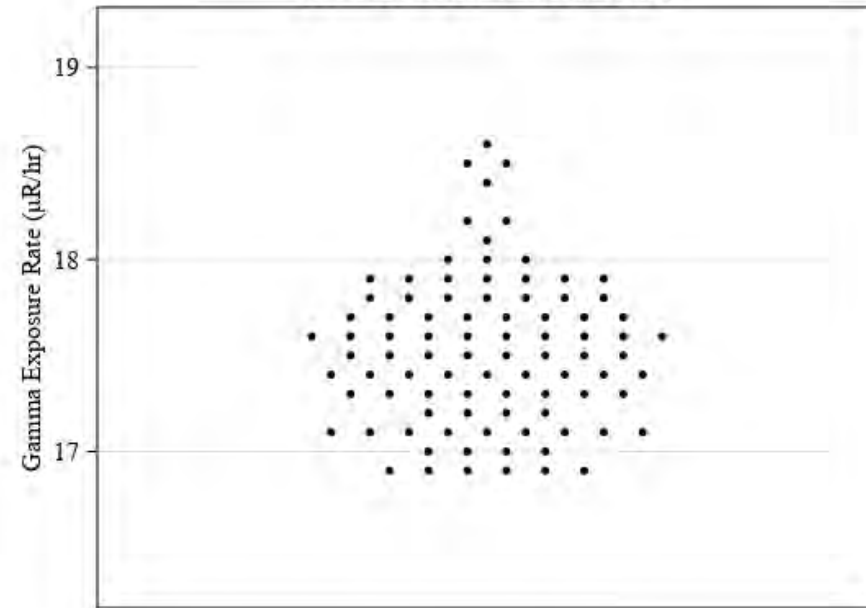


Summary Statistics	
Count (n)	90
Minimum (µR/hr)	17.2
Maximum (µR/hr)	20.3
Average (µR/hr)	18.6
Median (µR/hr)	18.6
Standard Deviation (µR/hr)	0.53
Relative Standard Deviation	2.837%
RPD of Mean and Median	0.042%
90th Percentile (µR/hr)	19.3
95th Percentile (µR/hr)	19.4
99th Percentile (µR/hr)	20.3

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR06 Type: High Pressure Ionization Chamber

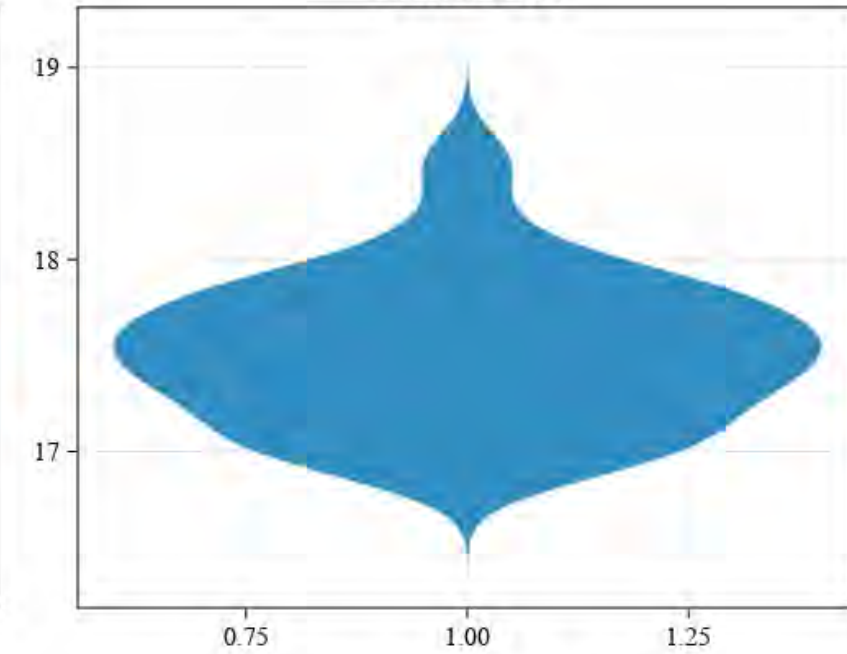
Individual Value Plot



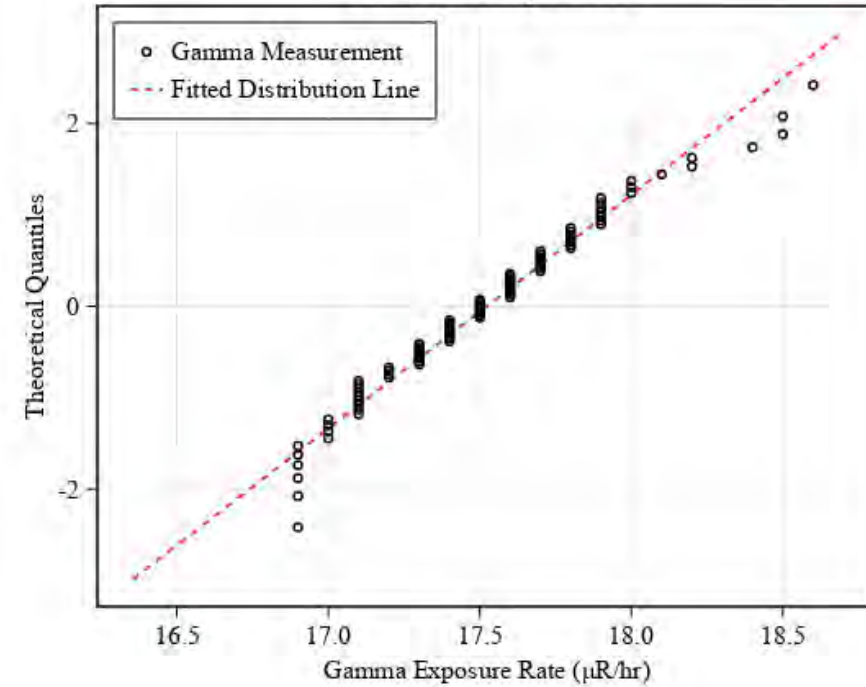
Box Plot



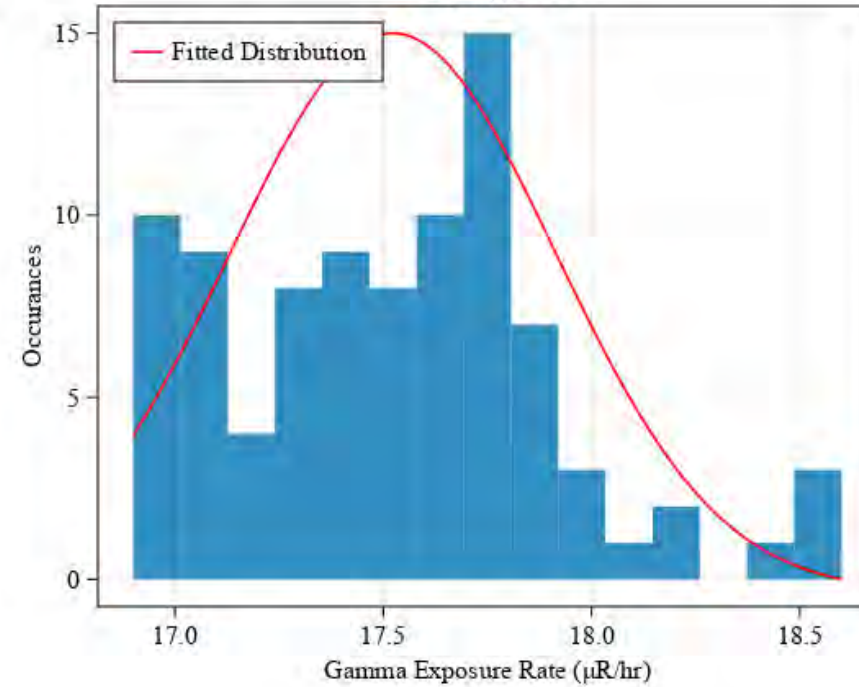
Violin Plot



Probability Plot



Histogram

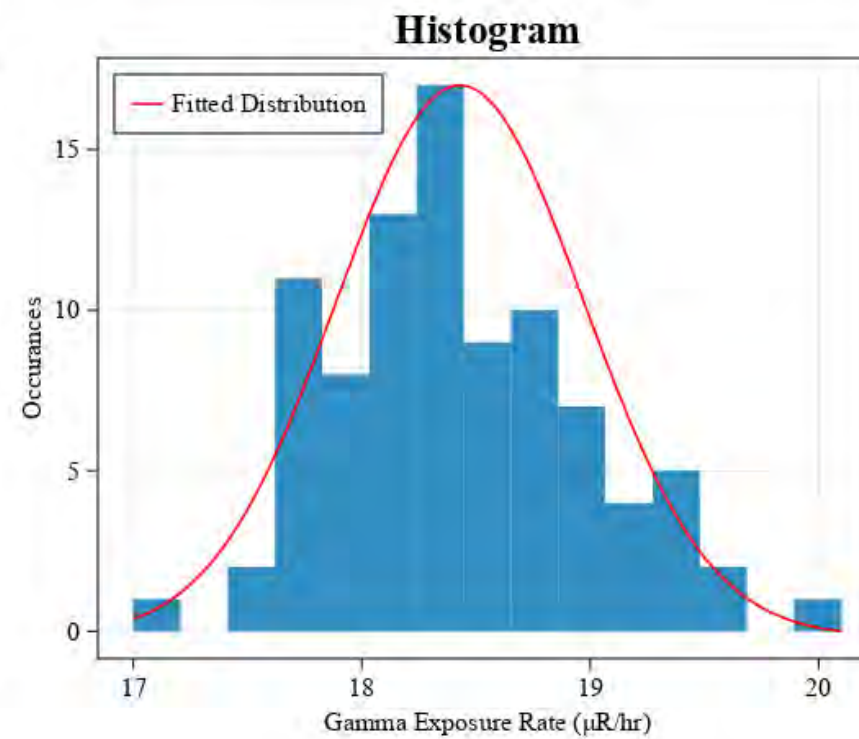
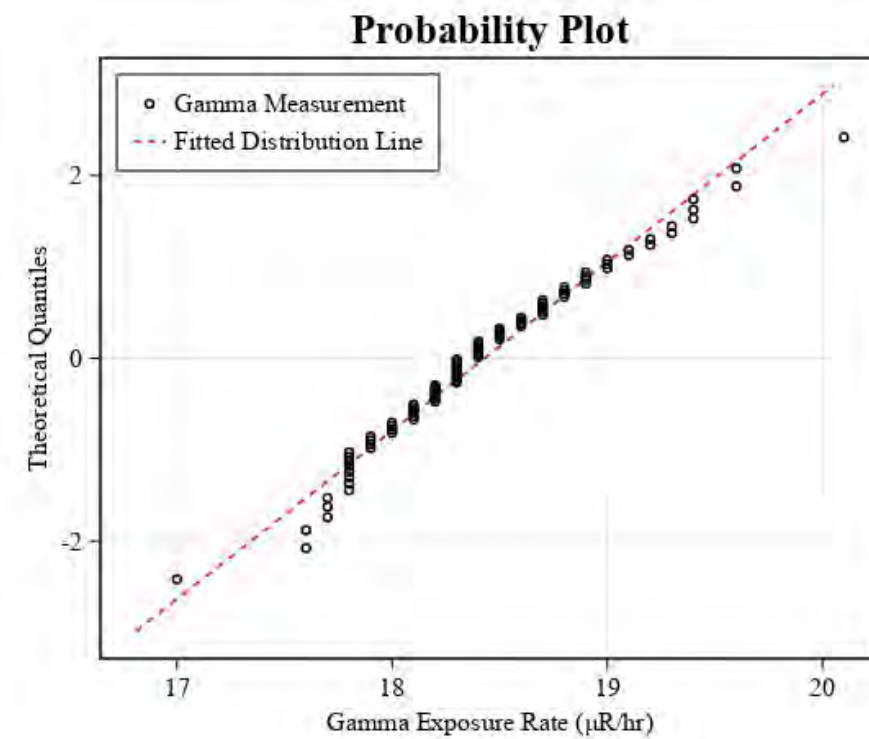
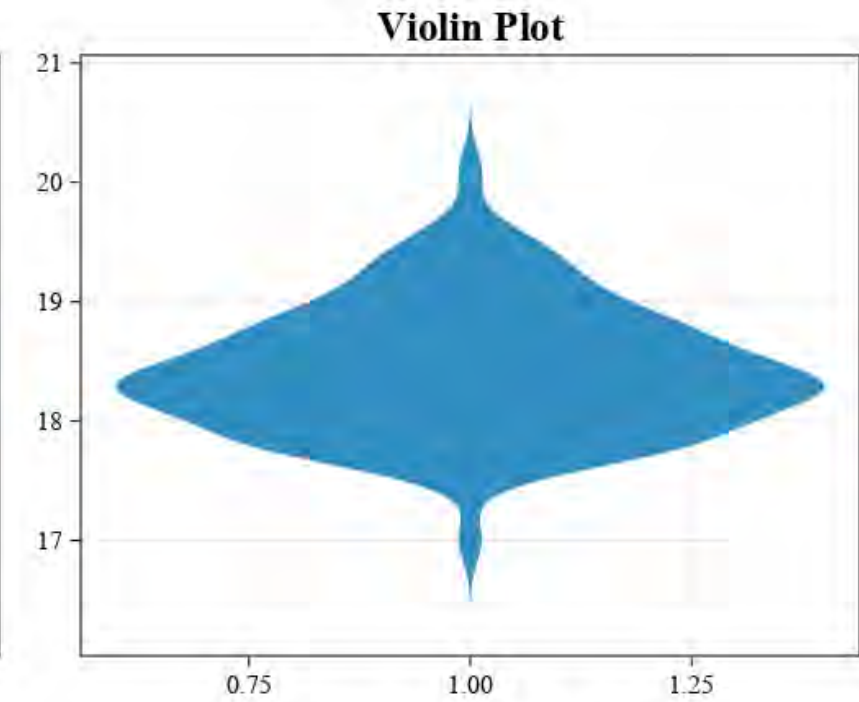
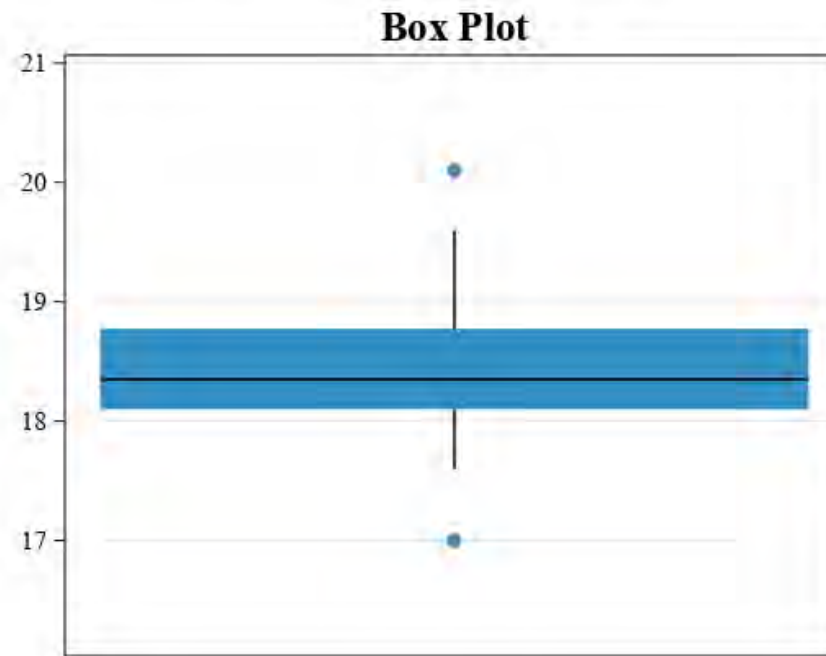
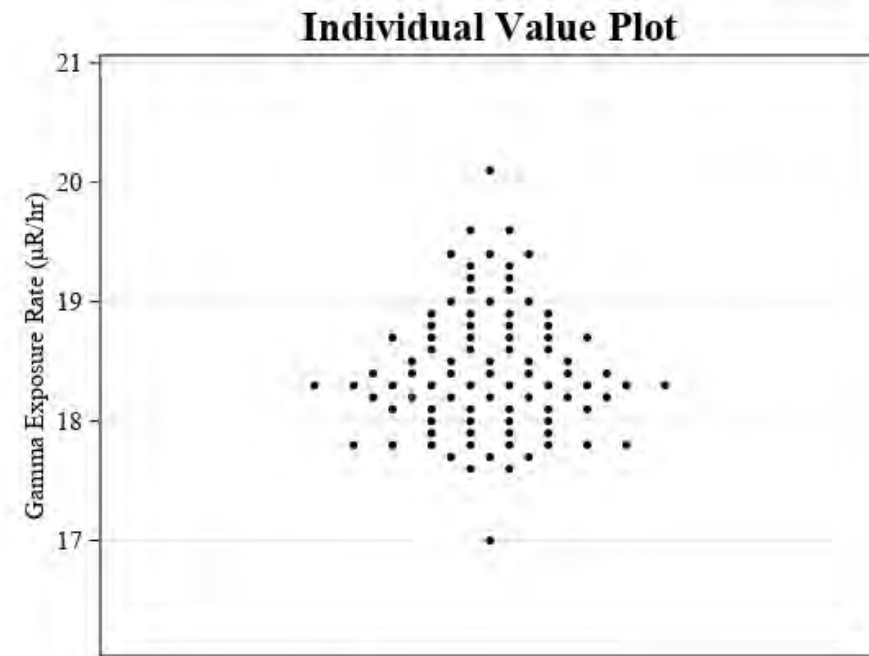


Summary Statistics

Count (n)	90
Minimum (µR/hr)	16.9
Maximum (µR/hr)	18.6
Average (µR/hr)	17.5
Median (µR/hr)	17.5
Standard Deviation (µR/hr)	0.39
Relative Standard Deviation	2.231%
RPD of Mean and Median	0.133%
90th Percentile (µR/hr)	18.0
95th Percentile (µR/hr)	18.2
99th Percentile (µR/hr)	18.6

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR07 Type: High Pressure Ionization Chamber



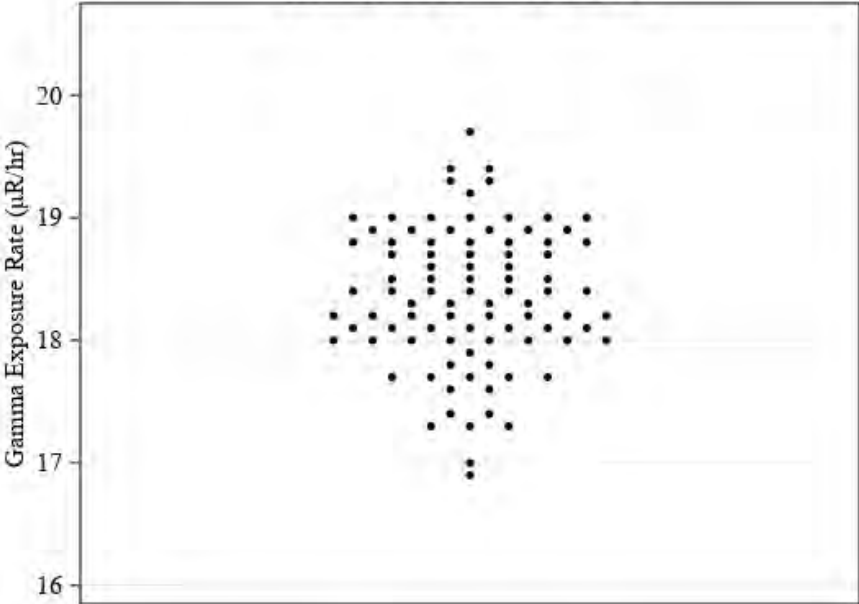
Summary Statistics

Count (n)	90
Minimum (µR/hr)	17.0
Maximum (µR/hr)	20.1
Average (µR/hr)	18.4
Median (µR/hr)	18.4
Standard Deviation (µR/hr)	0.54
Relative Standard Deviation	2.943%
RPD of Mean and Median	0.435%
90th Percentile (µR/hr)	19.2
95th Percentile (µR/hr)	19.4
99th Percentile (µR/hr)	20.1

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR08 Type: High Pressure Ionization Chamber

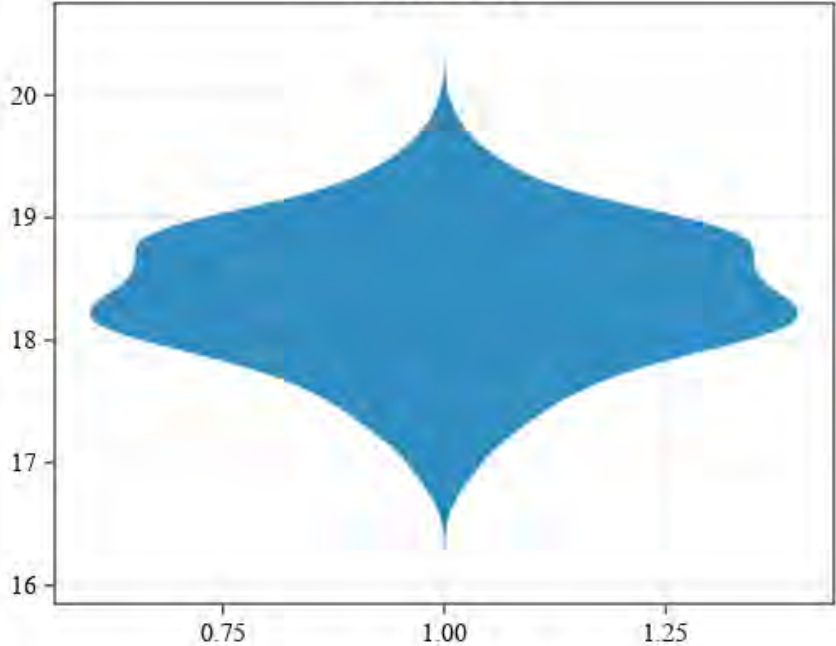
Individual Value Plot



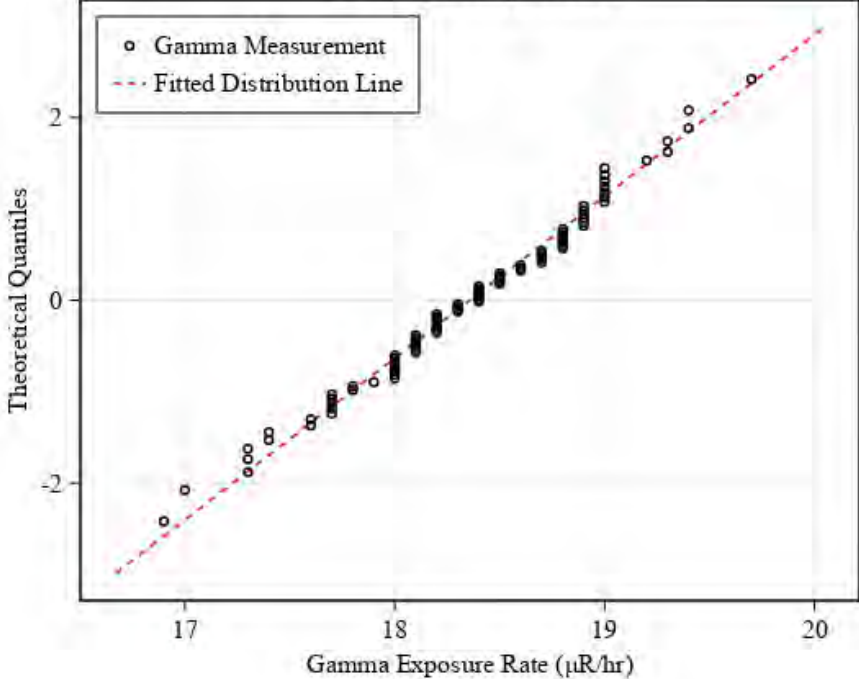
Box Plot



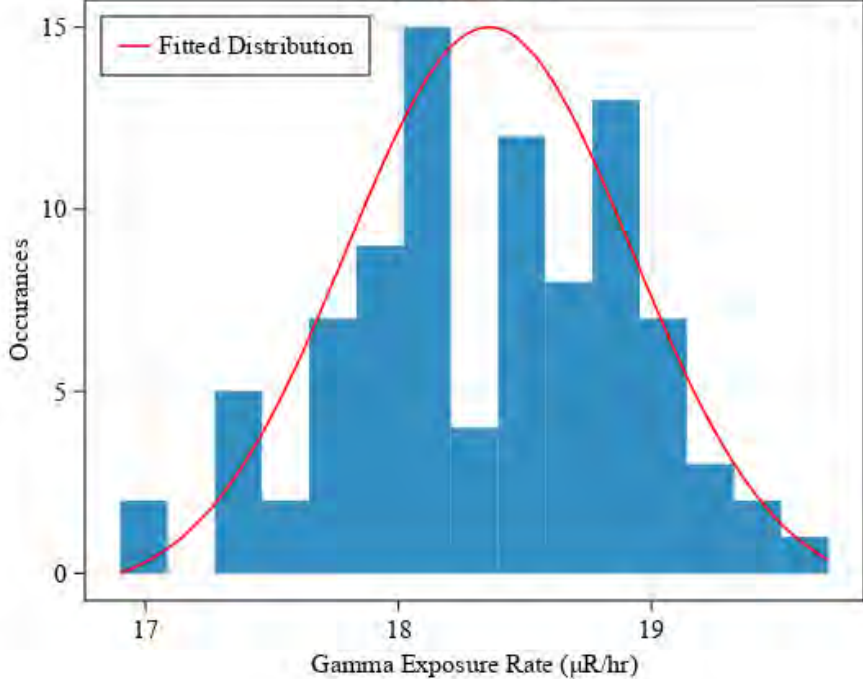
Violin Plot



Probability Plot



Histogram



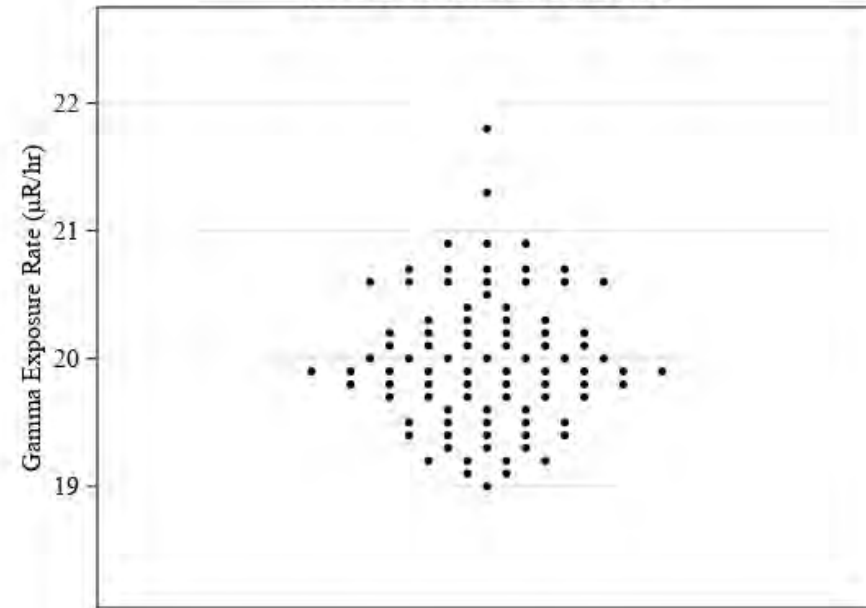
Summary Statistics

Count (n)	90
Minimum (µR/hr)	16.9
Maximum (µR/hr)	19.7
Average (µR/hr)	18.4
Median (µR/hr)	18.4
Standard Deviation (µR/hr)	0.56
Relative Standard Deviation	3.075%
RPD of Mean and Median	0.23%
90th Percentile (µR/hr)	19.0
95th Percentile (µR/hr)	19.3
99th Percentile (µR/hr)	19.7

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR09 Type: High Pressure Ionization Chamber

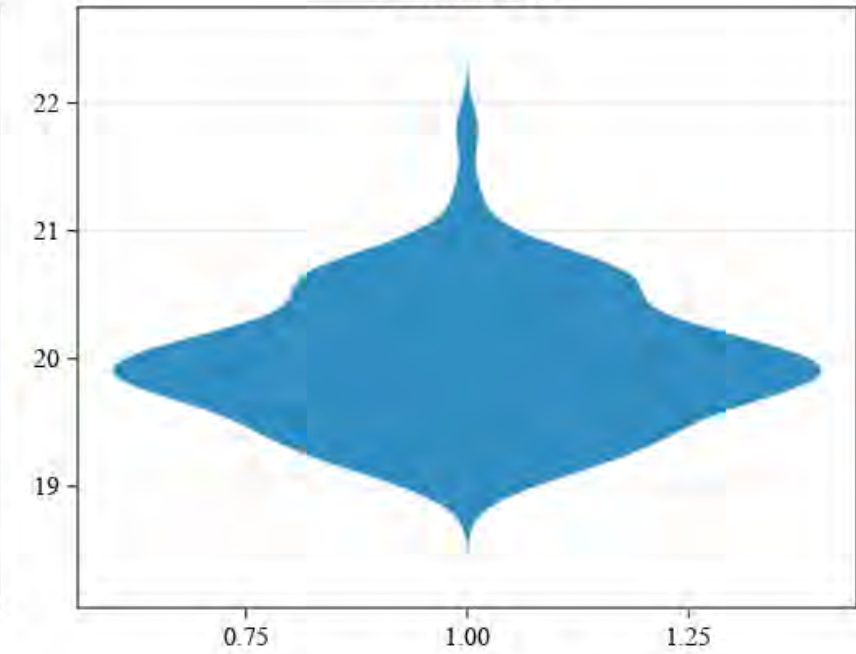
Individual Value Plot



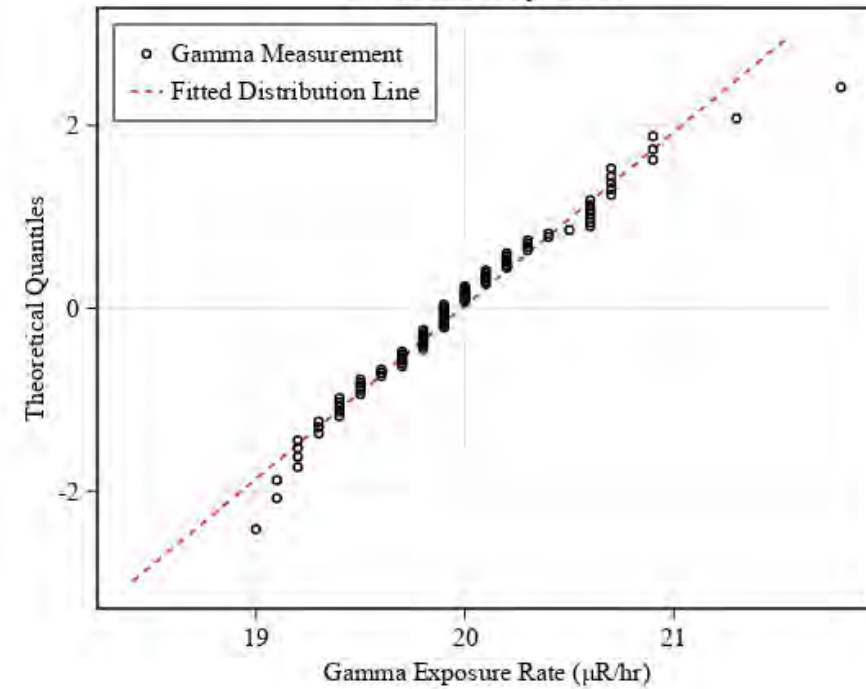
Box Plot



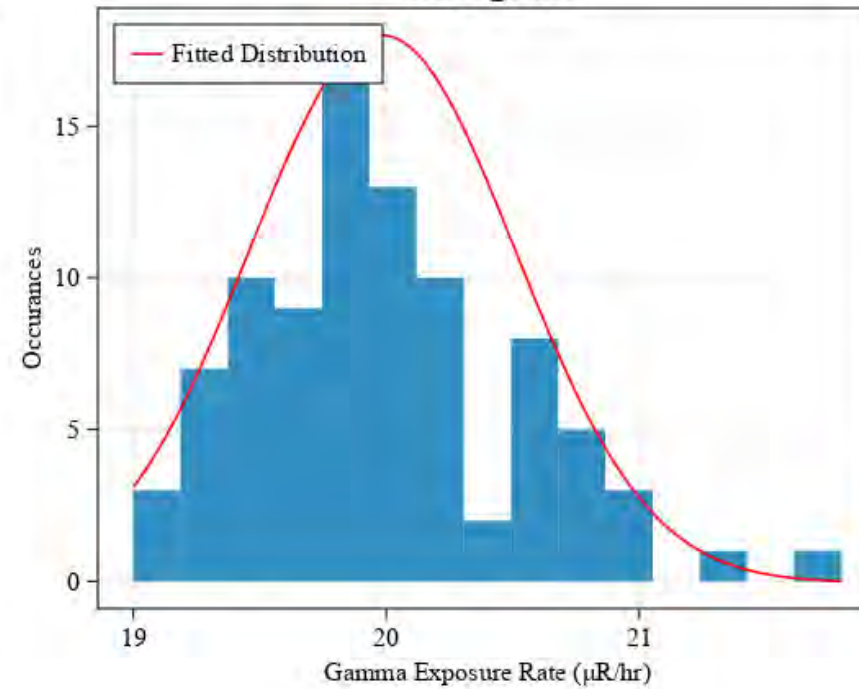
Violin Plot



Probability Plot



Histogram



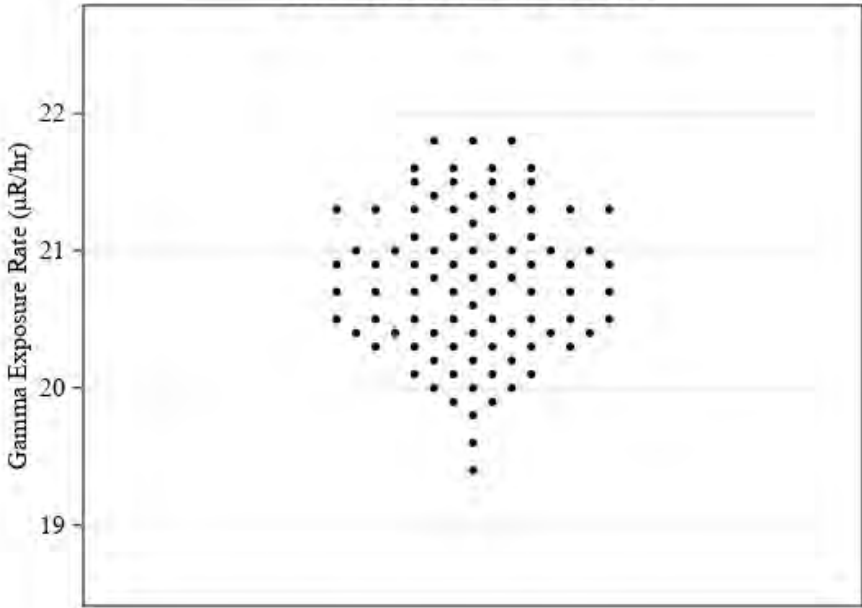
Summary Statistics

Count (n)	90
Minimum (µR/hr)	19.0
Maximum (µR/hr)	21.8
Average (µR/hr)	20.0
Median (µR/hr)	19.9
Standard Deviation (µR/hr)	0.53
Relative Standard Deviation	2.635%
RPD of Mean and Median	0.423%
90th Percentile (µR/hr)	20.7
95th Percentile (µR/hr)	20.9
99th Percentile (µR/hr)	21.8

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR10 Type: High Pressure Ionization Chamber

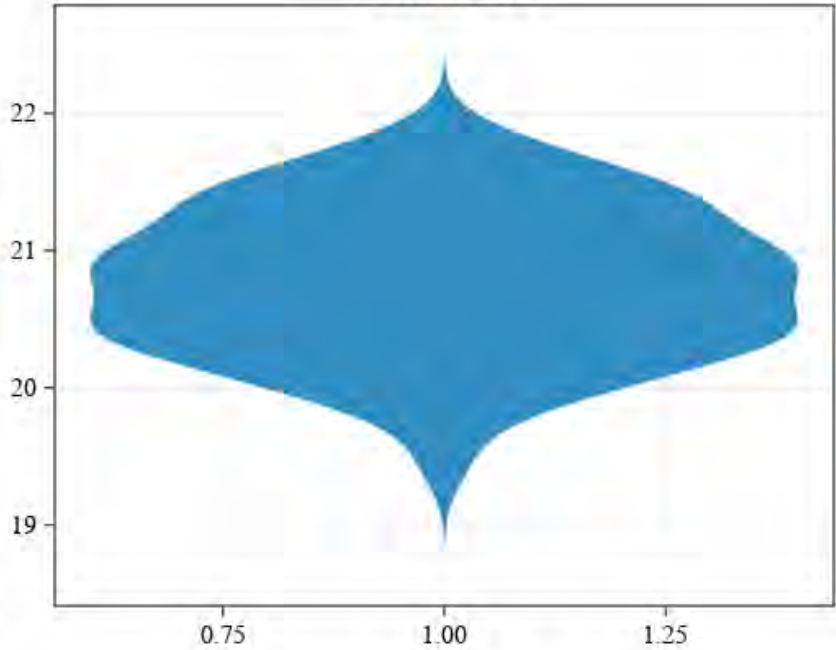
Individual Value Plot



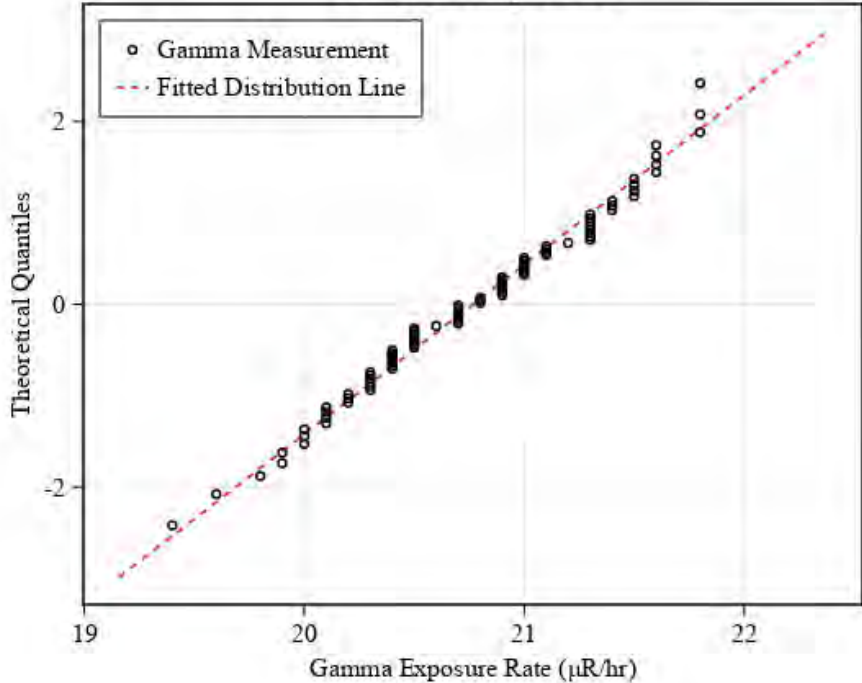
Box Plot



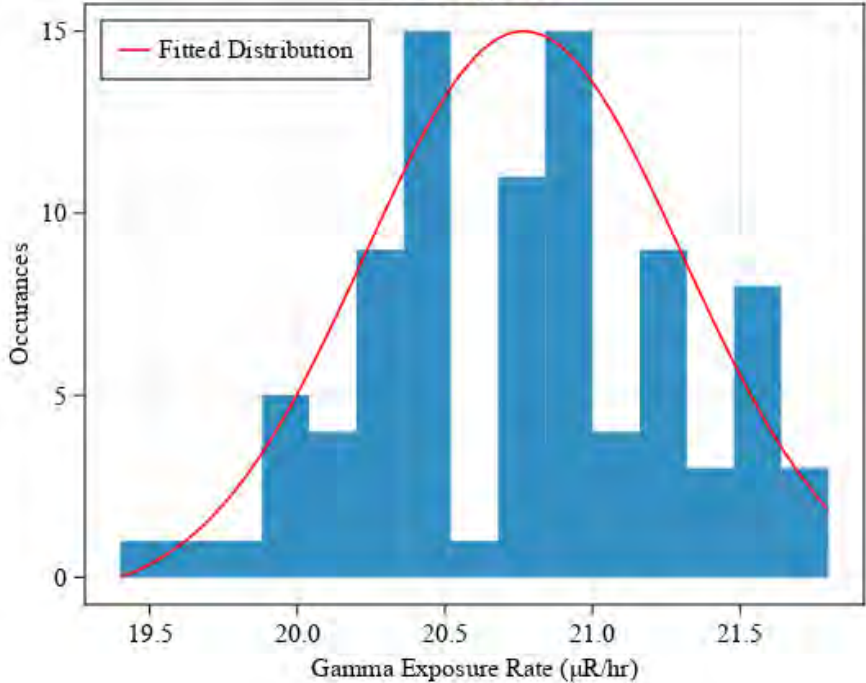
Violin Plot



Probability Plot



Histogram



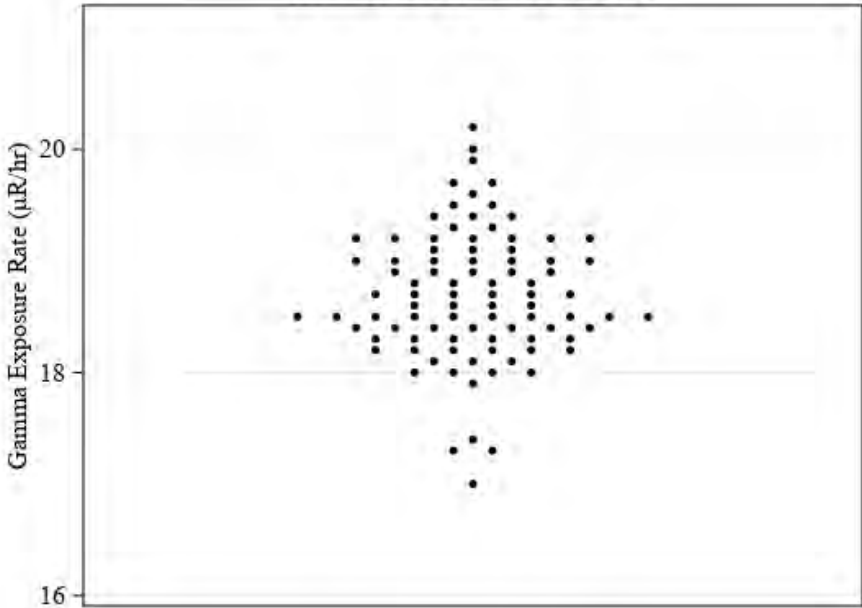
Summary Statistics

Count (n)	90
Minimum (µR/hr)	19.4
Maximum (µR/hr)	21.8
Average (µR/hr)	20.8
Median (µR/hr)	20.8
Standard Deviation (µR/hr)	0.54
Relative Standard Deviation	2.594%
RPD of Mean and Median	0.08%
90th Percentile (µR/hr)	21.5
95th Percentile (µR/hr)	21.6
99th Percentile (µR/hr)	21.8

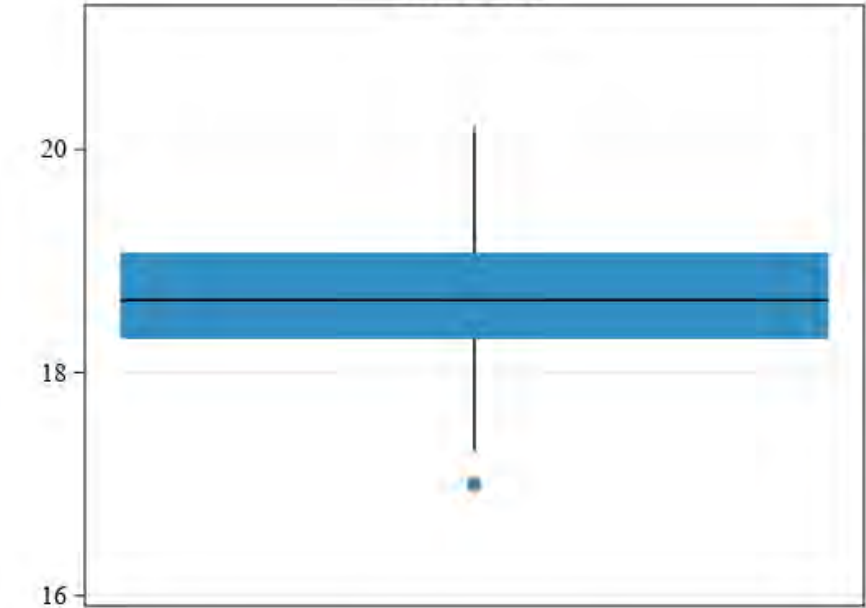
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR11 Type: High Pressure Ionization Chamber

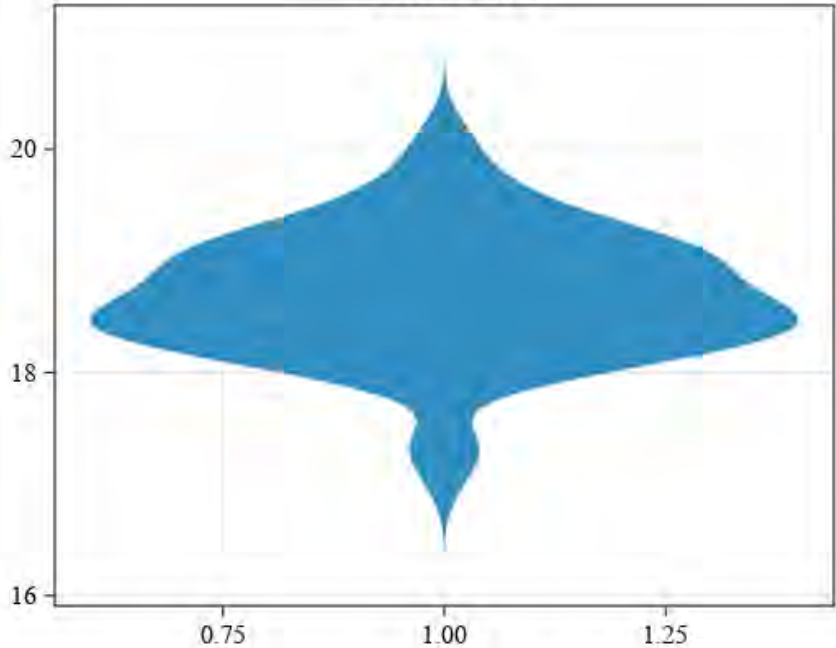
Individual Value Plot



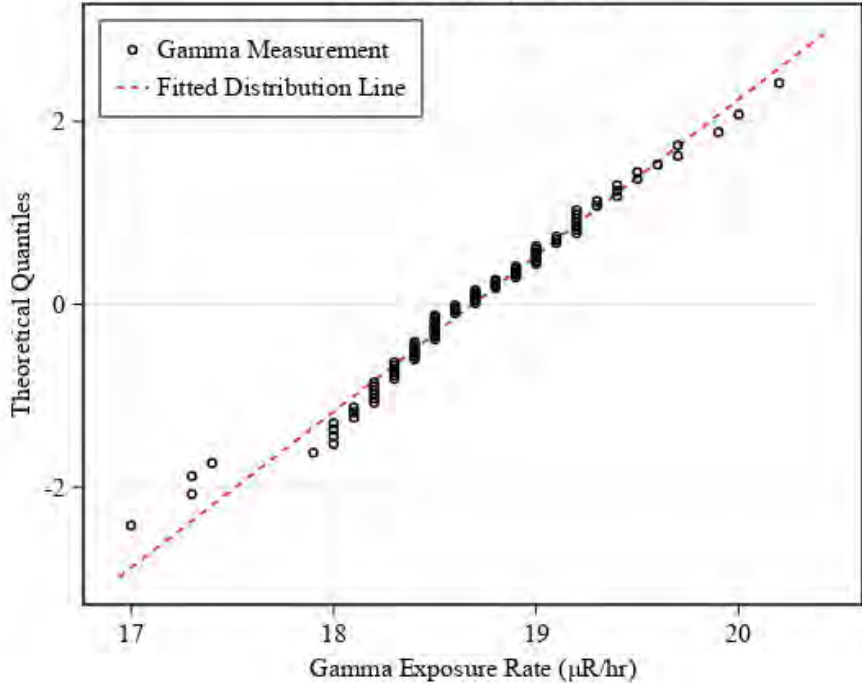
Box Plot



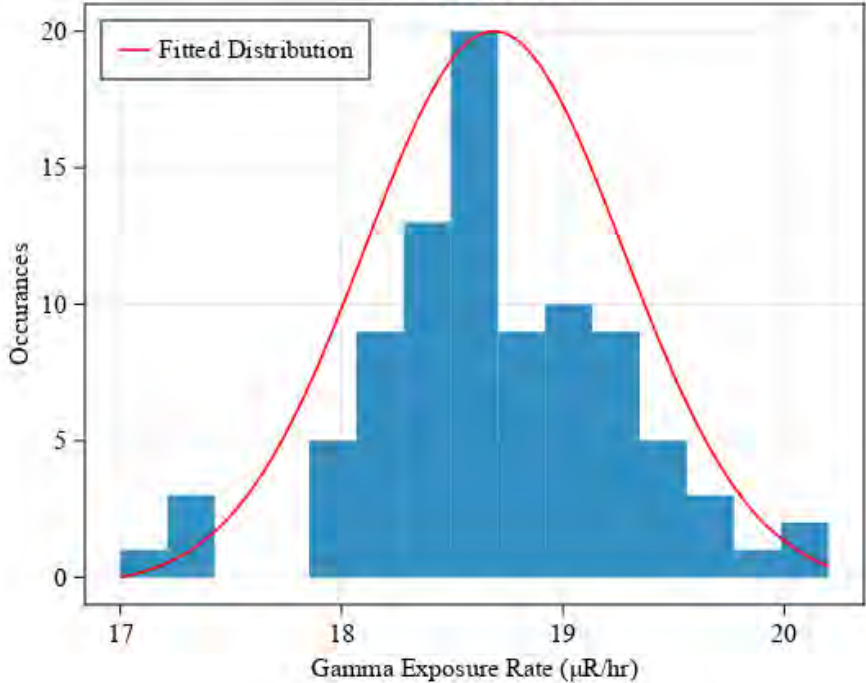
Violin Plot



Probability Plot



Histogram



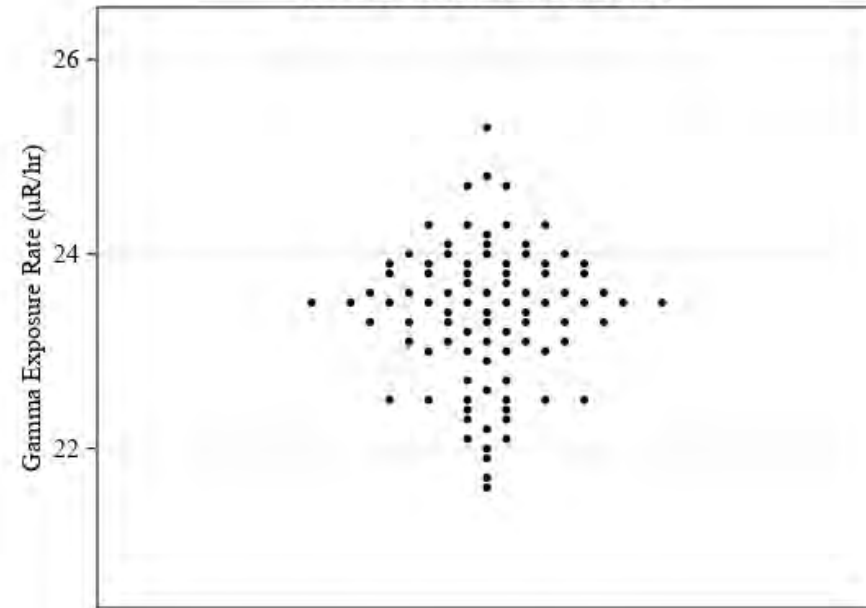
Summary Statistics

Count (n)	90
Minimum (µR/hr)	17.0
Maximum (µR/hr)	20.2
Average (µR/hr)	18.7
Median (µR/hr)	18.6
Standard Deviation (µR/hr)	0.58
Relative Standard Deviation	3.13%
RPD of Mean and Median	0.202%
90th Percentile (µR/hr)	19.4
95th Percentile (µR/hr)	19.7
99th Percentile (µR/hr)	20.2

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR12 Type: High Pressure Ionization Chamber

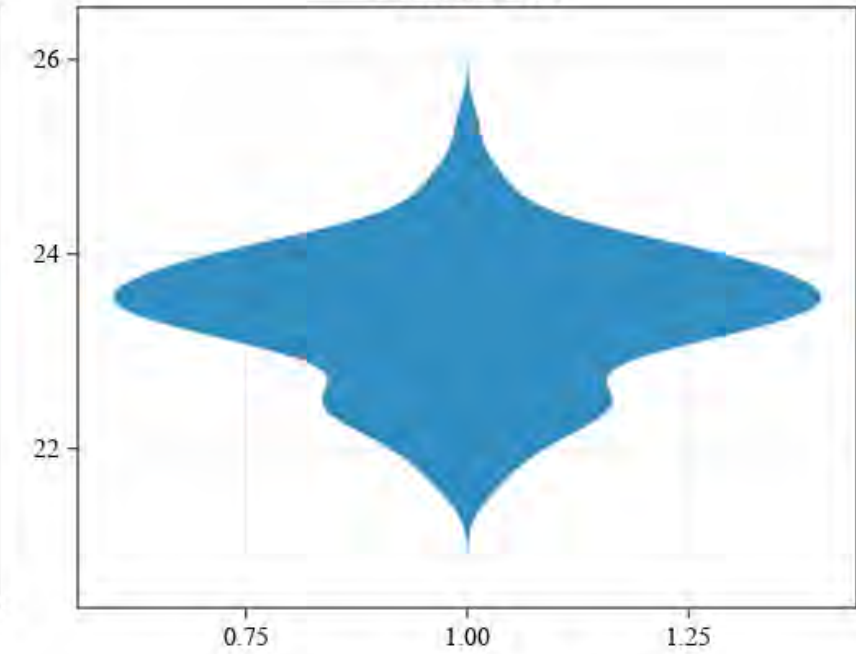
Individual Value Plot



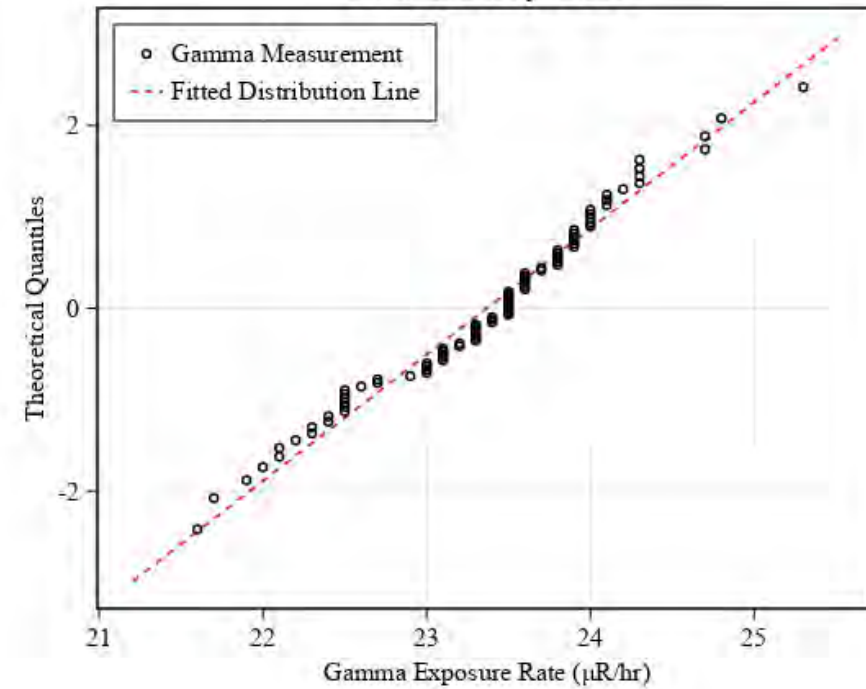
Box Plot



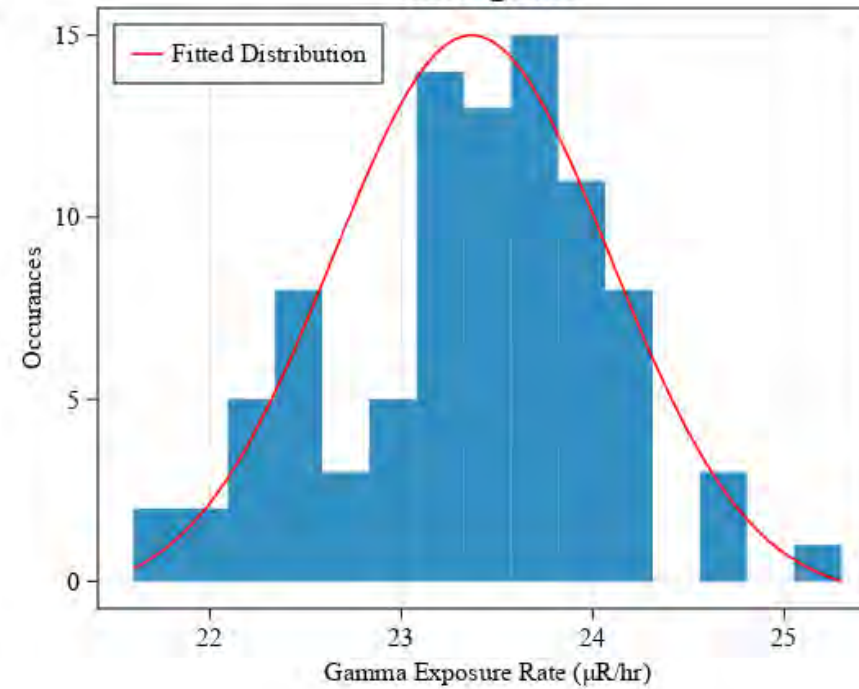
Violin Plot



Probability Plot



Histogram



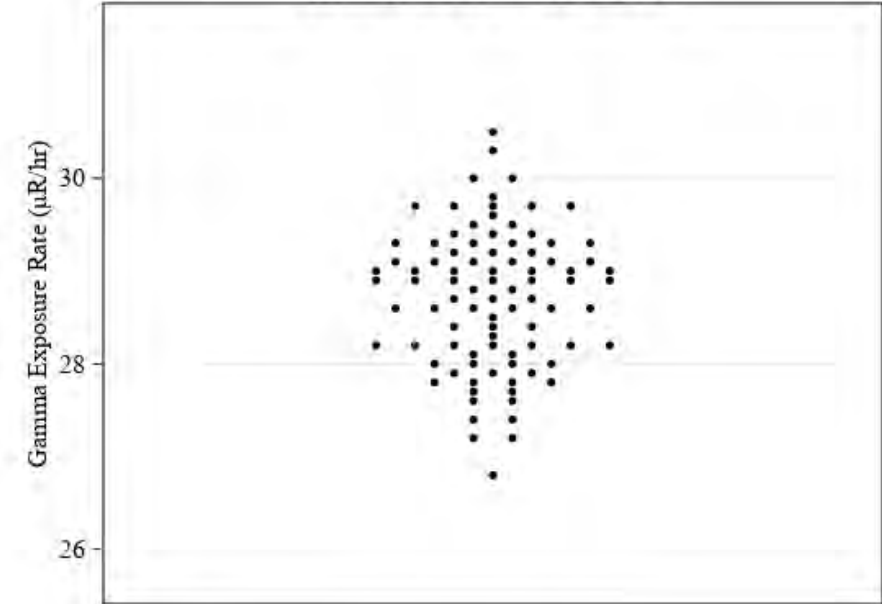
Summary Statistics

Count (n)	90
Minimum (µR/hr)	21.6
Maximum (µR/hr)	25.3
Average (µR/hr)	23.4
Median (µR/hr)	23.5
Standard Deviation (µR/hr)	0.72
Relative Standard Deviation	3.096%
RPD of Mean and Median	0.564%
90th Percentile (µR/hr)	24.2
95th Percentile (µR/hr)	24.3
99th Percentile (µR/hr)	25.3

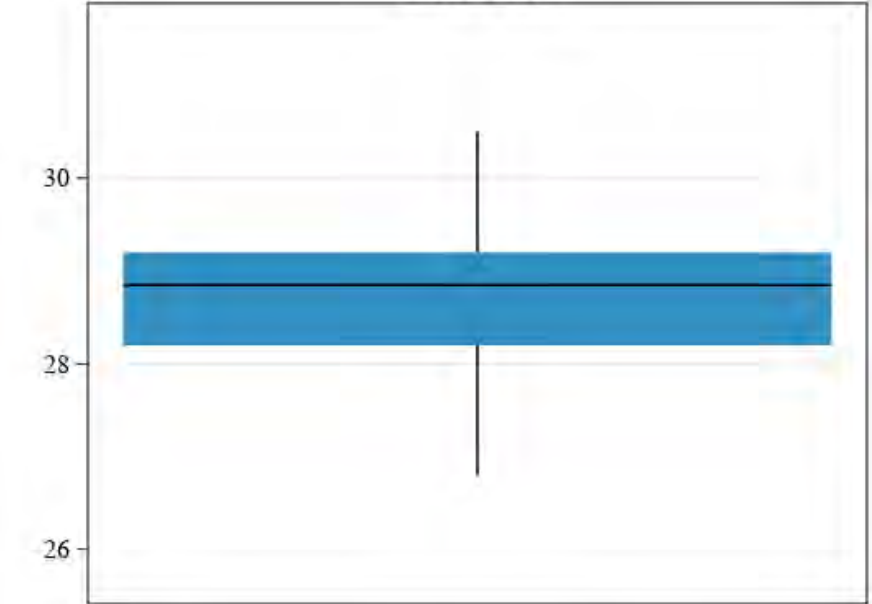
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR13 Type: High Pressure Ionization Chamber

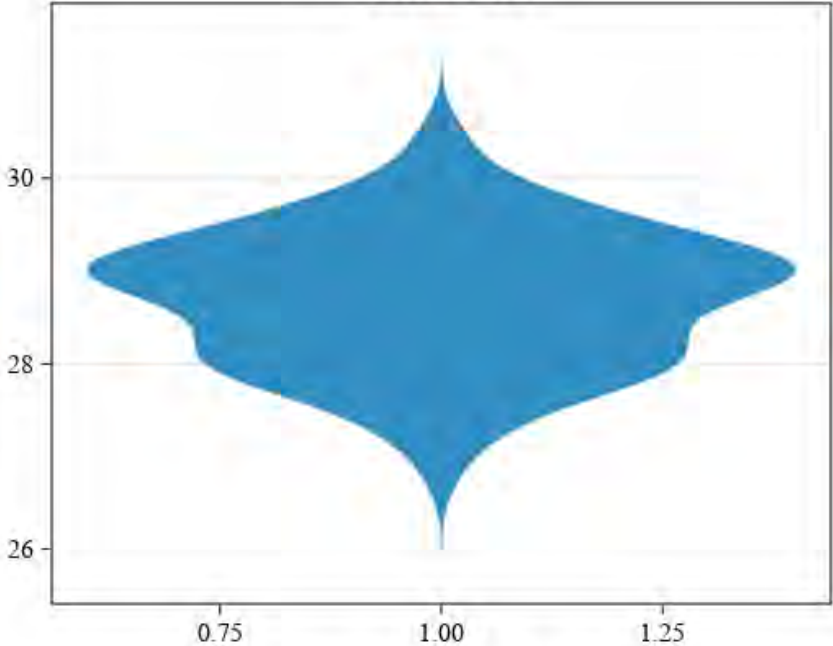
Individual Value Plot



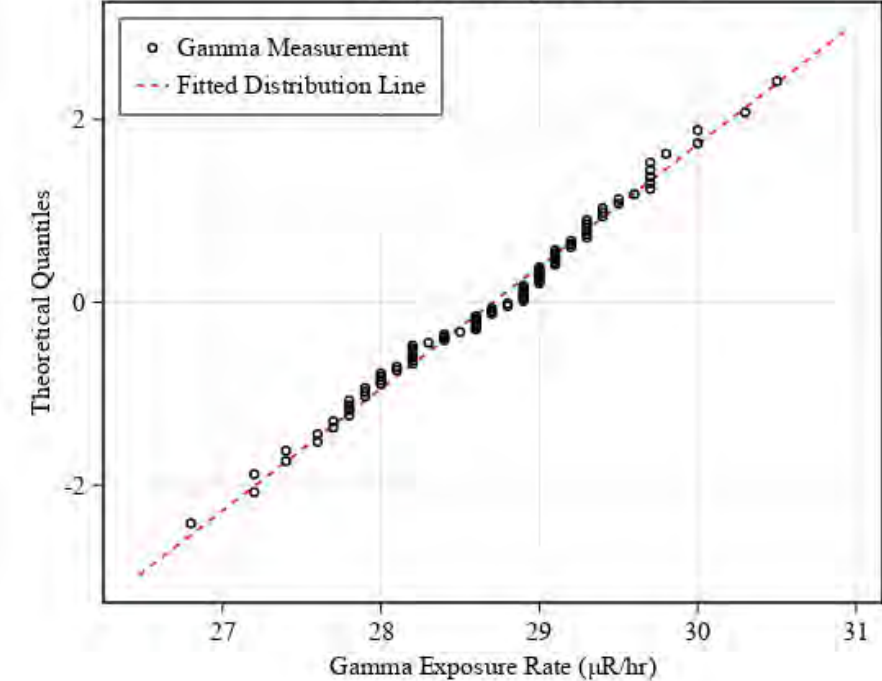
Box Plot



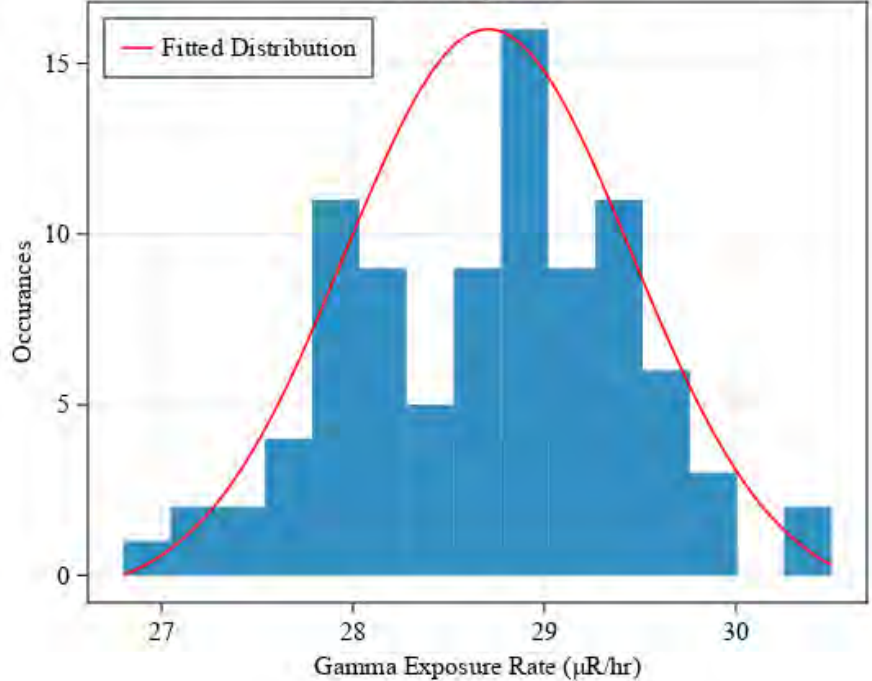
Violin Plot



Probability Plot



Histogram



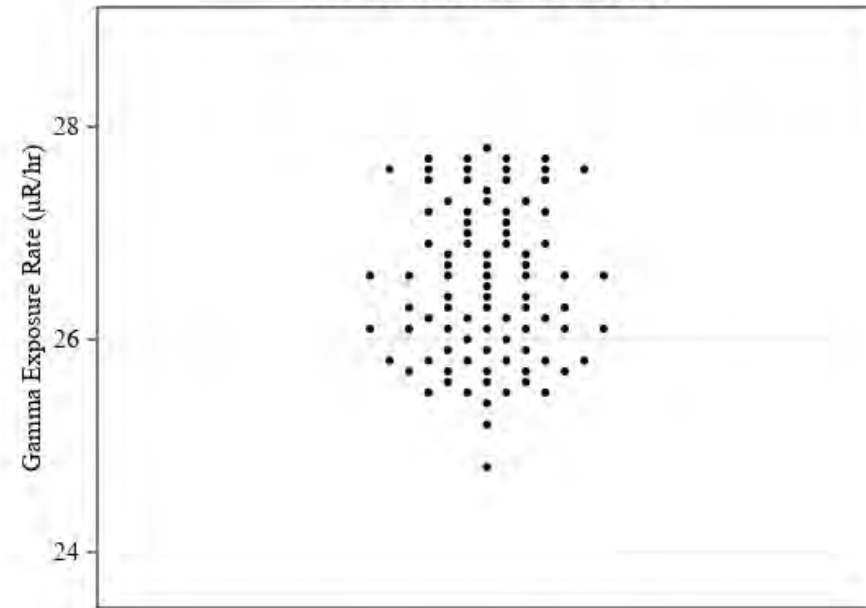
Summary Statistics

Count (n)	90
Minimum (µR/hr)	26.8
Maximum (µR/hr)	30.5
Average (µR/hr)	28.7
Median (µR/hr)	28.8
Standard Deviation (µR/hr)	0.75
Relative Standard Deviation	2.605%
RPD of Mean and Median	0.498%
90th Percentile (µR/hr)	29.7
95th Percentile (µR/hr)	29.8
99th Percentile (µR/hr)	30.5

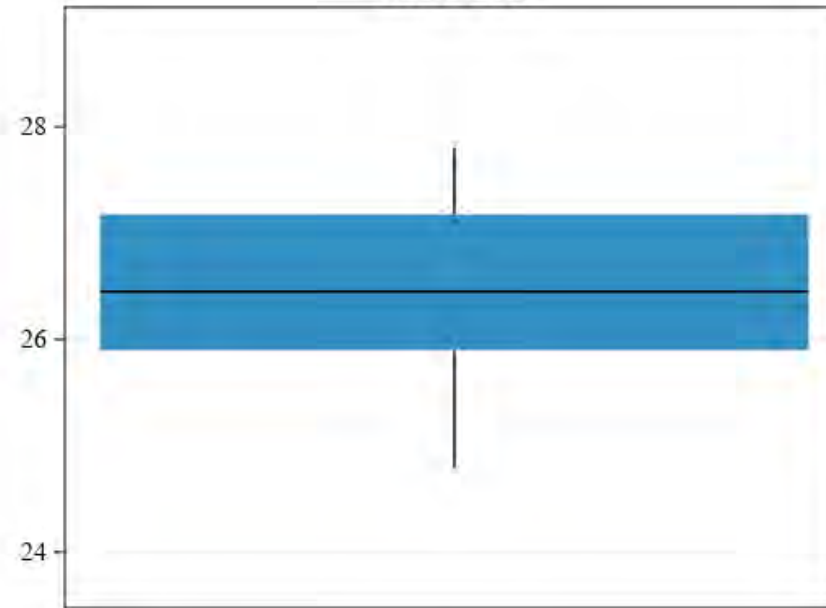
Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR14 Type: High Pressure Ionization Chamber

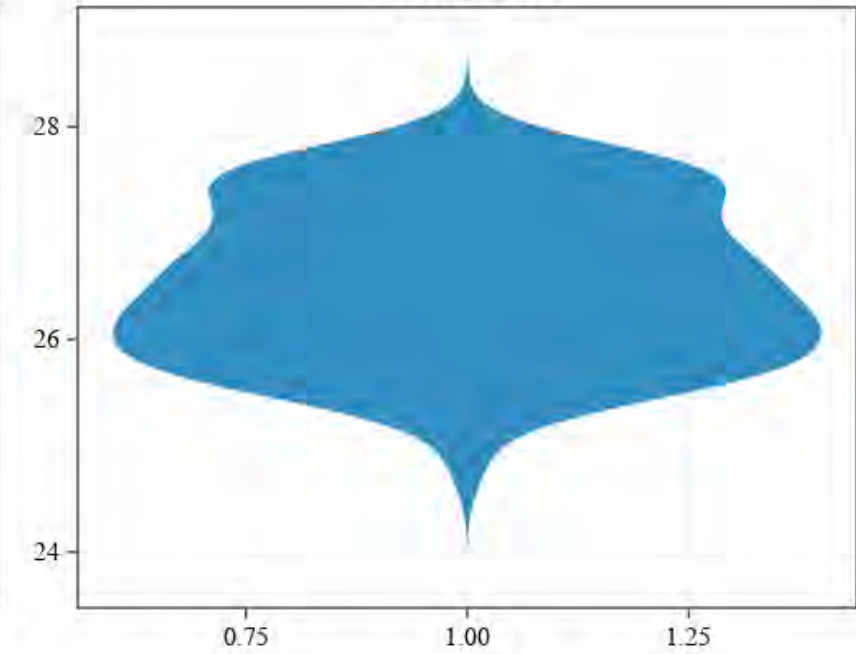
Individual Value Plot



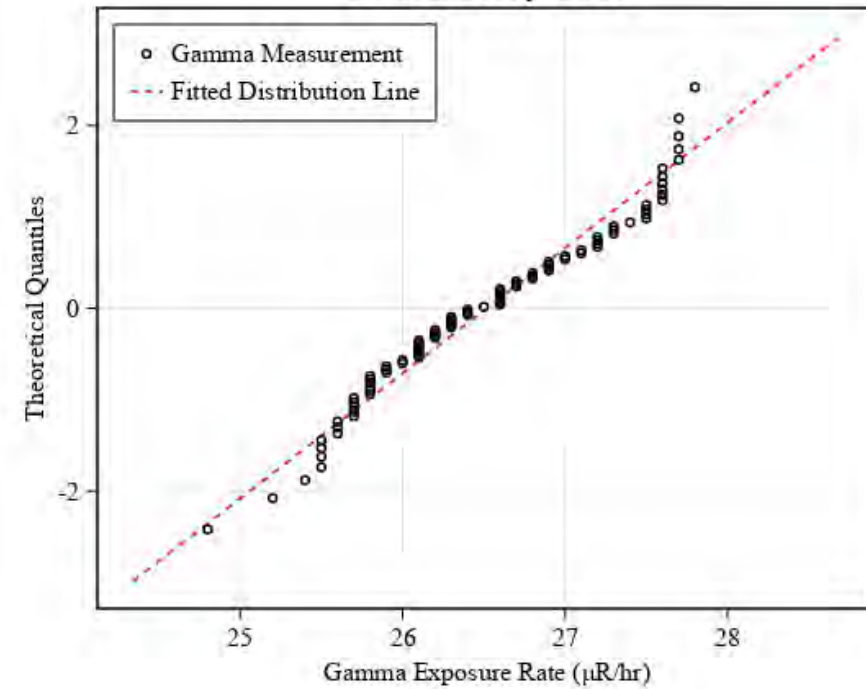
Box Plot



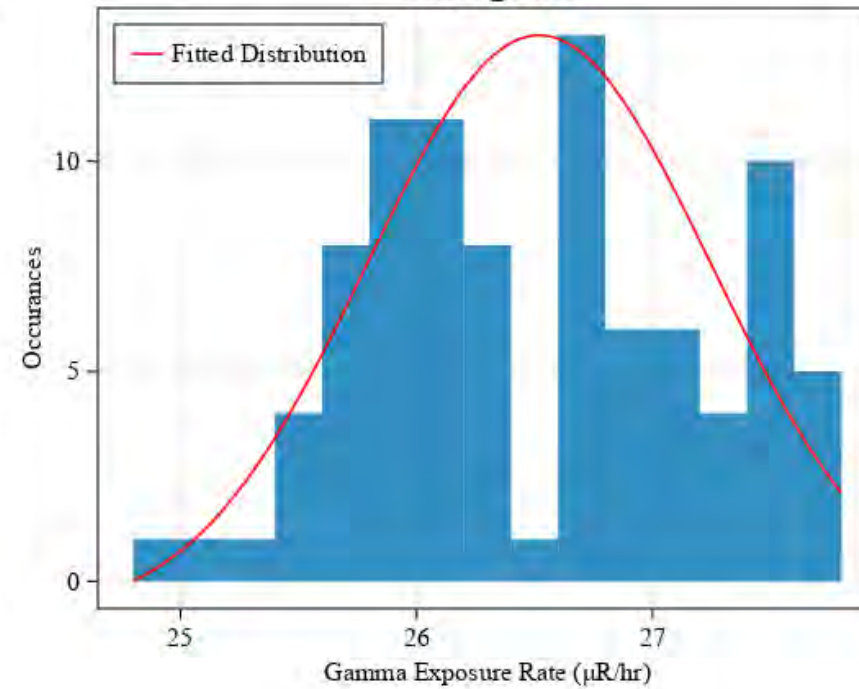
Violin Plot



Probability Plot



Histogram



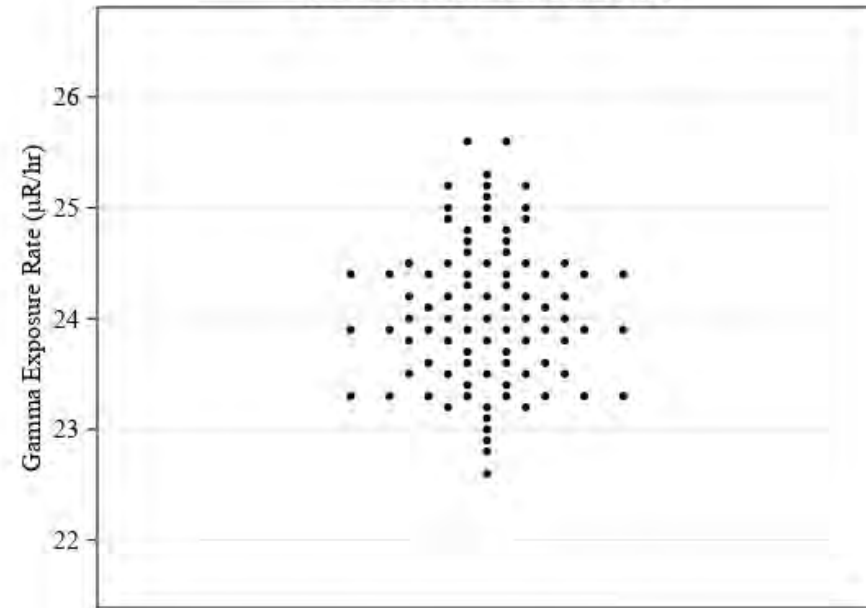
Summary Statistics

Count (n)	90
Minimum (µR/hr)	24.8
Maximum (µR/hr)	27.8
Average (µR/hr)	26.5
Median (µR/hr)	26.4
Standard Deviation (µR/hr)	0.73
Relative Standard Deviation	2.75%
RPD of Mean and Median	0.26%
90th Percentile (µR/hr)	27.6
95th Percentile (µR/hr)	27.7
99th Percentile (µR/hr)	27.8

Summary Statistics - Correlation Plots

Site: OCRM Plot ID: CORR15 Type: High Pressure Ionization Chamber

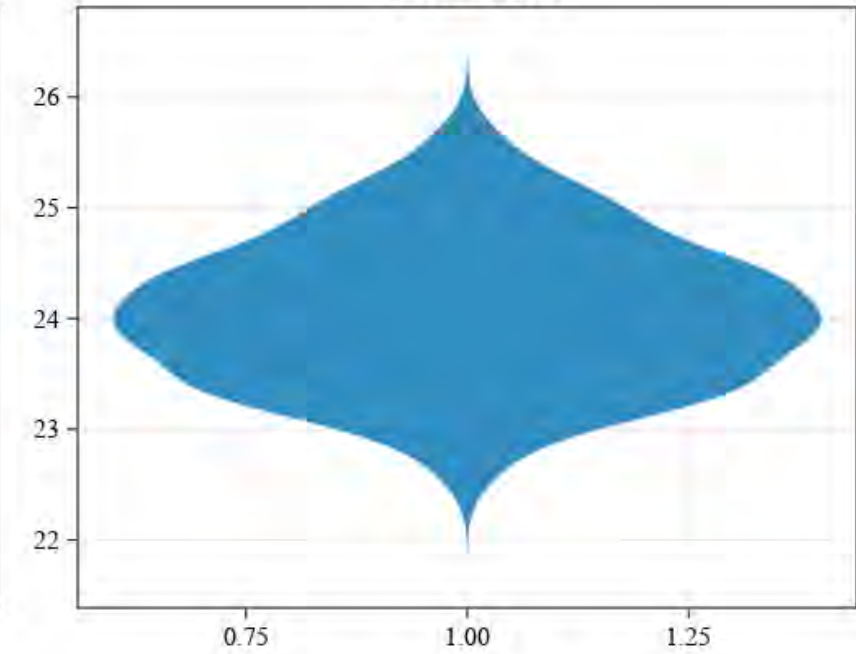
Individual Value Plot



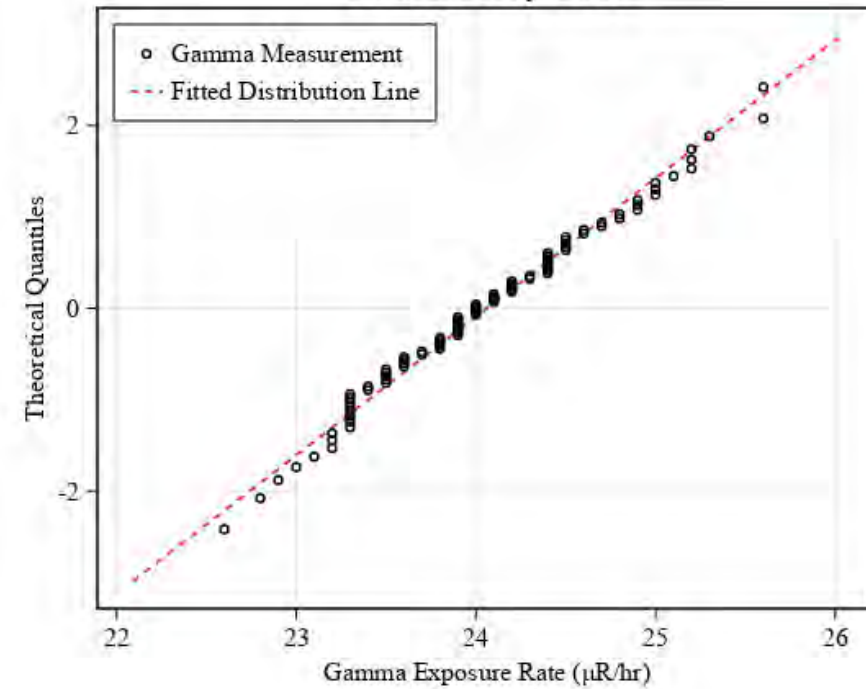
Box Plot



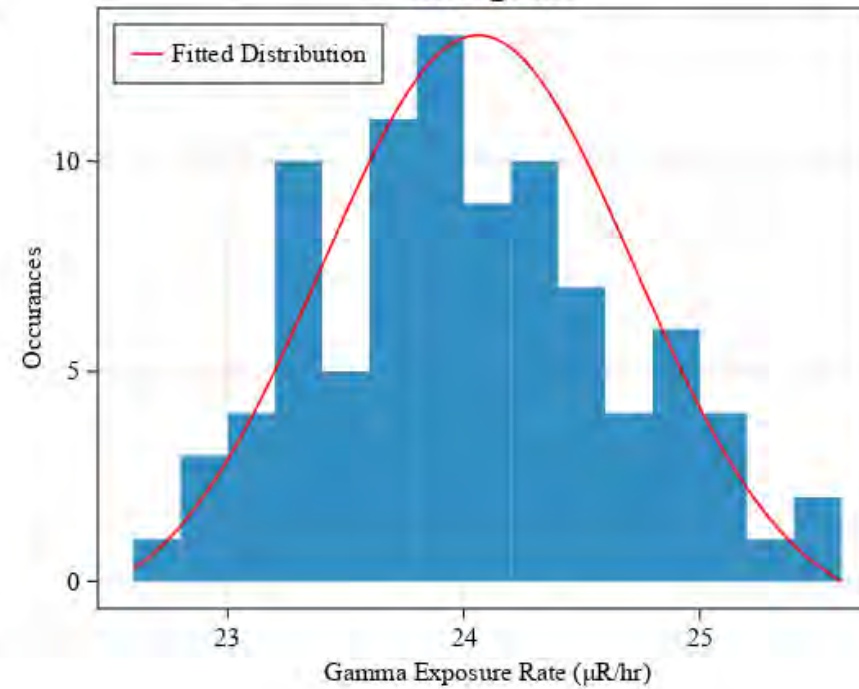
Violin Plot



Probability Plot



Histogram



Summary Statistics

Count (n)	90
Minimum (µR/hr)	22.6
Maximum (µR/hr)	25.6
Average (µR/hr)	24.1
Median (µR/hr)	24.0
Standard Deviation (µR/hr)	0.66
Relative Standard Deviation	2.74%
RPD of Mean and Median	0.254%
90th Percentile (µR/hr)	25.0
95th Percentile (µR/hr)	25.2
99th Percentile (µR/hr)	25.6

APPENDIX F

FIELD DOCUMENTATION



TETRA TECH, INC.

HEALTH AND SAFETY PLAN COMPLIANCE AGREEMENT

Project Name: T035 Removal Assessment OCRM

Project Number: T035

I have read and understand the health and safety plan indicated above and agree to comply with all of its provisions. I understand that I could be prohibited from working on the project for violating any of the safety requirements specified in the plan.

Name	Signature	Employer	Date
Billy Baray		Tt	11/14/22
Christine Phillips		Tt	11/14/22
Anya Mikheicheva		Tt	11/14/22
SEAN KITE		Tt	11-14-22
Sam Conner		Tt	11-14-22
TREYDEN DECHEE		DCRM	11/14/22
Robranda Alstang		DCRM	11/14/22
Cris D'Onofrio		NNEPA	11/14/22
Kengen Larson		US EPA	11/14/22
Justin Bleiler		NNEPA	11/14/22
Margaret Carolan		Tetra Tech	11/16/22
Al Scott		Tt	11/16/22
Jim Herning		Tt	11/16/22
Alison Creech		Tt	11/19/22



TETRA TECH, INC.

DAILY TAILGATE SAFETY MEETING FORM

Date: 11/14/22 Time: 0945 Project No.: 35

Client: EPA Site Location: OCRM

Site activities planned for today: Gamma Scanning

Current weather conditions: Cold, Clear

Safety Topics Discussed
Protective Clothing and Equipment: <u>Warm clothes</u>
Chemical and Physical Hazards: <u>Radiological internal + external, ALARA practices, PCBs near IX building</u>
Equipment hazards identified for activities planned for today: <u>Potential heavy equipment</u>
Review of emergency procedures from HASP (including muster point locations): <u>Muster point at road, route to hospital in Gallup</u>
Other: <u>Trips, Slips, Falls, presence of PRP on site</u>



TETRA TECH, INC.
DAILY TAILGATE SAFETY MEETING FORM

Sign In Signature and Time	Sign Out Signature and Time
Seth Clark 09:46	
Milly Baird 09:46	
Angie Mukhacheva 9:46	
Christine Phillips 9:46	
SEAN KITE 9:46	
Cris Donadio 9:46	
Kendon Larsen 9:46	
TREYDEN DECKER 9:46	
Robb - Alaburg 9:48	
Justin Bleiler 9:48	

Meeting Conducted by:

Marcus Quinlan
Name

[Signature]
Signature



TETRA TECH, INC.
DAILY TAILGATE SAFETY MEETING FORM

Date: 11/15/22 Time: 0845 Project No.: TO35
Client: EPA Site Location: OCRM
Site Activities Planned for Today: Camera Scanning
Weather Conditions: Cold, Clear

Safety Topics Discussed	
Protective clothing and equipment: <u>Masks in high wind, clothes for cold</u>	
Chemical and physical hazards: <u>slips trips falls, dark wire, cacti, blowing dust</u>	
Emergency procedures: 	
Equipment hazards: 	
Other: <u>Dogs,</u>	
Attendees	
Printed Name	Signature
<u>Braden Belliveau</u>	<u>[Signature]</u>
<u>Marcus Quinlan</u>	<u>[Signature]</u>
<u>Rubens Alsburg</u>	<u>[Signature]</u>
<u>TREYDEN DECHRE</u>	<u>[Signature]</u>

Meeting Conducted by:

Braden Belliveau
Name

[Signature]
Signature



TETRA TECH, INC.

DAILY TAILGATE SAFETY MEETING FORM

Date: 11/16/22 Time: 0945 Project No.: 35
Client: EPA Site Location: OCRM
Site activities planned for today: Gamma Scans, BSAs
Current weather conditions: Cool, Clear

Safety Topics Discussed
Protective Clothing and Equipment: <u>warm clothes, gloves, gators</u>
Chemical and Physical Hazards: <u>Radiation, inhalation and ingestion, heavy metals</u>
Equipment hazards identified for activities planned for today: <u>XRF radiation</u>
Review of emergency procedures from HASP (including muster point locations):
Other: <u>Rest in car if too cold</u>



TETRA TECH, INC.
DAILY TAILGATE SAFETY MEETING FORM

Sign In Signature and Time	Sign Out Signature and Time
<i>PC Smith</i> 9:52	
<i>[Signature]</i> 9:52	
<i>[Signature]</i> 9:53	
<i>Margaret Handman</i> 9:53	
<i>Don Wren</i> 9:53	
<i>[Signature]</i> 9:53	
<i>[Signature]</i> 9:53	
<i>[Signature]</i> 9:53	
<i>Braden Belliveau</i> 0953	
<i>Aleahh Smith</i> 9:53	
<i>TREYDEN DECHEE</i> 9:55	
<i>Robrend Alsbury</i> 09:55	
<i>Darren Vanover</i> 09:55	

Meeting Conducted by:

Name

Signature



TETRA TECH, INC.

DAILY TAILGATE SAFETY MEETING FORM

Date: 11/17/22 Time: 0845 Project No.: 35

Client: EPA Site Location: OCRM

Site activities planned for today: Soil Sampling

Current weather conditions: Cold, clear

Safety Topics Discussed
Protective Clothing and Equipment: <u>wear warm clothes, gloves, nitriles while sampling</u>
Chemical and Physical Hazards: <u>Radiation ALARA and heavy metals - wash hands between sampling</u>
Equipment hazards identified for activities planned for today: <u>Heavy metals and elevated gamma.</u>
Review of emergency procedures from HASP (including muster point locations): <u>Muster at parking lot</u>
Other:



Meeting Conducted by:

Signature Ming Chen



TETRA TECH, INC.
DAILY TAILGATE SAFETY MEETING FORM

Date: 11/18/22 Time: 0855 Project No.: 7035
Client: EPA Site Location: _____
Site activities planned for today: Gamma Scanning Stepouts, Homesites,
Current weather conditions: Cold, clear

Safety Topics Discussed
Protective Clothing and Equipment: <u>Warm clothes</u>
Chemical and Physical Hazards: <u>_____</u>
Equipment hazards identified for activities planned for today: <u>Trips, slips, falls</u>
Review of emergency procedures from HASP (including muster point locations): <u>Muster at cars, Rehoboth medical in Gallup</u>
Other:



Meeting Conducted by:

Signature



TETRA TECH, INC.
DAILY TAILGATE SAFETY MEETING FORM

Date: 11/19/22 Time: 0910 Project No.: 35
Client: EPA Site Location: CCRM
Site activities planned for today: XRF, Gamma, Correlation Study
Current weather conditions: cloudy, clear

Safety Topics Discussed
Protective Clothing and Equipment: <u>warm clothes</u>
Chemical and Physical Hazards: <u>slips, trips, falls</u>
Equipment hazards identified for activities planned for today: <u>XRF radiation</u>
Review of emergency procedures from HASP (including muster point locations): <u>muster at main gate</u>
Other: <u>masks if talking to residents.</u>



TETRA TECH, INC.
DAILY TAILGATE SAFETY MEETING FORM

Sign In Signature and Time	Sign Out Signature and Time
Anya Mikhacheva 9:10am	
Briden Belliveau 0910	
Milly Bean 0910	
Sean K. 0910	
James Kern 0910	
Aaron Orchwa 0910	
Adesah Foguth 9:10	
Darren Vanover T.10	
Robread. Alsburg 9:15	
Kimberly Austin 0915	
TREYDEN DECHG 0915	

Meeting Conducted by:

Marcus Quilan
Name

[Signature]
Signature



Safety Topics Discussed
Protective Clothing and Equipment: Warm clothes, gators
Chemical and Physical Hazards: Slips, trips, falls, traffic
Equipment hazards identified for activities planned for today: _____
Review of emergency procedures from HASP (including muster point locations):
Other:

Old Church Rock Mine Removal Assessment
November 2022

Soil Sampling Form

Site Name:

Area ID:

Sampling Team:

OCRM BSA 2

BSA 2 (B02)

Margaret Carolyn

Date:

Weather:

11/16/22
Sunny + Cold
Jim Herring, Al Scott

BSA

Surface

Subsurface

Correlation

OCRM-B01-SS01-01-112222

OCRM-SS01-01-112222

OCRM-SB01-0612-01-112222

OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)		Static Gamma (10s)	Notes
OCRM-B02-SS01	30"	11/16/22	10:34	OCRM-B02-SS01-01-111622		13953 12908 14802	13298 13987 14259	Shielded 4024 3532 2426 4571 Unshielded 12455 13402 12768 12847	3770 5115 4013 3531 4735 3980
OCRM-B02-SS02			10:42	OCRM-B02-SS02-01-111622		12967 13091 14305	13368 13903 14780	Shielded 4014 5280 4112 3825 Unshielded 14495 13834 14365 13633	3272 4197 4018 3938 4811 4441
OCRM-B02-SS03			10:48	OCRM-B02-SS03-01-111622		14227 13138 13083	13805 13311 15700	Shielded 4080 3541 3936 4776 Unshielded 14473 13904 15057 13894	3801 3273 4174 4385 4239 3800
OCRM-B02-SS04			10:53	OCRM-B02-SS04-01-111622		14554 14843 13072	13730 13908 13812	Shielded 4050 3822 3979 4307 Unshielded 13977 13058 13172 13195	4061 3995 4008 4166 4002 4101
OCRM-B02-SS05			10:58	OCRM-B02-SS05-01-111622		13064 13076 13032	13333 13699 14636	Shielded 3509 4057 3800 3855 Unshielded 14407 13167 14673 12580	4387 4250 4781 4509 4212 4122
OCRM-B02-SS10			11:06 11:05	OCRM-B02-SS10-01-111622	Yes	14988 15236 12396	13544 13867 14075	Shielded 3944 4289 3883 3795 Unshielded 14521 13597 13433 14664	3914 3776 4542 4565 4167 4070

2022

Soil Sampling Form

Site Name:

OCRM

Date:

11/16/22

Area ID:

Weather:

Sunny Cold

Sampling Team:

BSA OCRM-B01-SS01-01-112222
 Surface OCRM-SS01-01-112222
 Subsurface OCRM-SB01-0812-01-112222
 Correlation OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM B02-SS09	3-6"	11/16/22	11:11	OCRM-B02 SS09-01-11/16/22		14699 14999 13311 14496 13459 13665	Shielded 4506 3776 4089 4455 Unshielded 13955 14475 13574 14524	7438 3856 3922 4013 3618 3590
OCRM B02-SS08			11:16	OCRM-B02 SS08-01-11/16/22		14732 13298 14077 11940 13322 14950	Shielded 3730 4459 4331 4711 Unshielded 13602 15799 13495 14314	3517 4858 3983 3707 4157 3566
OCRM B02-SS07			11:20	OCRM-B02 SS07-01-11/16/22		13695 13601 14903 14104 14870 13323	Shielded 3843 4439 6440 3446 Unshielded 13723 13213 14527 13793	3780 3671 4042 4086 3581 3450
OCRM B02-SS06			11:25	OCRM-B02 SS06-01-11/16/22		14097 13061 12852 12876 14356 12836	Shielded 3965 5113 4886 4772 Unshielded 13607 13398 13114 13790	5205 4254 4639 4328 3807 4132
OCRM B02-SS11			11:31	OCRM-B02 SS11-01-11/16/22		12468 12643 13034 13146 13338 13038	Shielded 3621 3850 3821 3721 Unshielded 13646 13661 14098 12742	3652 4149 3784 3642 3843 3966
OCRM B02-SS12			11:34	OCRM-B02 SS12-01-11/16/22		13848 13650 13744 14200 12963 13236	Shielded 4541 3575 3551 3981 Unshielded 14577 13318 13450 13505	4237 3562 3944 4327 3705 3588

Old Church Rock Mine Removal Assessment
November 2022

Soil Sampling Form

Site Name: OCRM Date: 11/16/22
Area ID: _____ Weather: Sunny cold Breezy
Sampling Team: _____

BSA OCRM-B01-SS01-01-112222
Surface OCRM-SS01-01-112222
Subsurface OCRM-SB01-0612-01-112222
Correlation OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM-B02 SS13	0-6"	11/16/22	11:39	OCRM-B02 SS13 -01-111622		14086 13132 12942 13534 13689 13944	Shielded 3509 3427 3565 3318 Unshielded 13336 13450 12923 13610	3684 3751 3384 4630 3646 3502
OCRM-B02 SS14			11:44	OCRM-B02 SS14 -01-111622		13590 14672 13959 13862 14098 14451	Shielded 3961 3345 3759 3711 Unshielded 14314 14057 13461 13781	4031 3827 3787 3771 4143 4291
OCRM-B02 SS15			11:49	OCRM-B02 SS15 -01-111622		13688 14576 13563 13466 13157 14287	Shielded 3767 3315 4089 4347 Unshielded 13459 13490 13930 14696	4253 3603 3405 3456 3534 3896
OCRM-B02 SS20			11:54 H:55	OCRM-B02 SS20 -01-111622	Yes	13539 13291 13436 13655 14139 13326 OCRM-B02 SS20-02-111622	Shielded 3468 3963 3787 4106 Unshielded 13403 13789 12811 12485	4643 3082 4660 3603 3579 4189
OCRM-B02 SS19			12:03	OCRM-B02 SS19 -01-111622		13802 12245 13395 14260 13921 13175	Shielded 4392 3749 3891 4336 Unshielded 13729 11908 13504 12960	4109 3481 3796 3813 4273 3257
OCRM-B02 SS18			12:07	OCRM-B02 SS18 -01-111622		15095 15186 14908 14289 13883 13404	Shielded 3609 3943 3749 4203 Unshielded 15170 13496 13759 14063	5097 4645 3771 3995 4009 4553

Soil Sampling Form

Site Name:

OCRM

Date:

11/16/22

Area ID:

Weather:

Sunny Windy Cold Breezy

Sampling Team:

BSA

OCRM-B01-SS01-01-112222

Surface

OCRM-SS01-01-112222

Subsurface OCRM-SB01-0612-01-112222

Correlation OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM-B02 SS17	0-6"	11/16/22	12:11	OCRM-B02 SS17 -01-11/16/22		13443 14883 13257 13700 13576 13729	Shielded 5650 5601 3840 3923 Unshielded 13575 13736 13747 13062	3833 3540 4530 3988 4230 4094
OCRM-B02 SS16			12:16	OCRM-B02 SS16 -01-11/16/22		13537 1413446 12744 12865 13425 14100	Shielded 3222 4341 3854 3927 Unshielded 14380 13581 14029 13076	3427 3490 4391 5724 4706 3761
OCRM-B02 SS21			12:21	OCRM-B02 SS21 -01-11/16/22		12797 13483 14279 13037 13551 13794	Shielded 3955 4040 3991 4333 Unshielded 13768 13370 14345 13005	4786 3929 4251 4361 3938 5035
OCRM-B02 SS22			12:26	OCRM-B02 SS22 -01-11/16/22		13503 13630 13605 15156 13541 13218	Shielded 4183 3906 3991 4038 Unshielded 13386 13332 13295 13847	3752 3421 3998 4286 4394 4147
OCRM-B02 SS23			12:30	OCRM-B02 SS23 -01-11/16/22		12682 13126 12228 13164 13347 13195	Shielded 4230 3595 4833 3584 Unshielded 13173 12877 14013 13743	3776 4653 3907 4683 4417 4144
OCRM-B02 SS24	✓	✓	12:37	OCRM-B02 SS24 -01-11/16/22		13447 13712 12607 13000 12748 13093	Shielded 3594 4614 4070 3458 Unshielded 13006 14019 13211 12787	5122 4053 3733 3428 3681 4061

Old Church Rock Mine Removal Assessment
November 2022

Soil Sampling Form

Site Name:

OCRM

Date:

11/16/22

Area ID:

Weather:

Sunny Breezy Cold

Sampling Team:

BSA

OCRM-B01-SS01-01-112222

Surface

OCRM-SS01-01-112222

Subsurface

OCRM-SB01-0612-01-112222

Correlation

OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)		Static Gamma (10s)		Notes	
OCRM-B02 SS25	0-6"	11/16/22	12:42	OCRM-B02 SS25-01-111622		13106 13728 13962	13378 14161 13051	Shielded 3227 4718 3594 4599	4718 4185 3718 3617 3767 3921		
								Unshielded 12632 13409 13745 13634			
OCRM-B02 SS30			12:48	OCRM-B02 SS30-01-111622		13704 13607 14550	13663 14135 13020	Shielded 3678 4203 3700 4637	4755 4712 3915 4155 3386 4749		
								Unshielded 14577 13139 12405 14511			
OCRM-B02 SS29			12:53	OCRM-B02 SS29-01-111622		14305 12633 12581	12585 13484 13957	Shielded 4082 3580 3855 4105	3924 3759 3850 4330 4384 4088		
								Unshielded 13547 13993 13551 13155			
OCRM-B02 SS28			12:57	OCRM-B02 SS28-01-111622		13908 13437 13051	13809 12438 14156	Shielded 3280 3644 3553 4002	4164 4555 4419 3742 4704 4117		
								Unshielded 13499 12166 13945 13819			
OCRM-B02 SS27			13:01	OCRM-B02 SS27-01-111622		13091 13858 13726	13034 12487 13221	Shielded 3731 3942 3841 3868	5352 4314 3847 4286 4798 4676		
								Unshielded 13550 13527 14141 13069			
OCRM-B02 SS26	✓	✓	13:06	OCRM-B02 SS26-01-111622		12771 13027 13142	13627 13578 13148	Shielded 3877 4713 3909 3725	4550 4046 4426 4677 4742 4061		
								Unshielded 12582 13426 13236 12775			

Old Church Rock Mill Removal Assessment
November 2022

Soil Sampling Form

Site Name: OCRM Date: 11/16/22
Area ID: _____ Weather: Sunny Breezy Cold
Sampling Team: Marcus Quisenberry, Margaret Quisenberry, Jim Herring, Al Scott

BSA OCRM-B01-SS01-01-112222
Surface OCRM-SS01-01-112222
Subsurface OCRM-SB01-0612-01-112222
Correlation OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM-SS2975	0-3	11/16/22	14:31	OCRM-SS2975-01-111622			Shielded	
	0-6"						Unshielded	
OCRM-SS3006	0-6		14:38	OCRM-SS3006-01-111622			Shielded	
							Unshielded	
OCRM-SS2946A	0-6		14:44	OCRM-SS2946A-01-111622			Shielded	
							Unshielded	
OCRM-SS2946B	Scrape		14:47	OCRM-SS2946B-01-111622			Shielded	Inside Door on Concrete
							Unshielded	
OCRM-SS3099	0-6		15:03	OCRM-SS3099-01-111622			Shielded	
							Unshielded	
OCRM-SS2738	✓	✓	15:13	OCRM-SS2738-01-111622			Shielded	
	✓						Unshielded	

Old Church Rock Mill Removal Assessment
November 2022

Soil Sampling Form

Site Name: OCRM

Area ID: _____

Sampling Team: _____

Date: 11/16/22

Weather: Sunny Breezy COLD

BSA OCRM-B01-SS01-01-112222
Surface OCRM-SS01-01-112222
Subsurface OCRM-SB01-0612-01-112222
Correlation OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM - SS2679	0-6"	11/16/22	15:21	OCRM-SS2679 - 01-111622			Shielded	
							Unshielded	
OCRM - SS2217			15:28	OCRM-SS2217 - 01-111622			Shielded	
							Unshielded	
OCRM - SS2225			15:35	OCRM-SS2225 - 01-111622			Shielded	
							Unshielded	
OCRM - SS1804			15:44	OCRM-SS1804 - 01-111622			Shielded	
							Unshielded	
							Shielded	
							Unshielded	
							Shielded	
							Unshielded	

Old Church Rock Mine Removal Assessment
November 2022

Soil Sampling Form

Site Name:

OCRM

Area ID:

Sampling Team:

Date:

11/17/22

Weather:

Sunny Breezy Cold

BSA

OCRM-B01-SS01-01-112222

Surface

OCRM-SS01-01-112222

Subsurface OCRM-SB01-0612-01-112222

Correlation OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM - SS02	0-3"	11/17/22	09:24	OCRM-SS02 - 01-111722			Shielded	
							Unshielded	
OCRM - SS17			09:43	OCRM-SS17 - 01-111722			Shielded	
							Unshielded	
OCRM - SS10			09:57	OCRM-SS10 - 01-111722			Shielded	
							Unshielded	
OCRM - SS13			10:06	OCRM-SS13 - 01-111722			Shielded	
							Unshielded	
OCRM - SS11			10:17 10:06	OCRM-SS11 - 01-111722			Shielded	
							Unshielded	
OCRM - SS09	✓	✓	10:27	OCRM-SS09 - 01-111722			Shielded	
							Unshielded	

Old Church Rock Mine Removal Assessment
November 2022

Soil Sampling Form

Site Name: OCRM Date: 11/17/22
Area ID: _____ Weather: Sunny Breezy Cold
Sampling Team: _____

BSA OCRM-B01-SS01-01-112222
Surface OCRM-SS01-01-112222
Subsurface OCRM-SB01-0612-01-112222
Correlation OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM - SS06	0-3"	11/17/22	10:41	OCRM-SS06 - 01-111722			Shielded	
							Unshielded	
OCRM - SS05	|	|	10:49	OCRM-SS05 - 01-111722			Shielded	
							Unshielded	
OCRM - SS07	|	|	10:59	OCRM-SS07 - 01-111722			Shielded	
							Unshielded	
OCRM - SS08	|	|	11:08	OCRM-SS08 - 01-111722	Yes		Shielded	
							Unshielded	
OCRM - SS12	|	|	11:21 H	OCRM-SS12 - 01-111722	Yes	OCRM-SS12 - 02-111722	Shielded	
							Unshielded	
OCRM - SS16	v	v	11:31	OCRM-SS16 - 01-111722			Shielded	
							Unshielded	

Soil Sampling Form

Site Name:

Area ID:

Sampling Team:

OCRM

Date:

11/17/22

Weather:

Sunny Breezy Cld

BSA

OCRM-B01-SS01-01-112222

Surface

OCRM-SS01-01-112222

Subsurface

OCRM-SB01-0612-01-112222

Correlation

OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM - SS18	0-3"	11/17/22	11:36	OCRM-SS18 - 01-11/17/22 11722			Shielded	
							Unshielded	
OCRM - SS25			11:42	OCRM-SS25 - 01- 11/17/22 11722			Shielded	
							Unshielded	
OCRM - SS20			11:47	OCRM-SS20 - 01-11/722			Shielded	
							Unshielded	
OCRM - SS23			11:52	OCRM-SS23 - 01-11722			Shielded	
							Unshielded	
OCRM - SS26			11:58	OCRM-SS26 - 01-11722			Shielded	
							Unshielded	
OCRM - SS27	✓	✓	12:04	OCRM-SS27 - 01-11722			Shielded	
							Unshielded	

Old Church Rock Mine Removal Assessment
November 2022

Soil Sampling Form

Site Name:

OCRM

Area ID:

Date:

11/17/22

Weather:

Sunny

Sampling Team:

BSA

OCRM-B01-SS01-01-112222

Surface

OCRM-SS01-01-112222

Subsurface

OCRM-SB01-0612-01-112222

Correlation

OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM-SS24	0-3"	11/17/22	12:09	OCRM-SS24 - 01-111722			Shielded	
							Unshielded	
OCRM-SS35	1	11/17/22	13:05	OCRM-SS35 - 01-111722			Shielded	
							Unshielded	
OCRM-SS32	1	11/17/22	13:11	OCRM-SS32 - 01-111722			Shielded	
							Unshielded	
OCRM-SS31	1	11/17/22	13:17	OCRM-SS31 - 01-111722			Shielded	
							Unshielded	
OCRM-SS30	1	11/17/22	13:25	OCRM-SS30 - 01-111722			Shielded	
							Unshielded	
OCRM-SS29	✓	✓	13:31	OCRM-SS29 - 01-111722			Shielded	
							Unshielded	

Old Church Rock M Removal Assessment
November 2022

Soil Sampling Form

Site Name:

OCRM

Date:

11/17/22

Area ID:

Weather:

Sunny

Sampling Team:

BSA

OCRM-B01-SS01-01-112222

Surface

OCRM-SS01-01-112222

Subsurface

OCRM-SB01-0612-01-112222

Correlation

OCRM-CORR01-01-112222

Soil Sample Location	Depth (in)	Date (MM/DD/YY)	Time (MST)	Field Sample ID	Duplicate?	Duplicate ID and Time (MST)	Static Gamma (10s)	Notes
OCRM - SS 34	0-3"	11/17/22	13:37	OCRM-SS34 - 01-111722			Shielded	
							Unshielded	
OCRM - SS 36	1	11/17/22	13:53	OCRM-SS36 - 01-111722			Shielded	
							Unshielded	
OCRM - SS 28	1	11/17/22	14:14	OCRM-SS28 - 01-111722	Yes	OCRM-SS28 02-111722	Shielded	
			14:13				Unshielded	
OCRM - SS 19	1	11/17/22	14:26	OCRM-SS19 - 01-111722			Shielded	
							Unshielded	
OCRM - SS 21	1	11/17/22	14:38	OCRM-SS21 - 01-111722			Shielded	
							Unshielded	
OCRM - SS	✓	✓					Shielded	
							Unshielded	



Rite in the Rain®

ALL-WEATHER

FIELD

Nº 351FX

T035 task 3

Old Church Rock Mine

Removal Assessment

Church Rock, NM

11/19 - 11/20

MADE IN TACOMA

— SINCE 1916 —

Rite in the Rain®

= DEFYING MOTHER NATURE =

Name Marcus QuinlanAddress 3801 Automation Way
Fort Collins, CO 80525Phone 269-924-7059Project Old Church Rock Mine
Removal Assessment**RiteintheRain.com****CONTENTS**

PAGE

REFERENCE

DATE

11/14/22

11/14

OCRM Removal Assessment

Weather: Cold, clear

Planned daily activities: gamma scan primary
fenced area of OCRM

Tt Team: Seth Crank
Molly Baron
Sean Kite
Christine Phillips
Anya Mikheicheva

0730 Gamma meter fitting

0830 Arrived on site

0915 Met w/ Kenyon (EPA), Justin, Cris (EPA)
and David (NuFuels)
David agreed to build a fence
along the arroyo

0930 Signed in to NuFuels sign-in

0935 OCRM arrives

Wan Quil

11/14/22

0945 Conducted MRS

Present: Trey, OCRM
Roe, OCRM

1010 Start Kenyon, EPA
Cris, EPA
Justin, EPA
Seth, Tt
Molly, Tt
Anya, Tt
Sean, Tt
Christine, Tt
Marcus, Tt

1010 Began gamma scanning
Molly - Blue
Seth - Red
Anya - Yellow
Sean - Black
Christine - Orange

1010 Marcus walk site w/EPA

Wan Quil
Kite in the Rain

Site walk notes

11/14/22

- NuFuels has brought new material for roads and staging areas
- NuFuels has put a road through the arroyo
- NuFuels has graded and marked 7 boreholes
- Identified 4 locations around IX building for RAB soil analysis -
- Berm present outside map - expand gamma

Meetings w/ Residents

Johnny Livingston not at home

Larry King not at home

Rita King at home - discussed our presence and conveyed EPA's desire to scan the King's niece, Rita said would need Larry's permission - Larry might be at the chapter house

chapter house - nobody present

1345 Returned to OCRM

Mr. King

11/14/22

1400 Kenyon will provide technical direction to include BSA-2, an alternate, as a primary BSA, which will include the collection of an additional 30 soil samples for metals and radioisotope analysis

1515 Met with Larry King

Showed daily gamma scan to show extent of contamination at OCRM

Larry did not realize the heavy equipment on site was NuFuels, he thought it was EPA doing cleanup

Larry said he road to Johnny Livingston's house is new and that he won't speak up against NuFuels

Asked if we would scan his niece's home, we will need access agreement signed by her

1715 Obtained access agreement from Franene. Her mother, present, asked for hers to be scanned.

Mr. King

Rita in the Rain

11/15

Site: OCRM

Planned: Gamma scan BSA's,
correlation plots, drainages

Weather: cold, clear

Team: Marcus, Braden (TL)
Roe, Trey (DCRM)

0835 Arrive

0845 H+S w/ team led by Braden

0855 Began scanning BSA-2

0935 Completed BSA-2

0955 Started BSA-1

1015 Completed BSA-1

1030 Signed into site w/ NoFuels

1040 Began scanning correlation plots
<1m transect spacing

1225 Completed 9th correlation plot

Munier

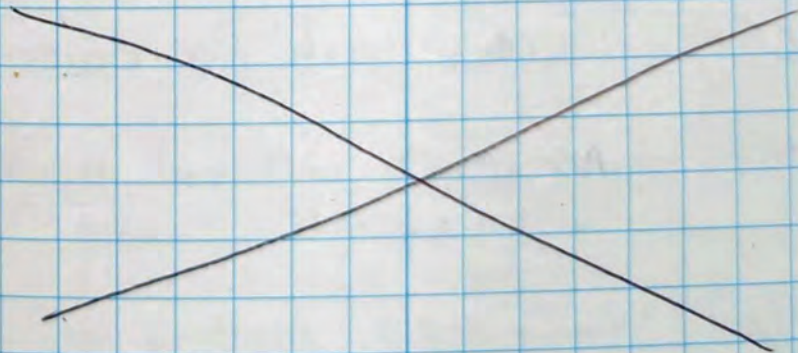
11/15

1230 Break for lunch

1305 Started scanning arrayo

Fences found installed in arrayo
at 3 different locationsBraden indicated these were not
present in August TO33 event.1430 Arrayo cliff faces increasing
gamma - geometry impact
Moving away from cliff faces
brings gamma below ~~IL~~ IL.

1545 Arrayo scanning finished, demob



Munier

11/16

Weather: cool, clear

Site: OCRM

Planned Activities: Stepouts gamma scanning
BSA XRF and BSA Soil SamplingGamma Team: Sean - black
Molly - blue
Seth - red
Anya - yellow
Braiden - green
Christine - orangeSoil Team: Margaret
Jim
Al
Morris - XRF

OCRM: Trey, Adezba, Roe, Darren

0940: Arrive at site and signed in
with NFuels0945: ~~Go to~~ H&S Meeting w/gamma,
soil, and OCRM Teams.

Deployed teams

BSA-2

XRF	Time	As	U	Dep?	Notes
01	1024	10	8	N	
02	1026	7	7	N	
03	1030	8	4	N	
04	1034	7	3	N	
05	1037	7	3	N	
10 06	1040	6	3	N	
09 07	1043	8	4	N	
08	1048	6	3	Y	U=3 A=7
07 09	1054	7	3	N	
06 10	1102	6	3	N	"06 actual"

Notes

Grid 10 logged in XRF as 06

Grid 09 logged in XRF as 07

Grid 07 logged in XRF as 09

BSA-2

XRF	Time	As	U	Dep	Notes
11	1104	5	3	N	
12	1107	5	3	N	
13	1111	7	4	N	
14	1115	7	4	N	

BSA 2

XRF Grid	Time	As	U	DJ	Notes
15	1117	7	2	N	
20	1120	7	3	Y	As=6 U=4
19	1126	6	3	N	
18	1129	7	3	N	
17	1134	6	2	N	
16	1138	7	4	N	
21	1142	6	3	N	
22	1146	8	3	N	
23	1149	7	4	N	
24	1209	5	2	N	
25	1213	6	3	Y	As=6 U=3
30	1220	6	3	N	
29	1223	6	3	N	
28	1226	6	2	N	
27	1230	5	3	N	
26	1233	4	3	Y	As=4 U=3

Reran XRF Grid 01 twice

R1) 1242 As: 7 U: 4

R2) 1243 As: 5 U: LOD

Reran XRF BSA2 Grid 02 twice

R1) 1247 As: 8 U: 3

R2) 1248 As: 7 U: 4

1300 Finished BSAs

1330 Spoke to Larry King

1415 Arrived at NuFuels gate

Began soil samples in man site

sample collected?

XRF screening

Grid ID	As	U	S	V	Time
Y 2975	8	3	4450	56	1431
N 3005	6	23	404	61	1434
Y 3006	5	24	752	37	1437
Y 2946	4	39	1170	45	1443
Y 3099	206	12	253	61	1502

1457 Miles (NuFuels) stopped by
indicated a fence is going
up around the ix building

tomorrow (11/17) said
 with 3 months transformer remediation
 would be removed and a remediation
 process for the PCBs would occur
 XRF screening (ppm)

Grid ID	As	Sr	Mo	V	U	Co	Time	Sample collection
2738	6	120	LOD	62	10	66	1511	Y
2679	8	126	2	90	12	LOD	1519	Y
2217	7	109	LOD	80	7	LOD	1522	Y
2225							1533	

1545

11/17

OCRM

Weather: Cold, clear

Activities: Soil sampling at high gamma areas

0835: Arrive at site

0850: Conduct H&S

Attendees:

Seth, TE

Marcus, TE

Jim, TE

Al, TE

Adeeba, OCRM

XRF Sample Grid	Time	U	Sr	Th	As	Co	V	Sample taken
02	0923	47	95	7	3	LOD	12	Y
17	0943	278	94	4	LOD	LOD	LOD	Y
10	0952	58	88	10	3	LOD	LOD	Y
13	1000	569	119	15	6	LOD	LOD	Y
11	1011	832	110	8	2	31	LOD	Y
09	1027	28	61	6	3	LOD	LOD	Y

XRF Sample	Time	U	Sr	Th	As	Co	V	Sample
06	1039	83	79	5	LOD	LOD	LOD	Y
05	1046	63	74	5	2	-	-	Y
07	1056	26	91	8	2	-	-	Y
08	1101	88	82	9	6	-	-	Y
12	1120	46	77	7	3	-	-	Y
16	1129	52	81	8	2	-	-	Y
18	1133	200	65	3	1	-	-	Y
25	1141	43	81	9	4	-	-	Y
20	1146	725	66	9	7	-	-	Y
23	1151	43	82	6	3	-	-	Y
26	1154	74	91	8	5	-	-	Y
27	1204	128	83	6	2	-	-	Y
24	1208	53	112	9	6	-	-	Y

Break for lunch

XRF Sample	Time	U	Sr	Th	As	Co	V	Sample?
35	1303	15	116	13	8	77	LOD	Y
32	1309	7	108	10	7	-	-	Y
31	1314	14	106	10	5	-	-	Y
30	1324	8	109	12	9	33	-	Y
29	1329	21		10	5			Y
29 (dup)	1330	21	101	11	5	-	-	-

XRF Gold	Time	U	Sr	Th	As	Co	V	Sample
34	1337	36	Th ¹²	12	5	7	-	Y
36	1348	12	103	11	6	53	-	N
36 (shifted)	1349	60	84	6	2	-	-	N
36 (shifted)	1351	278	89	4	2	-	-	Y
28	1412	162	79	4	4	-	18	Y
19	1424	74	88	7	4	-	-	Y
21	1437	36	93	H	7	38	-	Y

Completed Sampling

1500 Demos

11/18

Weather: cool, clear

Site: OCRM

Planned Activities: Gamma Skpouts, homesites,
radial gridsTeam: Marcus, Braden, Molly, Anya, Christine (TE)
Trey, Ru (OCRM)

0855 H&S brief

0950 Began scanning of Francine's homesite

1026 Completed scanning

1040 Began scanning Dorothy's

1120 Completed scanning

1245 Left Dorothy's

Homesite scanning finished, beginning XRF
and gamma radials

Time	XRF ID	U	Dup	Offset
1324	OCR-RTSWX12	4	N	N
1328	OCR-RTSWX11	3	N	N

Mun. Cont.

11/18

Time	XRF ID	U	Dup	Offset
1332	RTSWX10	3	N	N
1336	RTSWX09	5	N	N
1340	RTSWX08	4	N	N
1343	collected OCR-RTWS-XS68-01-111822			
1350	RTSWX07	5	N	N
1353	RTSWX06	6	N	N
1357	RTSWX05	7	N	N
1403	RTSWX04	3	N	N
1412	RTWX01	5	N	N
1417	RTWX02	5	N	N
1422	RTWX03	4	N	N
1424	RTWX04	3	N	N
1428	RTWX05	6	N	N
1431	RTWX06	5	N	N
1435	RTWX07	3	N	N
1438	RTWX08	5	N	N
1444	RTWX09	3	Y	N
1531	RTNEX08	4	N	N
1535	RTNEX09	5	N	N
1539	RTNEX10	7	N	N

Mun. Cont.

Rite in the Rain

11/19

Weather: cold, clear

Site: OCRM

Team: Marcus: Radial transects

Jim, Margaret, Sean, Aaron: Corrupt plots

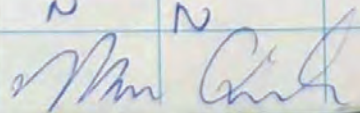
Christine, Maya, Braden, Molly: Skipout gammas

0910 HRS

0920 Teams deployed

0945 Headed to First radial transect

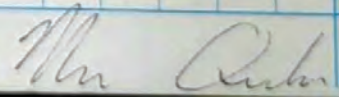
Time	XRF ID	U	Dup?	Offset
0945	OCR-RTS-X03	LOD	N	N
0949	OCR-RTS-X04	4	N	N
0953	OCR-RTS-X05	LOD	N	N
0958	OCR-RTS-X06	4	N	N
1001	OCR-RTS-X07	LOD	N	N
1004	OCR-RTS-X08	6	N	N
1007	OCR-RTS-X09	5	N	N
1011	OCR-RTS-X10	LOD	N	N
1032	OCR-RTSE-X12	4	N	N
1036	OCR-RTSE-X11	LOD	N	N
1038	OCR-RTSE-X10	3	N	N
1042	OCR-RTSE-X09	LOD	N	N
1045	OCR-RTSE-X08	LOD	N	N
1049	OCR-RTSE-X07	LOD	N	N



11/19

~~XRF ID~~

Time	XRF ID	U	Dup	Offset
1053	OCR-RTSE-X06	LOD	N	N
1056	OCR-RTSE-X05	LOD	N	N
1059	OCR-RTSE-X04	LOD	N	N
1104	OCR-RTSE-X03	LOD	N	N
1110	OCR-RTE-X04	3,3	Y	N
1127	OCR-RTE-X05	LOD	N	N
1132	OCR-RTE-X06	LOD	N	N
1135	OCR-RTE-X07	LOD	N	N
1139	OCR-RTE-X08	LOD	N	N
1142	OCR-RTE-X09	LOD	N	N
1145	OCR-RTE-X10	LOD	N	N
1148	OCR-RTE-X11	4	N	N
1151	OCR-RTE-X12	LOD	N	N
1221	OCR-RTNE-X11	5	N	N
1225	OCR-RTNE-X12	6	N	Y
1236	OCR-RTNE-X07	2	N	N
1239	OCR-RTNE-X06	8	N	N
1242	OCR-RTNE-X05	3	N	N
1301	OCR-RTN-X07 RTN-X07	LOD	N	Y
1305	OCR-RTN-X06	4	N	N
1316	OCR-RTNW-X07	LOD, LOD	Y	N



Rite in the Rain

20 11/19

Time	XRF ID	U	Dup	Offset
1319	OCR-RTNW-X06	LOD	N	N
1323	OCR-RTNW-X05	LOD	N	N
1326	OCR-RTNW-X04	LOD	N	N
1329	OCR-RTNW-X03	4	N	N
1333	OCR-RTNW-X02	LOD 4	N	N
1337	OCR-RTNW-X01	LOD	N	N

Completed exterior of CCRM

Spoke to Dave Thomas. He expects the road going through the arroyo to wash away. Once exploratory drilling is complete, will remediate.

Asked if any work to the fences will be done - Dave said the whole perimeter will undergo maintenance.

1410 signed into main site

Mark O'Brien

11/19

Time	XRF ID	U	Dup	Offset
1414	OCR-RTS-X02	990	N	N
1419	OCR-RTW-X03	875	N	N
1424	OCR-RTW-X02	1180	N	N
1428	OCR-RTS-X01	981	N	N
1433	OCR-RTSW-X01	926	N	N
1436	OCR-RTSE-X02	945	N	N
1445	^{OCR} RTE-X03	767	N	N
1449	OCR-RTE-X02	1025	N	N
1453	OCR-RTE-01	989	N	N
1458	OCR-RTNE-X02	1271	N	N
1503	OCR-RTN-X02	938	N	N
1511	OCR-RTN-X03	5	N	N
1514	OCR-RTN-X04	5	N	N
1517	OCR-RTN-X05	4,4	Y	N

Completed interior

1535 - demob

Mark O'Brien

Rite in the

WORM GAMMA-RADIUM
& HPC CORRELATION
STUDY FIELD NOTE BOOK



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RITE
GREENArchival
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2 11/19/22 Saturday

0900 ONSITE
H&S meeting

ARRIVE @ OCRM-CORR02 0930 MT

MARKED CHANGE FLAGS

SK INITIATED UNSHIELDED SCAN @ 0934

SK PERFORMED STATIC GAMMA @ 0936

$\mu = 12163$ cpm

$\sigma = 930.49$ cpm

$n = 60$

Photo ✓

open mostly
undisturbed
shrub brush
summer cypress

SK PERFORMED SHIELDED SCAN @ 0937

INITIATED HPIC IN CENTER OF PLOT

HPIC start: 0940

HPIC stop: 0950

MC collected soil sample ST: 0940

OCR02-CORR02-01-111922

Brown sandy clay, w/silt

LEFT CORR02 @ 0951

END OF FIELD ENTRIES
FOR PAGE

11/19/22 SATURDAY

ARRIVE @ OCRM-CORR01

SK PERFORM UNSHIELDED SCAN, SHIELDED SCAN
STATIC 1M IN CENTER

PHOTO TAKEN OF PLOT

Static 1m

$\mu = 14299$ cpm

$\sigma = 919.75$ cpm

$n = 60$

HPIC start: 955(?)
stop 1005

Open sparse plot saltbrush + ragweed
(summer cypress)

brown sandy clay w/silt

OCR01-CORR01-01-111922

ST: 1000

OCR01-CORR01-02-111922

* DUPLICATE SAMPLE COLLECTED *

LEFT OCRM-CORR01 1005

END OF ENTRIES

FOR PAGE

4 11/19/22 SATURDAY

ARRIVE @ OCRM - CORRO3 1007
SK UNSHIELDED SCAN, SHIELDED SCAN
STATIC

STATIC 1m
 $\mu = 11313$
 $\sigma = 796.02$
 $n = 60$
HPIC shot 1012
1022

light brown to brown sand

ragweed, salt bush, russian thistle,
+ ~~bass~~ african mustard

photo taken; GPS taken

LEFT OCRM - CORRO3
@ 1020

END OF ENTRIES
FOR PAGE

5 11/19/22 SATURDAY

ARRIVE OCRM - CORRO4 1040

LOCATED INSIDE POND; shrubs,

STATIC 1m (SK)
 $\mu = 15369$
 $\sigma = 919.34$
 $n = 60$
HPIC shot 1047
stop 1057

SK performed unshielded scan, shielded scan

OCRM - CORRO4 - 01-11-1922

ST: 1050

light brown to brown silty clay, some sand,

photo taken of plot + soil

GPS taken

LEFT OCRM - CORRO4
@ 1100

END OF ENTRIES
FOR PAGE

6 11/19/22 SATURDAY

ARRIVE @ OCRM - CORRO5 1100

MARKED FLAGS, UNSTABILIZED SCAN,
STATIC, UNSTABILIZED

Static 1m

HPIC Start: 1100

$\mu = 16119$

$\sigma = 1112.02$

$n = 60$

located along road between ponds
no vegetation or sparse

Collected photo of plot & soil, GPS taken

OCRM - CORRO6 - 01 - 111922 ST: 1100

loam to sandy loam
brownish tan LEFT @ 1102

END OF

* ENTRIES

FOR

PAW

11/19/22 SATURDAY

ARRIVE @ OCRM - CORRO6 1112

SK PERFORM UNSTABILIZED SCAN, STATIC
& SHIBBOLA

Static 1m

HPIC Start: 1117

$\mu = 16435$

$\sigma = 912.66$

$n = 60$

located in pond adjacent, aster
rabbit brush, russian thistle,

OCRM - CORRO6 - 01 - 111922

ST: 1120

brown loam silt / silt loam
organic debris

photo of plot, HPIC, soil taken
GPS taken

8 11/19/22 SATURDAY

ARRIVE OCRM-CORRO7 @ 1125

located in pond; less dense than
CORRO8. Vegetation includes wintery
fat & prickly pear.

Static 1m

$\mu = 17852$ cpm

$\sigma = 1032.13$ cpm

$n = 60$

HPIC start: 1131

stop 1141

OCRM - CORRO7-01-111922

brown silt loam ST 1130

* Photos, GPS, taken at plot *

LEFT OCRM-CORRO7

@ 1142

END OF ENTRIES
FOR PAGE

9 11/19/22 SATURDAY

ARRIVE OCRM-CORRO8 @ 1140

LOCATED AMONG PUNGBUNG
DISPERSED VEGETATION

STATIC 1m

$\mu = 17431$

$\sigma = 1046.16$

$n = 60$

HPIC start:

1147

HPIC stop:

* Similar gamma to CORRO7 *

SK unshielded scan, shielded scan
Static 1m, GPS taken

* Photos of plot & soil taken *

OCRM-CORRO8-01-111922

ST: 1150

collected by MC

Soil description: silty sand, light brown to
brown

LEFT OCRM-CORRO8 @ 1200

END OF ENTRIES
FOR PAGE

11/19/22 Saturday

ARRIVE @ OCRM-CORR09 1200

Static Im

 $\mu = 23286$ $\sigma = 1301.49$ $n = 60$ HPIC stat:
1203

HPIC stop:

LOCATED IN POND; large bushes/shrubs
less dense overallNOTE: HPIC offset from centroid of plot
(vegetation)- SK PERFORMED UNSHIELDED + SHIELDED
SCM

- MC collected soil sample at 1210

OCR-M-CORR09-01-111922

ST: 1210

Soil description: brown silty clay w/sand

Photo of plot from drone taken
along w/photo of soil.

LEFT OCRM-CORR09 1215

END OF ENTRIES
FOR PAGE

11/19/22 SATURDAY

ARRIVE @ OCRM-CORR10 @ 1217

Along road (new) above a pond.
Quite variable gamma, possibly because of
rock $\mu = 23048$

HPIC start: 1222

 $\sigma = 1082.33$

HPIC stop:

 $n = 60$ Road disturbance in plot, tire marks/tracks
etc. light shrub vegetation.

SK performed unshielded and shielded scm

JH performed HPIC

MC collected soil sample

OCR-M-CORR10-01-111922

ST: 1220

Soil description: brown silty sand

Photo of plot/HPIC + soil taken

LEFT OCRM-CORR10 @ 1233

END OF ENTRIES
FOR PAGE

11/19/22 SATURDAY

ARRIVE OCRM-CORR11 @ 1226

SK performed unshielded & static
located in pond w/ light vegetation
ragweed, salt bush, russian thistle

Static 1m

 $\mu = 18219$ $\sigma = 1062.80$ $n = 60$ HPIC start:
1235

HPIC stop:

* Note slight elevation on north portion
of plot

SK performed shielded scan (photo)

JH performed HPIC

MC collected soil sample

OCRMC-CORR11-01-111922

ST: 1230

soil description: brown loam to silt
loam

photo collected, GPS taken

END OF FIELD ENTRIES
FOR DAY



11/19/22 SATURDAY

* Completed study at OCRM-CORR11
~1245

- BREAK FOR LUNCH -

ARRIVE @ OCRM-CORR12 1310

* shifted plot to off road

Static 1m by SIL (center off plot)

 $\mu = 36408$ cpm $\sigma = 1631.62$ cpm $n = 60$

HPIC start: 1313 HPIC stop: 1323

SK completed unshielded and shielded scan

JH performed HPIC study

MC collected soil sample

Plot located off side of road above
on arroyo, photo, GPS taken.

OCRMC-CORR12-01-111922

ST: 1320

brown silty sand, moist (slightly)

LEFT OCRM-CORR12 @ 1325

END OF ENTRIES
FOR DAY



Return in car

11/19/22 SATURDAY

ARRIVE @ OCRM - CORR13 @ 1330

Located in waste area; drove to location.
Marked plot corners w/ pin flags then
performed static measurement.

Static 1m

 $\mu = 38311$ cpm $\sigma = 1641.32$ $n = 60$

HPIC start:

1334

HPIC stop:

1344

SK performed unshielded and shielded
scans

JH conducted HPIC study

MC collected soil sample

AO collected photo, GPS

OCRIM - CORR13-01-11/19/22

ST: 1335

soil description: Soil type same as
CORR12

LEFT OCRM - CORR13 @
1344

END OF ENTRIES
FOR PAGE



11/19/22 SATURDAY

ARRIVE @ OCRM - CORR14 @ 1345

Located across old road from CORR13
Very similar gamma and conditions.

Static 1m

 $\mu = 34464$ $\sigma = 1268.58$ $n = 60$

HPIC start: 1347

HPIC stop:

SK performed unshielded + shielded
scanning

JH conducted HPIC study

MC collected composite correlation
soil sample > AO photos, GPS

OCRIM - CORR14-01-11/19/22

ST: 1350

soil type: same as CORR12 + CORR13

Left OCRM - CORR14 @ 1352

11/19/22 SATURDAY

ARRIVE @ OCRM - CORR 15 @
1358(relocated from original corr 16
due to gamma bracket needed)

Static 1 m

HPIC start: 1359

 $\mu = 31050$

HPIC stop: 1409

 $\sigma = 1240.88$ $n = 60$

- > SK performed unshielded + shielded
- > JH conducted HPIC study
- > AD photos, GPS
- > MC collected soil sample

OCR-M - CORR 15 - 01 - 11/19/22

ST: 1400

Soil: same as CORR 12, 13, & 14
typeLEFT OCRM - CORR 15
@ 1410

11/19/22 SATURDAY

ARRIVE @ OCRM - CORR 16 @
"Ablation" fenced-in study area
@ 1415

- SK conducted high density gamma scan at ablation pilot study area per request of project manager.

Completed all site activities at
1430.LEFT OCRM @ 1430
to Gallup, NM for data
processing, analysis, and
field demobilization procedures.END OF FIELD
ENTRIES
FOR
11/19/22

APPENDIX G

LABORATORY REPORTS (ELECTRONIC)

APPENDIX H

BACKGROUND INVESTIGATION REPORT

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**OCRM Removal Assessment
Appendix H
Background Investigation Report**

Response, Assessment, and Evaluation Services

Contract No. EP-S9-17-03

Task Order 0035

August 25, 2023

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

1999 Harrison Street, Suite 500

Oakland, CA 94612



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ATTACHMENTS

Attachment H-1: Photographic Log
Attachment H-2: PROUCL Output



ACRONYMS AND ABBREVIATIONS

amsl	Above mean sea level
ASTM	ASTM International
AUM	Abandoned uranium mine
bgs	Below ground surface
BSA	Background study area
BTV	Background threshold value
COPC	Contaminant of potential concern
COV	Coefficient of variation
cpm	Counts per minute
DL	Detection limit
DQO	Data quality objective
ERG	Environmental Restoration Group, Inc.
GOF	Goodness of fit
GPS	Global Positioning System
K-40	Potassium-40
KM	Kaplan-Meier
m	Meter
m ²	Square meter
MDA	Minimal detectable amount
MDC	Minimum detectable concentration
MDL	Method detection limit
mg/kg	Milligrams per kilogram
NaI	Sodium iodide
ND	Nondetect
NRCS	National Resource Conservation Service
OCRM	Old Church Rock Mine
ppm	Parts per million
Qa	Quaternary alluvium
QL	Quantitation limit
Ra-226	Radium-226
Ra-228	Radium-228
RL	Reporting limit

**ACRONYMS AND ABBREVIATIONS (CONTINUED)**

ROS	Regression Order Statistics
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and analysis plan
SDG	Sample delivery group
TENORM	Technologically enhanced naturally occurring radioactive material
Th-228	Thorium-228
Th-230	Thorium-230
Th-232	Thorium-232
TPU	Total propagated uncertainty
U-234	Uranium-234
U-235	Uranium 235
U-238	Uranium-238
UCL	Upper confidence limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UTL	Upper tolerance limit
UTL95-95	95 percent upper tolerance limit with 95 percent coverage
WH	Wilson Hilferty
XRF	X-ray fluorescence



EXECUTIVE SUMMARY

This site-specific investigation report regarding Background Study Area (BSA)-02 presents the field sampling methods, results, and statistical evaluation of a gamma radiation survey, X-ray fluorescence (XRF) survey, and soil sampling event during November 2022. BSA-02 was selected as a reference site to represent pre-mining and undisturbed conditions within the Old Church Rock Mine (OCRM) area in the Eastern Abandoned Uranium Mine (AUM) Region of the Navajo Nation near Gallup, McKinley County, New Mexico. The geology at BSA-02 is characterized by Quaternary alluvium (Qa), and the soils are described as Sparank-San Matero-Zia series (symbol 230) with typical topographic relief ranging from 0 to 3 percent slopes. BSA-02 was selected as an appropriate reference site for the OCRM area because it is within the same geologic unit and hosts the same and similar soil types. Gamma radiation surveys and surface soil sampling at BSA-02 conformed to methods outlined in the OCRM removal assessment sampling and analysis plan (SAP) (Tetra Tech 2022). The gamma radiation survey was completed at a 100 percent density by use of 2-meter transects within the survey boundary, and 30 surface soil samples were collected for analysis for metals and radionuclides listed in [Table H-ES-1](#). A comprehensive analysis occurred to determine background concentrations of individual analytes and gamma radiation levels in order to establish background threshold values (BTV) for the analytes listed in [Table H-ES-1](#). The analysis involved use of the statistical software ProUCL version 5.2 for robust computations of upper statistical limits.

**Table H-ES-1. Individual Background Threshold Values for BSA-02**

Analyte	# of Non-Detects	Minimum	Maximum	Average	Standard Deviation	BTV	Units
Aluminum	0	10,400	18,800	15,440	1,727	19,274	mg/kg
Antimony ¹	30	0.33	3.5	NA	NA	NA	mg/kg
Arsenic	0	4.5	6.8	5.7	0.55	7.0	mg/kg
Barium	0	119	175	136	13	165	mg/kg
Beryllium	0	0.74	1.1	0.97	0.10	1.2	mg/kg
Cadmium	0	0.12	0.17	0.15	0.013	0.18	mg/kg
Calcium	0	5,690	8,680	6,814	614	8,177	mg/kg
Chromium	0	9.1	15	12	1.3	15.1	mg/kg
Cobalt	0	5.9	8.8	7.6	0.73	9.2	mg/kg
Copper	0	11	16	14	1.5	17.0	mg/kg
Iron	0	14,400	21,500	18,367	1,699	22,138	mg/kg
Lead	0	12	18	15	1.6	18.8	mg/kg
Lithium	0	10	17	14	1.5	17.6	mg/kg
Magnesium	0	3,670	4,780	4,283	280	4,905	mg/kg
Manganese	0	209	273	248	17	2,856	mg/kg
Molybdenum	0	0.28	0.40	0.34	0.035	0.41	mg/kg
Nickel	0	7.8	12	10	1.0	12.4	mg/kg
Selenium	0	1.4	2.8	2.0	0.37	2.8	mg/kg
Silver ¹	30	0.10	0.61	NA	NA	NA	mg/kg
Sodium	0	52	76	67	6.3	81.2	mg/kg
Thallium	0	0.16	0.26	0.22	0.023	0.27	mg/kg
Thorium	0	6.6	11	9.4	1.0	11.6	mg/kg
Uranium	0	0.87	1.3	1.1	0.10	1.4	mg/kg
Vanadium	0	21	32	27	2.6	32.6	mg/kg
Zinc	0	44	64	54	5.3	66.1	mg/kg
Radium-226	0	1.1	1.9	1.6	0.18	2.0	pCi/g
Radium-228	0	1.1	2.2	1.7	0.29	2.3	pCi/g
Potassium-40	0	18	24	21	1.1	23.2	pCi/g
Thorium-232	0	1.1	2.2	1.7	0.3	2.3	pCi/g
Raw Gamma	NA	10,300	16,400	13,216	784	14,555	cpm

Notes:

¹ Average, standard deviation, and BTV could not be calculated via KM Method because all values in the dataset were non-detects.

BTV Background threshold value

cpm Counts per minute

KM Kaplan-Meier

mg/kg Milligrams per kilogram

NA Not applicable

pCi/g Picocuries per gram



1.0 INTRODUCTION

As part of the desktop study presented in the Old Church Rock Mine (OCRM) removal assessment sampling and analysis plan (SAP), two background study areas (BSA) were identified within 0.5 mile of OCRM. The BSAs, BSA-01 and BSA-02, were both scanned with gamma scanning equipment. The gamma scanning results between the two were nearly indistinguishable and so BSA-02 was selected as a reference site to represent pre-mining and undisturbed conditions because BSA-02's geology and soil are similar to that of OCRM's and sits farther away from the next nearest geology. The purpose of this report is to answer the following study question as part of the data quality objective (DQO) process in the removal assessment SAP:

Study Question: What are the background levels of gamma radiation and what are the background concentrations of radionuclides and metals in soils and sediment that are representative of unimpacted conditions at each site?

This site-specific investigation report regarding BSA-02 summarizes BSA-02 field sampling methods; results of the gamma radiation survey, X-ray fluorescence (XRF) survey, and soil sampling; and analysis and interpretation of gamma radiation and analytical results. Although gamma radium survey results from BSA-01 also are included in this report to document its similarity to BSA-02, the analysis and interpretation of soil analytical data herein refer strictly to BSA-02.

2.0 SITE SETTING

This section describes the site setting of BSA-02.

2.1 SITE IDENTIFICATION AND SETTING

BSA-02 is the representative background site for OCRM. BSA-02 is approximately 0.5 mile south and upwind of OCRM, and can be accessed from OCRM by foot. Topographically, the BSA-02 area is flat and at the same approximate elevation of 6,800 feet above mean sea level (amsl) as OCRM. The location of and access route to BSA-02 are shown on [Figure H-1](#).

Tetra Tech team geologists and engineers visited BSA-02 on November 15, 2022 and observed no evidence of mining-related activity. [Attachment H-1](#) to this report is a photographic log from the background investigation study.

2.2 GEOLOGY AND SOILS

The geology at BSA-02 and OCRM is characterized by Quaternary alluvium (Qa). The alluvium soil at BSA-02 is described as the Sparank-San Matero-Zia series (symbol 230). The Sparank-San Matero-Zia series has a typical topographic relief ranging from 0 to 3 percent slopes, is well drained, and consists of fan and stream alluvium derived from sandstone and shale. The soils at OCRM include the Sparank-San Matero-Zia series and similar soil types. Other soil types present at OCRM are fan, slope, and eolian alluvium also derived from sandstone and shale.

Maps of the geology and soils of BSA-02 and OCRM are shown on [Figure H-2](#) and [Figure H-3](#), respectively.

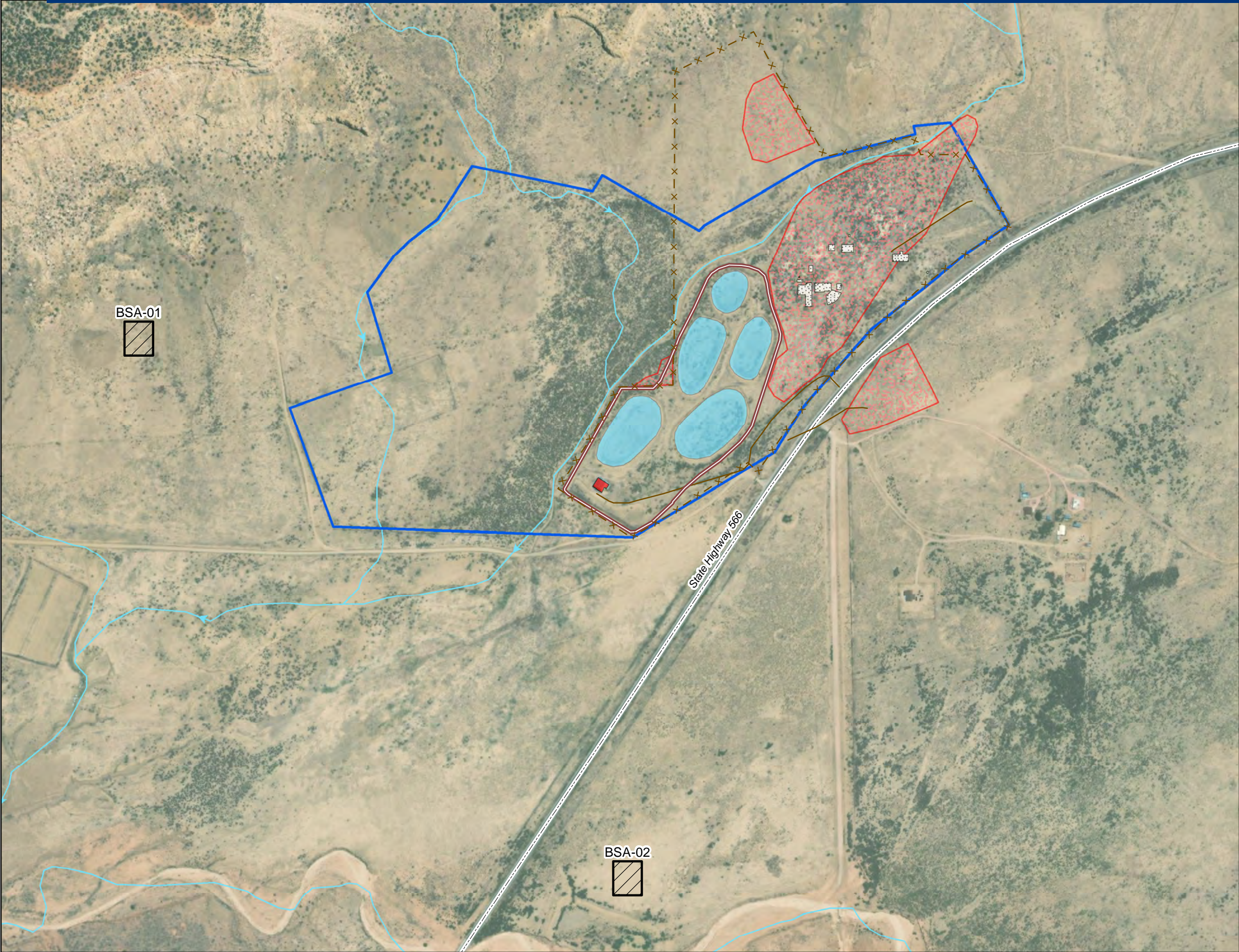
2.3 ECOLOGY

The landscape surrounding BSA-02 consists of flat to gently dipping sedimentary rocks eroded into mesas, valleys, and deep canyons. The area has a mild north-northwesterly aspect with slopes ranging from 1.5 to 3.5 percent, is at average elevation of 6,805 feet amsl, and receives approximately 9 inches of annual precipitation (United States Department of Agriculture [USDA] 2018). While the area does not benefit significantly from run-on moisture, the sandy soils capture moisture from both winter precipitation and intense summer thunderstorms with minimal runoff. Vegetation production is bimodal, with peaks in April and August (National Resource Conservation Service [NRCS] 2012). Evidence of grazing was observed during field surveys which, in combination with drought, can destabilize soil surface crust, and make the area susceptible to loss of topsoil from aeolian erosion.

The vegetation and environmental conditions of BSA-02 are representative of the Colorado Plateau Mixed Bedrock Canyon and Tableland ecological system (CES304.765) (United States Geological Survey [USGS] 2005). Vegetation within the area surrounding BSA-02 is a sparse shrubland with scattered short-statured juniper (*Juniperus sp.*). Total cover from juniper is less than 5 percent. Shrubs within this area include rabbitbrush (*Chrysothamnus sp.*), big sagebrush (*Artemisia tridentata*), broom snakeweed (*Gutierrezia sarothrae*), and yucca (*Yucca sp.*), which cumulatively provide approximately 8 percent cover. Herbaceous composition includes species adapted to grazing pressure in sandy soils such as fluffgrass (*Dasyochloa pulchella*) and Indian

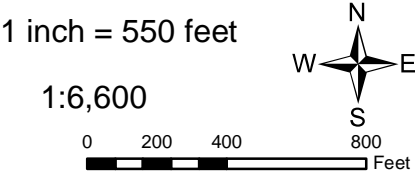


ricegrass (*Achnatherum hymenoides*), which cumulatively provide less than 5 percent cover. Forb and annual grass cover is negligible.



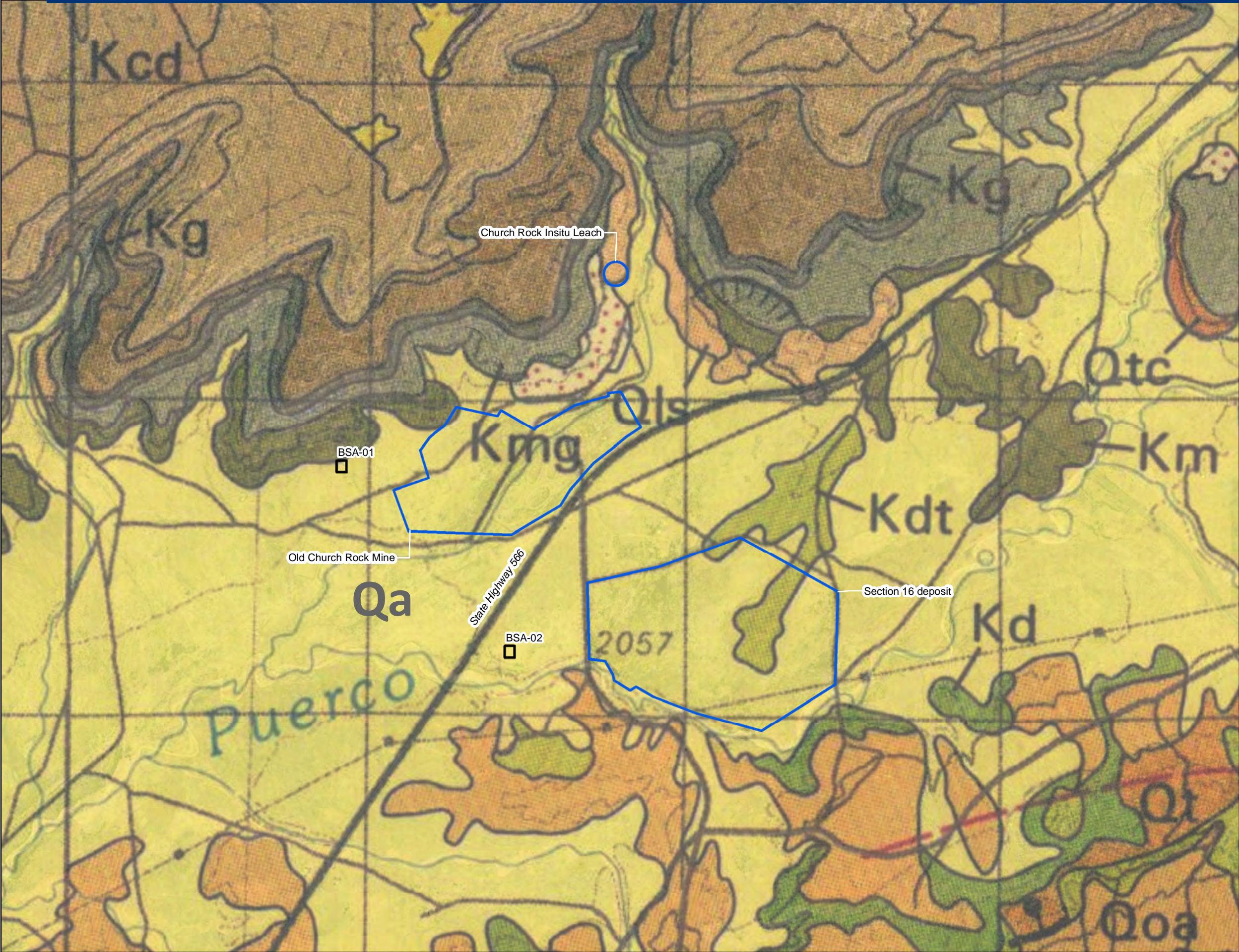
- Background Study Area
- AUM Site Boundary
- Site Features**
- Berm
- Fenced Boundary
- Facility Road
- Concrete Pad
- Former Pond
- Ion Exchange Building
- Suspected Waste Disposal
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AUM Abandoned uranium mine



OLD CHURCH ROCK MINE AUM
BACKGROUND STUDY AREA
SITE LOCATION AND ACCESS

Prepared For: U.S. EPA Region 9 	Prepared By: TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 1/25/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: H-1



Abandoned Uranium Mine Site

Background Study Area

Geologic Units¹

Alluvial Deposits (Qa)

Older Alluvium (Qoa)

Talus Deposits (Qt)

Tallus Depoists and Colluvium, Undivided (Qtc)

Landslide Deposits (Qls)

Dalton Sanstone Member, unnamed lower tongue, and Borrego Pass Lentil of Crevasse Canyon Formation, and Mulatto Tongue of Mancos Share, Undivided (Kcd)

Dilco Coal Member of Crevasse Canyon Formation (Kcdi)

Main Body Gallup Sandstone (Kg)

Lower Tongues of Gallup Sandstone, and Unnamed Tongues of Mancos Shale, Undivided (Kmg)

Twowells Tongue of Dakota Sandstone and Whitewater Arroyo Tongue of Mancos Shale, Undivided (Kdt)

Main Body of Dakota Sandstone (Kd)

Note:

¹Dillinger (1990).

1 inch = 1,600 feet

1:19,200

0

800

1,600

3,200

Feet

N

W

E

S

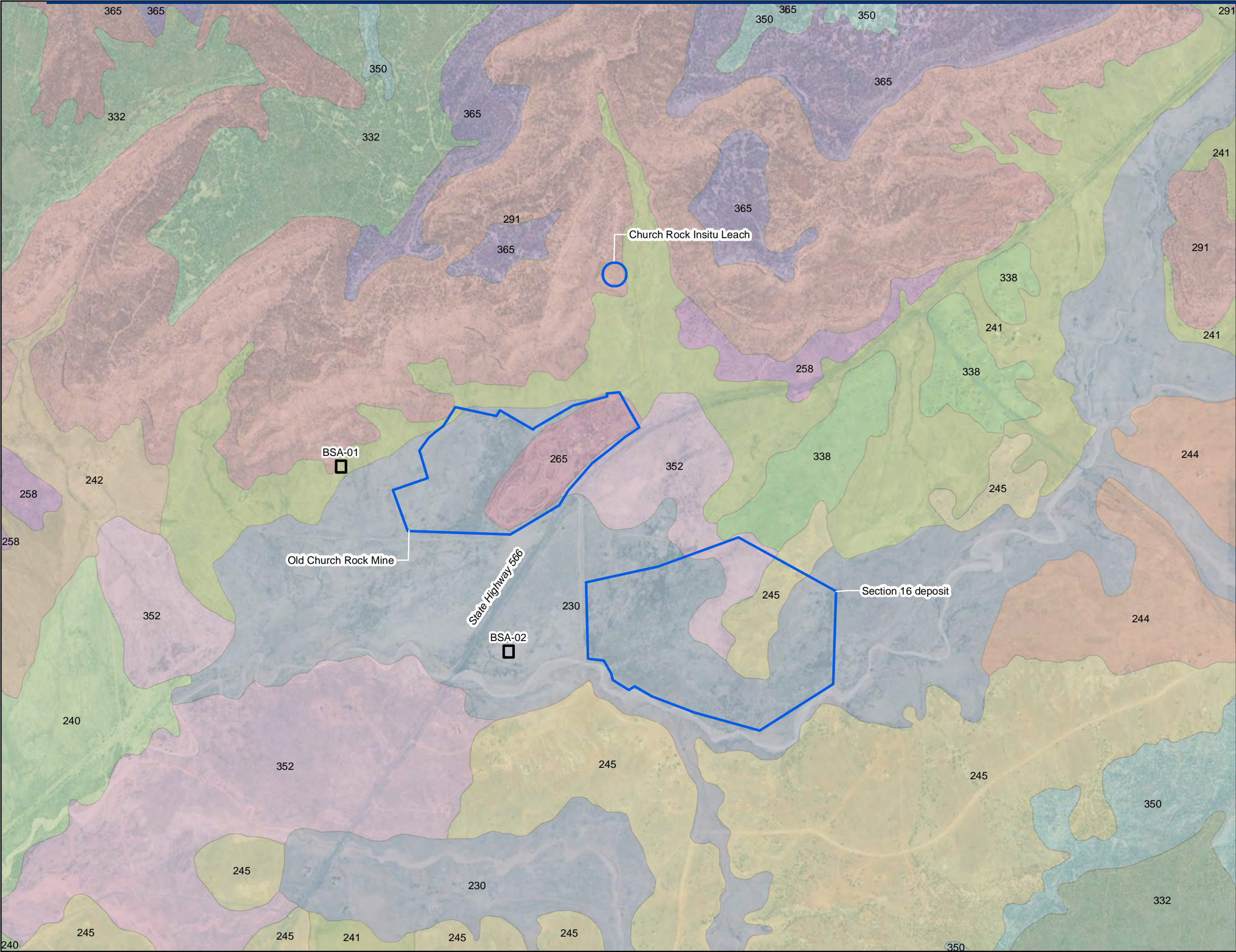
OLD CHURCH ROCK MINE

GEOLOGY

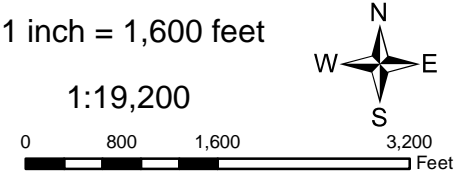
<div>Prepared For: U.S. EPA Region 9</div> <div></div>	<div>Prepared By:</div> <div><div><div>Tt</div><div>TETRA TECH</div><div>1999 Harrison Street, Suite 500</div><div>Oakland, CA 94612</div></div></div>
<div>Task Order No.:</div> <div>0035</div>	<div>Contract No.:</div> <div>EP-S9-17-03</div>
<div>Location:</div> <div>CHURCH ROCK CHAPTER</div> <div>NAVAJO NATION</div>	<div>Date:</div> <div>1/25/2023</div>
<div>Coordinate System:</div> <div>NAD 1983 State Plane New Mexico</div> <div>West FIPS 3003 Feet Transverse</div>	<div>Figure No.:</div> <div>H-2</div>

Contract No. EP-S9-17-03, Task Order 0035

H-5



- Abandoned Uranium Mine Site**
- Background Study Area**
- Soil Units**
- Breadsprings and Nahodish soils, 0 to 2 percent slopes (240)
 - Buckle fine sandy loam, 1 to 8 percent slopes (244)
 - Buckle-Gapmesa-Barboncito complex, 1 to 6 percent slopes (245)
 - Eagleye-Atchee-Rock outcrop complex, 2 to 35 percent slopes (258)
 - Evpark-Arabrab complex, 2 to 6 percent slopes (332)
 - Gish-Mentmore complex, 1 to 8 percent slopes (242)
 - Mentmore loam, 1 to 8 percent slopes (241)
 - Rock outcrop-Eagleye-Atchee complex, 35 to 70 percent slopes (291)
 - Sparank-San Mateo-Zia complex, 0 to 3 percent slopes (230)
 - Toldohn-Vessilla-Rock outcrop complex, 8 to 35 percent slopes (350)
 - Uranium mined lands (265)
 - Vessilla-Rock outcrop complex, 2 to 15 percent slopes (365)
 - Zia sandy loam, 1 to 5 percent slopes (352)
 - Zyme-Lockerby association, 5 to 35 percent slopes (338)



OLD CHURCH ROCK MINE
SOILS

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Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 1/25/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: H-3

3.0 METHODS

This section presents field sampling and background data interpretation methods for the investigation at BSA-02.

3.1 GAMMA RADIATION SURVEY

A gamma radiation survey at BSA-02 conformed to methods outlined in the OCRM Removal Assessment SAP (Tetra Tech 2022). Field staff used a Ludlum Model 44-10 (or equivalent) 2- by 2-inch sodium iodide (NaI) gamma scintillation detector coupled to a Ludlum Model 3000 ratemeter/scaler set in ratemeter mode. The detectors were coupled with an Environmental Restoration Group, Inc. (ERG) Model 105 Global Positioning System (GPS). The ERG Model 105 GPS consists of a Juniper Mesa 2 field computer and sub-meter accurate geode GPS receiver (or equivalent). The surveys were conducted on foot at approximately 1 meter (m) per second along 2-m transects within the BSA-02 survey boundary. Detector height was 1 m above ground surface. Consistent with recommendations in NUREG-5849 (Nuclear Regulatory Commission [NRC] 1992), the gamma measurements were processed after acquisition by (1) overlaying 100-square-meter (m²) grids across BSA, and (2) estimating the average of the gamma measurements within each grid. Results of the gamma radiation survey are in [Section 4.1](#).

3.2 SOIL SAMPLING

Soil sampling at BSA-02 followed methods outlined in the OCRM removal assessment SAP (Tetra Tech 2022). Thirty surface soil samples collected by use of a stainless steel trowel within 0 to 6 inches below ground surface (bgs) were analyzed for metals and radionuclides. Soil sample locations were selected from the approximate centroid of an unbiased systematic sampling grid (10 x 10 m) over a 0.75-acre tract of land.

The grid identification of each 100 m² sampling grid is shown at the upper corner of each grid on [Figure H-4](#). Surface soil sample locations are shown on [Figure H-4](#). Coordinates and associated laboratory sample delivery group information pertaining to each soil sample location are listed in [Table H-1](#).

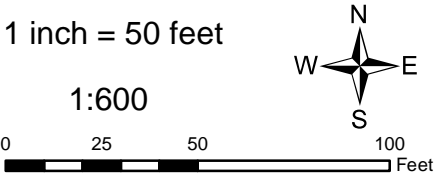
Field duplicates were collected at frequency of one per 20 samples. All samples were analyzed for 25 different metals, and radionuclides (potassium-40 [K-40], radium-226 [Ra-226], radium-228 [Ra-228], thorium-232 [Th-232], and uranium-238 [U-238]). In addition to these analytes, two soil samples from BSA-02 also were selected for analyses for isotopic uranium and isotopic thorium. The purpose of analyzing a subset of samples for isotopic uranium, and isotopic thorium was to evaluate the uranium series equilibrium. The evaluation of uranium series equilibrium will inform interpretation of fate and transport of radionuclides. Laboratory methods applied were:

- Metals via United States Environmental Protection Agency (USEPA) Method 6020
- K-40, Ra-226, Ra-228, Th-232, U-238 via USEPA Method 901.1 (EH300)
- Isotopic uranium and thorium via ASTM International (ASTM) method D3972 (HASL 300).



- Soil Sample Locations**
- Surface Soil (0-6 inches bgs)
 - Survey Unit Grid Cell (100 m²)
 - Background Study Area

Notes:
bgs Below ground surface
m² Square meter



OLD CHURCH ROCK MINE
BSA-02
SOIL SAMPLE LOCATIONS

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**Table H-1. Summary of BSA-02 Soil Sample Locations**

Sample ID	Latitude ¹	Longitude ¹	Laboratory ID	
OCRM-B02-SS01-01-111622	35.61307966	-108.5573664	601828001	601835001
OCRM-B02-SS02-01-111622	35.61307613	-108.5572453	601828002	601835002
OCRM-B02-SS03-01-111622	35.61307452	-108.557143	601828003	601835003
OCRM-B02-SS04-01-111622	35.61307743	-108.5570252	601828004	601835004
OCRM-B02-SS05-01-111622	35.6130806	-108.5569077	601828005	601835005
OCRM-B02-SS06-01-111622	35.61298823	-108.5573641	601828011	601835011
OCRM-B02-SS07-01-111622	35.61298655	-108.5572531	601828010	601835010
OCRM-B02-SS08-01-111622	35.61299656	-108.5571292	601828009	601835009
OCRM-B02-SS09-01-111622	35.61298595	-108.5570394	601828008	601835008
OCRM-B02-SS10-01-111622	35.61298455	-108.5569258	601828006	601835006
OCRM-B02-SS11-01-111622	35.61289275	-108.5573528	601828012	601835012
OCRM-B02-SS12-01-111622	35.61289344	-108.5572415	601828013	601835013
OCRM-B02-SS13-01-111622	35.61290314	-108.5571311	601828014	601835014
OCRM-B02-SS14-01-111622	35.61289734	-108.5570154	601828015	601835015
OCRM-B02-SS15-01-111622	35.61289444	-108.5569171	601828016	601835016
OCRM-B02-SS16-01-111622	35.61280822	-108.5573419	601838002	601840002
OCRM-B02-SS17-01-111622	35.61280543	-108.557253	601838001	601840001
OCRM-B02-SS18-01-111622	35.61280652	-108.5571466	601828020	601835020
OCRM-B02-SS19-01-111622	35.61281036	-108.557026	601828019	601835019
OCRM-B02-SS20-01-111622	35.61280498	-108.5569152	601828017	601835017
OCRM-B02-SS21-01-111622	35.612713	-108.5573476	601838003	601840003
OCRM-B02-SS22-01-111622	35.61271115	-108.5572421	601838004	601840004
OCRM-B02-SS23-01-111622	35.61271863	-108.557134	601838005	601840005
OCRM-B02-SS24-01-111622	35.61271929	-108.5570195	601838006	601840006
OCRM-B02-SS25-01-111622	35.61272413	-108.5569059	601838007	601840007
OCRM-B02-SS26-01-111622	35.61263639	-108.5573601	601838012	601840012
OCRM-B02-SS27-01-111622	35.61263221	-108.5572341	601838011	601840011
OCRM-B02-SS28-01-111622	35.61262694	-108.557132	601838010	601840010
OCRM-B02-SS29-01-111622	35.61262709	-108.5570212	601838009	601840009
OCRM-B02-SS30-01-111622	35.61261777	-108.5569125	601838008	601840008

Note:

¹ WGS84 Coordinate System

Soil sampling results are in [Section 4.2](#). Copies of all lab reports are in Appendix G to the removal assessment report. A soil verification report including all lab data is in Appendix D to the removal assessment report.

3.3 DETERMINATION OF BACKGROUND THRESHOLD VALUES

Background evaluation studies involve determinations of site-specific, background-level, constituent concentrations to establish background threshold values (BTV) (USEPA 2022). Comparing site-specific chemical and radiological BTVs to datasets acquired at historical mining sites allows determination of whether and to what extent historical mining operations have impacted those sites. Moreover, the comparative analysis is useful for identification of site-specific contaminants of potential concern (COPC). As part of this background evaluation, Tetra Tech used the USEPA-funded statistical software ProUCL version 5.2 for robust computations of upper statistical limits. The ProUCL Version 5.2 Technical Guide (USEPA 2022) was referenced to develop a process for determination of upper statistical limits for selection of BTVs as outlined in [Section 3.3.5](#).

The main objective of ProUCL software is to compute rigorous and reproducible statistics to help decision makers and project teams make decisions regarding a polluted site that are cost-effective and protective of human health and the environment (USEPA 2022). Because site-specific BTVs were to be used for decision making (i.e., identification of COPCs, determination of contamination with respect to background), careful analysis of outliers and data distributions occurred. The following subsections describe upper statistical limits, treatments of uncensored datasets, censored datasets, outliers, and sample size determination.

3.3.1 Upper Limits

For both parametric (normal, gamma, lognormal) and nonparametric distributions, the upper limits selected were the 95 percent upper tolerance limit with 95 percent coverage (UTL95-95) following the process outlined in [Section 3.3.5](#).

3.3.2 Treatment of Uncensored Datasets

An uncensored dataset is a dataset without any nondetect (ND) results. ProUCL provides goodness of fit (GOF) tests for normal, lognormal, and gamma distributions of uncensored datasets. Tetra Tech applied GOF testing in ProUCL to all analytes of interest detected at BSA-02. All uncensored datasets were analyzed by use of the ProUCL 5.2 statistical software package following guidance in Chapter 3 of the ProUCL Technical Guide (USEPA 2022), which focuses on computing upper limits to estimate BTVs based on datasets with no nondetects. Sometimes, multiple parametric distributions were identified within a single dataset; therefore, the following rules were followed as recommend by ProUCL:

1. A normal distribution was always selected over a lognormal or a gamma distribution if it appeared or approximated a normal distribution. For normally distributed data, the Normal UTL95-95 is selected as the BTV.
2. A gamma distribution was always selected over a lognormal distribution if a dataset did not appear to follow normal distribution. If a dataset approximated a normal distribution but appeared to follow a gamma distribution, the gamma distribution was selected. The Wilson Hilferty (WH) UTL95-95 was selected as the BTV for gamma distributed uncensored datasets.

3. If the data appeared only lognormally distributed, the lognormal UTL95-95 was selected as the BTV. If the dataset approximated a gamma distribution but appeared to follow a lognormal distribution, the lognormal distribution was selected.
4. If a dataset exhibited no discernible parametric distribution, the nonparametric upper statistical limit was selected.

3.3.3 Treatment of Censored Datasets

A censored dataset includes censored data (nondetects). ProUCL has GOF tests for normal, lognormal, and gamma distributions in left-censored datasets with nondetects. It is not easy to assess and verify the distribution of datasets with NDs, especially when multiple detection limits (DL) are present and those DLs exceed detected values (USEPA 2022). As for uncensored full datasets, skewness and data distribution of detected values are important in selecting appropriate estimates of BTVs for datasets with NDs. For datasets with NDs, it is important to determine the distribution and skewness of the dataset obtained by excluding NDs (USEPA 2022). This information aids selection of appropriate parametric or nonparametric methods to compute the various upper limits that account for NDs and adjust for data variability and skewness (USEPA 2022). ProUCL has GOF tests for normal, lognormal, and gamma distributions. The GOF tests in ProUCL include: (1) exclusion of all NDs, (2) replacement of NDs by their DL/2, and (3) Regression Order Statistics (ROS) methods. Notably, developers of ProUCL do not recommend the substitution method in any situation (i.e., replacement of NDs by their DL/2).

Analytical results from soil samples are in [Section 4.2](#). For the purposes of this background evaluation, regarding the censored datasets, ND values for a particular analyte at a BSA were set to the DL (method detection limit [MDL] or minimum detectable concentration [MDC]), not the reporting limit (RL) or quantitation limit (QL). This approach was selected because the inferred upper limits determined by ProUCL generally are more conservative for analyses of censored datasets by use of the DL than by use of the RL. The substitution method (i.e., DL/2) was not used for selection of BTVs during this project.

A number of guidelines for selecting BTVs from ProUCL output were used for determination of upper statistical limits of censored datasets, as follows:

- A normal distribution (of detected results) was always selected over a lognormal or a gamma distribution.
- A gamma distribution (of detected results) was always selected over a lognormal distribution.
- When detected data followed a normal distribution, use of Kaplan-Meier (KM) estimates in normal equations was selected (as recommended by developers of ProUCL) for computing upper limits (i.e., upper tolerance limit [UTL]) by application of the same principles as presented in [Section 3.3.2](#).
- When detected data followed a gamma distribution, the KM UTL95-95 was selected as the BTV by application of the same principles as presented in [Section 3.3.2](#).

- When detected data followed a lognormal distribution, use of KM estimates in lognormal equations was selected for computing upper limits (i.e., UTL) by application of the same principles as presented in [Section 3.3.2](#).
- For censored datasets in which detected data followed no discernible pattern, the nonparametric upper limit UTL 95-95 was selected as the BTV.

To summarize, all censored datasets were analyzed by use of the ProUCL 5.2 statistical software package following guidance in Chapter 5 of the ProUCL Technical Guide (USEPA 2022), which focuses on computing upper limits to estimate BTVs based on datasets with ND results.

3.3.4 Treatment of Outliers

A number of explanations are possible for presence of outliers within an analytical dataset, including laboratory error or sampling of a different population than the main, dominant, background population. Outliers distort most statistics of interest, including UTLs. Therefore, computations of decision statistics, such as BTVs, should be based on datasets representing the dominant population, and computations of distorted statistics via accommodation of a few low probability outliers should not occur (USEPA 2022). ProUCL provides classical outlier testing procedures including the Dixon test and the Rosner test. These tests often are marred by “masking effects” in the presence of multiple outliers (USEPA 2022). Therefore, ProUCL recommends always accompanying these outlier tests with graphical displays including probability plots and individual value plots.

Classical outlier tests were performed on the laboratory analytical datasets. No classical outlier tests were performed on the field-collected gamma data.

BSAs selected for this study to represent the background population of interest (i.e., established background dataset) were visually inspected by field staff to ensure (1) no evidence of anthropogenic activities related to mining at these sites, and (2) no presence of areas of technologically enhanced naturally occurring radioactive material (TENORM). Therefore, a criterion for an analytical dataset to have “statistical outliers” was set at 1 percent significance by application of either of the classical outlier tests in ProUCL.

When an outlier was identified at a 1 percent significance, further analysis was warranted. The criterion for decision making was that if the maximum concentration was two times the second highest concentration or greater, the sample containing the highest concentration was considered anomalous, was removed from the analysis, and ProUCL was rerun. For these situations in which the maximum concentration exceeds the second highest concentration by three times or more, the maximum sample is considered a “visual outlier.” No outliers were removed for BTV calculations for any of the analytes in the background dataset for BSA-02.

3.3.5 Procedures for Determination of Background Threshold Values

As described earlier, USEPA-funded statistical software ProUCL 5.2 was the primary tool for selection of BTVs for analytes within the BSA. Tetra Tech followed guidance in the ProUCL Technical Guidance Manual for determining BTVs and navigating ProUCL 5.2 statistical software. All ProUCL output is provided in [Attachment H-2](#). All upper limits selected for the

BTVs were obtained by use of ProUCL; detailed reasoning is conveyed for most manual selections of BTVs that did occur. [Section 4.0](#) presents field sampling results. [Section 5.0](#) presents selected BTVs for each analyte of interest and includes graphical displays of the datasets as individual value plots, probability plots, and histograms.

3.4 X-RAY FLUORESCENCE SURVEY

An XRF survey at BSA-02 conformed to methods outlined in the OCRM Removal Assessment SAP (Tetra Tech 2022). Thirty XRF measurements were taken for analysis for metals. XRF measurement locations align with the surface soil sampling locations, described in [Section 3.2](#), which were selected within an unbiased systematic sampling grid (10 x 10 m) over a 0.75-acre tract of land.

The grid identification of each 100 m² sampling grid is shown at the upper corner of each grid on [Figure H-4](#). XRF measurement locations were co-located with soil sample locations, shown in green on [Figure H-4](#). Field duplicates were collected at frequency of one per 20 samples. The evaluation of uranium series equilibrium will inform interpretation of fate and transport of radionuclides.

XRF survey results are in [Section 4.3](#).

4.0 FIELD SAMPLING RESULTS

This section presents gamma radiation survey results and soil sampling results.

4.1 GAMMA RADIATION SURVEY RESULTS

On November 15, 2022, a gamma radiation survey at BSA-02 occurred by application of the methods outlined in [Section 3.1](#). Summary statistics for the raw and grid-averaged gamma radiation survey results are listed in [Table H-2](#). A raw gamma radiation survey map and grid-averaged gamma radiation survey map are on [Figure H-5](#) and [Figure H-6](#), respectively. Gamma radiation ranged from 10,300 to 16,400 counts per minute (cpm).

Table H-2. Summary Statistics of Gamma Radiation Survey Results

Summary Statistic	Units	Raw Gamma Radiation Levels	Grid-Averaged Gamma Radiation Levels ¹
Number of Measurements	#	1,587	30
Minimum	cpm	10,300	12,650
Maximum	cpm	16,400	13,823
Average	cpm	13,216	13,231
Median	cpm	13,300	13,222
Standard Deviation	cpm	784	267
90 th Percentile	cpm	14,100	13,581
95 th Percentile	cpm	14,400	13,780
99 th Percentile	cpm	15,000	13,823
Relative Standard Deviation (RSD)	%	6%	2%

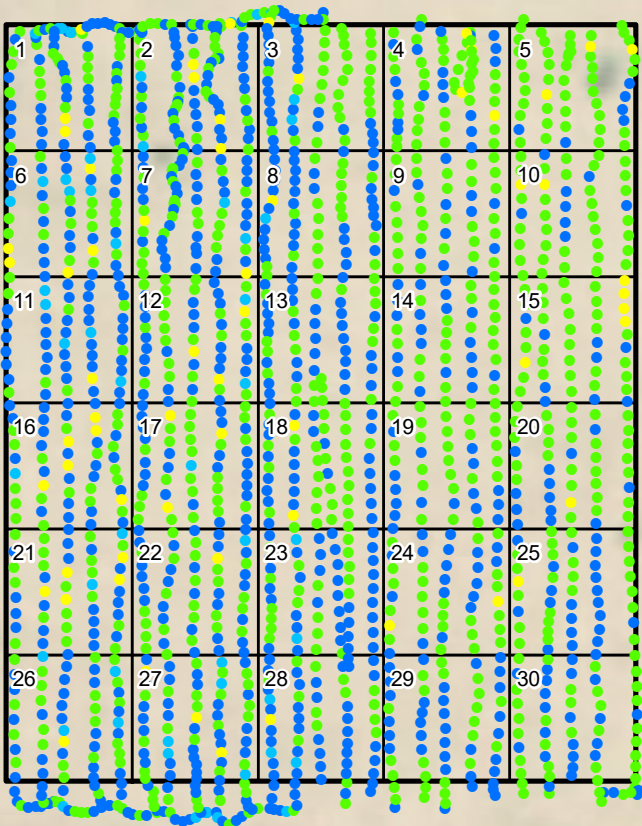
Notes:

¹ Grid-averaged gamma radiation was determined for each 100 m² grid.

cpm Counts per minute

m² Square meter

Results of the raw gamma radiation survey indicate gamma radiation levels ranging between 10,300 and 16,400 cpm. Average and median gamma radiation levels are 13,216 and 13,000 cpm, respectively. The standard deviation of the gamma radiation level is 784 cpm, and the relative standard deviation [RSD] (also referred to as the coefficient of variation [COV]) is 6 percent.



Gamma Reading (cpm)

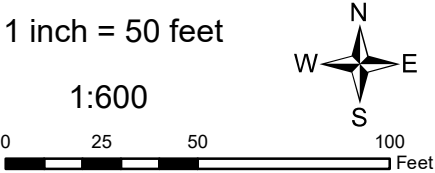
● ≤ 11,500	≤ Q1
● 11,500 - 13,228	Q1 - Avg
● 13,228 - 14,548	Avg - BTV ¹
● 14,548 - 29,096	BTV - 2 x BTV
● 29,096 - 72,740	2 x BTV - 5 x BTV
● 72,740 - 181,850	5 x BTV - 12.5 x BTV
● 181,850 - 250,000	12.5 x BTV - 17 x BTV
● >250,000	17 x BTV>

Survey Unit Grid Cell (100 m²)

Background Study Area

Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.

Avg	Average value of the background dataset
BTV	Background threshold value
cpm	Counts per minute
m ²	Square meter
Q1	Twentyfifth percentile of the background



OLD CHURCH ROCK MINE

BSA-02

RAW GAMMA RADIATION SURVEY

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1 13,119	2 13,061	3 13,209	4 13,581	5 13,823
6 13,044	7 13,005	8 13,025	9 13,531	10 13,573
11 12,650	12 13,100	13 13,096	14 13,326	15 13,780
16 13,283	17 13,263	18 13,391	19 13,412	20 13,470
21 13,235	22 13,175	23 13,037	24 13,270	25 13,317
26 13,065	27 12,841	28 12,823	29 13,115	30 13,307

Grid Averaged Gamma Rate (cpm)

≤ 11,500

11,500 - 13,228

13,228 - 14,548

14,548 - 29,096

29,096 - 72,740

72,740 - 181,850

181,850 - 250,000

> 250,000

≤ Q1

Q1 - Avg

Avg - BTV¹

BTV - 2 x BTV

2 x BTV - 5 x BTV

5 x BTV - 12.5 x BTV

12.5 x BTV - 17 x BTV

17 x BTV>

Survey Unit Grid Cell (100 m²)

Background Study Area

Notes:
¹BTV is based on the 95 percent upper tolerance limit with 95 percent coverage of the background dataset.
Avg Average value of the background dataset
BTV Background threshold value
cpm Counts per minute
m² Square meter
Q1 Twentyfifth percentile of the background

1 inch = 50 feet

1:600

02550100

Feet

N

W

E

S

OLD CHURCH ROCK MINE
BSA-02
GRIDDED AVERAGE GAMMA
RADIATON SURVEY

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Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 2/2/2023
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Contract No. EP-S9-17-03, Task Order 0035

H-16



4.2 SOIL SAMPLING RESULTS

Thirty surface soil samples were collected within 0 to 6 inches bgs, as shown on [Figure H-4](#). Geospatial coordinates of soil sample locations and associated laboratory sample delivery group (SDG) IDs are listed in [Table H-1](#). Two laboratory SDGs for each sample included one for metals analysis and one for radionuclide analysis. Surface soil sampling analytical results are presented in this report.

Furthermore, the laboratory analytical reports provided by the laboratory include 25 metals. Results for the metal analytes are listed in [Table H-3](#). Descriptive summary statistics for metals are listed in [Table H-4](#), based on detected concentrations only.

[Table H-5](#) lists analytical laboratory results for radionuclides of interest. Every sample was analyzed for Ra-226, Ra-228, K-40, Th-232, and U-238. A subset of samples also was analyzed for isotopic uranium, which includes uranium-238 (U-238), uranium-235/236 (U-235), and uranium-233/234 (U-234). This same subset of samples also was analyzed for isotopic thorium, which includes thorium-228 (Th-228), thorium-230 (Th-230), and thorium-232 (Th-232). Notably, although analytical results for these radioisotopes (i.e., isotopic uranium, isotopic thorium) appear in this report, BTVs are not calculated for these analytes. Descriptive summary statistics regarding the radionuclides of interest are listed in [Table H-6](#).

Copies of all lab reports appear in Appendix G. A soil verification report including all laboratory results is in Appendix D. [Section 5.0](#) analyzes and interprets data from the gamma radiation survey and analytical soil sampling at BSA-02, and presents final selections of site-specific BTVs for all analytes of interest.



Table H-3. Metals Laboratory Analytical Results for BSA-02

Site ID	Field Sample ID	Sample Date	Grid Location No.	Sample Depth (inches)	Aluminum		Antimony		Arsenic		Barium		Beryllium		Cadmium		Calcium		Chromium		Cobalt	
					Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q
BSA-02	OCRM-B02-SS01-01-111622	11/16/2022	1	0-6	10,400		0.39	U	4.5		121		0.74		0.17	B	7,320		9.1		5.9	
BSA-02	OCRM-B02-SS02-01-111622	11/16/2022	2	0-6	14,100		0.38	U	5.1		121		0.93		0.16	B	5,800		11		7.0	
BSA-02	OCRM-B02-SS03-01-111622	11/16/2022	3	0-6	16,200		0.39	U	5.8		129		0.98		0.15	B	6,630		13		8.3	
BSA-02	OCRM-B02-SS04-01-111622	11/16/2022	4	0-6	16,500		0.38	U	5.8		133		1.0		0.16	B	7,150		13		7.9	
BSA-02	OCRM-B02-SS05-01-111622	11/16/2022	5	0-6	17,100		0.35	U	5.8		131		1.0		0.16	B	7,040		13		8.3	
BSA-02	OCRM-B02-SS06-01-111622	11/16/2022	6	0-6	14,100		0.33	U	5.6		120		0.94		0.16	B	8,680		12		7.4	
BSA-02	OCRM-B02-SS07-01-111622	11/16/2022	7	0-6	18,800		0.41	U	6.4		136		1.1		0.17	B	6,360		15		8.8	
BSA-02	OCRM-B02-SS08-01-111622	11/16/2022	8	0-6	17,300		0.37	U	6.1		136		1.1		0.16	B	7,170		13		8.7	
BSA-02	OCRM-B02-SS09-01-111622	11/16/2022	9	0-6	14,900		0.38	U	5.8		132		0.99		0.17	B	7,430		12		8.0	
BSA-02	OCRM-B02-SS10-01-111622	11/16/2022	10	0-6	16,300		0.37	U	5.7		127		1.0		0.15	B	7,010		13		7.9	
BSA-02	OCRM-B02-SS11-01-111622	11/16/2022	11	0-6	16,500		0.40	U	5.6		127		1.0		0.14	B	5,850		13		7.5	
BSA-02	OCRM-B02-SS12-01-111622	11/16/2022	12	0-6	14,800		0.37	U	4.9		124		0.87		0.15	B	6,680		11		6.9	
BSA-02	OCRM-B02-SS13-01-111622	11/16/2022	13	0-6	17,400		0.39	U	6.0		127		1.1		0.17	B	6,270		13		8.1	
BSA-02	OCRM-B02-SS14-01-111622	11/16/2022	14	0-6	13,400		0.37	U	4.8		128		0.83		0.14	B	6,700		10		6.5	
BSA-02	OCRM-B02-SS15-01-111622	11/16/2022	15	0-6	16,800		0.36	U	5.6		138		1.0		0.16	B	7,050		13		7.9	
BSA-02	OCRM-B02-SS16-01-111622	11/16/2022	16	0-6	15,400		0.40	U	6.8		144		1.1		0.16	B	6,460		13		8.3	
BSA-02	OCRM-B02-SS17-01-111622	11/16/2022	17	0-6	16,500		0.39	U	6.5		175		1.1		0.16	B	7,360		14		8.3	
BSA-02	OCRM-B02-SS18-01-111622	11/16/2022	18	0-6	16,200		0.36	U	5.6		125		0.98		0.15	B	5,690		12		7.7	
BSA-02	OCRM-B02-SS19-01-111622	11/16/2022	19	0-6	14,300		3.5	U	5.3		126		0.89		0.15	B	6,780		11		7.1	
BSA-02	OCRM-B02-SS20-01-111622	11/16/2022	20	0-6	13,600		0.33	U	5.1		119		0.86		0.12	B	6,550		11		6.8	
BSA-02	OCRM-B02-SS21-01-111622	11/16/2022	21	0-6	13,000		0.34	U	5.3		142		0.81		0.14	B	7,960		10		7.8	
BSA-02	OCRM-B02-SS22-01-111622	11/16/2022	22	0-6	16,600		0.39	U	6.3		158		1.1		0.15	B	6,820		14		8.0	
BSA-02	OCRM-B02-SS23-01-111622	11/16/2022	23	0-6	15,400		0.39	U	5.9		145		0.97		0.15	B	6,390		13		7.4	
BSA-02	OCRM-B02-SS24-01-111622	11/16/2022	24	0-6	17,200		0.37	U	6.6		148		1.1		0.15	B	7,190		14		8.4	
BSA-02	OCRM-B02-SS25-01-111622	11/16/2022	25	0-6	14,000		0.34	U	5.9		141		0.93		0.13	B	6,840		12		7.4	
BSA-02	OCRM-B02-SS26-01-111622	11/16/2022	26	0-6	15,000		0.36	U	5.7		141		0.92		0.15	B	6,660		12		6.9	
BSA-02	OCRM-B02-SS27-01-111622	11/16/2022	27	0-6	15,400		0.37	U	6.1		150		0.95		0.14	B	6,530		12		7.5	
BSA-02	OCRM-B02-SS28-01-111622	11/16/2022	28	0-6	13,300		0.36	U	5.2		125		0.85		0.13	B	7,100		10		5.9	
BSA-02	OCRM-B02-SS29-01-111622	11/16/2022	29	0-6	16,900		0.39	U	6.4		151		1.0		0.14	B	6,250		14		8.0	
BSA-02	OCRM-B02-SS30-01-111622	11/16/2022	30	0-6	15,800		0.36	U	5.9		153		0.96		0.14	B	6,690		12		7.7	



Table H-3. Metals Laboratory Analytical Results for BSA-02 (Continued)

Site ID	Field Sample ID	Sample Date	Grid Location No.	Sample Depth (inches)	Copper		Iron		Lead		Lithium		Magnesium		Manganese		Molybdenum		Nickel	
					Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q
BSA-02	OCRM-B02-SS01-01-111622	11/16/2022	1	0-6	12		15,400		12		10		3,930		243		0.34	N	8.0	
BSA-02	OCRM-B02-SS02-01-111622	11/16/2022	2	0-6	13		18,100		14		13		3,880		254		0.33	N	9.5	
BSA-02	OCRM-B02-SS03-01-111622	11/16/2022	3	0-6	15		20,300		16		14		4,260		269		0.29	N	11	
BSA-02	OCRM-B02-SS04-01-111622	11/16/2022	4	0-6	15		20,000		15		15		4,350		262		0.30	N	11	
BSA-02	OCRM-B02-SS05-01-111622	11/16/2022	5	0-6	15		20,000		15		15		4,370		270		0.29	N	11	
BSA-02	OCRM-B02-SS06-01-111622	11/16/2022	6	0-6	14		17,900		14		14		4,480		250		0.32	N	10	
BSA-02	OCRM-B02-SS07-01-111622	11/16/2022	7	0-6	16		21,500		17		17		4,680		261		0.33	N	12	
BSA-02	OCRM-B02-SS08-01-111622	11/16/2022	8	0-6	16		19,800		16		16		4,430		260		0.31	N	12	
BSA-02	OCRM-B02-SS09-01-111622	11/16/2022	9	0-6	15		18,500		16		14		4,330		256		0.31	N	11	
BSA-02	OCRM-B02-SS10-01-111622	11/16/2022	10	0-6	15		18,800		15		14		4,220		253		0.28	N	11	
BSA-02	OCRM-B02-SS11-01-111622	11/16/2022	11	0-6	14		19,300		15		15		4,160		225		0.31	N	10	
BSA-02	OCRM-B02-SS12-01-111622	11/16/2022	12	0-6	13		17,500		14		13		4,190		263		0.33	N	9.2	
BSA-02	OCRM-B02-SS13-01-111622	11/16/2022	13	0-6	15		20,400		16		16		4,310		259		0.33	N	11	
BSA-02	OCRM-B02-SS14-01-111622	11/16/2022	14	0-6	12		16,400		12		12		3,670		214		0.35	N	8.5	
BSA-02	OCRM-B02-SS15-01-111622	11/16/2022	15	0-6	15		19,200		16		15		4,410		254		0.29	N	11	
BSA-02	OCRM-B02-SS16-01-111622	11/16/2022	16	0-6	15		19,600		18		16		4,550		250		0.36	N	11	
BSA-02	OCRM-B02-SS17-01-111622	11/16/2022	17	0-6	15		19,800		18		16		4,730		273		0.40	N	11	
BSA-02	OCRM-B02-SS18-01-111622	11/16/2022	18	0-6	14		19,000		15		14		3,970		251		0.31	N	10	
BSA-02	OCRM-B02-SS19-01-111622	11/16/2022	19	0-6	13		17,400		14		13		4,070		243		0.30	N	9.6	
BSA-02	OCRM-B02-SS20-01-111622	11/16/2022	20	0-6	12		16,400		13		13		3,790		211		0.31	N	9.2	
BSA-02	OCRM-B02-SS21-01-111622	11/16/2022	21	0-6	11		15,100		13		12		4,110		242		0.35	N	8.1	
BSA-02	OCRM-B02-SS22-01-111622	11/16/2022	22	0-6	14		19,100		17		16		4,560		256		0.37	N	11	
BSA-02	OCRM-B02-SS23-01-111622	11/16/2022	23	0-6	13		17,800		16		15		4,460		243		0.37	N	9.8	
BSA-02	OCRM-B02-SS24-01-111622	11/16/2022	24	0-6	15		20,000		18		16		4,780		270		0.37	N	11	
BSA-02	OCRM-B02-SS25-01-111622	11/16/2022	25	0-6	13		17,300		15		14		4,110		229		0.39	N	9.5	
BSA-02	OCRM-B02-SS26-01-111622	11/16/2022	26	0-6	12		16,900		15		14		4,430		246		0.37	N	9.1	
BSA-02	OCRM-B02-SS27-01-111622	11/16/2022	27	0-6	13		17,600		16		15		4,380		235		0.35	N	9.6	
BSA-02	OCRM-B02-SS28-01-111622	11/16/2022	28	0-6	11		14,400		13		13		3,930		209		0.33	N	7.8	
BSA-02	OCRM-B02-SS29-01-111622	11/16/2022	29	0-6	14		19,100		17		16		4,610		236		0.40	N	11	
BSA-02	OCRM-B02-SS30-01-111622	11/16/2022	30	0-6	13		18,400		16		15		4,340		249		0.39	N	9.9	



Table H-3. Metals Laboratory Analytical Results for BSA-02 (Continued)

Site ID	Field Sample ID	Sample Date	Grid Location No.	Sample Depth (inches)	Selenium		Silver		Sodium		Thallium		Thorium		Uranium		Vanadium		Zinc	
					Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q	Result (mg/kg)	Q
BSA-02	OCRM-B02-SS01-01-111622	11/16/2022	1	0-6	1.4		0.12	U	56		0.16	B	6.6		0.87		21	N	45	
BSA-02	OCRM-B02-SS02-01-111622	11/16/2022	2	0-6	1.7		0.12	U	58		0.20	B	8.3		0.98		23	N	52	
BSA-02	OCRM-B02-SS03-01-111622	11/16/2022	3	0-6	2.0		0.12	U	66		0.23	B	10		1.1		26	N	59	
BSA-02	OCRM-B02-SS04-01-111622	11/16/2022	4	0-6	1.9		0.11	U	74		0.23	B	9.7		1.3		27	N	57	
BSA-02	OCRM-B02-SS05-01-111622	11/16/2022	5	0-6	1.9		0.11	U	70		0.23	B	9.9		1.1		28	N	58	
BSA-02	OCRM-B02-SS06-01-111622	11/16/2022	6	0-6	1.9		0.10	U	69		0.21	B	9.0		1.1		26	N	53	
BSA-02	OCRM-B02-SS07-01-111622	11/16/2022	7	0-6	1.9		0.12	U	74		0.26	B	11		1.3		31	N	64	
BSA-02	OCRM-B02-SS08-01-111622	11/16/2022	8	0-6	2.0		0.11	U	74		0.24	B	10		1.2		28	N	60	
BSA-02	OCRM-B02-SS09-01-111622	11/16/2022	9	0-6	1.8		0.11	U	68		0.23	B	10		1.2		27	N	58	
BSA-02	OCRM-B02-SS10-01-111622	11/16/2022	10	0-6	1.7		0.11	U	74		0.23	B	9.6		1.2		27	N	56	
BSA-02	OCRM-B02-SS11-01-111622	11/16/2022	11	0-6	1.8		0.12	U	68		0.23	B	9.5		1.1		27	N	56	
BSA-02	OCRM-B02-SS12-01-111622	11/16/2022	12	0-6	1.5		0.11	U	63		0.21	B	8.5		1.0		26	N	50	
BSA-02	OCRM-B02-SS13-01-111622	11/16/2022	13	0-6	1.9		0.12	U	76		0.24	B	10		1.2		28	N	60	
BSA-02	OCRM-B02-SS14-01-111622	11/16/2022	14	0-6	1.5		0.11	U	60		0.19	B	7.9		1.1		23	N	45	
BSA-02	OCRM-B02-SS15-01-111622	11/16/2022	15	0-6	1.9		0.11	U	73		0.23	B	9.9		1.2		27	N	57	
BSA-02	OCRM-B02-SS16-01-111622	11/16/2022	16	0-6	2.8		0.61	U	71		0.24	B	11		1.2		29		61	
BSA-02	OCRM-B02-SS17-01-111622	11/16/2022	17	0-6	2.7		0.60	U	72		0.24	B	10		1.3		31		60	
BSA-02	OCRM-B02-SS18-01-111622	11/16/2022	18	0-6	1.8		0.11	U	68		0.21	B	9.4		1.2		26	N	55	
BSA-02	OCRM-B02-SS19-01-111622	11/16/2022	19	0-6	1.6		0.11	U	64		0.20	B	8.6		1.0		24	N	52	
BSA-02	OCRM-B02-SS20-01-111622	11/16/2022	20	0-6	1.6		0.10	U	65		0.20	B	8.5		1.1		24	N	48	
BSA-02	OCRM-B02-SS21-01-111622	11/16/2022	21	0-6	2.1		0.52	U	57		0.18	B	8.1		1.0		25		44	
BSA-02	OCRM-B02-SS22-01-111622	11/16/2022	22	0-6	2.5		0.59	U	73		0.23	B	10		1.2		30		57	
BSA-02	OCRM-B02-SS23-01-111622	11/16/2022	23	0-6	2.3		0.58	U	68		0.22	B	9.5		1.2		28		53	
BSA-02	OCRM-B02-SS24-01-111622	11/16/2022	24	0-6	2.7		0.57	U	75		0.24	B	11		1.2		31		59	
BSA-02	OCRM-B02-SS25-01-111622	11/16/2022	25	0-6	2.3		0.52	U	62		0.21	B	9.3		1.1		26		51	
BSA-02	OCRM-B02-SS26-01-111622	11/16/2022	26	0-6	2.3		0.54	U	64		0.21	B	8.8		1.0		27		49	
BSA-02	OCRM-B02-SS27-01-111622	11/16/2022	27	0-6	2.4		0.56	U	65		0.22	B	9.4		1.1		28		53	
BSA-02	OCRM-B02-SS28-01-111622	11/16/2022	28	0-6	1.9		0.55	U	52	B	0.18	B	7.5		0.95		24		44	
BSA-02	OCRM-B02-SS29-01-111622	11/16/2022	29	0-6	2.5		0.59	U	72		0.24	B	11		1.2		32		58	
BSA-02	OCRM-B02-SS30-01-111622	11/16/2022	30	0-6	2.3		0.55	U	65		0.22	B	9.6		1.2		28		54	

Notes:

B Either presence of analyte detected in the associated blank, or MDL/instrument detection limit < sample value < practical quantitation limit

BSA Background study area

LOD Limit of detection

MDA Minimal detectable amount

MDC Minimal detectable concentration

MDL Method detection limit

mg/kg Milligram per kilogram

N Metals – matrix spike sample recovery not within specified control limits.

Q Qualifier

U Analyte not detected at concentration above the MDL, MDA, MDC, or LOD.



Table H-4. Summary Statistics for Surface Soil Samples at BSA-02 (Metals)

Analyte	# of Surface Samples	# of Detects	# of Non-Detects	Minimum (mg/kg)	Maximum (mg/kg)	Average (mg/kg)	Median (mg/kg)	Standard Deviation (mg/kg)	90 th Percentile (mg/kg)	95 th Percentile (mg/kg)	99 th Percentile (mg/kg)	Relative Standard Deviation
Aluminum	30	30	0	10,400	18,800	15,440	15,600	1,727	17,210	17,355	18,394	11%
Antimony ¹	30	0	30	0.33	3.5	NA	NA	NA	NA	NA	NA	NA
Arsenic	30	30	0	4.5	6.8	5.7	5.8	0.55	6.4	6.6	6.8	10%
Barium	30	30	0	119	175	136	133	13	151	156	170	10%
Beryllium	30	30	0	0.74	1.1	0.97	0.98	0.10	1.1	1.1	1.1	10%
Cadmium	30	0	0	0.12	0.17	0.15	0.15	0.013	0.17	0.17	0.17	9%
Calcium	30	30	0	5,690	8,680	6,814	6,740	614	7,367	7,722	8,471	9%
Chromium	30	30	0	9.1	15	12	12.5	1.3	14	14	15	10%
Cobalt	30	30	0	5.9	8.8	7.6	7.7	0.73	8.3	8.6	8.7	10%
Copper	30	30	0	11	16	14	13.8	1.5	15.2	15.6	15.9	11%
Iron	30	30	0	14,400	21,500	18,367	18,650	1,699	20,030	20,355	21,181	9%
Lead	30	30	0	12	18	15	15	1.6	17	18	18	11%
Lithium	30	30	0	10	17	14	15	1.5	16	16	17	11%
Magnesium	30	30	0	3,670	4,780	4,283	4,335	280	4,617	4,708	4,766	7%
Manganese	30	30	0	209	273	248	251	17	269	270	272	7%
Molybdenum	30	30	0	0.28	0.40	0.34	0.33	0.035	0.39	0.40	0.40	10%
Nickel	30	30	0	7.8	12	10	10.3	1.0	11	11	12	10%
Selenium	30	30	0	1.4	2.8	2.0	1.91	0.37	2.5	2.7	2.7	19%
Silver ¹	30	0	30	0.10	0.61	NA	NA	NA	NA	NA	NA	NA
Sodium	30	30	0	52	76	67	67.8	6.3	74	75	76	9%
Thallium	30	30	0	0.16	0.26	0.22	0.22	0.023	0.24	0.24	0.26	10%
Thorium	30	30	0	6.6	11	9.4	9.6	1.0	11	11	11	11%
Uranium	30	30	0	0.87	1.3	1.1	1.1	0.10	1.2	1.3	1.3	9%
Vanadium	30	30	0	21	32	27	26.8	2.6	31	31	32	10%
Zinc	30	30	0	44	64	54	55.5	5.3	60	60	63	10%

Notes:
All summary statistics represent detected data only.
¹ Average, standard deviation, and BTV could not be calculated via KM Method because all values in the dataset were non-detects.
BSA Background study area
BTV Background threshold value
cpm Counts per minute
KM Kaplan-Meier
mg/kg Milligram per kilogram
NA Not applicable



Table H-5. Radionuclides Laboratory Analytical Results for BSA-02 (Lab Method EH300)

Field Sample ID	Sample Date	Grid Location No.	Sample Depth (inches)	Radium-226			Radium-228			Potassium-40			Thorium-232			Uranium-238		
				Activity (pCi/g)	TPU	Q	Activity (pCi/g)	TPU	Q	Activity (pCi/g)	TPU	Q	Activity (pCi/g)	TPU	Q	Activity (pCi/g)	TPU	Q
OCRM-B02-SS01-01-111622	11/16/2022	1	0-6	1.3	0.299		1.3	0.381		20	2.96		1.3	0.381		2.9	3.92	U
OCRM-B02-SS02-01-111622	11/16/2022	2	0-6	1.7	0.249		1.6	0.366		21	2.68		1.6	0.366		1.9	2.07	U
OCRM-B02-SS03-01-111622	11/16/2022	3	0-6	1.7	0.344		2.0	0.59		20	2.95		2.0	0.59		3.7	2.83	
OCRM-B02-SS04-01-111622	11/16/2022	4	0-6	1.6	0.262		1.3	0.379		21	2.77		1.3	0.379		0.89	2.71	U
OCRM-B02-SS05-01-111622	11/16/2022	5	0-6	1.7	0.265		1.9	0.377		22	2.76		1.9	0.377		1.6	2.28	U
OCRM-B02-SS06-01-111622	11/16/2022	6	0-6	1.5	0.296		1.5	0.421		21	2.68		1.5	0.421		1.3	2.8	U
OCRM-B02-SS07-01-111622	11/16/2022	7	0-6	1.8	0.274		2.0	0.394		20	2.55		2.0	0.394		0.78	2.33	U
OCRM-B02-SS08-01-111622	11/16/2022	8	0-6	1.7	0.3		2.2	0.454		20	2.9		2.2	0.454		0.094	2.08	U
OCRM-B02-SS09-01-111622	11/16/2022	9	0-6	1.9	0.256		2.0	0.44		20	2.74		2.0	0.44		0.000	2.83	UI
OCRM-B02-SS10-01-111622	11/16/2022	10	0-6	1.7	0.276		1.9	0.4		20	2.77		1.9	0.4		2.4	4.82	U
OCRM-B02-SS11-01-111622	11/16/2022	11	0-6	1.6	0.301		1.7	0.46		20	2.81		1.7	0.46		-0.27	3.11	U
OCRM-B02-SS12-01-111622	11/16/2022	12	0-6	1.7	0.259		1.6	0.506		22	2.72		1.6	0.506		0.000	1.45	UI
OCRM-B02-SS13-01-111622	11/16/2022	13	0-6	1.7	0.277		1.7	0.402		24	2.96		1.7	0.402		0.000	3.87	UI
OCRM-B02-SS14-01-111622	11/16/2022	14	0-6	1.4	0.232		1.5	0.414		21	2.85		1.5	0.414		1.8	4.15	U
OCRM-B02-SS15-01-111622	11/16/2022	15	0-6	1.6	0.222		1.7	0.465		22	2.85		1.7	0.465		2.1	2.6	
OCRM-B02-SS16-01-111622	11/16/2022	16	0-6	1.9	0.241		2.0	0.457		21	2.61		2.0	0.457		1.9	2.05	U
OCRM-B02-SS17-01-111622	11/16/2022	17	0-6	1.7	0.315		1.9	0.484		22	3		1.9	0.484		1.1	3.59	U
OCRM-B02-SS18-01-111622	11/16/2022	18	0-6	1.3	0.27		1.5	0.482		21	2.91		1.5	0.482		0.000	2.15	UI
OCRM-B02-SS19-01-111622	11/16/2022	19	0-6	1.5	0.289		1.2	0.439		22	2.81		1.2	0.439		0.000	2.9	UI
OCRM-B02-SS20-01-111622	11/16/2022	20	0-6	1.1	0.235		1.4	0.373		20	2.76		1.4	0.373		-0.20	3.34	U
OCRM-B02-SS21-01-111622	11/16/2022	21	0-6	1.3	0.263		1.2	0.453		22	2.82		1.2	0.453		1.5	1.43	
OCRM-B02-SS22-01-111622	11/16/2022	22	0-6	1.7	0.222		2.0	0.434		21	2.56		2.0	0.434		0.81	1.88	U
OCRM-B02-SS23-01-111622	11/16/2022	23	0-6	1.7	0.261		2.0	0.502		20	3.03		2.0	0.502		1.2	1.42	U
OCRM-B02-SS24-01-111622	11/16/2022	24	0-6	1.6	0.295		1.6	0.481		19	3.02		1.6	0.481		1.0	2.28	U
OCRM-B02-SS25-01-111622	11/16/2022	25	0-6	1.4	0.287		1.4	0.57		21	2.87		1.4	0.57		1.5	1.75	
OCRM-B02-SS26-01-111622	11/16/2022	26	0-6	1.6	0.285		1.7	0.547		20	2.8		1.7	0.547		1.7	2.27	U
OCRM-B02-SS27-01-111622	11/16/2022	27	0-6	1.4	0.233		1.7	0.362		21	2.54		1.7	0.362		2.3	1.25	
OCRM-B02-SS28-01-111622	11/16/2022	28	0-6	1.3	0.241		1.1	0.39		20	2.74		1.1	0.39		1.8	2.9	U
OCRM-B02-SS29-01-111622	11/16/2022	29	0-6	1.6	0.249		1.7	0.4		18	2.76		1.7	0.4		3.1	1.97	U
OCRM-B02-SS30-01-111622	11/16/2022	30	0-6	1.6	0.258		1.7	0.419		22	2.73		1.7	0.419		0.88	3.19	U
OCRM-B02-SS10-01-111622	11/16/2022	10	0-6	1.5	0.268		1.9	0.481		1.8	2.75		1.1	0.481		0.15	4.01	U
OCRM-B02-SS30-01-111622	11/16/2022	30	0-6	1.1	0.259		1.5	0.39		1.6	2.71		1.3	0.39		0.17	1.04	U

Notes:
BSA Background study area
EH300 Gamma spectrometry
LOD Limit of detection
MDA Minimum detectable amount
MDC Minimum detectable concentration
MDL Minimum detectable limit
pCi/g Picocurie per gram
Q Qualifier
TPU Total propagated uncertainty
U Analyte not detected at concentration above the MDL, MDA, MDC, or LOD.
UJ Results are considered a false positive due to high counting uncertainty.



Table H-6. Summary Statistics for Surface Soil Samples at BSA-02 (Radionuclides)

Analyte	# of Surface Samples	# of Detects	# of Non-Detects	Minimum (pCi/g)	Maximum (pCi/g)	Average (pCi/g)	Median (pCi/g)	Standard Deviation (pCi/g)	90 th Percentile (pCi/g)	95 th Percentile (pCi/g)	99 th Percentile (pCi/g)	Relative Standard Deviation
Radium-226	30	30	0	1.1	1.9	1.6	1.6	0.18	1.7	1.8	1.9	12%
Radium-228	30	30	0	1.1	2.2	1.7	1.7	0.29	2.0	2.0	2.2	17%
Potassium-40	30	30	0	18	24	21	21	1.1	22	22	23	5%
Uranium-238 (EH300)	30	5	20	-0.27	3.7	1.3	1.2	1.0	2.4	3.0	3.6	83%
Uranium-238 (HASL 300)	2	2	0	1.1	1.3	1.2						
Uranium-235/236	2	0	2	0.15	0.17	0.16						
Uranium-233/234	2	2	0	0.70	1.0	0.85						
Thorium-232 (EH300)	30	30	0	1.1	2.2	1.7	1.7	0.29	2.0	2.0	2.2	17%
Thorium-232 (HASL 300)	2	2	0	1.1	1.5	1.3						
Thorium-230	2	2	0	1.5	1.9	1.7						
Thorium-228	2	2	0	1.6	1.8	1.7						

Notes:
BSA Background study area
EH300 Gamma spectrometry
HASL 300 Alpha spectrometry
pCi/g Picocurie per gram

4.3 X-RAY FLUORESCENCE SURVEY RESULTS

Thirty XRF survey measurements were taken at locations co-located with surface soil samples, as shown on [Figure H-4](#). Geospatial coordinates of the co-located measurements are listed in [Table H-1](#).

Descriptive summary statistics for metals are listed in [Table H-4](#) based on detected concentrations only. XRF spectrometry was unable to detect the laboratory analytes (metals) beryllium, cadmium, calcium, lithium, magnesium, sodium, and thallium, but was able to detect gold, mercury, rubidium, strontium, titanium, tungsten, and zirconium. However, because the latter set of analytes was not included in the laboratory analytical suite, XRF results for those analytes were excluded.

One XRF result from BSA02 was removed from the dataset. Grid X01 of BSA02 hosted an abnormally high uranium concentration, 7.6 parts per million (ppm), which field staff identified as an oddity in the field and which was confirmed to be an outlier via the Rosner Outlier test at 5 percent and 1 percent significance levels. While in the field, staff returned to Grid X01 and repeated the measurement twice at the location. The measurements were more aligned with the uranium concentrations measured in the rest of the BSA. Additionally, the uranium concentration of the soil sample collected at Grid X01, 0.87 mg/kg, was not an outlier from the rest of the BSA. For this reason, the XRF measurement OCRMBSA02X01 was replaced with the first rescan of the grid, OCRMBSA02X01A.

[Table H-7](#) summarizes the various readings and samples collected at BSA-02 Grid X01. [Table H-8](#) summarizes the XRF measurement statistics for BSA-02.

Table H-7. XRF and Soil Sample Results for BSA-02 Grid X01

Sample Type	Sample ID	Uranium Result	Units	RPD (U result vs U mean)
XRF	OCRMBSA02X01	8	ppm	227%
XRF	OCRMBSA02X01A	4.3	ppm	128%
XRF	OCRMBSA02X01B	<LOD	ppm	-
Soil Sample	BSA02-SS01-01-111622	0.87	mg/kg	79%

Notes:

LOD Limit of detection
 mg/kg Milligram per kilogram
 ppm Parts per million
 RPD Relative percent difference
 U Uranium
 XRF X-ray fluorescence



Table H-8. Summary Statistics for XRF Measurements at BSA-02

Analyte	n	n Nondetects	% Nondetects	RSD	Distribution	GOF	Statistical Outliers Present?	Outliers Removed?	BTV Selection Method	Final BTV Selected	BTV Units	Notes
Arsenic	30	0	0%	13%	Normal	Appear	No	No	Normal UTL 95-95	8.181	ppm	
Barium	30	30	100%	-	-	-	No	No	-	>LOD	ppm	No detections of analyte in background; any detections above the LOD measured in field will be considered above background
Cobalt	30	5	17%	29%	Normal	Appear	No	No	Normal UTL 95-95	61.14	ppm	
Chromium	30	0	0%	24%	Normal	Appear	Yes	No	Normal UTL 95-95	43.01	ppm	
Copper	30	0	0%	23%	Normal	Appear	No	No	Normal UTL 95-95	15.14	ppm	
Iron	30	0	0%	10%	Normal	Appear	No	No	Normal UTL 95-95	25012	ppm	
Manganese	30	0	0%	12%	Normal	Appear	No	No	Normal UTL 95-95	270.4	ppm	
Lead	30	0	0%	11%	Normal	Appear	No	No	Normal UTL 95-95	20.32	ppm	
Molybdenum	30	24	80%	15%	-	-	No	No	Maximum Recorded Value	1.61	ppm	>50% nondetects in background
Nickel	30	17	57%	41%	-	-	Yes	No	Maximum Recorded Value	19.93	ppm	>50% nondetects in background
Selenium	30	30	100%	-	-	-	No	No	-	>LOD	ppm	No detections of analyte in background; any detections above the LOD measured in the field will be considered above background
Thorium	30	0	0%	10%	Normal	Appear	No	No	Normal UTL 95-95	13.35	ppm	
Uranium	30	0	0%	24%	Gamma	Approximate	Yes	No	WH Approx Gamma UTL 95-95	5.195	ppm	
Vanadium	30	1	3%	18%	Normal	Appear	No	No	Normal UTL 95-95	97.28	ppm	
Zinc	30	0	0%	12%	Normal	Appear	No	No	Normal UTL 95-95	71.56	ppm	

Notes:
- Not applicable
BSA Background study area
BTV Background threshold value
GOF Goodness of fit
LOD Limit of detection
n Number of
RSD Relative standard deviation
UTL Upper tolerance limit
WH Wilson Hilferty
XRF X-ray fluorescence

5.0 DATA ANALYSIS AND INTERPRETATION

Tetra Tech used ProUCL 5.2 statistical software for determination of upper limits for selections of site-specific BTVs, as described in [Section 3.3](#). Minitab software also was used for more robust graphical analysis and for inference of parametric distributions not currently available in ProUCL. ProUCL was used for GOF testing and calculation of upper threshold or upper simultaneous limits to calculate gamma radiation BTVs and soil concentration BTVs. The following subsections convey development of BTVs for gamma radiation at BSA-02 and selections of BTVs for the analytes of interest at BSA-02.

5.1 GAMMA RADIATION SURVEY BACKGROUND THRESHOLD VALUES

As described in [Section 4.1](#), field staff performed a gamma radiation survey in November 2022 at BSA-02. A raw gamma radiation survey map and grid-averaged gamma radiation survey map are on [Figure H-5](#) and [Figure H-6](#), respectively. GOF testing on the raw dataset proceeded by use of ProUCL as described in [Section 3.3](#). The GOF tests in ProUCL indicated that gamma radiation levels at BSA-02 approximate a normal distribution. A frequency histogram of the raw gamma radiation dataset is on [Figure H-7](#). A probability plot fitted to a normal distribution is on [Figure H-8](#)—the trend is linear, indicating a strong fit with a normal distribution.

The computed normal UTL 95-95 for the raw gamma radiation levels was selected as the site-specific BTV for BSA-02. The site-specific BTV for gamma radiation is 14,555 cpm. As shown on [Figure H-8](#), 95.6 percent of the dataset falls below the BTV.

The BTV was used to identify additional survey locations at sites associated with this specific BSA (as described in [Section 1.0](#)). Areas of the sites were classified as Class 3 (unimpacted), Class 2 (potentially impacted), or Class 1 (impacted). This classification scheme is consistent with MARSSIM (USEPA 2000) for classifying radiologically contaminated sites.

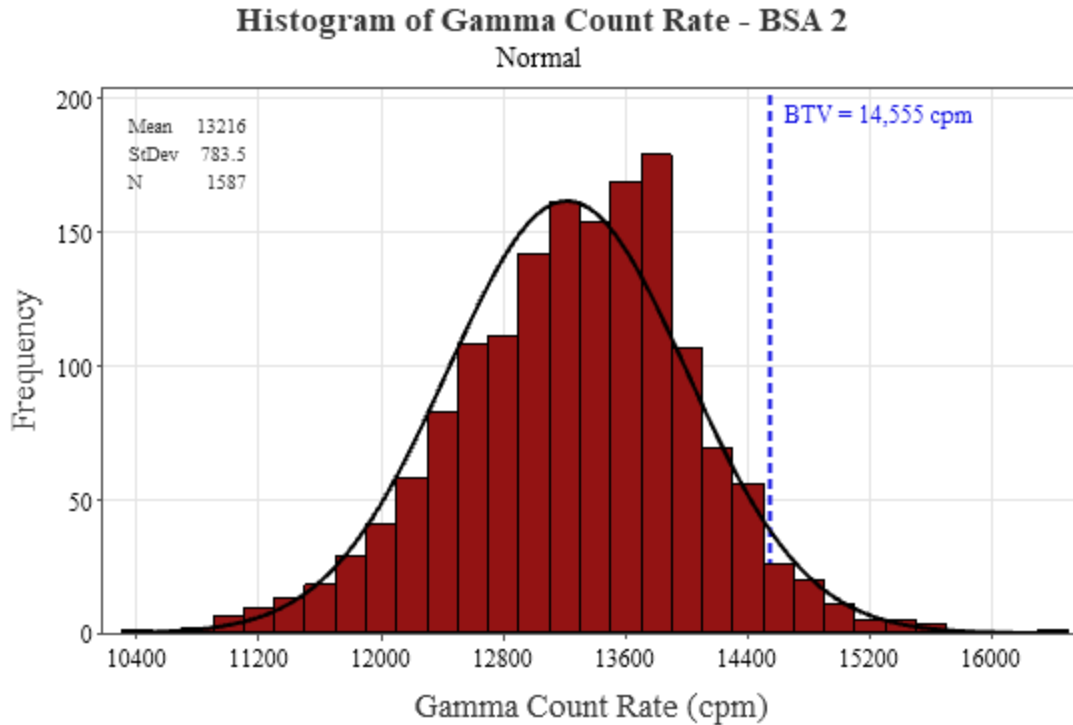


Figure H-7. Normal Histogram of BSA-02 Raw Gamma Radiation Survey Data

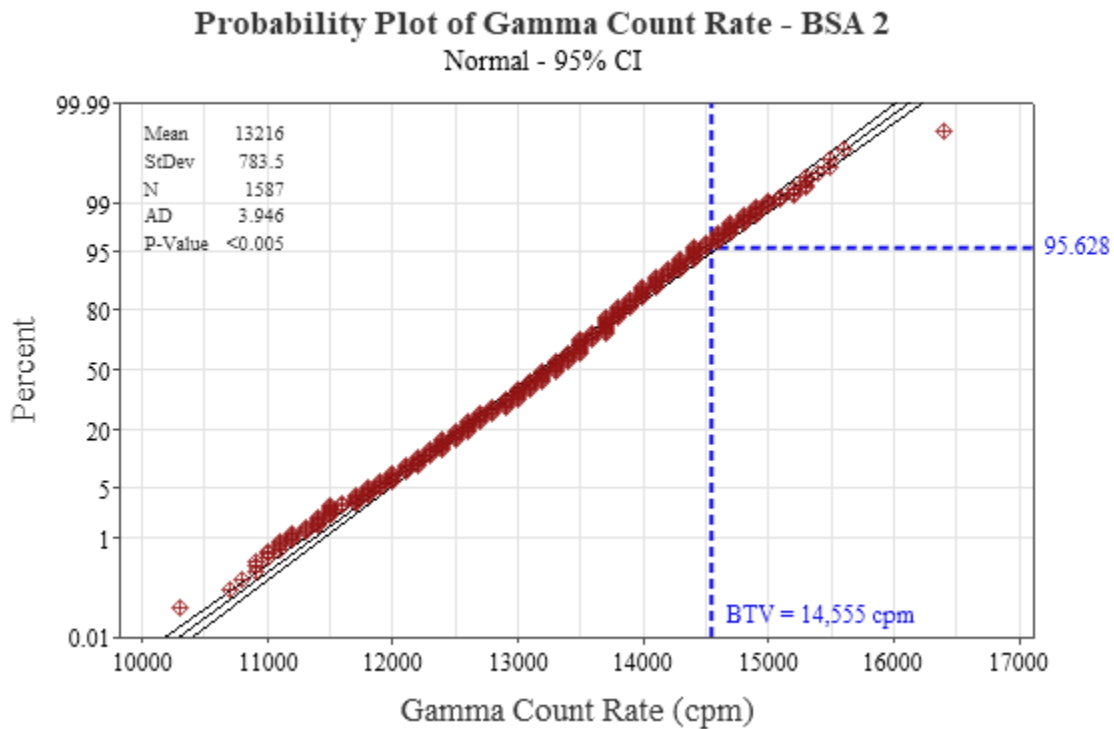


Figure H-8. Normal Probability Plot of BSA-02 Raw Gamma Radiation Survey Data

5.2 SOIL SAMPLING GRAPHICAL ANALYSIS

This section describes statistical and graphical analysis of site-specific BTVs for the analytes of interest at BSA-02. Each of the following nine subsections presents a detailed analysis and interpretation of selection of a BTV. The selected BTVs and upper confidence limits (UCL) for all analytes of interest at BSA-02 are listed in [Table H-9](#).

5.2.1 Arsenic

Analytical results and descriptive statistics for the 30 arsenic surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All arsenic results from surface soil samples collected at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the arsenic dataset for BSA-02 involved GOF and outlier testing in ProUCL. The Rosner outlier test found no potential outliers at the 1 percent significance level in the dataset. No visual outliers were identified for arsenic at BSA-02 per the criteria specified in [Section 3.3.4](#). Results of GOF testing in ProUCL indicated that arsenic appeared to follow a normal distribution.

The normal UTL95-95 of 7.0 mg/kg identified in ProUCL was selected as the BTV for arsenic at BSA-02. An individual value plot showing the arsenic concentrations at BSA-02 with the BTV plotted is on [Figure H-9](#). The box plot of the data is on [Figure H-10](#). A probability plot with the arsenic data fitted to the normal distribution is on [Figure H-11](#). By use of this parametric fit, 98.7 percent of the inferred population falls below the BTV. A histogram fitted to the normal distribution for arsenic data is on [Figure H-12](#).

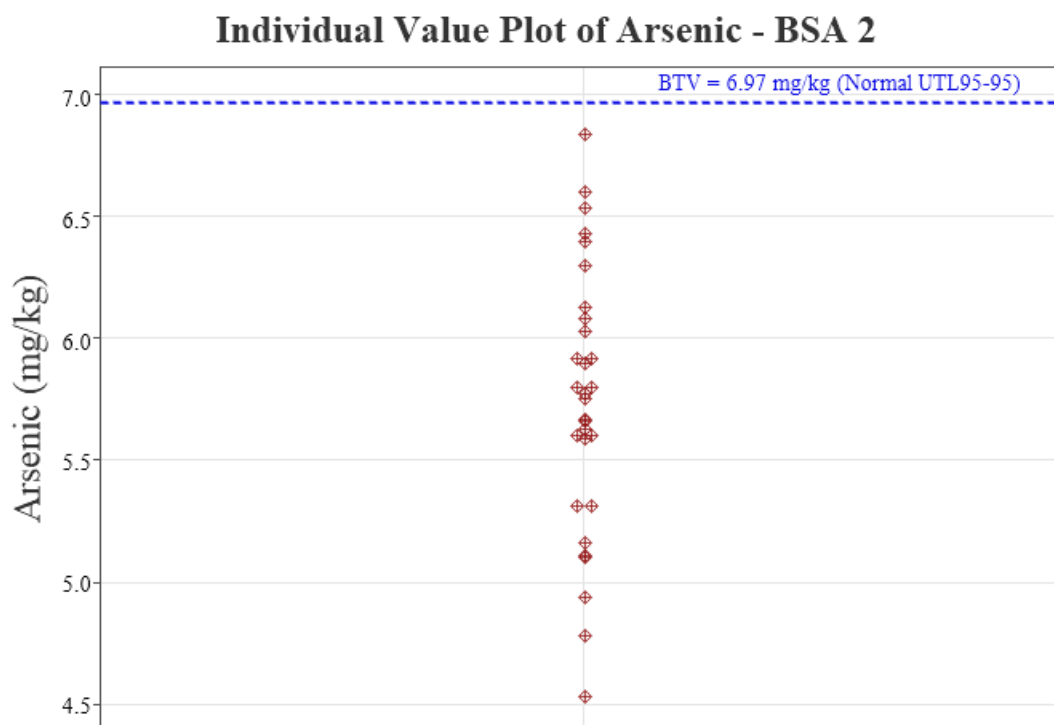


Figure H-9. Individual Value Plot of Arsenic at BSA-02

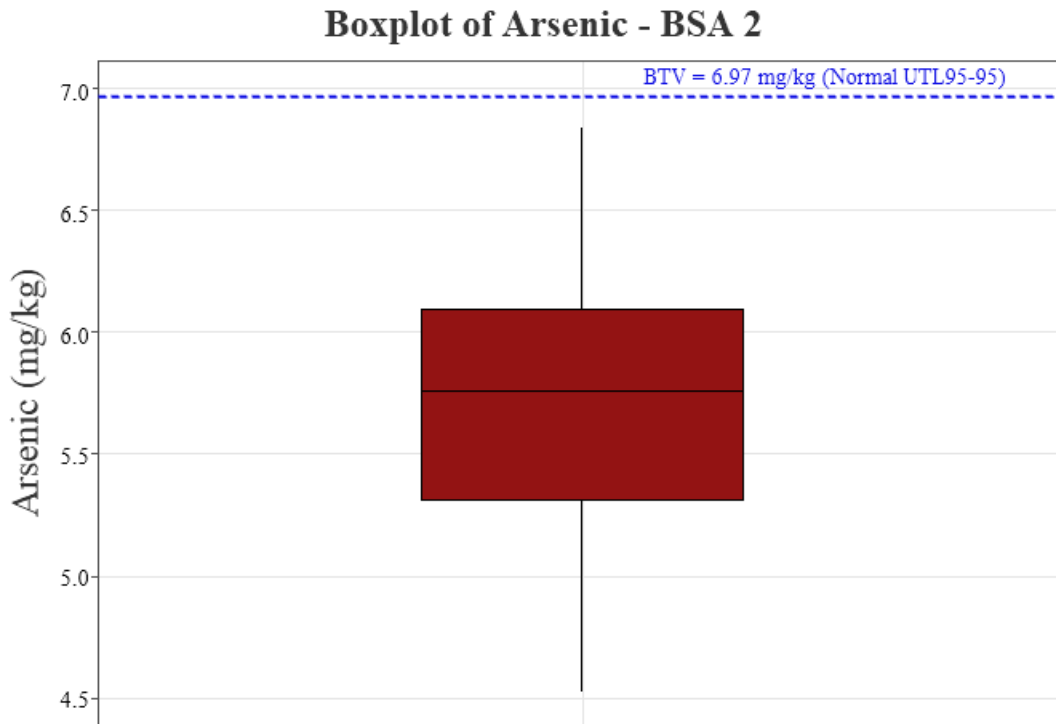


Figure H-10. Box Plot of Arsenic at BSA-02

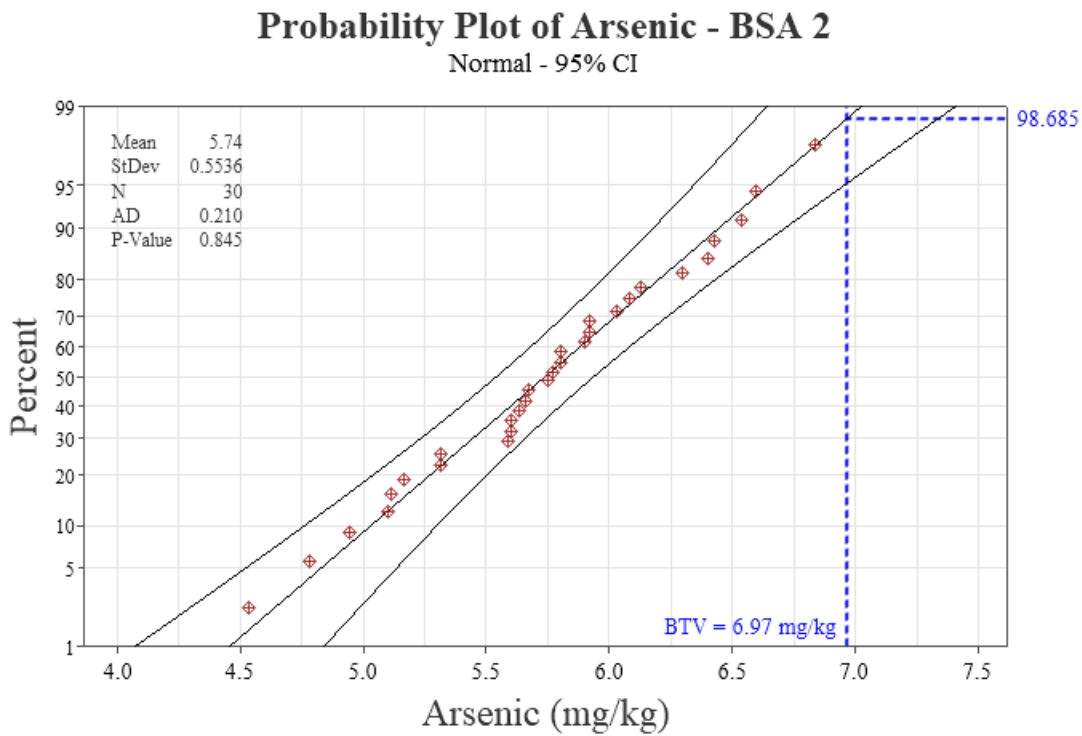


Figure H-11. Probability Plot of Arsenic Soil Concentrations at BSA-02 (Normal)

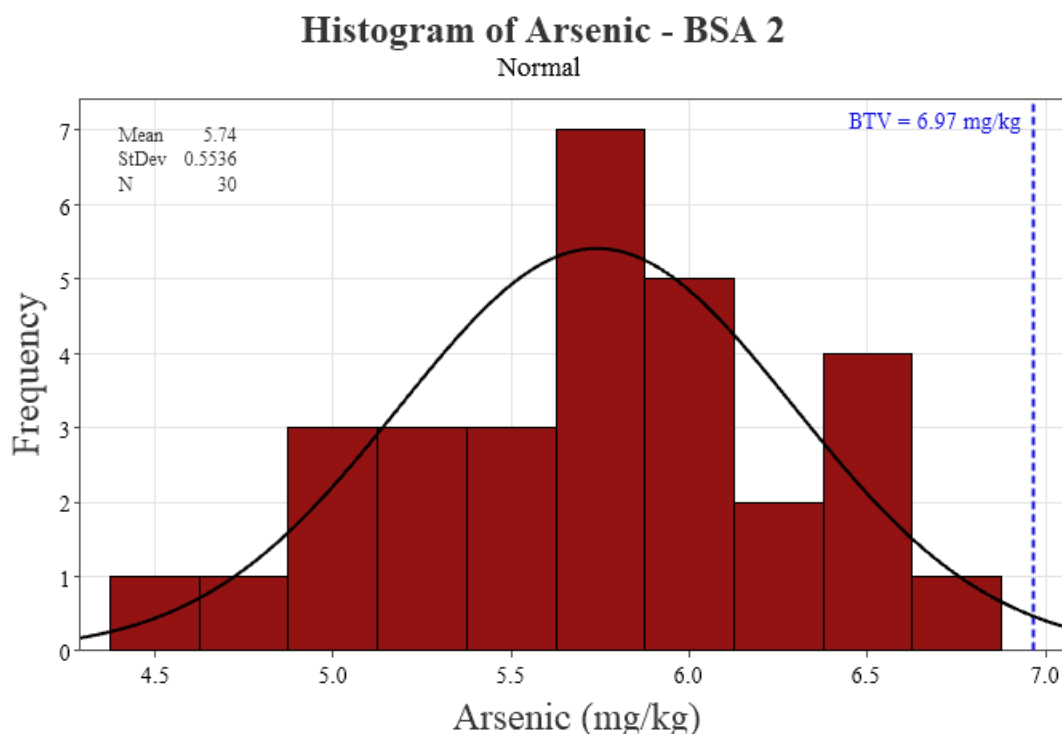


Figure H-12. Histogram of Arsenic Soil Concentrations at BSA-02 (Normal)

5.2.2 Lead

Analytical results and descriptive statistics for the 30 lead surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All lead results from surface soils at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the lead dataset from BSA-02 involved GOF and outlier testing in ProUCL. Results of the ProUCL GOF testing indicated that lead data at BSA-02 follows a normal distribution, and no outliers were identified by use of Rosner's outlier analysis. Visual inspection also identified no outliers.

The normal UTL95-95 of 19 mg/kg was selected as the BTV for lead at BSA-02. An individual value plot showing the spread of the lead surface soil concentration data obtained at BSA-02 is on [Figure H-13](#). The box plot of the data is on [Figure H-14](#). A normal probability plot showing lead surface soil concentrations at BSA-02 is on [Figure H-15](#). By use of this parametric fit, 98.8 percent of the inferred population falls below the BTV. A histogram with a fitted normal distribution of lead surface soil concentrations at BSA-02 is on [Figure H-16](#).

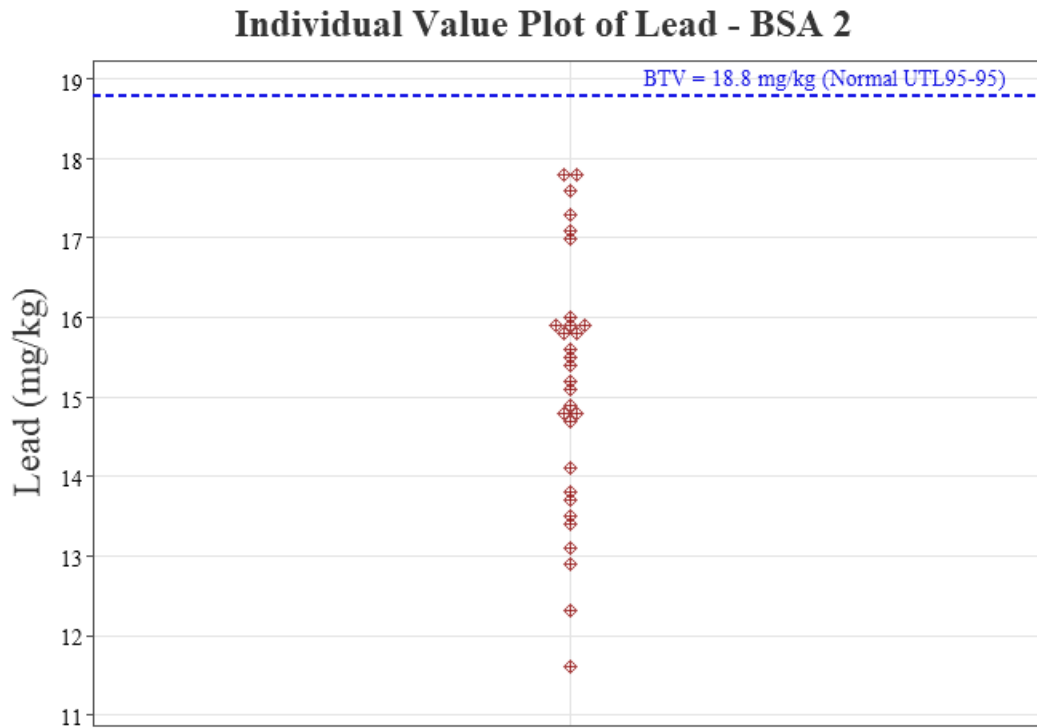


Figure H-13. Individual Value Plot of Lead at BSA-02

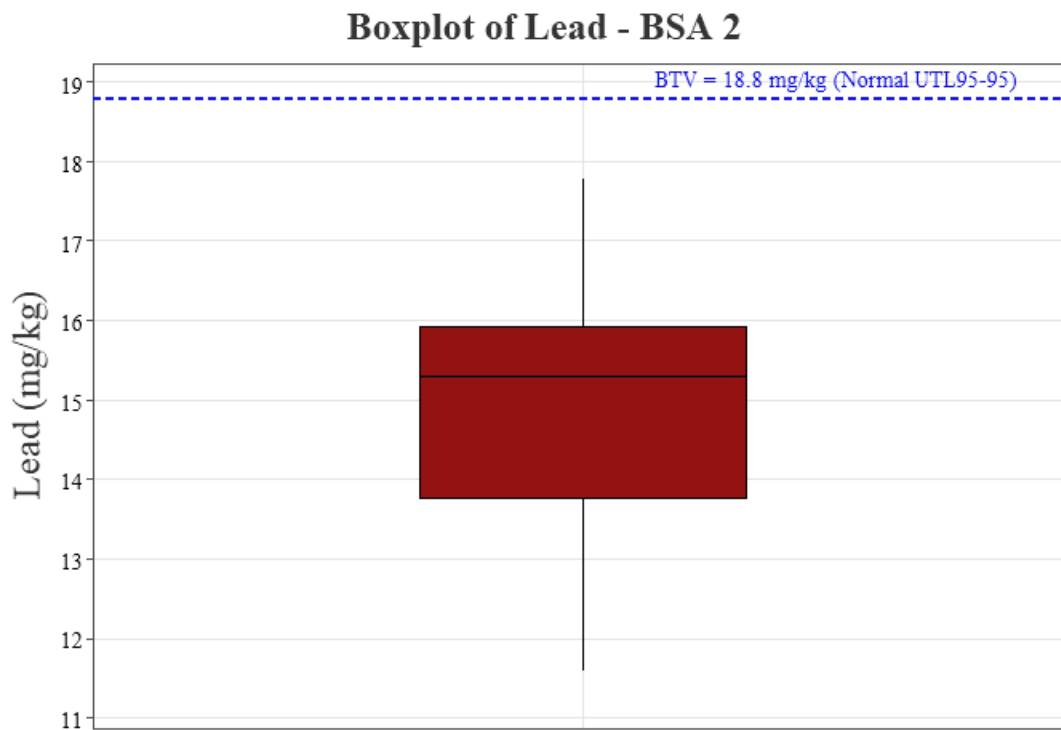


Figure H-14. Box Plot of Lead at BSA-02

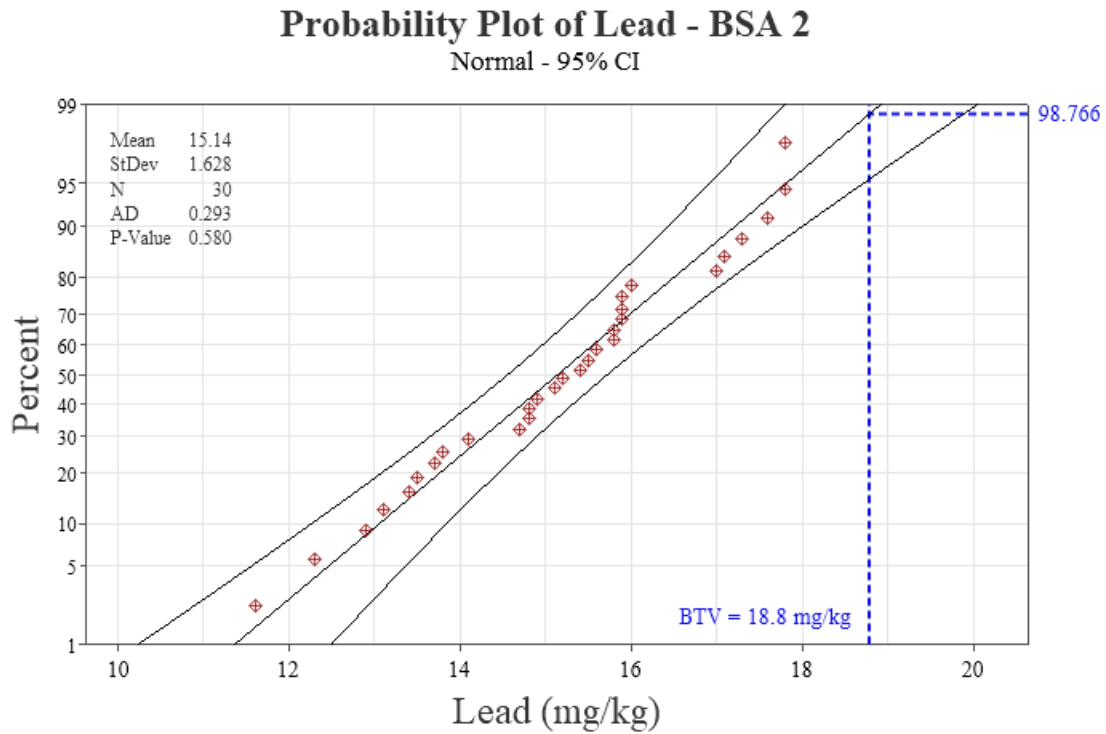


Figure H-15. Probability Plot of Lead Concentration at BSA-02 (Normal)

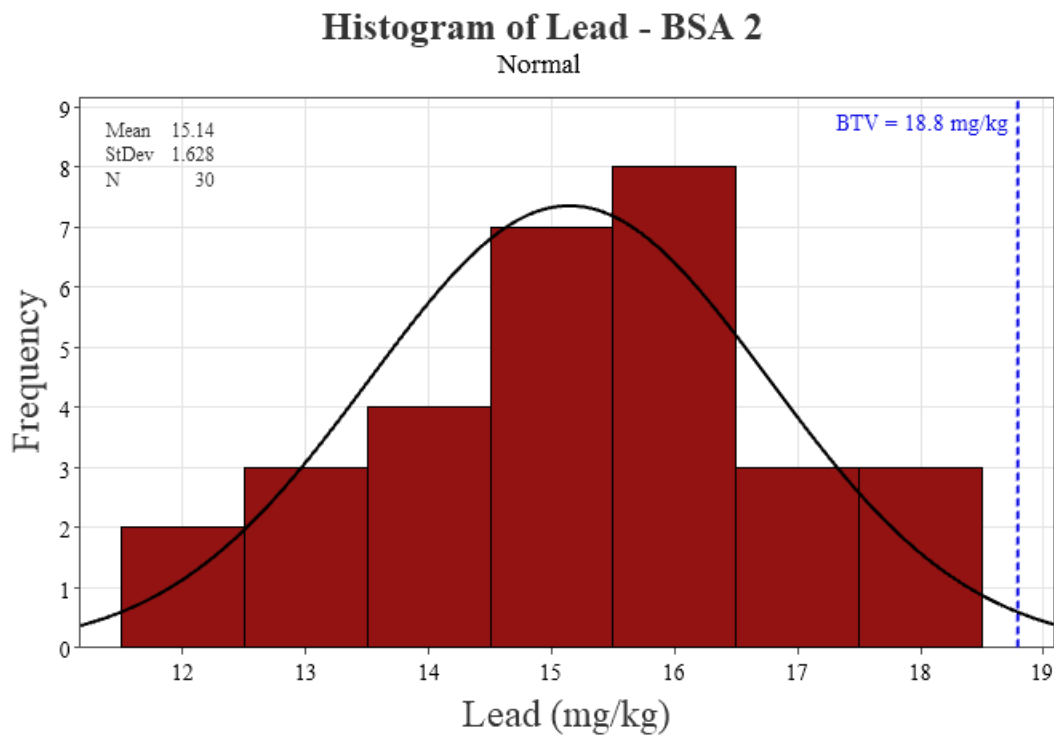


Figure H-16. Histogram of Lead Concentration at BSA-02 (Normal)

5.2.3 Molybdenum

Analytical results and descriptive statistics for the 30 molybdenum surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All molybdenum results from surface soil samples collected at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the molybdenum dataset for BSA-02 involved GOF and outlier testing in ProUCL. Results of the ProUCL GOF testing indicated that molybdenum data at BSA-02 appeared to follow a normal distribution. The Rosner outlier test determined that no potential outliers at the 1 percent significance level were present in the dataset.

The site-specific BTV for molybdenum was selected to be the normal UTL95-95 value of 0.41 mg/kg. An individual value plot with the full dataset is on [Figure H-17](#). The box plot of the data is on [Figure H-18](#). A normal probability plot showing molybdenum surface soil concentrations at BSA-02 is on [Figure H-19](#). Using this parametric fit, 98.6 percent of the inferred population falls below the BTV. A histogram with a fitted normal distribution of molybdenum surface soil concentrations at BSA-02 is on [Figure H-20](#).

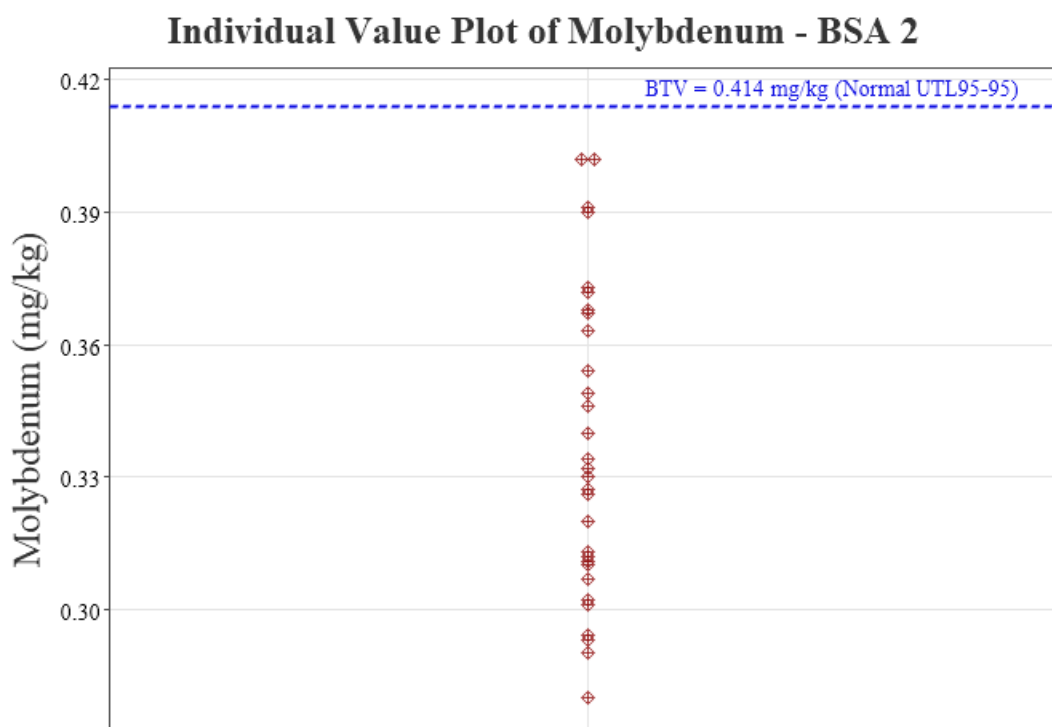
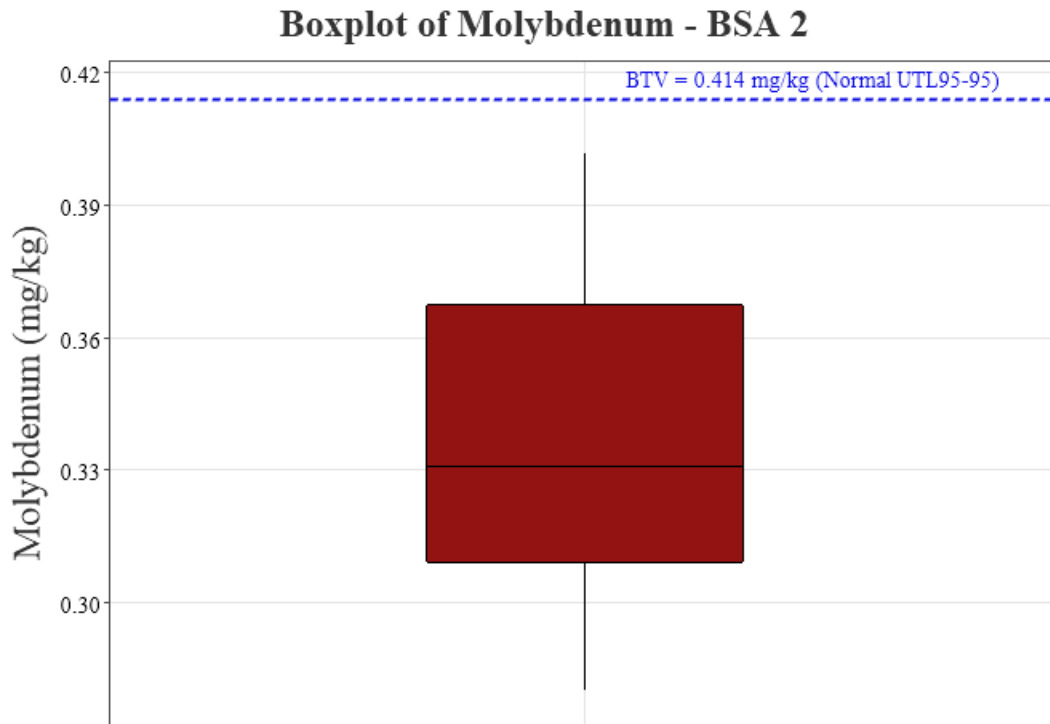
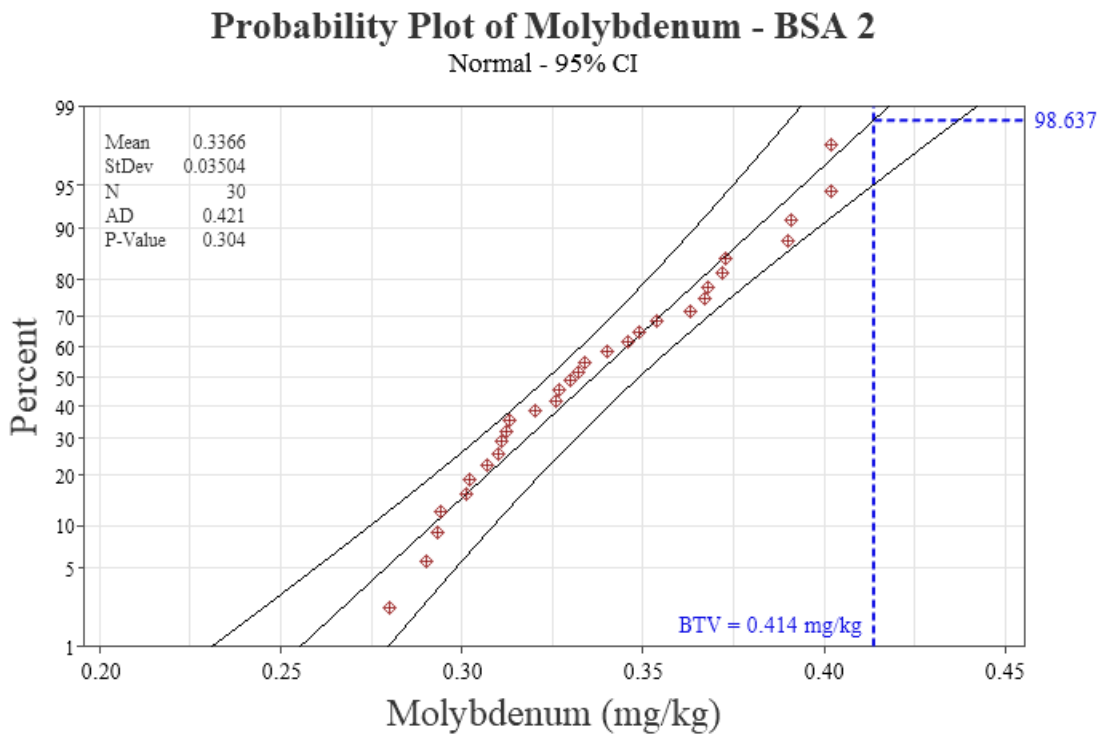


Figure H-17. Individual Value Plot of Molybdenum at BSA-02

**Figure H-18. Box Plot of Molybdenum at BSA-02****Figure H-19. Probability Plot of Molybdenum Concentration at BSA-02 (Normal)**

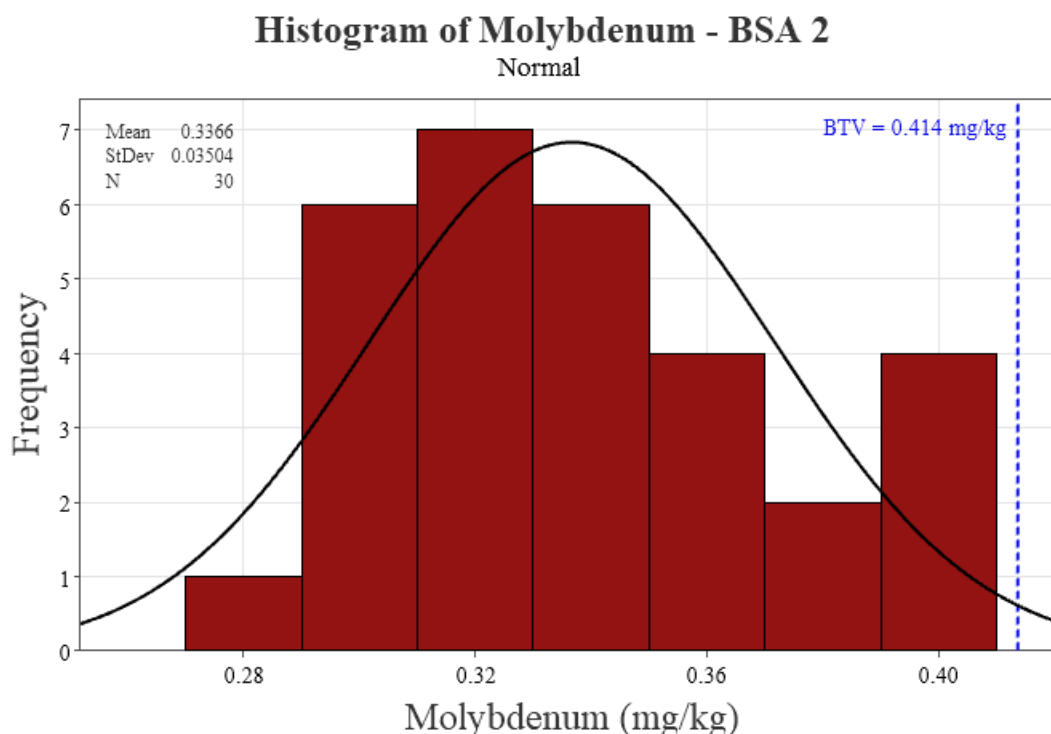


Figure H-20. Histogram of Molybdenum Concentration at BSA-02 (Normal)

5.2.4 Potassium-40

Analytical results and descriptive statistics for the 30 K-40 surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All K-40 results from surface soils at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the K-40 dataset from BSA-02 involved GOF and outlier testing in ProUCL. The Rosner outlier test identified one potential outlier at a 5 percent significance level, but not at a 1 percent significance level (OCRM-B02-SS13-01-111622). Determination was that this statistical outlier was likely part of the background population, and thus it was not removed from the final BTV selection analysis. No visual outliers were identified for K-40 at BSA-02 per the criteria identified in [Section 3.3.4](#). Results of the ProUCL GOF testing indicated that K-40 data at BSA-02 follows a normal distribution.

The normal UTL95-95 of 23 pCi/g was selected as the BTV for K-40 at BSA-02. An individual value plot showing the spread of the K-40 surface soil concentration data obtained at BSA-02 is on [Figure H-21](#). The box plot of the data is on [Figure H-22](#). A normal probability plot showing K-40 surface soil concentrations at BSA-02 is on [Figure H-23](#). By use of this parametric fit, 98.7 percent of the inferred population falls below the BTV. A histogram with a fitted normal distribution of K-40 surface soil concentrations at BSA-02 is on [Figure H-24](#).

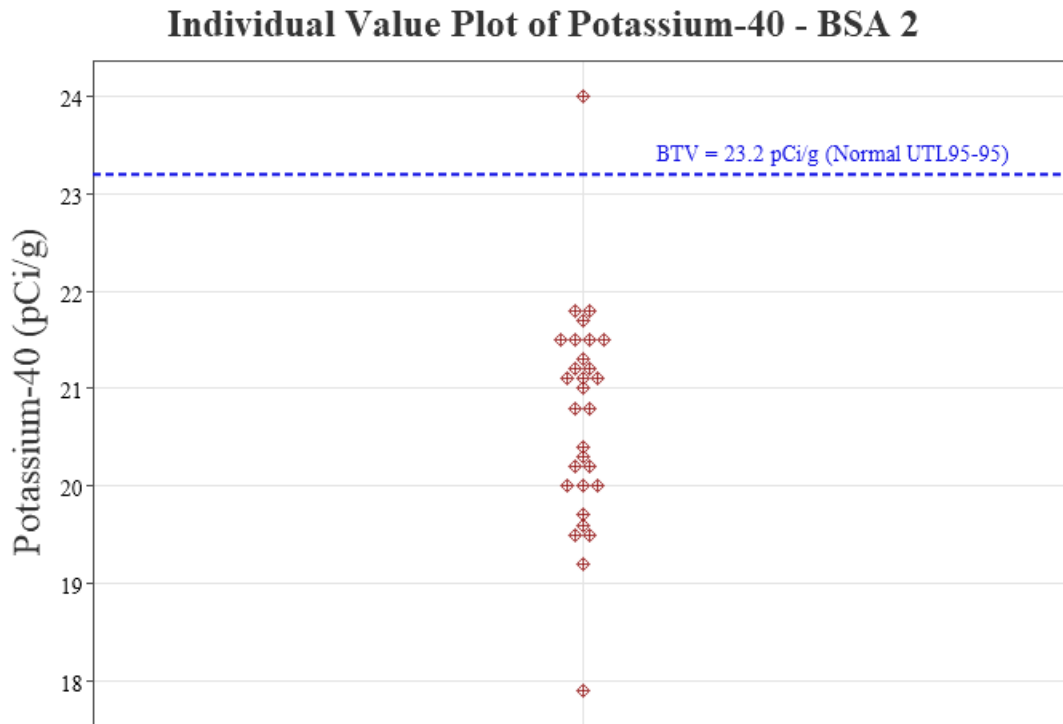


Figure H-21. Individual Value Plot of Potassium-40 Soil Concentrations at BSA-02

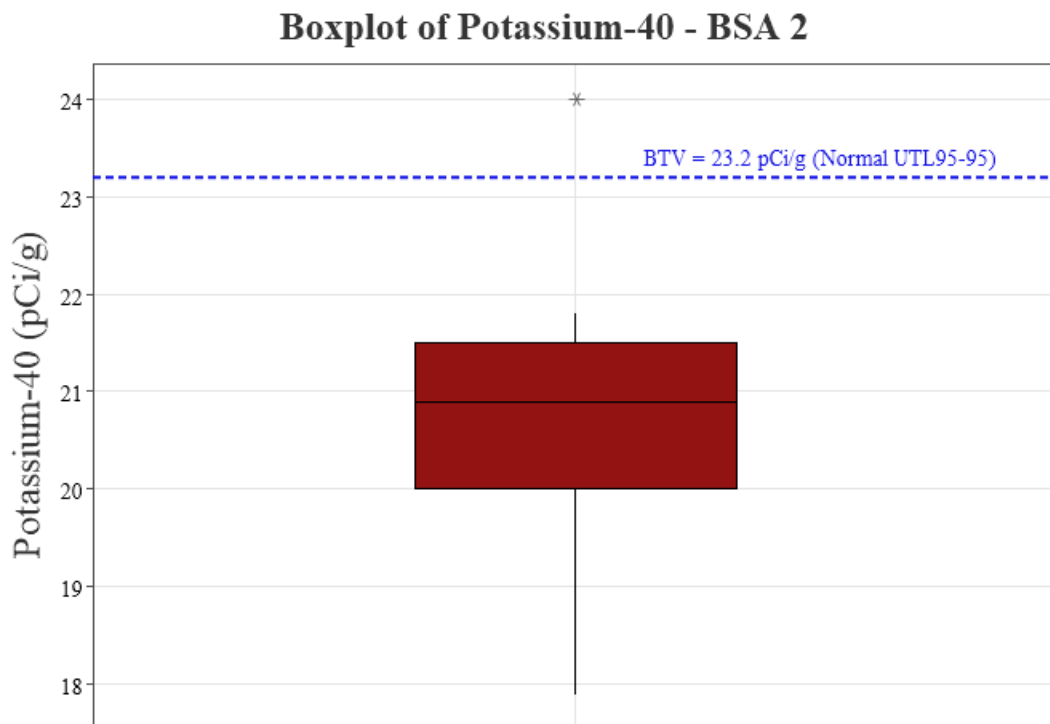


Figure H-22. Box Plot of Potassium-40 at BSA-02

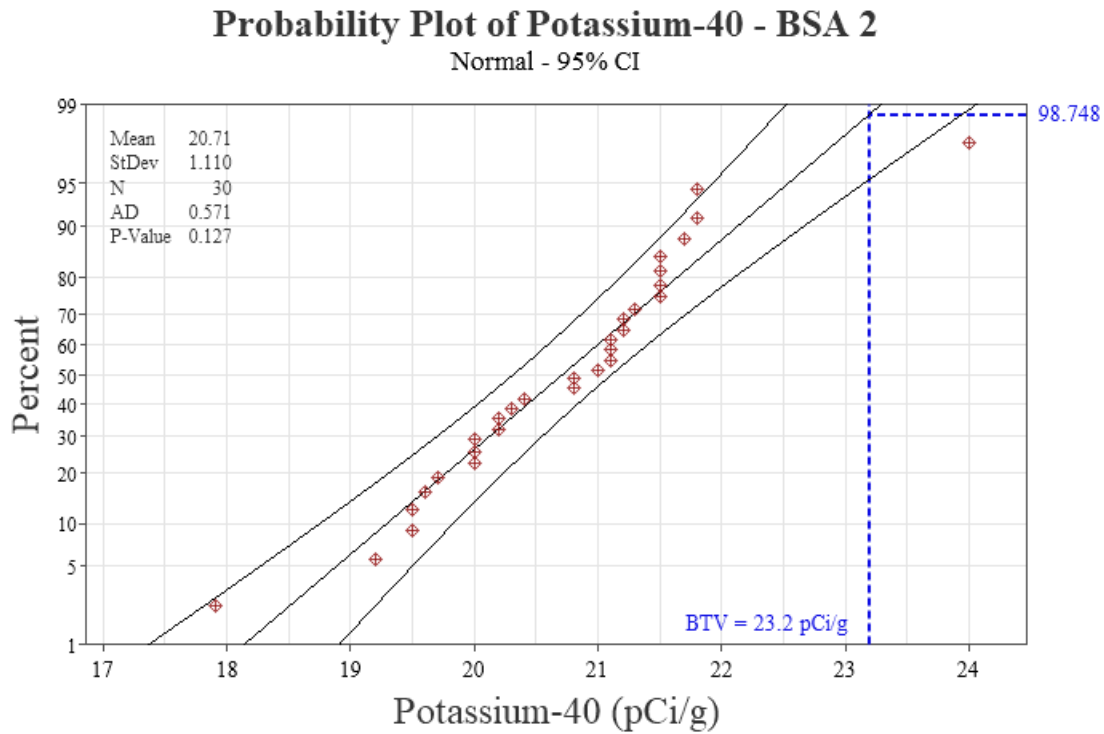


Figure H-23. Probability Plot of Potassium-40 Soil Concentrations at BSA-02 (Normal)

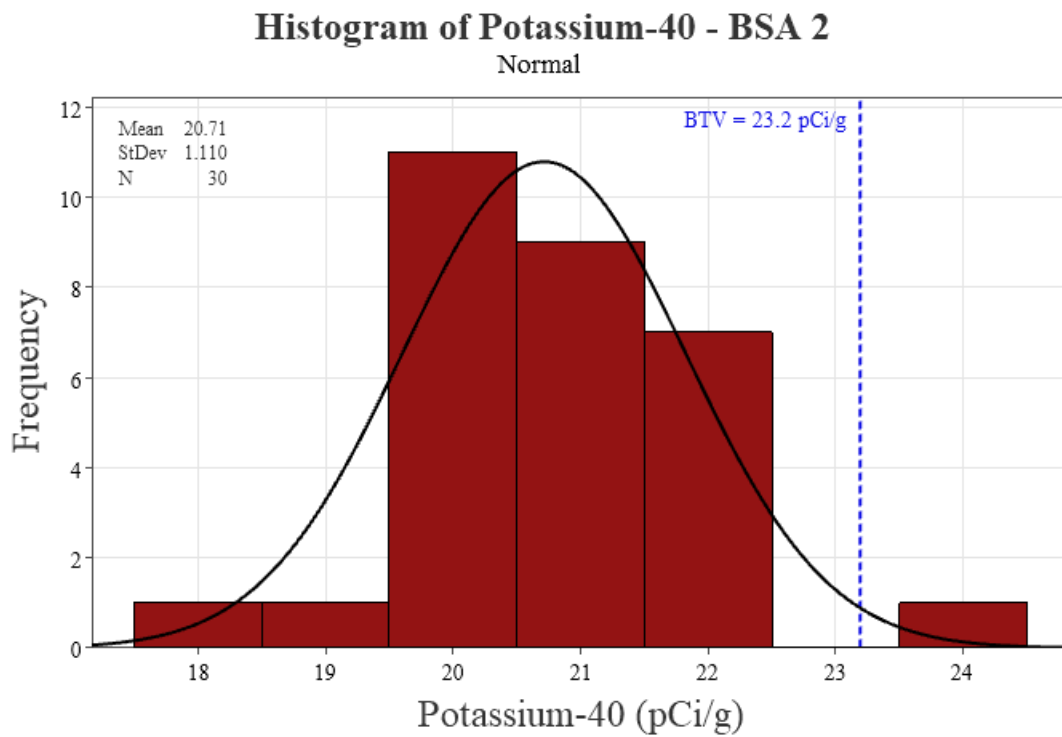


Figure H-24. Histogram of Potassium-40 Soil Concentrations at BSA-02 (Normal)

5.2.5 Radium-226

Analytical results and descriptive statistics for the 30 Ra-226 surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All Ra-226 results from surface soils at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the Ra-226 dataset from BSA-02 involved GOF and outlier testing in ProUCL. The Rosner outlier test identified no potential outliers. No visual outliers were identified for Ra-226 at BSA-02 per the criteria identified in [Section 3.3.4](#). Results of the ProUCL GOF testing indicated that Ra-226 data at BSA-02 follows a normal distribution.

The normal UTL95-95 of 2.0 pCi/g was selected as the BTV for Ra-226 at BSA-02. An individual value plot showing the spread of the Ra-226 surface soil concentration data obtained at BSA-02 is on [Figure H-25](#). The box plot of the data is on [Figure H-26](#). A normal probability plot showing Ra-226 surface soil concentrations at BSA-02 is on [Figure H-27](#). By use of this parametric fit, 98.7 percent of the inferred population falls below the BTV. A histogram with a fitted normal distribution of Ra-226 surface soil concentrations at BSA-02 is on [Figure H-28](#).

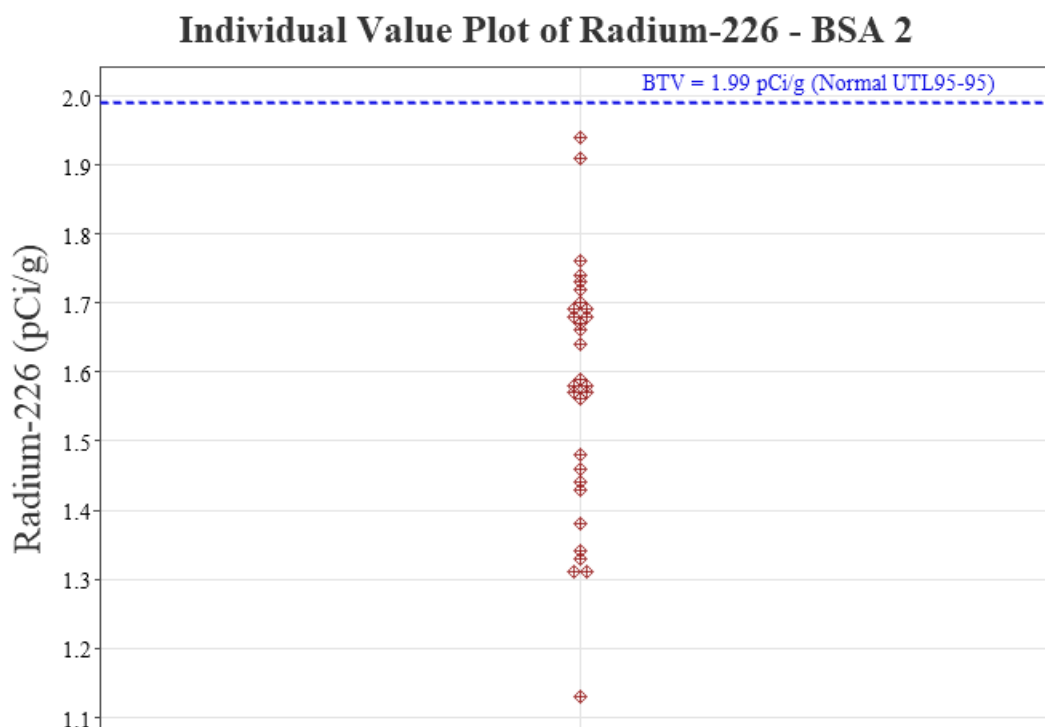


Figure H-25. Individual Value Plot of Radium-226 Soil Concentrations at BSA-02

Boxplot of Radium-226 - BSA 2

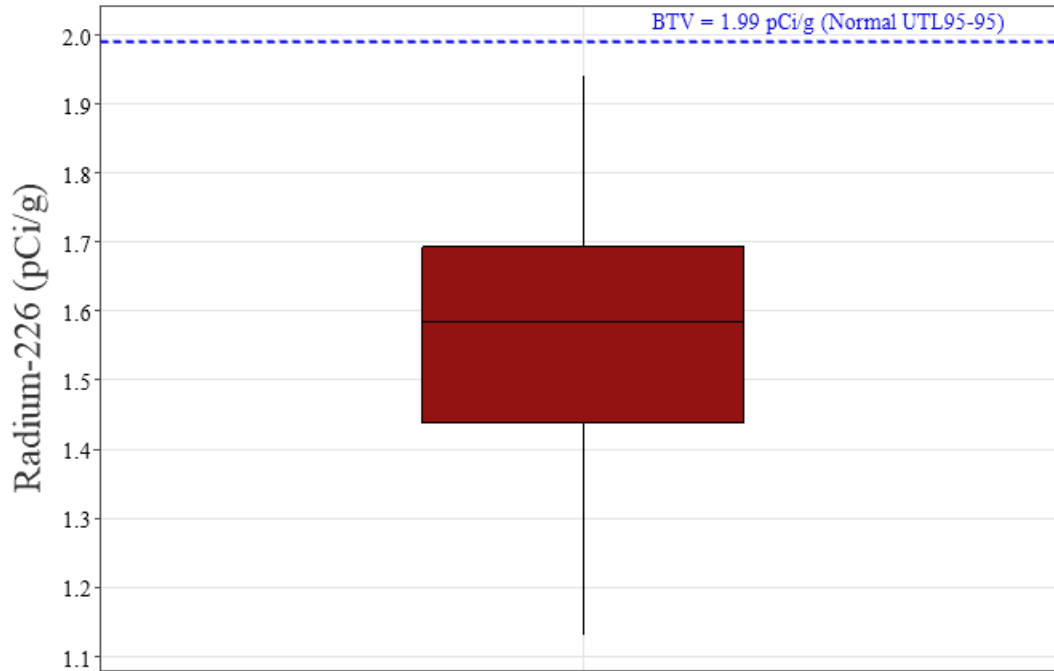


Figure H-26. Box Plot of Radium-226 at BSA-02

Probability Plot of Radium-226 - BSA 2

Normal - 95% CI

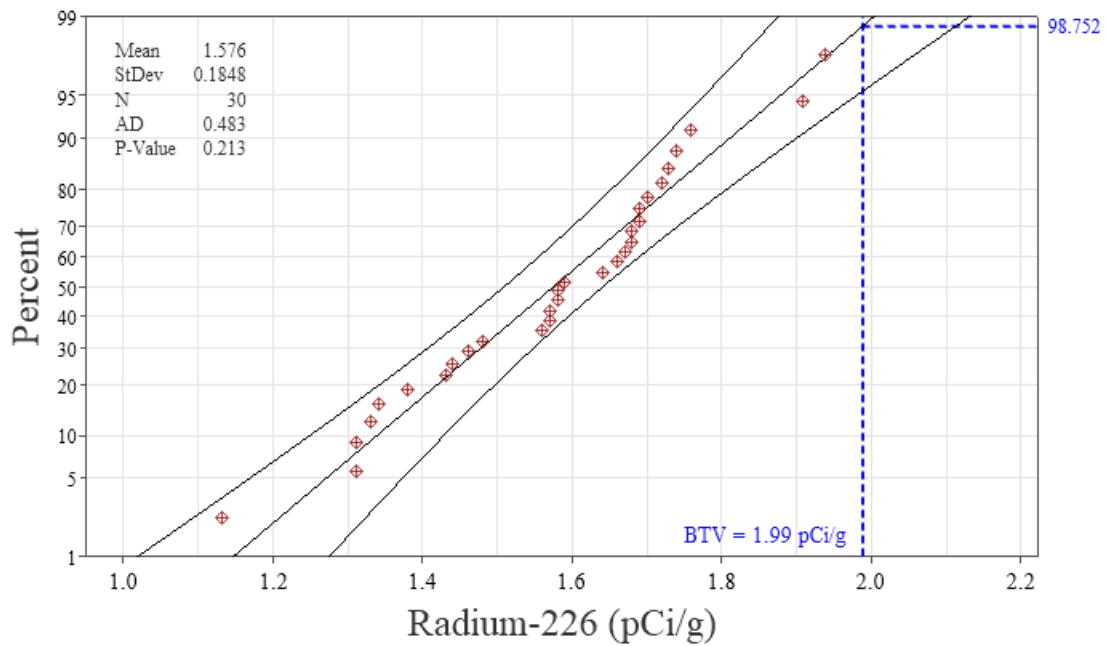


Figure H-27. Probability Plot of Radium-226 Soil Concentrations at BSA-02 (Normal)

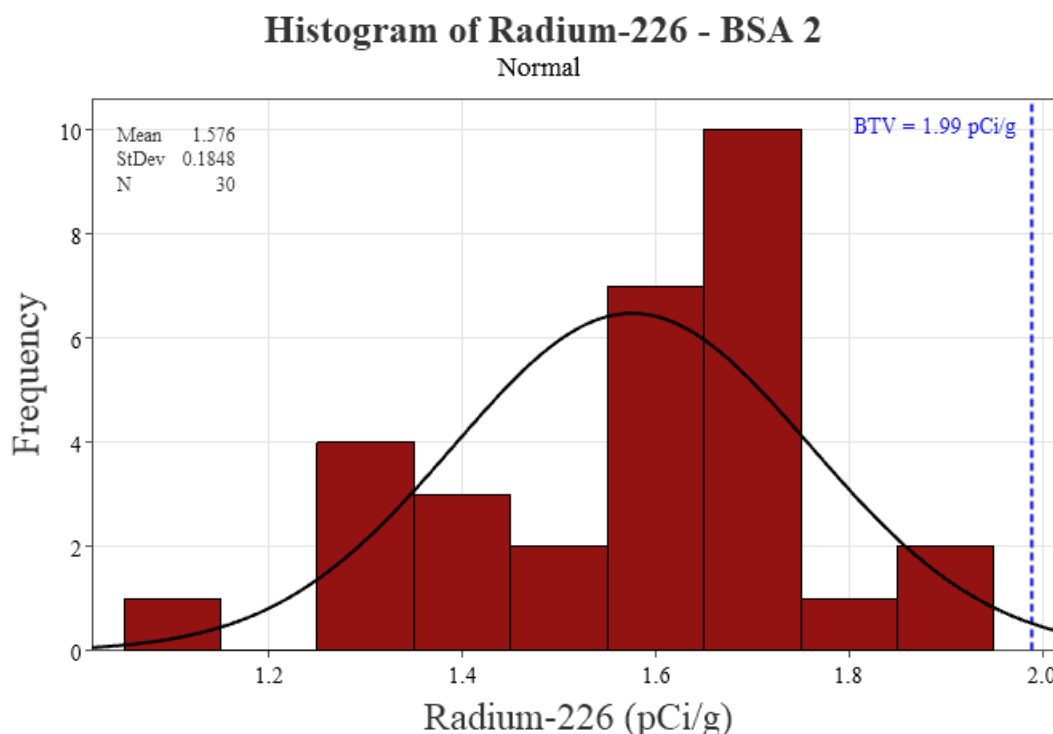


Figure H-28. Histogram of Radium-226 Soil Concentrations at BSA-02 (Normal)

5.2.6 Selenium

Analytical results and descriptive statistics for the 30 selenium surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All selenium results in surface soil samples collected at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the selenium dataset for BSA-02 involved GOF and outlier testing in ProUCL. Results of the ProUCL GOF testing indicated that selenium data at BSA-02 appeared to follow a normal distribution. No outliers were identified via the Rosner's outlier analysis. Visual inspection also occurred, and no outliers were identified.

The normal UTL95-95 of 2.8 mg/kg identified by ProUCL was selected as the BTV for selenium at BSA-02. An individual value plot on [Figure H-29](#) shows the full selenium dataset for surface soils at BSA-02 plotted with the BTV. The box plot of the data is on [Figure H-30](#). [Figure H-31](#) provides a probability plot for a normal distribution for selenium at BSA-02. By use of this parametric fit, 98.7 percent of the inferred population falls below the BTV. [Figure H-32](#) provides a histogram fitted to a normal distribution for selenium at BSA-02.

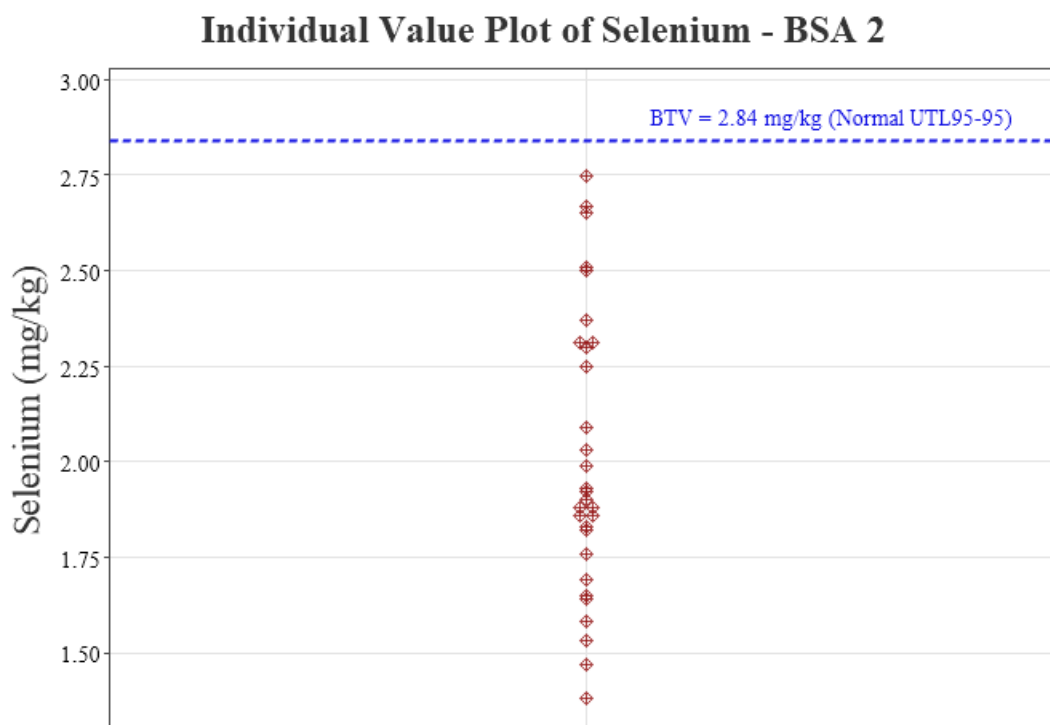


Figure H-29. Individual Value Plot of Selenium Concentrations at BSA-02

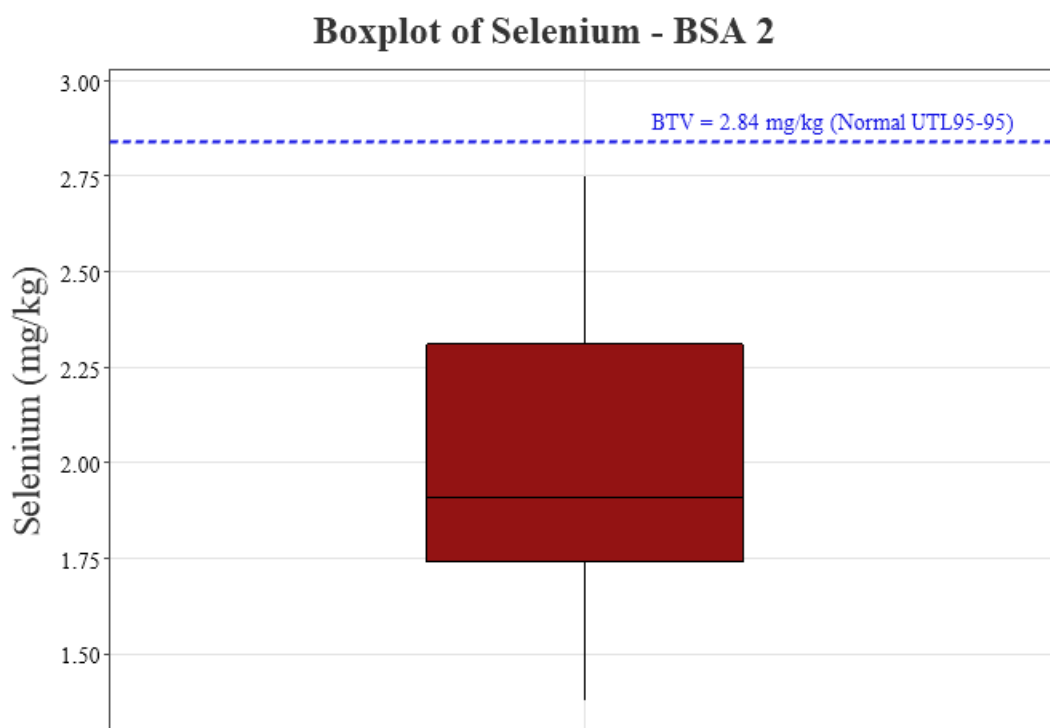


Figure H-30. Box Plot of Selenium at BSA-02

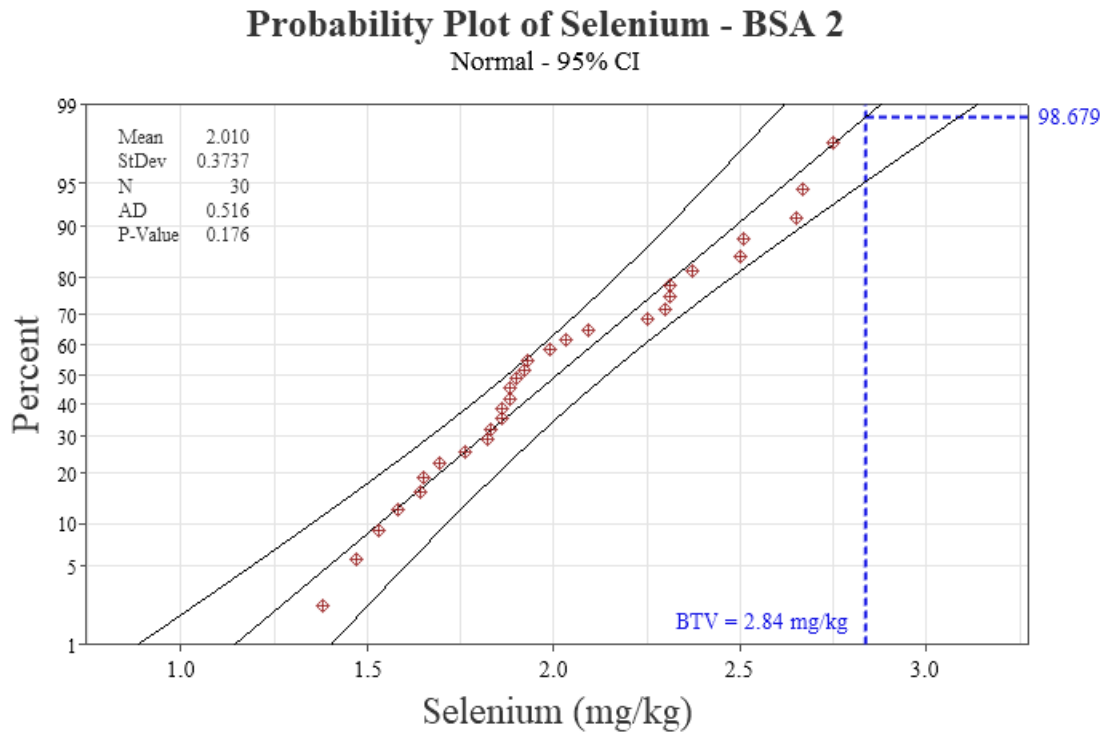


Figure H-31. Probability Plot of Selenium Concentrations at BSA-02 (Normal)

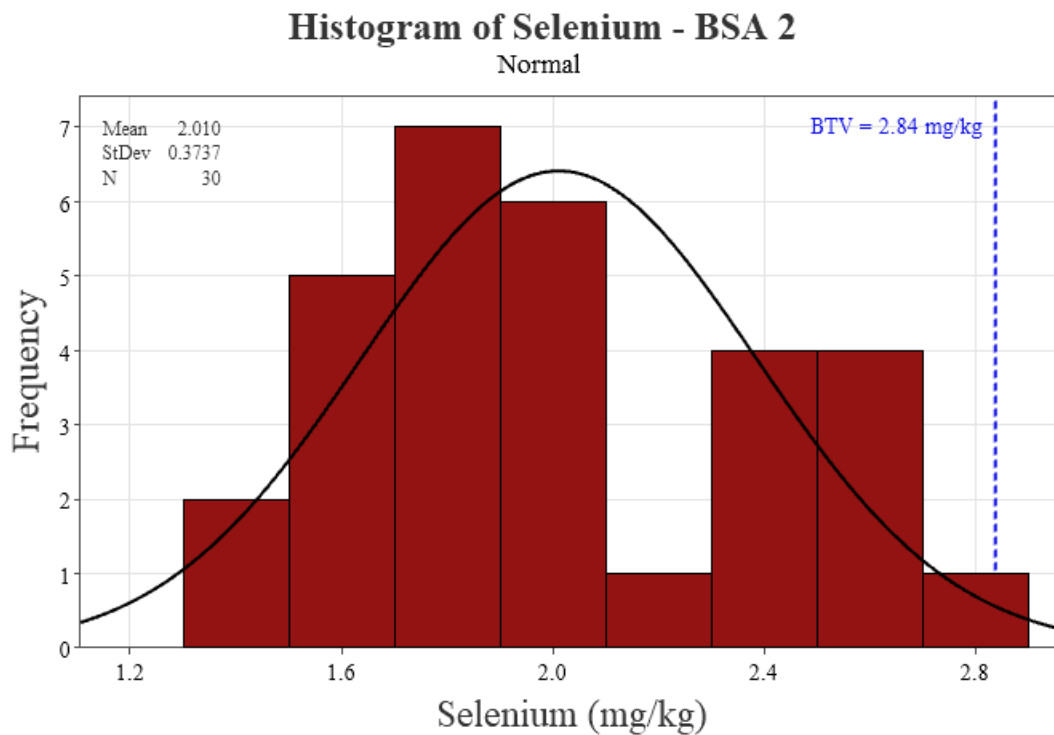


Figure H-32. Histogram of Selenium Concentrations at BSA-02 (Normal)

5.2.7 Thorium

Analytical results and descriptive statistics for the 30 thorium surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All thorium results in surface soil samples collected at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the thorium dataset for BSA-02 involved GOF and outlier testing in ProUCL. Results of the ProUCL GOF testing indicated that thorium data at BSA-02 appeared to follow a normal distribution. No outliers were identified via the Rosner's outlier analysis. Visual inspection also occurred, and no outliers were identified.

The normal UTL95-95 of 11.6 mg/kg identified by ProUCL was selected as the BTV for thorium at BSA-02. An individual value plot on [Figure H-33](#) shows the full thorium dataset for surface soils at BSA-02 plotted with the BTV. The box plot of the data is on [Figure H-34](#). [Figure H-35](#) provides a probability plot for a normal distribution for thorium at BSA-02. By use of this parametric fit, 98.6 percent of the inferred population falls below the BTV. [Figure H-36](#) provides a histogram fitted to a normal distribution for thorium at BSA-02.

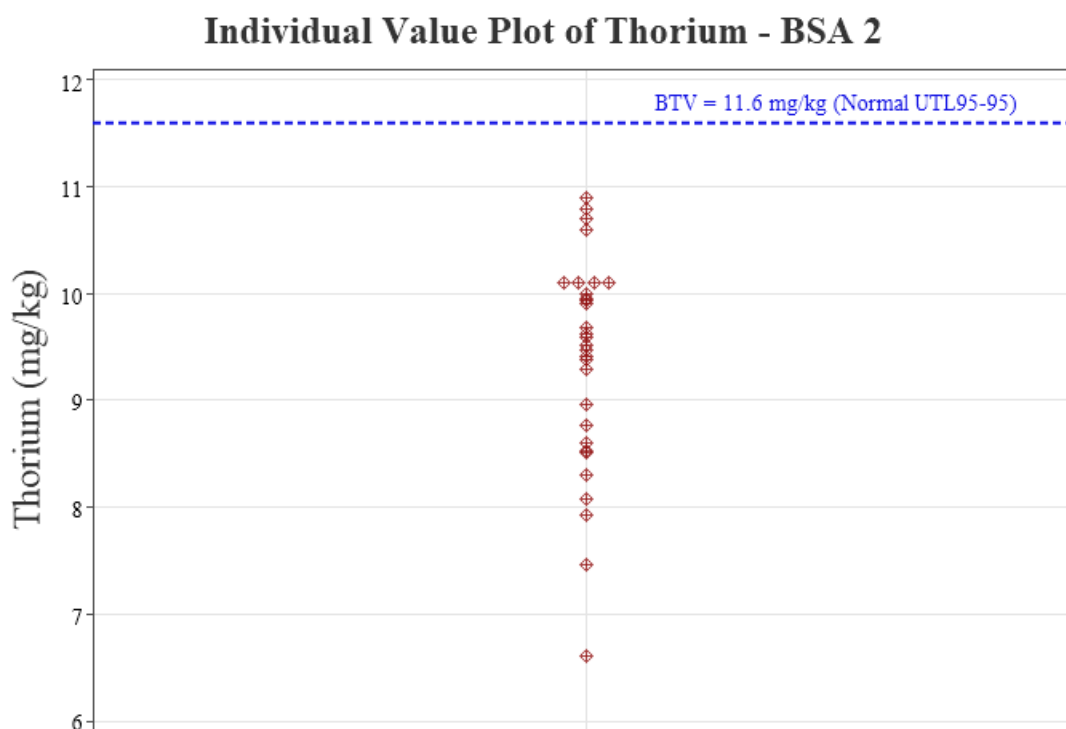
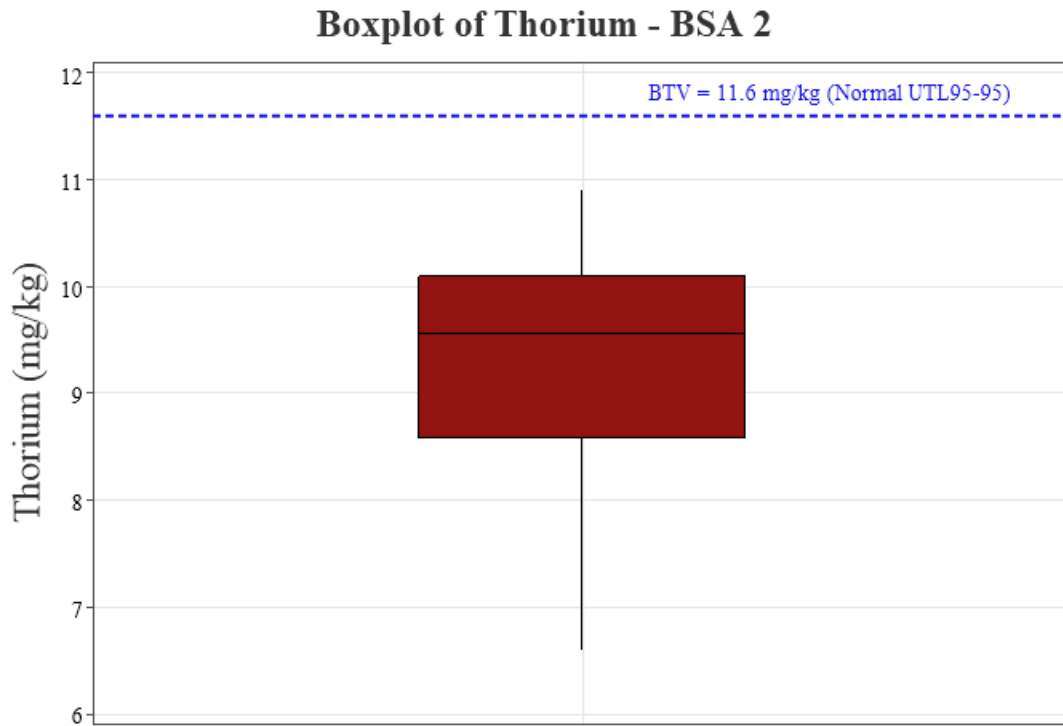
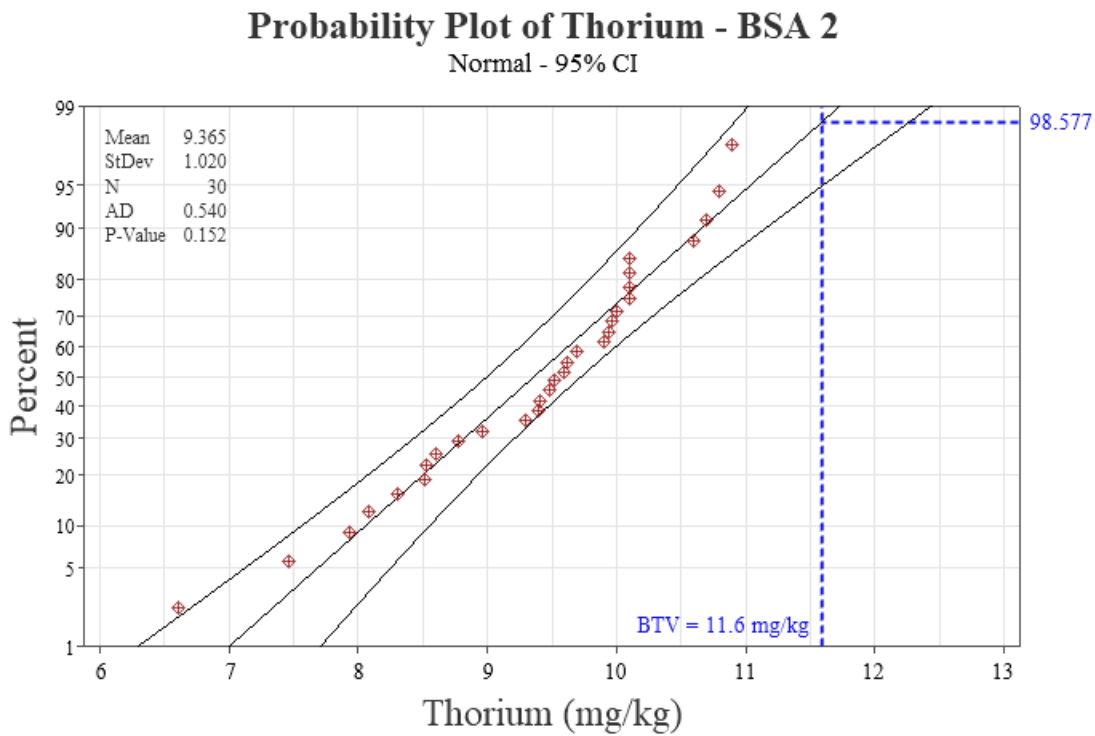


Figure H-33. Individual Value Plot of Thorium Soil Concentrations at BSA-02

**Figure H-34. Box Plot of Thorium at BSA-02****Figure H-35. Probability Plot of Thorium Soil Concentrations at BSA-02 (Normal)**

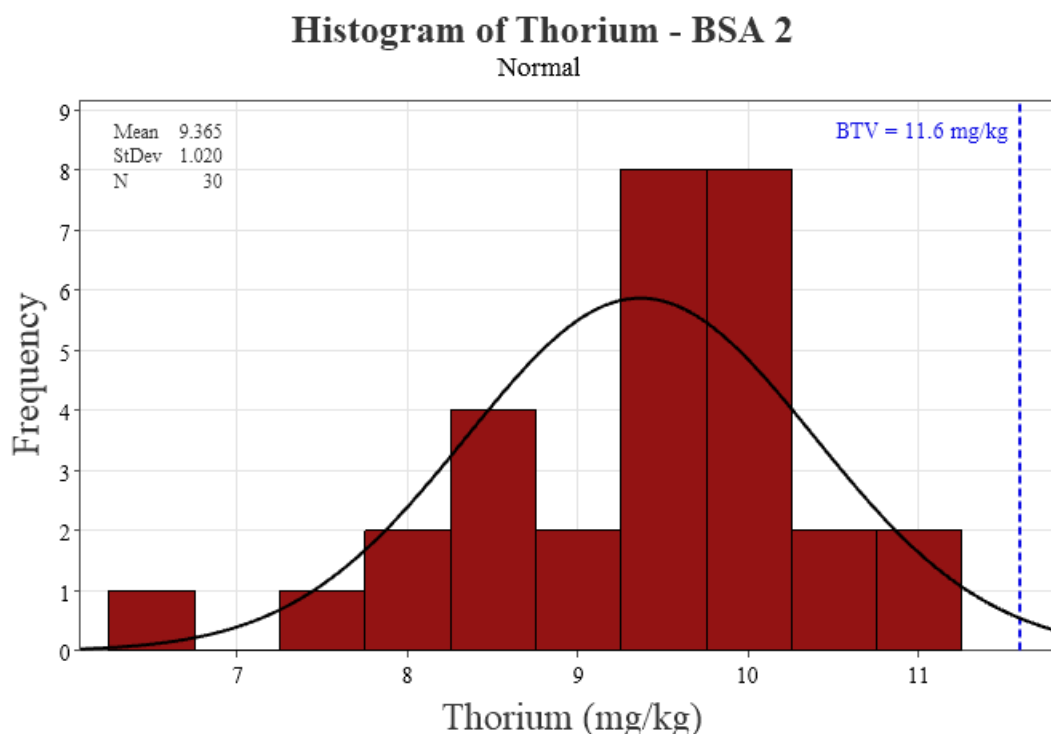


Figure H-36. Histogram of Thorium Soil Concentrations at BSA-02 (Normal)

5.2.8 Uranium

Analytical results and descriptive statistics for the 30 uranium surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All uranium results from surface soils at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the uranium dataset from BSA-02 involved GOF and outlier testing in ProUCL. Results of the ProUCL GOF testing indicated that uranium data at BSA-02 follows a normal distribution, and no outliers were identified by use of Rosner's outlier analysis. Visual inspection also identified no outliers.

The normal UTL95-95 of 1.4 mg/kg was selected as the BTV for uranium at BSA-02. An individual value plot showing the spread of the uranium surface soil concentration data obtained at BSA-02 is on [Figure H-37](#). The box plot of the data is on [Figure H-38](#). A normal probability plot showing uranium surface soil concentrations at BSA-02 is on [Figure H-39](#). By use of this parametric fit, 98.6 percent of the inferred population falls below the BTV. A histogram with a fitted normal distribution of uranium surface soil concentrations at BSA-02 is on [Figure H-40](#).

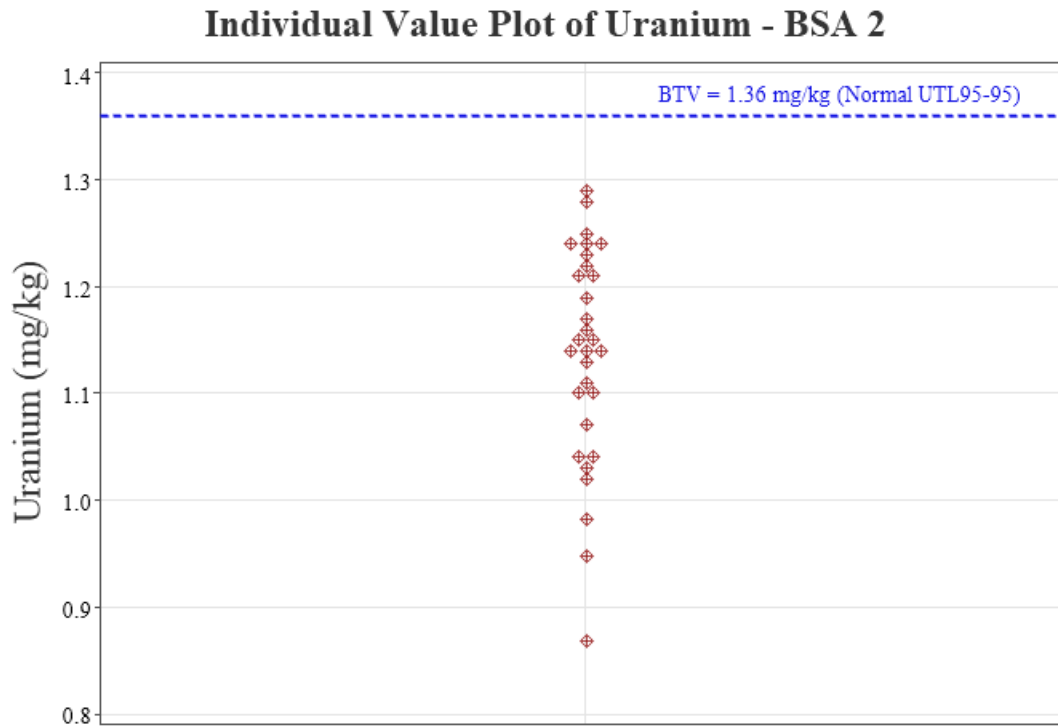


Figure H-37. Individual Value Plot of Uranium Soil Concentrations at BSA-02

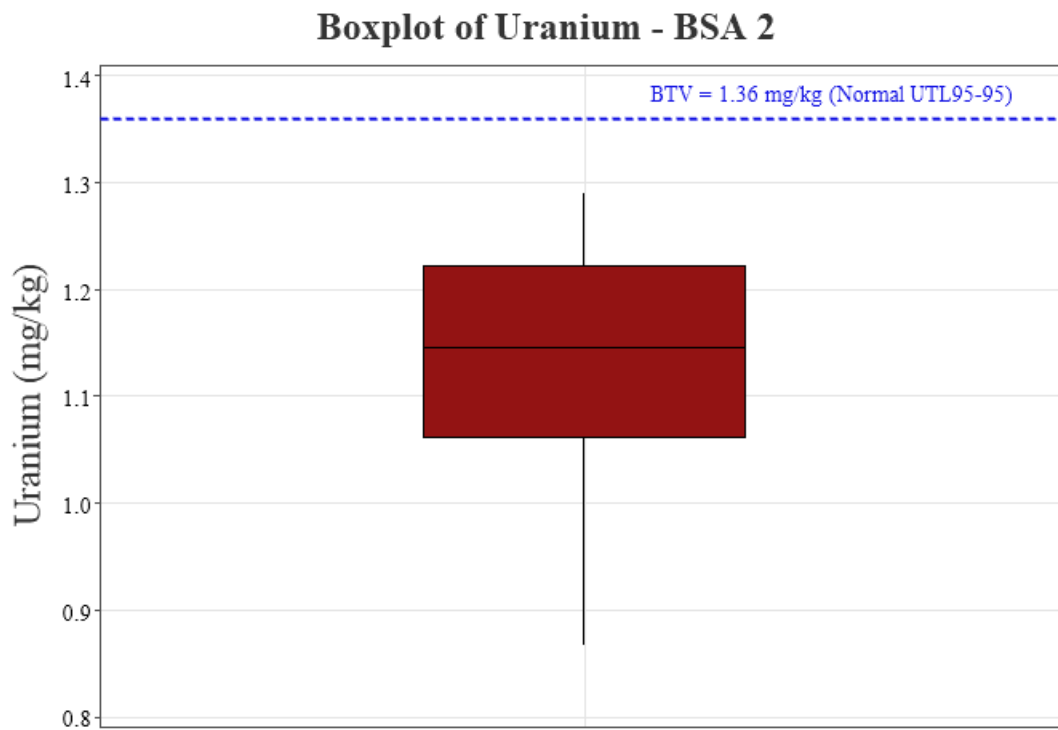


Figure H-38. Box Plot of Uranium at BSA-02

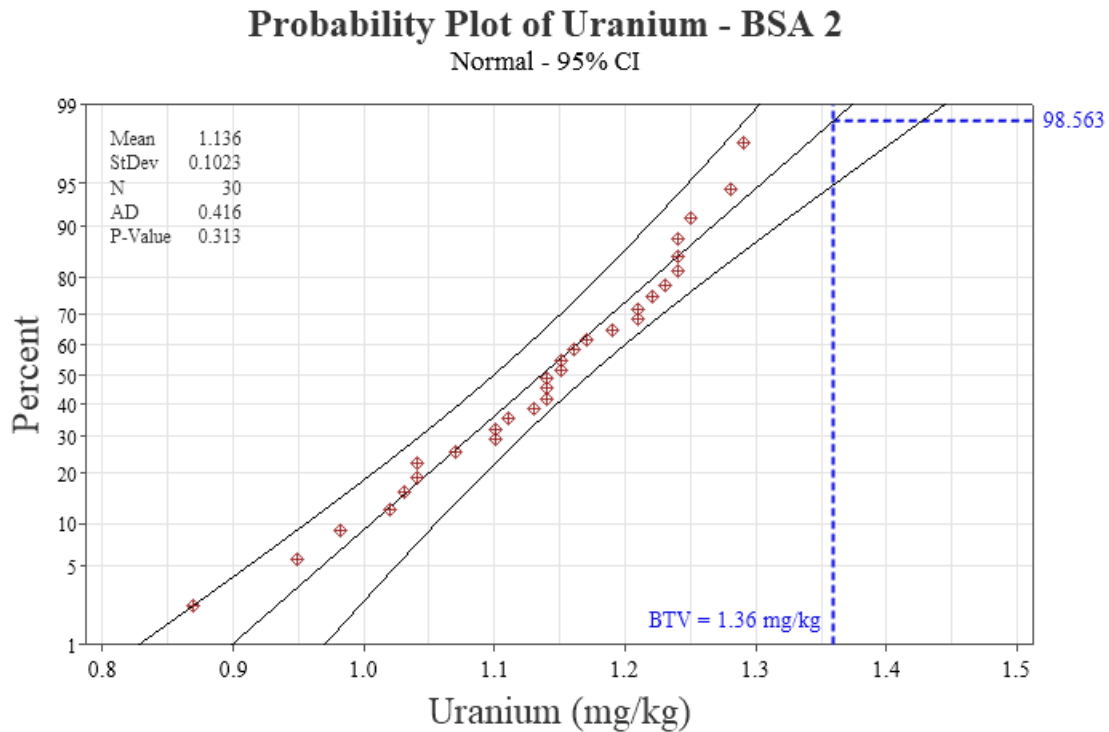


Figure H-39. Probability Plot of Uranium Soil Concentrations at BSA-02 (Normal)

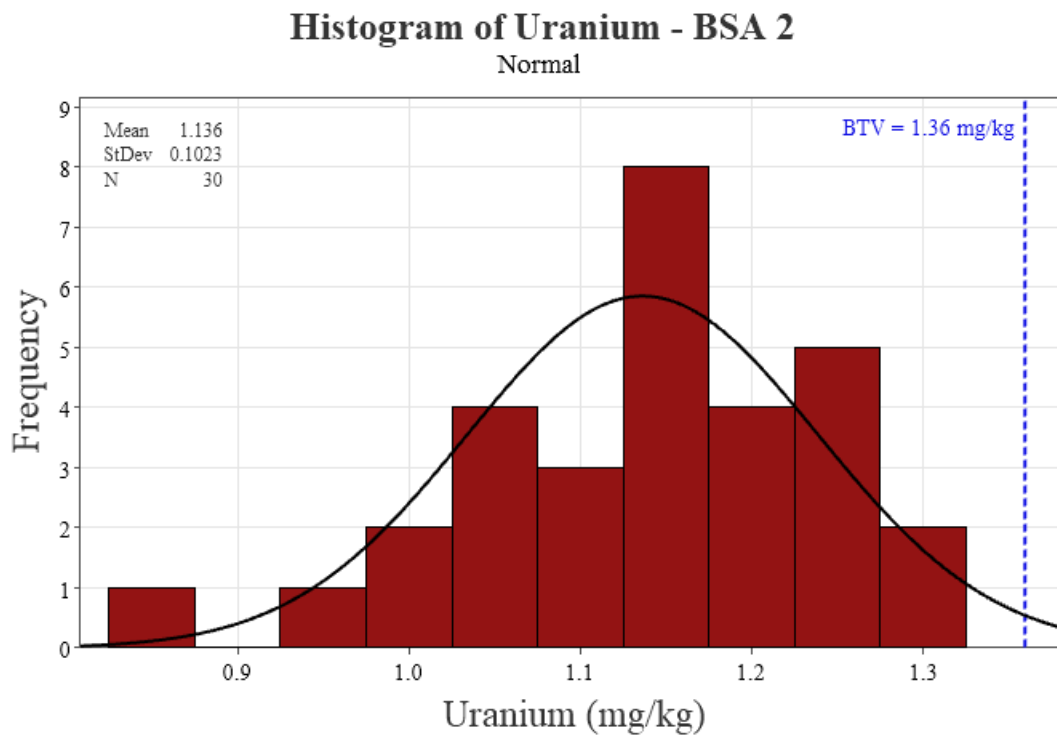


Figure H-40. Histogram of Uranium Soil Concentrations at BSA-02 (Normal)

5.2.9 Vanadium

Analytical results and descriptive statistics for the 30 vanadium surface soil results are listed in [Table H-3](#) and [Table H-4](#), respectively. The selected BTVs for all analytes are listed in [Table H-9](#). All vanadium results from surface soils at BSA-02 were detectable concentrations (i.e., no NDs). A statistical and graphical analysis of the vanadium dataset from BSA-02 involved GOF and outlier testing in ProUCL. Results of the ProUCL GOF testing indicated that vanadium data at BSA-02 follows a normal distribution, and no outliers were identified by use of the Rosner's outlier analysis. Visual inspection also identified no outliers.

The normal UTL95-95 of 32.6 mg/kg was selected as the BTV for vanadium at BSA-02. An individual value plot showing the spread of the vanadium surface soil concentration data obtained at BSA-02 is on [Figure H-41](#). The box plot of the data is on [Figure H-42](#). A normal probability plot showing vanadium surface soil concentrations at BSA-02 is on [Figure H-43](#). By use of this parametric fit, 98.7 percent of the inferred population falls below the BTV. A histogram with a fitted normal distribution of vanadium surface soil concentrations at BSA-02 is on [Figure H-44](#).

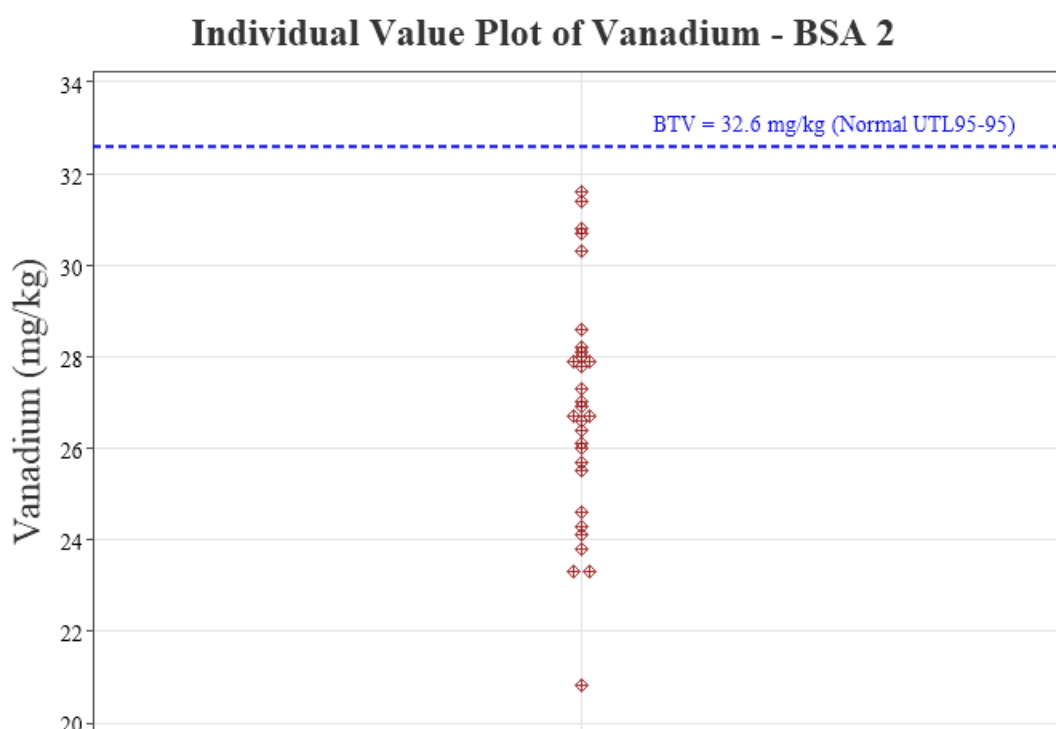
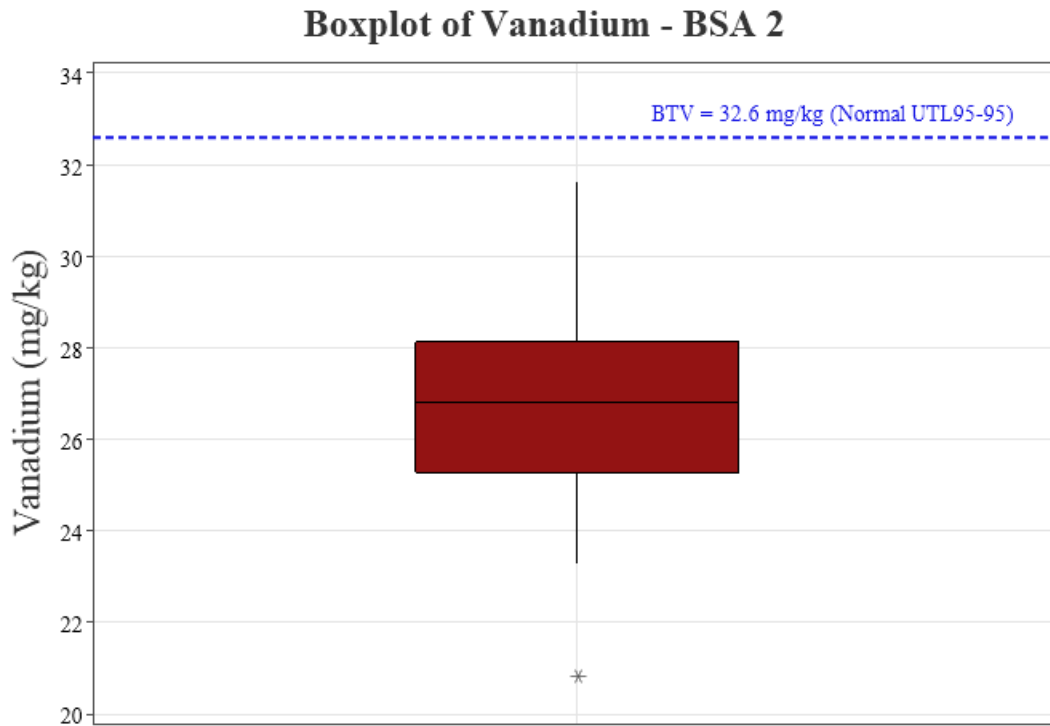
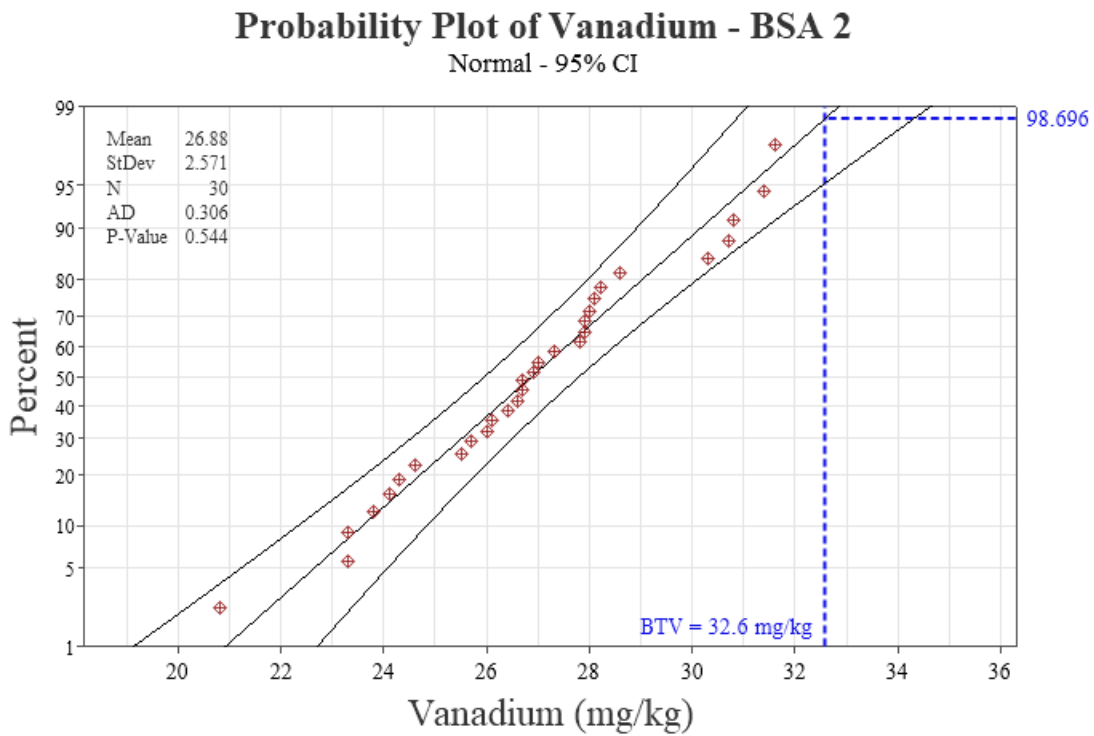


Figure H-41. Individual Value Plot of Vanadium Soil Concentrations at BSA-02

**Figure H-42. Box Plot of Vanadium at BSA-02****Figure H-43. Probability Plot of Vanadium Soil Concentrations at BSA-02 (Normal)**

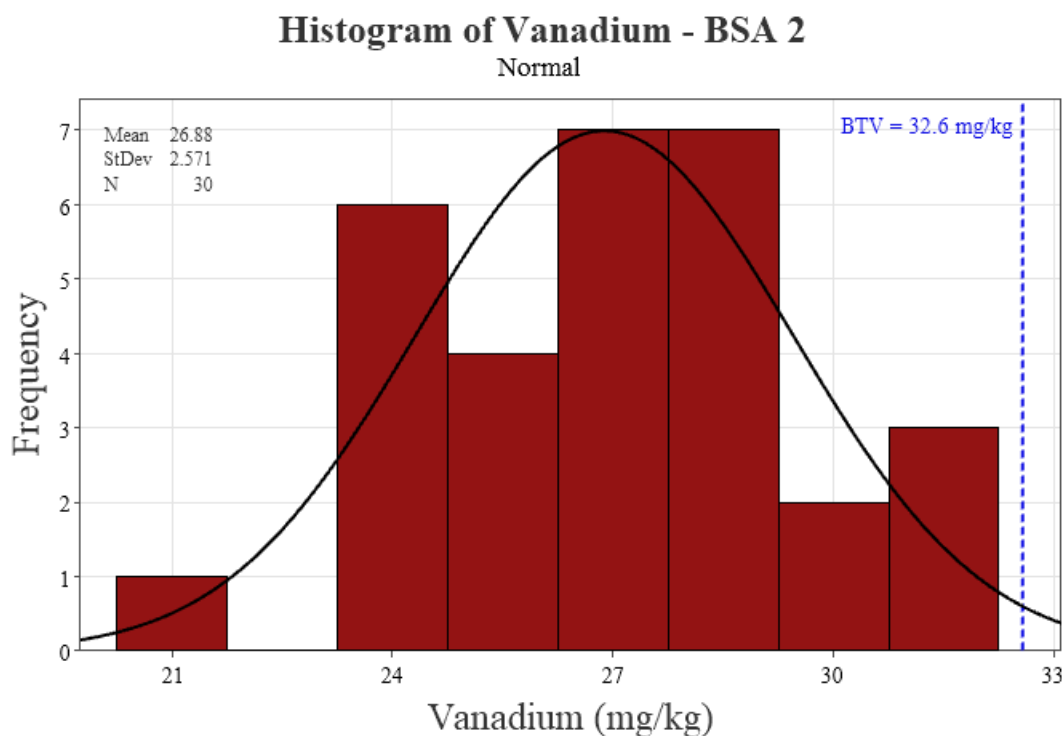


Figure H-44. Histogram of Vanadium Soil Concentrations at BSA-02 (Normal)

5.3 SOIL SAMPLING BACKGROUND THRESHOLD VALUES

The BTV selection process for the 29 analytes of interest at BSA-02 followed the data analysis procedures outlined in [Section 3.3](#). Selections of BTVs occurred following data processing in ProUCL, graphical analysis of each dataset in Minitab, and identification of outliers by both visual inspection and outlier testing in ProUCL. Outliers identified by ProUCL were determined to be representative of the background population for those analytes of interest, and therefore were retained in the ProUCL analysis.

Final site-specific BTVs selected for all analytes of interest are listed in [Table H-9](#). Out of the 29 analytes of interest, 27 appeared to follow or approximate a normal distribution in ProUCL at a 1 percent significance level. The remaining two analytes, antimony and silver, were undetected in all samples collected at BSA-02, and no BTV was calculated for these analytes. Datasets for the other 27 analytes evaluated were uncensored, containing no NDs.

5.4 X-RAY FLUORESCENCE SURVEY BACKGROUND THRESHOLD VALUES

The XRF selection process followed a method similar to that of the BTV selection process described in [Section 5.3](#) for soil sampling analytical results.

[Table H-10](#) summarizes the final site-specific XRF BTVs.



Table H-9. Site-Specific Background Threshold Values for BSA-02

Analyte	# of Nondetects	Relative Standard Deviation (%)	Statistical Outliers Present?	Outliers Removed? ¹	BTV Selection Method	Parametric Distribution for Graphical Display	Final BTV Selected	BTV Units
Aluminum	0	11%	Yes	No	Normal UTL95-95	Normal	19,274	mg/kg
Antimony	30	-	-	-	-	-	-	mg/kg
Arsenic	0	10%	No	No	Normal UTL95-95	Normal	7.0	mg/kg
Barium	0	10%	Yes	No	Normal UTL95-95	Normal	165	mg/kg
Beryllium	0	10%	No	No	Normal UTL95-95	Normal	1.2	mg/kg
Cadmium	0	9%	No	No	Normal UTL95-95	Normal	0.18	mg/kg
Calcium	0	9%	Yes	No	Normal UTL95-95	Normal	8,177	mg/kg
Chromium	0	10%	No	No	Normal UTL95-95	Normal	15.1	mg/kg
Cobalt	0	10%	No	No	Normal UTL95-95	Normal	9.2	mg/kg
Copper	0	11%	No	No	Normal UTL95-95	Normal	17.0	mg/kg
Iron	0	9%	No	No	Normal UTL95-95	Normal	22,138	mg/kg
Lead	0	11%	No	No	Normal UTL95-95	Normal	18.8	mg/kg
Lithium	0	11%	No	No	Normal UTL95-95	Normal	17.6	mg/kg
Magnesium	0	7%	No	No	Normal UTL95-95	Normal	4,905	mg/kg
Manganese	0	7%	No	No	Normal UTL95-95	Normal	2,856	mg/kg
Molybdenum	0	10%	No	No	Normal UTL95-95	Normal	0.41	mg/kg
Nickel	0	10%	No	No	Normal UTL95-95	Normal	12.4	mg/kg
Potassium-40	0	5%	Yes	No	Normal UTL95-95	Normal	23.2	pCi/g
Radium-226	0	12%	No	No	Normal UTL95-95	Normal	2.0	pCi/g
Radium-228	0	17%	No	No	Normal UTL95-95	Normal	2.3	pCi/g
Selenium	0	19%	No	No	Normal UTL95-95	Normal	2.8	mg/kg
Silver	30	-	-	-	-	-	-	mg/kg
Sodium	0	9%	No	No	Normal UTL95-95	Normal	81.2	mg/kg
Thallium	0	10%	No	No	Normal UTL95-95	Normal	0.27	mg/kg
Thorium	0	11%	No	No	Normal UTL95-95	Normal	11.6	mg/kg
Thorium-232	0	17%	No	No	Normal UTL95-95	Normal	2.3	pCi/g
Uranium	0	9%	No	No	Normal UTL95-95	Normal	1.4	mg/kg
Vanadium	0	10%	No	No	Normal UTL95-95	Normal	32.6	mg/kg
Zinc	0	10%	No	No	Normal UTL95-95	Normal	66.1	mg/kg

Notes:
¹ Outliers were identified by ProUCL (i.e., Dixon or Rosner) outlier tests but were representative of background and were included in analysis.
- Not applicable
BTV Background threshold value
mg/kg Milligram per kilogram
NA Not applicable
pCi/g Picocurie per gram
UTL Upper threshold limit



Table H-10. Site-Specific XRF Background Threshold Values for BSA-02

Analyte	# of Non-detects	Distribution	GOF	Statistical Outliers Present?	Outliers Removed?	BTV Selection Method	Final BTV Selected (ppm)	Notes
Arsenic	0	Normal	Appear	Yes	Yes	Normal UTL 95-95	8.217	
Barium	30	-	-	No	No	-	>LOD	No detections of analyte in background; any detections above the LOD measured in the field will be considered above background
Chromium	0	Normal	Appear	Yes	No	Normal UTL 95-95	43.32	
Cobalt	5	Normal	Appear	No	No	Normal UTL 95-95	61.7	
Copper	0	Normal	Appear	No	No	Normal UTL 95-95	15.21	
Gold	30	-	-	No	No	-	>LOD	No detections of analyte in background; any detections above the LOD measured in the field will be considered above background
Iron	0	Normal	Appear	No	No	Normal UTL 95-95	25130	
Lead	0	Normal	Appear	No	No	Normal UTL 95-95	20.42	
Manganese	0	Normal	Appear	Yes	No	Normal UTL 95-95	269.7	
Mercury	30	-	-	No	No	-	>LOD	No detections of analyte in background; any detections above the LOD measured in the field will be considered above background
Molybdenum	24	-	-	No	No	Maximum Recorded Value	1.61	Too few detects; maximum detected value used
Nickel	17	-	-	No	No	Maximum Recorded Value	19.93	Too few detects; maximum detected value used
Rubidium	1	Normal	Appear	No	No	Normal UTL 95-95	100.1	
Selenium	30	-	-	No	No	-	>LOD	No detections of analyte in background; any detections above the LOD measured in the field will be considered above background
Strontium	0	Normal	Appear	Yes	Yes	Normal UTL 95-95	111.9	
Thorium	0	Normal	Appear	No	No	Normal UTL 95-95	13.97	
Titanium	0	Normal	Appear	Yes	Yes	Normal UTL 95-95	3491	
Tungsten	30	-	-	No	No	-	>LOD	No detections of analyte in background; any detections above the LOD measured in the field will be considered above background
Uranium	0	Gamma	Approximate	Yes	Yes	WH Approx Gamma UTL 95-95	5.138	
Vanadium	1	Normal	Appear	No	No	Normal UTL 95-95	97.93	
Zinc	0	Normal	Appear	No	No	Normal UTL 95-95	71.81	
Zirconium	0	Normal	Appear	Yes	Yes	Normal UTL 95-95	328.6	

Notes:
- Not applicable
BTV Background threshold value
GOF Goodness of fit
LOD Limit of detection
ppm Parts per million
UTL Upper threshold limit
WH Wilson Hilferty

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ATTACHMENT H-1: PHOTOGRAPHIC LOG

SURFACE SOIL SAMPLING PHOTOS

The following photos were taken during RAES Task Order 35 in November 2022.



PHOTOGRAPH 1

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS01

35.6130, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS01-
111622.



PHOTOGRAPH 2

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS02

35.6130, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS02-
111622.



PHOTOGRAPH 3

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS03

35.6130, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS03-
111622.



PHOTOGRAPH 4

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS04

35.6130, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS04-
111622.



PHOTOGRAPH 5

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS05

35.6130, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS05-
111622.



PHOTOGRAPH 6

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS06

35.6129, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS06-
111622.



PHOTOGRAPH 7

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS07

35.6129, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS07-
111622.



PHOTOGRAPH 8

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS08

35.6129, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS08-
111622.



PHOTOGRAPH 9

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS09

35.6129, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS09-
111622.



PHOTOGRAPH 10

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS10

35.6129, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS10-
111622.



PHOTOGRAPH 11

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS11

35.6128, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS11-
111622.



PHOTOGRAPH 12

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS12

35.6128, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS12-
111622.



PHOTOGRAPH 13

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS13

35.6129, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS13-
111622.



PHOTOGRAPH 14

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS14

35.6128, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS14-
111622.



PHOTOGRAPH 15

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS15

35.6128, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS15-
111622.



PHOTOGRAPH 16

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS16

35.6128, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS16-
111622.



PHOTOGRAPH 17

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS17

35.6128, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS17-
111622.



PHOTOGRAPH 18

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS18

35.6128, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS18-
111622.



PHOTOGRAPH 19

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS19

35.6128, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS19-
111622.



PHOTOGRAPH 20

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS20

35.6128, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS20-
111622.



PHOTOGRAPH 21

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS21

35.6127, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS21-
111622.



PHOTOGRAPH 22

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS22

35.6127, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS22-
111622.



PHOTOGRAPH 23

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS23

35.6127, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS23-
111622.



PHOTOGRAPH 24

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS24

35.6127, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS24-
111622.



PHOTOGRAPH 25

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS25

35.6127, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS25-
111622.



PHOTOGRAPH 26

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS26

35.6126, -108.5573

DESCRIPTION:

Surface soil sample
OCRM-B02-SS26-
111622.



PHOTOGRAPH 27

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS27

35.6126, -108.5572

DESCRIPTION:

Surface soil sample
OCRM-B02-SS27-
111622.



PHOTOGRAPH 28

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS28

35.6126, -108.5571

DESCRIPTION:

Surface soil sample
OCRM-B02-SS28-
111622.



PHOTOGRAPH 29

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS29

35.6126, -108.5570

DESCRIPTION:

Surface soil sample
OCRM-B02-SS29-
111622.



PHOTOGRAPH 30

DATE: 11/16/2022

LOCATION:

OCRM-B02-SS30

35.6126, -108.5569

DESCRIPTION:

Surface soil sample
OCRM-B02-SS30-
111622.

X-RAY FLUORESCENCE IN SITU PHOTOS



PHOTOGRAPH 1

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-
35.6128, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-.



PHOTOGRAPH 2

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-01

35.6130, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-01.



PHOTOGRAPH 3

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-02

35.6130, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-02.



PHOTOGRAPH 4

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-05

35.6130, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-05.



PHOTOGRAPH 5

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-06

35.6129, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-06.



PHOTOGRAPH 6

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-07

35.6129, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-07.



PHOTOGRAPH 7

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-08

35.6129, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-08.



PHOTOGRAPH 8

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-10

35.6129, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-10.



PHOTOGRAPH 9

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-11

35.6129, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-11.



PHOTOGRAPH 10

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-12

35.6129, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-12.



PHOTOGRAPH 11

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-13

35.6129, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-13.



PHOTOGRAPH 12

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-14

35.6129, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-14.



PHOTOGRAPH 13

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-15

35.6129, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-15.



PHOTOGRAPH 14

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-17

35.6128, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-17.



PHOTOGRAPH 15

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-19

35.6128, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-19.



PHOTOGRAPH 16

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-20

35.6128, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-20.



PHOTOGRAPH 17

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-21

35.6127, -108.5573

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-21.



PHOTOGRAPH 18

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-22

35.6127, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-22.



PHOTOGRAPH 19

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-23

35.6127, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-23.



PHOTOGRAPH 20

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-24

35.6127, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-24.



PHOTOGRAPH 21

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-25

35.6127, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-25.



PHOTOGRAPH 22

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-27

35.6126, -108.5572

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-27.



PHOTOGRAPH 23

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-28

35.6126, -108.5571

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-28.



PHOTOGRAPH 24

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-29

35.6126, -108.5570

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-29.



PHOTOGRAPH 25

DATE: 11/16/2022

LOCATION:

111622-OCRM-
BSA02-30

35.6126, -108.5569

DESCRIPTION:

XRF measurement at
111622-OCRM-
BSA02-30.

ATTACHMENT H-2: PROUCL OUTPUT

APPENDIX I

VOLUME ESTIMATES

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**OCRM Removal Assessment
Appendix I
Volumetric Estimates**

Response, Assessment, and Evaluation Services

Contract No. EP-S9-17-03

Task Order 0035

Date

August 25, 2023

Submitted to

U.S. Environmental Protection Agency

Submitted by

Tetra Tech, Inc.

1999 Harrison Street, Suite 500

Oakland, CA 94612



TETRA TECH

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ATTACHMENTS

Attachment I-1: HRI Letter
Attachment I-2: 2013 Intera Investigation Soil Boring Locations
Attachment I-3: 2013 Intera Investigation Soil Boring Logs



ACRONYMS AND ABBREVIATIONS

AUM	Abandoned uranium mine
bgs	Below ground surface
cpm	Counts per minute
CY	Cubic yard
HRI	HydroResources, Inc.
IDW	Inverse distance weight
OCRM	Old Church Rock Mine
pCi/g	Picocuries per gram
R ²	Coefficient of determination
SF	Square foot
TCRA	Time-critical removal action
USEPA	United States Environmental Protection Agency



1.0 INTRODUCTION

This Appendix I to the Old Church Rock Mine (OCRM) removal assessment report presents methodology and estimates related to a future cleanup at OCRM, including volumes of former settling ponds and concrete slabs, and areas subject to cleanup in the event of a Time-Critical Removal Action (TCRA).

2.0 SETTLING POND ESTIMATES

Five former settling ponds are on site at OCRM, as identified on [Figure I-1](#). Because these ponds are potential temporary repositories for waste, calculation of the air volume in each pond is necessary.

2.1 CALCULATION METHODOLOGY

To estimate the airspace volume of each settling pond, dimensions of each pond were obtained from a letter from HydroResources, Inc. (HRI) to the New Mexico Energy, Minerals, and Natural Resources Department (HRI 1996). This letter with pond dimensions is in [Attachment I-1](#).

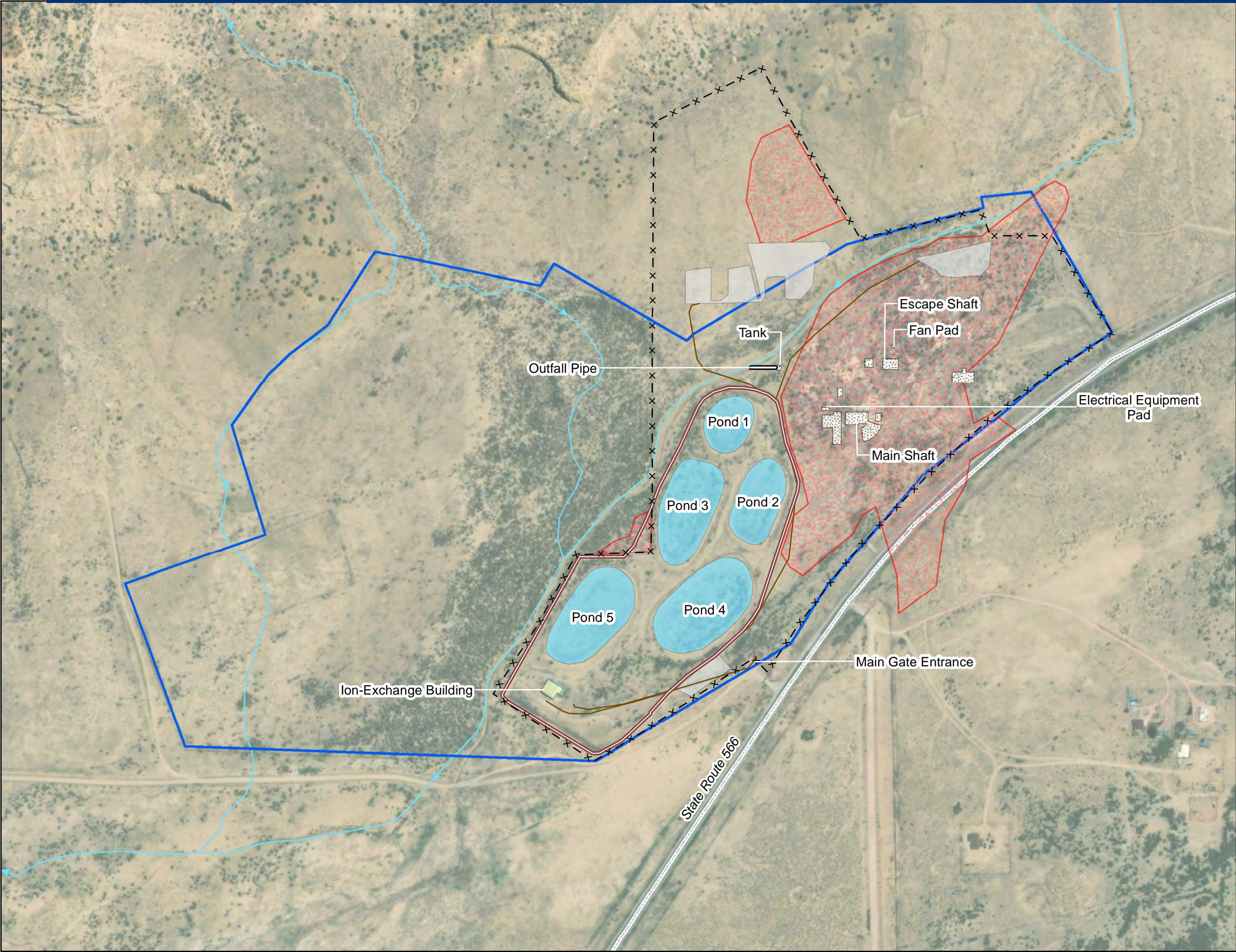
For the airspace volume calculation of each settling pond, the following dimensions were taken from [Attachment I-1](#):

H:	Average height from the base of the pond to top of the berm around the settling pond
$SL_{N,E,S,W}$:	Length of berm slope in four cardinal directions
$PB_{N,S,E,W}$:	Length of pond bed across two opposite cardinal directions (N-S, E-W)

From the dimensions in [Attachment I-1](#), the following features were calculated for each pond:

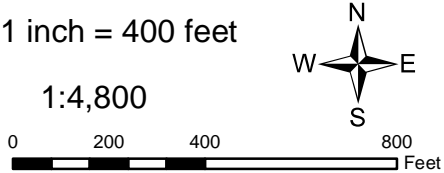
$SB_{N,E,S,W}$	Length of the base formed by the berm slope in four cardinal directions
$B_{N,S,E,W}$	Total length of the base between berm edges in opposite cardinal directions
A_{PB}	Pond bed area
A_T	Total area
V_S	Soil volume of the berm
V_T	Total airspace volume of the settling pond and the soil volume of the berm
V	Airspace Volume of the settling pond

[Figure I-2](#) shows a north-south (NS) cross section, east-west (EW) cross section, and overhead view of an example settling pond with the above-defined dimensions identified.



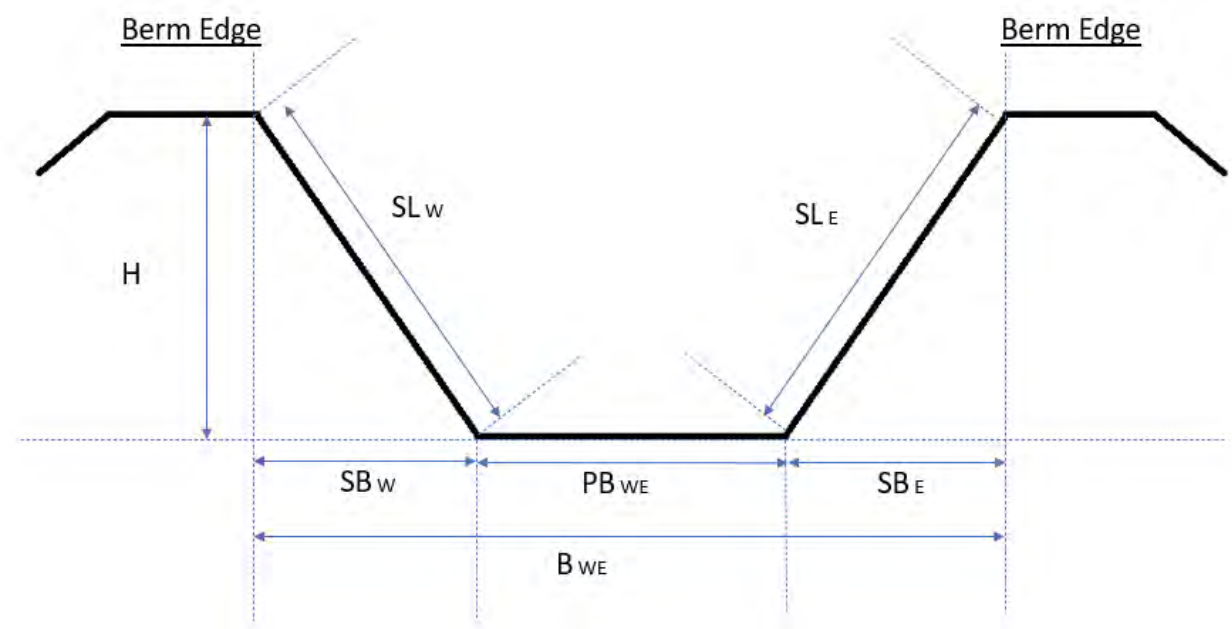
- 2007 EPA Navajo AUM Atlas Boundary
- Site Features**
- Berm
 - Fenced Boundary
 - Outfall Pipe
 - Drill Road - Fall 2022
 - Concrete Pad
 - Former Pond
 - Ion-Exchange Building
 - Laydown Areas - Fall 2022
 - Approximate Waste Disposal Area
 - Community Road
 - Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AUM Abandoned uranium mine

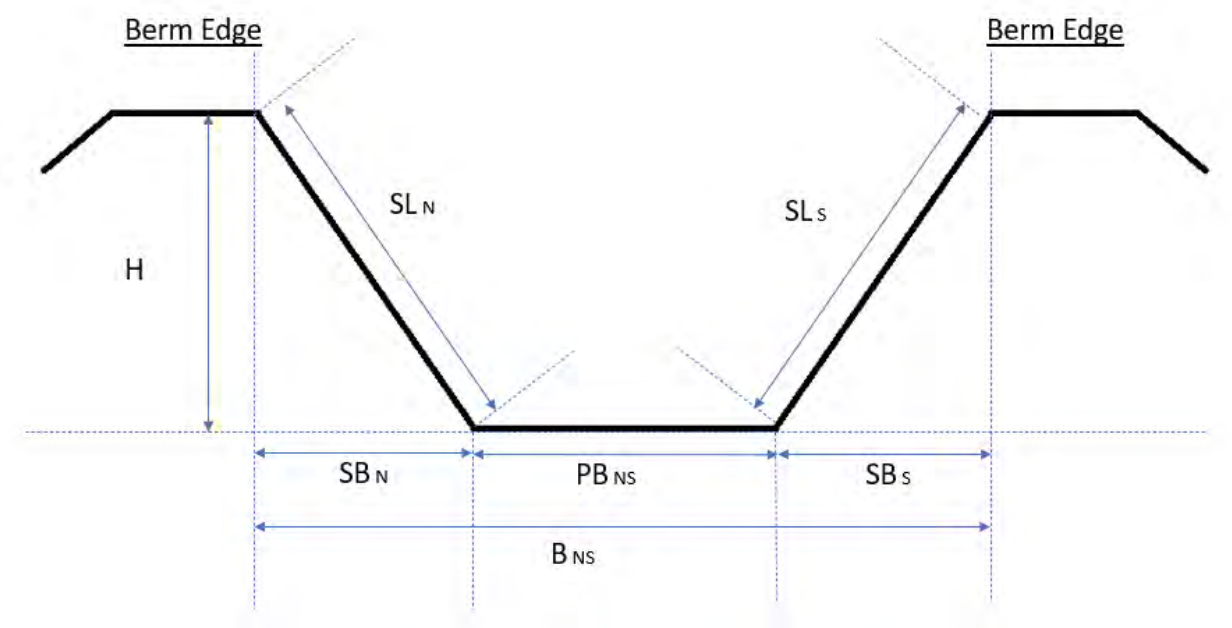


OLD CHURCH ROCK MINE AUM
AND AUM-RELATED FEATURES

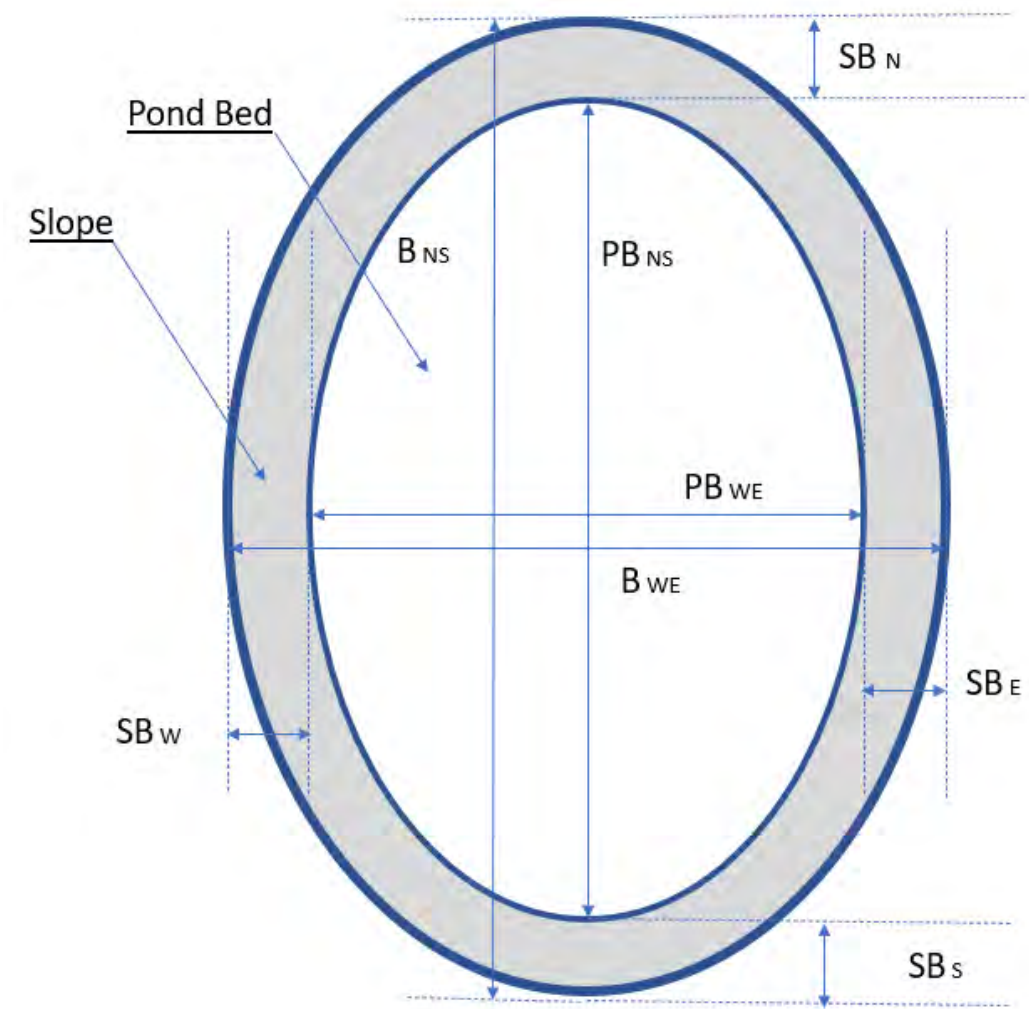
Prepared For: U.S. EPA Region 9	Prepared By:
	TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/4/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: I-1



Settling Pond Cross Section View - EW



Settling Pond Cross Section View - NS



Settling Pond Overhead View

Figure I-2. Settling Pond Cross Section

The length of the slope base (SB_x) is calculated by the Pythagorean relationship between the length of the slope and the height of the berm above the bottom of the pond, as in Equation (Eqn)-I1:

$$SB_{N,E,S,W} = \sqrt{SL_{N,E,S,W}^2 \cdot H_{N,E,S,W}^2} \quad \text{Eqn-I1}$$

Total length of the pond is calculated by summing the pond bottom plus the two opposite slope base lengths, calculated in Eqn-I1, as in Eqn-I2:

$$B_{NS,EW} = PB_{NS,EW} + SB_{N,E} + SB_{S,W} \quad \text{Eqn-I2}$$

Area of the pond bed and total area of the settling pond, including the area of the berm, are calculated by approximating them as ellipses, as indicated in Eqn-I3 and Eqn-I4, respectively:

$$A_{PB} = \pi \cdot \frac{PB_{NS}}{2} \cdot \frac{PB_{EW}}{2} \quad \text{Eqn-I3}$$

$$A_T = \pi \cdot \frac{B_{NS}}{2} \cdot \frac{B_{EW}}{2} \quad \text{Eqn-I4}$$

Soil volume of the berm is calculated by multiplying the difference between the total settling pond area and the pond bed area by the average berm height, giving the volume of the airspace above the berm slope and the soil volume of the berm. The berm is approximated as a right triangle, and so volume of the berm and the airspace above the berm slope is then divided by 2, giving the soil volume of the berm as indicated in Eqn-I5:

$$V_S = H \cdot \frac{A_T - A_{PB}}{2} \quad \text{Eqn-I5}$$

Total volume of the settling pond includes total airspace of the settling pond and soil volume of the berm, and is calculated as the product of the total settling pond area and the average berm height of the pond, as indicated in Eqn-I6:

$$V_T = H \cdot A_T \quad \text{Eqn I6}$$

The airspace volume of the settling pond then can be calculated as the difference between total volume of the settling pond and soil volume of the berm, as indicated in Eqn-I7:

$$V = V_T - V_S \quad \text{Eqn-I7}$$



2.2 POND ESTIMATES

Applying the methodology described in [Section 2.1](#), volumetric capacity of each of the former settling ponds at OCRM was calculated. [Table I-1](#) provides those calculations (using Eqn-I1 through Eqn-I7) of the unoccupied volume in each settling pond. [Table I-2](#) lists the volume of each pond along with total volume of all five.



Table I-1. Estimation of Former Settling Pond Volumes

	Slope	Height (feet)	Slope Length (feet)	Pond Bed Length (feet)	Slope Base (feet)	Total Base Length (feet)	Pond Bed Area (feet²)	Total Area (feet²)	Slope Volume (feet³)	Total Volume (feet³)	Volume of Pond (feet³)	Volume of Pond (CY)
Pond 1	North	15	50	160	50	250	15,080	38,681	177,009	580,213	403,204	14,933
	South		40		40							
	West		45	120	45	197						
	East		32		32							
Pond 2	North	12	40	290	40	365	22,777	51,601	172,945	619,208	446,263	16,528
	South		35		35							
	West		40	100	40	180						
	East		40		40							
Pond 3	North	12	45	320	45	397	32,673	63,296	183,741	759,552	575,812	21,326
	South		32		32							
	West		40	130	40	203						
	East		33		33							
Pond 4	North	9	25	320	25	380	50,265	75,508	113,592	679,574	565,981	20,962
	South		35		35							
	West		25	200	25	253						
	East		28		28							
Pond 5	North	10	40	320	40	385	35,186	60,476	126,449	604,757	478,307	17,715
	South		25		25							
	West		30	140	30	200						
	East		30		30							
Reference:		Attachment I-1	Attachment I-1	Attachment I-1	Eqn-I1	Eqn-I2	Eqn-I3	Eqn-I4	Eqn-I5	Eqn-I6	Eqn-I7	Eqn-I7*

Note:
CY Cubic yard

**Table I-2. Summary of Volume Estimates of Settling Ponds**

Settling Pond	Volume Estimate (CY)
Pond 1	14,372
Pond 2	16,172
Pond 3	20,658
Pond 4	20,230
Pond 5	17,044
Total	88,475

Note:

CY Cubic yard

3.0 CONCRETE SLAB ESTIMATES

In the fenced area of OCRM within the area of former conventional mine operations, a number of concrete slabs remain. This section estimates the volume of each concrete slab based on dimensions of each concrete slab obtained from a letter from HRI to the New Mexico Energy, Minerals, and Natural Resources Department (HRI 1996). This letter with the concrete dimensions is in [Attachment I-1](#).

[Table I-3](#) provides calculations for estimating each concrete slab's volume by subdividing each slab into smaller rectangular slabs, each of known length, width, and height. Regarding concrete slab dimensions not conveyed in the HRI letter, the area of the slab was estimated by use of Google Earth, and thickness of the concrete slab was assumed to be 0.5 feet thick which is the most common thickness of slab with a known thicknesses.



Table I-3. Estimates of Concrete Slab Volumes

Slab Area	Concrete Slab	Area and Volume Calculations							Notes
		Length (feet)	Width (feet)	Area (feet²)	Area (SY)	Thickness (feet)	Volume (feet³)	Volume (CY)	
Main Shaft Slabs	Main Shaft Collar Section 1 Slab	55	55	3,025	336	2.0	6,050	224.1	
	Main Shaft Collar Section 2 Slab	42	55	2,310	257	2.0	4,620	171.1	
	Unnamed Adjacent Slab 1	-	-	6,390	710	0.5	3,195	118.3	Not included in HRI Calculations. Forms a semi-circle extending from between the main shaft and the main shaft hoist slabs. Area calculations are taken from Google Earth, and thickness is assumed to be 0.5 feet.
	Unnamed Adjacent Slab 2	2	3	6	1	0.5	3	0.1	Not included in HRI Calculations. Located 26 feet south of Main Shaft. Area calculations are taken from Google Earth, and thickness is assumed to be 0.5 feet.
	Main Shaft Hoist Slab	30	24	720	80	0.5	360	13.3	
	Main Shaft Hoist Foundation 1	16	32	512	57	4.0	2,048	75.9	
	Main Shaft Hoist Foundation 2	10	20	200	22	3.0	600	22.2	
Switch Gear Slabs	Unnamed Easternmost Slab Section 1	42	95	3,990	443	0.5	1,995	73.9	
	Unnamed Easternmost Slab Section 2	20	16	320	36	0.5	160	5.9	
	Unnamed Adjacent Slab	12	12	144	16	0.5	72	2.7	
	Switchgear Slab 1	7	9	63	7	0.5	32	1.2	
	Switchgear Slab 2	8	10	80	9	0.5	40	1.5	
Escape Shaft Slabs	Escape Shaft Collar Slab	68	42	2,856	317	2.0	5,712	211.6	
	Escape Shaft Hoist Slab	35	36	1,260	140	0.5	630	23.3	
	Fan Slab	10	12	120	13	0.5	60	2.2	
	Headframe Slabs 1	38	3	114	13	4.0	456	16.9	
	Headframe Slabs 2	38	3	114	13	4.0	456	16.9	
	Unnamed Hoist Slab 1	45	4	180	20	0.5	90	3.3	
	Unnamed Hoist Slab 2	16	35	560	62	2.5	1,400	51.9	
Electrical Equipment Slabs	Main Electrical Equipment Slab Section 1	60	45	2,700	300	0.5	1,350	50.0	
	Main Electrical Equipment Slab Section 2	35	140	4,900	544	0.5	2,450	90.7	
	Main Electrical Equipment Slab Section 3	10	20	200	22	0.5	100	3.7	
	Main Electrical Equipment Slab Section 4	5	20	100	11	0.5	50	1.9	
	Adjacent Electric Substation Slab Section 1	16	35	560	62	0.5	280	10.4	
	Adjacent Electric Substation Slab Section 2	3	3	9	1	0.5	5	0.2	
	Adjacent Electric Substation Slab Section 3	3	3	9	1	0.5	5	0.2	
	Unnamed Adjacent Slab 1	10	8	80	9	0.5	40	1.5	
	Unnamed Adjacent Slab 2	40	24	960	107	0.5	480	17.8	
Water Tank Slabs	Water Tank Circular Slab	-	-	452	50	0.5	226	8.4	Not included in HRI Calculations. Located next to unnamed arroyo. Area calculations are taken from Google Earth, and thickness is assumed to be 0.5 feet.
	Unnamed Adjacent Slab	5	21	105	12	0.5	53	1.9	Not included in HRI Calculations. Located 26 feet south of Main Shaft. Area calculations are taken from Google Earth and thickness is assumed to be 0.5 feet.

Notes:
- Not applicable
CY Cubic yard
HRI HydroResources, Inc.
SY Square yard



4.0 TIME-CRITICAL REMOVAL ACTION VOLUMES

Four areas of interest have been identified for cleanup within the scope of the TCRA. While no subsurface investigation occurred during the removal assessment in November 2022, the company Intera conducted a subsurface investigation in 2013 and drafted a report conveying their results in a document titled “DRAFT 2013 Phase II Site Characterization Report Old Church Rock Mine McKinley County, New Mexico” (Intera 2013).

This section proceeds through the process of digitizing raw results from the 2013 Draft report from Intera, correlating Intera’s raw results with the gamma-radium correlation included in Appendix E, and then assessing the four areas of interest for preliminary TCRA volume estimates.

The 2013 Draft Investigation report is a draft report. No interpretations or calculations in the draft report will be used for volume estimates in this appendix—only raw measurements by field instruments. Accuracy of instruments used in the investigation cannot be verified, so any and all volumes derived in this section are just estimates.

4.1 2013 INVESTIGATION RESULTS

The 2013 Draft Investigation report identifies 97 borings completed across OCRM and the surrounding area. Figure 5 of the 2013 Draft Investigation report ([Attachment I-2](#)) shows locations of all borings. At each borehole, a downhole gamma scan was completed, and a soil boring log from there included counts per minute (cpm) and associated depth (feet).

4.2 CORRELATING 2013 RAW MEASUREMENTS WITH REMOVAL ASSESSMENT GAMMA-RADIUM CORRELATION

Of the 97 borings completed during the 2013 investigation, 50 were in areas scanned during the 2022 Removal Assessment. The surface gamma reading of the downhole gamma survey at each boring was extracted from the soil boring log, included as [Attachment I-3](#), and matched with a gamma survey measurement from the 2022 removal assessment that was co-located with the 2013 downhole gamma survey surface reading. [Table I-4](#) lists each 2013 downhole gamma survey surface reading with its co-located 2022 removal assessment gamma survey measurement, as well as the corresponding gamma-radium equivalent calculated by application of Model 1 and Model 2 from Appendix E to this removal assessment report.



Table I-4. 2013 Downhole Gamma Surface Measurements with Co-Located 2022 Removal Assessment Gamma Survey Measurements

Soil Boring ID	Intera Raw Gamma (cpm)	Tetra Tech Co-Located Raw Gamma (cpm)	Tetra Tech Estimated Ra-226 – Model 1 (pCi/g)	Tetra Tech Estimated Ra-226 – Model 2 (pCi/g)
SB-18	1,922	11,801	-0.54	1.10
SB-19	1,686	12,007	-0.42	1.18
SB-102	1,700	12,069	-0.38	1.20
SB-103	1,723	12,365	-0.19	1.30
SB-10	1,647	12,402	-0.17	1.32
SB-3	1,909	12,783	0.07	1.46
SB-12	1,694	12,982	0.20	1.53
SB-2	1,623	13,301	0.40	1.64
SB-42	2,581	13,323	0.41	1.65
SB-5	2,101	14,281	1.01	1.99
SB-55	2,408	14,282	1.02	1.99
SB-28	1,573	14,419	1.10	2.04
SB-72	1,914	14,623	1.23	2.12
SB-6	1,776	14,700	1.28	2.14
SB-47	2,314	14,716	1.29	2.15
SB-26	2,041	14,759	1.32	2.16
SB-86	2,177	14,776	1.33	2.17
SB-27	2,308	14,795	1.34	2.18
SB-32	2,094	14,960	1.44	2.24
SB-39	2,443	14,970	1.45	2.24
SB-79	2,138	15,074	1.51	2.28
SB-22	2,011	15,202	1.59	2.32
SB-65	2,431	15,532	1.80	2.44
SB-49	2,434	15,574	1.83	2.46
SB-64	1,809	15,665	1.89	2.49
SB-24	2,407	15,966	2.07	2.60
SB-30	2,344	16,061	2.13	2.63
SB-20	2,195	16,262	2.26	2.70
SB-25	2,734	16,351	2.32	2.74
SB-81	2,437	16,381	2.34	2.75
SB-4	2,266	16,455	2.38	2.77
SB-21	3,082	17,284	2.90	3.07
SB-80	2,362	17,549	3.07	3.17
SB-35	2,196	17,887	3.28	3.29
SB-58	2,541	18,651	3.76	3.56
SB-85	2,323	18,933	3.94	3.66

Table I-4. 2013 Downhole Gamma Surface Measurements with Co-Located 2022 Removal Assessment Gamma Survey Measurements

Soil Boring ID	Intera Raw Gamma (cpm)	Tetra Tech Co-Located Raw Gamma (cpm)	Tetra Tech Estimated Ra-226 – Model 1 (pCi/g)	Tetra Tech Estimated Ra-226 – Model 2 (pCi/g)
SB-73	2,590	19,550	4.33	3.88
SB-74	2,760	19,557	4.33	3.89
SB-71	2,301	20,063	4.65	4.07
SB-78	2,501	21,621	5.63	4.63
SB-31	2,289	21,715	5.69	4.66
SB-91	2,697	21,917	5.82	4.73
SB-50	2,998	22,791	6.37	5.05
SB-63	2,904	24,442	7.41	5.64
SB-36	3,647	29,125	10.35	7.32
SB-75	3,217	29,512	10.60	7.46
SB-67	3,695	31,809	12.04	8.29
SB-46	3,396	33,909	13.36	9.04
SB-59	3,425	34,780	13.91	9.35
SB-54	3,515	36,915	15.25	10.12

Notes:

cpm Counts per minute
pCi/g Picocurie per gram
Ra-226 Radium-226
Tetra Tech Tetra Tech, Inc.

A qualitative relationship between the 2013 raw gamma dataset and the 2022 estimated radium dataset, by applying both Model 1 and Model 2, was derived with a coefficient of determination (R^2) of 0.757. This relationship allows conversion of the downhole gamma raw counts to estimated radium-226 (Ra-226) concentrations. Eqn-I7 and Eqn-I8 indicate the relationship between the Intera shielded downhole gamma raw counts and Tetra Tech estimated Ra-226 concentrations by applying both Model 1 and Model 2:

$$Gamma_{Intera, Model\ 1}(cpm) = 121.5x \cdot \left[{}^{226}Ra_{Tt,estimated,Model\ 1} \left(\frac{pCi}{g} \right) \right] + 1967.5 \quad \text{Eqn-I7}$$

$$Gamma_{Intera, Model\ 2}(cpm) = 212.93x \cdot \left[{}^{226}Ra_{Tt,estimated,Model\ 2} \left(\frac{pCi}{g} \right) \right] + 1666.5 \quad \text{Eqn-I8}$$

Per the findings in Appendix E from applications of Model 1 and Model 2, Model 1 more accurately models the gamma-radium correlation in areas higher than background, while Model 2 more accurately models the gamma-radium correlation in areas close to background. [Table I-5](#) summarizes the downhole gamma equivalents to benchmark Ra-226 concentrations.

Table I-5. 2013 Downhole Gamma Equivalents to Ra-226 Concentrations (Estimated)

Estimated Ra-226 Concentration (pCi/g)	Gamma-Radium Correlation Model	Downhole Gamma (cpm)
2	2	2,100
5	1	2,500
10	1	3,200
15	1	3,800
25	1	5,000

Notes:

cpm Counts per minute

pCi/g Picocuries per gram

By use of the downhole gamma values corresponding to Ra-226 concentrations listed in [Table I-5](#), the downhole gamma data from the 2013 investigation boring logs can be analyzed to determine the depth at which Ra-226 concentration drops below a benchmark value. These results are summarized in [Table I-6](#).

The results listed in [Table I-6](#) can be analyzed by application of an interpolation method of inverse distance weight (IDW), which allows estimate of depth of contamination at any of the Ra-226 concentrations identified in [Table I-6](#) at any point between neighboring boreholes.

Table I-6. Estimated Maximum Depths of Various Ra-226 Concentrations

Boring ID	Surface Gamma (cpm)	Maximum Drill Depth (feet bgs)	Depth to: (feet)					Note
			2 pCi/g (2100 cpm)	5 pCi/g (2500 cpm)	10 pCi/g (3200 cpm)	15 pCi/g (3800 cpm)	25 pCi/g (5000 cpm)	
SB-2	1,623	8	0	0	0	0	0	
SB-3	1,909	12	0	0	0	0	0	Reaches 2,100 cpm at 8 feet
SB-4	2,266	4	3	1.5	0	0	0	
SB-5	2,101	8	5	0	0	0	0	
SB-6	1,776	20	0	0	0	0	0	
SB-8	2,087	24	4.5	0	0	0	0	
SB-10	1,647	4	0	0	0	0	0	
SB-12	1,694	8	0	0	0	0	0	
SB-18	1,922	4	2	0	0	0	0	
SB-19	1,686	4	0	0	0	0	0	
SB-20	2,195	8	8	0	0	0	0	
SB-21	3,082	4	4	3	0	0	0	Contamination above 2 pCi/g may continue
SB-22	2,011	4	0	0	0	0	0	
SB-24	2,407	12	12	3	0	0	0	Contamination above 2 pCi/g may continue
SB-25	2,734	4	4	0.5	0	0	0	Contamination above 2 pCi/g may continue
SB-26	2,041	4	4	0	0	0	0	Contamination above 2 pCi/g may continue
SB-27	2,308	4	4	0	0	0	0	Contamination above 2 pCi/g may continue
SB-28	1,573	4	0	0	0	0	0	
SB-29	7,296	8	8	7	1	1	1	Contamination above 5 pCi/g may continue
SB-30	2,344	4	4	0	0	0	0	Contamination above 2 pCi/g may continue

Table I-6. Estimated Maximum Depths of Various Ra-226 Concentrations

Boring ID	Surface Gamma (cpm)	Maximum Drill Depth (feet bgs)	Depth to: (feet)					Note
			2 pCi/g (2100 cpm)	5 pCi/g (2500 cpm)	10 pCi/g (3200 cpm)	15 pCi/g (3800 cpm)	25 pCi/g (5000 cpm)	
SB-31	2,289	4	4	0	0	0	0	Contamination above 2 pCi/g may continue
SB-32	2,094	4	2.5	0	0	0	0	
SB-34	2,332	4	4	0	0	0	0	Contamination above 2 pCi/g may continue
SB-35	2,196	8	8	0	0	0	0	Contamination above 2 pCi/g may continue
SB-36	3,647	4	4	4	4	2.5	0	Contamination above 10 pCi/g may continue
SB-37	7,169	4	4	4	4	4	4	Contamination above 25 pCi/g may continue
SB-38	9,030	8	8	8	8	8	1	Contamination above 15 pCi/g may continue
SB-39	2,443	8	8	2.5	0	0	0	Contamination above 2 pCi/g may continue
SB-42	2,581	4	4	0.5	0	0	0	Contamination above 2 pCi/g may continue
SB-43	6,557	4	4	4	4	3	0.5	Contamination above 10 pCi/g may continue
SB-44	2,026	8	0	0	0	0	0	
SB-45	17,742	4	4	4	4	4	4	Contamination above 25 pCi/g may continue
SB-46	3,396	8	8	8	8	0	0	Contamination above 10 pCi/g may continue
SB-47	2,314	8	8	0	0	0	0	Contamination above 2 pCi/g may continue
SB-49	2,434	4	4	2.5	0	0	0	Contamination above 2 pCi/g may continue
SB-50	2,998	4	4	4	1	0	0	Contamination above 5 pCi/g may continue
SB-51	2,455	4	0.5	0	0	0	0	
SB-52	4,129	12	1	1	1	1	0	

Table I-6. Estimated Maximum Depths of Various Ra-226 Concentrations

Boring ID	Surface Gamma (cpm)	Maximum Drill Depth (feet bgs)	Depth to: (feet)					Note
			2 pCi/g (2100 cpm)	5 pCi/g (2500 cpm)	10 pCi/g (3200 cpm)	15 pCi/g (3800 cpm)	25 pCi/g (5000 cpm)	
SB-53	21,737	4	4	4	4	4	4	Contamination above 25 pCi/g may continue
SB-54	3,515	8	8	8	7	0	0	Contamination above 10 pCi/g may continue
SB-55	2,408	4	4	0	0	0	0	Hovers around 2,100 cutoff
SB-58	2,541	8	8	8	0	0	0	Contamination above 5 pCi/g may continue
SB-59	3,425	8	8	8	8	0	0	Contamination above 10 pCi/g may continue
SB-60	20,130	12	12	12	12	12	12	Contamination above 25 pCi/g may continue
SB-61	21,499	24	24	24	24	24	24	Contamination above 25 pCi/g may continue
SB-62	4,681	4	4	4	4	4	0	Contamination above 15 pCi/g may continue
SB-63	2,904	4	4	4	0	0	0	Contamination above 5 pCi/g may continue
SB-64	1,809	4	0	0	0	0	0	Reaches 2100 cpm at 4 feet
SB-65	2,431	8	8	5.5	0	0	0	Contamination above 2 pCi/g may continue
SB-66	5,800	16	16	16	13	4	4	Contamination above 5 pCi/g may continue
SB-67	3,695	4	4	4	4	0	0	Contamination above 10 pCi/g may continue
SB-68	8,859	4	4	4	4	4	4	Contamination above 25 pCi/g may continue
SB-69	7,665	12	12	12	12	12	12	Contamination above 25 pCi/g may continue
SB-70	4,908	4	4	4	4	4	0	Contamination above 15 pCi/g may continue
SB-71	2,301	4	4	0	0	0	0	Contamination above 2 pCi/g may continue
SB-72	1,914	8	0	0	0	0	0	

Table I-6. Estimated Maximum Depths of Various Ra-226 Concentrations

Boring ID	Surface Gamma (cpm)	Maximum Drill Depth (feet bgs)	Depth to: (feet)					Note
			2 pCi/g (2100 cpm)	5 pCi/g (2500 cpm)	10 pCi/g (3200 cpm)	15 pCi/g (3800 cpm)	25 pCi/g (5000 cpm)	
SB-73	2,590	4	4	4	0	0	0	Contamination above 5 pCi/g may continue
SB-74	2,760	8	8	8	0	0	0	Contamination above 5 pCi/g may continue
SB-75	3,217	4	4	4	2.5	0	0	Contamination above 5 pCi/g may continue
SB-76	3,606	4	4	4	4	0	0	Contamination above 10 pCi/g may continue
SB-77	3,636	4	4	4	1	0	0	Contamination above 5 pCi/g may continue
SB-78	2,501	8	8	8	0	0	0	Contamination above 5 pCi/g may continue
SB-79	2,138	8	0.5	0	0	0	0	
SB-80	2,362	8	8	2.5	0	0	0	Contamination above 2 pCi/g may continue
SB-81	2,437	8	8	8	0	0	0	Reaches 2500 cpm at 6.5 ft Contamination above 2 pCi/g may continue
SB-85	2,323	4	4	0	0	0	0	Contamination above 2 pCi/g may continue
SB-86	2,177	4	4	0	0	0	0	Contamination above 2 pCi/g may continue
SB-91	2,697	4	4	2.5	0	0	0	Contamination above 2 pCi/g may continue
SB-102	1,700	12	0	0	0	0	0	
SB-103	1,723	12	0	0	0	0	0	

Notes:

bgs Below ground surface
cpm Counts per minute
pCi/g Picocurie per gram

4.3 WASTE REMOVAL VOLUME ESTIMATES

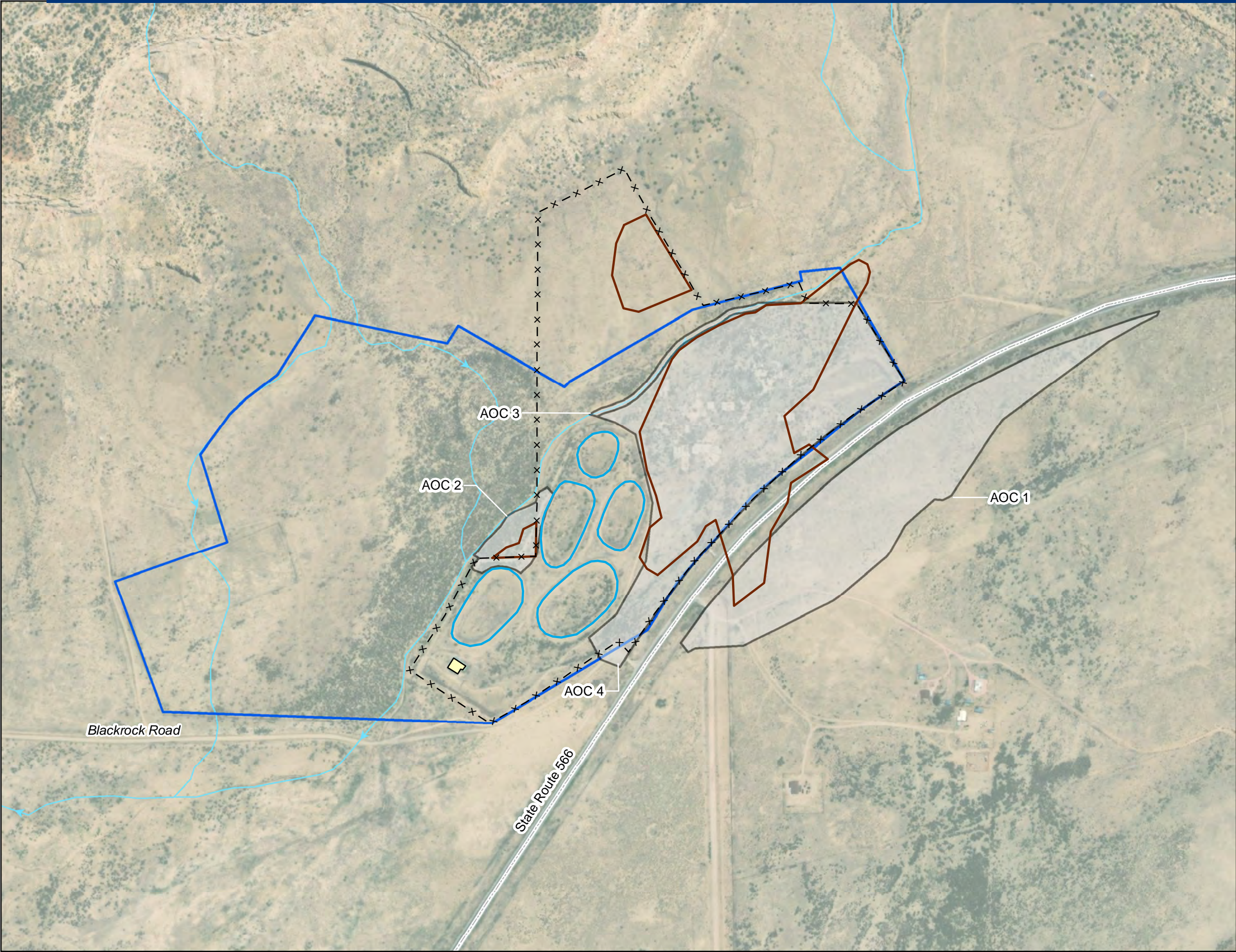
Based on results from the removal assessment, potential exposure pathways from contamination pose a potential threat to nearby residents in the following four areas of concern at the OCRM site (see [Figure I-3](#)):

- **Area 1** is on the south/southeast side of State Route 566 from OCRM, on a nearby resident's grazing lands. Contamination was identified in this area as a result of windblown transport, as well as an extension of the mine waste piles deposited prior to construction of Route 566. Removing material from this area would mitigate surficial exposure to contamination caused by windblown transport and past mine waste deposition.
- **Area 2** is a berm of waste material partially within but primarily outside the western fenced area at OCRM, but east of the eastern bank of the unnamed arroyo that runs west of OCRM. Removing material from this area would mitigate potential for windblown and stormwater transport of contaminants into the arroyo.
- **Area 3** is the eastern bank of the unnamed arroyo upstream of Area 2 running beside OCRM from the center point of the arroyo and 10 feet inward toward the eastern bank. Area 3 extends from where a road crosses through the arroyo in Section 17 to where the arroyo crosses into Section 8. Removing material from this area would mitigate potential for windblown and stormwater transport of contaminants into the arroyo.
- **Area 4** encompasses the surficial waste material within the fenced area of the OCRM site, excluding Area 3 and the areas around the former settling ponds and ion-exchange building. Removing material from this area would mitigate potential for windblown transport off site.

A fifth area of potential concern is a waste disposal area north of the unnamed arroyo in an open field within Section 8. While this area is of concern, it is not considered to pose an imminent and substantial threat to the nearby community. It will be addressed along with all other areas of concern through the non-time-critical removal action process.

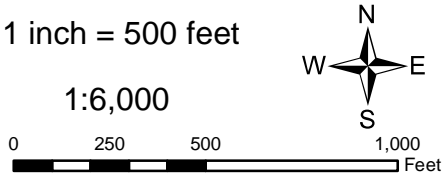
[Figure I-4](#), [Figure I-5](#), [Figure I-6](#), [Figure I-7](#), and [Figure I-8](#) show areal extents of Ra-226 contamination at concentrations of 2, 5, 10, 15, and 25 pCi/g, respectively, to maximum estimated depth.

[Table I-7](#) summarizes the total volume of material exceeding various levels of contamination in each of the areas, as well as the total volume exceeding various levels of contamination to maximum depth of 2 feet bgs.



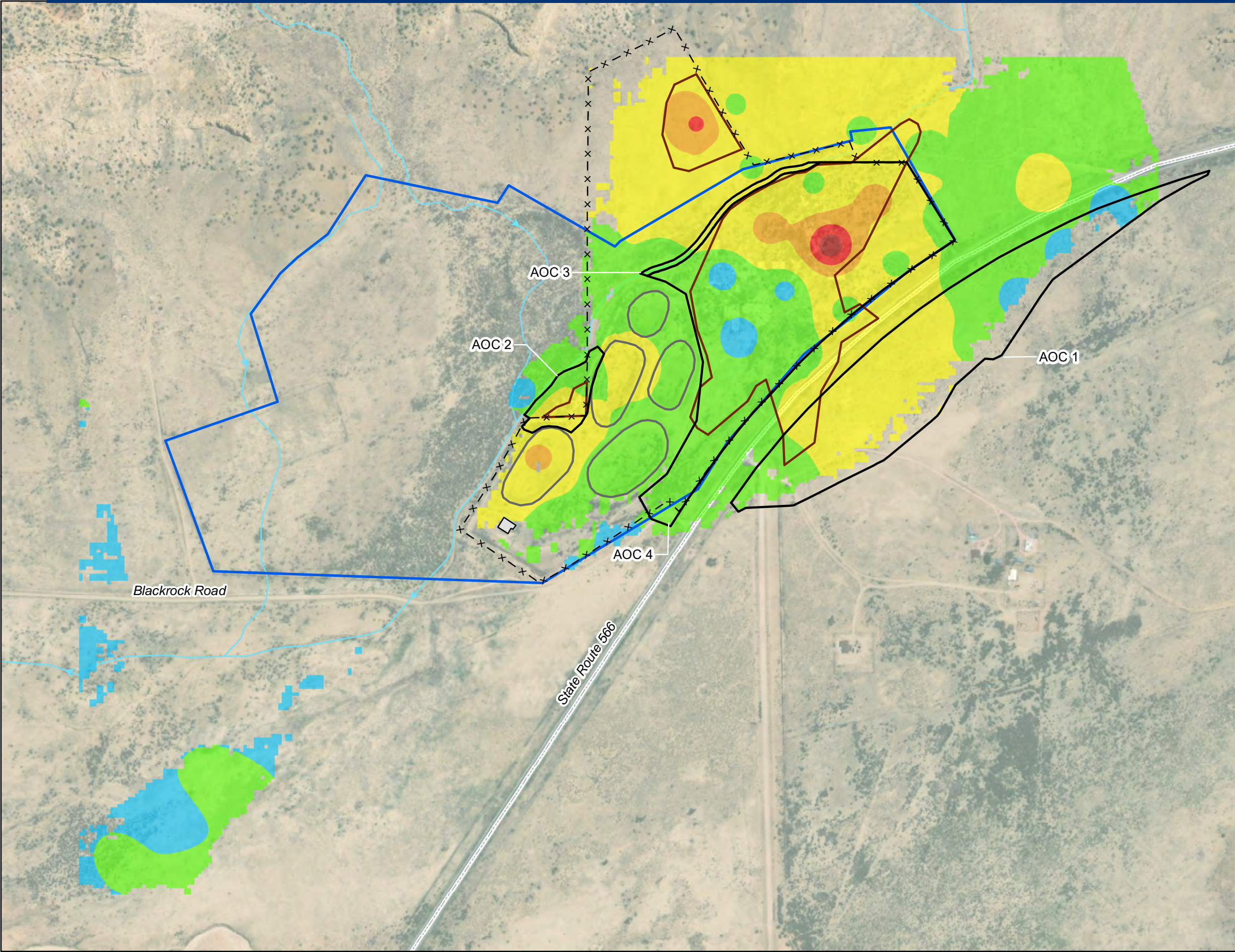
- Aera of Concern
- AUM Site Boundary
- Site Features**
- Fenced Boundary
- Former Pond
- Ion Exchange Building
- Approximate Waste Disposal Area
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AOC Area of concern
AUM Abandoned uranium mine



OLD CHURCH ROCK MINE
AREAS OF CONCERN

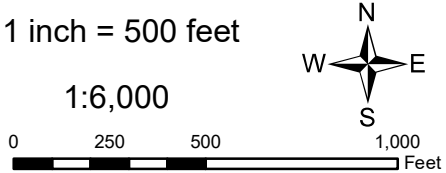
Prepared For: U.S. EPA Region 9	Prepared By:
	 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/4/2023
Coordinate System: NAD 1983 State Plane Arizona East FIPS 0201 Feet Transverse Mercator	Figure No.: I-3





- Area of Concern**
- Cleanup Depth (feet)
at 2pCi/g Estimated Radium-226
- ≤ 2
 - 2 - 5
 - 5 - 10
 - 10 - 15
 - 15 - 20
 - > 20
- Site Features**
- Fenced Boundary
 - Former Pond
 - Ion Exchange Building
 - Approximate Waste Disposal Area
 - Community Road
 - Surface Water Pathway¹

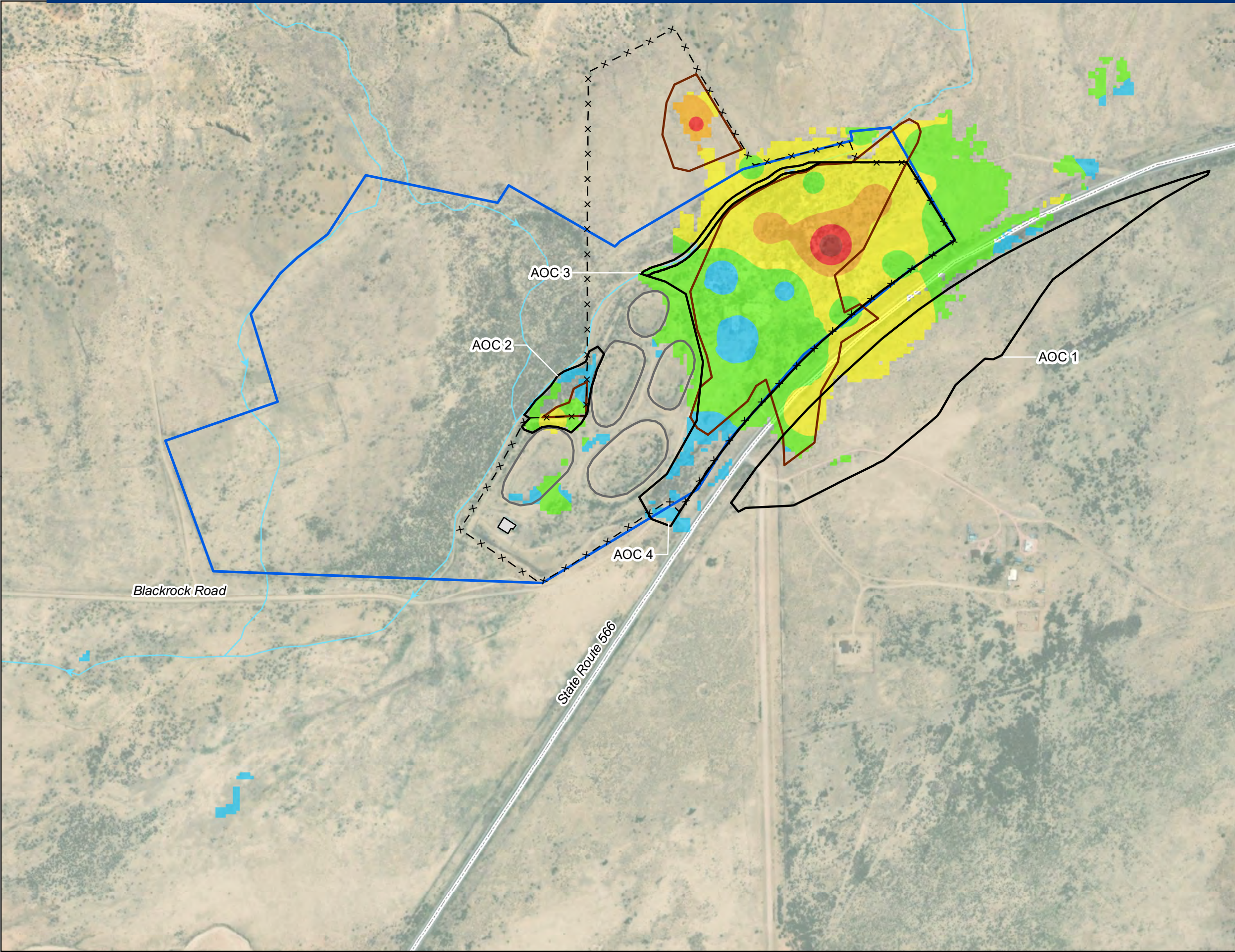
Notes:
¹All surface water pathways drain to the Puerco River.

AOC Area of concern
AUM Abandoned uranium mine
pCi/g Picocurie per gram



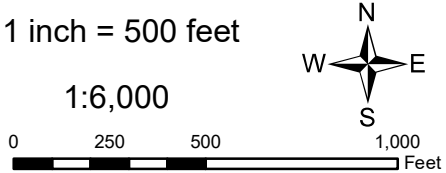
OLD CHURCH ROCK MINE
ESTIMATED DEPTH OF
RADIUM-226 CONTAMINATION
AT 2 PCi/G

Prepared For: U.S. EPA Region 9 	Prepared By:  TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/4/2023
Coordinate System: NAD 1983 State Plane Arizona East FIPS 0201 Feet Transverse Mercator	Figure No.: I-4



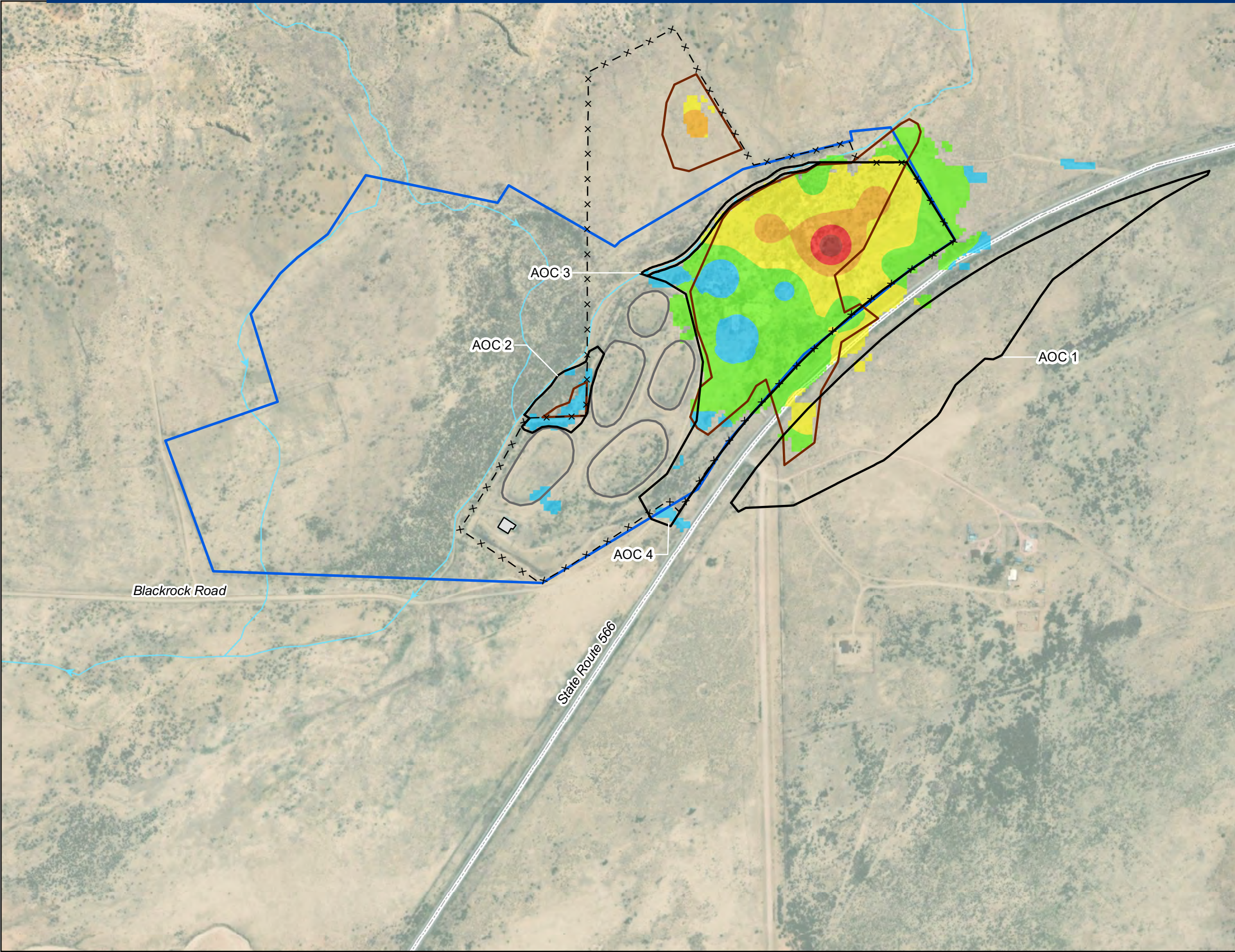
- Area of Concern
- Cleanup Depth (feet)
at 5pCi/g Estimated Radium-226
- ≤ 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- > 20
- AUM Site Boundary
- Site Features
- × — Fenced Boundary
- Former Pond
- Ion Exchange Building
- Approximate Waste Disposal Area
- Community Road
- Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AOC Area of concern
AUM Abandoned uranium mine
pCi/g Picocurie per gram



OLD CHURCH ROCK MINE
ESTIMATED DEPTH OF
RADIUM-226 CONTAMINATION
AT 5 PC I/G

Prepared For: U.S. EPA Region 9	Prepared By:
	TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/4/2023
Coordinate System: NAD 1983 State Plane Arizona East FIPS 0201 Feet Transverse Mercator	Figure No.: I-5



- Aera of Concern
- Cleanup Depth (feet)
at 10 pCi/g Estimated Radium-226
- ≤ 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- > 20
- AUM Site Boundary

Site Features

× —

Fenced Boundary

Former Pond

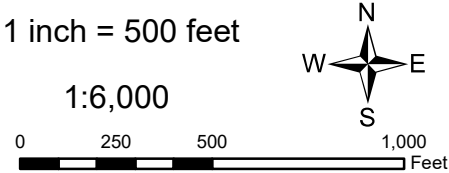
Ion Exchange Building

Approximate Waste Disposal Area

Community Road

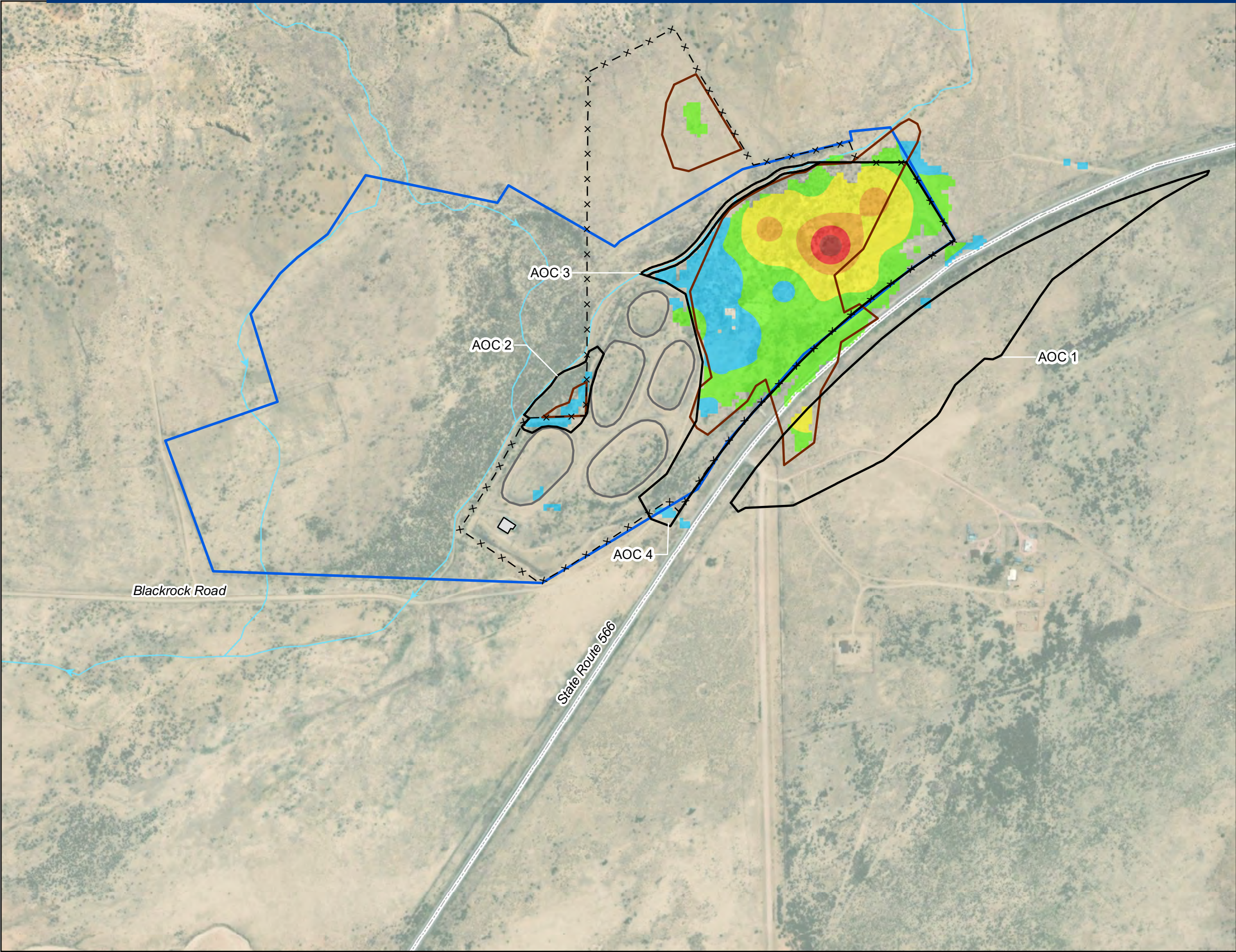
Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AOC Area of concern
AUM Abandoned uranium mine
pCi/g Picocurie per gram



OLD CHURCH ROCK MINE
ESTIMATED DEPTH OF
RADIUM-226 CONTAMINATION
AT 10 PCI/G

Prepared For: U.S. EPA Region 9	Prepared By:
	 TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/4/2023
Coordinate System: NAD 1983 State Plane Arizona East FIPS 0201 Feet Transverse Mercator	Figure No.: I-6



Aera of Concern

Cleanup Depth (feet)
at 15 pCi/g Estimated Radium-226

≤ 2

2 - 5

5 - 10

10 - 15

15 - 20

> 20

AUM Site Boundary

Site Features

×

Fenced Boundary

Former Pond

Ion Exchange Building

Approximate Waste Disposal Area

Community Road

Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.
AOC Area of concern
AUM Abandoned uranium mine
pCi/g Picocurie per gram

1 inch = 500 feet

1:6,000

0

250

500

1,000

Feet

N

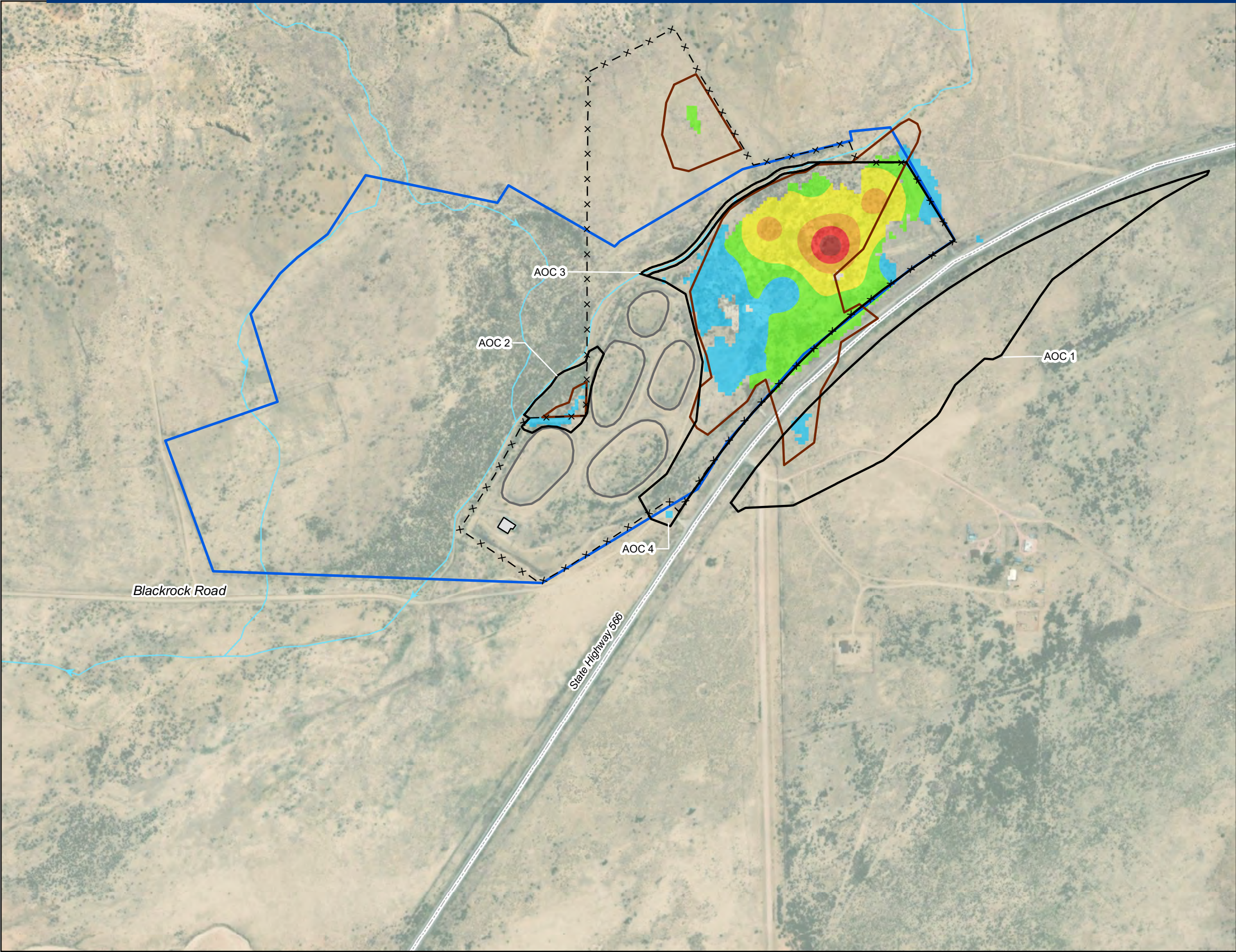
W

E

S

OLD CHURCH ROCK MINE
ESTIMATED DEPTH OF
RADIUM-226 CONTAMINATION
AT 15 PCI/G

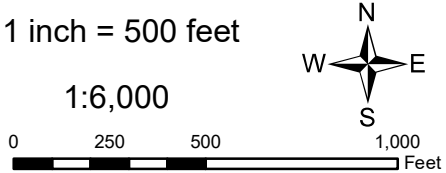
Prepared For: U.S. EPA Region 9	Prepared By:
	TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/4/2023
Coordinate System: NAD 1983 State Plane Arizona East FIPS 0201 Feet Transverse Mercator	Figure No.: I-7



- Area of Concern
- Cleanup Depth (feet)**
at 25 pCi/g Estimated Radium-226
- ≤ 2
 - 2 - 5
 - 5 - 10
 - 10 - 15
 - 15 - 20
 - > 20
- AUM Site Boundary
- Site Features**
- Fenced Boundary
 - Former Pond
 - Ion Exchange Building
 - Approximate Waste Disposal Area
 - Community Road
 - Surface Water Pathway¹

Notes:
¹All surface water pathways drain to the Puerco River.

AOC Area of concern
AUM Abandoned uranium mine
pCi/g Picocurie per gram



OLD CHURCH ROCK MINE
ESTIMATED DEPTH OF
RADIUM-226 CONTAMINATION
AT 25 PCI/G

Prepared For: U.S. EPA Region 9 	Prepared By: TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0016	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/4/2023
Coordinate System: NAD 1983 State Plane Arizona East FIPS 0201 Feet Transverse Mercator	Figure No.: I-8

Table I-7. Area of Concern Volume Estimates

Area of Concern	Target Ra-226 Cleanup Concentration (pCi/g)	Total Surface Area (acres)	Average Depth (feet)	Total Estimated Volume Maximum Estimated Depth (CY)	Total Estimated Volume Maximum 2 feet bgs (CY)
Total Site	2	170	5.3	1,447,277	532,983
	5	56	5.3	477,479	9,571
	10	36	5.3	305,224	8,316
	15	29	3.8	224,461	12,484
	25	22	4.8	168,821	11,395
Area 1 – Offsite Grazing Area ¹	2	15	5.3	130,970	47,993
	5	-	-	-	-
	10	-	-	-	-
	15	-	-	-	-
	25	-	-	-	-
Area 2 – Waste Material Berm	2	2.1	5.5	18,453	6,694
	5	1.4	3.0	6,839	3,629
	10	0.8	0.5	628	628
	15	0.6	0.5	512	512
	25	0.3	0.6	341	341
Area 3 – Arroyo Bank	2	0.8	6.1	7,462	2,458
	5	0.6	6.2	6,004	2,458
	10	0.1	5.6	953	319
	15	0.0	0.0	0	0
	25	0.0	0.0	0	0
Area 4 – Main Site	2	29	6.1	281,909	91,228
	5	27	5.9	257,797	83,403
	10	26	5.6	233,728	80,543
	15	24	5.3	201,761	70,314
	25	20	5.1	162,839	54,502

Table I-7. Area of Concern Volume Estimates

Notes:

¹ Area 1 cleanup volumes are estimated only for 2 pCi/g because the critical exposure pathway to residents is through animal product consumption.

bgs Below ground surface

CY Cubic yard

pCi/g Picocurie per gram

Ra-226 Radium-226



5.0 REFERENCES

- Hydro Resources, Inc. (HRI). 1996. "Prior Reclamation Status – Churchrock Mine McKinley, County, New Mexico."
- Intera. 2013. "2013 Phase II Site Characterization Report Old Church Rock Mine McKinley County, New Mexico." September.
- Tetra Tech, Inc. (Tetra Tech). 2022. "OCRM Removal Assessment Sampling and Analysis Plan." Response, Assessment, and Evaluation Services. Contract No. EP-S9-17-02. Task Order 0035.

ATTACHMENT I-1: HRI LETTER

HRI, INC.

(A Subsidiary of Uranium Resources, Inc.)

5656 South Staples
Suite 250, LB 8
Corpus Christi, Texas 78411
Telephone: (512) 993-7731
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12750 Merit Drive
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Dallas, Texas 75251
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Fax: (214) 387-7779

P.O. Box 777
Crownpoint, New Mexico 87313
Telephone: (505) 786-5845
Fax: (505) 786-5555

April 15, 1996

Dr. Kathleen A. Garland, Director
Mining and Minerals Division
New Mexico Energy, Minerals and Natural Resources Department
P.O. Box 6429
Santa Fe, New Mexico 87505-6429

RE: Prior Reclamation Status - Churchrock Mine
McKinley County, New Mexico



Dear Dr. Garland:

The following Amendment of HRI's prior reclamation plan for the subject property is submitted pursuant to your letter dated September 29, 1995, and more recent telephone conversations with Mr. Holland Sheperd. Our intent is to perform the work in 1996.

You noted in your letter that HRI is proposing to license this facility with the Nuclear Regulatory Commission for in-situ mining. You are correct. We expect licensing to be complete at the end of this year. The entire area being considered for Prior Reclamation Improvement falls within the NRC license area and will be disturbed through in-situ wellfield development. If this results in an exemption from the New Mexico Mining Act, please notify me, as we would prefer to perform the dirtwork and revegetation portion of the attached plan only once, that is after in-situ mining development.

Thank you for your assistance in this matter.

Sincerely,

A handwritten signature in blue ink is located below the word 'Sincerely,'. The signature appears to be 'Mark S. Pelizza'.

Mark S. Pelizza
Vice President
Health, Safety and Environmental Affairs

cc: Salvador Chavez, HRI, Inc./Crownpoint, New Mexico

Proposed Improvements to Prior Reclamation HRI, Inc. Churchrock Site

Introduction

On September 29, 1995, New Mexico Energy Minerals and Natural Resources Department advised HRI of three areas where additional remediation would be required at the Section 17 Churchrock Site, before "Prior Reclamation" status could be approved. These included the following:

1. Removal and burial of all concrete slabs and foundations that can be safely removed without affecting the structural integrity of the mine shafts or their steel and concrete covers.
2. Regrading of embankments around each pond.
3. Discing and reseeding of barren and disturbed areas.

This report will detail HRI's plan for each of the three items slated above.

Concrete Removal

The building and Hoist Foundation slabs will be broken up into small enough pieces to transport them to the No. 1 Pond for burial. This will be done by ripping with a dozer, lifting with a loader and cutting the reinforced steel with a torch. The anticipated quantity of material is tabulated below.

Buildings and Equipment Slabs

(L) x (W) x (H)
30' x 24' x 1/2' = 360 Cu. ft.
20' x 16' x 1/2' = 160
42' x 95' x 1/2' = 1,995
12' x 12' x 1/2' = 72
7' x 9' x 1/2' = 32
8' x 10' x 1/2' = 40
40' x 24' x 1/2' = 480
10' x 8' x 1/2' = 40
3' x 3' x 1/2' = 5
3' x 3' x 1/2' = 5
16' x 35' x 1/2' = 280
65' x 40' x 1/2' = 1,300
140' x 35' x 1/2' = 2,450
10' x 20' x 1/2' = 100
5' x 20' x 1/2' = 50
16' x 20' x 1/2' = 160
10' x 12' x 1/2' = 60
7,589 = 280 Cu.yds.

Hoist Foundations

(L) x (W) x (H)
10' x 20' x 3' = 600 Cu. ft.
16' x 32' x 4' = 2,048
16' x 35' x 3' = 1,680
4,328 Cu. yds.

As built drawing for the Hoist Foundations have not been located. Excavation will be done to determine the actual thickness, time, effort and cost to remove these slabs. If the equipment made available for this job is not adequate to break up and remove these slabs, they will be left in place. Provisions for drilling and blasting or for specialized concrete breaking equipment have not been made for this job because, doing so may threaten the integrity of the shafts. Removal of slabs will be limited to what can be removed with the equipment specified in this report.

The concrete that obviously extends above the ground at the shafts will be broken down to the level of the collar slabs.

The quantity of material from headframe slabs at the escape shaft will be calculated below:

$$(L) \times (W) \times (L)$$

$$38' \times 3' \times 4' = 456 \text{ Cu. ft.}$$

$$38' \times 3' \times 4' = 456 \text{ Cu. ft.}$$

$$(L) \times (W) \times (L)$$

$$45' \times 4' \times 1/2' = 90 \text{ Cu.ft.}$$

$$1,002 \text{ Cu. ft.} = 37 \text{ Cu. yds.}$$

The two slabs that comprise the shaft collars can not be removed without affecting the integrity of the two 10' diameter shafts and will be left intact. The quantity of concrete to be left in place is tabulated below.

Escape Shaft

$$68' \times 42' \times 2' = 5,712$$

Main Shaft

$$97' \times 55' \times 2' = \underline{10,670}$$

$$16,382 \text{ Cu. ft.} = 607 \text{ Cu. yds.}$$

Regrading Embankment of Five Existing Ponds

The berms surrounding each of the five ponds will be pushed into the ponds. There is not enough soil in the pond berms to fill the ponds so the soil will be pushed toward the center of the ponds leaving a gradual downgrade toward the center. This work will be done with the use of a dozer and a loader. A total of 17,000 cubic yards will be moved for this purpose. (See tabulation in Attachments.)

The scrap metal that was removed when the cement seals were poured on the two main shafts, one vent shaft (42" diameter) and one gravel hole (12" diameter) will be buried in the No. 1 pond with the concrete. An old metal water tank and several metal manholes will also be removed and buried.

Final grading of the site will be so that runoff ends up in an existing catch pond on the south side of the property.

Reseeding and Revegetation

The areas in the vicinity of the shafts that have not supported vegetation will be covered with soil borrowed from a berm that surrounds the ponds. These areas total 3-3/4 acres and will be covered with 6" of soil. A total of 3,000 cubic yards of soil will be moved for this purpose. This will be done with the use of loaders, belly dump trucks and a blade to spread the soil.

Reseeding of all disturbed areas will be done before the rainy season and will be done with a 50/50 mixture of Alkali sacation and western wheatgrass at the rate of 10# per acre.

The areas to be reseeded are:

Concrete Slab Removal	1/4 acre
Regrading of Ponds	12 acres
Areas covered with 6" of soil	<u>3-3/4</u> acres
	16 acres

The equipment that will be used will consist of:

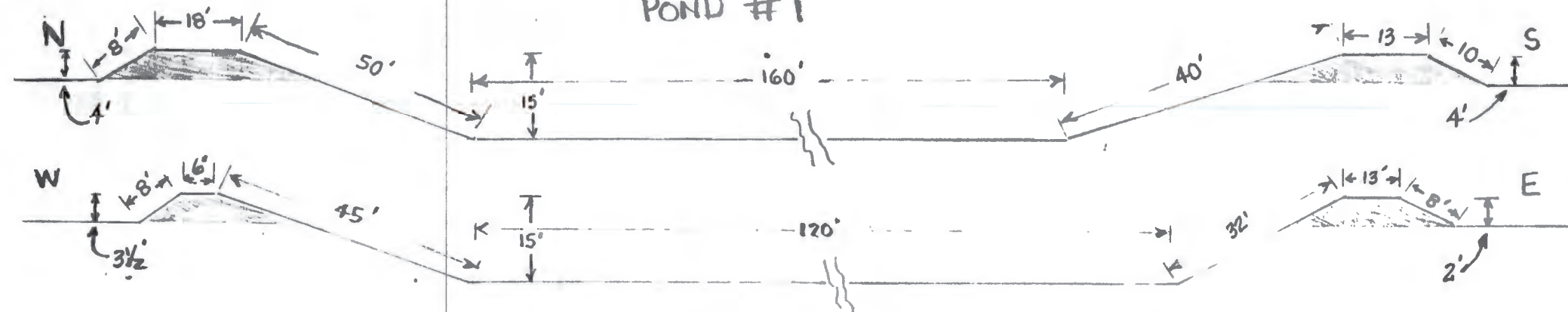
One CAT 980 Loader
6 yard bucket
Three Belly Dump Trucks 12-G Cat Blade
TD25G - (D-8 Equivalent) Dozer

There will be a total of 20,000 cubic yards of dirt moved and 478 cubic yards of cement will be broken, moved and buried. The job is expected to take 20 working days.

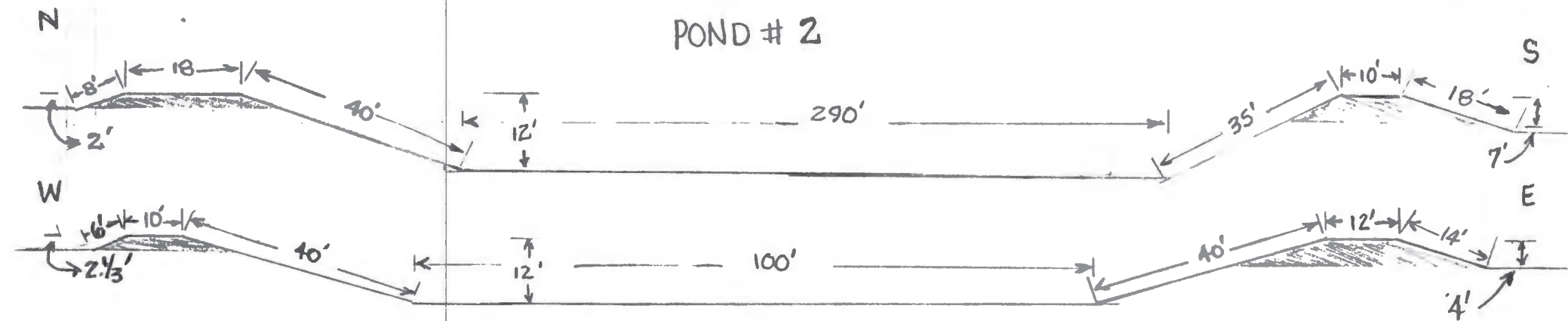
Attachment

Various Maps and Drawings

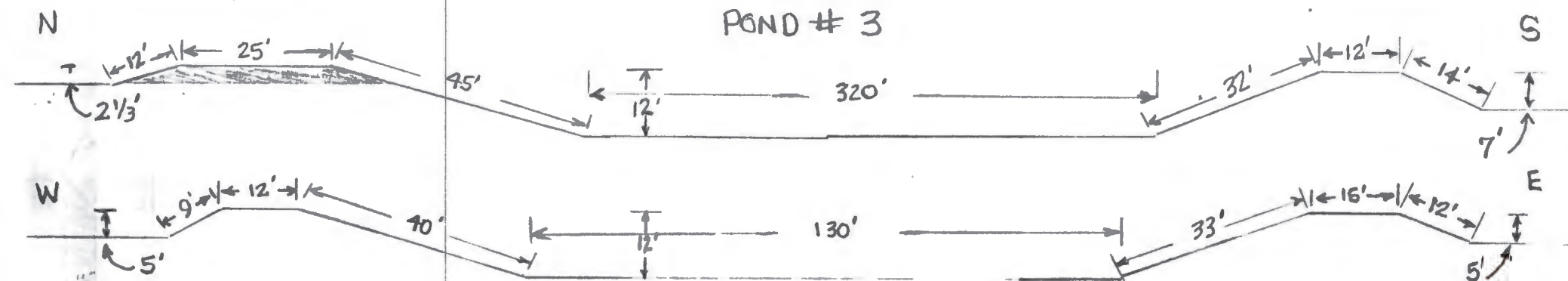
POND # 1

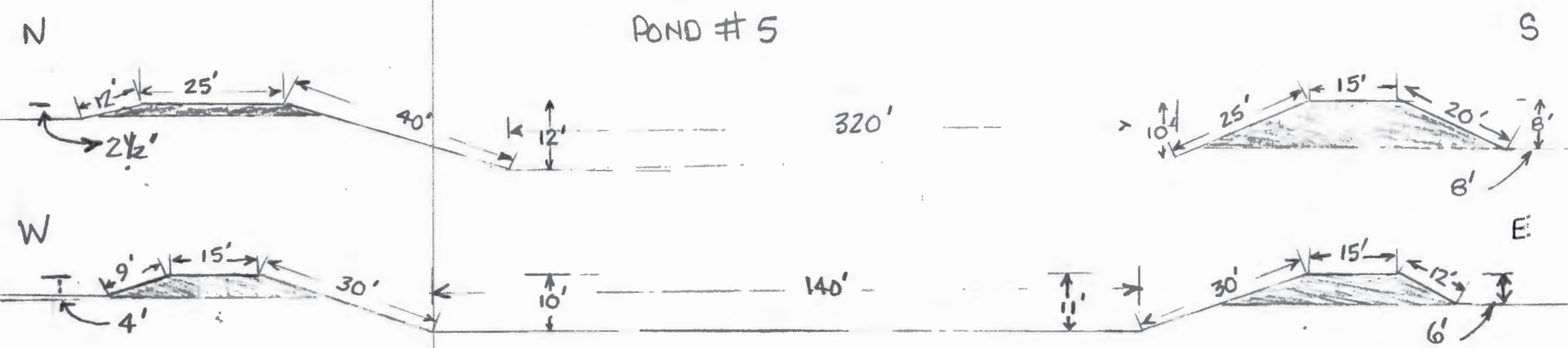
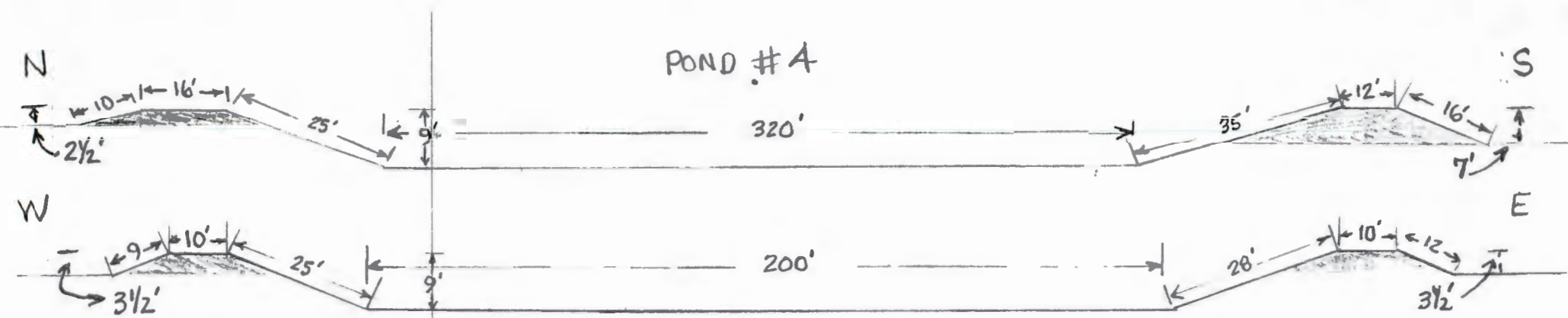


POND # 2



POND # 3





POND #1

N



$$\begin{aligned} 37 \times 4 &= 148 \\ \textcircled{A} \quad 11 \times 4 \times \frac{1}{2} &= < 22 > \\ \textcircled{B} \quad 7 \times 4 \times \frac{1}{2} &= < 14 > \\ \hline &112 \text{ sq ft} \end{aligned}$$

$$112 \times 120 = 13,440 \text{ cu ft}$$

S



$$\begin{aligned} 31 \times 4 &= 124 \\ \text{A} \quad 9 \times 4 \times \frac{1}{2} &= < 18 > \\ \text{B} \quad 8 \times 4 \times \frac{1}{2} &= < 16 > \\ \hline &90 \text{ sq ft} \end{aligned}$$

$$90 \times 120 = 10,800 \text{ cu ft}$$

W



$$\begin{aligned} 24 \times 3\frac{1}{2} &= 84 \\ \text{A} \quad 6 \times 3\frac{1}{2} \times \frac{1}{2} &= < 10 > \\ \text{B} \quad 10 \times 3\frac{1}{2} \times \frac{1}{2} &= < 17 > \\ \hline &57 \text{ sq ft} \end{aligned}$$

$$57 \times 160 = 9,120 \text{ cu ft}$$

E



$$\begin{aligned} 25 \times 2 &= 50 \\ \text{A} \quad 7 \times 2 \times \frac{1}{2} &= < 7 > \\ \text{B} \quad 4 \times 2 \times \frac{1}{2} &= < 4 > \\ \hline &39 \text{ sq ft} \end{aligned}$$

$$39 \times 160 = 6,240 \text{ cu ft}$$

10'

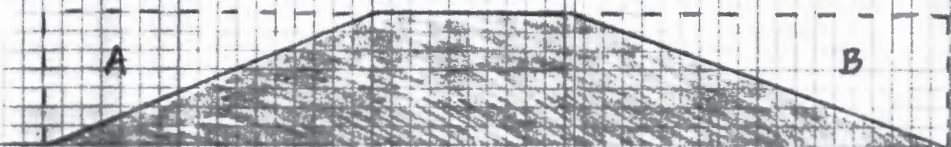
$$39,600 \div 27 = 1,467 \text{ cu yds}$$

POND. # 2



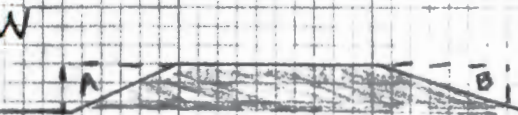
$$\begin{aligned} 32 \times 2 &= 64 \\ A \quad 8 \times 2 \times \frac{1}{2} &= < 8 > \\ B \quad 6 \times 2 \times \frac{1}{2} &= < 6 > \\ \hline &50 \text{ sq. ft} \end{aligned}$$

$$50 \times 100 = 5000 \text{ cu ft}$$



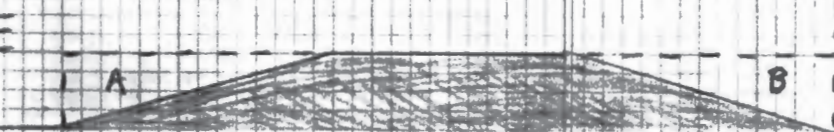
$$\begin{aligned} 47 \times 7 &= 329 \\ \textcircled{A} \quad 17 \times 7 \times \frac{1}{2} &= < 59 > \\ B \quad 20 \times 7 \times \frac{1}{2} &= < 70 > \\ \hline &200 \text{ sq. ft} \end{aligned}$$

$$200 \times 100 = 20,000 \text{ cu ft}$$



$$\begin{aligned} 23 \times 2\frac{1}{3} &= 54 \\ A \quad 6 \times 2\frac{1}{3} \times \frac{1}{2} &= < 7 > \\ B \quad 7 \times 2\frac{1}{3} \times \frac{1}{2} &= < 8 > \\ \hline &39 \text{ sq. ft} \end{aligned}$$

$$39 \times 290 = 11,310 \text{ cu ft}$$



$$\begin{aligned} 40 \times 4 &= 160 \\ A \quad 14 \times 4 \times \frac{1}{2} &= < 28 > \\ B \quad 14 \times 4 \times \frac{1}{2} &= < 28 > \\ \hline &104 \text{ sq. ft} \end{aligned}$$

$$104 \times 290 = 30,160 \text{ cu ft}$$

10'

$$66,470 \text{ sq. ft} \cdot 2462 \text{ cu yd}$$

POND # 3

47 x 2 1/3

110

A $12 \times 2 \frac{1}{3} \times \frac{1}{2} = < 14 >$

B $10 \times 2 \frac{1}{3} \times \frac{1}{2} = < 12 >$

84 sq. ft

84 x 130 = 10,920 cu ft

cu ft

42 x 7 = 294

A $13 \times 7 \times \frac{1}{2} = < 46 >$

B $17 \times 7 \times \frac{1}{2} = < 59 >$

189 sq. ft

189 x 130 = 24,570 cu ft

37 x 5 = 185

A $8 \times 5 \times \frac{1}{2} = < 20 >$

B $17 \times 5 \times \frac{1}{2} = < 42 >$

123 sq. ft

123 x 320 = 39,360 cu ft

39 x 5 = 195

A $11 \times 5 \times \frac{1}{2} = < 27 >$

B $13 \times 5 \times \frac{1}{2} = < 32 >$

136 sq. ft

136 x 320 = 43,520 cu ft

cu ft

10'

118,370.827 4384 cu yds

ROND # 4

N

A B

$$32 \times 2\frac{1}{2} = 80$$

$$A \ 10 \times 2\frac{1}{2} \times \frac{1}{2} = < 12 >$$

$$B \ 6 \times 2\frac{1}{2} \times \frac{1}{2} = < 8 >$$

$$60 \text{ sq. ft}$$

$$60 \times 200 = 12,000 \text{ cu. ft}$$

S

A

B

$$53 \times 7 = 371$$

$$A \ 15 \times 7 \times \frac{1}{2} = < 52 >$$

$$B \ 26 \times 7 \times \frac{1}{2} = < 91 >$$

$$228 \text{ sq. ft}$$

$$228 \times 200 = 45,600 \text{ cu. ft}$$

W

A

B

$$27 \times 3\frac{1}{2} = 95$$

$$A \ 8 \times 3\frac{1}{2} \times \frac{1}{2} = < 14 >$$

$$B \ 9 \times 3\frac{1}{2} \times \frac{1}{2} = < 16 >$$

$$65 \text{ sq. ft}$$

$$65 \times 320 = 20,800 \text{ cu. ft}$$

E

A

B

$$32 \times 3\frac{1}{2} = 112$$

$$A \ 12 \times 3\frac{1}{2} \times \frac{1}{2} = < 21 >$$

$$B \ 10 \times 3\frac{1}{2} \times \frac{1}{2} = < 17 >$$

$$74 \text{ cu. ft}$$

$$74 \times 320 = 23,680 \text{ cu. ft}$$

10'

$$102,000 \div 27 = 3781 \text{ cu. yds}$$

POND #5

$$\begin{aligned}
 &45 \times 2\frac{1}{2} = 113 \\
 &A \quad 12 \times 2\frac{1}{2} \times \frac{1}{2} = \langle 15 \rangle \\
 &B \quad 8 \times 2\frac{1}{2} \times \frac{1}{2} = \langle 10 \rangle \\
 &\quad \quad \quad \underline{88 \text{ sq. ft}}
 \end{aligned}$$

$$88 \times 140 = 12,320 \text{ cu. ft.}$$

$$\begin{aligned}
 &53 \times 8 = 424 \\
 &A \quad 19 \times 8 \times \frac{1}{2} = \langle 76 \rangle \\
 &B \quad 19 \times 9 \times \frac{1}{2} = \langle 76 \rangle \\
 &\quad \quad \quad \underline{272 \text{ sq. ft.}}
 \end{aligned}$$

$$272 \times 140 = 38,080 \text{ cu. ft.}$$

$$\begin{aligned}
 &34 \times 4 = 136 \\
 &A \quad 8 \times 4 \times \frac{1}{2} = \langle 16 \rangle \\
 &B \quad 11 \times 4 \times \frac{1}{2} = \langle 22 \rangle \\
 &\quad \quad \quad \underline{98 \text{ sq. ft.}}
 \end{aligned}$$

$$98 \times 320 = 31,360 \text{ cu. ft.}$$

$$\begin{aligned}
 &41 \times 6 = 246 \\
 &A \quad 11 \times 6 \times \frac{1}{2} = \langle 33 \rangle \\
 &B \quad 15 \times 6 \times \frac{1}{2} = \langle 45 \rangle \\
 &\quad \quad \quad \underline{168 \text{ sq. ft.}}
 \end{aligned}$$

$$168 \times 320 = 53,760 \text{ cu. ft.}$$

$$135,520 \div 27 = 5019 \text{ cu. yd.}$$

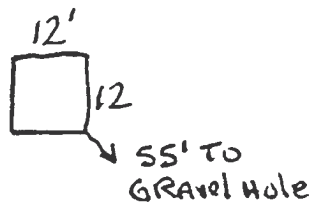
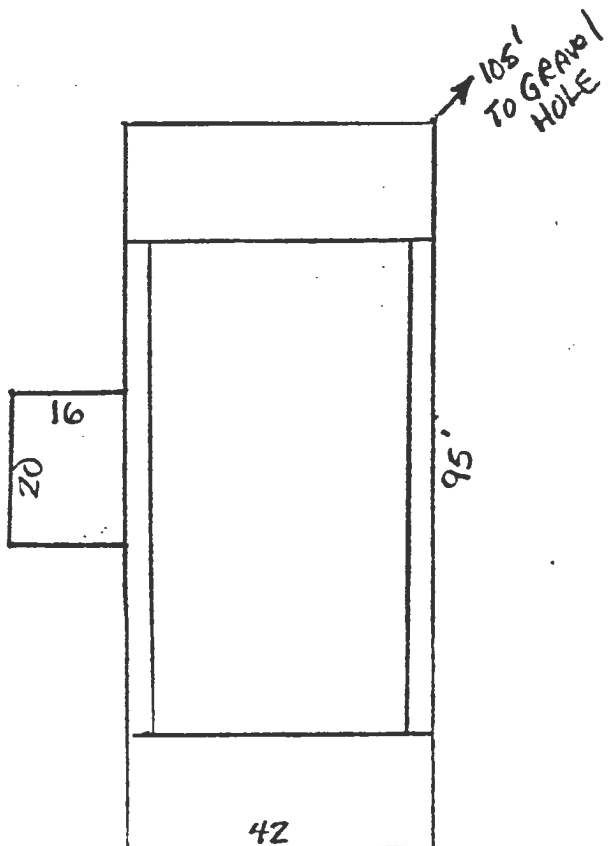
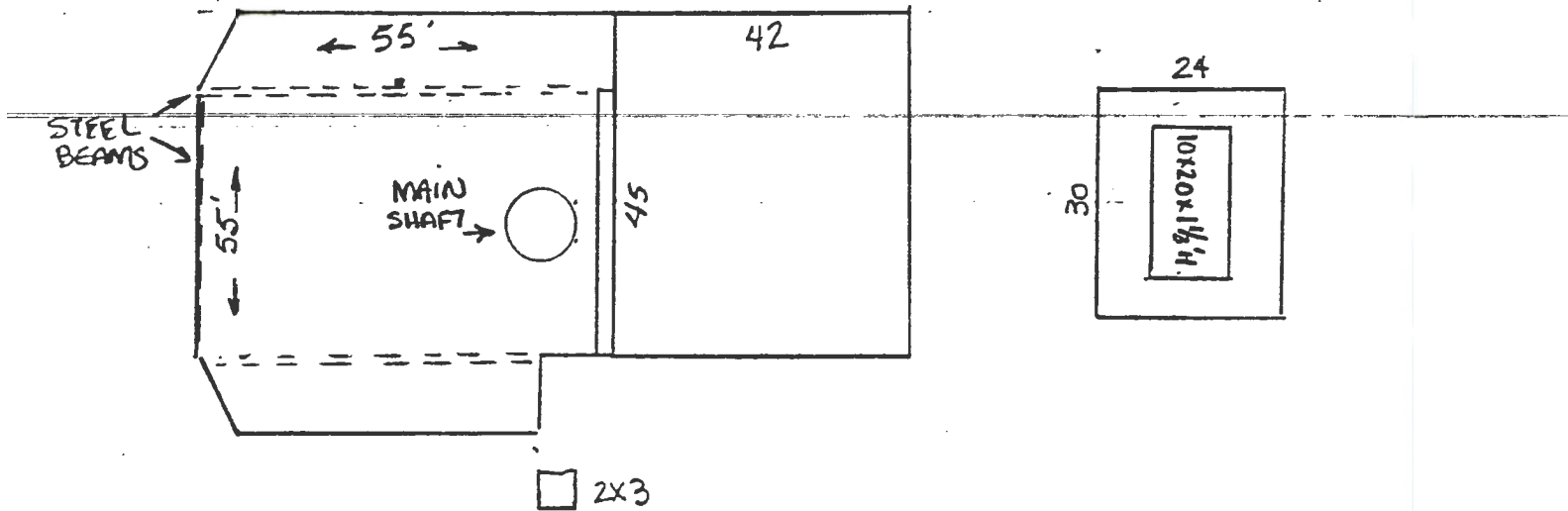
10'

CEMENT SLABS @ SEC 17 Churchrock

Salvador

12-1-94

Pg. 1-OF-3



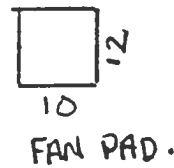
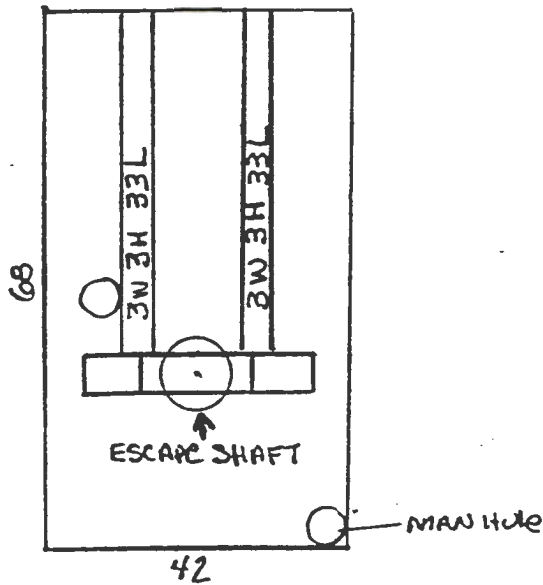
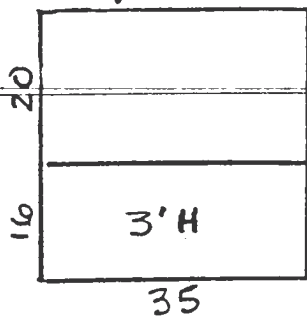
7'x9 SWITCHGEAR PAD

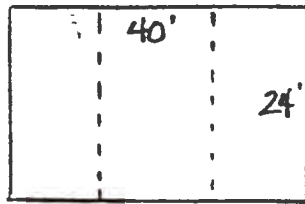
8'x10 SWITCHGEAR PAD

CEMENT SLABS @ SEC 17 Churchralc

Schulder

Pg 2 of 3

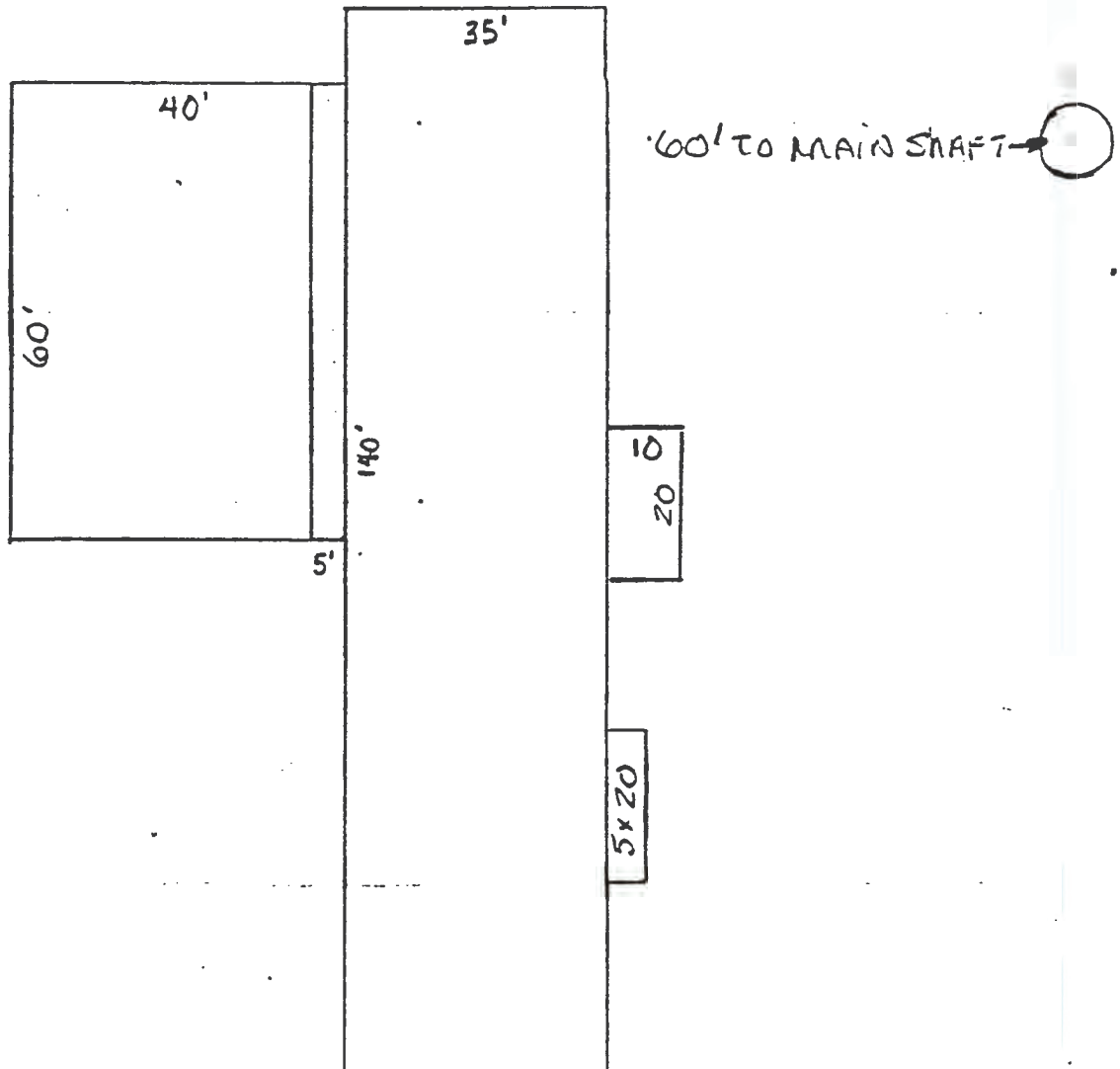
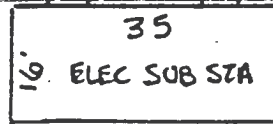
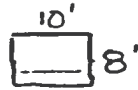




CEMENT SLABS
SEC 17 Churchville

Salvador
12-1-94

Pg 3 of 3



**ATTACHMENT I-2: 2013 INTERA INVESTIGATION SOIL BORING
LOCATIONS**

DRAFT 2013 PHASE II SITE CHARACTERIZATION REPORT

**Old Church Rock Mine
McKinley County, New Mexico**



Prepared for:

Uranium Resources, Inc.
5041 Indian School Rd. NE
Albuquerque, NM 87110

Prepared by:



INTERA Incorporated
6000 Uptown Boulevard, NE, Suite 220
Albuquerque, New Mexico 87110

August 20, 2013

APPENDIX D
Soil Boring Logs

Log of Boring SB-0-A

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): NA
 Bore Loc Background (cpm): 13165
 Total Depth (ft.): 16
 Total Depth Criterion: NA



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.2	SM	Silty SAND, poorly graded, fine-grained sand, non-plastic, loose, light brown, dry, no HCl reaction		1775	NA	
1					1821	NA	
					1669	NA	
2					1768	NA	
					1858	NA	
3	-		NA				
	-		NA				
4	-		NA				
	1817		NA				
5	2.7		Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, no HCl reaction		1776	NA	
					1688	NA	
6					1718	NA	
					1804	NA	
7					-	NA	
	-		NA				
8	-		NA				
	1786		NA				
9	2.7		Silty SAND, trace caliche, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, weak HCl reaction		1694	NA	
					1717	NA	
10					1681	NA	
					1763	NA	
11					-	NA	
	-		NA				
12	-		NA				
	1728		NA				
13	2.5		Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, no HCl reaction		1738	NA	
					1834	NA	
14					1822	NA	
					1815	NA	
15					-	NA	
	-		NA				
16	-		NA				

Notes:

Log of Boring SB-0-B

Date: 2/7/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): NA
 Bore Loc Background (cpm): 13165
 Total Depth (ft.): 16
 Total Depth Criterion: NA



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	SM	Silty SAND, poorly graded, fine-grained sand, non-plastic, loose, light brown, dry, no HCl reaction		2162	NA	
1					2146	NA	
2					2172	NA	
3					2159	NA	
4					2107	NA	
5					2152	NA	
6	3.3		Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, no HCl reaction		-	NA	
7					-	NA	
8					2135	NA	
9					2265	NA	
10					2032	NA	
11					2110	NA	
12	4		Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, no HCl reaction		2164	NA	
13					2121	NA	
14					2109	NA	
15					-	NA	
16					2024	NA	
17					2226	NA	
18	4		Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, no HCl reaction		2152	NA	
19					2017	NA	
20					2093	NA	
21					2046	NA	
22					2266	NA	
23					2025	NA	
24	4		Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, no HCl reaction		2062	NA	
25					2179	NA	
26					2085	NA	
27					2176	NA	
28					2106	NA	
29					2182	NA	
30	4		Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subround, non-plastic, loose, light brown, dry, no HCl reaction		2198	NA	
31					2122	NA	

Notes:

Log of Boring SB-0-C

Date: 2/7/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 2
 Logged By: L. Dalton
 SCAG Blank (cpm): NA
 Bore Loc Background (cpm): 13165
 Total Depth (ft.): 16
 Total Depth Criterion: NA



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	SM	Silty SAND, poorly graded, fine-grained sand, non-plastic, loose, light brown, dry, no HCl reaction		2496	NA	
1					2467	NA	
					2522	NA	
2					2507	NA	
					2403	NA	
3					2351	NA	
					2431	NA	
4	-		NA				
	2431		NA				
5	2458		NA				
	2238		NA				
6	2264		NA				
	2540		NA				
7	-		NA				
	-		NA				
8	-		NA				
	2380		NA				
9	2273		NA				
	2366		NA				
10	2317		NA				
	2250		NA				
11	2337		NA				
	2385		NA				
12	-		NA				
	2374		NA				
13	2287		NA				
	2361		NA				
14	2500		NA				
	2409		NA				
15	2493		NA				
	2434		NA				
16	-		NA				

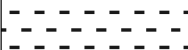
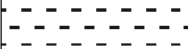
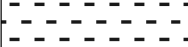
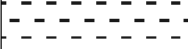
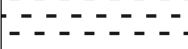
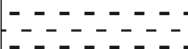
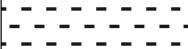
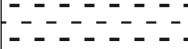



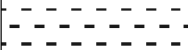
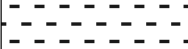



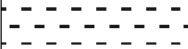
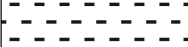




Notes:

Log of Boring SB-01

Date: 2/6/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1540
 Bore Loc Background (cpm): 10139
 Total Depth (ft.): 12
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.4	CL	Lean CLAY, trace fine-grained sand, medium plasticity, soft, light brown, dry, weak HCl reaction		1564	24	
1					1548	8	
					-		
2					-		
					-		
3					-		
					-		
4	2.3		Lean CLAY, trace fine-grained sand, medium plasticity, soft, light brown, dry, weak HCl reaction		1517	-23	
5					1512	-28	
					1597	57	
6					1674	134	
					-		
7					-		
					-		
8	2		Lean CLAY, trace fine-grained sand, medium plasticity, soft, light brown, dry, weak HCl reaction		1527	-13	
9					1534	-6	
					1488	-52	
10					1530	-10	
					-		
11					-		
					-		
12					-		

Notes:

Log of Boring SB-02

Date: 2/6/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1635
 Bore Loc Background (cpm): 13269
 Total Depth (ft.): 8
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.9	CL	Lean CLAY, fine-grained sand, low plasticity, soft, light brown, dry, weak HCl reaction		1623	-12	
0.4					1595	-40	
0.8					1589	-46	
1.2					1662	27	
1.6					-		
2					-		
2.4					-		
2.8					-		
3.2	-						
3.6	-						
4	2.5		Lean CLAY, trace fine-grained sand, medium plasticity, soft, light brown, dry, weak HCl reaction		1618	-17	
4.4					1704	69	
4.8					1625	-10	
5.2					1564	-71	
5.6					1594	-41	
6					-		
6.4		-					
6.8		-					
7.2	-						
7.6	-						

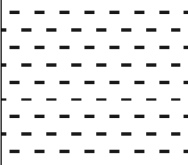
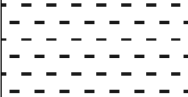
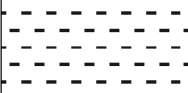
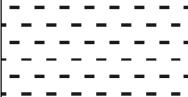
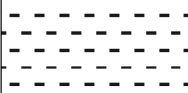
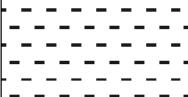
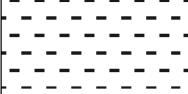
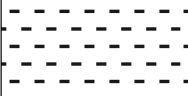
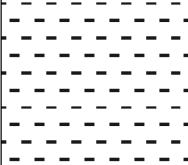
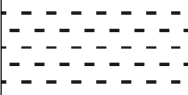
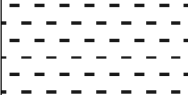
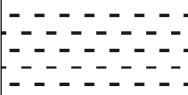
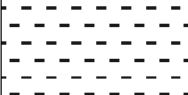


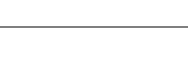
Notes:

Log of Boring SB-03

Date: 2/8/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): 1881
 Bore Loc Background (cpm): 12640
 Total Depth (ft.): 12
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	4	CL	Lean CLAY, few fine-grained sand, low plasticity, soft, brown, dry, weak HCl reaction		1909	28	15.1395
					1879	-2	14.7735
1					2033	152	16.6523
					2046	165	16.8109
2					1999	118	16.2375
					1989	108	16.1155
3					1935	54	15.4567
			1909	28	15.1395		
4	3.6		Lean CLAY, trace fine-grained sand, medium plasticity, firm, brown, dry, weak HCl reaction, trace fine white sand stringers		1877	-4	14.7491
					2023	142	16.5303
5					2040	159	16.7377
					2072	191	17.1281
6					2098	217	17.4453
					2016	135	16.4449
7					1974	93	15.9325
			-				
8	4		Lean CLAY, trace fine-grained sand, medium plasticity, hard, brown, dry, strong HCl reaction, trace fine white sand stringers		2152	271	18.1041
					1939	58	15.5055
9					2046	165	16.8109
					2028	147	16.5913
10					2022	141	16.5181
					2110	229	17.5917
11					2080	199	17.2257
			2113	232	17.6283		
12							

Notes:

Log of Boring SB-04

Date: 2/7/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): 2250
 Bore Loc Background (cpm): 16123
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.9	CL	Sandy CLAY, fine-grained sand, low plasticity, soft, brown, dry, strong HCl reaction		2266	16	14.9931
0.2					2373	123	16.2985
0.4					2698	448	20.2635
0.6					2276	26	15.1151
0.8					2189	-61	14.0537
1					2146	-104	13.5291
1.2					-		
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-05

Date: 2/8/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): 1980
 Bore Loc Background (cpm): 14839
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	4	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, brown, dry, weak HCl reaction, trace fine white sand stringers		2101	121	16.2741
0.4					2196	216	17.4331
0.8					2133	153	16.6645
1.2					2156	176	16.9451
1.6					2197	217	17.4453
2					2039	59	15.5177
2.4					2201	221	17.4941
2.8					2036	56	15.4811
3.2	3.3	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, brown, dry, strong HCl reaction, trace charcoal		2062	82	15.7983
3.6					2111	131	16.3961
4					2030	50	15.4079
4.4					2051	71	15.6641
4.8					2080	100	16.0179
5.2					2098	118	16.2375
5.6					-		
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-06

Date: 2/6/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1796
 Bore Loc Background (cpm): 13757
 Total Depth (ft.): 20
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.1	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, weak HCl reaction		1776	-20	
1					1889	93	
2					-		
3					-		
4					-		
5	1.5		Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, weak HCl reaction		1756	-40	
6					1824	28	
7					1887	91	
8					-		
9					-		
10	1.5		Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown and moderate gray, dry, weak HCl reaction		1835	39	
11					1808	12	
12					-		
13					-		
14					-		
15	2		Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown and moderate gray, dry, weak HCl reaction		1785	-11	
16					1858	62	
17					1922	126	
18					1865	69	
19					-		
20	2.8		Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown and moderate gray, dry, weak HCl reaction		-		
1					1798	2	
2					1818	22	
3					1821	25	
4					1771	-25	
5	2.8		Lean CLAY with Sand, fine-grained sand, low plasticity, firm, light brown, dry, strong HCl reaction		1744	-52	
6					-		
7					-		

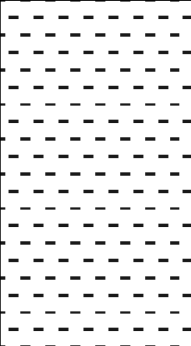
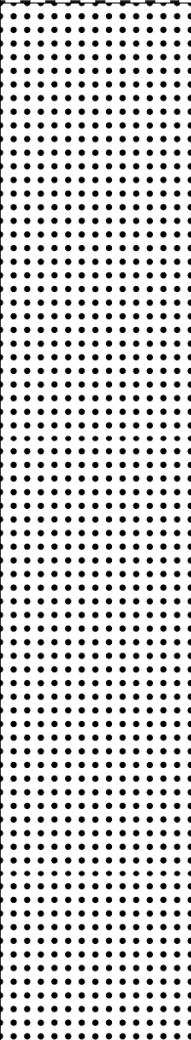
Notes:

Log of Boring SB-07

Date: 2/8/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): 2098
 Bore Loc Background (cpm): 14102
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	CL	Lean CLAY, trace fine-grained sand, low plasticity, soft, brown, dry, weak HCl reaction, roots		-		
0.2							
0.4		SW	Well Graded SAND, fine- to coarse-grained sand (predominantly fine to medium), subangular to subround, loose, light brown, dry, no HCl reaction, weakly cemented		2043	-55	14.1269
0.6							
0.8							
1							
1.2					2179	81	15.7861
1.4							
1.6							
1.8					2088	-10	14.6759
2							
2.2					1930	-168	12.7483
2.4							
2.6					1991	-107	13.4925
2.8							
3							
3.2					1964	-134	13.1631
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-08

Date: 2/6/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1953
 Bore Loc Background (cpm): 21926
 Total Depth (ft.): 24
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.6	ML	Clayey SILT, low plasticity, soft, brown, moist	.....	2087	134	
				.....	2460	507	
				.....	2113	160	
2		SP	Poorly Graded SAND, few silt, fine-grained sand, non-plastic, loose, light brown, dry, weak HCl reaction	.....	-	
				-		
				-		
4	1.2			.....	-	
				.....	2268	315	
				.....	2086	133	
				-		
6	0.7		Lean CLAY, few fine-grained sand, low to medium plasticity, soft, light brown, dry, strong HCl reaction	.....	-	
				-		
				-		
				-		
8	0.7			.....	-	
				.....	1985	32	
				-		
				-		
10	1.5		Lean CLAY, few fine-grained sand, low to medium plasticity, soft, light brown, dry, strong HCl reaction	.....	-	
				-		
				-		
				-		
12	1.5			.....	-	
				.....	1916	-37	
				.....	2000	47	
				.....	2013	60	
14	4		Lean CLAY, trace fine-grained sand, medium plasticity, soft, light brown, dry, weak HCl reaction	.....	-	
				-		
				-		
				-		
16	3.5			.....	-	217	
				.....	2170	129	
				.....	2082	163	
				.....	2116	252	
18	3.5		Lean CLAY, trace fine-grained sand, medium plasticity, soft, light brown, dry, weak HCl reaction	.....	2205	-23	
				.....	1930	11	
				.....	1964	86	
				.....	2039	132	
20	3.5			.....	2085	56	
				.....	2009	103	
				.....	2056	34	
				.....	1987	31	
22	3.5		Lean CLAY, trace fine-grained sand, medium plasticity, soft, light brown, dry, weak HCl reaction	.....	1984	31	
				.....	1984	-50	
				.....	1903	-11	
				.....	1942		
24				.....		

Notes:

Log of Boring SB-09

Date: 2/8/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): 2015
 Bore Loc Background (cpm): NM
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, brown, dry, weak HCl reaction		1999	-16	14.6027
0.2							
0.4		CL			1995	-20	14.5539
0.6							
0.8		CL			1862	-153	12.9313
1							
1.2		CL			1795	-220	12.1139
1.4							
1.6		CL			1968	-47	14.2245
1.8							
2	3.2	ML	SILT, trace fine-grained sand, low plasticity, soft, light brown, dry, strong HCl reaction		1839	-176	12.6507
2.2							
2.4		ML			-		
2.6							
2.8		ML			-		
3							
3.2		ML					
3.4							
3.6		ML					
3.8							

Notes:

Log of Boring SB-10

Date: 2/6/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1760
 Bore Loc Background (cpm): 12056
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction		1647	-113	
0.2							
0.4							
0.6							
0.8					1647	-113	
1							
1.2					-		
1.4							
1.6					-		
1.8							
2							
2.2					-		
2.4							
2.6					-		
2.8							
3					-		
3.2							
3.4					-		
3.6							
3.8					-		

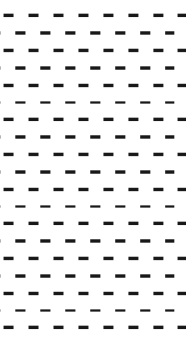
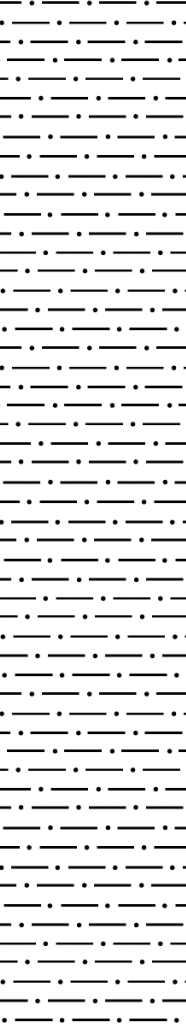
Notes:

Log of Boring SB-11

Date: 2/8/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): 1915
 Bore Loc Background (cpm): NM
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, brown, soft, dry, weak HCl reaction		1910	-5	14.7369
0.2					2004	89	15.8837
0.4							
0.6							
0.8		ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, weak HCl reaction, trace charcoal		1939	24	15.0907
1					1904	-11	14.6637
1.2							
1.4					1899	-16	14.6027
1.6							
1.8					1996	81	15.7861
2							
2.2					1817	-98	13.6023
2.4							
2.6					-		
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-12

Date: 2/6/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1756
 Bore Loc Background (cpm): 15144
 Total Depth (ft.): 8
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1	CL	Lean CLAY, few silt, trace fine-grained sand, low plasticity, soft, light brown, dry, no HCl reaction		1694	-62	
0.4					1923	167	
0.8					-		
1.2					-		
1.6					-		
2					-		
2.4					-		
2.8					-		
3.2	1.2	CL	Lean CLAY, trace silt, trace caliche, low plasticity, soft, light brown, dry, strong HCl reaction		-		
3.6					-		
4					1677	-79	
4.4					1687	-69	
4.8					-		
5.2					-		
5.6					-		
6					-		
6.4					-		
6.8					-		
7.2					-		
7.6					-		

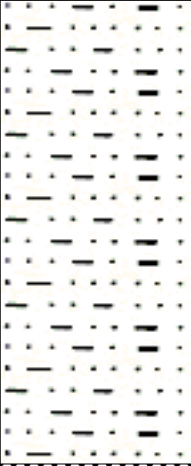
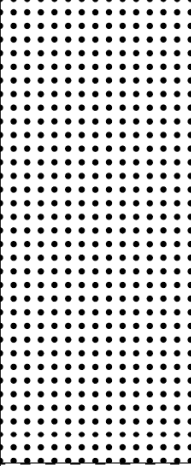
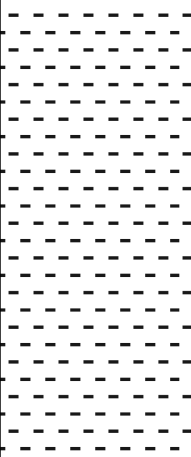
Notes:

Log of Boring SB-13

Date: 2/5/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 13290
 Total Depth (ft.): 12
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.4	SM	Silty SAND, poorly graded, fine-grained sand, non-plastic, loose, light brown, dry, strong HCl reaction		1537	-88	
					1584	-41	
1					-		
					-		
2					-		
					-		
3					-		
4	2.1	SW	Well Graded SAND, trace silt, fine- to coarse-grained sand (predominantly fine to medium), loose, light brown, dry, strong HCl reaction		1565	-60	
					1458	-167	
5					1518	-107	
					1523	-102	
6					-		
					-		
7					-		
8	0.8	CL	Lean CLAY, few fine-grained sand, medium plasticity, soft, olive-brown, dry, strong HCl reaction		1589	-36	
					1545	-80	
9					-		
					-		
10					-		
					-		
11					-		
12					-		

Notes:

Log of Boring SB-14

Date: 2/5/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 10405
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.4	SM	Silty SAND, poorly graded, fine to medium-grained sand, subangular to subround, non-plastic, loose, light brown, dry, strong HCl reaction				
0.2					1569	-56	
0.4							
0.6							
0.8					1556	-69	
1							
1.2					-		
1.4							
1.6					-		
1.8							
2							
2.2					-		
2.4							
2.6					-		
2.8							
3							
3.2					-		
3.4							
3.6					-		
3.8							

Notes:

Log of Boring SB-15

Date: 2/5/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 20308
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.5	ML	Sandy SILT, fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction		1688	63	
0.2							
0.4							
0.6							
0.8					1628	3	
1							
1.2					1531	-94	
1.4							
1.6							
1.8					-		
2							
2.2					-		
2.4							
2.6					-		
2.8							
3					-		
3.2							
3.4					-		
3.6							
3.8					-		






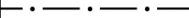



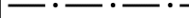
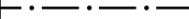




















Notes:

Log of Boring SB-16

Date: 2/5/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 12046
 Total Depth (ft.): 16
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.4	ML	Sandy SILT, fine-grained sand, low to medium plasticity, soft to firm, light brown, dry, no HCl reaction		1706	81	
1					1597	-28	
					1685	60	
2					-		
					-		
3			-				
			-				
4			1527	-98			
			-				
5	0.5		Sandy SILT, fine-grained sand, low to medium plasticity, hard, light brown, dry, strong HCl reaction, caliche, (Harder drilling ~3.5'-5')		1589	-36	
					-		
6					-		
					-		
7					-		
	0.6		Sandy SILT, fine-grained sand (increased %), low to medium plasticity, soft to firm, light brown, dry, strong HCl reaction, caliche (decreased %)		-		
8				-			
				-			
9				-			
				-			
10	0.8	SC	Sandy CLAY, fine-grained sand, medium plasticity, firm, brown, dry, strong HCl reaction		1624	-1	
					-		
11					-		
					-		
12					-		
	1.1	SM	Silty SAND, poorly graded, fine-grained sand, non-plastic, medium dense, light brown, dry, weak HCl reaction		1521	-104	
13					-		
					-		
14					-		
					-		
15					-		
16					-		

Notes:

Log of Boring SB-17

Date: 2/5/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 19119
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.4	ML	Sandy SILT, fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction		1625	0	
0.2							
0.4							
0.6							
0.8					1585	-40	
1							
1.2					-		
1.4							
1.6					-		
1.8							
2					-		
2.2							
2.4					-		
2.6							
2.8					-		
3							
3.2					-		
3.4							
3.6					-		
3.8							

Notes:

Log of Boring SB-18

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2024
 Bore Loc Background (cpm): 10360
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	SM	Moist Clay, Silt & Sand surface material		1922	-102	13.5535
0.2							
0.4		SM	Moist Clay, Silt & Sand surface material		1983	-41	14.2977
0.6							
0.8		SM	Moist Clay, Silt & Sand surface material		2069	45	15.3469
1							
1.2		SM	Moist Clay, Silt & Sand surface material		2135	111	16.1521
1.4							
1.6		SM	Moist Clay, Silt & Sand surface material		2085	61	15.5421
1.8							
2	3.2	SC	Clayey SAND, poorly graded, fine-grained sand, loose, light brown		2018	-6	14.7247
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-19

Date: 2/5/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 13898
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.3	ML	Sandy SILT, fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction		1686	61	
0.2							
0.4							
0.6							
0.8					1579	-46	
1							
1.2					-		
1.4							
1.6					-		
1.8							
2					-		
2.2							
2.4					-		
2.6							
2.8					-		
3							
3.2					-		
3.4							
3.6					-		
3.8							

Notes:

Log of Boring SB-20

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2146
 Bore Loc Background (cpm): 16281
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.8	SM	Moist Clay, Silt & Sand surface material		2195	49	15.3957
0.4					2200	54	15.4567
0.8					2073	-73	13.9073
1.2			Dry Clay, Silt & Sand surface material		2150	4	14.8467
1.6					2185	39	15.2737
2					2248	102	16.0423
2.4		CL	Lean CLAY with Caliche, medium plasticity, hard, tan and gray with white caliche streaks, dry, no HCl reaction (clay), strong HCl reaction (caliche)		2284	138	16.4815
2.8					-		
3.2							
3.6							
4	3.8	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, no HCl reaction		2325	179	16.9817
4.4					2334	188	17.0915
4.8					2220	74	15.7007
5.2					2327	181	17.0061
5.6					2270	124	16.3107
6					2185	39	15.2737
6.4					2198	52	15.4323
6.8					-		
7.2							
7.6							

Notes:

Log of Boring SB-21

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2569
 Bore Loc Background (cpm): 13359
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, strong HCl reaction		3082	513	21.0565
0.2							
0.4							
0.6							
0.8					2597	28	15.1395
1							
1.2					2466	-103	13.5413
1.4							
1.6							
1.8					2394	-175	12.6629
2	3.5	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, strong HCl reaction				
2.2					2384	-185	12.5409
2.4							
2.6							
2.8					2597	28	15.1395
3							
3.2					2439	-130	13.2119
3.4	3.5	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, strong HCl reaction				
3.6							
3.8					-		

Notes:

Log of Boring SB-22

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2173
 Bore Loc Background (cpm): 16966
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.9	SM	Moist Clay, Silt & Sand surface material		2011	-162	12.8215
0.2							
0.4		SP	Poorly Graded SAND with Silt, fine-grained sand, loose to medium dense, light brown, dry, no HCl reaction		1970	-203	12.3213
0.6							
0.8							
1							
1.2					2094	-79	13.8341
1.4							
1.6					1964	-209	12.2481
1.8							
2							
2.2					2010	-163	12.8093
2.4		SP	Poorly Graded SAND with Silt, fine-grained sand, loose to medium dense, light brown, dry, no HCl reaction				
2.6					2033	-140	13.0899
2.8							
3							
3.2					-		
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-23

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 12768
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.2	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction				
0.2					1601	-24	
0.4							
0.6							
0.8					1619	-6	
1							
1.2					-		
1.4							
1.6					-		
1.8							
2	1.2	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction				
2.2					-		
2.4							
2.6					-		
2.8							
3					-		
3.2							
3.4					-		
3.6	1.2	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction				
3.8					-		

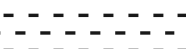
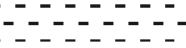

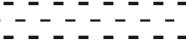


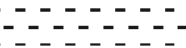















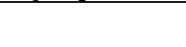
Notes:

Log of Boring SB-24

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2372
 Bore Loc Background (cpm): 12086
 Total Depth (ft.): 12
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.8	CL	Lean CLAY with Sand, fine-grained sand, low plasticity, firm, light brown, dry, weak HCl reaction		2407	35	15.2249
1					2394	22	15.0663
					2523	151	16.6401
2					2507	135	16.4449
					2527	155	16.6889
3					2639	267	18.0553
					2400	28	15.1395
4							-
5	3.3	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry		2360	-12	14.6515
					2446	74	15.7007
6					2378	6	14.8711
					2427	55	15.4689
7					2379	7	14.8833
					2410	38	15.2615
8					-		
					-		
9	3.7				2327	-45	14.2489
					2436	64	15.5787
10					2344	-28	14.4563
					2371	-1	14.7857
11					2341	-31	14.4197
					2476	104	16.0667
12					2482	110	16.1399
					-		

Notes:

Log of Boring SB-25

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2318
 Bore Loc Background (cpm): 14794
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SM	Moist Clay, Silt & Sand surface material		2734	416	19.8731
0.2					2401	83	15.8105
0.4					2286	-32	14.4075
0.6	3.5	SP	Poorly Graded SAND with Silt, fine-grained sand, medium dense, light brown, dry, weak HCl reaction		2310	-8	14.7003
0.8					2263	-55	14.1269
1					2342	24	15.0907
1.2					2277	-41	14.2977
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-26

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2648
 Bore Loc Background (cpm): 11817
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.6	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, no HCl reaction		2041	-607	7.3925
0.2					2167	-481	8.9297
0.4					2278	-370	10.2839
0.6					2376	-272	11.4795
0.8					2294	-354	10.4791
1					2172	-476	8.9907
1.2					2264	-384	10.1131
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-27

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2208
 Bore Loc Background (cpm): 17067
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0		SM	Moist Clay, Silt & Sand surface material		2308	100	16.0179
0.2							
0.4	3.4	SP	Poorly Graded SAND with Silt, fine-grained sand, low plasticity, very loose to loose, light brown, dry		2243	35	15.2249
0.6							
0.8							
1							
1.2					2277	69	15.6397
1.4							
1.6							
1.8					2357	149	16.6157
2							
2.2					2169	-39	14.3221
2.4							
2.6							
2.8					2286	78	15.7495
3							
3.2					2175	-33	14.3953
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-28

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 13918
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.3	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction				
0.2					1573	-52	
0.4							
0.6							
0.8					1606	-19	
1							
1.2					-		
1.4							
1.6					-		
1.8							
2	1.3	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction				
2.2					-		
2.4							
2.6					-		
2.8							
3					-		
3.2							
3.4					-		
3.6	1.3	CL	Lean CLAY, trace fine-grained sand, low to medium plasticity, soft, light brown, dry, no HCl reaction				
3.8					-		

Notes:

Log of Boring SB-29

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2546
 Bore Loc Background (cpm): 106174
 Total Depth (ft.): 8
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SM	Moist Clay, Silt & Sand surface material		7296	4750	72.7479
0.4					7977	5431	81.0561
0.8					3121	575	21.8129
1.2	3.6	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry		2755	209	17.3477
1.6					2561	15	14.9809
2					2593	47	15.3713
2.4					2600	54	15.4567
2.8					-		
3.2					2758	212	17.3843
3.6					2513	-33	14.3953
4					2531	-15	14.6149
4.4					2385	-161	12.8337
4.8					2436	-110	13.4559
5.2					2533	-13	14.6393
5.6					2478	-68	13.9683
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-30

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2306
 Bore Loc Background (cpm): 17701
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	SP	Poorly Graded SAND with Silt, fine-grained sand, very loose, light brown, dry, weak HCl reaction		2344	38	15.2615
0.2					2225	-81	13.8097
0.4					2367	61	15.5421
0.6					2294	-12	14.6515
0.8					2356	50	15.4079
1					2278	-28	14.4563
1.2					2235	-71	13.9317
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-31

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2380
 Bore Loc Background (cpm): 16770
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SP	Poorly Graded SAND with Silt, fine-grained sand, very loose, light brown, dry, no HCl reaction		2289	-91	13.6877
0.2					2332	-48	14.2123
0.4					2419	39	15.2737
0.6					2292	-88	13.7243
0.8					2216	-164	12.7971
1					2276	-104	13.5291
1.2					2374	-6	14.7247
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-32

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2208
 Bore Loc Background (cpm): 15314
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	SM	Moist Clay, Silt & Sand surface material		2094	-114	13.4071
0.2					2146	-62	14.0415
0.4					2301	93	15.9325
0.6					2215	7	14.8833
0.8	3.2	SP	Poorly Graded SAND with Silt, fine-grained sand, very loose-loose, light brown, dry		2275	67	15.6153
1					2018	-190	12.4799
1.2					-		
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-33

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 1936
 Bore Loc Background (cpm): NM
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3	CL	Lean CLAY, few fine-grained sand, medium plasticity, soft to firm, tan to light brown, dry		1996	60	15.5299
0.4					2112	176	16.9451
0.8					2219	283	18.2505
1.2					2050	114	16.1887
1.6					2050	114	16.1887
2					2052	116	16.2131
2.4					-		
2.8					-		
3.2	3.1	ML	SILT with Sand, low plasticity, soft to firm, light brown, dry		2078	142	16.5303
3.6					2175	239	17.7137
4					2127	191	17.1281
4.4					2128	192	17.1403
4.8					2123	187	17.0793
5.2					2089	153	16.6645
5.6					-		
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-34

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2212
 Bore Loc Background (cpm): 17747
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SM	Moist Clay, Silt & Sand surface material		2332	120	16.2619
0.2					2263	51	15.4201
0.4		SP	Poorly Graded SAND with Clay, few silt, fine-grained sand, low plasticity, medium dense, light brown, dry		2219	7	14.8833
0.6					2229	17	15.0053
0.8					2164	-48	14.2123
1					2240	28	15.1395
1.2					2201	-11	14.6637
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-35

Date: 2/15/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2212
 Bore Loc Background (cpm): 15291
 Total Depth (ft.): 8
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3	SP	Poorly Graded SAND with Silt, fine-grained sand, loose-medium dense, light brown, dry, weak HCl reaction		2196	-16	14.6027
0.4					2283	71	15.6641
0.8					2197	-15	14.6149
1.2					2300	88	15.8715
1.6					2281	69	15.6397
2					2322	110	16.1399
2.4					-		
2.8	3.5				-		
3.2					2228	16	14.9931
3.6					2371	159	16.7377
4					2302	90	15.8959
4.4					2217	5	14.8589
4.8					2251	39	15.2737
5.2					2202	-10	14.6759
5.6	2200				-12	14.6515	
6	-						
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-36

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3787
 Bore Loc Background (cpm): 19255
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.1	SM	Moist Clay, Silt & Sand surface material		3647	-140	13.0899
0.2					3569	-218	12.1383
0.4	3.1	SP	Poorly Graded SAND with Silt, fine-grained sand, medium dense, light brown, dry, weak HCl reaction		3693	-94	13.6511
0.6					3764	-23	14.5173
0.8					3848	61	15.5421
1					3753	-34	14.3831
1.2					-		
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-37

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 7065
 Bore Loc Background (cpm): 29214
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0		SM	Moist Clay, Silt & Sand surface material		7169	104	16.0667
0.2							
0.4	3.5	SP	Poorly Graded SAND with Silt, fine-grained sand, very loose to loose, light brown, dry		7187	122	16.2863
0.6							
0.8							
1							
1.2					6614	-451	9.2957
1.4							
1.6							
1.8					6775	-290	11.2599
2							
2.2							
2.4					6612	-453	9.2713
2.6							
2.8					6750	-315	10.9549
3							
3.2					6836	-229	12.0041
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-38

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 4466
 Bore Loc Background (cpm): 196780
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	CL	Moist Clayey surface material		9030	4564	70.4787
0.4					5293	827	24.8873
0.8					4779	313	18.6165
1.2	3.4	CL/M L	Lean CLAY with Sand and Silt, fine-grained sand, low plasticity, soft, light brown, dry		4736	270	18.0919
1.6					4507	41	15.2981
2					4649	183	17.0305
2.4					-		
2.8					-		
3.2					4652	186	17.0671
3.6					4560	94	15.9447
4					4383	-83	13.7853
4.4					4403	-63	14.0293
4.8					4402	-64	14.0171
5.2	3.5				4438	-28	14.4563
5.6					4564	98	15.9935
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-39

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2409
 Bore Loc Background (cpm): 12559
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.9	SM	Silty SAND, poorly graded, fine- to medium-grained sand, loose, light brown, dry		2443	34	15.2127
0.4					2389	-20	14.5539
0.8					2412	3	14.8345
1.2					2452	43	15.3225
1.6					2538	129	16.3717
2					2466	57	15.4933
2.4					-		
2.8					-		
3.2	3.2	CL	Lean CLAY with Sand, fine-grained sand, low plasticity, firm, light brown, dry		2406	-3	14.7613
3.6					2363	-46	14.2367
4					2445	36	15.2371
4.4					2411	2	14.8223
4.8					2437	28	15.1395
5.2					2457	48	15.3835
5.6					-		
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-40

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2079
 Bore Loc Background (cpm): 13622
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	SM	Silty SAND, poorly graded, fine-grained sand, medium dense, light brown, dry, some white caliche streaks		2128	49	15.3957
0.4					2273	194	17.1647
0.8					2260	181	17.0061
1.2					2146	67	15.6153
1.6					2192	113	16.1765
2					2226	147	16.5913
2.4					2152	73	15.6885
2.8					-		
3.2	3	SP	Poorly Graded SAND with Silt, fine-grained sand, medium dense, light brown, dry		2088	9	14.9077
3.6					2199	120	16.2619
4					2254	175	16.9329
4.4					2126	47	15.3713
4.8					2207	128	16.3595
5.2					2155	76	15.7251
5.6					-		
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-41

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 13670
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.8	CL	Lean CLAY, low to medium plasticity, soft, light brown, dry, no HCl reaction				
0.2					1515	-110	
0.4							
0.6							
0.8					1609	-16	
1							
1.2					1630	5	
1.4							
1.6					-		
1.8							
2							
2.2					-		
2.4							
2.6							
2.8					-		
3							
3.2					-		
3.4							
3.6							
3.8					-		

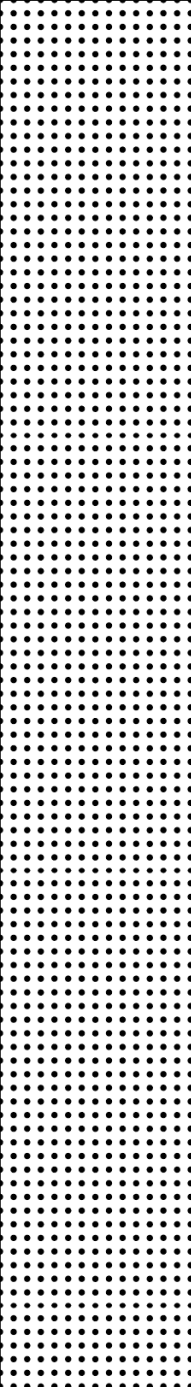
Notes:

Log of Boring SB-42

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2403
 Bore Loc Background (cpm): 14092
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3	SW	Well Graded SAND with Clay and Gravel, gravel = 3 centimeters, clay in discrete lumps & nodules, fine- to coarse-grained sand, loose, gray, brown & orange (iron staining), weak HCl reaction on gray sandstone clasts		2581	178	16.9695
0.2							
0.4							
0.6							
0.8					2434	31	15.1761
1							
1.2							
1.4					2488	85	15.8349
1.6							
1.8					2451	48	15.3835
2							
2.2					2429	26	15.1151
2.4							
2.6							
2.8					2345	-58	14.0903
3							
3.2					-		
3.4							
3.6					-		
3.8							

Notes:

Log of Boring SB-43

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3787
 Bore Loc Background (cpm): 89961
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SM	Moist Clay, Silt & Sand surface material		6557	2770	48.5919
0.2							
0.4		SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, no HCl reaction, gray calcareous sandstone in shoe		4793	1006	27.0711
0.6							
0.8							
1							
1.2					4140	353	19.1045
1.4							
1.6							
1.8					3666	-121	13.3217
2							
2.2					3837	50	15.4079
2.4							
2.6					3833	46	15.3591
2.8							
3							
3.2					3744	-43	14.2733
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-44

Date: 2/5/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 48947
 Total Depth (ft.): 8
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.9	ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, no HCl reaction	.....	2026	401	
0.4				.....		
0.8				.....	1781	156	
1.2				.....	1709	84	
1.6				.....	1527	-98	
2				.....	-	
2.4				.....	-	
2.8				.....	-	
3.2				.....	-	
3.6				.....	-	
4	0.7		Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, no HCl reaction	.....	-	
4.4				.....	-	
4.8				.....	-	
5.2				.....	-	
5.6				.....	-	
6				.....	-	
6.4				.....	-	
6.8				.....	-	
7.2		.....		-		
7.6		.....		-		

Notes:

Log of Boring SB-44RD

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 19991
 Bore Loc Background (cpm): 111358
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.8	SM	Rock fragments over light brown Silty SANDstone		19664	-327	10.8085
0.2					17836	-2155	-11.493 1
0.4							
0.6							
0.8							
1							
1.2							
1.4							
1.6							
1.8			Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, no HCl reaction		17041	-2950	-21.192 1
2					18329	-1662	-5.4785
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

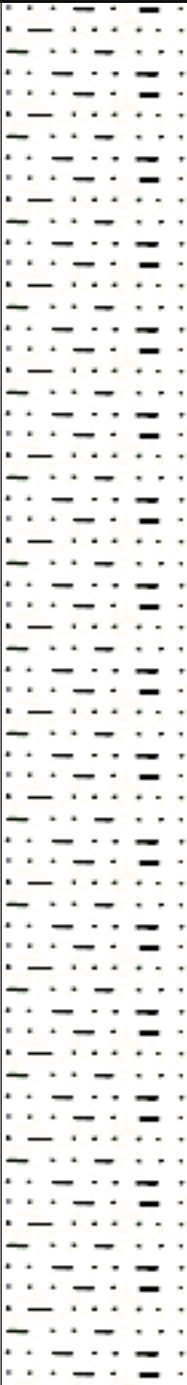
Notes:

Log of Boring SB-45

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 19941
 Bore Loc Background (cpm): 55452
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)	
0	3	SM	Moist Silt & Sand surface material		17742	-2199	-12.029 9	
0.2								
0.4								
0.6								
0.8					18353	-1588	-4.5757	
1			Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry					
1.2					18167	-1774	-6.8449	
1.4								
1.6								
1.8					17840	-2101	-10.834 3	
2								
2.2					18775	-1166	0.5727	
2.4								
2.6								
2.8					19437	-504	8.6491	
3								
3.2					-			
3.4								
3.6								
3.8					-			

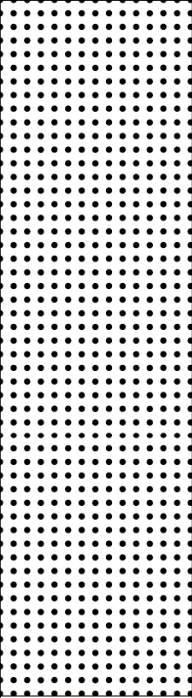
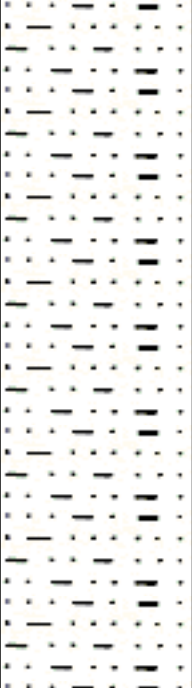
Notes:

Log of Boring SB-46

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3215
 Bore Loc Background (cpm): 23154
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.7	SW	Well Graded SAND, fine- to coarse-grained sand, 5% Dakota gravel <1.5 cm, loose, light brown, dry		3396	181	17.0061
0.4					3361	146	16.5791
0.8					3434	219	17.4697
1.2					3389	174	16.9207
1.6					3227	12	14.9443
2					3451	236	17.6771
2.4					-		
2.8					-		
3.2	2.8	SM	Silty SAND, poorly graded, fine-grained sand, medium dense, light brown, dry		3306	91	15.9081
3.6					3058	-157	12.8825
4					3096	-119	13.3461
4.4					3187	-28	14.4563
4.8					3283	68	15.6275
5.2					-		
5.6					-		
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-47

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2253
 Bore Loc Background (cpm): 13448
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SM	Moist Clay, Silt & Sand surface material		2314	61	15.5421
0.4					2192	-61	14.0537
0.8					2150	-103	13.5413
1.2	3.3	SM	Silty SAND, poorly graded, fine-grained sand, very loose to loose, light brown, dry		2124	-129	13.2241
1.6					2223	-30	14.4319
2					2279	26	15.1151
2.4					-		
2.8					-		
3.2							
3.6	3.3	SM	Silty SAND, poorly graded, fine-grained sand, medium dense, light brown, dry		2231	-22	14.5295
4					2342	89	15.8837
4.4					2284	31	15.1761
4.8					2234	-19	14.5661
5.2					2367	114	16.1887
5.6					2295	42	15.3103
6					-		
6.4					-		
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-48

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 12324
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.5	SM	Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subangular to subround, non-plastic, loose, light brown, dry, no HCl reaction		1532	-93	
0.2							
0.4							
0.6							
0.8					1593	-32	
1							
1.2							
1.4					1540	-85	
1.6							
1.8					-		
2							
2.2					-		
2.4							
2.6							
2.8					-		
3							
3.2					-		
3.4							
3.6							
3.8					-		

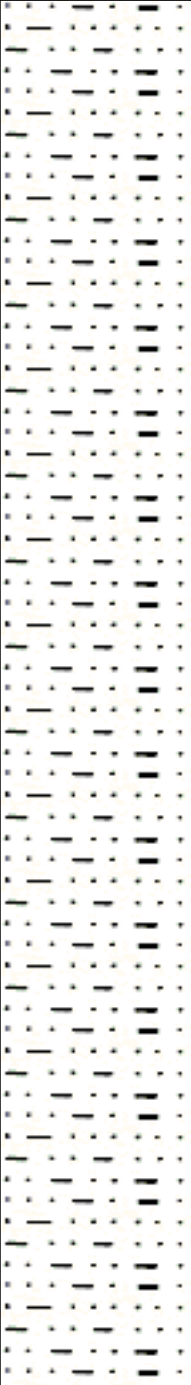
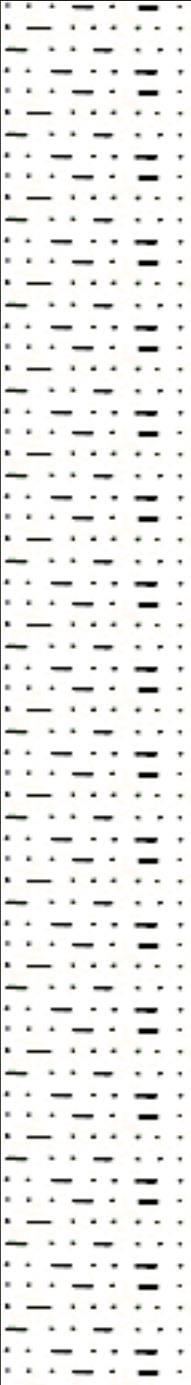
Notes:

Log of Boring SB-49

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2361
 Bore Loc Background (cpm): 15224
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3	SM	Silty SAND, few clay poorly graded, fine-grained sand, medium dense, light brown, dry, caliche streaks		2434	73	15.6885
0.2							
0.4							
0.6							
0.8					2508	147	16.5913
1							
1.2							
1.4					2477	116	16.2131
1.6							
1.8							
2					2375	14	14.9687
2.2					2560	199	17.2257
2.4							
2.6							
2.8					2287	-74	13.8951
3							
3.2					-		
3.4							
3.6							
3.8					-		

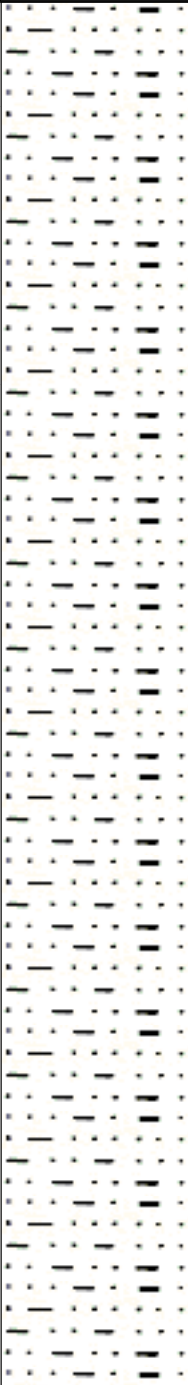
Notes:

Log of Boring SB-50

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3093
 Bore Loc Background (cpm): 13220
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)				
0	3.3	SM	Moist Clay, Silt & Sand surface material		2998	-95	13.6389				
0.2											
0.4					Silty SAND, iron stained	3210	117	16.2253			
0.6											
0.8					Moist Clay, Silt & Sand surface material	3064	-29	14.4441			
1											
1.2											
1.4											
1.6											
1.8											
2											
2.2											
2.4					Silty SAND, few clay, poorly graded, fine-grained sand, medium dense, light brown, dry, caliche streaks				2957	-136	13.1387
2.6											
2.8											
3											
3.2											
3.4											
3.6											
3.8											

Notes:

Log of Boring SB-51

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 118854
 Total Depth (ft.): 4
 Total Depth Criterion: Refusal



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2	ML	Sandy SILT, fine-grained sand, low plasticity, soft, light brown, dry, no HCl reaction				
0.2					2455	830	
0.4							
0.6							
0.8					2005	380	
1							
1.2					1837	212	
1.4							
1.6					1692	67	
1.8							
2							
2.2					-		
2.4							
2.6					-		
2.8							
3							
3.2					-		
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-51RD

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 19991
 Bore Loc Background (cpm): 135307
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.6	ML	SILT with Sand, no to low plasticity, soft, light brown, dry, strong HCl reaction				
0.2					20303	312	18.6043
0.4							
0.6							
0.8					18252	-1739	-6.4179
1							
1.2					18206	-1785	-6.9791
1.4							
1.6							
1.8					18292	-1699	-5.9299
2	3.6	ML	SILT with Sand, no to low plasticity, soft, light brown, dry, strong HCl reaction				
2.2					18650	-1341	-1.5623
2.4							
2.6							
2.8					19041	-950	3.2079
3							
3.2					17977	-2014	-9.7729
3.4							
3.6	3.6	ML	SILT with Sand, no to low plasticity, soft, light brown, dry, strong HCl reaction				
3.8					-		

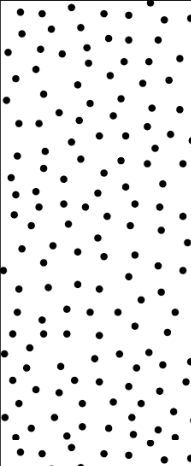
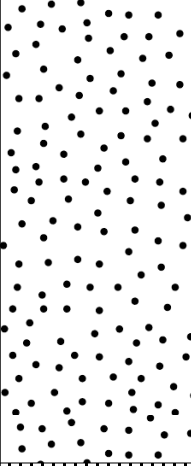
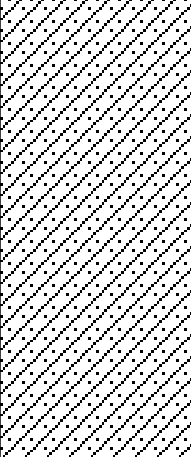
Notes:

Log of Boring SB-52

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 178348
 Total Depth (ft.): 12
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.6	SP	Poorly Graded SAND, fine-grained sand, loose, light brown, dry weak HCl reaction		4129	2504	
1					3837	2212	
2					2016	391	
3					-		
4					-		
5					-		
6	0.5	SP	Poorly Graded SAND, trace clay, fine-grained sand, non-plastic, medium dense, light brown, dry, weak HCl reaction		1665	40	
7					-		
8					-		
9					-		
10					-		
11					-		
12	0.8	SP-S C	Poorly Graded SAND with Clay, fine-grained sand, medium dense, non-plastic, light brown, dry to moist, weak HCl reaction		1557	-68	
					-		
					-		
					-		
					-		
					-		

Notes:

Log of Boring SB-52-R

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 178348
 Total Depth (ft.): 12
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	1.4	SP	Poorly Graded SAND, trace clay, fine-grained sand, non-plastic, loose, light brown, dry, weak HCl reaction		4912	3287	
1					5035	3410	
2					2553	928	
3					-		
4					-		
5					-		
6	1.4	SP	Poorly Graded SAND, few clay, fine-grained sand, non-plastic, loose, light brown, dry, weak HCl reaction		1683	58	
7					1628	3	
8					1600	-25	
9					-		
10					-		
11					-		
12	0.7	SP-S C	Poorly Graded SAND with Clay, fine-grained sand, medium dense, non-plastic, light brown, dry to moist, weak HCl reaction		1525	-100	
					-		
					-		
					-		
					-		
					-		

Notes:

Log of Boring SB-52RD

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 19991
 Bore Loc Background (cpm): 189692
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.8	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, no HCl reaction		22065	2074	40.1007
0.2							
0.4							
0.6							
0.8					23907	3916	62.5731
1							
1.2							
1.4					23924	3933	62.7805
1.6							
1.8					22762	2771	48.6041
2	3.8	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, no HCl reaction				
2.2					18446	-1545	-4.0511
2.4							
2.6							
2.8					18479	-1512	-3.6485
3							
3.2					18355	-1636	-5.1613
3.4							
3.6	3.8	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, no HCl reaction				
3.8					-		

Notes:

Log of Boring SB-53

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 19991
 Bore Loc Background (cpm): 77765
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, no HCl reaction				
0.2					21737	1746	36.0991
0.4							
0.6							
0.8					23316	3325	55.3629
1							
1.2							
1.4					23486	3495	57.4369
1.6							
1.8					22348	2357	43.5533
2	3.5	ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, no HCl reaction				
2.2					19520	-471	9.0517
2.4							
2.6							
2.8					19533	-458	9.2103
3							
3.2					18461	-1530	-3.8681
3.4							
3.6	3.5	ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, no HCl reaction				
3.8					-		


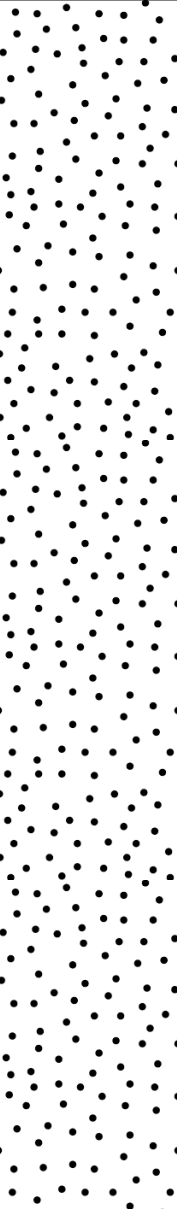
Notes:

Log of Boring SB-54

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3199
 Bore Loc Background (cpm): 16594
 Total Depth (ft.): 8
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SM	Moist Clay, Silt & Sand surface material		3515	316	18.6531
0.4					3253	54	15.4567
0.8		SP	Poorly Graded Sand, fine-grained sand, very loose to loose, light brown, dry		3381	182	17.0183
1.2					3369	170	16.8719
1.6					3469	270	18.0919
2					3347	148	16.6035
2.4					3220	21	15.0541
2.8					-		
3.2					3222	23	15.0785
3.6					3388	189	17.1037
4	3247				48	15.3835	
4.4	3423				224	17.5307	
4.8	3.3			3470	271	18.1041	
5.2				3453	254	17.8967	
5.6				3175	-24	14.5051	
6				-			
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-55

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2472
 Bore Loc Background (cpm): 13312
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SM	Moist Clay, Silt & Sand surface material		2408	-64	14.0171
0.2							
0.4							
0.6		SP	Poorly Graded SAND with Silt, fine-grained sand, very loose to loose, light brown, dry		2066	-406	9.8447
0.8							
1							
1.2					2107	-365	10.3449
1.4							
1.6							
1.8					2093	-379	10.1741
2							
2.2		SP	Poorly Graded SAND with Silt, fine-grained sand, very loose to loose, light brown, dry		2044	-428	9.5763
2.4							
2.6							
2.8					2172	-300	11.1379
3							
3.2					-		
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-56

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 14003
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.7	SM	Silty SAND, poorly graded, fine- to medium-grained sand (predominantly fine), subangular to subround, non-plastic, loose, light brown, dry, no HCl reaction		1646	21	
0.2							
0.4							
0.6							
0.8					1705	80	
1							
1.2					1711	86	
1.4							
1.6							
1.8					1793	168	
2					1645	20	
2.2							
2.4							
2.6							
2.8					-		
3							
3.2					-		
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-57

Date: 2/4/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/8
 Logged By: L. Dalton
 SCAG Blank (cpm): 1625
 Bore Loc Background (cpm): 12352
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.3	SM	Silty SAND with gravel, well graded, fine- to coarse-grained sand, fine gravel, subangular to subround, non-plastic, loose, light brown, dry, weak HCl reaction		1776	151	
0.2							
0.4							
0.6							
0.8					1749	124	
1							
1.2							
1.4					1806	181	
1.6							
1.8					1626	1	
2							
2.2					-		
2.4							
2.6							
2.8					-		
3							
3.2					-		
3.4							
3.6							
3.8					-		


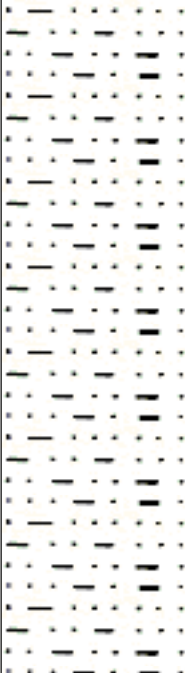
Notes:

Log of Boring SB-58

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2437
 Bore Loc Background (cpm): 15179
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)	
0	3	SM	Moist Clay, Silt & Sand surface material		2541	104	16.0667	
0.4					2712	275	18.1529	
0.8			Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, white caliche streaks		2572	135	16.4449	
1.2					2645	208	17.3355	
1.6					2635	198	17.2135	
2					2712	275	18.1529	
2.4					-			
2.8					-			
3.2					Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, white caliche streaks	2516	79	15.7617
3.6						2668	231	17.6161
4	2571	134	16.4327					
4.4	2582	145	16.5669					
4.8	2637	200	17.2379					
5.2	2574	137	16.4693					
5.6	-							
6	-							
6.4	3.2	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, white caliche streaks					
6.8								
7.2								
7.6								

Notes:

Log of Boring SB-59

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3425
 Bore Loc Background (cpm): NM
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.1	SW	Well Graded GRAVEL with Sand, trace silt and clay, fine- to coarse-grained sand, gravel = 4 centimeters, loose, gray, light brown & orange (iron staining), moist, weak HCl reaction		3425	0	14.7979
0.4					3493	68	15.6275
0.8					3525	100	16.0179
1.2					3562	137	16.4693
1.6					3687	262	17.9943
2					3726	301	18.4701
2.4					-		
2.8	2.7	CL	Lean CLAY, trace caliche, low plasticity, firm, brown, moist		-		
3.2					3530	105	16.0789
3.6					3699	274	18.1407
4					3705	280	18.2139
4.4					3467	42	15.3103
4.8					3713	288	18.3115
5.2					-		
5.6					-		
6					-		
6.4					-		
6.8					-		
7.2							
7.6							

Notes:

Log of Boring SB-60

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 15138
 Bore Loc Background (cpm): 174829
 Total Depth (ft.): 12
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SM	Moist Clay, Silt & Sand surface material		20130	4992	75.7003
1					21728	6590	95.1959
2		SP	Weathered gray sandstone - possible ore material		17378	2240	42.1259
3	3.1	ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, weak HCl reaction		16803	1665	35.1109
4					16400	1262	30.1943
5					15444	306	18.5311
6					17813	2675	47.4329
7					-		
8					17732	2594	46.4447
9					14914	-224	12.0651
10					15210	72	15.6763
11					15266	128	16.3595
12					15065	-73	13.9073
	3.6	CL	Lean CLAY, few fine-grained sand, medium plasticity, firm to hard, brown, dry to moist, white caliche streaks		16227	1089	28.0837
					-		
					-		
					16943	1805	36.8189
					14990	-148	12.9923
					14471	-667	6.6605
					14836	-302	11.1135
	3.6	CL	Lean CLAY, few fine-grained sand, medium plasticity, firm to hard, brown, dry to moist, white caliche streaks		15110	-28	14.4563
					13742	-1396	-2.2333
					14111	-1027	2.2685
					-		

Notes:

Log of Boring SB-61

Date: 2/7/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: L. Dalton
 SCAG Blank (cpm): 16578
 Bore Loc Background (cpm): NM
 Total Depth (ft.): 24
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	4	SP-S C	Poorly Graded SAND with Clay, fine- to coarse-grained sand (predominantly fine), subangular to subround, loose, non-plastic, light gray (some white color 0.8-1.5), moist to moist, no HCl reaction		21499		
					19342	2764	48.5187
					17762	1184	29.2427
2					16143	-435	9.4909
	3.7	ML	Sandy SILT, fine- to medium-grained sand (predominantly fine), non-plastic, soft, light brown, dry, weak HCl reaction		16271	-307	11.0525
					16751	173	16.9085
					16645	67	15.6153
4					17229		
					17200		
					16004	-574	7.7951
					16143	-435	9.4909
6					16238	-340	10.6499
	3.3	ML	Sandy SILT, fine- to medium-grained sand (predominantly fine), non-plastic, soft, light brown, dry, weak HCl reaction		16785	207	17.3233
					16518	-60	14.0659
8					17407		
					-		
					16953	-292	11.2355
					16286	-561	7.9537
10	3.4	SM	Silty SAND, poorly graded, fine-grained sand, non-plastic, loose, light brown, dry, strong HCl reaction		16017	227	17.5673
					16805	-1649	-5.3199
					14929		
					16575		
12					-		
	3.5	SM	Silty SAND, poorly graded, fine-grained sand, non-plastic, loose, light brown, dry, strong HCl reaction		16397	-557	8.0025
					16021	-1050	1.9879
14					15528	-1156	0.6947
					15422	-2169	-11.6639
					14409		
					16324		
16					-		
					-		
	3	SC	Clayey SAND, fine-grained sand, non-plastic, medium dense, light brown, dry to moist, strong HCl reaction		18909	-57	14.1025
					16521	-637	7.0265
18					15941	-729	5.9041
					15849	-912	3.6715
					15666	-1479	-3.2459
					15099		
20	3	SC	Clayey SAND, fine-grained sand, non-plastic, medium dense, light brown, dry to moist, strong HCl reaction		17181		
					-		
					17349	-307	11.0525
					16271	-268	11.5283
22					16310	-889	3.9521
					15689	-891	3.9277
	3	SC	Clayey SAND, fine-grained sand, non-plastic, medium dense, light brown, dry to moist, strong HCl reaction		15687	-19	14.5661
24					16559		

Notes:

Log of Boring SB-62

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 4366
 Bore Loc Background (cpm): 50571
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.8	SM	Moist Clay, Silt & Sand surface material		4681	315	18.6409
0.2							
0.4							
0.6							
0.8							
1							
1.2		ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry, weak HCl reaction, white caliche streaks		4175	-191	12.4677
1.4							
1.6					4105	-261	11.6137
1.8							
2					4069	-297	11.1745
2.2							
2.4					-		
2.6							
2.8					-		
3							
3.2	-						
3.4							
3.6	-						
3.8							

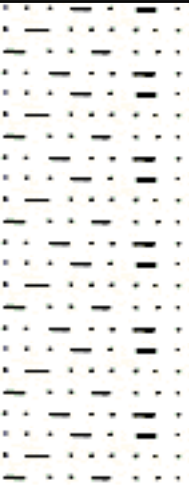
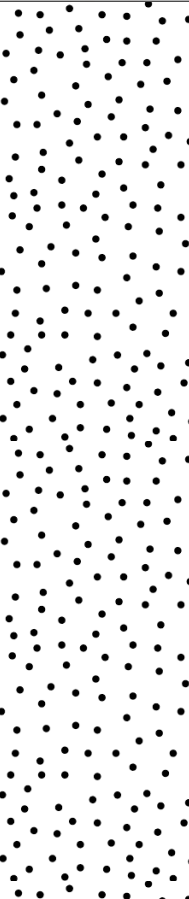
Notes:

Log of Boring SB-63

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2901
 Bore Loc Background (cpm): 19933
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)				
0	3.5	SM	Moist Clay, Silt & Sand surface material		2904	3	14.8345				
0.2											
0.4											
0.6		SP	Poorly Graded SAND with Silt, fine-grained sand, very loose to loose, light brown, dry		2695	-206	12.2847				
0.8											
1											
1.2					2531	-370	10.2839				
1.4											
1.6					2602	-299	11.1501				
1.8											
2											
2.2					2644	-257	11.6625				
2.4											
2.6									2648	-253	11.7113
2.8											
3											
3.2	2617	-284	11.3331								
3.4											
3.6					-						
3.8											

Notes:

Log of Boring SB-64

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2109
 Bore Loc Background (cpm): 12848
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.8	SP	Poorly Graded SAND with Silt, <5% gravel, <0.5 cm diameter, fine-grained sand, loose to medium dense, light brown		1809	-300	11.1379
0.2							
0.4							
0.6							
0.8					2013	-96	13.6267
1							
1.2							
1.4					2086	-23	14.5173
1.6							
1.8					1951	-158	12.8703
2							
2.2					2110	1	14.8101
2.4							
2.6							
2.8					-		
3							
3.2					-		
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-65

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2289
 Bore Loc Background (cpm): 12961
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	SM	Moist Clay, Silt & Sand surface material		2431	142	16.5303
0.4					2379	90	15.8959
0.8			Silty SAND, trace gravel, poorly graded, fine-grained sand, gravel = 1 centimeter, brown, loose, dry, white caliche streaks		2348	59	15.5177
1.2					2436	147	16.5913
1.6					2390	101	16.0301
2					2463	174	16.9207
2.4					-		
2.8					-		
3.2							
3.6	3.5	SM	Silty SAND, trace gravel, poorly graded, fine-grained sand, gravel = 1 centimeter, brown, loose, dry, white caliche streaks, rock in shoe		2345	56	15.4811
4					2451	162	16.7743
4.4					2500	211	17.3721
4.8					2293	4	14.8467
5.2					2493	204	17.2867
5.6					2496	207	17.3233
6					2408	119	16.2497
6.4					-		
6.8							
7.2							
7.6							

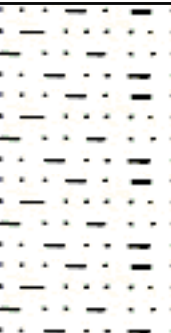

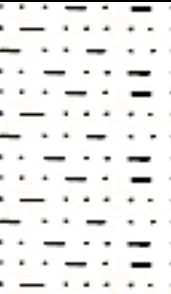




Notes:

Log of Boring SB-66

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2767
 Bore Loc Background (cpm): 107459
 Total Depth (ft.): 16
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.6	SM	Moist Clay, Silt & Sand surface material		5800	3033	51.8005
1					7685	4918	74.7975
					9499	6732	96.9283
2			Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry		9111	6344	92.1947
					8605	5838	86.0215
3					8751	5984	87.8027
					5912	3145	53.1669
4		-					
4	3.7	Slough	Slough		4955	2188	41.4915
5		SM	Silty SAND, poorly graded, fine-grained sand, <1% gravel 1/2 cm diameter, loose, light brown, dry, caliche streaks		3439	672	22.9963
					3141	374	19.3607
6					3063	296	18.4091
					3195	428	20.0195
7					3010	243	17.7625
					3054	287	18.2993
8		-					
8	3.7	Slough	Slough		4225	1458	32.5855
9		SM	Silty SAND, few clay, trace gravel, poorly graded, fine-grained sand, gravel = 0.5 centimeter, 5-10% clay, loose, light brown, dry, caliche streaks		3206	439	20.1537
					3071	304	18.5067
10					3185	418	19.8975
					2981	214	17.4087
11					3013	246	17.7991
					3066	299	18.4457
12		-					
12	3.5	Slough	Slough		4464	1697	35.5013
13		SM	Silty SAND, trace gravel, poorly graded, fine-grained sand, gravel = 0.5 centimeter, 5-10% clay, loose, light brown, dry, caliche streaks, minor iron staining		3213	446	20.2391
					3050	283	18.2505
14					2971	204	17.2867
					2998	231	17.6161
15					3115	348	19.0435
					3089	322	18.7263
16		-					

Notes:

Log of Boring SB-67

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3710
 Bore Loc Background (cpm): 17201
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SM	Moist Clay, Silt & Sand surface material		3695	-15	14.6149
0.2							
0.4							
0.6							
0.8							
1							
1.2							
1.4							
1.6							
1.8							
2	3.5	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, white caliche streaks		3643	-67	13.9805
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-68

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 7416
 Bore Loc Background (cpm): 92958
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.8	SM	Moist Clay, Silt & Sand surface material		8859	1443	32.4025
0.2					8395	979	26.7417
0.4					8475	1059	27.7177
0.6		ML	Sandy SILT, fine-grained sand, non-plastic, soft, light brown, dry		7809	393	19.5925
0.8					7630	214	17.4087
1					7426	10	14.9199
1.2					7376	-40	14.3099
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-69

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 7110
 Bore Loc Background (cpm): 46023
 Total Depth (ft.): 12
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.5	SM	Moist Clay, Silt & Sand surface material		7665	555	21.5689
1					7654	544	21.4347
2			Silty SAND, poorly graded, fine-grained sand, loose to very loose, light brown, dry, no HCl reaction		7520	410	19.7999
3					7433	323	18.7385
4					7503	393	19.5925
5					7613	503	20.9345
6					7549	439	20.1537
7					-		
8	3.4	ML	Sandy SILT, non-plastic, soft, light brown, dry		6943	-167	12.7605
9					6355	-755	5.5869
10					6950	-160	12.8459
11					6783	-327	10.8085
12					7073	-37	14.3465
13					7014	-96	13.6267
14					7405	295	18.3969
15					-		
16	2.6	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, white caliche streaks		7585	475	20.5929
17					7492	382	19.4583
18					7331	221	17.4941
19					7316	206	17.3111
20					7399	289	18.3237
21					-		
22					-		
23					-		

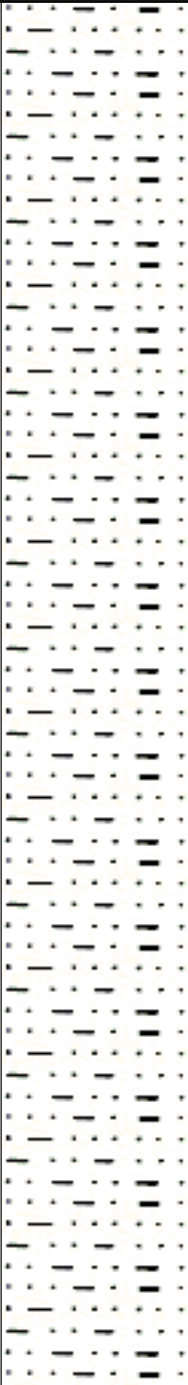
Notes:

Log of Boring SB-70

Date: 2/18/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 4366
 Bore Loc Background (cpm): 45686
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	SM	Moist Clay, Silt & Sand surface material		4908	542	21.4103
0.2							
0.4							
0.6			Silty SAND, poorly graded, loose, fine-grained sand, light brown, dry		3901	-465	9.1249
0.8							
1							
1.2					4070	-296	11.1867
1.4							
1.6							
1.8					3995	-371	10.2717
2							
2.2					3977	-389	10.0521
2.4							
2.6					3980	-386	10.0887
2.8							
3							
3.2							
3.4					3916	-450	9.3079
3.6							
3.8							

Notes:

Log of Boring SB-71

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2267
 Bore Loc Background (cpm): 16487
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0		SM	Moist Clay, Silt & Sand surface material		2301	34	15.2127
0.2					2243	-24	14.5051
0.4	3	SP	Poorly Graded SAND with Silt, fine-grained sand, loose to medium dense, light brown, dry		2368	101	16.0301
0.6					2320	53	15.4445
0.8					2268	1	14.8101
1					2246	-21	14.5417
1.2					-		
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-72

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 1960
 Bore Loc Background (cpm): 12389
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3	SM	Moist Clay, Silt & Sand surface material		1914	-46	14.2367
0.4					1969	9	14.9077
0.8					1928	-32	14.4075
1.2	3	SW	Well Graded SAND with Silt, fine- to coarse-grained sand, <5% gravel, <1 cm diameter, loose, light brown, some orange iron staining, dry		1942	-18	14.5783
1.6					1973	13	14.9565
2					1997	37	15.2493
2.4					-		
2.8					-		
3.2					1970	10	14.9199
3.6					2016	56	15.4811
4					2084	124	16.3107
4.4					2089	129	16.3717
4.8					2069	109	16.1277
5.2	3.3	SW	Well Graded SAND with Silt, fine- to coarse-grained sand, <5% gravel, <1 cm diameter, loose, light brown, some orange iron staining, dry		2043	83	15.8105
5.6					2060	100	16.0179
6					-		
6.4					-		
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-73

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2600
 Bore Loc Background (cpm): 13759
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	SM	Moist Clay, Silt & Sand surface material		2590	-10	14.6759
0.2							
0.4							
0.6		CL	Clay & Silt, dry, gray		2576	-24	14.5051
0.8							
1							
1.2					2531	-69	13.9561
1.4							
1.6		SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, no HCl reaction		2470	-130	13.2119
1.8							
2							
2.2					2573	-27	14.4685
2.4							
2.6					2725	125	16.3229
2.8							
3							
3.2					2572	-28	14.4563
3.4							
3.6							
3.8					-		

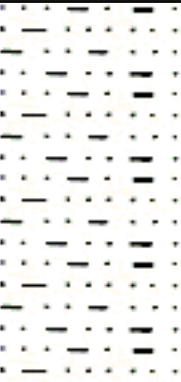
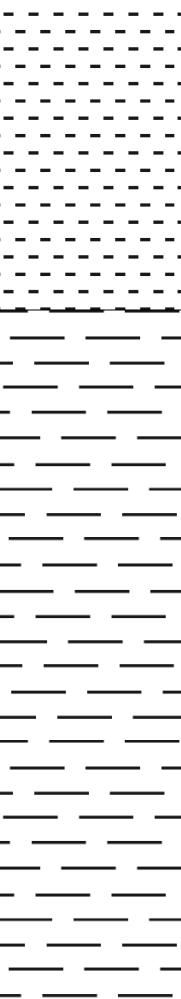
Notes:

Log of Boring SB-74

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2716
 Bore Loc Background (cpm): 17287
 Total Depth (ft.): 8
 Total Depth Criterion: Bedrock



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	SM	Moist Clay, Silt & Sand surface material		2760	44	15.3347
0.4					2841	125	16.3229
0.8			Silty SAND, light brown, dry		2810	94	15.9447
1.2					2822	106	16.0911
1.6		2708			-8	14.7003	
2		2981			265	18.0309	
2.4		CL	Sandy CLAY, fine-grained sand, low plasticity, medium dense, brown, dark gray, dry, weathered black shale fragments		-		
2.8					-		
3.2							
3.6							
4	3.5	Shale	Mancos SHALE, slightly weathered, dark gray, caliche, iron minerals, gypsum mineralized in fractures and partings		2553	-163	12.8093
4.4					2634	-82	13.7975
4.8					2802	86	15.8471
5.2					2834	118	16.2375
5.6					2793	77	15.7373
6					2849	133	16.4205
6.4					2648	-68	13.9683
6.8					-		
7.2							
7.6							

Notes:

Log of Boring SB-75

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3255
 Bore Loc Background (cpm): 21676
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	CL	Sandy CLAY, fine-grained sand, medium plasticity, dark brown, dry, strong HCl reaction		3217	-38	14.3343
0.2							
0.4							
0.6							
0.8					3105	-150	12.9679
1							
1.2							
1.4					3075	-180	12.6019
1.6							
1.8					3083	-172	12.6995
2	3.3	CL	Sandy CLAY, fine-grained sand, medium plasticity, dark brown, dry, strong HCl reaction				
2.2					3239	-16	14.6027
2.4							
2.6							
2.8					3186	-69	13.9561
3							
3.2					-		
3.4							
3.6	3.3	CL	Sandy CLAY, fine-grained sand, medium plasticity, dark brown, dry, strong HCl reaction				
3.8					-		

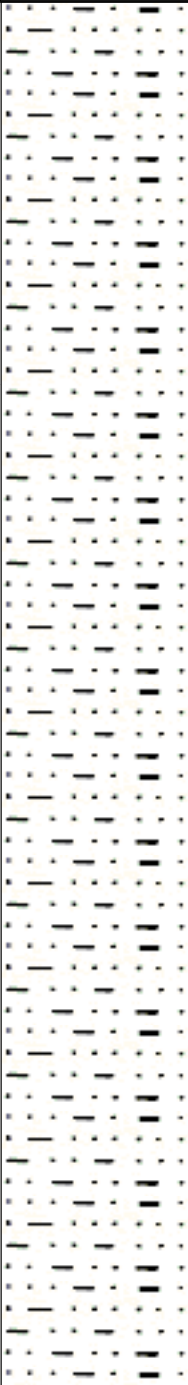
Notes:

Log of Boring SB-76

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3660
 Bore Loc Background (cpm): 23509
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3	SM	Moist Clay, Silt & Sand surface material		3606	-54	14.1391
0.2							
0.4							
0.6							
0.8							
1							
1.2			Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry		3564	-96	13.6267
1.4							
1.6							
1.8					3545	-115	13.3949
2							
2.2					3683	23	15.0785
2.4							
2.6							
2.8					3562	-98	13.6023
3							
3.2					-		
3.4							
3.6					-		
3.8							

Notes:

Log of Boring SB-77

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 3188
 Bore Loc Background (cpm): 29845
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry		3636	448	20.2635
0.2							
0.4							
0.6							
0.8					3374	186	17.0671
1							
1.2							
1.4					3166	-22	14.5295
1.6	3.3	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry				
1.8					3142	-46	14.2367
2							
2.2					3176	-12	14.6515
2.4							
2.6							
2.8					3036	-152	12.9435
3							
3.2	3.3	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry		-		
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-78

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2352
 Bore Loc Background (cpm): 19009
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.8	SM	Moist Clay, Silt & Sand surface material		2501	149	16.6157
0.4					2428	76	15.7251
0.8					2451	99	16.0057
1.2	3	SP	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, weak HCl reaction		2536	184	17.0427
1.6					2451	99	16.0057
2					-		
2.4					-		
2.8					-		
3.2					2343	-9	14.6881
3.6					2343	-9	14.6881
4					2313	-39	14.3221
4.4					2446	94	15.9447
4.8					2505	153	16.6645
5.2	3	SP	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, weak HCl reaction		2516	164	16.7987
5.6					-		
6					-		
6.4	3	SP	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, weak HCl reaction		-		
6.8					-		
7.2	3	SP	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, weak HCl reaction		-		
7.6					-		

Notes:

Log of Boring SB-79

Date: 2/14/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 1963
 Bore Loc Background (cpm): 13022
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SM	Moist Clay, Silt & Sand surface material		2138	175	16.9329
0.4					2083	120	16.2619
0.8					1956	-7	14.7125
1.2		SP	Poorly Graded SAND with Silt, fine-grained sand, very loose to loose, light brown, dry		1909	-54	14.1391
1.6					2050	87	15.8593
2					2053	90	15.8959
2.4					-		
2.8					-		
3.2							
3.6							
4	3.2	SW	Well Graded SAND with Silt, fine- to coarse-grained sand, Light brown, gray & orange (heterogeneous & mottled), dry, crushed limestone in shoe		1918	-45	14.2489
4.4					2011	48	15.3835
4.8					1962	-1	14.7857
5.2					2060	97	15.9813
5.6					1995	32	15.1883
6					1981	18	15.0175
6.4					-		
6.8					-		
7.2							
7.6							

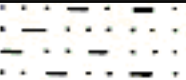
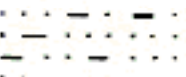
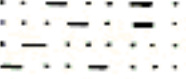
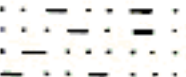
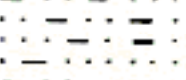
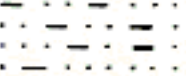
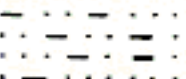
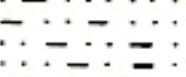
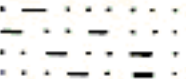
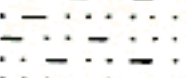
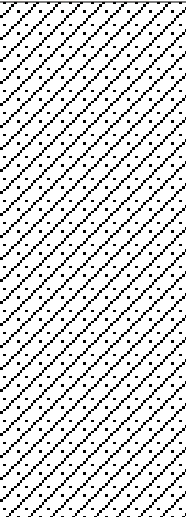
Notes:

Log of Boring SB-80

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2303
 Bore Loc Background (cpm): 15290
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.6	SM	Moist Clay, Silt & Sand surface material		2362	59	15.5177
0.4			Silty SAND, trace caliche, poorly graded, fine-grained sand, 30% clay/silt, loose, light brown, dry		2467	164	16.7987
0.8					2573	270	18.0919
1.2					2540	237	17.6893
1.6					2565	262	17.9943
2					2451	148	16.6035
2.4					2444	141	16.5181
2.8					-		
3.2					2460	157	16.7133
3.6					2464	161	16.7621
4	3.3	SC/C L	Clayey SAND/Sandy CLAY, trace caliche, poorly graded, fine-grained sand, medium dense, dark brown, low to medium plasticity		2359	56	15.4811
4.4					2412	109	16.1277
4.8					2434	131	16.3961
5.2					2433	130	16.3839
5.6					-		
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-81

Date: 2/17/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2415
 Bore Loc Background (cpm): 14199
 Total Depth (ft.): 8
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SM	Moist Clay, Silt & Sand surface material		2437	22	15.0663
0.4					2442	27	15.1273
0.8		CL	Sandy CLAY, fine-grained sand, medium dense, dark brown, dry, strong HCl reaction, caliche		2352	-63	14.0293
1.2					2428	13	14.9565
1.6					2490	75	15.7129
2					2436	21	15.0541
2.4					2484	69	15.6397
2.8					-		
3.2	3	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry		2474	59	15.5177
3.6					2438	23	15.0785
4					2433	18	15.0175
4.4					2414	-1	14.7857
4.8					2375	-40	14.3099
5.2					2518	103	16.0545
5.6					-		
6					-		
6.4							
6.8							
7.2							
7.6							

Notes:

Log of Boring SB-85

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2334
 Bore Loc Background (cpm): 15928
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.8	SM	Silty SAND, poorly graded, fine-grained sand, very loose, light brown, dry, weak HCl reaction		2323	-11	14.6637
0.2							
0.4							
0.6					2462	128	16.3595
0.8							
1							
1.2					2356	22	15.0663
1.4							
1.6							
1.8					2355	21	15.0541
2							
2.2							
2.4					2405	71	15.6641
2.6							
2.8							
3					2333	-1	14.7857
3.2							
3.4							
3.6					2322	-12	14.6515
3.8							

Notes:

Log of Boring SB-86

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2208
 Bore Loc Background (cpm): NM
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, weak HCl reaction		2177	-31	14.4197
0.2							
0.4							
0.6							
0.8					2195	-13	14.6393
1							
1.2							
1.4					2139	-69	13.9561
1.6							
1.8					2141	-67	13.9805
2	3.2	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, weak HCl reaction				
2.2					2174	-34	14.3831
2.4							
2.6							
2.8					2170	-38	14.3343
3							
3.2					2160	-48	14.2123
3.4							
3.6	3.2	SM	Silty SAND, poorly graded, fine-grained sand, loose, light brown, dry, weak HCl reaction				
3.8					-		

Notes:

Log of Boring SB-91

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2497
 Bore Loc Background (cpm): 17763
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0		SM	Moist Clay, Silt & Sand surface material		2697	200	17.2379
0.2							
0.4	3.4	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, weak HCl reaction		2581	84	15.8227
0.6							
0.8							
1							
1.2					2421	-76	13.8707
1.4							
1.6							
1.8					2489	-8	14.7003
2							
2.2					2503	6	14.8711
2.4							
2.6							
2.8					2488	-9	14.6881
3							
3.2					2463	-34	14.3831
3.4							
3.6							
3.8					-		

Notes:

Log of Boring SB-92

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2494
 Bore Loc Background (cpm): 17566
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.4	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, no HCl reaction		2662	168	16.8475
0.2					2562	68	15.6275
0.4					2574	80	15.7739
0.6					2463	-31	14.4197
0.8					2405	-89	13.7121
1					2451	-43	14.2733
1.2					2458	-36	14.3587
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-93

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2228
 Bore Loc Background (cpm): 15290
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SM	Moist Clay, Silt & Sand surface material		2146	-82	13.7975
0.2					2187	-41	14.2977
0.4	3.3	SP	Poorly Graded SAND with Silt, fine-grained sand, loose, light brown, dry, no HCl reaction		2085	-143	13.0533
0.6					2117	-111	13.4437
0.8					2212	-16	14.6027
1					2190	-38	14.3343
1.2					-		
1.4					-		
1.6							
1.8							
2							
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6							
3.8							

Notes:

Log of Boring SB-97

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 2464
 Bore Loc Background (cpm): 15084
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.3	SC	Clayey SAND, poorly graded, fine-grained sand, low plasticity, medium dense, light brown, dry, no HCl reaction		2413	-51	14.1757
0.2					2444	-20	14.5539
0.4					2462	-2	14.7735
0.6					2407	-57	14.1025
0.8					2319	-145	13.0289
1					2264	-200	12.3579
1.2					-		
1.4					-		
1.6							
1.8							
2	3.3	SC	Clayey SAND, poorly graded, fine-grained sand, low plasticity, medium dense, light brown, dry, no HCl reaction				
2.2							
2.4							
2.6							
2.8							
3							
3.2							
3.4							
3.6	3.3	SC	Clayey SAND, poorly graded, fine-grained sand, low plasticity, medium dense, light brown, dry, no HCl reaction				
3.8							

Notes:

Log of Boring SB-102

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 1730
 Bore Loc Background (cpm): 9365
 Total Depth (ft.): 12
 Total Depth Criterion: Stability



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	2.5	SM	Moist Clay, Silt & Sand surface material, iron staining visible throughout core		1700	-30	14.4319
1					1789	59	15.5177
2					1723	-7	14.7125
3					1767	37	15.2493
4					1819	89	15.8837
5	3.5	CH	Fat CLAY, trace caliche, high plasticity, firm, brown, moist, packed clay in shoe		-		
6					-		
7					-		
8		SM	Moist Clay, Silt & Sand material, iron staining visible throughout core		1768	38	15.2615
9					1915	185	17.0549
10	3.4	CH	Fat CLAY, brown, moist		1872	142	16.5303
11					1815	85	15.8349
12		SP	Poorly Graded SAND with Silt, fine-grained sand, loose, orange, light brown, moist, no HCl reaction		1804	74	15.7007
13					1796	66	15.6031
14					1970	240	17.7259
15	3.4	CL	Lean CLAY, brown, moist		-		
16					1765	35	15.2249
17					1862	132	16.4083
18		SC	Clayey SAND, light brown, orange, iron stained		1771	41	15.2981
19					1866	136	16.4571
20	3.4	SC	Clayey SAND, poorly graded, fine-grained sand, medium dense, light brown, moist, no HCl reaction		1796	66	15.6031
21					1908	178	16.9695
22					1889	159	16.7377
23	3.4	SC	Clayey SAND, poorly graded, fine-grained sand, medium dense, light brown, moist, no HCl reaction		-		
24					-		

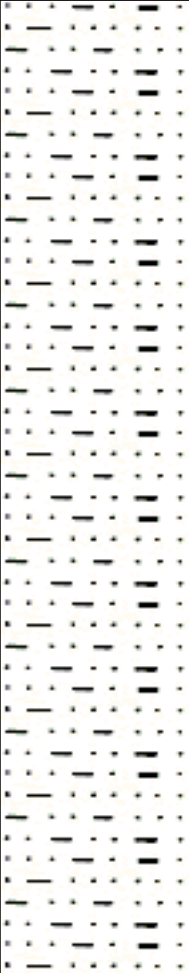
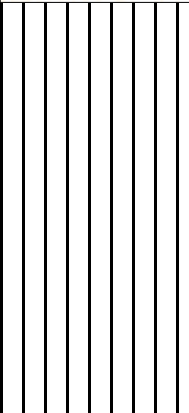
Notes:

Log of Boring SB-103

Date: 2/16/2013
 Drilling Method: Geoprobe
 Drilling Co.: EarthWorx
 Driller: L. Trujillo
 Sampling Method: Continuous/Grab

Diameter (in.): 1 3/4 Macrocore
 Logged By: C. Short
 SCAG Blank (cpm): 1752
 Bore Loc Background (cpm): 10962
 Total Depth (ft.): 4
 Total Depth Criterion: Below background



Depth (ft.)	Recovery (of 4')	Symbol	Lithology Description	Lithology	Core Gamma (cpm)	BACG (cpm)	Ra-226 (pCi/g)
0	3.2	SM	Moist Clay, Silt & Sand surface material, iron staining visible throughout core		1723	-29	14.4441
0.2					1754	2	14.8223
0.4					1731	-21	14.5417
0.6					1762	10	14.9199
0.8					1697	-55	14.1269
1					1751	-1	14.7857
1.2					-		
1.4	3.2	CH	Fat CLAY, high plasticity, firm, dark brown, moist		-		
1.6					-		
1.8					-		
2					-		
2.2					-		
2.4					-		
2.6					-		
2.8					-		
3					-		
3.2					-		
3.4					-		
3.6					-		
3.8					-		

Notes:

**ATTACHMENT I-3: 2013 INTERA INVESTIGATION SOIL BORING
LOGS**

DRAFT 2013 PHASE II SITE CHARACTERIZATION REPORT

**Old Church Rock Mine
McKinley County, New Mexico**



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