Rock Door No. 1

Removal Site Evaluation Report

Final

April 18, 2023

Cyprus Amax Minerals Company

Certification Page

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Jennifer Laggan

Cyprus Amax Minerals Company

Executive Summary

Introduction

The United States of America (U.S.) and the Navajo Nation entered into a Consent Decree (CD) with Cyprus Amax Minerals Company (Cyprus Amax)[1] and Western Nuclear, Inc. The CD was approved by the U.S. District Court for the District of Arizona and has an effective date of May 22, 2017. This Removal Site Evaluation (RSE) Report is submitted in accordance with the Statement of Work described in and pursuant to the terms of the CD. This RSE Report describes the activities performed and summarizes the results of investigations conducted to characterize chemical and radiological conditions at the Rock Door No. 1 Mine Site (Mine Site). Site characterization data collected at the Mine Site will be used to determine the volume of mining-impacted material, including technologically enhanced naturally occurring radioactive material (TENORM) in excess of the Investigation Levels (ILs) due to historical mining activities. This RSE Report does not establish cleanup levels or evaluate potential cleanup options. Following approval of this RSE Report, the U.S. Environmental Protection Agency (U.S. EPA), after consultation with Navajo Nation Environmental Protection Agency (NNEPA), will determine whether there is sufficient information to warrant additional work at the Mine Site, which may include the performance of a risk assessment and evaluation of response action alternatives through an engineering evaluation/cost analysis (EE/CA).

Rock Door No. 1 Mine Site

The Mine Site is located in the Oljato Chapter of the Navajo Nation, in San Juan County, Utah, on Tribal Trust Land (Figure ES-1). The Mine Site is located in southeastern Utah west of the Monument Valley Tribal Park and is located 9 miles southeast of the Oljato Chapter house and can be viewed from Oljato Road, approximately 2.4 miles west of Highway 163 and approximately 0.75 mile west of the historic Goulding's Trading Post (Figure ES-1). The Mine Site covers 5.36 acres. The Mine Site was identified by U.S. EPA as one of 46 Priority Abandoned Uranium Mine Sites as described in Section 1 of this RSE Report. The Mine Site was identified as a Priority Mine Site because of its proximity to potentially inhabited structures and gamma screening measurements elevated above background, as identified by U.S. EPA (U.S. EPA 2014).

The Mine Site was located on Rock Door Mesa approximately 700 feet above the valley floor. From 1953 to 1954, 25 tons of ore was produced through 3 portals: 2 located on a ledge approximately 20 feet below the northeast mesa top and one reportedly located on a ledge below the northern mesa top (NAMLRP 2000). Additionally, a rim strip was reported on top of the mesa (NAMLRP 2000). The ore was reportedly transported by a cable and bucket/sack system to the valley floor. No ore processing was conducted at the Mine Site, because ore was hauled off site to a mill for processing. Historical mining at the Mine Site targeted naturally occurring uranium ore deposits in the Shinarump member of the Chinle Formation.

The Navajo Nation Abandoned Mine Lands Reclamation Program (NAMLRP) conducted reclamation and closure activities at the Mine Site between 2001 and 2002. Navajo Abandoned Mine Lands (NAML) closed the three mine portals and covered the portals with native rock. During the RSE field work, Cyprus Amax evaluated the Mine Site for accessibility and made two trips to the top of the mesa (one with NAML on January 26, 2018 and one with U.S. EPA and NNEPA on June 6, 2019). Cyprus Amax consulted with both U.S. EPA and NNEPA following these visits, and it was determined that the access route to the Mine Site was too steep, rugged, and dangerous for access by sampling crews, which needed to carry heavy sampling equipment and backpacks to perform work. Therefore, the top of the mesa was deemed inaccessible for investigation activities because of health and safety concerns and sampling of the Mine Site was limited to the valley floor.

[1] Cyprus Amax refers to its former subsidiaries, Climax Uranium Company, American Metal (AMAX) Inc., and Foote Mineral Company, and to the Vanadium Corporation of America, an entity to which Cyprus Amax has an indemnity obligation.

Removal Site Evaluation Investigation Field Activities (2017 to 2019)

Between September 2017 and October 2019, Jacobs Engineering Group Inc. (Jacobs)[2] conducted field activities in accordance with the CD, the approved RSE Work Plan (CH2M 2017a), and the approved RSE Work Plan Addendum (CH2M 2018), the latter two of which are collectively referred to hereafter as the Work Plans. Through the investigation, the following information was developed to assist with the evaluation of data quality objectives (DQOs):

1. Determine representative background threshold values (BTVs) for the Mine Site. (A BTV is a calculated value that represents a typical value for gamma count rates and concentrations for primary contaminants of potential concern [COPCs] that naturally occur in the environment.)
2. Identify IL exceedances in soil and sediment using site characterization data, including gamma count rates from walkover gamma scanning and surface and subsurface soil and sediment sampling.
3. Statistically evaluate the relationship between concentrations of radium-226 (Ra-226) in surface soil and gamma count rates, as well as gamma count rates and dose rates.
4. Investigate whether mining-related activities such as blasting, machine maintenance and refueling, and use of electrical equipment resulted in releases of explosives (including perchlorate), petroleum hydrocarbons, or polychlorinated biphenyls.
5. Identify whether there is evidence that surface water and/or groundwater has been impacted by mining-related activities, if present and accessible for sampling.
6. Estimate the area and volume of mining-impacted material, including TENORM at the Mine Site.

Findings and Discussion

Jacobs conducted field activities between September 2017 and October 2019 to address the DQOs (CH2M 2017b, 2018) and evaluate the extent of mining-impacted material, including TENORM and naturally occurring radioactive material (NORM), at the Mine Site. The findings of the RSE are as follows:

1. DQO 1 was attained.

- One background reference area (BRA) was selected based on the predominant surficial geologic formation (the Colluvium BRA) at the Mine Site. BTVs were calculated from gamma count rates and analytical concentrations for the primary COPCs at the BRA. BTVs, in addition to U.S. EPA Regional Screening Levels, if available, were used to derive ILs, which informed the evaluation of subsequent DQOs.

2. DQO 2 was attained with a data gap.

- The type and extent of affected environmental media has been defined through gamma radiation surveys, surface and subsurface soil sampling, and sediment sampling. One subsurface soil sample location (32-MS-013) was not vertically delineated due to refusal.

3. DQO 3 was attained with a data gap.

- The data were collected in accordance with the Work Plans to determine if a correlation existed between gamma count rate (in counts per minute [cpm]) and Ra-226 surface soil concentrations (in picocuries per gram). The correlation achieved acceptable statistical performance criteria and model validation. The correlation is therefore considered usable for estimating the lateral extent of Ra-226 surface soil concentrations during an EE/CA.
- The data were collected in accordance with the Work Plans to determine if a correlation existed between gamma count rate (in cpm) and dose rate (in microrem per hour). The correlation did not

[2] On December 15, 2017, CH2M HILL Companies Ltd. and its subsidiaries, including CH2M HILL, Inc. (CH2M) became part of Jacobs. CH2M/Jacobs performed the RSE work, and Jacobs prepared this RSE Report. Jacobs and CH2M are referred to collectively as “Jacobs.”

achieve acceptable statistical performance criteria and model validation. Therefore, the correlation is not considered usable for estimating dose rate from gamma count rates. Cyprus Amax is exploring additional methodologies for dose rate correlation at Group 2 Mine Sites.

4. DQO 4 was attained.

- Sufficient data were collected in accordance with the Work Plan to evaluate whether mining-related activities released secondary COPCs into the environment. Mine Site soil sampling data indicated that the secondary COPCs were less than ILs.

5. DQO 5 was attained.

- Multiple lines of evidence support that historical mining activities have not impacted surface water or groundwater. These lines of evidence include aquicludes in strata below the Mine Site that limit vertical migration to groundwater; no perennial or intermittent surface water flow on the Mine Site; minimal infiltration of water at the Mine Site; limited leaching of COPCs in soil and sediment; and no impacts to water wells within one mile of the Mine Site.

6. DQO 6 was attained.

- The volume of mining-impacted material, including TENORM in excess of the ILs, was estimated to be 3,705 cubic yards. An area of mixed NORM and mining-impacted material, including TENORM, was estimated to be 9,900 cubic yards.

Contents

Appendixes

Tables

Figures

Acronyms and Abbreviations

°F	degrees Fahrenheit
µR/hr	microroentgen per hour
µrem/hr	microrem per hour
AEC	Atomic Energy Commission
ANSI	American National Standards Institute
ASTM	ASTM International (formerly American Society for Testing and Materials)
AUM	abandoned uranium mines
BTV	background threshold value
bgs	below ground surface
BRA	background reference area
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CH2M	CH2M HILL Engineers, Inc.
COPC	contaminant of potential concern
cpm	counts per minute
Cyprus Amax	Cyprus Amax Minerals Company
DCRM	Dinétahdóó Cultural Resources Management
DOE	U.S. Department of Energy
DQO	data quality objective
DRO	diesel range organics
EE/CA	engineering evaluation/cost analysis
ERG	Environmental Restoration Group
FESA	federal Endangered Species Act
GEMS	Geospatial Environmental Mapping System
GIS	geographic information system
gpm	gallons per minute
GPS	global positioning system
IL	investigation level
Kd	partition coefficient
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MBTA	Migratory Bird Treaty Act
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MDER	minimum detectable exposure rate
mg/kg	milligrams per kilogram

Mine Site	Rock Door No. 1 Mine Site
MSE	mean squared error
NaI	sodium iodide
NAML	Navajo Abandoned Mine Lands
NAMLRP	Navajo Abandoned Mine Lands Reclamation Program
NNDFW	Navajo Nation Department of Fish and Wildlife
NNDOJ	Navajo Nation Department of Justice
NNDWR	Navajo Nation Department of Water Resources
NNEPA	Navajo Nation Environmental Protection Agency
NNHP	Navajo Natural Heritage Program
NNHPD	Navajo Nation Historic Preservation Department
NORM	naturally occurring radioactive material
ORP	oxidation-reduction potential
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
Ra-226	radium-226
RSE	Removal Site Evaluation
RSL	Regional Screening Level
SOP	standard operating procedure
SOW	Statement of Work
TENORM	technologically enhanced naturally occurring radioactive material
TPH	total petroleum hydrocarbons
U.S. EPA	U.S. Environmental Protection Agency
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
USL	upper simultaneous limit
UTL	upper tolerance level
Weston	Weston Solutions, Inc.
WRCC	Western Regional Climate Center

1. Introduction

This Removal Site Evaluation (RSE) Report describes the activities and results of investigations to characterize chemical and radiological conditions at Rock Door No. 1 Mine Site (Mine Site). Jacobs Engineering Group Inc. (Jacobs)[3] performed the activities for Cyprus Amax Minerals Company (Cyprus Amax)[4] in accordance with the Consent Decree (CD) (United States of America and the Navajo Nation 2017) entered into by the United States of America (U.S.), Navajo Nation, Cyprus Amax, and Western Nuclear, Inc. with an effective date of May 22, 2017. Jacobs performed fieldwork according to the CD, the approved RSE Work Plan (CH2M 2017a), and the approved RSE Work Plan Addendum (CH2M 2018), the latter two of which are collectively referred to as the Work Plans. The U.S. Environmental Protection Agency (U.S. EPA) approved the RSE Work Plan on September 13, 2017 (RSE Work Plan) and May 31, 2018 (RSE Work Plan Addendum), before commencement of the RSE field activities. This RSE Report presents the RSE results but does not establish cleanup levels or evaluate potential cleanup options. Following approval of the RSE Report, U.S. EPA after consultation with the Navajo Nation Environmental Protection Agency (NNEPA) will determine whether there is sufficient information to warrant additional action at the Mine Site, which may include evaluation of response action alternatives through performance of a risk assessment and an engineering evaluation/cost analysis (EE/CA).

The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), also known as Superfund, was developed to allow the U.S. EPA to facilitate or direct the cleanup of contaminated sites, with the overarching goals of protecting human health and the environment, imposing financial accountability on the responsible parties, involving communities in the process, and returning sites to productive use. Cleaning up Superfund sites is a multi-phase process that includes assessment, decision-making, cleanup, and operation and maintenance. The CERCLA process for abandoned uranium mines (AUMs) on the Navajo Nation is depicted on Figure 1-1. During the assessment phase, RSEs are conducted to evaluate the extent of contamination and associated risks. During the decision-making phase, potential cleanup solutions are evaluated and compared in an EE/CA and then presented to the public for input. Following the public comment period, the selected cleanup solution is documented in an Action Memorandum. During the cleanup phase, the selected cleanup solution is designed and implemented. During the operation and maintenance phase, the sites will be monitored and maintained to keep the public and the environment safe. Community involvement, coordination with applicable Nation Navajo governmental agencies, and planning for a site’s future are ongoing throughout the process.

The information in this RSE Report is intended to describe the results of investigations to help inform the four nested stages of problem-solving, consistent with the CERCLA and the Fundamental Laws of the Diné. This RSE Report recognizes that under the Fundamental Laws of the Diné, the four problem-solving stages are: (1) thinking (nitsahakees), (2) planning (nahat’a), (3) implementation (lina/jina’), and (4) eventual results (sihasin).

The Mine Site is located within the Oljato Chapter of the Navajo Nation (Figure 1-2). This RSE Report describes activities performed and summarizes the results of the RSE investigation conducted to characterize chemical and radiological conditions at the Mine Site. The Mine Site was identified by U.S. EPA as a Priority Abandoned Uranium Mine Site (Priority Mine Site) located within the Navajo Nation. Priority designation was given because the Mine Site is located near a potentially inhabited structure and gamma screening measurements were elevated above background levels identified by U.S. EPA (U.S. EPA 2014). The Mine Site area includes the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP) boundary plus a 100-foot-wide buffer surrounding the boundary. A 1-mile radius around the Mine Site was considered for the evaluation of groundwater and surface water (Figure 1-3).

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[3] On December 15, 2017, CH2M HILL Companies Ltd. and its subsidiaries, including CH2M HILL, Inc. (CH2M) became part of Jacobs Engineering Group Inc. (Jacobs). CH2M/Jacobs performed the RSE work, and Jacobs prepared this RSE Report. Jacobs and CH2M are referred to collectively as “Jacobs.”

[4] Cyprus Amax refers to its former subsidiaries, Climax Uranium Company, American Metal (AMAX) Inc., and Foote Mineral Company, and to the Vanadium Corporation of America, an entity to which Cyprus Amax has an indemnity obligation.

1.1 Objectives

The primary objective of completing the RSE at the Mine Site was to provide the data required to evaluate site conditions and to estimate the volume and area of mining-impacted materials, including technologically enhanced naturally occurring radioactive material (TENORM) related to historical mining activities above the established investigation levels (ILs). This RSE Report was not intended to establish cleanup levels or evaluate future potential remedies, which may result in lower volumes of mining-impacted material, including TENORM that requires remediation.

The terms “naturally occurring radioactive material” (NORM) and TENORM are not defined in federal environmental statutes or regulations. At U.S. EPA’s direction, NORM and TENORM are used in this RSE Report with the definitions provided in an April 2008 U.S. EPA guidance document (EPA 402-R-08-005):

> The term NORM is defined as ‘materials which may contain any of the primordial radionuclides or radioactive elements as they occur in nature, such as radium, uranium, thorium, potassium, and their radioactive daughter products that are undisturbed as a result of human activities.’
>
> The term TENORM is defined as ‘naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing. “Technologically enhanced” means that the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures.’

To be called TENORM, U.S. EPA’s definition does not require that a material’s radiological concentrations or properties actually have been increased by human activity; instead, a material may be called TENORM under U.S. EPA’s definition simply because it has been “disturbed” in its natural setting in a way that increases potential exposure. At U.S. EPA’s direction, to be consistent with other similar reports overseen by U.S. EPA on the Navajo Nation, this RSE Report uses TENORM terminology, in addition to the plain language that more clearly describes these materials such as waste rock and impacted material on the Mine Site, haul roads, drainages, and other structures.

1.2 Overview

On behalf of Cyprus Amax, Jacobs initiated RSE activities at the Mine Site, following previous investigations by U.S. EPA. Specifically, U.S. EPA contracted with Weston Solutions, Inc. (Weston) to complete an initial site screening investigation in 2012 that found that gamma radiation was present at the Mine Site at measurements greater than an average background established for the area (U.S. EPA 2012). The U.S. EPA prepared a site-specific screening report for the Mine Site; the report is summarized in Section 2.4 of this RSE Report.

To perform the RSE, Jacobs conducted RSE investigations in accordance with the CD and the Work Plans, which included the following activities:

- Cultural resource surveys
- Biological surveys
- Site mapping to digitize and georeference Mine Site features and physical attributes (Appendix A)
- Review of historical documents pertaining to the Mine Site (Appendix A)
- Gamma scanning to identify potentially impacted areas based on radiation levels
- Collection and laboratory analysis of soil samples to characterize the lateral and vertical extent of contamination in soil and sediment

- Evaluation of groundwater and surface water within 1 mile of the Mine Site
- Reporting

According to the SOW, the RSE Report is to include the following components:

- A summary of the results of the RSE activities
- Field and validated laboratory data, including gamma scan results
- Laboratory reports
- Data validation results
- Summary tables, graphs, and maps
- Identification of the vertical and lateral extent of mining-impacted material, including TENORM
- Conclusions that indicate whether historical activities at the Mine Site have potentially impacted nearby surface water and groundwater

The RSE Work Plans (CH2M 2017a, 2018) define “impacts” on the Mine Site as exceedances of contaminants of potential concern (COPCs) compared to an IL that equates to a site-specific background threshold value (BTV) and or U.S. EPA Regional Screening Level (RSL), whichever is higher. As further explained in the RSE Work Plans, this approach is too simplistic because uranium and metals are naturally occurring in the environment and typically display a range of concentrations in their natural state. Therefore, reported concentrations of constituents that exceeded the IL may be indicative of natural conditions or related to historical mining activities. Therefore, a multiple-lines-of-evidence approach has been developed for the Mine Site to allow for evaluation of materials impacted by mining-related activities, including the designation of NORM and TENORM.

The RSE Report is not intended to establish cleanup levels or evaluate response action alternatives. Following approval of the RSE Report, U.S. EPA after consultation with NNEPA will determine whether there is sufficient evidence to warrant additional work at the Mine Site, which may include conducting a risk assessment and potential evaluation of response action alternatives through performance of an EE/CA. If a risk assessment and EE/CA are deemed necessary, cleanup levels will be determined and the volume of mining-impacted material, including TENORM, may be reduced.

1.3 Project Management and Organization

The Work Plans describe management and organization of the Mine Site RSE (CH2M 2017a, 2018). A brief synopsis of the management and organization is in the following paragraphs. Ms. Jennifer Laggan, representative of Cyprus Amax and project coordinator under the CD, provided project management and oversight services to Jacobs.

The project manager, Ms. Dawn Townsen of Jacobs, and field investigation task manager, Mr. Gavin Wagoner of Jacobs, managed the implementation of activities specified in the approved Work Plans. Mr. Eric Packard, Certified Health Physicist of Jacobs served as the radiation health physicist. Mr. Joshua Painter of Jacobs acted as the health and safety officer. Table 1-1 lists the Jacobs project management team.

Jacobs subcontracted specialized services as necessary. Dinétahdóó Cultural Resources Management (DCRM) performed the cultural resource assessments, and Hemlock Environmental Consulting, LLC and Earth and Sky, LLC[5] performed the biological monitoring; Ground Penetrating Radar Systems performed utility locate services; Cascade Drilling provided subsurface drilling services; and ALS Environmental Laboratory in Fort Collins, Colorado, provided analytical laboratory services.

[5] Subcontracted biological services switched from Hemlock Environmental Consultants LLC to Earth and Sky LLC in 2019. The same biologist was subcontracted under these companies. This RSE Report will reference the biological services as being provided by Earth and Sky LLC.

U.S. EPA Region 9 Remedial Project Managers were Ms. Linda Reeves through July 2021, and Mr. Kenyon Larsen through the date of this report. The NNEPA Remedial Project Managers were Mr. Binod Chaudhary through April 2019, Ms. Valinda Shirley through January 2020, Ms. Tennille Denetdeel through February 2022, and Ms. Dawn Begay through the date of this RSE Report.

1.4 Report Organization

This RSE Report documents the activities performed during the Mine Site RSE. The Report is structured as follows:

- Section 1 summarizes the RSE investigation objectives, project management and organization, and report organization.
- Section 2 describes the Mine Site, including mining and reclamation history, ownership and land use, and regional and site-specific geology and hydrogeology, and summarizes the cultural and biological assessments.
- Section 3 summarizes RSE methodology.
- Section 4 includes results of RSE investigations, field activities, and radium-226 (Ra-226) correlation for surface soil.
- Section 5 provides NORM and TENORM designations and area and volume estimates for mining-impacted material, including TENORM.
- Section 6 provides a summary of the Mine Site data quality objectives (DQOs), uncertainties, and data gaps.
- Section 7 provides an RSE investigation summary and conclusions.
- Section 8 provides references cited in this RSE Report.

2. Site Description, History, and Physical Characteristics

2.1 Site Description

The Mine Site is located in the Oljato Chapter of the Navajo Nation, in San Juan County, Utah, on Tribal Trust Land (Figure 1-2). The Mine Site was identified by the U.S. EPA as 1 of 46 Priority Mine Sites located within the Navajo Nation. A designation of "Priority" is based on the Mine Site's proximity to residences and gamma screening measurements elevated above an U.S. EPA established background (U.S. EPA 2014).

The Mine Site is located in southeastern Utah west of the Monument Valley Tribal Park. The Mine Site is located 9 miles southeast of the Oljato Chapter house and can be viewed from Oljato Road, approximately 2.4 miles west of Highway 163 and approximately 0.75 mile west of the historic Goulding's Trading Post (Figure 1-2). The area of the Mine Site given in the CD was 5.36 acres (United States of America and Navajo Nation 2017). Because of the potential for impacts beyond the Mine Site boundary, a 100-foot-wide buffer was added to the boundary of the Mine Site, so that RSE investigations could efficiently delineate the potential extent of impacted environmental media related to historical mining activities. Therefore, the investigation area for the Mine Site was approximately 11.36 acres, which included the inaccessible areas (Figure 2-1).

The originally selected background reference area (BRA) for the Chinle Formation was not representative, because the area was ultimately determined to be in the Moenkopi formation, which is below the ore-bearing Chinle formation and above the valley floor colluvial deposits. Therefore, the data were not usable. A new BRA was selected (the Colluvium BRA) on a talus slope of the Cutler Formation (Figure 1-3). This new BRA was more representative of the eroded material from the multiple formations of the mesa (where the Mine Site is located) and valley floor.

Steep cliffs and rugged terrain prevented safe access to the top of the mesa to conduct RSE field activities; therefore, the investigation efforts focused on the portions of the Mine Site along the base of the mesa, which included scree slopes and drainages (Figure 2-1). There are no roads to the top of the mesa, and access by foot requires traversing steep, exposed cliff ledges. Jacobs accessed the top of the mesa with U.S. EPA and NNEPA on June 6, 2019 and completed a qualitative evaluation of conditions. Because additional attempts to access areas at the top of the mesa would present an unacceptable level of risk to field workers, U.S. EPA and NNEPA agreed that Cyprus Amax would not be required to conduct fieldwork at the top of the mesa. Additional assessment may be required in the future, if a safe and accessible route is established or technology becomes available to allow for remote assessment of the mesa.

2.2 Ownership and Access Agreements

Legal title to the 94 Mine Sites identified in the CD is held by the U.S. government in trust for the Navajo Nation. Pursuant to the terms of the CD, the Navajo Nation Department of Justice (NNDOJ) designated Cyprus Amax as NNEPA's representative for the purposes of conducting RSE activities at the 94 Mine Sites. This designation allows Cyprus Amax to access Navajo Trust lands to perform RSE activities. NNDOJ provided documentation of this designation in a letter dated October 16, 2017 (Appendix B).

As stated in Section VIII (Property Requirements) of the CD and Section 4 of the SOW, Cyprus Amax worked with local officials to obtain access agreements from grazing permit and homesite lease holders before conducting fieldwork activities. In a letter to U.S. EPA and NNEPA dated September 5, 2017, Cyprus Amax provided documentation of its successful best effort to obtain permission to access the Mine Site (Appendix B).

2.3 Surrounding Land Use

The closest residential areas are approximately 0.25 mile north and northeast of the Mine Site and approximately 0.25 mile east of the Mine Site (Figure 2-1). The area to the north and northeast of the Mine Site appears undeveloped in the 1950 aerial photograph (Figure 2-2). The area was developed after 1980, after the termination of mining activities. This is evident in the 1980, 1993, 2019 historic aerial photographs (Figure 2-3, 2-4, and 2-5); houses become more apparent to the north and northeast in the 1993 and 2019 historic aerial photographs when compared to the 1980 historic aerial photograph. Each of the residential areas are comprised of three to five single- or multi-family homes. The residential areas are limited to housing, farming, and gardening. No livestock grazing was observed. Short-term rental properties, associated with the Goulding's Lodge, are located 0.5 mile southeast of the Mine Site.

2.4 Historical Practices and Reclamation History

The land (where the Mine Site is located) was originally claimed in 1952 by Harry A. Binale within mining permit number MP-32, and mining rights were assigned shortly thereafter to Harry Goulding (Chenoweth 1991). Although exploratory drilling was performed under Harry Goulding, no ore was produced at the Mine Site during this time. The Mine Site was transferred to Dean Nicholson in 1953, who mined from 1953 to 1954 (Chenoweth 1991). According to Atomic Energy Commission (AEC) records, a total of approximately 25 tons of ore containing 331 pounds of uranium and 937 pounds of vanadium (U.S. EPA 2007) were extracted. Ore was reportedly transported by a system of cables and buckets/sacks from three portals to a loadout area on the valley floor (Chenoweth 1991), which was supported by an interview with a local resident (DCRM 2018). Ore that met the minimum grade of uranium[6] set by the AEC was removed from the Mine Site for processing. The remaining material, which consisted of overburden and waste rock with concentrations of uranium below minimum grades set by the AEC, was left onsite[7].

From December 2001 to April 2002, NAML performed reclamation activities at the Mine Site under the Monument Valley 4 Reclamation Program (NAMLRP 2001, 2002). NAML applied the site identification of NA-0237 to the Mine Site (NAMLRP 2001). Reclamation features (closed portals) identified by NAML are shown on Appendix A Figure A-1 and additional information is provided in Appendix A. The NAMLRP's Point Features database identified the location of the three reclaimed portals (U.S. EPA 2007). The three reclaimed portals were documented in the NAML Point Features database as feature Mon050 and are shown in Appendix A. A rim strip was identified in the NAMLRP document, but the location was not provided. NAML reported that the following reclamation activities were performed:

- Excavate and stabilize the three portals
- Close the portals with approximately 50 cubic yards of polyurethane foam
- Backfill the exterior with native Class A rock to ensure a complete hidden seal

2.5 Previous Investigations

2.5.1 Remote Sensing Radiation Surveys

From 1994 to 1999, U.S. EPA Region 9 funded 41 aerial radiological surveys conducted by the U.S. Department of Energy (DOE) Remote Sensing Laboratory (DOE 2001; U.S. EPA 2007). These aerial radiological surveys were conducted in support of U.S. EPA's scientific study of AUMs to determine if AUMs and related mine features pose a significant risk to human health and environment. The surveys covered approximately 1,144 square miles within the Navajo Nation. For the Mine Site, the aerial radiological surveys characterized the overall radioactivity (ground surface exposure rate in microroentgen per hour (µR/hr) and excess bismuth 214 levels). The Mine Site was covered in one of the aerial radiological survey areas, and the results are presented on Figure 2-6. The aerial radiological survey results displayed elevated measurements (5.2 to 7.4 µR/hr) in the immediate vicinity of the former portals near the top of the mesa; and less than 2.4 µR/hr in the eastern and western portions of the Mine Site, and in the southern portion of the loadout area

[6] In the mining industry and as used in the Atomic Energy Act, the definition of "ore" is an economic one, and materials containing target metals that are not "ore" at one price may well become "ore" if the price or circumstances change in the future. The terminology used to refer to materials that do not contain the minimum grade varies, such materials but have been referred to as "protore/low-grade ore" or "waste rock" in different circumstances and contexts and depending on their grades.

[7] For additional information describing the AEC and uranium mining on the Navajo Nation, refer to *El Paso Natural Gas Co., LLC v. United States of America* (D. Ariz. 2019).

located north of the Mine Site. Survey data did not encompass the former haul route and northern half of the loadout area on the valley floor.

2.5.2 U.S. EPA Atlas with Geospatial Data

The U.S. EPA Atlas (2007) reported the production history as stated in Section 2.4. Site features presented in the U.S. EPA Atlas included the three portal locations. Based on field observation during the RSE activities, the locations of the three portal locations were not correctly georeferenced, so Jacobs revised the georeferencing of the site features, which are used on the figures in this RSE Report. The U.S. EPA Atlas did not report the location of the reported rim strip and this feature is not presented on figures.

2.5.3 Site Screening Assessment

During 2012, U.S. EPA conducted a site screening assessment of the Mine Site (U.S. EPA 2012). The site screening assessment conducted by Weston Solution, Inc. (Weston) did not observe the three portals or rim strip reported by NAML on the Mine Site (U.S. EPA 2012). Weston did not identify potential loadout areas for the cable and bucket/sack transport system or other former Mine Site features; however, Weston indicated the potential of waste rock and fine material to be over the edge of the mesa. Radiological measurements collected on top of the mesa ranged from 9442 to 218136 cpm. Gamma count rates were elevated near the bench area at the top of the mesa.

2.6 Review of Historical Aerial Photographs

As part of the RSE for the Mine Site, a review of historical aerial imagery from 1950, 1980, 1993, and 2019 was conducted (Figures 2-2 through 2-5) These aerial photographs reveal the following:

- The 1950 aerial photograph (Figure 2-2) presents pre-mining conditions and, therefore, no mining features or potential haul roads are apparent. Several drainages, flowing to the northeast from the mesa within the scree slope, are visible. There is a large degree of distortion in the 1950s aerial image, which alters the size and shape of the cliff side from later aerial images. This distortion appears to be caused by the non-vertical camera angle of the photograph. The ledge just below the top of the mesa on the north side is distorted and appears smaller than it would be if the photograph was collected at a vertical angle.
- The 1980 aerial photograph (Figure 2-3) is post-mining and pre-NAML reclamation. The 1980 photograph shows a distinct outline of the potential loadout area and haul road northeast of the Mine Site. Again, no mining features are visible within the Mine Site or buffer area. Approximately 0.25 mile east of the Mine Site, a local residence is visible that was not visible in the earlier aerial photograph. The apparent change in the size of the cliff ledge is from the distortion related to the 1950s photograph and is not mining-related.
- The 1993 aerial photograph (Figure 2-4) is post-mining and pre-NAML reclamation, and no mining features can be observed. Along the northern boundary of the 1993 aerial photograph a local residence is visible approximately 0.25 mile north of the Mine Site boundary. The residence along the eastern boundary of the Mine Site is still visible and it appears additional buildings have been added.
- The 2019 aerial photograph (Figure 2-5) is post-NAML reclamation and exhibits the potential loadout area and haul road. These areas now appear faint. No other mining-related features can be distinguished from the 2019 aerial photograph. The footprint of the residences on the valley floor appears to have expanded.

2.7 Physical Characteristics

2.7.1 Regional and Site-specific Physiography

The Mine Site is located within the Colorado Plateau physiographic province, which is an area of approximately 240,000 square miles in the Four Corners region of Utah, Colorado, Arizona, and New Mexico. The Colorado Plateau is bounded to the east and north by the Rocky Mountains in Colorado and Wyoming, to the west by the Basin and Range province in Utah and Nevada, and to the south by the Mogollon Rim in Arizona and the Rio Grande Rift in New Mexico. The Colorado River and its tributaries, including the Green, San Juan, and Little Colorado, drain the vast majority of the Colorado Plateau. The Colorado Plateau is typically high desert with scattered forests and varying topography. Incised drainages, canyons, volcanic intrusions, cliffs, buttes, and arroyos are common features of this uplifted, high-elevation, semi-arid plateau.

The Mine Site is located in Monument Valley, which is well known for isolated towers, buttes, and mesas of red sandstone separated by sunbaked, arid valleys of sparse vegetation and sand dunes. The historical mining area of the Mine Site is located on top of Rock Door Mesa, which is adjacent to Oljato Mesa. These mesas are guarded by imposing cliffs to the north, west, and east and by steep slickrock, cliffs, and loose scree to the south. These mesas were two of the many mesas in the area explored for uranium ore resources (Chenoweth 1991). Below the cliffs of these mesas, scree slopes composed of weathered and eroded geologic units form naturally at the angle of repose. These scree slopes are dissected by incised drainages that run ephemerally during strong storms. The scree slopes and washes grade into the valley floor, which forms large areas of relatively flat topography when compared to the abrupt cliffs located nearby. The elevation difference of the Mine Site from the top of the mesas to the valley floor is approximately 700 feet (approximately 5,100 to 5,800 feet above mean sea level), with roughly 250 feet of that elevation change occurring as a sheer cliff immediately below the ore-bearing historical mining unit. The Mine Site topographic map is presented on Figure 2-7. The elevation of the BRA is approximately 5,160 feet above mean sea level, with approximately 117 feet of elevation change.

2.7.2 Geologic Conditions

2.7.2.1 Regional Geology and Stratigraphy

The Colorado Plateau is a massive uplift of generally flat-lying sedimentary rocks ranging in age from the Paleozoic Era to the Cenozoic Era. Very little structural deformation has occurred on the Colorado Plateau over the past 600 million years (Fillmore 2011), as compared to the mountainous Basin and Range province to the west and the Rocky Mountains to the east. Changes in paleoclimate and elevation throughout the sedimentary deposition process produced alternating occurrences of deserts, streams, lakes, and shallow inland seas, as well as topographic high elevation resulting in erosion. The rock units of the Colorado Plateau consist of shallow submarine, sub-aerial, and eolian deposits forming sandstone, shale, mudstone, siltstone, conglomerates, and limestones. The sedimentary beds range widely in thickness from less than 1 inch to hundreds of feet.

The Monument Upwarp is a geologic feature within the greater Colorado Plateau and is responsible for the development of the dramatic landscape characteristic of Monument Valley. The Monument Upwarp is a large asymmetrical anticline bounded on its southern and eastern margins by the Comb Ridge monocline (Blakey and Baars 1987), which is a feature that stretches 110 miles in a north-south orientation from the Abajo Mountains of Utah to Kayenta, Arizona, where it arcs west to merge with the Organ Rock monocline (Fillmore 2011). Many agree that Comb Ridge and the Monument Upwarp, like many other larger monoclines across the Colorado Plateau, are cored at depth by approximately 900- to 700-million-year-old regional-scale reverse faults, in which the western block of basement rock is thrust up and eastward during times of reactivation. The most recent incarnation occurred during the Laramide Orogeny, approximately 60 million years ago, resulting in the formation of Comb Ridge and the Monument Upward as exposed today (Fillmore 2011).

The sedimentary rocks of the Monument Valley area generally consist of eolian and fluvial deposits that are generally light buff to deep reddish brown, creating a sequence of rocks about 5,000 feet thick (Longsworth 1994). The sedimentary rocks range in age from Permian to Jurassic, and Quaternary deposits are present in valleys, drainages, and scree slopes. In Monument Valley, the major geologic units present include the following, from oldest to youngest (Figure 2-8):

- Permian Cutler Formation, which includes the Halgaito Shale, Cedar Mesa Sandstone, Organ Rock Shale, and the De Chelly Sandstone members
- Triassic Moenkopi Formation
- Triassic Chinle Formation, which includes, importantly, the ore-bearing Shinarump Member
- Triassic Wingate Sandstone

- Jurassic Kayenta Formation
- Jurassic Navajo Sandstone
- Quaternary eolian and colluvial/alluvial deposits

The four major geologic units that predominately form the towers and mesas of Monument Valley are the Organ Rock Shale and De Chelly Sandstone Members of the Cutler Formation, the Moenkopi Formation, and the Shinarump member of the Chinle Formation.

2.7.2.2 Site-specific Geology and Stratigraphy

The surficial bedrock at the Mine Site is consistent with that of Monument Valley (Figure 2-9) consisting of, from top to bottom, the Triassic Shinarump member of the Chinle Formation, Triassic Moenkopi Formation, and Permian De Chelly Sandstone and Organ Rock Shale Members of the Cutler Formation. A geologic cross section of the Mine Site is presented on Figure 2-10. Bedrock is found exposed on the surface of Rock Door Mesa. RSE activities mapped the shallow bedrock using aerial images (Figure 2-11).

The Shinarump member of the Chinle Formation is located at the top of the mesa and serves as a resistant cap to weathering. Below the Chinle is the Moenkopi Formation, which erodes more easily and often appears as a sloping shelf. The dramatic cliff faces that are prevalent in Monument Valley are formed of the De Chelly Sandstone member, which underlies the Moenkopi Formation. Below the De Chelly Sandstone is the Organ Rock Shale. At the Mine Site, colluvial deposits comprised of weathered and eroded Chinle, Moenkopi, and De Chelly Sandstone form scree slopes against a base of Organ Rock Shale.

Historical mining activity at the Mine Site targeted the Shinarump member of the Chinle Formation. Throughout the region, the Shinarump is between 50 to 100 feet thick and predominantly consists of a gray to buff sandstone and pebble conglomeratic sandstone, typical of a complex fluvial system; both rock types are lenticular and cross bedded. Shinarump pebble conglomerates are composed of well-rounded quartz, quartzite, and chert pebbles in a quartz sand matrix, cemented by silica and iron oxides (Grundy 1957). Basal deposits of the Shinarump fill channels cut into the underlying Moenkopi Formation. These scour-and-fill sediments contain abundant amounts of silicified wood and fossilized plant matter, and the contact may be marked by a zone of bleaching developed in the underlying Moenkopi Formation (Chenoweth and Malan 1973). The mineralization is typically found within or close to the narrow channels and typically does not extend far outside the channels. This formation hosts extensive uranium and vanadium mineralization deposits and uranium ore bodies are generally in the conglomeratic sandstones that fill paleostream channel scours (Grundy 1957).

The Moenkopi Formation consists of brick red and maroon shale, siltstone, and mudstone deposited in a fluvial environment. As the Moenkopi erodes, it forms steep slopes (Repenning et al. 1969). In the Monument Valley area, the Moenkopi Formation thins to the southeast, ranging from approximately 500 feet to 50 feet across the region (Repenning et al. 1969). At the Mine Site, the thickness of the Moenkopi Formation is closer to 50 feet thick.

The De Chelly Sandstone is a fine-grained, cross-bedded, light red eolian sandstone that forms vertical cliffs ranging in thickness from 300 to 550 feet (Longsworth 1994). Much of the dramatic scenery in Monument Valley is attributed to this rock formation. At the Mine Site, the De Chelly Sandstone cliffs are estimated to be approximately 250 feet thick.

The Organ Rock Shale consists of red to red-brown shale, siltstone, and sandstone, deposited in braided streams and tidal flats adjacent to marine lowlands (Vaughn 1964). The Organ Rock Shale is 670 to 700 feet thick in the Monument Valley area (Longsworth 1994). Weathering and erosion of the Organ Rock Shale often results in a lumpy appearance, in stark contrast to the featureless cliffs and slickrock characteristic of the overlying De Chelly Sandstone.

The scree slopes at the base of the Mine Site are colluvial deposits, which are characterized as sediments deposited at the base of a hillslope by either rainwash, sheetwash, downslope creep, or a combination of these processes. The colluvial deposits consist of weathered Chinle, Moenkopi, and De Chelly rock in grain sizes ranging from boulder-sized to silt-sized. In some locations along the base of the Monument Valley cliffs, eolian deposits (for example, sand dunes) are present; however, none were observed within the boundaries of the Mine Site.

2.7.3 Regional and Site-specific Climate

Climate data for the Mine Site are available from a weather station near Monument Valley Tribal Park, Arizona (025665) (WRCC 2021). Temperatures peak in July and trough in January. The maximum July temperature averages 92.0 degrees Fahrenheit (°F), while the minimum January temperature averages 40.6°F (WRCC 2021). Relative humidity of less than 10 percent may be recorded seasonally across much of the region. Lack of moisture in the air provides a limited heat reservoir and allows for large fluctuations in air temperatures. Daily temperature fluctuations of 25°F to 40°F are common.

Wind direction and magnitude in the region varies by location, season, and elevation. A wind rose from the Monument Valley Tribal Park, Arizona showing the number of hours per year the wind blows from a specific direction is shown on Figure 1-3 (Meteoblue 2019); the predominant wind direction is from south to north. These wind directions are consistent with field observations of wind direction at the Mine Site. High wind is present seasonally, with sustained wind speeds potentially reaching more than 40 miles per hour.

Precipitation is seasonally variable, with an average annual precipitation of 4.5 inches (WRCC 2021). The average annual pan evaporation rate from 1948 to 2005, as recorded at the Mexican Hat, Utah weather station, located approximately 26 miles northeast of the Mine Site, is 86 inches (WRCC 2021). August is generally the wettest month, with an average of 0.79 inches of precipitation due to seasonal monsoons and a pan evaporation rate of 12.48 inches. June is generally the driest month, averaging 0.10 inch precipitation. Monsoonal type rain events that typically come in the summer months can cause flash flooding within the normally dry drainages. These events can cause the transport of significant erosion material.

During reconnaissance-level vegetation classification, botanists observed two vegetation types at the Mine Site and BRA: pinyon-juniper woodland and Great Basin Desert scrub. Refer to Appendix B for additional discussion of vegetation at the Mine Site.

2.7.4 Regional Hydrogeology and Hydrology

The Mine Site lies within the Monument Valley hydrogeologic subdivision of the Navajo Indian Reservation, which is part of the Henry Hydrogeologic Basin and the San Juan River Watershed (Cooley et al. 1969). Monument Valley is one of the driest and least favorable areas for groundwater supplies on the Navajo Nation because of the relative impermeability of the sedimentary rocks and because extreme dissection (i.e., channels formed in the landscape through erosion) has drained some of the former water-yielding units (Cooley et al. 1969).

The Shinarump member of the Chinle Formation, the Moenkopi Formation, and the De Chelly Sandstone member and Organ Rock Shale of the Cutler Formation are part of the C-aquifer system in the Monument Valley area (Longsworth 1994). Although groundwater may be found in the alluvium and in consolidated sedimentary rocks, it generally is available to wells only in the alluvium and in the relatively more permeable units of the C-aquifer (Cooley et al. 1969). The alluvium may yield more than 10 gallons per minute (gpm) of water to wells. Pumping rates determined by single well test or the Neuman method range from 10 to 130 gallons per minute for pumping wells in the Oljato alluvial aquifer (USGS 1999). Within the C-aquifer, the Shinarump Member may yield 5 to 10 gpm, the De Chelly Sandstone member may yield 5 gpm, and the Organ Rock Tongue may yield 1 to 2 gpm. The Moenkopi Formation generally does not yield water to wells. Due to the relatively low production rates of the units in the C-aquifer, most groundwater is obtained locally from the stratigraphically lower Cedar Mesa Sandstone of the Cutler Formation, which is not exposed in the Monument Valley area, or from the alluvium (Longsworth 1994).

Recharge to the alluvium and the C-aquifer is directly from rainfall, from ephemeral streams, or from leakage from underlying water-bearing units (Cooley et al. 1969). Alluvium and other surficial deposits are recharged by rainfall, by influent streams, and by discharge from the consolidated aquifers. Recharge to the C-aquifer in outcrop areas occurs mostly through fractures and along bedding planes. High rates of evaporation and low permeabilities limit the amount of recharge in the nonfractured parts of the aquifer (Cooley et al. 1969). Groundwater in the area generally flows toward the north to the San Juan River (Longsworth 1994).

2.7.5 Site-specific Hydrogeology and Hydrology

The Oljato aquifer is a primary groundwater source for domestic use in vicinity of the Mine Site. The Oljato aquifer was studied south of the Oljato Mesa and over 1 mile south the Mine Site (USGS 1999). The aquifer consists of unconsolidated alluvium that is probably associated with paleochannel(s) and that overlies the De Chelly Sandstone member and Organ Rock member of the Cutler Formation. The maximum thickness of the aquifer is 101 feet, and the measured depth to groundwater ranges from about 65 feet below ground surface (bgs) in upgradient areas to only about 10 feet bgs near Oljato Wash (USGS 1999). Recharge to the aquifer originates primarily from direct precipitation in the valley and from infiltration of stormwater runoff from mesas immediately adjacent to the valley (USGS 1999). Groundwater flow is toward the northwest until it intersects with Oljato Wash. Groundwater then flows northward toward the San Juan River.

The Oljato aquifer is in alluvium directly overlying the Organ Rock Tongue member of the Cutler Formation. The Chinle Formation and De Chelly sandstone member of the Cutler Formation is located above the Oljato aquifer, on the steep bluffs above the alluvium. Lateral groundwater hydraulic conductivity in the alluvial aquifer ranges from 3.2 to 40 feet per day (USGS 1999). The differences in hydraulic conductivity are associated with the changes in depositional environment and gradation of the alluvium within areas of the aquifer but are all in the range expected for a fine to coarse grained sand. Vertical hydraulic conductivities in these types of depositional environments are lower than lateral hydraulic conductivity by about an order of magnitude, with preferential flow laterally along depositional bedding planes.

The Organ Rock Tongue member is predominately a poorly sorted siltstone with few thin, very fine-grained silty sandstone lenses near the base of the unit. The Organ Rock Tongue member is a poorly permeable formation (Longsworth 1994) that acts as an aquitard, limiting flow vertical flow (USGS 1999) with recharge from outcrop faces through fractures and bedding planes laterally within the depositional layers in the formation.

Groundwater is used for municipal, domestic, commercial, irrigation, and stock purposes. Monument Valley Tribal Park, Goulding's Trading Post and Lodge, Monument Valley High School, Monument Valley Hospital/Mission, and the community of Oljato use the Oljato aquifer as their primary source of drinking water. The average total volume of water withdrawn by these users was about 3,600,000 gallons per month (133 acre-feet per year), based on water-use records from January 1992 to June 1998 (USGS 1999). Monument Valley High School and Goulding's Trading Post and Lodge are the principal users of groundwater, averaging almost three-fourths of the total volume withdrawn during this period. Some groundwater in the area is withdrawn by windmills and dug wells or is supplied naturally by springs and is used mostly for watering livestock. The amount of use from these sources is unknown and not monitored but is considered small in comparison with that used for public water supply (USGS 1999).

Several databases were reviewed to identify groundwater sampling locations within 1 mile of the Mine Site. The following databases were reviewed: Navajo Nation Department of Water Resources (NNDWR) database (NNDWR 2017), DOE's Geospatial Environmental Mapping System (GEMS) (DOE 2019), and U.S. EPA's Atlas with Geospatial Data (U.S. EPA 2007). The database searches resulted in identification of two water wells and one potential spring/seep within 1 mile of the Mine Site (Figure 1-3) as follows:

- One of the water wells (08K-418) is located on the south end of the Monument Valley airstrip. Well 08K418 is reported to be 990 feet deep and screened in the Cedar Mesa Sandstone aquifer. No additional information, such as historical water quality or water use, is known about this well (NNDWR 2017).
- The second water well (Goulding) is located at the corner of Monument Valley Clinic Road and 5th Street (NNDWR 2017). No additional information about this well was found in the NNDWR database; however, the Goulding well is likely not screened in the alluvial aquifer because it was not included in the USGS study (USGS 1999).

- The spring/seep (08-UNK-0001) is identified in the NNDWR database as a "Developed Spring." The spring/seep is located at the base of a drainage in a side canyon on a different mesa that is southeast of the Mine Site. Based on visual observations, the spring/seep is likely located near the contact of the De Chelly Sandstone and the Organ Rock Shale. The spring/seep is ephemeral; however, it historically may have flowed more regularly because, at one time, concrete catchment improvements were made where the spring/seep daylights. The concrete catchment was in disrepair during RSE field visits. The spring/seep is likely connected to localized recharge. No additional details about this spring/seep are provided in the in NNDWR (2017) database.

2.8 Biological and Cultural Assessments

This RSE Report seeks to consider the Fundamental Law of the Diné with respect to inherent beliefs of members of the Navajo Nation and considers traditional ecological knowledge, which may include understanding the importance of plants, animals, landscapes, and natural phenomena, when possible. Before beginning fieldwork at the Mine Site, Cyprus Amax consulted with Navajo Nation governmental organizations responsible for stewardship of Navajo biological and cultural heritage, such as the Navajo Nation Historic Preservation Department (NNHPD) for cultural resources and the Navajo Nation Department of Fish and Wildlife (NNDFW) for biological resources.

2.8.1 Biological Assessment

Before beginning RSE fieldwork, Jacobs (on behalf of Cyprus Amax) consulted with NNDFW, which is responsible for stewardship of Navajo biological resources and heritage. NNDFW determined that the RSE sampling activities (hand tools, walking, and light vehicle traffic, including a small drill rig) would have minimal disturbance. The activities were not considered development; therefore, NNDFW did not require formal consultation with a biological evaluation. Jacobs was required to obtain an annual biological investigation permit. The biological assessments conducted for the Mine Site and BRAs were authorized by NNDFW under the following biological investigation permits and amendments (Appendix B):

1) Biological Investigation Permit Number 1095, issued June 16, 2017
2) Amendment to Permit Number 1095, issued March 30, 2018, to add Dan Fillipi as a sub-permittee
3) Biological Investigation Permit Number 1190, issued February 19, 2019
4) Amendment to Permit Number 1190, issued September 9, 2019, to change permittee to Morgan King

In accordance with the conditions of the biological investigation permit, biologists conducted a Navajo Natural Heritage Program (NNHP) resource review to identify special-status plant and wildlife species potentially present at the Mine Site. Special-status species are defined as those listed by federal Endangered Species Act (FESA) of 1973, as amended (FESA) (16 *United States Code* Section 1531 et seq.) or those listed by NNDFW Navajo Endangered Species List, and those species protected under the Migratory Bird Treaty Act (MBTA). The FESA requires federal agencies to seek to conserve endangered species, threatened species, and critical habitat, and through consultation with U.S. Fish and Wildlife Service, the primary implementing agency for FESA, ensure an action does not jeopardize the continued existence of species and their habitat (USFWS 1998).

Before conducting RSE fieldwork, Jacobs and Earth and Sky, LLC (Earth and Sky) biologists conducted pedestrian biological assessments of the Mine Site and BRAs with a focus on identifying potentially suitable habitat for special-status plant and wildlife species within the area. Surveys and biological monitoring of the Mine Site and BRA were conducted in September and October 2017, April and October 2018, and May 2019. The results of the biological assessment are presented in Appendix B.

Observations made by Jacobs' biologists during the biological investigation of the Mine Site and BRAs are summarized as follows:

- Vegetation
  - Two vegetation types were present at the Mine Site and BRA: pinyon-juniper woodland and Great Basin Desert scrub.

- Special-status Wildlife
  - Golden eagle (*Aquila chrysaetos*) and peregrine falcon (*Falco peregrinus anatum*) have been known to occur in the vicinity. Golden eagle nests were not observed in the vicinity of the BRA and Mine Site during field work. A peregrine falcon was incidentally observed during the biological investigation, but peregrine falcon nests were not observed. NNHP records are provided in Appendix B.
  - No other FESA or NNDFW special-status species were observed, but potentially suitable foraging and nesting habitat was present for ferruginous hawk (*Buteo regalis*).
- Special-status Plants
  - No FESA or NNDFW special-status plants were observed, but potentially suitable habitat was observed for Jones cycladenia (*Cycladenia humilis* var. *jonesii*).
- MBTA-protected Species
  - Active nests for wildlife protected by the MBTA were not observed, but three potentially active nests were observed outside the BRA and Mine Site.

2.8.2 Cultural Resources Assessment

Before performing RSE field activities, DCRM, with Jacobs' oversight, assessed cultural resources at the Mine Site and associated BRA. DCRM conducted the cultural resources investigation in compliance with Section 106 of the National Historic Preservation Act, Title 35 of the *Code of Federal Regulations* Part 800.

The cultural resources assessment included an archival literature search and interviews with local residents, workers, and local chapter officials, as well as a field survey. DCRM conducted a Class I literature search using archives of the NNHPD in Window Rock, Arizona, to capture previous survey data and previously recorded resources within 1 mile of the Mine Site. DCRM conducted a Class III intensive cultural resources survey under Navajo Antiquities Permit Number B17646 to identify prehistoric and historic cultural resources. Fieldwork for the surveys was conducted between October 20 and December 17, 2017, and step-out cultural surveys were conducted in October 2018. A crew of qualified archaeologists performed the field surveys by walking parallel transects, spaced at a maximum of 50-foot intervals, through the accessible areas of the Mine Site and buffer, and an additional 50-foot-wide buffer area. The crew surveyed drainages by walking 2 parallel transects, spaced 50 feet apart. DCRM prepared an archaeological inventory report and submitted it to NNHPD (DCRM 2018). The report detailed the results of the literature review and field survey, and lists cultural resources, eligible properties, non-eligible properties, and archaeological resources identified on the Mine Site and BRA. A Cultural Resource Compliance Form issued by NNHPD as approval of the archaeological inventory report lists the actions to be taken during the RSE investigation to respect and protect cultural sites, properties, and resources. The Cultural Resource Compliance Form is presented in Appendix B.

Ethnographic surveys conducted as part of the cultural resources assessment included interviews with local residents, workers, and local chapter officials and revealed that cables ran up to the Mine Site, and workers would lower uranium ore by cables and buckets/sacks. Although interviewees discussed multiple access routes to the Mine Site, none of them were observed during field visits except for a walking trail from the south side of the mesa (DCRM 2018).

3. Field Activities and Methods

Jacobs performed an RSE at the Mine Site to provide information to evaluate the DQOs that were developed using the processes described in U.S. EPA's DQOs process, according to *Guidance on Systematic Planning Using the Data Quality Objectives Process* (U.S. EPA 2006) and following DQO guidance from the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (U.S. EPA 2000). The DQO process is a series of logical and iterative steps that guide the plan for acquisition of environmental data. It is composed of the following steps:

1. **State the problem**. Define the problem to be studied. Review prior studies and existing information to gain an understanding sufficient to define the problem. Prepare problem statements.
2. **Identify the goal of the study**. Define the decisions to be made. Describe how environmental data will be used in meeting objectives and solving the problem, identify study questions, define what actions may result from each decision, and develop decision statements.
3. **Identify the information inputs**. Identify the data that must be obtained and the measurements that must be taken to answer the decision statements.
4. **Define the boundaries of the study**. Define the target population and characteristics of interest. Specify the temporal and spatial boundaries for which decisions will apply.
5. **Develop the analytical approach**. Define the parameter of interest, specify the project screening criteria, and develop the logic for drawing conclusions from findings.
6. **Develop performance criteria for data being collected**. Define tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.
7. **Optimize sampling design**. Evaluate information from the previous steps and develop the sampling design that meets the decision statements.

A further explanation of the DQO process and how it was used to develop the methodology for performing RSE activities was presented in the approved Work Plans (CH2M 2017a, 2018).

The following section presents DQOs that were developed for the RSE. A description is also provided of the type and quality of data that were collected to inform the DQOs and future environmental decisions and the methods for collecting and assessing those data.

3.1 Data Quality Objectives

The DQOs of the RSE work and the methodology used to evaluate each DQO, as described in the Work Plans (CH2M 2017a, 2018), includes:

1) Identify the background level of radiation and metal concentrations from naturally occurring materials at the Mine Site.
   - To evaluate this DQO, Jacobs identified one BRA for the Mine Site, conducted gamma scanning at the BRA to assess surface gamma count rates, and collected surface and subsurface soil samples for laboratory analysis of the primary COPCs in background, including arsenic, molybdenum, mercury, Ra-226, selenium, thorium, uranium, and vanadium. BTVs were calculated for gamma count rate and the primary COPCs to represent a typical background concentration for those parameters. Actual background conditions may vary based on the heterogeneity of the natural environment.
2) Determine the type and extent of affected environmental media, including surface soil, subsurface soil, and sediment.
   - Jacobs evaluated this DQO by collecting soil and sediment data at the Mine Site, associated haul road and drainages, and in step-out areas, as needed. Step-out areas are defined as areas outside of the Mine Site where gamma scans indicated count rates greater than the BTV. Data collection efforts included performing gamma scan surveys and collecting surface soil, subsurface soil, and sediment

samples for laboratory analysis of the primary COPCs. Surface soil was defined as 0 to 0.5 foot bgs, and subsurface soil was defined as below 0.5 foot bgs.

3) Determine if there is a correlation between Ra-226 soil concentration in surface soil with gamma scan survey results and dose rate following the methods presented in this RSE Report.

   – Jacobs evaluated this DQO by collecting gamma count rates, dose rates, and Ra-226 in surface soil samples from nine correlation plots at the Mine Site and statistically evaluating the data to determine the relationships between concentrations of Ra-226 in soil and gamma count rates, as well as gamma count rates and dose rates.

4) Identify if mining-related activities, such as blasting, machine maintenance and refueling, or use of electrical equipment, resulted in releases of explosives (including perchlorate), total petroleum hydrocarbons (TPH), or polychlorinated biphenyls (PCBs).

   – Jacobs evaluated evidence of mining-related activities at the Mine Site by collecting surface and subsurface soil samples. One surface soil sample was analyzed for secondary COPCs (explosives, including perchlorate, TPH, and PCBs), and a subsurface sample was collected, if secondary COPCs were detected in the surface soil sample.

5) Identify whether there is evidence that surface water and/or groundwater has been impacted by mining-related activities, if present and able to be sampled.

   – Jacobs reviewed water well inventories; performed a records search; and reviewed information provided by NNEPA, U.S. EPA, and NNDOJ, as well as conducted field reconnaissance to evaluate potential sources of groundwater and surface water and their suitability for sampling. Jacobs collected groundwater samples from two water wells that met the criteria set forth in the approved Work Plans and analyzed the samples for the primary COPCs as well as additional changes to the COPC list requested by U.S. EPA (U.S. EPA 2018). U.S. EPA requested that nitrates be removed from the water sampling COPC list and metals be sampled for both total and dissolved fractions. Water samples were also analyzed for aluminum, boron, iron, lithium, manganese, magnesium, potassium, phosphorous, strontium, uranium isotopes, potassium-40, lead-210, alkalinity, and flow (if any).

6) Estimate the area and volume of mining-impacted material, including TENORM at the Mine Site.

   – Multiple lines of evidence were obtained and used for the Mine Site to determine the nature and extent of contamination, understand potential fate and transport pathways, and estimate the volume of mining-impacted material, including TENORM. The multiple lines of evidence included reviewing historical activities, including reclamation; conducting interviews with residents and consultation with NAML staff; reviewing historical and current aerial photographs; analyzing geologic stratigraphy, hydrogeology, and hydrology; identifying prominent wind direction; conducting visual observations of disturbed areas for evidence of historical mining; and conducting a field investigation, including gamma scanning measurements, along with surface and subsurface soil sample analysis.

3.2 Accessibility

As discussed in the approved Work Plans, during the fall 2017 field season, a safe way to access the top of the mesa at the Mine Site was not observed. Cyprus Amax was able to access the top of the mesa on January 26, 2018 with NAML and on June 6, 2019, with U.S. EPA and NNEPA to document the conditions and perform a qualitative assessment of the area. During the June 2019 visit, USEPA and NNEPA reaffirmed their agreement with the assessment that further attempts to access the mesa top would not be required due to the health and safety concerns. Because attempts to access the top of the mesa for sampling would present an unacceptable level of risk to field workers, U.S. EPA and NNEPA agreed that Cyprus Amax would not be required to conduct field work at these inaccessible areas. Additional assessment may be required in the future, if a safe and accessible route is established or technology becomes available to allow for remote assessment of the areas.

The portion of the Mine Site in the valley floor is accessed by parking along one of the dirt paths near Oljato Road and hiking approximately 0.25 mile southwest to the Mine Site. Most of this area is accessible; however, steep scree slopes with large boulders impeded assessment at several locations at the base of the cliff.

3.3 RSE Field Observations

As part of RSE field activities, Jacobs performed, observed, and documented the following at the Mine Site. A summary of these observations is provided in Section 3.3.1, except where noted.

- Verification of the location and attributes of historically documented mine features, such as portals, shafts, and vents. Many historical mine features could not be accurately located because geographic information system (GIS) coordinates provided in historical documents have poor accuracy due to limitations of GIS technology (low resolution) at the time of collection. Natural erosion forces have contoured the Mine Site, which may have obscured many of these features from being located. Additionally, NAML generally reclaimed features such that they blend with the surrounding landscape; as such, field observations may not match with pre-reclamation NAML records.
- Current conditions at the Mine Site, including mine-related features, such as portals, waste rock piles, and haul roads.
- Documentation of visual waste rock. Waste rock was visually identified in the field during RSE field activities. Waste rock typically resembled a gray, fine-grained sand with elevated gamma count rates.
- Documentation of disturbed areas. Disturbed areas were documented as areas outside of known mining and reclamation areas. Areas associated with historical mining or reclamation, such as roads, waste rock piles, and portals were considered to be disturbed and were not separately documented as such.
- Surface water flow pathways, including drainages.
- Areas of shallow bedrock. Shallow bedrock mapping was conducted using a combination of field observations and aerial images. Shallow bedrock is defined as areas where bedrock is visually exposed at the surface and soil mantle consists of less than 6 inches. A Mine Site-specific shallow bedrock map is shown on Figure 2-11.
- Geologic contacts.
- An interim action was conducted by Cyprus Amax at the request of the U.S. EPA and NNEPA to address potential chemical concerns at the Mine Site. The interim action, conducted from October 25 through November 3, 2021, consisted of construction of an 8-foot-high, 415-foot-long chain-link fence located north of the Mine Site and around the area near sample location 32-MS-010. The fence construction followed the approved Rock Door No. 1 Fencing Work Plan (Jacobs 2021). The boundaries of the fence are presented on Figure 2-1.
- Descriptions of Mine Site-specific features.

3.3.1 Summary of RSE Field Observations

RSE activities conducted by Jacobs personnel from September 2017 through October 2019 observed mining and reclamation features at the Mine Site. Field documentation of the features can be found in Appendix C. The observed mining features are presented in Figure 2-1 and discussed as follows:

- Jacobs personnel observed two of the three NAML reclaimed portals on a field visit with NAML on January 26, 2018 to the top of the mesa. The two observed portals were sealed with an outer stack of natural rock to blend in with the surroundings. Photos of the portals are included in Appendix C. The NAML rim strip was not identified during the RSE investigation.
- During RSE activities, a flattened-out area on one of the scree slopes in the valley floor was observed and may be the location of a potential loadout area for the reported cable and bucket/sack system, but this area is unconfirmed in literature, historical photographs, and interviews. Evidence of the cable and bucket/sack system was not observed in the field and is presumed to have been abandoned and removed after mining ceased. The potential loadout area for the cable and bucket/sack system on the valley floor was approximately 700 feet lower in elevation from the former portals and approximately 400 feet north-northeast from the base of the cliff face beneath the former portals.
- A potential haul road (Haul Road 1) was observed leading away from the potential loadout area to the northeast. The potential haul road leads to Oljato Road (Figure 2-1).

- During RSE field activities conducted between November 6 and 11, 2017, a trash dump was observed along Haul Road 1 and the bottom of Drainage 7 (Figure 2-1). The trash dump was observed to contain rubber tires, paint cans, broken glass bottles, car parts, an electrical panel, and various household appliances. In review of Google Earth imagery from October 2011, May 2013, and March 2016, it appears that the trash dump was first evident in May 2013 and is therefore not mining related (CH2M 2017b). DCRM interviewed several nearby residents who indicated that the trash was dumped recently by a local person and Oljato Chapter officials were aware of the issue.
- In addition to the trash contents, a damaged, rusted drum that appeared to have contained a hard black material and burned wood was also observed. The drum and its contents were scattered around on the ground surface near the haul road and Drainage 7 (Figure 2-1).
- During a site visit conducted by NAML and Cyprus Amax on January 26, 2018, NAML verbally reported the potential for waste rock to be over the edge of the mesa. During a site visit by U.S. EPA, NNEPA, and Cyprus Amax on June 6, 2019, an area of scattered waste rock was observed (0.002 acre) on the top of the mesa (Figure 3-1). Gamma scan surveys collected from the top of the mesa ranged from less than the BTV (11100 cpm) to a maximum of 110298 cpm. The maximum count rate was located in the area of waste rock scattered on the surface of the bedrock. The gamma count rates presented on Figure 3-1 are usable for screening purposes only because the data were not collected using the methodology set forth in the approved Work Plan (CH2M 2017a). Within the area of scattered waste rock, a hard black material and burned wood was observed. Photographs of the hard black material and burned wood are presented in Appendix C. No waste rock was observed on the valley floor.
- Six drainages were identified in the Work Plans for the Mine Site (Figure 2-1). A seventh drainage was identified in the field within the area of the trash dump. These drainages flow to the north-northeast and travel for short distances before dispersing into the flat plains below the colluvium.
- No water was observed flowing through these drainages during RSE activities.
- Jacobs conducted shallow bedrock mapping on the Mine Site, drainages, and haul road to identify where exposed bedrock was present and minimal soil mantle existed (Figure 2-11). Bedrock mapping was conducted using a combination of field observations and aerial images. Shallow bedrock is defined as areas where bedrock is visually exposed at the surface, and soil mantel consists of less than 6 inches. This map is meant to provide a generalized representation of the exposed bedrock around the Mine Site and small exposures of the bedrock may not be included.
- Geologic contacts were observed in the field to match the information presented in Section 2.7.2.

3.4 Background Reference Areas

Gamma scanning and soil characterization samples from one BRA were collected to determine background conditions for the Mine Site. Section 2.2 of MARSSIM (U.S. EPA 2000) defines a BRA as “a geographical area from which representative reference measurements are collected for comparison with measurements performed in specific survey units. The BRA is defined as an area that has similar physical, chemical, radiological, and biological characteristics as the survey unit(s) being investigated but has not been affected by site activities.” Investigation of the BRA was designed to evaluate the naturally occurring background radiation and metal concentrations for comparison to the Mine Site.

The original BRA selected for the Chinle Formation in September 2017 was not representative of accessible areas of the Mine Site and valley floor and the data were not usable. Therefore, Jacobs established a new BRA upon approval from the U.S. EPA, within the colluvium and on a scree slope within the Cutler Formation (Figure 1-3). The BRA was selected as described in the approved Work Plans (CH2M 2017a, 2018) to characterize the predominant geologic formation from which gamma scan surveys and soil analytical samples were collected at the Mine Site. The new BRA consisted of colluvial material from overlying strata (Cutler, Moenkopi, and Chinle Formations), according to U.S. Geological Survey (USGS) geologic maps (Figure 2-9) and was field-verified to be more representative of the accessible portions of the Mine Site being investigated (that is, the valley floor consisting of scree colluvium). The colluvial material ranged in size from silts to boulders. The BRA was also located upgradient of the Mine Site and unassociated nearby mine sites.

The BRA for the Mine Site aligns well with the geologic unit boundaries presented on the Cooley et al. (1969) geologic map (Figure 2-9). Geologic maps provide a general sense of the large-scale geology and should not necessarily be used for fine-scale interpretation. Geologic maps were created based on professional approximation of largescale geologic units, contacts, and structures by the map authors (Cooley et al. 1969), which are accurate for use at the scale (1:125,000) the map is published. However, the geologic boundaries become more qualitative when the area to be investigated has not been extensively mapped or field validated. Jacobs field crews preformed field verification of the BRA before evaluation.

3.4.1 Gamma Scan Survey

In June 2019, Jacobs performed gamma scan surveys at the BRA to provide data to calculate BTVs for naturally occurring radiation in soils similar to those found at the Mine Site. BTVs were used to establish the boundary of the scanned area at the Mine Site. Before the field characterization work was performed, the approximately 2-acre BRA was selected, and a grid separating the area into 25 predetermined, equally sized cells were uploaded to the Environmental Restoration Group (ERG) Model 105G handheld global positioning system (GPS) system.

Gamma scan surveys were performed in accordance with the RSE Work Plans (CH2M 2017a, 2018). For the gamma scan surveys, a Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) gamma scintillation detector connected to a Ludlum Model 2221 scaler/ratemeter, coupled with an ERG Model 105G handheld GPS system for automated data logging, was used to collect survey measurements. Gamma scan geolocated data were collected in Universal Transverse Mercator Zone 12 North coordinate system.

The Ludlum Model 44-10 detects gamma radiation in the soil from approximately 50 to 3,000 kiloelectron volts, which includes gamma radiation emitted from bismuth-214 (Bi-214) and lead-214 (Pb-214), which are the primary gamma-emitting radionuclides in the uranium series. These radionuclides are decay products of Ra-226.

Background gamma scan surveys were traversed at 7.5-foot transects at a rate of 2 to 3 feet per second, holding the detector 18 inches above the ground surface with the detector in a vertical position pointing toward the ground. Individual gamma count rate measurements and associated geolocations were recorded once every second. If obstructions or inaccessible areas were encountered (such as large boulders), field personal paused the gamma scanning and/or walked around the obstacle, and continued gamma scanning on the other side. Guidance from MARSSIM (U.S. EPA 2000) and NUREG-1507 (U.S. Nuclear Regulatory Commission 1995) were used to establish a scan minimum detectable concentration (MDC) for the NaI detection system. The 2-inch by 2-inch sodium iodide (NaI) detector was used on this project as an investigation tool to measure gamma radiation levels relative to background. The approximate detection sensitivity for Ra-226 with a 2-inch by 2-inch NaI gamma scintillation detector under the conditions described is 1.58 picocurie(s) per gram (pCi/g) as calculated in the RSE Work Plans (CH2M 2017a, 2018). Additionally, an estimate of the minimum detectable count rate (MDCR) and scan MDC in pCi/g in soil is provided as follows.

The MARSSIM framework is used to calculate the a priori MDCR and scan MDC using the following equations:

$$MDCR = S_i\left(\frac{60}{i}\right)$$

$$S_i = d'\sqrt{b_i}$$

Where:

MDCR = minimum detectable count rate (cpm)

S_i (counts) = the minimal number of net source counts required for a specified level of performance for the counting interval *i* (seconds)

i = counting or observation interval, equal to 1 second for this calculation *d′* = the index of sensitivity, equal to 1.38 for a true positive rate of 0.95 and a false positive rate of 0.60 (from MARSSIM Table 6.5)

b_i = the number of background counts, taken from the mean value of the representative BRAs (that is, Morrison Formation) measured in the Cove Draft RSE (Jacobs 2019, Table 4-1) in the 1 second interval (approximately 2 to 3 feet per second scan speed), equal to 10967 cpm or 182.8 counts per second

Therefore, the MDCR is calculated as follows:

$$MDCR = d'\sqrt{b_i}\left(\frac{60}{i}\right) = 1.38\sqrt{(182.8)}\left(\frac{60}{1}\right) = 1{,}119\ cpm$$

The $MDCR_{Surveyor}$ is then calculated using the following equation to account for potential surveyor error in survey performance:

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}}$$

Where:

MDCR = minimum detectable count rate (cpm)

p = surveyor efficiency, estimated in MARSSIM to be between 0.5 and 0.75, but use of electronic data logging equipment is estimated to increase the surveyor efficiency to 0.9

Therefore, the $MDCR_{Surveyor}$ is calculated as follows:

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}} = \frac{1{,}119}{\sqrt{0.9}} = 1{,}180\ cpm$$

To determine the scan MDC in units of pCi/g, the relationship of count rate to exposure rate for the detector must first be established. MARSSIM Table 6.7 identifies the ratio of 760 cpm/ µR/hr for a 2-inch by 2-inch NaI detector for measurement of Ra-226 in equilibrium in progeny (U.S. EPA 2000). The minimum detectable exposure rate (MDER) is then calculated as follows:

$$MDER = \frac{MDCR_{Surveyor}}{Count\ Rate\ to\ Exposure\ Rate\ Ratio} = \frac{1{,}180\ cpm}{760\,\frac{cpm}{\mu R/hr}} = 1.55\ \mu R/hr$$

Based on these calculations, the scan MDC can be calculated as follows using a conversion factor from pCi/g to µR/hr of 1.017 from Microshield (a photon/gamma ray shielding and dose assessment computer program) as recommended by NUREG 1507 (NRC 1998):

$$Scan\ MDC = MDER \times Conversion\ Factor = 1.55\ \mu R/hr \times 1.017\frac{pCi/g}{\mu R/hr} = 1.58\ pCi/g$$

Gamma scanning logs captured the location, date and time, personnel, and equipment serial number used for scanning (Appendix C). Gamma scanning continued until the full background area was completed, and the results were used to calculate gamma count rate BTVs. Gamma scan data were uploaded daily to a computer and secure server.

3.4.2 Soil Sampling

BRA surface soil sampling was conducted in June 2019, and subsurface sampling was conducted in October 2019. BRA surface soil (0 to 0.5 foot bgs) sample locations were selected in real time by field sampling personnel at a frequency of 1 location within each of the predetermined 25 cells. The sample location was selected within each of the 25 grids at a location safely accessible and where soil thicknesses were deep enough to allow for soil sampling. A dose rate measurement and a 1-minute static gamma count were also recorded at each surface soil sample location. The dose rate measurement was collected at 3 feet above ground surface, while the static gamma count was collected at 18 inches above ground surface. Dose rates were recorded with a Bicron MicroREM tissue-equivalent plastic scintillation detector, and the static gamma count was recorded with a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector. The detector was connected to a Ludlum Model 2221 scaler/ratemeter. Readings are included in the characterization surface soil sampling logs in Appendix C. The static gamma counts were performed for consistency with the Mine Site soil samples and provide general information on the radiological conditions at each sample location; however, these field measurements were not used to develop a BTV or for any other purpose at this time.

During the October 2019 sampling events, three subsurface soil samples were collected from areas that corresponded with the minimum, maximum, and mean concentrations of Ra-226 in surface soil. BRA surface soil samples were collected using a hand trowel, while subsurface soil sampling was conducted using hand tools, including hand trowels, shovel, hand auger, and/or powered hammer drill, in accordance with the approved Work Plans (CH2M 2017a, 2018). The soil samples were logged according to Unified Soil Classification System (USCS) methods (ASTM 2017) and Munsell color chart, then placed into unpreserved and unused sample jars, and labeled with the sample identification, date, and time.

Additionally, photographs were taken of the filled sample jars and the surrounding vicinity, and submeter accuracy GPS coordinates were collected at the sample location. Filled soil samples were packaged and shipped to ALS Environmental Laboratories in Fort Collins, Colorado, under the appropriate chain of custody. Each surface and subsurface soil sample was analyzed for the primary COPCs, which included Ra-226 by U.S. EPA Method 901.1 and metals (arsenic, vanadium, molybdenum, selenium, thorium, uranium, and mercury) by U.S. EPA Methods 6020 and 7471A. Soil samples were digested according to U.S. EPA Method 3050B before the analysis of metals by U.S. EPA Method 6020, and the analysis of mercury was performed after digestion of soil according to U.S. EPA Method 7471. Analytical results for the background surface soil samples were used to calculate BTVs for COPCs in soil. Analytical laboratory results are presented in Appendix D.

3.5 Background Threshold Values and Investigation Levels

The methodology for calculating the BTVs and ILs was set forth in the approved Work Plans (CH2M 2017a, 2018) and are discussed in the following subsections.

3.5.1 Background Threshold Values

Because metals and Ra-226 are naturally present in soil, it is necessary to evaluate the concentrations of both in naturally occurring environmental media so that an evaluation of potential impacts from historical activities can be quantified. Both the tolerance limits (UTL95-95) and the upper simultaneous limits (USL95) were used to estimate potential BTVs. The ProUCL Technical Guide (U.S. EPA 2015) recommends using the USL95 to estimate BTVs because it provides a proper balance between false positives and false negatives. However, the USL95 should be used only when raw background data represent a single environmental population without statistical outliers. The inclusion of multiple populations and/or statistical outliers tends to yield elevated values of USLs, which can result in substantial false negatives. The UTL95-95 is alternatively recommended in cases with statistical outliers. Therefore, the following stepwise procedure was used to estimate BTVs for background data:

1) Conduct exploratory data analyses using background data, while ensuring statistical independency and no significant spatial variability.
2) Identify potential outliers and conduct confirmatory outlier tests using both parametric and nonparametric methods.
3) Conduct goodness of fit tests to characterize an appropriate distribution.
4) Two approaches (parametric and nonparametric) were used to determine BTVs based upon the distributional characteristics of a given background data set. If the background data can be characterized by a well-known distribution, a parametric method was used to estimate BTVs; otherwise, a nonparametric method was used to estimate BTVs.

5) If the raw background data set did not include statistical outliers, the USL95 was used to determine BTVs; otherwise, the UTL95-95 was used to estimate BTVs. The USL95 or the UTL 95-95 were dependent upon the presence of statistical outliers. Additional information on background statistics are provided in Appendix E.

3.5.2 Investigation Levels

ILs for metals and Ra-226 are defined as the greater of the BTV and U.S. EPA RSLs. RSLs are not available for Ra-226 and thorium; therefore, the BTVs for these contaminants were used as the ILs. For secondary COPCs, the ILs were set at the U.S. EPA RSLs because these constituents are not naturally found in the environment and therefore have no background value. ILs were used to identify locations of “elevated” gamma count rates or soil COPC concentrations. For gamma scanning, the IL was used as a field screening level to inform the field team when to stop scanning or sampling. In accordance with the approved Work Plans (CH2M 2017a, 2018), the IL for lateral extent was set at the applicable BTV plus 1500 cpm; for vertical extent, the IL was set at 2 times the applicable BTV.

ILs were developed to provide a preliminary evaluation of the investigation results and are not the levels that will define the extent of media to be cleaned up. The exceedance of an IL does not indicate there is a risk to human health or the environment. If U.S. EPA determines an EE/CA is needed, then cleanup levels will be established during the risk assessment and EE/CA process, which considers human and ecological risk.

3.6 Mine Site – Gamma Scan Surveys

Jacobs performed gamma scan surveys at the Mine Site in November 2017 and step-out gamma scan surveys were conducted in May 2018 and October 2019 (Appendix C).

Gamma scan surveys were used for the following:

- To determine the lateral extent of elevated gamma count rates
- To determine locations where potential stepout gamma scanning and soil sampling were required
- To determine potential contaminant migration off the Mine Site (for example, from runoff or wind)
- To determine locations of potential waste rock
- To determine areas with naturally occurring but elevated radiation levels
- To determine soil sample locations

As with the BRA gamma scan surveys, a Ludlum Model 44-10 2-inch by 2-inch NaI gamma scintillation detector connected to a Ludlum Model 2221 scaler/ratemeter, coupled with an ERG Model 105G handheld GPS system for automated data logging, was used to collect survey measurements. The equipment was inspected and calibrated by an accredited facility before use (Appendix C). Gamma scanning was conducted as described in Section 3.4.1, in accordance with the approved Work Plans (CH2M 2017a, 2018). Quality assurance/quality control (QA/QC) checks of each instrument were performed daily as described in Section 3.12. Multiple identical radiation detection systems were used for the surveys performed. The radiation detection equipment, while exhibiting minor differences, were within the tolerances allowed under instrumentation calibration described in American National Standards Institute (ANSI) N323AB.

Gamma scan surveys were conducted along 15-foot transects over the Mine Site, which included the buffer area. The 15-foot transects were laid out in GIS and loaded onto the ERG Model 105G handheld GPS system for field personnel to follow while conducting the gamma scan survey. If the gamma count rates were above the IL at the edge of the Mine Site buffer, then gamma scanning continued outside of the Mine Site buffer until gamma count rates were consistently less than the IL or it was determined that naturally occurring materials were biasing gamma count rates, such as slopes or drainages with large quantities of eroded and weathered ore-bearing bedrock. The 15-foot traverses are estimated to provide 40 percent coverage with the detector held at 18 inches above ground surface.

For drainages, gamma scanning was performed along each side of the drainage, centerline of the drainage (sinusoidal wave pattern), and approximately 8 feet away from both sides of the drainage. The scanning of the drainages started at the buffer and continued downstream until gamma count rates were consistently less than the IL. If needed, step-out gamma scanning was completed outside the drainages until gamma count rates were consistently less than the IL or it was determined that naturally occurring materials were biasing gamma count rates, such as drainage geometry or significant quantities of eroded and weathered ore-bearing bedrock. Because Drainage 7 was located within an area where trash had recently been dumped (unrelated to historical mining activities), it was initially excluded from gamma scanning. When it was determined that a portion of the drainage may be downgradient of the former loadout of the cable and bucket/sack system, this portion of Drainage 7 was scanned.

At the former haul road, gamma scan surveys were conducted along the shoulders, centerline (sinusoidal wave pattern between the shoulders), and 8 feet away from each shoulder. The scanning of the former haul road started at the Mine Site buffer and continued to the intersection with another roadway. If needed, step-out gamma scan surveys were completed outside the former haul road until gamma count rates were consistently less than the IL or it was determined that naturally occurring materials such as the presence of bedrock were biasing the gamma count rates.

3.7 Soil and Sediment Characterization

Soil and sediment sampling were performed according to the approved Work Plans (CH2M 2017a, 2018). Gamma scan surveys and observed and reported feature locations were used to select surface soil and sediment sample locations to provide field information about the extent of radiological impacts at the Mine Site. Following receipt of the surface soil and sediment laboratory data, which could take up to 2 months, the data were reviewed to determine where subsurface soil and sediment samples would be collected to define the vertical extent of potentially impacted soil. The approved RSE Work Plan Addendum (CH2M 2018) summarizes the method for collecting subsurface soil and sediment samples.

Surface and subsurface soil and sediment samples were conducted in November 2017, May 2018, June 2018, and October 2019 to characterize the extent of COPCs. Surface soil and sediment samples were initially collected in November 2017. The analytical results from the November 2017 sampling event were used to determine the locations for collection of subsurface soil samples during the May and June 2018 sampling events. A third surface and subsurface soil sampling event was performed in October 2019.

The following subsections summarize the field sample methods, soil field screening methods, and laboratory analysis.

3.7.1 Surface Soil and Sediment Sampling

Surface soil and sediment samples were collected according to the approved Work Plans (CH2M 2017a, 2018). Surface soil and sediment samples were characterized as being collected from 0 to 6 inches bgs. Samples collected from within drainages were designated as sediment samples. Sample locations were selected based on the gamma scan surveys conducted at the Mine Site. Surface soil and sediment samples were placed in areas with gamma count rates greater than the IL, in areas downgradient of elevated gamma count rates, and in areas to provide adequate spatial coverage. The gamma scan surveys were also used to determine the acreage of accessible areas at the Mine Site, drainages, and the former haul roads, which was used to calculate the total number of samples to be collected. Two surface soil samples were collected for each accessible acre within the Mine Site and buffer area in accordance with the approved Work Plans (CH2M 2017a, 2018). Likewise, for each accessible mile of drainage, 12 surface sediment samples were collected; for haul roads, samples were collected at a frequency of 4 surface soil samples per mile. During the RSE process, U.S. EPA and NNEPA requested additional samples to be added to the sampling plan.

At each soil and sediment sample location, a dose rate measurement, and a 1-minute static gamma count weas collected, recorded, and analyzed following the methods prescribed in Section 3.4.2. Each surface soil sample was analyzed for the primary COPCs. One location was selected for secondary COPC analysis, including TPH by U.S. EPA Method 8015, PCBs by U.S. EPA Method 8082, explosives by U.S. EPA Method 8330, and perchlorate by U.S. EPA Method 6850. As described in the approved Work Plans, the secondary COPC soil sample location was selected at the observed portal or from an area with the highest recorded static gamma count. At the Mine Site, because the portals were inaccessible, the secondary COPC surface soil sample was collected from the area with the highest gamma count rate was chosen (CH2M 2017a, 2018).

3.7.2 Subsurface Soil and Sediment Sampling

Subsurface soil and sediment samples were collected according to the approved Work Plans (CH2M 2017a, 2018). Surface soil and sediment locations with primary COPC concentrations that exceeded applicable ILs were identified as potential subsurface sample locations to inform the horizontal and vertical delineation of potential impacts on soil and sediment. Subsurface soil and sediment locations were selected to delineate areas around higher concentrations of primary COPCs, detections of secondary COPCs, and areas around buried and exposed waste rock and other mine features, including locations downgradient of these areas (such as drainages). Subsurface soil and sediment sample locations were also selected to provide adequate spatial coverage of the Mine Site and drainages.

Subsurface samples were generally co-located with previously collected surface sample locations; however, if a surface sample was not collected previously at a location, a surface soil or sediment sample was collected from 0 to 0.5 foot bgs. Subsurface hand tool samples were collected from 1.0 to 1.5 foot bgs and 3.0 to 3.5 foot bgs intervals, unless refusal or bedrock was encountered. If refusal was encountered, up to two additional borings within 2 feet of the original location were attempted. Where bedrock or refusal was encountered, samples were collected from the 0.5 foot bgs interval directly above bedrock or refusal unless the interval was previously sampled. If the static gamma count rate at the 3.0 to 3.5 foot bgs interval exceeded 2 times the IL or waste rock was observed, soil sampling continued in 2-foot depth intervals (5 to 5.5 feet bgs, 7 to 7.5 feet bgs, etc.) until the static gamma count rates was less than 2 times the IL and no waste rock was observed, or until bedrock or refusal was encountered.

Subsurface soil sampling was conducted using either hand tools or a drill rig. For areas outside of identified waste rock piles or if the area was not accessible by the drill rig, subsurface soil and sediment samples were collected using hand tools. Hand tools included a hand auger, shovel, breaker bar, hand-operated hammer drill, and/or hand trowels. If accessible, subsurface soil along the haul road and loadout area was collected with a drill rig. The drill rig used for sampling was a GeoProbe 6620DT direct-push rig with a MacroCore 2.00- or 2.25-inch-diameter core barrel with standard drive point and sand catchers. Drill rig cores were collected in clean, unused acetate liners. Drill rig subsurface soil sample intervals span a 1-foot interval, whereas hand tool sample intervals span a 0.5-foot interval. This change was required to provide adequate sample volume for laboratory analysis. Initial drill rig borings were pushed to 5 feet bgs unless refusal or bedrock was encountered. Drill rig samples were collected from 1 to 2 feet bgs and from 3 to 4 feet bgs. If the static gamma count rate at the 3 to 4 foot bgs interval exceeded 2 times the IL or waste rock was observed, soil sampling continued in 2-foot depth intervals (5 to 6 feet bgs, 7 to 8 feet bgs, etc.) until a gamma count rate less than 2 times the IL and no waste rock was observed, or until bedrock or refusal was encountered.

Subsurface soil collection methods followed the approved Work Plans (CH2M 2017a, 2018). Subsurface samples were logged according to USCS methods and Munsell color chart and if observed, waste rock was recorded in the soil boring logs (Appendix C). A gamma scan survey of the sample core was conducted approximately 1 inch above the sample at 6-inch intervals over the length of the core (drill rig sampling only). Gamma count rates were conducted with the sample core on the level tailgate of the field truck or folding table in an area at or less than background radiation levels using a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector connected to a Ludlum Model 2221 scaler/ratemeter. The gamma count rates were recorded in the boring logs in Appendix C. Professional judgment either by geologist or other trained personnel was used to identify waste rock during sampling. Visible waste rock (if present) was recorded on the field form and typically presents as a gray, fine-grained sand with elevated gamma scan measurement. Because visible waste rock can vary in appearance, professional judgment either by a geologist or other trained personnel was used to identify waste rock during sampling.

The soil sample was placed into a new, unpreserved sample jar and labeled with the sample identification, date, and time. A 1-minute static gamma count was conducted on the filled sample jar in an area where radiation levels were at or less than gamma IL. Measurements were performed by removing the sample jar lid and holding the sample jar approximately 3 feet above ground surface with the Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector approximately 1 inch above the sample. Because of the different collection methods, it is not appropriate to compare gamma count rates recorded from subsurface soil samples with surface soil sample gamma count rates or gamma scan surveys results.

Photographs were taken of the drill core, filled sample jars, and surrounding vicinity of the sample location. Submeter accuracy GPS coordinates were collected at the sample location and recorded. Samples were packaged and shipped to ALS Environmental Laboratories in Fort Collins, Colorado, for analysis. Each surface soil or sediment sample was analyzed for the primary COPCs. If secondary COPCs were detected in the surface sample, a subsurface soil sample was collected from 1.0 to 1.5 feet bgs at that location and analyzed only for those secondary COPCs that were detected.

3.8 Surface Water and Groundwater

An attempt to collect samples at the two water wells (Goulding and 08K-418) and one spring/seep location (08-UNK-001) occurred in June 2018. The spring could not be sampled, because it was dry when observed. Groundwater samples were collected from the two wells and were analyzed for the primary COPCs specified for water in the CD (Section 4.3b), which include the primary soil COPCs plus Ra-228, gross alpha, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, silver, thallium, and zinc. The groundwater samples also were analyzed for total dissolved solids, anions (carbonate, bicarbonate, chloride, and sulfate), cations (sodium and calcium), and field parameters (including pH, conductivity, turbidity, temperature, and oxidation-reduction potential [ORP]), as required under the CD. Salinity was not analyzed in the field, because the portable multiparameter water quality meter did not analyze for salinity. Instead, salinity was calculated using specific conductance and temperature (Fofonoff and Millard 1983), which is a deviation from the Work Plan. Sample locations were recorded using a handheld submeter accuracy GPS unit.

As stated in the Work Plans and at the request of U.S. EPA, the list of COPCs for water was amended (U.S. EPA 2018). Nitrates were removed from the COPC list for water, and additional COPCs were added were analyzed for both total and dissolved metals as well as aluminum, boron, iron, lithium, manganese, magnesium, potassium, phosphorous, strontium, uranium isotopes (uranium-234, uranium-235, and uranium-238), potassium-40, lead-210, and alkalinity.

Surface water drainages at the Mine Site are ephemeral. No water was observed in the drainages during the June 2018 sampling event, so no samples were collected. Additionally, Jacobs has routinely visited the Mine Site during each of the four seasons since work began in 2017 and has never observed water in the drainages at the Mine Site.

3.9 Correlation Studies

A correlation study was performed at the Mine Site by comparing dose rate measurements (in microrem per hour [µrem/hr]), gamma count rate (in cpm), and Ra-226 soil concentration (in pCi/g) in soil. From these data, two correlations were derived. One correlation compared gamma count rates to Ra-226 concentrations (Ra-226 correlation); the other correlation compared gamma count rates to dose rates (dose rate correlation).

The purpose of the Ra-226 correlation was to provide a way for potential future response action to estimate Ra-226 concentrations in surface soil by using walkover gamma count rate data in locations where soil and sediment samples were not collected. This estimate would then be used as a line of evidence to estimate the lateral extent of impacted areas. The relationship between the gamma count rate and Ra-226 surface soil concentrations can exhibit both linear and nonlinear characteristics depending on the site (Whicker et al. 2008). Therefore, a number of different regression models was assessed to determine which model was most representative of the conditions for the Mine Site. The relationship can be skewed because of the heterogeneity of soil, instrumentation uncertainty, and input from other gamma-emitting radionuclides (for example, thorium or potassium-40) present in soil. Input from other sources can often disproportionately influence the correlation at the lowest range of activities because the ratio of gamma radiation from other sources is higher in relation to gamma radiation from Ra-226 in soil. Jacobs designed the correlation to target lower gamma count rates (typically between background and approximately 25000 cpm) to allow for evaluation of Ra-226 concentration ranges useful for response action decision-making (estimated between 1 to 10 pCi/g).

The purpose of the dose rate correlation was not explicitly defined in the SOW and was developed at the request of U.S. EPA (2017). The dose rate correlation could be used to allow a common, instrument independent basis of comparison for evaluations with future gamma scanning, which may use different gamma survey instruments, configurations, or measurement technologies. Gamma count rates measured by NaI detectors are highly energy dependent. A correlation using an instrument that does not exhibit strong energy dependence, provides a way to express gamma count rate in terms of dose rate. A Bicron MicroREM meter was used for the dose rate correlation.

To perform the correlations, the field team, in consultation with a radiation health physicist, selected 9 plots approximately 30 feet by 30 feet to focus on low (close to background) and medium gamma count rates to represent the desired Ra-226 concentrations. However, the exact shape and size of each correlation plot was determined in the field to achieve homogenous gamma count rates. Correlation plots were selected in areas with gamma homogeneity and away from geometric conditions, such as pits, holes, or trenches, that could skew the gamma count rate relative to Ra-226 concentrations in surface soil and dose rate. As a preliminary indication of homogeneity, five equally spaced points were selected within the plot, and a 1-minute static gamma count was collected at each point. If the variability of the static counts was narrow (for example, less than approximately 3000 cpm) the correlation plot was determined usable, soil samples were collected, and a gamma scan of the plot was conducted. Higher gamma counts had more tolerance for variability (for example, less than approximately 5000 cpm) was allowed for correlation plots in the higher range of gamma count rates. If the range of the static counts exceeded the tolerance for variability, the correlation plot was discarded, and an additional plot was evaluated based on a review of field gamma scans. To minimize inconsistencies between correlation plots, the same field operator and the same radiation detection equipment were used for each correlation plot at the Mine Site.

Only nine correlation plots were selected for the Mine Site. This is because only a small area of the Mine Site was accessible and the valley floor is a heterogenous environment, characterized by boulders and other large erosional soils. Field gamma scanning revealed that elevated gamma count rates were often from rocks or erosional material too big to be sampled. Therefore, it was necessary to focus on plots that had consistently low gamma count rates and soil particles that could be sampled (that is, less than 0.25 inch in diameter). Only nine plots were identified that satisfied these criteria, all of which had relatively low gamma count rates. U.S. EPA agreed with this approach.

The following data were collected at each correlation plot:

1) A continuous gamma scan survey consisting of consecutive 1-second integrated counts was conducted for the correlation plot area. The gamma scan survey was performed with approximately 3-foot transects to provide high-density measurements. The same scanning speed of 2 to 3 feet per second and average height geometry of 18 inches above ground surface used for all other RSE gamma surveys was maintained. The average of the gamma count rate from the survey was computed and reported as a single value for each plot.
2) A single dose rate measurement, consisting of a user-interpreted reading of the analog dial of the Bicron MicroREM, was performed at the center of the five-point dice pattern to obtain a dose rate representative of the plot area. The measurement was performed with the waist-height geometry of 3 feet above ground surface.
3) At each of the five locations, a surface soil aliquot from 0 to 0.5-foot bgs and a 1-minute static gamma count were collected. The five aliquots were field composited (mixed and homogenized), and from this, a surface soil sample was collected and analyzed for Ra-226 using the same certified laboratory (ALS Environmental in Fort Collins, Colorado) and U.S. EPA Method 901.1 that were used for all other RSE soil sampling.

Data collected from the correlation plots were analyzed using both qualitative and quantitative statistical methods to identify data distribution and outliers. Outliers identified during analysis were not removed from the data set unless laboratory error, sample contamination, or collection errors were identified that could compromise the data. Regression modeling was then used to identify the best relationship between the average gamma count rates from the gamma scan survey and the surface soil Ra-226 concentrations in pCi/g was defined. In addition, a correlation between gamma count rate (in cpm) and dose rate (in µrem/hr) was developed at U.S. EPA's request. For both of the correlations, the DQO was to determine if there is a correlation between gamma count rate and concentrations of Ra-226 in surface soil and sediment, as well as gamma count rate and dose rate.

Validation studies were performed for both correlation studies to assess how well the chosen correlation models predict Ra-226 surface soil concentrations and dose rate. Validation studies were performed using data collected during Mine Site surface soil sample locations collected during the RSE. Each surface soil sample location also included a 1-minute static gamma count and a dose rate measurement as described in the RSE Work Plans. The validation studies attempted to locate sample locations that resembled the conditions required for the correlation plots. As such, the validation study used RSE data that fell within the range of the correlation plot gamma count rates and those samples not in the vicinity of pits, holes, or trenches that could skew the gamma count rates and dose rates. Validation was assessed by qualitatively observing Mine Site data points overlain by the regression equations. A quantitative validation was also performed by plotting observed versus predicted Ra-226 soil concentration values and performing regression analysis to determine the best data fit. The regression was compared with a 1:1 regression line to determine the degree of potential under-prediction or over-prediction.

3.10 Mining-impacted Material, Including TENORM Volume Calculations

The multiple-lines-of-evidence approach was used to determine the volume of mining-impacted material, including TENORM, related to historical mining activities and NORM. The area was mined based on the presence of naturally occurring uranium minerals in the local geology; therefore, some amount of natural uranium and uranium daughter products are assumed to be present at the Mine Site. The multiple-lines-of-evidence approach involved evaluating the following:

- Information obtained during consultation with NAML staff
- Historical documentation on mining and past reclamation efforts
- Historical and current aerial photographs
- Geologic stratigraphy, hydrogeology, and hydrology
- Prominent wind direction
- Visual observations of disturbed areas for evidence of historical mining
- A field investigation, including gamma scans and surface and subsurface soil sample analysis

For mining-impacted material, including TENORM, a volume was calculated based on the lateral and vertical extent based on the multiple-lines-of-evidence approach. Field work is limited in restricted areas to minimize impacts on culturally or biologically sensitive resources or other areas where access is not allowed (for example, utility rights-of-way). These areas were included or excluded from the TENORM volume calculation based on surrounding data and professional judgment. The lateral extent (that is, area) of mining-impacted material, including TENORM, was calculated using GIS software. The vertical extent was determined by subsurface soil data or depth to encountered bedrock. Minor variations in the surface topography of potentially impacted areas are assumed to be accounted for in the horizontal and vertical extent estimates, because the maximum depth of a given area was used. For each sample location, the depth of mining-impacted material, including TENORM, was rounded up to the nearest 0.5 foot, and areas with similar depths were aggregated.

3.10.1 Waste Rock

- Visible waste rock within a pile, regardless of gamma count rates or Ra-226 soil concentrations, was considered mining-impacted material, including TENORM.
- The vertical dimension of the waste rock pile was defined at the depth at which bedrock was encountered or soil analytical data were less than ILs.
- Former and observed waste rock piles (if present) were considered disturbances.

3.10.2 Impacted Areas (Mine Site, Drainage, Haul Roads)

The following assumptions were used to calculate mining-impacted materials, including TENORM, volumes. Please note that “elevated” included actual (laboratory samples) radiological or metals concentrations exceeding the IL and gamma scan data greater than the ILs. Impacted areas included areas within the Mine Site, drainages, and haul road.

- Elevated unconsolidated material was considered mining-impacted material, including TENORM, if it met the multiple lines of evidence.
- Elevated unconsolidated material was considered NORM if it did not meet the multiple lines of evidence.

3.11 Health and Safety

The fieldwork at the Mine Site was conducted in accordance with health and safety plans submitted to U.S. EPA with the Work Plans (CH2M 2017a, 2018), which identified and outlined necessary safety precautions and nearby medical facilities and resources. Daily safety briefings were conducted with field staff. In addition to routine safety precautions for heavy equipment operation and rugged field conditions, radiation exposure monitoring was performed for workers entering and leaving mine feature areas. The results of radiation exposure monitoring indicated that no field staff were exposed to significant health risks.

3.12 Quality Assurance/Quality Control

The Quality Assurance Project Plan (QAPP) presents QA/QC procedures, policies, and requirements for collecting data that are scientifically valid and defensible. The QAPP was included in the approved RSE Work Plan (CH2M 2017a). Quality of field data collection was assured by use of a QAPP and standard operating procedures (SOPs) that included daily instrument calibration and checks, and subcontractor oversight. Quality of laboratory data was assured by using the QAPP, which specifies analytical methods, laboratory instrument checks, QC sampling, and reporting limits. Additionally, the laboratory data were validated by an experienced chemist.

3.12.1 Field Data Quality

RSE activities included collecting large quantities of field screening data. SOPs were developed for the field activities, and contractor experience and credentials were verified before mobilization. Field staff checked calibration records of the instrumentation, completed initial and daily source checks on the radiation equipment, verified compliance with SOPs, and reviewed preliminary data during the field activities. The data collected from field activities were documented and preserved in archives. The data were reviewed for completeness, errors, and accuracy. The final quality checked data are presented in this Report.

3.12.1.1 Field Instrumentation Calibration and Checks

The field instruments were maintained and operated in accordance with their respective technical manuals and approved operating procedures. Each detector and scaler/ratemeter set was calibrated at a minimum of every 12 months in accordance with ANSI N323AB, *American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* (ANSI 2013). The field survey instruments used to collect survey data were required to operate within acceptable tolerances and in accordance with the SOPs. Each survey instrument was required to pass a daily QC check. Failure of any of these daily checks would result in removal of the equipment from service until the equipment operated within acceptable tolerances or could be fixed. Appendix C contains copies of the calibration certificates and instrument source checks.

3.12.1.2 Field Confirmation

Field staff verified compliance with the SOPs and reviewed preliminary data during the field activities. Field staff were experienced and versed in the use of field equipment. The following QA/QC practices were performed by field oversight staff:

1) Field equipment was inspected by a health physicist or trained personnel during mobilization and initiation of fieldwork. At this time, equipment calibration logs were reviewed and confirmed. The source was confirmed to be of appropriate type and energy.
2) Transect survey areas were verified by GPS and field maps. Area boundaries were marked with flagging and other markers.

3) Field staff were audited before conducting gamma scan surveys to document adherence to the RSE Work Plans, including maintaining proper probe height and walking speed. Allowances were made for uneven ground.
4) Preliminary field data were reviewed on a data logger intermittently.
5) Static gamma counts were collected and recorded on separate GPS devices and field logbooks for verification of data reports.

No significant deficiencies were observed.

3.12.2 Laboratory Data Quality

RSE activities included collecting soil samples for laboratory analysis. The QAPP was provided to the analytical laboratory. The reported data were evaluated according to QAPP requirements, U.S. EPA method guidance, and the *U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (U.S. EPA 2010). The QAPP identifies the method-specific QC requirements for each analytical parameter and matrix and defines a plan to test that the correct sampling, analytical, and data reduction procedures were followed. The Data Quality Evaluation Summary Report is included in Appendix D.

3.13 Decontamination, Investigation-derived Waste, and Personal Monitoring

Decontamination procedures were designed to minimize health risk for field staff, minimize the spread and transport of radioactive material, and prevent cross-contamination of samples. Non-disposable field sampling equipment and radiation meters were decontaminated. Decontamination was performed on reusable personal protective equipment and field equipment not used for sampling and field measurements to mitigate the transport of and minimize exposure to dust and soil with potentially elevated levels of radioactive material. Soil sampling equipment, such as hand augers, trowels, and scoops that contacted soils, were decontaminated before sampling, between each sample location, and daily after sampling in accordance with the approved SOPs. Sampling equipment was thoroughly decontaminated by removing sediment and dust with decontamination wipes and disposable towels, and equipment blanks were collected to demonstrate effective decontamination processes.

Field staff performed personal monitoring of their bodies, including personal clothing, exposed skin, and equipment, as well as reusable personal protective equipment, such as boots and hardhats. Personal monitoring was performed during breaks before handling or consuming food, when field staff exited areas where a radioactive contamination potentially existed, and at the end of the workday. Personal monitoring was performed with a Ludlum Model 12 equipped with a 44-9 Geiger-Mueller detector. If any locations exceeded 2 times the detector background measurement, decontamination activities were performed in accordance with the Health and Safety Plan (CH2M 2017a, 2018).

Soil cuttings from hand sampling and drilling were returned to the location from where they were sampled or scattered at the Mine Sites in an area of similar radioactivity, as identified by previous gamma scans. Water samples were collected from a spigot, and therefore, no investigation-derived waste was produced during the RSE investigation.

4. Investigation Results

This section presents the results of the background investigation; gamma scan surveys and surface and subsurface soil sampling; gamma count rate to Ra-226 soil and gamma count rate to dose rate correlations; and water sampling. Field investigations were limited to areas outside inaccessible areas, as shown on Figure 2-1. Inaccessible areas were areas where health and safety concerns prevented access by field personnel; for example, steep slopes or cliff ledges. There were no restricted areas identified as having biologically or culturally sensitive items.

4.1 Background Assessment

As indicated in Section 3.4, one BRA was established for the Mine Site (the Colluvium BRA). The investigation at the BRA provided data to assess background conditions using gamma scan surveys and surface soil concentrations for Ra-226 and metals.

4.1.1 Background Reference Area Gamma Scan Survey Results

Table 4-1 presents the summary statistics for the gamma scan survey data performed within the Colluvium BRA. Gamma scan survey data were plotted over an aerial image (Figure 4-1), with data color-coded as based on gamma count rate ranges. The results showed that gamma count rates ranged from 6206 to 14374 cpm with an average of 9022 cpm.

4.1.2 Background Reference Area Surface Soil Sampling Results

Table 4-1 provides the summary statistics for metals and Ra-226 laboratory analytical results for surface soil samples collected within the Colluvium BRA. Analytical laboratory results are summarized in Table 4-2 and shown on Figure 4-1. Field sampling forms are provided in Appendix C, laboratory reports are provided in Appendix D, and a detailed statistical analysis of the background data is presented in Appendix E.

4.1.3 Background Reference Area Subsurface Soil Sampling Results

Three subsurface soil samples were collected at the BRA corresponding with locations containing the low, medium, and high concentrations of Ra-226 in surface soil (Figure 4-1). Concentrations of metals and Ra-226 in subsurface soil were within the same range of concentrations as surface soil. Table 4-2 presents the subsurface soil sample results collected at the Colluvium BRA.

4.2 Background Threshold Values and Preliminary Investigation Levels

Background concentrations in nature typically vary and can span a range of values. For the purpose of the RSE investigation, a BTV for the Colluvium BRA gamma count rate and primary COPC soil concentrations was established based on the results obtained from the BRA investigation. An IL was derived from the BTV to allow for assessment of the extent of field scanning and the type and extent of potentially mining-impacted material, including TENORM. ILs are not the same as the preliminary remediation goals (cleanup goals) that will be defined during the risk assessment and EE/CA, if required. The method used for calculating the BTV is described as follows:

R (U.S. EPA endorsed statistical computing software) (R Core Team 2018) and ProUCL Version 5.1.00 (U.S. EPA-approved software) (U.S. EPA 2015) were used to evaluate the data and calculate required values. BTVs and ILs were set as follows, and documentation of statistical methods, assumptions, and calculations are provided in Appendix E.

The BTVs were calculated using the following method, as stipulated in the Work Plans (CH2M 2017a, 2018). Background statistics used to calculate the BTVs are presented in Table 4-1.

- Gamma count rate and primary COPC concentrations: The BTV was set at the USL95 if no outliers were present in the data set; the BTV was calculated this way for arsenic, mercury, molybdenum, selenium, and thorium. If outliers were present, they were evaluated to determine whether they should be removed for reasons such as sample contamination, lab errors, and the like. If there was no reason to remove the outliers then they were not removed from the data set, and the UTL95-95 was used as the BTV; the BTV was calculated this way for the gamma count rate, Ra-226, uranium, and vanadium.
- Gamma count rate ILs were round to the nearest 100 from the calculated value.

The IL equaled the greater of the BTV and the U.S. EPA RSL. If no RSL had been established by U.S. EPA, then the IL was the BTV, as approved by U.S. EPA in the Work Plans (CH2M 2017a, 2018). ILs are listed in Tables 4-3 and 4-4. For field investigation gamma scanning the IL was the BTV plus 1500 cpm; for vertical field delineation the IL was 2 times the BTV. For analytical data the IL was set as follows:

- U.S. EPA RSL was greater than the BTV for mercury, molybdenum, selenium, uranium, and vanadium; therefore, the IL was set at the U.S. EPA RSL.
- BTV was greater than the U.S. EPA RSL for arsenic; therefore, the IL was set at the BTV.
- No U.S. EPA RSL was established for gamma count rate, Ra-226, and thorium; therefore, the BTV was used as the IL.
- Secondary COPCs: Because these compounds are not naturally occurring, the IL was set at the U.S. EPA RSL.

4.3 Gamma Scan Surveys

The gamma scan results for the Mine Site and mine features were compared to the IL (Table 4-3). The IL for gamma count rate was used to evaluate the need for further lateral or vertical scanning or sampling in the field, to inform locations of surface soil samples, and as a preliminary tool to indicate areas of potentially elevated radioactivity. Table 4-5 presents the BTV and multiples of the BTV used to analyze the gamma count rate data. The gamma scan surveys were conducted at the Mine Site in November 2017 and step-out surveys were conducted in May 2018 and October 2019; results are provided on Figures 4-2 to 4-4.

4.3.1 Gamma Survey Results

- **Mine Site**: Because access to known former mining areas of the Mine Site (for example, the Mine Site portals on the northern cliff face of Rock Door Mesa) were limited, the gamma survey was performed along the base of the mesa's cliff face and northward toward the valley floor until the limit of the lateral extent of the gamma survey was determined (Figure 4-2). The extent of the gamma survey at the Mine Site approximated 4.15 acres. Figures 4-2 and 4-3 show the gamma survey results for the Mine Site.
  - Two areas within the Mine Site boundary were found to exceed the IL (11100 cpm). These areas included (1) the talus slope at base of the cliff face below the former portals and rim strip; and (2) the area north of the former loadout area along the haul road on the valley floor, where the rusted drum was located.
    - The north-central section of the talus slope below the former portals and rim strip had gamma count rates above the IL. However, the elevated gamma count rates were often co-located with large boulders (greater than 1 foot in diameter) that had eroded from the top of the mesa or portions of the cliff face.
    - The drum area located just north of the potential loadout area contained elevated gamma scanning measurements in the shape of an oval. These gamma scan measurements decrease with distance from the center of the oval.
- **Drainages:** Gamma scan surveys were conducted within seven drainages downgradient of the Mine Site. The drainages generally originate on the talus slope near the base of the mesa's cliff face and flow northward from the Mine Site onto the valley floor (Figure 4-3). Gamma scan survey data were collected for a total distance of 0.94 mile within the drainages.

- Drainage 1 had gamma count rates that were consistently less than the IL along the centerlines and boundaries of the drainages. Drainage 1 was gamma scanned for 0.13 mile.
- Drainage 2 was gamma scanned for approximately 0.15 mile, and Drainage 3 was gamma scanned for approximately 0.21 mile. The centerline and boundaries of these two drainages closest to the base of the cliff face near the north-central section of the Mine Site have the highest gamma count rates above the IL. However, the farthest reaches of these drainages closer to Oljato Road are bounded by gamma count rates less than the IL.
- Drainages 4, 5, and 6 had infrequent gamma count rates above the IL along the centerlines and boundaries of the drainages at the valley floor, but unlike Drainages 2 and 3, gamma count rates greater than the IL were observed to a lesser extent at the base of the cliff face. The total accessible mileage for Drainages 4, 5, and 6 was recorded as 0.11 mile for Drainage 4, 0.21 mile for Drainage 5, and 0.10 mile for Drainage 6.
- Drainage 7 had elevated gamma count rates along the eastern boundary but decreased in counts toward the centerline of the drainage and reaching background conditions along the western boundary. Elevated gamma count rates in the drainage coincide with the area surrounding the drum found along the haul road (eastern boundary of Drainage 7). The total accessible mileage for Drainage 7 was recorded as 0.03 mile.

- **Former Haul Road:** A gamma survey was conducted along the former haul road for a distance of 0.17 mile from the loadout area to Oljato Road (Figure 4-3). Gamma count rates were less than the IL along the centerline and boundary of the haul road, except for the area surrounding the drum.

4.3.2 Gamma Scanning Investigation Level Exceedance Lateral Extent

- Based on gamma scans in the accessible areas previously described the lateral extent of gamma detections above the IL has been delineated within the former Mine Site, haul road, and drainage boundaries. Gamma scanning in the loadout area is less than the IL and is therefore delineated. The elevated gamma count rates exceed the IL on the talus slope at the base of the cliff face and along the haul road where the drum was identified. Gamma count rates also exceed the IL within the upper reaches of Drainages 2 and 3 near the base of the cliff face. The eastern boundary and centerline of Drainage 7 exceeded the IL, which are downgradient of the drum location. The lateral extent of gamma count rates greater than the IL was determined by drawing polygons around multiple contiguous gamma count rates that exceeded the IL and calculating the area of the polygon. The lateral extent of gamma count rates greater than the IL is 4.31 acres, as shown on Figure 4-4.

4.4 Soil Sampling Results

The following subsections discuss the results for the soil and sediment sampling that was completed at the Mine Site and drainages. Sample locations are shown on Figures 4-2 and 4-3 and are compared to ILs that are presented in Tables 4-3 and 4-4. Sample descriptions are summarized in Table 4-6 and analytical data are presented in Tables 4-7 and 4-8. Soil sample logs and boring logs are presented in Appendix C, laboratory analytical reports are provided in Appendix D, and descriptive statistics for the soil sample data are located in Appendix E.

Sample identifiers were in the following format:

AA-BB-CC-DDD

- AA: The first two digits indicate the sample media, such as SD for sediment, SS for surface soil, or SB for subsurface soil.
- BB: The next two digits indicate the Mine Site ID, which is 32 for the Mine Site. Waste rock pile locations are named using NNWP (for Navajo Nation waste rock pile) or CAWP (for Cyprus Amax waste rock pile) and include a two-digit waste rock pile designation.

- CC: The next two digits indicate the mine feature from which the sample was collected. For example, MS indicates the sample was collected from the Mine Site, and H1 indicates the sample was collected from Former Haul Road 1.
- DDD: The next three digits indicate the sample number, numbered sequentially by order of collection.

4.4.1 Soil and Sediment Sampling Frequency

Soil and sediment samples collected at the Mine Site are summarized in the following subsections and in Tables 4-6 and 4-7. Sampling locations are shown on Figures 4-2 and 4-3, supporting the attainment of DQO 2.

- **Mine Site:** A total of 4.15 acres of accessible area is present at the Mine Site and step-out areas. A total of 15 surface soil samples were collected from the Mine Site. Nine locations were selected for subsurface soil sampling, co-located at surface soil sample locations that contained the highest concentration of Ra-226 or metals that were greater than the applicable IL.
- **Drainages:** Seven drainages are present near the Mine Site with an accessible mileage of 0.94 mile. Twelve surface sediment samples were collected.
- **Former Haul Road:** Haul Road 1 was sampled at a frequency of four samples per mile. Therefore, one surface soil sample was collected from the 0.17 mile of accessible haul road.

4.4.2 Radium-226 in Soil

The sample descriptions and analytical results for Ra-226 are presented in Table 4-7 and shown on Figures 4-2 and 4-3.

- **Mine Site:** Detected concentrations of Ra-226 in the 15 surface soil samples ranged from 0.31 to 478 pCi/g. The maximum concentration was detected at sample location 32-MS-010, which is near the drum along the haul road. Seven of the 15 surface samples exceeded the IL for Ra-226 (1.01 pCi/g).

  Concentrations of Ra-226 in the 17 subsurface samples ranged from 0.36 to 18.6 pCi/g. The maximum subsurface concentration was detected from 1 to 1.5 feet bgs at sample 32-MS-004, which was located on a scree slope. Seven of the subsurface samples exceeded the IL for Ra-226.
- **Drainages:** Concentrations of Ra-226 in the 12 surface sediment samples ranged from 0.53 to 3.12 pCi/g. The maximum concentration was detected in Drainage 3 at sample location 32-D3-003. Seven of the surface samples exceeded the IL for Ra-226.

  Concentrations of Ra-226 in the six subsurface soil samples ranged from 0.59 to 1.05 pCi/g. The maximum subsurface concentration, which was the only exceedance of the IL, was detected from 1 to 1.5 feet bgs in sample 32-D6-001.
- **Former Haul Road:** The concentration of Ra-226 in the one surface soil sample was 1.08 pCi/g, which exceeded the IL for Ra-226. The two subsurface soil samples did not exceed the IL for Ra-226.

4.4.3 Radium-226 Investigation Level Exceedance Extent

The Ra-226 soil analytical concentrations exceeding the IL were not laterally bound by soil sample results less than the IL in the east but were laterally bound by soil samples in the west and north and by soil sample results less than the IL in the south and east. The Ra-226 soil analytical concentrations exceeding the IL were heterogenous throughout the base of the scree slopes and upper reaches of several drainages. The highest concentration of Ra-226 was in a localized hot spot along the haul road at 32-MS-010. Elevated concentrations of Ra-226 at this location were vertically delineated at 3 feet bgs. Additionally, elevated concentrations of Ra-226 were detected from 0 to 3 feet bgs in the surface and subsurface soil samples collected from the talus slope at the base of the cliff face (32-MS-004). Drainages 2 and 3 contain elevated concentrations in surface sediment, while Ra-226 concentrations in Drainages 5 and 6 were slightly above the IL in surface sediment samples without exceeding the IL in the subsurface in Drainage 5 and delineated at 1.5 feet bgs in Drainage 6. The Ra-226 exceedances at other Mine Site and drainage sample locations are at least one order of magnitude less than the exceedances at sample location 32-MS-010. The heterogenous nature of the naturally eroded ore-bearing Shinarump soils along the base of the cliffs within the Mine Site limited the ability to laterally bound Ra-226 exceedances.

Per the Work Plans, vertical delineation was investigated by subsurface sampling at locations with higher concentrations of primary COPCs and areas around potentially buried and exposed waste rock and other mine features (for example, portals and former haul roads), including locations downgradient of these areas. No waste rock was observed on the valley floor and elevated gamma count rates and Ra-226 concentrations were related to naturally occurring erosion of the ore-bearing Shinarump Formation; therefore, subsurface soil sample locations were selected in areas with the highest gamma count rates and Ra-226 concentrations in surface soil. Subsurface soil sample locations were also selected to provide adequate spatial coverage at the Mine Site; therefore, not all surface soil samples that exceeded the IL were selected for subsurface sampling. Subsurface soil samples were collected at 10 Mine Site locations, 5 drainage locations, and 1 haul road location. Of the 10 Mine Site samples, 3 locations were vertically delineated by bedrock (32-MS-002, 32-MS-004, and 32-MS-006), 2 locations were delineated at Ra-226 concentrations less than the IL (32-MS-010 and 32-MS-014), 1 location encountered refusal (32-MS-013) and is not vertically delineated, and 4 (32-MS-009, 32-MS-011, 32-MS-012, and 32-MS-015) locations did not exceed the IL for Ra-226 in soil samples collected. Of the five drainage locations, two locations were delineated at bedrock (32-D2-001 and 32-D3-001 and), two locations (32-D6-001 and 32-D07-001) were delineated at Ra-226 concentrations less than the IL, and one location (32-D2-002) did not exceed the IL for Ra-226. Subsurface soil samples were collected at one location along the haul road; the subsurface soil sample location (32-H01-001) was delineated by concentrations less than the IL.

4.4.4 Metals Results

The analytical data for metals in soil and sediment are presented in Table 4-7 and shown on Figures 4-2 and 4-3. The analytical results from soil boring are plotted by depth in Appendix E.

- **Mine Site:** Arsenic, thorium, and uranium were detected at concentrations exceeding the ILs in one or more of the surface or subsurface soil samples.
  - Arsenic concentrations in the 15 surface samples ranged from 0.93 to 10 milligrams per kilogram (mg/kg). The maximum concentration was detected at sample location 32-MS-005. None of the other surface samples exceeded the IL for arsenic (3.91 mg/kg). Concentrations of arsenic in the 17 subsurface samples ranged from 1.0 to 19 mg/kg. The maximum subsurface concentration was detected from 1 to 1.5 feet bgs at sample location 32-MS-004. The sample collected from 2.5 to 3 feet at this sample location did not exceed the IL. None of the other subsurface samples exceeded the IL for arsenic. No trends in arsenic concentration with depth were observed in the Mine Site (Appendix E).

    For reference, a regional study of the western U.S. documented arsenic concentrations in soil that ranged from less than 0.10 to 97 mg/kg (Shacklette and Boerngen 1984). Arsenic concentrations at the Mine Site were within the typical range of regional background values in soil samples.
  - Thorium concentrations in the 15 surface samples on the Mine Site ranged from 0.43 to 4.6 mg/kg. The maximum concentration was detected at sample location 32-MS-005, which had a thorium concentration of 4.6 mg/kg and was the only Mine Site surface soil sample to exceed the IL for thorium (3.62 mg/kg). Concentrations of thorium in the 17 subsurface samples ranged from 1.4 to 2.8 mg/kg. No subsurface soil samples exceeded the IL for thorium. No trends in thorium concentration with depth were observed in the Mine Site analytical data (Appendix E).

    For reference, a regional study of the western U.S. documented thorium concentrations in soil (collected at depths of approximately 0.66-foot bgs from areas exhibiting natural conditions) that ranged from 2.4 to 31 mg/kg (Shacklette and Boerngen 1984). The thorium data at the Mine Site are within the typical range of regional background values in soil samples. Further, the partition coefficient (Kd) for thorium, which is an indicator of how mobile a contaminant is in the environment, is higher than that for other metals (range from 3,200 to 89,000 cubic centimeters per gram) (RESRAD Table E.3; Argonne National Laboratory 2001). This suggests that thorium would bind to soil, immobilizing it, and tend not to migrate or be bioavailable (U.S. EPA 1999).

- Uranium concentrations in the 15 surface samples ranged from 0.17 to 54 mg/kg. The maximum concentration was detected at sample location 32-MS-010. Two surface samples (32-MS-004 and 32-MS-010) exceeded the IL for uranium (16 mg/kg). Concentrations of uranium in the subsurface samples ranged from 0.53 to 79 mg/kg. The maximum subsurface concentration was detected from 1 to 1.5 feet bgs at sample location 32-MS-004. None of the other subsurface samples exceeded the IL for uranium. Changes in concentrations of uranium with depth generally follow changes of Ra-226 and vanadium soil concentrations with depth (Appendix E).

- **Drainages:** Arsenic was detected at concentrations exceeding the ILs.
  - Concentrations of arsenic in the 12 surface sediment samples ranged from 1.1 to 5.2 mg/kg. Two surface samples (32-D1-001 and 32-D2-002) exceeded the IL for arsenic (3.91 mg/kg). The maximum concentration was detected in Drainage 2 at sample location 32-D2-002. None of the six subsurface samples exceeded the IL for arsenic. No trends in arsenic concentration with depth were observed in the drainage analytical data (Appendix E).
- **Former Haul Road:** None of the soil samples exceeded the ILs for the metals.

4.4.5 Metals Investigation Level Exceedance Extent

The IL exceedance for metals in surface and subsurface analytical results at the Mine Site indicate that the highest concentrations of arsenic and uranium were detected from 0 to 1.5 feet bgs in the surface and subsurface soil samples collected from the talus slope at base of the cliff face (32-MS-004). In surface soil sample 32-MS-010, the highest uranium was collected along the haul road. Elevated concentrations of arsenic and thorium in surface soil in the western part of the Mine Site were detected at 32-MS-005. Uranium exceedances at other Mine Site sample locations are at least one order of magnitude lower than the exceedances at sample location 32-MS-010. Arsenic in surface soil was the only metal to exceed in the drainages and was found to be above the IL in Drainages 1 and 2. No metals exceeded the IL in the haul road. Changes in concentrations of uranium and vanadium with depth generally follow changes of Ra-226 soil concentrations with depth (Appendix F). Arsenic and thorium generally do not follow the trends seen in Ra-226, uranium, and vanadium (Appendix F). The heterogenous nature of the naturally eroded soils along the base of the cliffs within the Mine Site limited the ability to laterally bound metals exceedances.

Per the Work Plans, vertical delineation was investigated by subsurface sampling at locations with higher concentrations of primary COPCs and areas around buried and exposed waste rock and other mine features (for example, portals and former haul roads), including locations downgradient of these areas. Subsurface soil sample locations were also selected to provide adequate spatial coverage at the Mine Site; therefore, not all surface soil samples that exceeded the IL were selected for subsurface sampling. Subsurface soil samples were collected at 10 Mine Site locations, 5 drainage locations, and 1 haul road location. Of the 10 Mine Site subsurface locations, 2 locations had metals results delineated by metal results less than the IL (32-MS-004, and 32-MS-010) and the remaining 8 Mine Site subsurface soil sample locations (32-MS-002, 32-MS-006, 32-MS-009, 32-MS-011, 32-MS-012, 32-MS-013, 32-MS-014, and 32-MS-015) did not exceed the ILs for metals. Of the five drainage subsurface locations, one location (32-D2-002) vertically delineated by metals results less than the ILs, and the remaining four locations (32-D2-001, 32-D3-001, 32-D6-001, and 32-D7-001) had metals result less than the ILs. Along the haul road, soil sample location 32-H01-001 did not exceed metals ILs.

4.4.6 Visible Waste Rock Investigation

Field teams conducted visual observations of subsurface soil samples to determine the presence or absence of visible waste rock and documented their observations in field logs (Appendix C, summarized in Table 4-6). Visual waste rock was not observed within the accessible portion (valley floor) of the Mine Site. A hard black material and burned wood (not waste rock) was observed at sample location 32-MS-010 from 0.0 to 0.5 foot bgs.

During a site tour with U.S. EPA and NNEPA on top of the mesa on June 6, 2019, thinly scattered waste rock was observed on top of exposed bedrock over a small area (0.002 acre). The top of the mesa was later determined to be inaccessible for sampling.

4.4.7 Secondary Contaminants of Potential Concern in Soil

Jacobs evaluated the evidence of mining-related activities at the Mine Site by collecting a surface soil sample for secondary COPCs; a subsurface soil sample was also collected if secondary COPCs were detected in the surface soil sample. One Mine Site surface soil sample was collected at 32-MS-004, where gamma count rates were highest, and analyzed for secondary COPCs, including TPH, PCBs, explosives, and perchlorate (Table 4-8). Only TPH-diesel-range organics (DRO) was detected in the surface soil sample (2 J mg/kg); however, its concentration did not exceed the TPH IL of 96 mg/kg (Table 4-8). In accordance with the Work Plans (CH2M 2017a, 2018), subsurface soil samples were collected and analyzed for each secondary COPC that was detected in a surface soil sample. A subsurface soil sample was collected from 1.0 to 1.5 feet bgs at the sample location and was analyzed for TPH-DRO. TPH-DRO was not detected in this sample.

In accordance with the Work Plan, a sufficient number of samples were collected at the Mine Site for secondary COPC analysis and evaluation of potential historical mining impacts. None of the secondary COPCs exceeded ILs. Because secondary COPCs did not exceed the IL, there is no evidence to suggest that historical mining activities resulted in the release of explosives, TPH, or PCBs.

4.5 Contaminants of Potential Concern

Soil samples at the Mine Site were analyzed for the primary COPCs, which included Ra-226, arsenic, mercury, molybdenum, selenium, thorium, uranium, and vanadium. Based on the results presented in Section 4.4, concentrations of Ra-226, arsenic, thorium, and uranium in soil exceeded their respective ILs at the Mine Site, and therefore were confirmed as Mine Site COPCs. No secondary COPCs were confirmed as COPCs at the Mine Site.

4.6 Correlation Studies

Correlation studies were performed for both gamma count rate (in cpm) and Ra-226 surface soil concentration (in pCi/g), and for gamma count rate (in cpm) and dose rate (in µrem/hr). Correlation data were acquired according to the methodology described in Section 3.9. The correlation plot locations are presented on Figure 4-5. The purpose of the Ra-226 correlation is to provide a way for potential future response actions to estimate Ra-226 concentrations in surface soils using walkover gamma scans in locations where soil samples are not collected for laboratory analysis. The purpose of the dose rate correlation is to provide a method to convert the gamma count rate from an energy-dependent detector to the dose rate from a detector that is largely energy independent over a broad energy range. The Ra-226 surface soil correlation was not used for the site characterization, which relied instead on the Mine Site gamma scans and soil/sediment analytical results. Details of the analyses performed on the data are provided in Appendix F.

4.6.1 Gamma Count Rate and Radium-226 Surface Soil Concentration Correlation

Analytical results of the correlation sample data in conjunction with the high-density gamma scan data were used to develop the regression equation. Linear regression analysis under log transformation was the model found that best represents the relationship in the correlation plot data between gamma count rate and Ra-226 soil concentration for the Mine Site. The best fit regression equation to convert gamma in cpm to predicted surface soil Ra-226 concentrations in pCi/g for the Mine Site is presented. Figure 4-6 graphically depicts the gamma count rate to Ra-226 surface soil concentration regression.

$$y = 0.0249e^{0.00035x}$$

Where:

y = Ra-226 surface soil concentration (pCi/g)

x = Gamma count rate (cpm)

Example correlation estimates:

1) 10580 cpm correlates to 1.01 pCi/g of Ra-226 concentration
2) 12530 cpm correlates to 2.00 pCi/g of Ra-226 concentration
3) 13330 cpm correlates to 2.66 pCi/g of Ra-226 concentration (maximum value correlation can be used)

The regression for the gamma count rate (cpm) to Ra-226 surface soil concentration (pCi/g) resulted in a coefficient of determination (R-squared) value of 0.818. Therefore, the mean detector output explained 81.8 percent of the observed variability in mean Ra-226 concentration. The equation produced a mean squared error (MSE) of 0.52, which describes the average error of the regression line from the individual data points. A probability value (p-value) of less than 0.001 suggests that the relationship between gamma count rate and Ra-226 soil concentration is significant and not due to chance. These regression statistics demonstrate a strong statistical relationship between gamma count rate and Ra-226 concentrations in surface soil at the Mine Site.

A model validation study using data from surface soil sample locations collected across the Mine Site was performed based on the methods presented in Section 3.9. Details of this analysis are described in Appendix F. The results of the validation were inconclusive regarding the chosen regression model due to the low volume of sample data available for the validation study. Qualitative observation of Mine Site data compared to the correlation appeared representative but quantitative validation suggests moderate underprediction. On average, the regression model exhibits a slight overprediction of less than 1.3 pCi/g and an underprediction above 1.3 pCi/g. For example, a hypothetical surface soil sample with a measured Ra-226 concentration of 1.0 pCi/g would be predicted as 1.05 pCi/g and a hypothetical surface soil sample with a measured Ra-226 concentration of 4.0 pCi/g would be predicted as 2.45 pCi/g.

In accordance with the Work Plans, sufficient data were collected to evaluate whether a correlation between the gamma count rate and Ra-226 surface soil concentration is present at the Mine Site. The regression equation can be used to predict Ra-226 surface soil concentrations from gamma count rates only within the range of 9,473 to 13,333 cpm, which is the range of values used to produce the regression. Predicted values outside of that range should be used qualitatively and with caution when making decisions. Detailed analysis is found in Appendix F.

4.6.2 Gamma Count Rate and Dose Rate Data Correlation

NaI detection systems used for this RSE are commonly used to scan and characterize radiological conditions at a site. These types of instruments are widely accepted for characterizing spatial distributions of gamma radiation caused by naturally occurring radioactive materials. These systems, however, exhibit strong energy dependence and tend to over respond significantly to low-energy photons and under respond to high-energy photons. To mitigate the drawbacks of the energy-dependent system, a site-specific dose correlation to normalize NaI detector measurements to a less energy-dependent instrument was performed. A Bicron MicroREM instrument was chosen for this study for its relative energy independence across a broad range of photon energies and ease of portability.

Analytical linear regression analysis did not provide a statistically significant model. The linear regression for gamma count rate (in cpm) to dose rate (in µrem/hr) resulted in an R-squared value of 0.0473 and an MSE of 1.50. A regression p-value of 0.6788 resulted. A regression p-value greater than 0.05 means the model is not statistically significant and these data are essentially random. Therefore, no correlation for gamma count rate to dose rate could be developed. The lack of measurement precision of the dose rate instrument (Bicron MicroREM) when performing measurements at low ranges is considered a significant factor. The Bicron MicroREM has a significant uncertainty when measurements are collected at low dose rate conditions (less than 15 µrem/hr) and relies on analog interpretation by the field operator. This uncertainty is greatest at radiation levels that are at or near background.

4.7 Water Sampling Results

Well water samples were collected from two locations on (08K-418 and Goulding) on June 19, 2018 (Figure 4-7). Analytical and field parameter data are presented in Table 4-9. Water sampling was not performed at the spring/seep (08-UNK-0001) because flowing water was not identified. No analytes were detected above the project screening levels defined in the QAPP (Jacobs 2017a) and U.S. EPA's *National Primary Drinking Water Regulations and Secondary Standards* (U.S. EPA 2017a).

Flowing water was not observed in any of the drainages at the Mine Site during RSE activities.

5. NORM and Mining-impacted Material, Including TENORM

The approximate lateral extent of gamma count rates and soil/sediment COPC concentrations that exceeded the IL is presented on Figure 5-1. The multiple-lines-of-evidence approach was used to determine areas of NORM and historical mining impacts, including TENORM, as described in Section 3.10. The multiple lines of evidence included the evaluation of historical features; NAML reclamation activities; evaluation of historical and current aerial photographs; investigation reports; site geology, hydrology, and geomorphology; and prominent wind direction and site characterization data, such as field observations, gamma count rates, and analytical results from surface and subsurface soil sampling. From the multiple lines of evidence, polygons of mining-impacted material, including TENORM, were derived and used to calculate volume.

5.1 Areas of Mining-impacted Material, Including TENORM

Investigated areas that had multiple lines of evidence indicating the area was impacted by historical mining-related activities or material transported via the haul road were designated as areas of mining-impacted material, including TENORM.

Based on the multiple-lines-of-evidence approach, the areas of mining-impacted material, including TENORM, are located in the following locations:

- A small area of scattered waste rock at the top of the mesa near the location of the historical portals was designated as containing mining-impacted material, including TENORM, based on visual observations made during a site visit by Cyprus Amax, U.S. EPA, and NNEPA in 2019; the evidence is as follows:
  - NAML historical documentation, the NAML Point Features database, and an interview with a local resident identified three reclaimed portals (point features Mon050) and a rim strip located on top of the mesa surrounding the observed waste rock pile. Ore was reportedly transported by a system of cables and buckets/sacks from three portals to a loadout area on the valley floor (Chenoweth 1991).
  - NAML performed reclamation activities from December 2001 to April 2002 at the Mine Site under the Monument Valley 4 Reclamation Project and excavated and stabilized the three portals, closed the portals with approximately 50 cubic yards of polyurethane foam, and backfilled the exterior with native Class A rock to ensure a complete hidden seal.
  - The portal locations, reported rim strip, and mining-related features, including waste rock, were not clearly identified on top of the mesa in the historical aerial photographs from 1950, 1980, 1993, and 2019.
  - During the RSE investigation, two of the three NAML reclaimed portals were observed on a field visit with NAML on January 26, 2018 to the top of the mesa. The two observed portals were sealed with an outer stack of natural rock to blend in with the surroundings. During a site visit by U.S. EPA, NNEPA, and Cyprus Amax on June 6, 2019, an area of scattered waste rock was observed (0.002 acre) on the top of the mesa.
  - The Shinarump member of the Chinle Formation is located at the top of the mesa and serves as a resistant cap to weathering. Below the Chinle is the Moenkopi Formation, which erodes more easily and often appears as a sloping shelf. The dramatic cliff faces that are prevalent in Monument Valley are formed of the De Chelly Sandstone member, which underlies the Moenkopi Formation. Historical mining activities targeted ore deposits in the Shinarump member of the Chinle Formation, which contain naturally occurring uranium minerals. The predominant wind direction is from south to north and is consistent with field observations of wind direction at the Mine Site. The observed waste rock is located near the center of the Mine Site.
  - Elevated gamma count rates collected from the top of the mesa ranged from less than the BTV (11100 cpm) to a maximum of 110298 cpm. The maximum gamma count rates were located in the area of waste rock scattered on the surface of the bedrock. No sampling was conducted on top of the mesa.

- The area near the observed drum and soil sample location 32-MS-010, north of the loadout area, is designated as TENORM and the evidence is as follows:
  - According to NAML documents, ore was reportedly transported by a system of cables and buckets/sacks from three portals to a loadout area on the valley floor (Chenoweth 1991). During an interview with a local resident and as part of the cultural survey, DCRM recorded an account of a cable and bucket/sack system for removal of personnel and ore from the mesa (DCRM 2018).
  - From December 2001 and April 2002, NAML performed reclamation activities at the Mine Site under the Monument Valley 4 Reclamation Project (NAMLRP 2001, 2002). However, there was no documentation identifying NAML performed work in the loadout area.
  - Historical aerial photographs from 1980 exhibit a distinct outline of the potential loadout area. The trash dump was not clearly identified in the historical aerial photographs.
  - During RSE activities, a flattened-out area on one of the scree slopes in the valley floor was observed and may be the location of a potential loadout area for the reported cable and bucket/sack system, but this area is unconfirmed in literature, historical photographs, and interviews. Evidence of the cable and bucket/sack system was not observed in the field and is presumed to have been abandoned and removed after mining ceased. The potential loadout area for the cable and bucket/sack system on the valley floor was approximately 700 feet lower in elevation from the former portals and approximately 400 feet north-northeast from the base of the cliff face beneath the former portals.
  - During the RSE field investigation a trash dump was observed along Haul Road 1 and Drainage 7 (Figure 5-1). The trash dump was observed to contain rubber tires, paint cans, broken glass bottles, car parts, an electrical panel, and various household appliances. In a review of Google Earth images, the trash dump was first evident in May 2013, and therefore not mining related (CH2M 2017b). DCRM interviewed several nearby residents who indicated that the trash was dumped recently by a local person and Oljato Chapter officials were aware of the issue. In addition to the trash contents, a damaged, rusted drum that appeared to have contained a hard black material and burned wood was also observed. The drum and its contents were scattered around on the ground surface near the haul road and Drainage 7 (Figure 5-1).
  - Gamma count rates exceeding the IL were identified in the area surrounding the drum. The area upgradient of this location and downgradient along Drainage 5 and Haul Road 1 had gamma count rates less than the IL. The IL exceedances of gamma readings, Ra-226, and uranium in surface or subsurface soil collected from 32-MS-010, located in the area of the drum, is mining-impacted material, including TENORM. This area is where hard, black material and burned wood was observed to a depth of 0.5 foot bgs.

The extent of mining-impacted material, including TENORM, was estimated to include 0.802 acre of the Mine Site and Haul Road.

5.2 Area of Mixed NORM and Mining-impacted Material, Including TENORM

Using the multiple-lines-of-evidence approach, it was uncertain whether the following location contained solely NORM or mining-impacted material, including TENORM. Therefore, an area of mixed NORM and mining-impacted material, including TENORM, was assumed to be present at the following location:

- The talus slopes along the base of the mesa below the portals and reported rim strip are assumed to contain a mix of NORM and mining-impacted material, including TENORM, that extends partially down Drainages 2 and 3. Cyprus Amax acknowledges there are uncertainties associated with this area as discussed in Section 6.3. The evidence to support the assumption that this area is a mix of NORM and mining-impacted material, including TENORM is as follows:
  - The Mine Site produced 25 tons of ore during its entire operation period.
  - Mining occurred upgradient of this area, and minimal TENORM was identified on the top of the mesa. Mining-impacted material, including TENORM, may have been transported over the cliff edge onto the talus slope and Drainages 2 and 3.

  - The mineral deposits in the Monument Valley area occurred in channels of the Shinarump Formation, which are incised into the Moenkopi Formation. Natural mineralization likely would not have extended far from the mined area near the portals. The natural erosion of the overlying mineralized Shinarump Formation caused elevated gamma count rates and analytical soil sampling results along the talus slope. Areas along the talus slope to the east and west do not present elevated gamma count rates and soil analytical results, because the overlying material likely did not originate from the highly mineralized channels of the Shinarump Formation.
  - Large boulders (some larger than 1 foot in diameter) of the Shinarump Formation were observed along the talus slopes. Photographs of the naturally eroded material in the talus slopes are presented in photo logs located in Appendix C. The large quantity, large size, and large spatial extent of these boulders indicate that they were deposited by natural weathering of the cliff face and were not the result of the limited historical mining activities.
  - No evidence of waste rock or mining-related materials was observed along the talus slope below the portals or in Drainages 2 and 3.
  - Arsenic and Ra-226 soil sample results within TENORM areas do not have exceedances within the same soil borings. The heterogenous environment observed in the soil sample results suggests natural erosional processes.
  - According to AEC records and in accordance with the AEC directives in place at the time of mining, any waste rock produced would have been consolidated near the portals, which were left open after mining ceased pursuant to standard lease terms. Additionally, ore was reportedly transported by a system of cables and buckets/sacks from three portals to a loadout area on the valley floor (Chenoweth 1991). NAML historical documents, the NAML's Point Features database, and NAML reclamation documents did not identify mining-related features along the talus slopes or near Drainages 2 and 3.
  - Aerial photographs beginning in 1950 (pre-mining) display Drainages 2 and 3 flowing to the northeast from the mesa within the talus slope. These drainages are apparent in the 2019 aerial photograph and show no mining-related features along the talus slopes.

The extent of mixed NORM and mining-impacted material, including TENORM, was estimated to include 3.30 acres of the Mine Site and Drainages 2 and 3.

5.3 Area of NORM

The multiple-lines-of-evidence approach was used to determine the area of NORM. The area of NORM at the Mine Site is described as follows:

- The samples within the Mine Site (32-MS-005 and MS-002) and drainages that exceeded the IL for arsenic (32-D1-001 and 32-D2-002) and Ra-226 (32-D6-001 and 32-D5-002) are considered to be NORM, and the evidence is as follows:
  - AEC records, NAML historical documents, and NAML reclamation documents did not indicate mining-related activities near the western or eastern portions of the Mine Site or along the drainages.
  - The IL exceedances for arsenic and thorium at the base of the cliff face on the western end of the Mine Site (sample location 32-MS-005) are considered NORM because gamma count rates in the immediate vicinity of the sample location do not exceed the IL, and there are no Ra-226 exceedances of the IL. The Mine Site topography slopes to the northeast from the portal locations, which puts sample location 32-MS-005 cross-gradient from potential mining impacts. No disturbed areas were recorded in the area around 32-MS-005.
  - The slight IL exceedance of Ra-226 at sample location 32-MS-002 along the northeastern boundary of the Mine Site buffer is determined to be NORM. Gamma count rates around the sample location are less than the IL. The location is cross-gradient (east) from the portals and potential mining-related material transported off the cliff.

- The Mine Site topography along the cliff face excludes Drainages 1, 5, and 6 from being influenced by former Mine Site activities because the drainages are not downgradient from the mined area (the portals).
- Gamma count rates along the Drainages 1, 5, and 6 do not exceed the IL. Gamma exceedances along the centerline of Drainage 2 stop before reaching 32-D2-001. In Drainage 2, arsenic does not exceed the IL in the upstream sample location.
- No evidence of waste rock or mining-related materials was identified within the Mine Site samples 32-MS-005 and 32-MS-002 or drainage samples during RSE activities.
- Aerial photographs beginning in 1950 (pre-mining) display the drainages, flowing to the northeast from the mesa within the scree slope; these features are apparent through the 2019 aerial photographs and show no mining-related features along the drainages.

5.4 Mining-impacted Material, Including TENORM Volume Estimate

The preliminary volume estimates of mining-impacted material, including TENORM, that exceed one or more ILs is approximately 3,705 cubic yards as shown on Figure 5-2 and summarized in Table 5-1. The area of mixed NORM and impacted material, including TENORM, that exceeded one or more ILs is approximately 9,900 cubic yards. Mining-impacted material, including TENORM, volumes were calculated based on the methods presented in Section 3.10 of this RSE Report. The multiple-lines-of-evidence approach was used to categorize the area as naturally occurring or the result of historical mining impacts, including TENORM. The intent of the RSE in the CERCLA process is to provide a conceptual estimate of the nature and extent of soil impacts and an evaluation of the volume of mining-impacted material, including TENORM. The levels at which cleanup will be required will be determined during the risk assessment, after which potential response actions will be evaluated in the EE/CA. Once the cleanup level and response actions are selected, additional sampling may be conducted to further refine the extent of mining-impacted material, including TENORM, either during the design or implementation stage.

5.5 Surface Water and Ground Water

To evaluate if surface water and/or groundwater have been impacted by mining-related activities a multiple lines-of-evidence approach was used. The following lines of evidence were considered.

- Precipitation is the only input of water into the Mine Site, that is, no rivers or stream are present.
- The pan evaporation rate compared with the average annual rainfall may provide an indication of the potential for infiltration at the Mine Sites. The average pan evaporation is almost 20 times the average annual rainfall (86 inches per year versus 4.5 inches per year). The relationship also holds during times of high rains (i.e., monsoon season), as the average pan evaporation rate in August of 12.48 inches is 16 times greater than the highest average monthly rainfall in August of 0.79 inch. With an evaporation rate greater than rainfall, infiltration is expected to be minimal, stored in soil, and released through evaporation and transpiration without further, deeper, infiltration of water (Cadmus Group Inc. 2011).
- Flowing or ponding surface water was not observed at the Mine Site during any of the many site visits conducted by Jacobs since work began in 2017, including during monsoon season.
- Sediment sample results exceeding the IL were limited to surficial soils above bedrock (approximately 1 to 3 feet bgs).
- Well water samples collected from within 1 mile of the Mine Site are not representative of the groundwater conditions at the Mine Site because the wells are presumably screened in much deeper formations than the geologic units exposed at the Mine Site.
- The area that was mined on top of the Mesa is underlain by the Moenkopi Formation, which would have acted as an aquiclude limiting vertical migration to groundwater.
- According to literature reviews, the Organ Rock Member of the Cutler Formation acts as an aquiclude to prohibit vertical migration of groundwater flow (Longsworth 1994). The colluvium at the base of the cliff and the TENORM area around 32-MS-010 are underlain by the Organ Rock Member of the Cutler Formation, which acts as an aquiclude limiting vertical migration to groundwater.

6. Mine Site Data Quality Objective, Uncertainties, and Data Gap Summary

6.1 Data Quality Objectives

An evaluation of the DQOs is presented in Table 6-1. The DQOs have been met; however, some DQOs have been met with data gaps, as discussed in Section 6.3.

6.2 Deviations from the Work Plans

Three deviations from the Work Plans (CH2M 2017a, 2018) were documented for the Mine Site, which included the following:

- Salinity in water samples was calculated and not measured. Salinity was not analyzed in the field because the portable multiparameter water quality meter did not analyze for salinity. Instead, salinity was calculated using specific conductance and temperature (Fofonoff and Millard 1983), which is a deviation from the Work Plan.
- Section 4.2.3 of the RSE Work Plan states that "Subsurface soil samples at the BRAs and Group 1 Mine Sites are expected to be collected using a combination of drilling and hand tool methods, depending on accessibility, potential biological impact, and depth to bedrock at each area." Table 4-3 of the RSE Work Plan provided the anticipated method of sampling at each Mine Site and notes that the final sampling method would be determined in the field. However, a deviation is noted from the Work Plan Section 4.2.2, which states that "Subsurface soil samples will be collected by a track-mounted drill rig where accessible, and by using hand tools in areas where a drill rig cannot access." The deviation from the Work Plan was because subsurface sample location 32-D2-002 was collected by hand tools even though it may have been accessible by a drill rig.
- Only nine correlation plots were selected for the Mine Site. This is because only a small area of the Mine Site was accessible and the valley floor is a heterogenous environment, characterized by boulders and other large erosional soils. Field gamma scanning revealed that elevated gamma count rates were often from rocks or erosional material too big to be sampled. Therefore, it was necessary to focus on plots that had consistently low gamma count rates and soil particles that were sampleable (that is, less than 0.25 inch in diameter). Only nine plots were identified that satisfied these criteria, which is a deviation from the Work Plans.
- Dose rate measurements were not collected in three correlation plots.

6.3 Uncertainties

The following uncertainties and data gaps have been identified and may be considered during additional evaluations, including the risk assessment and EE/CA, if required. Some uncertainties may be permanent and not addressable during subsequent work at the Mine Site.

Uncertainties and their significance to the RSE process include:

- An exceedance of the IL is not a definitive indicator of impacts from historical operations. The IL used to calculate the volume of mining impacts, including TENORM, may not accurately estimate the volume that is subject to a response action. Once the risk assessment is complete and cleanup values are determined, the volume of mining impacts, including TENORM, may change.
- Areas without data that were inaccessible for health and safety reasons encountered during field investigations could contain impacted material. These areas may require cleanup, increasing the estimated volume that is subject to a response action.
- There is uncertainty whether the area at the base of the cliffs below the portals and extending downgradient into Drainages 2 and 3 is NORM or TENORM because it is hard to distinguish if the elevated gamma count rates and analytical data are attributed to natural erosional processes of the

Shinarump Formation or mining impacts. Using the multiple lines of evidence described in Section 5.3, this area was assumed to be a mix of NORM and mining-impacted material, including TENORM.

- The correlation between the static gamma count (in cpm) and the dose rate data (in µrem/hr) has significant uncertainties associated with the instrumentation and the narrow range of data collected.

6.4 Data Gaps

The following data gaps have been identified and may be considered during additional evaluations, including the risk assessment and EE/CA, if required. Some data gaps may be permanent and not addressable during subsequent work or assessment at the Mine Site. The following data gaps and their significance to the RSE process are as follows:

- A portion of the Mine Site on the top of the mesa was not evaluated during the RSE because of inaccessibility for sampling teams due to steep terrain. Gamma scanning and soil sampling were conducted only on accessible portions of the Mine Site (that is, the valley floor). Additional assessment may be required in the future, if a safe and accessible route is established or technology becomes available to allow for remote assessment of the mesa.
- The vertical extent of mining-impacted material, including TENORM, was not delineated at sample location 32-MS-013 (Figure 4-2). Subsurface sampling at 32-MS-013 was conducted in accordance with the Work Plans (CH2M 2017a, 2018); however, refusal was encountered before collection of a sample less than the IL for analytes at the soil boring. Once a cleanup level for COPCs is determined, additional deeper soil sampling at the Mine Site may be required. Collection of deeper soil samples at this location may not be feasible because of site conditions.
- Because of the uncertainties in the instrumentation used for dose rate collection, the dose rate correlation cannot be used. No further correlation sampling will be conducted at the Mine Site; however, Cyprus Amax is exploring additional methodologies for dose rate correlation at the Group 2 Mine Sites.
- Secondary COPCs were collected before the additional scanning and sampling of the area near 32-MS-010. Additional TPH (including fractional TPH) sampling will be conducted under a future phase of work in the vicinity of 32-MS-010.
- The TENORM and mixed NORM and mining-impacted material, including TENORM areas, were delineated with the exception of Ra-226 to the north of sample location 32-D7-001.

7. Mine Site Summary and Conclusions

The Mine Site RSE investigation revealed the following:

- The Mine Site is located in the Oljato Chapter of the Navajo Nation, in San Juan County, Utah. The Mine Site was active between 1953 and 1954, producing a total of 25 tons of ore containing uranium and vanadium from 3 portals near the top of Rock Door Mesa. Additionally, a rim strip was reported by NAML on top of the mesa. Personnel, materials, and ore were reportedly transported via a cable and bucket/sack system from the top of the mesa to a loadout area approximately 700 feet below on the valley floor.
- Historical mining activities targeted ore deposits in the Shinarump member of the Chinle Formation, which contain naturally occurring uranium minerals. Therefore, some amount of natural uranium and uranium daughter products are assumed to be present at the Mine Site.
- The closest residential areas are approximately 0.25 mile north and northeast of the Mine Site and approximately 0.25 mile east of the Mine Site (Figure 2-1). The area to the north and northeast of the Mine Site was developed after 1980, which was after termination of mining activities. The residential area to the east is visible in the 1980 photo. Each of the residential areas is comprised of three to five single- or multi-family homes. The residential areas are limited to housing, farming, and gardening. No livestock grazing was observed. Short-term rental properties, associated with Goulding's Lodge, are located 0.5 mile southeast of the Mine Site.
- NAML conducted reclamation and closure activities at the Mine Site between 2001 and 2002. As part of its work, NAML closed the three portals by covering them with native rock.
- By mutual agreement with U.S. EPA and NNEPA, Jacobs determined that the top of the mesa is inaccessible for field work. Two reconnaissance trips were made to the top of the mesa by select members of the Cyprus Amax teams accompanied by NAML, U.S. EPA, and NNEPA. Following these trips, Jacobs' health and safety personnel determined the path was too steep and treacherous for field team personnel to carry equipment and supplies.
- An interim action was conducted by Cyprus Amax at the request of the U.S. EPA and NNEPA to address potential chemical concerns at the Mine Site. A chain-link fence was constructed around the area near sample location 32-MS-010.

The RSE investigation concludes the following:

- IL exceedances of gamma count rates, Ra-226, and metals in soil samples along the talus slope at the base of the cliff face and Drainages 2 and 3 were assumed to be a mix of NORM and mining-impacted material, including TENORM.
- COPCs identified at the Mine Site include Ra-226, arsenic, thorium, and uranium. Arsenic exceeded the IL in 4 of 53 samples collected and concentrations were within the range of western U.S. regional background. Thorium exceeded the IL in 1 of 53 samples and was within the range of the western U.S. regional background. Therefore, historical mining activities have not affected the concentrations of arsenic and thorium in the soil at the Mine Site.
- No secondary COPCs exceeding ILs were reported at the Mine Site. Therefore, the Mine Site was not impacted by historical releases from blasting, machine maintenance, refueling, or use of electrical equipment.
- Offsite mobilization via wind and surface water flows through ephemeral drainages across the Mine Site are not a significant transport mechanism for COPCs at the Mine Site. High winds are predominantly from the southwest to northeast as indicated by the wind rose presented on Figure 2-9. The northeastern portion of the Mine Site was not identified as having been affected by wind-blown transport of COPCs.
- Analytical results from well water samples collected at the two wells within a 1-mile radius of the Mine Site were less than drinking water standards defined in the QAPP (CH2M 2017a). Multiple lines of evidence support that historical mining activities have not impacted surface water or groundwater. These lines of evidence include aquicludes in strata below the Mine Site limit vertical migration to groundwater; no

perennial or intermittent surface water flow on the Mine Site; minimal infiltration of water at the Mine Site; limited leaching of COPCs in soil and sediment; and no impacts to water wells within 1 mile of the Mine Site.

- The correlation between gamma count rate (in cpm) and Ra-226 surface soil concentrations (in pCi/g) achieved acceptable statistical performance criteria and model validation. The correlation may be usable for estimating the lateral extent of Ra-226 soil concentrations during an EE/CA.
- The correlation between gamma count rate (in cpm) and dose rate (in µrem/hr) did not achieve acceptable statistical performance criteria and model validation indicated that predicted values were not aligned with measured values. Therefore, the correlation may not be usable for estimating dose rate from gamma count rates. Cyprus Amax is exploring additional methodologies for dose rate correlation at Group 2 Mine Sites.
- The lateral extent of mining-impacted material, including TENORM, at the Mine Site covers approximately 0.802 acre; the volume estimate of mining-impacted material, including TENORM, is 3,705 cubic yards. Mixed NORM and mining-impacted material, including TENORM, covered 3.30 acres with an estimated volume of 9,900 cubic yards.

8. References

American National Standards Institute (ANSI). 2013. *American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments*. N323AB-2013.

ASTM International (ASTM). 2017. ASTM D2487-17, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

Argonne National Laboratory. 2001. User's Manual for RESRAD Version 6 ANL/EAD-4. July.

Blakey, R. C. and D. K. Baars. 1987. *Monument Valley, Arizona, and Utah.* Geological Society of America Centennial Field Guide – Rocky Mountain Section.

Cadmus Group Inc. 2011. *Modeling Water Balance Covers for Colorado Ecozones.* September 28.

CH2M HILL Engineers, Inc. (CH2M). 2017a. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.

CH2M HILL Engineers, Inc. (CH2M). 2017b. *Rock Door No. 1 Mine Site, November 2017 Site Visit Findings: Trash Dump*. December 20.

CH2M HILL Engineers, Inc. (CH2M). 2018. *Draft Addendum to Removal Site Evaluation Work Plan for Consent Decree Sites: Group 1 Mine Sites*. August.

Chenoweth, William L. and Roger C. Malan. 1973. *The Uranium Deposits of Northeastern Arizona.* pp. 139-149 in Monument Valley (Arizona, Utah, and New Mexico) James, H. L. [ed.]. New Mexico Geological Society 24th Annual Fall Field Conference Guidebook.

Chenoweth, William L. 1991. *The Geology and Production History of the Uranium-Vanadium Deposits in Monument Valley San Juan County, Utah*. Utah Geological and Mineral Survey, Contract Report 91-4. February.

Cooley, M. E., J. W. Harshbarger, J. P. Akers, and W. F. Hardy. 1969. *Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah*. Geological Survey Professional Paper 521-A.

Cyprus Amax. 2017. *Re: 94 Mine Sites, Consent Decree, Case Nos. 2:17-CV-00140-DLR and 3:17-CV-08007-DLR, Demonstration of Best Efforts to Secure Access to Group 1 Mine Sites*. September.

Dinétahdóó Cultural Resources Management (DCRM). 2018. *A Cultural Resource Inventory of the Rock Door Mine Site in Oljato Chapter, San Juan County, Utah for Jacobs.* August.

El Paso Natural Gas Co., LLC v. United States of America, No. CV14-8165-PCT-DGC at 2 (D. Ariz., Apr. 16, 2019)

Fillmore, Robert. 2011. *Geologic Evolution of the Colorado Plateau of Eastern Utah and Western Colorado.* The University of Utah Press.

Fofonoff, N. P. and R. C. Millard. 1983. Algorithms for Computation of Fundamental Properties of Seawater. Unesco Technical Papers in Marine Science. Working Group 51.

Jacobs Engineering Group. 2019. Cove Draft Removal Site Evaluation Report.

Jacobs Engineering Group. 2021. *Rock Door No. 1 Fencing Work Plan.* August

Grundy, W. D. 1957. Summary of geology and uranium deposits of the Shinarump Member of the Chinle Formation: U.S. Atomic Energy Commission Report RME-161, 54 p.

Longsworth, Steve A. 1994. *Geohydrology and Water Chemistry of Abandoned Uranium Mines and Radiochemistry of Spoil-Material Leachate, Monument Valley and Cameron Areas, Arizona and Utah.* U.S. Geological Survey Water-Resources Investigation Report 93-4226.

Meteoblue. 2019. "Simulated historical climate & weather data for Monument Valley Navajo Tribal Park." Accessed May 21, 2019, https://www.meteoblue.com/en/weather/forecast/modelclimate/monument-valley-navajo-tribal-park_united-states-of-america_5305400 (last updated 2022).

Navajo Nation Abandoned Mine Lands Reclamation Program (NAMLRP). 2000. *Navajo Nation Abandoned Mine Lands Reclamation Program Monument Valley 4 Biological Evaluation.* October.

Navajo Nation Abandoned Mine Reclamation Program (NAMLRP). 2001. *Navajo Abandoned Mine Lands Reclamation Department, General Construction Contract.* August.

Navajo Abandoned Mine Lands Reclamation Program (NAMLRP). 2002. *Navajo Abandoned Mine Lands Reclamation Department*, *Tuba City AML Reclamation Program GR#807810, Close Out Report.* August.

Navajo Nation Department of Water Resources (NNDWR). 2017. Navajo Nation Department of Water Resources Database.

Nuclear Regulatory Commission (NRC). 1998. Minimum Detectable Concentrations with Typical Radiation Survey for Instruments for Various Contaminants and Field Conditions NUREG 1507.

R Core Team. 2018. R: A language and environment for statistical computing. The R Project for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Repenning, C. A., M. E. Cooley, and J. P. Akers. 1969. Stratigraphy of the Chinle and Moenkopi Formations, Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah, in Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. U.S. Geological Survey Professional Paper 521-B. pp. B1–B34, 2 sheets, scale 1:500,000.

Shacklette, H. T. and J. G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. U.S. Geological Survey Professional Paper 1270.

U.S. Geological Survey (USGS). 1999. *Hydrology and water quality of the Oljato alluvial aquifer, Monument Valley area, Utah and Arizona.* Water-Resources Investigations Report 99-4074.

United States of America and the Navajo Nation. 2017. *Consent Decree.* Cyprus Amax Minerals Company and Western Nuclear, Inc. (defendants). United States District Court for the District of Arizona, Case 2:17-cv-00140-MHB. May 22.

U.S. Department of Energy (DOE). 2001. An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation. August.

U.S. Department of Energy (DOE). 2019. "Legacy Management." Geospatial Environmental Mapping System (GEMS). Accessed June 11, 2019. https://gems.lm.doe.gov/#.

U.S. Environmental Protection Agency (U.S. EPA). 1999. *Understanding Variation in Partition Coefficient, Kd, Values. Volume II: Review of Geochemistry and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (^{3}H), and Uranium*. EPA 402-R-99-004B. August.

U.S. Environmental Protection Agency (U.S. EPA). 2000. *Multi-Agency Radiation Survey and Site Investigation Manual.* EPA 402-R-97-016 rev 1, Rev 1. NUREG-1575. Prepared by U.S. Department of

Energy, U.S. Environmental Protection Agency, Nuclear Regulatory Commission, and Department of Defense. August.

U.S. Environmental Protection Agency (U.S. EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process.* EPA QA/G-4. February.

U.S. Environmental Protection Agency (U.S. EPA). 2007. *Abandoned Uranium Mines and the Navajo Nation, Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data*. August.

U.S. Environmental Protection Agency (U.S. EPA). 2008. *Technical Report on Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining*. EPA 402-R-08-005. April.

U.S. Environmental Protection Agency (U.S. EPA). 2010. *U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review*. January.

U.S. Environmental Protection Agency (U.S. EPA). 2012. *Navajo Abandoned Uranium Mine Site Screening Report. Rock Door No. 1, Mine ID: 223, Navajo AUM North Central Region.* Prepared by Weston Solutions, Inc. April.

U.S. Environmental Protection Agency (U.S. EPA). 2014. *Federal Actions to Address Impacts of Uranium Contamination in the Navajo Nation*. September.

U.S. Environmental Protection Agency (U.S. EPA). 2015. *ProUCL Version 5.1.002. Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*. October.

U.S. Environmental Protection Agency (U.S. EPA). 2017a. *Joint agency comments from U.S. EPA and NNEPA on the Group 1 RSE Work Plan received.*

U.S. Environmental Protection Agency (U.S. EPA). 2017b. *Conference call between U.S. EPA Cyprus Amax. November 29.*

U.S. Environmental Protection Agency (U.S. EPA). 2018. *Letter from U.S. EPA on July 19, 2018. Consent Decree Among Cyprus Amax, EPA, NNEPA for 94 Mines*. July 19.

U.S. Fish and Wildlife Service (USFWS) 1998. Final Endangered Species Act (ESA) Section 7 Consultation Handbook, March 1998. https://www.fws.gov/endangered/esalibrary/pdf/esa_section7_handbook.pdf

Vaughn, P. P. 1964. Vertebrates from the Organ Rock Shale of the Cutler Group, Permian of Monument Valley and Vicinity, Utah and Arizona: Journal of Paleontology, Vol. 38, No. 3 (May 1964), pp. 567–583.

Western Regional Climate Center (WRCC). 2021. “Monument Valley, Arizona (025665).” Period of Monthly Climate Summary. Period of Record: 10/01/1980 to 11/30/2012*.* Accessed September 2021. https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?az5665 (last update 2022).

Whicker, R., P. Cartier, J. Cain, K. Milmine, and M. Griffin. 2008. “Radiological Site Characterizations: Gamma Surveys, Gamma/Radium-226 Correlations, and Related Spatial Analysis Techniques.” *Health Physics Journal*. S180. November.

Tables

Table 1-1. Jacobs Project Management Team

Rock Door No. 1 Mine Area Removal Site Evaluation Report

Name	Title	Education/Credentials
Dawn Townsen	Project Manager	M.S., Hydrology; B.S., Biology and Chemistry
Kira Aiello	Senior Technical Consultant	M.S., Environmental Engineering and Radiation Health Physics, B.S., Nuclear Engineering
Gavin Wagoner	Field Investigation Task Manager	B.S., Geological Sciences, with Environmental Science minor
Eric Packard	Radiation Safety Officer	B.S., Radiation Health Physics; American Board of Health Physics, Certification #6036
George Tangalos	Senior Geologist	Professional Geologist, Utah; M.S., Geology and Geophysics; B.A., Geology with Biochemistry minor
Jon Russ	Risk Assessor, Quality Assurance Manager	B.S., Wildlife Sciences; Certified Hazardous Materials Manager.
Aditya Tyagi	Statistician	Ph.D., Biosystems Engineering; M.S., Environmental Engineering; B.S., Civil Engineering; Professional Engineer, Texas, Certification #92042
Joshua Painter	Health and Safety Officer	B.S., Environmental Remediation and Hazardous Waste Management; Certified Safety Professional, Certification #18665

Notes:

= Number

B.A. = Bachelor of Arts

B.S. = Bachelor of Science

M.S. = Master of Science

Table 2-1. Surface Water and Groundwater Sample Location Summary
Rock Door No. 1 Removal Site Evaluation Report

Mine Site Area	NDWR Well Database Location	NDWR Northing (Zone 12 S)	NDWR Easting (Zone 12 S)	Cyprus Amax Observed Northing if Different from NDWR	Cyprus Amax Observed Easting if Different from NDWR	Cyprus Amax Location Notes	Well Water or Surface Water Sample Locations	Location to be Sampled (yes or no)	Comments
Rock Door No. 1	08K-418	37.011669	-110.200700	N/A	N/A	N/A	Water well	Sampled 6/19/2018	N/A
	08-UNK-0001	37.005284	-110.205701	N/A	N/A	N/A	Surface water, seep	No	No evidence of water at this location on 3/7/2018 and 6/19/2018
	Goulding	37.004892	-110.218001	N/A	N/A	N/A	Water well	Sampled 6/19/2018	N/A

Notes:
Cyprus Amax = Cyprus Amax Minerals Company
N/A = not applicable
NDWR = Navajo Nation Department of Water Resources

Table 4-1. Summary of Background Statistics
Rock Door No. 1 Removal Site Evaluation Report

Statistic	Gamma Count Rate (cpm)[a]	Radium-226 (pCi/g)	Arsenic (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thorium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)
Distribution	None	Normal	Normal	None	Normal	Normal	Normal	Gamma	Transformed
Minimum	6206	0.55	1.1	0.001	0.044	0.34	1.1	0.17	6.7
Maximum	14374	0.95	3.8	0.004	0.20	0.83	3.2	0.75	34
Mean	9022	0.738	2.210	0.000412	0.12	0.603	2.31	0.34	11.4
Standard Deviation	1076	0.119	0.64	0.000892	0.03	0.12	0.49	0.13	5.23
Outlier	Yes	Yes	No	No	No	No	No	Yes	Yes
95-95 UTL	11110	1.01	3.67	0.004	0.18	0.89	3.43	0.67	29.9
95% USL	14374	1.05	3.91	0.004	0.19	0.93	3.62	0.75	44.20

Notes:

Statistics were calculated using ProUCL Version 5.1 (U.S. EPA released 2015).

[a] Data collected from revised background location on June 6, 2019

cpm = count(s)s per minute

mg/kg = milligram(s) per kilogram

pCi/g = picocurie(s) per gram

USL = upper simultaneous limit

UTL = upper tolerance limit

Table 4-2. Soil Sample Laboratory Results - Background Reference Area

Rock Door No. 1 Removal Site Evaluation Report

Mine Area	Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]	Sample Date	Gamma Count Rate (cpm)[b, c]	Dose Rate (urem/hr)[d]	Radium 226		Arsenic		Mercury		Molybdenum		Selenium		Thorium		Uranium		Vanadium	
												(pCi/g)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)	
Monument Valley	Rock Door No. 1	SS-RD-B2-001-06072019	0	0.5	Colluvium	Hand Tools	-110.2568822	37.03517023	06/07/2019	9749	7	0.84	UJ	2		0.000053	U	0.087	J	0.59	J	1.9		0.33		10	
Monument Valley	Rock Door No. 1	SS-RD-B2-002-06072019	0	0.5	Colluvium	Hand Tools	-110.256885	37.03500913	06/07/2019	10742	9	0.9		1.7		0.000056	U	0.097	J	0.61	J	2.1		0.32		13	
Monument Valley	Rock Door No. 1	SS-RD-B2-003-06072019	0	0.5	Colluvium	Hand Tools	-110.256975	37.03481275	06/07/2019	8446	9	0.69		3.8		0.0019	J	0.16	J	0.75	J	2.7		0.37		12	J
Monument Valley	Rock Door No. 1	SS-RD-B2-004-06072019	0	0.5	Colluvium	Hand Tools	-110.2569399	37.03448159	06/07/2019	8618	10	0.67	J	2.8		0.000059	U	0.14	J	0.57	J	2.2		0.29		9.3	
Monument Valley	Rock Door No. 1	SS-RD-B2-005-06072019	0	0.5	Colluvium	Hand Tools	-110.2570226	37.03423888	06/07/2019	7982	11	0.47	UJ	1.7		0.000059	U	0.044	J	0.34	J	1.1		0.17		7.6	
Monument Valley	Rock Door No. 1	SB-RD-B2-005-1.0-1.5-10042019	1	1.5	Colluvium	Hand Tools	-110.2570226	37.03423888	10/04/2019	9937	- -	0.4	U	0.9		0.005	U	0.065	J	0.32	U	0.94		0.21		11	
Monument Valley	Rock Door No. 1	SS-RD-B2-006-06072019	0	0.5	Colluvium	Hand Tools	-110.2571889	37.03443032	06/07/2019	10850	12	0.74	J	1.9		0.000056	U	0.13	J	0.56	J	2.4		0.3		11	
Monument Valley	Rock Door No. 1	SS-RD-B2-007-06072019	0	0.5	Colluvium	Hand Tools	-110.2573767	37.03432073	06/07/2019	9117	12	0.68		1.7		0.000059	U	0.1	J	0.55	J	2		0.23		7.5	
Monument Valley	Rock Door No. 1	SS-RD-B2-008-06072019	0	0.5	Colluvium	Hand Tools	-110.2575313	37.03443756	06/07/2019	9589	11	0.63		1.1		0.000057	U	0.074	J	0.39	J	1.5		0.18		6.7	
Monument Valley	Rock Door No. 1	SS-RD-B2-009-06072019	0	0.5	Colluvium	Hand Tools	-110.2576908	37.03438439	06/07/2019	10871	12	0.55		1.8		0.000057	U	0.13	J	0.45	J	2		0.25		11	
Monument Valley	Rock Door No. 1	SS-RD-B2-010-06072019	0	0.5	Colluvium	Hand Tools	-110.2576782	37.03455061	06/07/2019	10648	14	0.93		2.1		0.000059	U	0.16	J	0.55	J	2.7		0.75		12	
Monument Valley	Rock Door No. 1	SS-RD-B2-011-06072019	0	0.5	Colluvium	Hand Tools	-110.2574829	37.03457635	06/07/2019	8882	14	0.94		1.7		0.000058	U	0.1	J	0.57	J	1.8		0.26		6.8	
Monument Valley	Rock Door No. 1	SS-RD-B2-012-06072019	0	0.5	Colluvium	Hand Tools	-110.2572767	37.03460594	06/07/2019	10356	12	0.95		2.8		0.000054	U	0.12	J	0.76	J	2.7		0.31		14	
Monument Valley	Rock Door No. 1	SB-RD-B2-012-1.0-1.5-10042019	1	1.5	Colluvium	Hand Tools	-110.2572767	37.03460594	10/04/2019	8676	- -	0.86		1.7		0.0027	U	0.15	J	0.55	J	2.4		0.36		13	
Monument Valley	Rock Door No. 1	SS-RD-B2-013-06072019	0	0.5	Colluvium	Hand Tools	-110.2570877	37.03461931	06/07/2019	8738	14	0.58		3.2	J	0.00059	J	0.2	J	0.64	J	2.2		0.53		10	
Monument Valley	Rock Door No. 1	SS-RD-B2-014-06072019	0	0.5	Colluvium	Hand Tools	-110.2571259	37.03473027	06/07/2019	9933	13	0.61		1.7		0.000059	U	0.1	J	0.48	J	1.9		0.26		8	
Monument Valley	Rock Door No. 1	SS-RD-B2-015-06072019	0	0.5	Colluvium	Hand Tools	-110.2572822	37.03477556	06/07/2019	8750	12	0.79		2.2		0.00006	U	0.12	J	0.73	J	2.7		0.31		13	
Monument Valley	Rock Door No. 1	SS-RD-B2-016-06072019	0	0.5	Colluvium	Hand Tools	-110.257426	37.03484522	06/07/2019	10164	8	0.71		2.4		0.000055	U	0.13	J	0.5	J	3.1		0.4		14	
Monument Valley	Rock Door No. 1	SS-RD-B2-017-06072019	0	0.5	Colluvium	Hand Tools	-110.2576492	37.03476093	06/07/2019	10688	13	0.83		2.4		0.000058	U	0.12	J	0.61	J	2.9		0.41		14	
Monument Valley	Rock Door No. 1	SS-RD-B2-018-06072019	0	0.5	Colluvium	Hand Tools	-110.2575713	37.03496806	06/07/2019	9015	12	0.72		2.4		0.00006	U	0.13	J	0.75	J	2.6		0.3		11	
Monument Valley	Rock Door No. 1	SS-RD-B2-019-06072019	0	0.5	Colluvium	Hand Tools	-110.257399	37.03504295	06/07/2019	9486	8	0.82		1.6		0.000058	U	0.1	J	0.57	J	2.1		0.27		8.2	
Monument Valley	Rock Door No. 1	SS-RD-B2-020-06072019	0	0.5	Colluvium	Hand Tools	-110.2572254	37.03495634	06/07/2019	8573	13	0.76		2.3		0.000061	U	0.13	J	0.72	J	2.6		0.55		11	
Monument Valley	Rock Door No. 1	SS-RD-B2-021-06072019	0	0.5	Colluvium	Hand Tools	-110.2570769	37.03502994	06/07/2019	8626	13	0.59		3		0.004	J	0.11	J	0.7	J	2.3		0.35		11	
Monument Valley	Rock Door No. 1	SS-RD-B2-022-06072019	0	0.5	Colluvium	Hand Tools	-110.2570304	37.03512614	06/07/2019	9341	12	0.74		3.2		0.00095	J	0.13	J	0.83	J	2.7		0.39		13	
Monument Valley	Rock Door No. 1	SB-RD-B2-022-1.0-1.5-10042019	1	1.5	Colluvium	Hand Tools	-110.2570304	37.03512614	10/04/2019	8695	- -	0.63		4.5		0.0071	U	0.21		0.64	J	2.6		0.46		18	
Monument Valley	Rock Door No. 1	SS-RD-B2-023-06072019	0	0.5	Colluvium	Hand Tools	-110.2571966	37.03520002	06/07/2019			0.79	UJ	2.4		0.0018	J	0.1	J	0.69	J	3		0.42		28	
Monument Valley	Rock Door No. 1	SS-RD-B2-024-06072019	0	0.5	Colluvium	Hand Tools	-110.2574608	37.03515618	06/07/2019	9818	9	0.78	J	1.5		0.000059	U	0.11	J	0.54	J	2.1		0.28		8.6	
Monument Valley	Rock Door No. 1	SS-RD-B2-025-06072019	0	0.5	Colluvium	Hand Tools	-110.2575488	37.03524957	06/07/2019	9415	13	0.8		1.9		0.000057	U	0.12	J	0.58	J	2.2		0.28		8.9	
Quality Control Samples[e]																											
Monument Valley	Rock Door No. 1	SS-RD-B2-003-06072019-DUP	0	0.5	Colluvium	Hand Tools	-110.2569736	37.0348133	06/07/2019	8446	9	0.66		3.2		0.00006	U	0.14	J	0.8	J	2.6		0.44		11	
Monument Valley	Rock Door No. 1	SS-RD-B2-013-06072019-DUP	0	0.5	Colluvium	Hand Tools	-110.2570877	37.03461932	06/07/2019	8738	14	0.72		1.9	J	0.000055	U	0.1	J	0.63	J	2.1		0.42		10	
Monument Valley	Rock Door No. 1	SS-RD-B2-023-06072019-DUP	0	0.5	Colluvium	Hand Tools	-110.2571966	37.03520002	06/07/2019	8503	10	0.73		2		0.000059	U	0.088	J	0.67	J	3.2		0.43		34	

Notes:

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.

[b] For surface soil data, the measurement is the surface radiation reading and for subsurface soil, the measurement is the on-contact sample jar reading, as collected from Ludlum 2221 2x2 NaI detector.

[c] Gamma radiation measurement from collimated 1-minute static reading from Ludlum 2221 2x2 NaI detector at 6 inches above ground prior to collection.

[d] Dose rate measurements were collected at waist height (36 inches) using a Bicron MicroRem meter with a tissue-equivalent plastic scintillator. The Bicron MicroREM instrument used for dose rate measurements does not have the resolution required for measurements at low dose rate conditions (less than approximately 15 µrem/hr) and requires reliance on analog interpretation by the field operator. This instrument is appropriate only for its intended use as a health and safety tool.

[e] Quality Control samples were collected for field quality assurance and quality control.

U.S. EPA laboratory analytical Method SW846 6020 was used to analyze samples for metals arsenic, molybdenum, selenium, uranium, and vanadium. U.S. EPA Method SW846 7471A was used for mercury analysis. U.S. EPA Method 901.1 was used for radium-226 analysis.

'- - = Not analyzed

µrem/hr = microrem per hour

cpm = count(s) per minute

mg/kg = milligram(s) per kilogram

NaI = sodium iodide

pCi/g = picocurie(s) per gram

J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.

U = The analyte was not detected above the indicated method detection limit.

UJ = The analyte was not detected above the indicated estimated method detection limit.

U.S. EPA = U.S. Environmental Protection Agency

WGS = World Geodetic System

Table 4-3. Investigation Levels for Primary COPCs in Surface and Subsurface Soil
Rock Door No. 1 Removal Site Evaluation Report

	Primary COPCs[a]								
Criteria	Gamma Count Rate (cpm)	Arsenic (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Radium 226 (pCi/g)	Selenium (mg/kg)	Thorium (mg/kg)	Uranium (mg/kg) [c]	Vanadium (mg/kg)
Background Threshold Values - Colluvium	**11100**	**3.91**	0.004	0.19	**1.01**	0.93	**3.62**	0.67	29.9
Regional Screening Level[b]	- -	0.68	**11**	**390**	- -	**390**	- -	**16**	**390**

Notes:

[a] The investigation level for each primary COPC is **bolded** and defined as the higher of the RSL and the calculated BTV for each analyte. For analytes in which there was no applicable RSL, the investigation level is equal to the background threshold value.

[b] Based on U.S. EPA Regional Screening Level for residential soil (June 2017) and a target hazard quotient of 1.0.

[c] The residential RSL for uranium has been modified to 16 mg/kg.

- - = not applicable

BTV = background threshold value

COPC = contaminant of potential concern

cpm = count(s) per minute

mg/kg = milligram(s) per kilogram

pCi/g = picocurie(s) per gram

RSL = regional screening level

U.S. EPA = U.S. Environmental Protection Agency

Table 4-4. Investigation Levels for Secondary COPCs in Surface and Subsurface Soil
Rock Door No. 1 Removal Site Evaluation Report

Analyte[a]	Unit	Investigation Level[b]	Reporting Limit
Perchlorate	µg/kg	55	0.004
TPH-Purgeable (gas-range organics)	mg/kg	82	1
TPH-Extractable (diesel-range organics)	mg/kg	96	10
TPH-Extractable (motor oil-range)	mg/kg	2,500	20
Aroclor-1016	µg/kg	4100	0.033
Aroclor-1221	µg/kg	200	0.033
Aroclor-1232	µg/kg	170	0.033
Aroclor-1242	µg/kg	230	0.033
Aroclor-1248	µg/kg	230	0.033
Aroclor-1254	µg/kg	240	0.033
Aroclor-1260	µg/kg	240	0.033
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	mg/kg	3,900	0.5
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	mg/kg	6.1	0.5
1,3,5-Trinitrobenzene	mg/kg	2,200	0.5
1,3-Dinitrobenzene	mg/kg	6.3	0.5
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	mg/kg	160	0.5
Nitrobenzene	mg/kg	5.1	0.5
2,4,6-Trinitrotoluene	mg/kg	21	0.5
4-Amino-2,6-dinitrotoluene	mg/kg	150	0.5
2-Amino-4,6-dinitrotoluene	mg/kg	150	0.5
2,4-Dinitrotoluene	mg/kg	1.7	0.5
2,6-Dinitrotoluene	mg/kg	0.36	0.5
2-Nitrotoluene	mg/kg	3.2	0.5
3-Nitrotoluene	mg/kg	6.3	0.5
4-Nitrotoluene	mg/kg	34	0.5

Notes:

[a] U.S. EPA Methods SW6850, SW8015B, and SW8082.

[b] Based on U.S. EPA Regional Screening Levels for Residential Soil (June 2017).

µg/kg = microgram(s) per kilogram

mg/kg = milligram(s) per kilogram

TPH = total petroleum hydrocarbons

U.S. EPA = U.S. Environmental Protection Agency

Table 4-5. Gamma Scan Bin Ranges

Rock Door No. 1 Removal Site Evaluation Report

Level	Geology	Colluvium Formation
1	BTV	0 to 11100 cpm
2	BTV to IL	11101 to 12600 cpm
3	IL to 2 times BTV	12601 to 22200 cpm
4	2 to 5 times BTV	22201 to 55500 cpm
5	5 to 10 times BTV	55501 to 111000 cpm
6	>10 times BTV	111001 to 481300 cpm

Notes:

> = greater than

BTV = background threshold value

cpm = count(s) per minute

IL = Investigation Level

Table 4-6. Sample Descriptions

Sample Location Identification	Sample Depths (feet)	Maximum Boring Depth (feet)	Reason for Boring Termination	Presence of Waste Rock (feet)
32-MS-001	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-MS-002	0.0-0.5	0.5	Bedrock	No waste rock observed
32-MS-003	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-MS-004	0.0-0.5, 1.0-1.5, 2.5-3.0	3.0	Bedrock	No waste rock observed
32-MS-005	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-MS-006	0.0-0.5, 1.0-1.5, 2.0-2.5	2.5	Bedrock	No waste rock observed
32-MS-007	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-MS-008	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-MS-009	0.0-0.5, 1.0-2.0, 3.0-4.0	5.0	Gamma count less than 2x BTV	No waste rock observed
32-MS-010	0.0-0.5, 1.0-2.0, 3.0-4.0	5.0	Depth below black material achieved and Gamma count less than 2x BTV	Hard black material and burned wood observed from 0.0-0.5. No waste rock observed
32-MS-011	0.0-0.5, 1.0-2.0, 3.0-4.0	5.0	Gamma count less than 2x BTV	No waste rock observed
32-MS-012	0.0-0.5, 1.0-1.5, 3.0-3.5	3.5	Gamma count less than 2x BTV	No waste rock observed
32-MS-013	0.0-0.5, 1.0-1.5	1.5	Refusal	No waste rock observed
32-MS-014	0.0-0.5, 1.0-1.5, 3.0-3.5	3.5	Gamma count less than 2x BTV	No waste rock observed
32-MS-015	0.0-0.5, 1.0-1.5, 3.0-3.5	3.5	Gamma count less than 2x BTV	No waste rock observed
32-D1-001	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-D2-001	0.0-0.5	0.5	Bedrock	No waste rock observed
32-D2-002	0.0-0.5, 1.0-1.5, 3.0-3.5	3.5	Gamma count less than 2x BTV	No waste rock observed
32-D3-001	0.0-0.5	1.0	Bedrock	No waste rock observed
32-D3-002	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-D3-003	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-D4-001	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-D4-002	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-D5-001	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-D5-002	0.0-0.5	0.5	Surface Sample only	No waste rock observed
32-D6-001	0.0-0.5, 1.0-1.5, 2.0-2.5	2.5	Bedrock	No waste rock observed
32-D7-001	0.0-0.5, 1.0-1.5, 3.0-3.5	3.5	Gamma count less than 2x BTV	No waste rock observed
32-H1-001	0.0-0.5, 1.0-2.0, 3.0-4.0	5.0	Gamma count less than 2x BTV	No waste rock observed

Notes:

2x = two times

BTV = background threshold value

Table 4-7. Laboratory Results for Primary COPCs in Surface and Subsurface Soil
Rock Door No. 1 Removal Site Evaluation Report

Mine Area	Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]	Sample Date	Gamma Count Rate (cpm)[b,c]	Dose Rate (urem/hr)[e]	Radium-226		Arsenic		Mercury		Molybdenum		Selenium		Thorium		Uranium		Vanadium	
												(pCi/g)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)	
											BTV[d]	**1.01**		**3.91**		0.004		0.19		0.93		**3.62**		0.67		29.9	
											RSL[d]	- -		0.68		**11**		**390**		**390**		- -		**16**		**390**	
Monument Valley	Rock Door No. 1	SS-32-MS-001-11082017	0.0	0.5	Colluvium	Hand Tools	-110.21335	37.014655	11/08/2017	8200	4.0	0.46		0.99		0.0044	J	0.056	U	0.25	J	0.73		0.17	U	4.6	
Monument Valley	Rock Door No. 1	SS-32-MS-002-11082017	0.0	0.5	Colluvium	Hand Tools	-110.214007	37.015431	11/08/2017	24093	9.0	**1.68**	**J**	0.93		0.0013	J	0.069	U	0.21	J	0.87		0.58		5.8	
Monument Valley	Rock Door No. 1	SS-32-MS-003-11082017	0.0	0.5	Colluvium	Hand Tools	-110.214522	37.015453	11/08/2017	12399	6.0	0.41	J	1.1		0.0011	J	0.039	U	0.17	J	1.1	J	0.46		6.4	
Monument Valley	Rock Door No. 1	SS-32-MS-004-11082017	0.0	0.5	Colluvium	Hand Tools	-110.214794	37.01543	11/08/2017	54890	28	**13.8**		3.4		0.0041	J	0.35	U	0.4	J	1.6		**18**		22	
Monument Valley	Rock Door No. 1	SB-32-MS-004-1.0-1.5-06062018	1.0	1.5	Colluvium	Hand Tools	-110.21482	37.015442	06/06/2018	- -	- -	**18.6**	**J**	**19**		0.012	J	8.2	J	0.7	J	2.6	J	**79**	**J**	67	
Monument Valley	Rock Door No. 1	SB-32-MS-004-2.5-3.0-06062018	2.5	3.0	Colluvium	Hand Tools	-110.21482	37.015442	06/06/2018	- -	- -	**2.15**	**J**	3.1		0.0072	J	0.69		0.35	J	1.8		3.1		10	
Monument Valley	Rock Door No. 1	SS-32-MS-005-11082017	0.0	0.5	Colluvium	Hand Tools	-110.216045	37.015769	11/08/2017	11814	7.0	0.83		**10**		0.0045	J	0.14	U	0.6	J	**4.6**		0.53		23	
Monument Valley	Rock Door No. 1	SS-32-MS-006-11082017	0.0	0.5	Colluvium	Hand Tools	-110.215462	37.01587	11/08/2017	17444	10	**5.91**	**J**	3.5		0.0048	J	0.27	U	0.45	J	2.3		5.0		19	
Monument Valley	Rock Door No. 1	SB-32-MS-006-1.0-1.5-06062018	1.0	1.5	Colluvium	Hand Tools	-110.215487	37.015873	06/06/2018	- -	- -	**1.1**	**J**	2.2		0.0029	J	0.14	J	0.41	J	2.4		1.0		11	
Monument Valley	Rock Door No. 1	SB-32-MS-006-2.0-2.5-06062018	2.0	2.5	Colluvium	Hand Tools	-110.215487	37.015873	06/06/2018	- -	- -	**1.05**	**J**	2.2		0.0035	J	0.14	J	0.41	J	2.3		1.5		11	
Monument Valley	Rock Door No. 1	SS-32-MS-007-11082017	0.0	0.5	Colluvium	Hand Tools	-110.214952	37.015787	11/08/2017	10088	5	0.69		1.4		0.0052	J	0.069	U	0.33	J	1.7		0.38		9.8	
Monument Valley	Rock Door No. 1	SS-32-MS-008-11082017	0.0	0.5	Colluvium	Hand Tools	-110.214632	37.015745	11/08/2017	17157	12	**2.51**	**J**	1.3		0.0012	J	0.077	U	0.26	J	1.5		0.49		8.6	
Monument Valley	Rock Door No. 1	SS-32-MS-009-10032019	0.0	0.5	Colluvium	Hand Tools	-110.2133549	37.0172844	10/03/2019	10910	7.0	0.98		2.0		0.0043	U	0.15	J	0.39	J	1.9	J	0.33		13	J
Monument Valley	Rock Door No. 1	SB-32-MS-009-1.0-2.0-10032019	1.0	2.0	Colluvium	Drill Rig	-110.2133549	37.0172844	10/03/2019	9725	- -	0.64		2.2		0.0042	U	0.3		0.53	J	1.7		2.0		12	
Monument Valley	Rock Door No. 1	SB-32-MS-009-3.0-4.0-10032019	3.0	4.0	Colluvium	Drill Rig	-110.2133549	37.0172844	10/03/2019	9958	- -	0.76		2.1		0.003	U	0.23		0.39	J	1.8		1.1		10	
Monument Valley	Rock Door No. 1	SS-32-MS-010-10032019	0.0	0.5	Colluvium	Hand Tools	-110.2134777	37.0170956	10/03/2019	310000	200	**478**	**J**	2.4		0.0052	U	0.18	J	0.41	J	1.8		**54**	**J**	95	J
Monument Valley	Rock Door No. 1	SB-32-MS-010-1.0-2.0-10032019	1.0	2.0	Colluvium	Drill Rig	-110.2134777	37.0170956	10/03/2019	10134	- -	**2.58**		2.6		0.004	U	0.45		0.49	J	2.1		5.8		22	
Monument Valley	Rock Door No. 1	SB-32-MS-010-3.0-4.0-10032019	3.0	4.0	Colluvium	Drill Rig	-110.2134777	37.0170956	10/03/2019	10076	- -	0.66		1.8		0.0024	U	0.22		0.38	J	1.6		0.83		17	
Monument Valley	Rock Door No. 1	SS-32-MS-011-10032019	0.0	0.5	Colluvium	Hand Tools	-110.2135903	37.0166921	10/03/2019	9418	4.0	0.61		1.5		0.008	U	0.13	J	0.44	J	1.8		0.75		10	
Monument Valley	Rock Door No. 1	SB-32-MS-011-1.0-2.0-10032019	1.0	2.0	Colluvium	Drill Rig	-110.2135903	37.0166921	10/03/2019	9837	- -	0.36		1.4		0.0024	U	0.15	J	0.37	J	1.4		0.49		7.9	
Monument Valley	Rock Door No. 1	SB-32-MS-011-3.0-4.0-10032019	3.0	4.0	Colluvium	Drill Rig	-110.2135903	37.0166921	10/03/2019	9881	- -	0.42		1.0		0.0024	U	0.17	J	0.33	U	1.4		0.5		7.5	
Monument Valley	Rock Door No. 1	SS-32-MS-012-10042019	0.0	0.5	Colluvium	Hand Tools	-110.2135325	37.0165017	10/04/2019	8709	5.0	0.31		1.0		0.0046	U	0.08	J	0.32	U	1.3		0.34		7.0	
Monument Valley	Rock Door No. 1	SB-32-MS-012-1.0-1.5-10042019	1.0	1.5	Colluvium	Hand Tools	-110.2135325	37.0165017	10/04/2019	8376	- -	0.51	UJ	1.6		0.0045	U	0.11	J	0.46	J	2.0		0.73		11	
Monument Valley	Rock Door No. 1	SB-32-MS-012-3.0-3.5-10042019	3.0	3.5	Colluvium	Hand Tools	-110.2135325	37.0165017	10/04/2019	9609	- -	0.75	J	1.8		0.0026	U	0.14	J	0.49	J	2.1		1.4		11	
Monument Valley	Rock Door No. 1	SS-32-MS-013-10042019	0.0	0.5	Colluvium	Hand Tools	-110.2131322	37.0169768	10/04/2019	12639	5.0	**2.87**	**J**	1.8		0.0079	U	0.14	J	0.55	J	2.1		1.6		15	
Monument Valley	Rock Door No. 1	SB-32-MS-013-1.0-1.5-10042019	1.0	1.5	Colluvium	Hand Tools	-110.2131322	37.0169768	10/04/2019	9473	- -	**1.46**	**J**	2.2		0.0046	U	0.18	J	0.56	J	2.3		1.5		24	
Monument Valley	Rock Door No. 1	SS-32-MS-014-10042019	0.0	0.5	Colluvium	Hand Tools	-110.2131229	37.0171432	10/04/2019	13950	4.0	**5.23**		2.0		0.0067	U	0.13	J	0.5	J	2.3		4.1		22	
Monument Valley	Rock Door No. 1	SB-32-MS-014-1.0-1.5-10042019	1.0	1.5	Colluvium	Hand Tools	-110.2131229	37.0171432	10/04/2019	9450	- -	**5.01**		1.6		0.004	U	0.12	J	0.38	J	1.5		5.0		22	
Monument Valley	Rock Door No. 1	SB-32-MS-014-3.0-3.5-10042019	3.0	3.5	Colluvium	Hand Tools	-110.2131229	37.0171432	10/04/2019	9140	- -	0.37		1.4		0.0015	U	0.092	J	0.35	J	1.5		0.41		9.9	
Monument Valley	Rock Door No. 1	SS-32-MS-015-10042019	0.0	0.5	Colluvium	Hand Tools	-110.2138056	37.0170798	10/04/2019	11060	4.0	0.65	J	3.4		0.0046	U	0.26		0.36	J	1.9		1.3		15	
Monument Valley	Rock Door No. 1	SB-32-MS-015-1.0-1.5-10042019	1.0	1.5	Colluvium	Hand Tools	-110.2138056	37.0170798	10/04/2019	10376	- -	0.45	UJ	1.4		0.0031	U	0.085	J	0.34	J	1.7		0.33		9.6	
Monument Valley	Rock Door No. 1	SB-32-MS-015-3.0-3.5-10042019	3.0	3.5	Colluvium	Hand Tools	-110.2138056	37.0170798	10/04/2019	11341	- -	0.56	J	2.2		0.0015	U	0.15	J	0.69	J	2.8		0.53		13	
Monument Valley	Rock Door No. 1	SD-32-D1-001-11092017	0.0	0.5	Colluvium	Hand Tools	-110.216001	37.017839	11/09/2017	8675	5.0	0.53	J	**4.3**		0.0031	J	0.28	U	0.47	J	3.0		4.4		24	
Monument Valley	Rock Door No. 1	SD-32-D2-001-11082017	0.0	0.5	Colluvium	Hand Tools	-110.215419	37.016353	11/08/2017	12407	8.0	**1.66**	**J**	1.5		0.0012	J	0.065	U	0.37	J	1.5		0.25		9.1	
Monument Valley	Rock Door No. 1	SD-32-D2-002-11092017	0.0	0.5	Colluvium	Hand Tools	-110.215672	37.017839	11/09/2017	10738	6.0	0.9	J	**5.2**		0.0011	J	0.11	U	0.49	J	2.6		14		33	
Monument Valley	Rock Door No. 1	SB-32-D2-002-1.0-1.5-06062018	1.0	1.5	Colluvium	Hand Tools	-110.215686	37.017848	06/06/2018	- -	- -	0.74	J	1.5		0.0037	J	0.074	J	0.35	J	1.7		0.36		10	
Monument Valley	Rock Door No. 1	SB-32-D2-002-3.0-3.5-06062018	3.0	3.5	Colluvium	Hand Tools	-110.215686	37.017848	06/06/2018	- -	- -	0.59	J	1.4		0.0025	J	0.068	J	0.32	U	1.4		0.34		8.2	
Monument Valley	Rock Door No. 1	SD-32-D3-001-11082017	0.0	0.5	Colluvium	Hand Tools	-110.214704	37.016388	11/08/2017	15486	6.0	**2.36**	**J**	2.4		0.001	U	0.25	U	0.31	J	2.0	J	3.3	J	14	J
Monument Valley	Rock Door No. 1	SD-32-D3-002-11092017	0.0	0.5	Colluvium	Hand Tools	-110.214308	37.018637	11/09/2017	10076	5.0	**1.05**	**J**	1.5		0.0018	J	0.12	U	0.25	J	1.3		1.8		10	
Monument Valley	Rock Door No. 1	SD-32-D3-003-05102018	0.0	0.5	Colluvium	Hand Tools	-110.2147102	37.0175934	05/10/2018	11417	7.0	**3.12**	**J**	2.6		0.0014	J	0.25		0.33	J	1.8		4.0	J	81	J
Monument Valley	Rock Door No. 1	SD-32-D4-001-11082017	0.0	0.5	Colluvium	Hand Tools	-110.213956	37.016172	11/08/2017	9092	6.0	0.64	J	1.1		0.0029	J	0.061	U	0.25	J	1.1		0.31		5.9	
Monument Valley	Rock Door No. 1	SD-32-D4-002-11092017	0.0	0.5	Colluvium	Hand Tools	-110.213987	37.017192	11/09/2017	9891	5.0	0.69		1.5		0.0063	J	0.07	U	0.35	J	1.5		0.39	U	9.0	
Monument Valley	Rock Door No. 1	SD-32-D5-001-11082017	0.0	0.5	Colluvium	Hand Tools	-110.213388	37.016218	11/08/2017	10092	7.0	0.89	UJ	1.5		0.0086	J	0.092	U	0.33	J	1.5		0.3		7.8	
Monument Valley	Rock Door No. 1	SD-32-D5-002-11092017	0.0	0.5	Colluvium	Hand Tools	-110.212311	37.017696	11/09/2017	10231	5.0	**1.22**	**J**	2.0		0.0022	J	0.13	U	0.45	J	1.5		1.0		12	
Monument Valley	Rock Door No. 1	SD-32-D6-001-11092017	0.0	0.5	Colluvium	Hand Tools	-110.212207	37.01602	11/09/2017	9824	4.0	**1.54**	**J**	2.5		0.00096	U	0.2	U	0.36	J	1.9		0.58		11	

Table 4-7. Laboratory Results for Primary COPCs in Surface and Subsurface Soil
Rock Door No. 1 Removal Site Evaluation Report

Mine Area	Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]	Sample Date	Gamma Count Rate (cpm)[b,c]	Dose Rate (urem/hr)[e]	Radium-226 (pCi/g)		Arsenic (mg/kg)		Mercury (mg/kg)		Molybdenum (mg/kg)		Selenium (mg/kg)		Thorium (mg/kg)		Uranium (mg/kg)		Vanadium (mg/kg)	
											BTV[d]	**1.01**		**3.91**		0.004		0.19		0.93		**3.62**		0.67		29.9	
											RSL[d]	- -		0.68		**11**		**390**		**390**		- -		**16**		**390**	
Monument Valley	Rock Door No. 1	SB-32-D6-001-1.0-1.5-06062018	1.0	1.5	Colluvium	Hand Tools	-110.212214	37.016042	06/06/2018	- -	- -	**1.05**	**J**	2.0		0.0014	J	0.18	J	0.4	J	2.0		0.53		9.9	
Monument Valley	Rock Door No. 1	SB-32-D6-001-2.0-2.5-06062018	2.0	2.5	Colluvium	Hand Tools	-110.212214	37.016042	06/06/2018	- -	- -	0.63	J	1.4		0.0059	J	0.14	J	0.32	U	1.5		0.35		6.9	
Monument Valley	Rock Door No. 1	SD-32-D07-001-10042019	0.0	0.5	Colluvium	Hand Tools	-110.2136665	37.017309	10/04/2019	11620	4.0	**2.63**	**J**	1.8		0.002	U	0.13	J	0.49	J	1.8		4.9	J	20	J
Monument Valley	Rock Door No. 1	SB-32-D07-001-1.0-1.5-10042019	1.0	1.5	Colluvium	Hand Tools	-110.2136665	37.017309	10/04/2019	11018	- -	0.66	UJ	0.9		0.0021	U	0.06	U	0.32	U	1.1		0.65		6.4	
Monument Valley	Rock Door No. 1	SB-32-D07-001-3.0-3.5-10042019	3.0	3.5	Colluvium	Hand Tools	-110.2136665	37.017309	10/04/2019	11556	- -	0.61	J	1.5		0.0023	U	0.1	J	0.48	J	2.2		0.66		14	
Monument Valley	Rock Door No. 1	SS-32-H01-001-10032019	0.0	0.5	Colluvium	Hand Tools	-110.2124492	37.018739	10/03/2019	9297	4.0	**1.08**	**J**	2.0		0.0034	U	0.097	J	0.68	J	1.9	J	0.33		19	J
Monument Valley	Rock Door No. 1	SB-32-H01-001-1.0-2.0-10032019	1.0	2.0	Colluvium	Drill Rig	-110.2124492	37.018739	10/03/2019	9328	- -	0.89	J	1.7		0.0026	U	0.19	J	0.48	J	1.5		0.5		10	
Monument Valley	Rock Door No. 1	SB-32-H01-001-3.0-4.0-10032019	3.0	4.0	Colluvium	Drill Rig	-110.2124492	37.018739	10/03/2019	9355	- -	0.82		2.4		0.0021	U	0.41		0.49	J	1.8		0.92		10	
Quality Control Samples[f]																											
Monument Valley	Rock Door No. 1	SS-32-MS-003-11082017-DUP	0	0.5	Colluvium	Hand Tools	-110.214522	37.015453	11/08/2017	12399	6.0	0.49		1.3		0.00081	J	0.047	J	0.22	J	1.3		0.42		7.7	
Monument Valley	Rock Door No. 1	SB-32-MS-004-1.0-1.5-06062018-DUP	1	1.5	Colluvium	Hand Tools	-110.21482	37.015442	06/06/2018	- -	- -	41.4	J	16	J	0.012	J	3.9	J	2.9	U	3		25	J	41	
Monument Valley	Rock Door No. 1	SS-32-MS-009-10032019-DUP	0	0.5	Colluvium	Hand Tools	-110.2133549	37.0172844	10/03/2019	10910	7.0	1.09		2.6		0.0062	U	0.17		0.46		2.2		0.43		25	J
Monument Valley	Rock Door No. 1	SS-32-MS-010-10032019-DUP	0	0.5	Colluvium	Hand Tools	-110.2134777	37.0170956	10/03/2019	310000	200	30.7	J	2.3		0.0054	U	0.14		0.44		1.7		13	J	39	J
Monument Valley	Rock Door No. 1	SB-32-D02-002-1.0-1.5-06062018-DUP	1	1.5	Colluvium	Hand Tools	-110.215686	37.017848	06/06/2018	=R43	- -	0.8	J	1.7		0.0046	J	0.099	J	0.51	J	1.8		0.57		12	
Monument Valley	Rock Door No. 1	SD-32-D3-001-11082017-DUP	0	0.5	Colluvium	Hand Tools	-110.214704	37.016388	11/08/2017	15486	6.0	2.18	J	3.3		0.00062	J	0.32		0.45	J	2.1		2.2		28	J
Monument Valley	Rock Door No. 1	SD-32-D3-003-05102018-DUP	0	0.5	Colluvium	Hand Tools	-110.2147102	37.0175934	05/10/2018	11417	7.0	5.99	J	2.5		0.0012	J	0.26		0.39	J	1.6		1.7	J	15	J
Monument Valley	Rock Door No. 1	SD-32-D07-001-10042019-DUP	0	0.5	Colluvium	Hand Tools	-110.2136665	37.017309	10/04/2019	11620	4.0	2.74	J	1.7		0.0017	U	0.11	J	0.4	J	1.5		1.5	J	20	
Monument Valley	Rock Door No. 1	SS-32-H01-001-10032019-DUP	0	0.5	Colluvium	Hand Tools	-110.2124492	37.018739	10/03/2019	9297	4.0	1.34		2.6		0.0056	U	0.14		0.85		2.9		0.41		14	

Notes:

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.

[b] For surface soil data, the measurement is the surface radiation reading and for subsurface soil, the measurement is the on-contact sample jar reading, as collected from Ludlum 2221 2x2 NaI detector.

[c] Gamma radiation measurement from collimated 1 minute static reading from Ludlum 2221 2x2 NaI detector at 6 inches above ground prior to collection.

[d] The investigation level for each analyte is the higher of the U.S. EPA RSL and calculated background threshold value. For analytes in which there was no applicable RSL, the investigation level is equal to the background threshold value.

[e] Dose rate measurements were collected at waist height (36 inches) using a Bicron MicroRem meter with a tissue-equivalent plastic scintillator. The Bicron MicroREM instrument used for dose rate measurements does not have the resolution required for measurements at low dose

[f] Quality Control samples were collected for field quality assurance and quality control and are not compared to investigation levels.

U.S. EPA laboratory analytical Method SW846 6020 was used to analyze samples for metals arsenic, molybdenum, selenium, uranium, and vanadium. U.S. EPA Method SW846 7471A was used for mercury analysis. U.S. EPA Method 901.1 was used for radium-226 analysis.

The residential RSL for uranium has been modified to 16 mg/kg

Bold Gray Data = Analytical detections exceeding the investigation level

- - = Not analyzed
µrem/hr = microrem per hour
BTV = background threshold value
COPC = contaminant of potential concern
cpm = count(s) per minute
IL = investigation level
J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.
mg/kg = milligram(s) per kilogram
NaI = sodium iodide
pCi/g = picocurie(s) per gram
RSL = U.S. EPA Regional Screening Levels (based on a Hazard Quotient of 1.0 and a residential exposure scenario)
U = The analyte was not detected above the indicated method detection limit.
UJ = The analyte was not detected above the indicated estimated method detection limit.
U.S. EPA = U.S. Environmental Protection Agency
WGS = The World Geodetic System

Table 4-8. Laboratory Results for Secondary COPCs in Surface and Subsurface Soil
Priority Rock Door No. 1 Removal Site Evaluation Report

Mine Area	Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Geologic Unit	Sample Method	Longitude[a]	Latitude[a]		U.S. EPA Method SW6850		TPH by U.S. EPA Method SW8015				PCBs by U.S. EPA Method SW8082													
										Perchlorate		Diesel Range Organics		Gasoline Range Organics		Aroclor 1016		Aroclor 1221		Aroclor 1232		Aroclor 1242		Aroclor 1248		Aroclor 1254		Aroclor 1260	
									USEPA RSL[b]	(µg/kg)		(mg/kg)		(mg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)		(µg/kg)	
									-->	55		96		82		4100		200		170		230		230		240		240	
									Sample Date																				
Monument Valley	Rock Door No. 1	SS-32-MS-004-11082017	0	0.5	Colluvium	Hand Tools	-110.214794	37.01543	11/08/2017	2	U	2	J	0.43	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ
Monument Valley	Rock Door No. 1	SB-32-MS-004-1.0-1.5-06062018	1	1.5	Colluvium	Hand Tools	-110.21482	37.015442	06/06/2018	- -		4.9	U	- -		- -		- -		- -		- -		- -		- -		- -	
Quality Control Samples [c]																													
Monument Valley	Rock Door No. 1	SS-32-MS-004-11082017-DUP	0	0.5	Colluvium	Hand Tools	-110.214794	37.01543	11/08/2017	2	U	**2.2**	**J**	0.49	U	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ	17	UJ
Monument Valley	Rock Door No. 1	SB-32-MS-004-1.0-1.5-06062018-DUP	1	1.5	Colluvium	Hand Tools	-110.21482	37.015442	06/06/2018	- -		5	U	- -		- -		- -		- -		- -		- -		- -		- -	

Notes:

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.

[b] U.S. EPA Regional Screening Levels are based on a Hazard Quotient of 1.0, a 1 × 10^{-6} target risk, and a residential exposu

[c] Quality Control samples were collected for fi [c] Quality Control samples were collected for field quality assurance and quality control and are not compared to investigation levels.

- - = Not analyzed
µg/kg = microgram(s) per kilogram
COPC = contaminant of potential concern
HMX = octogen
J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.
mg/kg = milligram(s) per kilogram
PCB = polychlorinated biphenyl
RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine
RSL = regional screening level
TPH = total petroleum hydrocarbons
U = The analyte was not detected above the indicated method detection limit.
UJ = The analyte was not detected above the indicated estimated method detection limit.
U.S. EPA = U.S. Environmental Protection Agency
WGS = The World Geodetic System

Table 4-8. Laboratory Results for Secondary COPCs in Surface and Subsurface Soil
Priority Rock Door No. 1 Removal Site Evaluation Report

Mine Area	Mine Site	Sample Identification	Top of Sample Interval (feet)	Bottom of Sample Interval (feet)	Explosives by US. EPA Method SW8330B				Explosives by US. EPA Method SW8330B												Explosives by US. EPA Method SW8330B															
					1,3,5-Trinitrobenzene		1,3-Dinitrobenzene		2,4,6-Trinitrotoluene		2,4-Dinitrotoluene		2,6-Dinitrotoluene		2-Amino 4,6-dinitrotoluene		2-Nitrotoluene		3-Nitrotoluene		4-Amino 2,6-Dinitrotoluene		4-Nitrotoluene		HMX		Nitrobenzene		RDX		Trinitrophenyl methylnitramine (Tetryl)	
					(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)		(mg/kg)	
					2200		6.3		21		1.7		0.36		150		3.2		6.3		150		34		3900		5.1		6.1		160	
Monument Valley	Rock Door No. 1	SS-32-MS-004-11082017	0	0.5	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	UJ
Monument Valley	Rock Door No. 1	SB-32-MS-004-1.0-1.5-06062018	1	1.5	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	
Quality Control Samples [c]																																				
Monument Valley	Rock Door No. 1	SS-32-MS-004-11082017-DUP	0	0.5	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.49	U	0.2	U	0.2	U	0.2	UJ
Monument Valley	Rock Door No. 1	SB-32-MS-004-1.0-1.5-06062018-DUP	1	1.5	- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -		- -	

Notes:

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.

[b] U.S. EPA Regional Screening Levels are based on a Hazard Quotient of 1.0, a 1 × 10^{-6} target risk, and a residential exposu

[c] Quality Control samples were collected for fi [c] Quality Control samples were collected for field quality assurance and quality

- - = Not analyzed

µg/kg = microgram(s) per kilogram

COPC = contaminant of potential concern

HMX = octogen

J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.

mg/kg = milligram(s) per kilogram

PCB = polychlorinated biphenyl

RDX = hexahydro-1,3,5-trinitro-1,3,5-triazine

RSL = regional screening level

TPH = total petroleum hydrocarbons

U = The analyte was not detected above the indicated method detection limit.

UJ = The analyte was not detected above the indicated estimated method detection limit.

U.S. EPA = U.S. Environmental Protection Agency

WGS = The World Geodetic System

Table 4-9.Groundwater Laboratory Results
Rock Door No. 1 Removal Site Evaluation Report

Analyte	Unit	U.S. EPA Maximum Contaminant Level	Navajo Nation Surface Water Quality Standards	Well Water Project Screening Criteria[b]	Agricultural Water Supply Water Quality Standards [c]	Livestock Watering Surface Water Quality Standards [c]						
						Mine Area	**Monument Valley**		**Monument Valley**		**Monument Valley**	
						Feature ID	**08K 418**		**Goulding**		**Quality Control Sample [f]**	
						Mine Site	**Rock Door No. 1**		**Rock Door No. 1**		**Rock Door No. 1**	
						Sample Identification	**RD WW 001-06192018**		**RD WW 002-06192018**		**RD WW 001-06192018-DUP**	
						Sample Method	**Spigot**		**Spigot**		**Spigot**	
						Longitude[a]	**110.2007**		**110.218005**		**110.2007**	
						Latitude[a]	**37.01166882**		**37.004896**		**37.01166882**	
						Sample Date	**06/19/2018**		**06/19/2018**		**06/19/2018**	
Metals by U.S. EPA Methods SW6010 / SW6020 / SW7470A												
Aluminum, Total	mg/L	- -	- -	0.2	20,000	--	0.014	U	0.016	U	0.01	U
Aluminum, Dissolved	mg/L	- -	- -	0.2	--	--	0.016	J	0.011	J	0.011	J
Antimony, Total	mg/L	0.006	0.0056	0.006	--	--	0.00012	U	0.00012	U	0.00012	U
Antimony, Dissolved	mg/L	0.006	0.0056	0.006	--	--	0.00012	U	0.00012	U	0.00012	U
Arsenic, Total	mg/L	0.010	0.01	0.01	2,000	200	0.00041	J	0.0006	J	0.00077	J
Arsenic, Dissolved	mg/L	0.010	0.01	0.01	--	--	0.00041	J	0.00065	J	0.00066	J
Barium, Total	mg/L	2.0	1	2	--	--	0.087		0.17		0.09	
Barium, Dissolved	mg/L	2.0	1	2	--	--	0.092		0.18		0.092	
Beryllium, Total	mg/L	0.004	0.004	0.004	500	--	0.000054	U	0.000054	U	0.000054	U
Beryllium, Dissolved	mg/L	0.004	0.004	0.004	--	--	0.000054	U	0.000054	U	0.000054	U
Boron, Total	mg/L	- -	0.63	- -	2,000	5,000	0.15	J	0.15	J	0.15	J
Boron, Dissolved	mg/L	- -	0.63	- -	--	--	0.055	J	0.051	J	0.066	J
Cadmium, Total	mg/L	0.005	0.005	0.005	50	50	0.000083	U	0.000083	U	0.000083	U
Cadmium, Dissolved	mg/L	0.005	0.005	0.005	--	--	0.000083	U	0.000083	U	0.000083	U
Calcium, Total	mg/L	- -	- -	- -	--	--	30		26		30	
Chromium, Total	mg/L	0.1	0.1	0.1	1,000	1,000	0.0026	U	0.0014	U	0.00046	U
Chromium, Dissolved	mg/L	0.1	0.1	0.1	--	--	0.0015	J	0.0023	J	0.0021	J
Cobalt, Total	mg/L	- -	1	- -	5,000	1,000	0.00011	U	0.00011	U	0.00011	U
Cobalt, Dissolved	mg/L	- -	1	- -	--	--	0.00011	U	0.00011	U	0.00011	U
Copper, Total	mg/L	1.3	1.3	1.3	5,000	500	0.01	J	0.00053	J	0.014	J
Copper, Dissolved	mg/L	1.3	1.3	1.3	--	--	0.0091	J	0.00077	J	0.012	J
Iron, Total	mg/L	- -	- -	0.3	--	--	0.016	J	0.0098	U	0.013	J
Iron, Dissolved	mg/L	- -	- -	0.3	--	--	0.0098	U	0.0098	U	0.011	J
Lead, Total	mg/L	0.015	0.015	0.015	10,000	100	0.00061	J	0.000079	U	0.00072	J
Lead, Dissolved	mg/L	0.015	0.015	0.015	--	--	0.00046	J	0.000079	U	0.00054	J
Lithium, Total	mg/L	- -	- -	- -	--	--	0.024		0.02	J	0.024	
Lithium, Dissolved	mg/L	- -	- -	- -	--	--	0.024		0.014	J	0.024	
Magnesium, Total	mg/L	- -	- -	- -	--	--	26		21		27	
Magnesium, Dissolved	mg/L	- -	- -	- -	--	--	26		21		26	
Manganese, Total	mg/L	- -	- -	0.05	10,000	--	0.0016	U	0.00036	U	0.00036	U

Table 4-9.Groundwater Laboratory Results

Rock Door No. 1 Removal Site Evaluation Report

Analyte	Unit					Mine Area	Monument Valley		Monument Valley		Monument Valley	
						Feature ID	08K 418		Goulding		Quality Control Sample[f]	
						Mine Site	Rock Door No. 1		Rock Door No. 1		Rock Door No. 1	
						Sample Identification	RD WW 001-06192018		RD WW 002-06192018		RD WW 001-06192018-DUP	
						Sample Method	Spigot		Spigot		Spigot	
						Longitude[a]	110.2007		110.218005		110.2007	
						Latitude[a]	37.01166882		37.004896		37.01166882	
						Sample Date	06/19/2018		06/19/2018		06/19/2018	
		U.S. EPA Maximum Contaminant Level	Navajo Nation Surface Water Quality Standards	Well Water Project Screening Criteria[b]	Agricultural Water Supply Water Quality Standards[c]	Livestock Watering Surface Water Quality Standards[c]						
Manganese, Dissolved	mg/L	- -	- -	0.05	--	--	0.001	J	0.00087	J	0.0016	J
Mercury, Total	mg/L	0.002	0.002	0.002	--	10	0.00006	U	0.00006	U	0.00006	U
Mercury, Dissolved	mg/L	0.002	0.002	0.002	--	--	0.00006	U	0.00006	U	0.00006	U
Molybdenum, Total	mg/L	- -	- -	- -	50	--	0.001	J	0.00071	J	0.0012	J
Molybdenum, Dissolved	mg/L	- -	- -	- -	--	--	0.0011	J	0.00076	J	0.0011	J
Nickel, Total	mg/L	- -	0.61	- -	2,000	--	0.00092	U	0.00092	U	0.00092	U
Nickel, Dissolved	mg/L	- -	0.61	- -	--	--	0.00092	U	0.00092	U	0.00092	U
Phosphorus, Total	mg/L	- -	- -	- -	--	--	0.0053	U	0.0053	U	0.0053	U
Phosphorus, Dissolved	mg/L	- -	- -	- -	--	--	0.0053	U	0.0053	U	0.017	J
Potassium, Total	mg/L	- -	- -	- -	--	--	3		2		3	
Potassium, Dissolved	mg/L	- -	- -	- -	--	--	2.9		2.2		2.8	
Selenium, Total	mg/L	0.05	0.05	0.05	20	50	0.0056	J	0.0035	J	0.0052	J
Selenium, Dissolved	mg/L	0.05	0.05	0.05	--	--	0.0059	J	0.0046	J	0.0049	J
Silver, Total	mg/L	- -	0.035	- -	--	--	0.000029	U	0.000029	U	0.000029	U
Silver, Dissolved	mg/L	- -	0.035	- -	--	--	0.000029	U	0.00007	J	0.000029	U
Sodium, Total	mg/L	- -	- -	- -	--	--	28		14		28	
Strontium, Total	mg/L	- -	- -	- -	8 (pCi/L)	8 (pCi/L)	0.44		0.28		0.45	
Strontium, Dissolved	mg/L	- -	- -	- -	--	--	0.44		0.3		0.44	
Thallium, Total	mg/L	0.002	0.002	0.002	--	--	0.0000041	U	0.0000041	U	0.0000041	U
Thallium, Dissolved	mg/L	0.002	0.002	0.002	--	--	0.0000041	U	0.0000041	U	0.0000041	U
Uranium, Total	mg/L	0.03	0.03	0.03	--	--	0.0039		0.0024		0.0038	
Uranium, Dissolved	mg/L	0.03	0.03	0.03	--	--	0.0038		0.0025		0.0037	
Vanadium, Total	mg/L	- -	- -	- -	1000	100	0.0016	J	0.0044	J	0.0016	J
Vanadium, Dissolved	mg/L	- -	- -	- -	--	--	0.0016	J	0.0046	J	0.0017	J
Zinc, Total	mg/L	- -	2.1	5	10,000	25,000	0.022	J	0.0036	J	0.023	J
Zinc, Dissolved	mg/L	- -	2.1	5	--	--	0.033	J	0.035	J	0.031	J
General Chemistry by U.S. EPA Method E300 / SM2320B / SM2540C												
Chloride	mg/L	- -	- -	250	--	11	10		9		10	
Sulfate	mg/L	- -	- -	250	--	--	39		16		39	
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	- -	- -	- -	--	--	210		160		210	
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	- -	- -	- -	--	--	20	U	20	U	20	U
Alkalinity, Total (as $CaCO_3$)	mg/L	- -	- -	- -	--	--	210		160		210	
Total Dissolved Solids	mg/L	- -	- -	- -	--	--	290		220		290	

Table 4-9.Groundwater Laboratory Results

Rock Door No. 1 Removal Site Evaluation Report

Analyte	Unit	U.S. EPA Maximum Contaminant Level	Navajo Nation Surface Water Quality Standards	Well Water Project Screening Criteria[b]	Agricultural Water Supply Water Quality Standards [c]	Livestock Watering Surface Water Quality Standards [c]						
						Mine Area	**Monument Valley**		**Monument Valley**		**Monument Valley**	
						Feature ID	**08K 418**		**Goulding**		**Quality Control Sample [f]**	
						Mine Site	**Rock Door No. 1**		**Rock Door No. 1**		**Rock Door No. 1**	
						Sample Identification	**RD WW 001-06192018**		**RD WW 002-06192018**		**RD WW 001-06192018-DUP**	
						Sample Method	**Spigot**		**Spigot**		**Spigot**	
						Longitude[a]	**110.2007**		**110.218005**		**110.2007**	
						Latitude[a]	**37.01166882**		**37.004896**		**37.01166882**	
						Sample Date	**06/19/2018**		**06/19/2018**		**06/19/2018**	
Radiochemistry by U.S. EPA Methods E900.0 / E901.1 / E903.0 / E904.0 / D3972 / ALS704												
Lead-210	pCi/L	- -	- -	- -	--	--	0.21	U	-0.22	U	0.07	U
Potassium-40	pCi/L	- -	- -	- -	--	--	10	U	68	U	50	U
Radium-226	pCi/L	- -	- -	- -	--	--	0	U	0.34	U	0	U
Radium-228	pCi/L	- -	- -	- -	--	--	0.04	U	-0.11	U	0.15	U
Radium-226 + Radium-228	pCi/L	5	5	5	5	5	0.04	U	0.23	U	0.15	U
Uranium, Total	pCi/L	- -	- -	- -	--	--	1.76		1.19		1.71	
Uranium-234	pCi/L	- -	- -	- -	--	--	2.53		1.65		2.17	
Uranium-235	pCi/L	- -	- -	- -	--	--	0.064		0.039		0.13	
Uranium-238	pCi/L	- -	- -	- -	--	--	1.76		1.19		1.71	
Alpha Gross	pCi/L	- -	- -	- -	--	--	2.4		2	U	2	
Adjusted Gross Alphad [d,e]	pCi/L	15	15	15	--	15	0.0		0.0		0.0	
Field Parameters												
Temperature	Celsius	- -	- -	- -	- -	- -	29.86		23.32		29.86	
pH	--	- -	- -	- -	- -	- -	7.87		7.96		7.87	
Salinity [f]	PSU	- -	- -	- -	- -	- -	0.26		0.22		0.26	
Turbidity	NTU	- -	- -	- -	- -	- -	34.9		0.37		34.9	
Specific conductivity	mS/cm	- -	- -	- -	- -	- -	0.596		0.442		0.596	
Dissolved oxygen	Percent	- -	- -	- -	- -	- -	90.4		108.7		90.4	
Dissolved oxygen	mg/L	- -	- -	- -	- -	- -	6.83		9.24		6.83	

Notes:

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.

[b] Based on National Primary Drinking Water Regulations and Secondary Standards, 2017.

[c] Agricultural Water Supply and Livestock Watering Surface Water Standards are provided for reference and are not used for data comparison. Surface Water Quality Standards presented are from the *Navajo Nation Surface Water Quality Standars 2015* .

[d] The project screening criteria for gross alpha is adjusted gross alpha after removal of uranium content.

[e] Because of differences in analytical technique, removal of isotopic uranium content may result in negative values. A zero value is reported in this scenario.

[f] Salinity was calculated from specific conductivity and temperature (Fofonoff 1983)

[f] Quality Control samples were collected for field quality assurance and quality control and are not compared to investigation levels.

- - = Not analyzed or not available

$CaCO_3$ = calcium carbonate

J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.

mg/L = milligram(s) per liter

mS/cm = millisiemen(s) per centimeter

NTU = nephelometric turbidity unit

pCi/L = picocurie(s) per liter

U = The analyte was not detected above the indicated method detection limit.

U.S. EPA = U.S. Environmental Protection Agency

Table 5-1. Mining Impacted Material or TENORM Volume Estimate Summary
Rock Door No. 1 Removal Site Evaluation Report

TENORM Areas greater than the IL	Area (acres)	Depth (feet below ground surface)	Volume (cubic yards)
Area A	0.002	0.0 -0.5	5
Area B	0.02	0.0 -1.0	100
Area C	0.05	0.0 -1.5	100
Area D	0.73	0.0-3.0	3,500
TENORM Total	**0.802**	**N/A**	**3,705**
Mixed NORM and TENORM Areas greater than the IL	**Area (acres)**	**Depth (feet below ground surface)**	**Volume (cubic yards)**
Area E	1.37	0.0 -1.0	2,200
Area F	0.97	0.0 -2.0	3,100
Area G	0.96	0.0 -3.0	4,600
Mixed NORM and TENORM Total	**3.30**	**N/A**	**9,900**

Notes:

IL = investigation level

N/A = not applicable

NORM = naturally-occurring radioactive materials

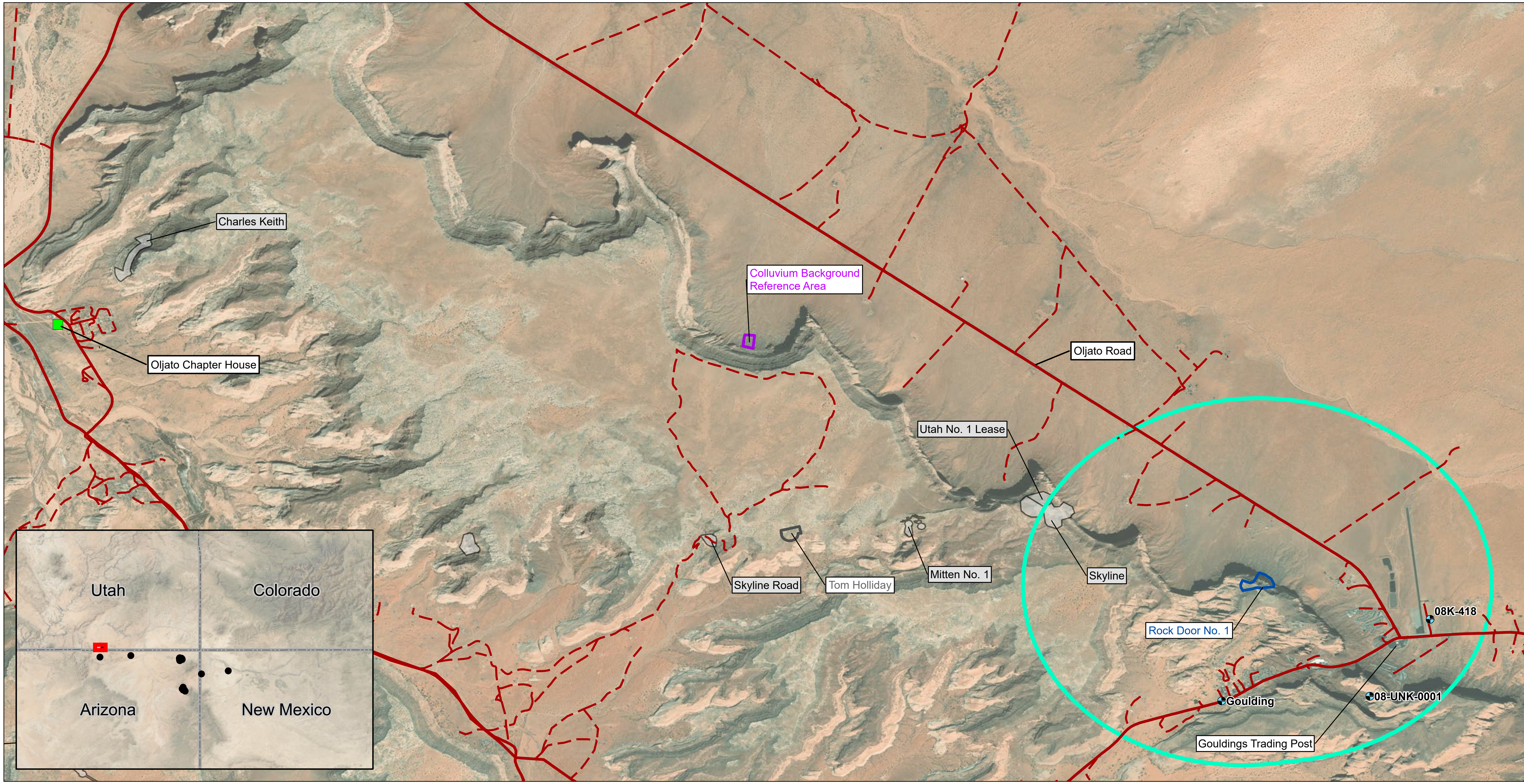
TENORM = technologically enhanced naturally-occurring radioactive materials

Table 6-1. Data Quality Objectives
Rock Door No. 1 Removal Site Evaluation Report

DQO Number	Data Quality Objective	Data Quality Objective met?	Supporting Information
1	Identify the background level of radiation and metal concentrations from naturally occurring materials at the Mine Site.	This DQO has been met. Background level radiation and metal concentrations were defined through field investigations including gamma radiation surveys and soil analytical samples collected from the background reference areas.	Section 4 presents the background investigation data and analysis. Tables 4-1, 4-2, and 4-3 list the background comparison values for the gamma count rate and primary COPCs. Figure 4-1 shows the radiation survey results in the background reference area.
2	Determine the type and extent of affected environmental media, including surface soil, subsurface soil, and sediment.	This DQO has been met with data gaps. The type and extent of affected environmental media has been determined through gamma radiation surveys and surface, subsurface, and sediment soil sampling. portions of the Mine Site were inaccessible to RSE activities. Vertical delineation was not achieved at sample location 32-MS-013 because refusal was encountered.	Results are presented in Table 4-7 and in Figures 4-2 and 4-3. A discussion of type and extent is presented as part of Section 4.
3	Determine the correlation between gamma count rate and concentrations of Ra-226 in surface soil and sediment, as well as the correlation between gamma count rate and dose rate.	This DQO has been met with data gaps. Sufficient samples were collected to assess the relationship between gamma count rate and Radium-226 and between gamma count rate and dose rate. The gamma/Radium-226 correlation is usable for estimating Radium-226 concentrations at the Mine Site within the data range used to create it. The gamma/dose rate correlation is not usable because the Bicron MicroRem instrument is analog and has significant uncertainty for measurements collected at low dose rate conditions.	Results of the correlations are presented in Section 4.6 and on Figures 4-5 and 4-6. Appendix F contains detailed analysis of the correlations.
4	Identify if mining-related activities such as blasting, machine maintenance and refueling, or use of electrical equipment resulted in releases of explosives (including perchlorate), TPH, or PCBs.	This DQO has been met because sufficient data were collected in accordance with the Work Plan to evaluate if mining-related activities released secondary COPCs into the environment. Mine Site soil sampling data indicated that all secondary COPCs were below IL.	Results are presented in Section 4; Tables 4-4 and 4-8 list the investigation levels and laboratory results for the secondary COPCs.
5	Identify whether surface water and/or well water, if present and able to be sampled, has been impacted by mining-related activities.	This DQO has been met. Analytical results from water samples collected at the two wells within a 1-mile radius of the Mine Site were below drinking water standards defined in the QAPP (CH2M 2017a). While the water sampling location were located upgradient from the Mine Site this may suggest that historical mining activities have not impacted groundwater.	Section 2 and Table 2-1 identify the surface and well water sources identified within a 1-mile radius of the Mine Site. The analytical results from water sampling are summarized in Section 4.7, Table 4-9, and Figure 4-7.
6	Estimate the area and volume of TENORM at the Mine Site.	This DQO has been met, and an area and volume of TENORM has been estimated for the Mine Site. The area and volume of TENORM was delineated using multiple lines of evidence, including historical information, vegetation disturbance mapping, geology and hydrology analysis, and site characterization data. The estimated TENORM area is 0.802 acres; the estimated TENORM volume is 3,705 cubic yards. An area of Mixed NORM and TENORM was identified with an area of 3.30 acres and volume of 9,900 cubic yards.	TENORM area and volume estimations are discussed in Section 5 and are depicted on Figures 5-1 and 5-2.

Notes:
COPC = contaminant of potential concern
DQO = data quality objective
IL = investigation level
PCB = polychlorinated biphenyl
RA-226 = radium -226
RSE = Removal Site Evaluation
NORM = naturally-occurring radioactive materials
TENORM = technological enhanced naturally-occurring radioactive materials
TPH = total petroleum hydrocarbons

Figures



LEGEND

- Oljato Chapter House
- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria
- Group One Mine Boundary
- Consent Decree Mine Boundary
- Non-Consent Decree Mine Boundary
- Background Reference Area
- 1-Mile radius around Mine Site
- Major Roads
- Unpaved / Local Road

Notes:
Water wells and surface water features meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and sampling was attempted.
CH2M = CH2M HILL Engineers, Inc.
NDWR = Navajo Nation Department of Water Resources
RSE = removal site evaluation

Sources:
1. Navajo Nation Department of Water Resources Water Management Branch Well Database. Accessed online August 2017.
2. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.

N

0 1,500 3,000 6,000
Feet
1:36,000 1 inch = 3,000 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure ES-1. Rock Door No. 1 Location Map
Rock Door No. 1
Removal Site Evaluation Report

JACOBS

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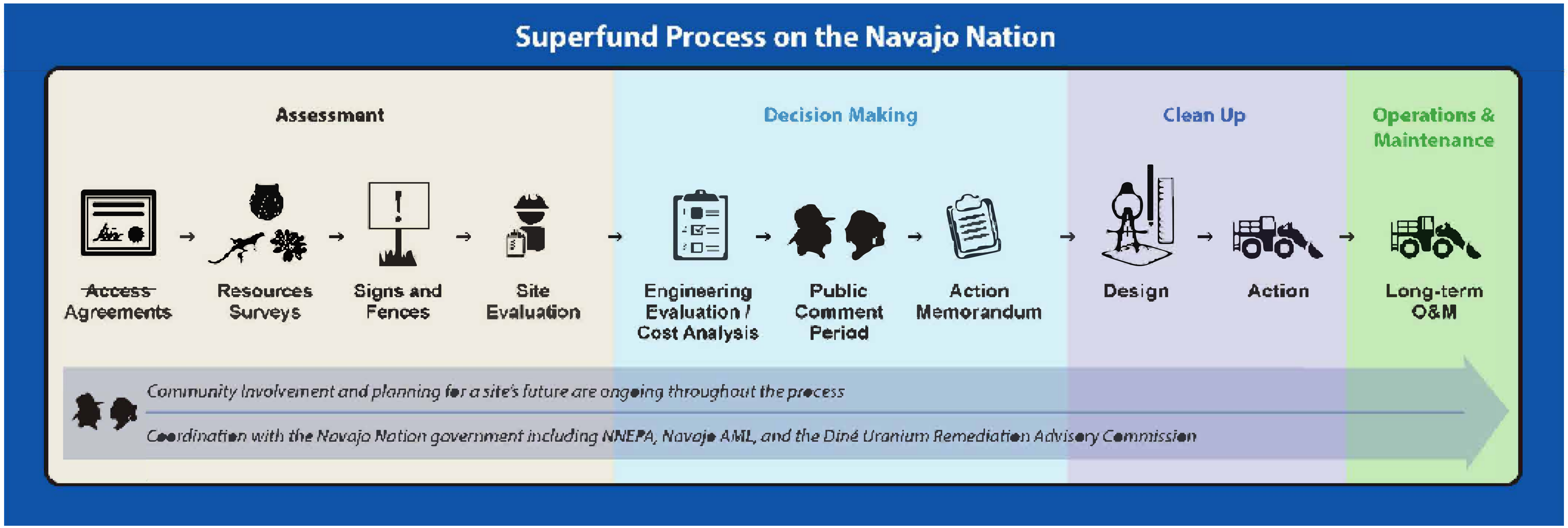
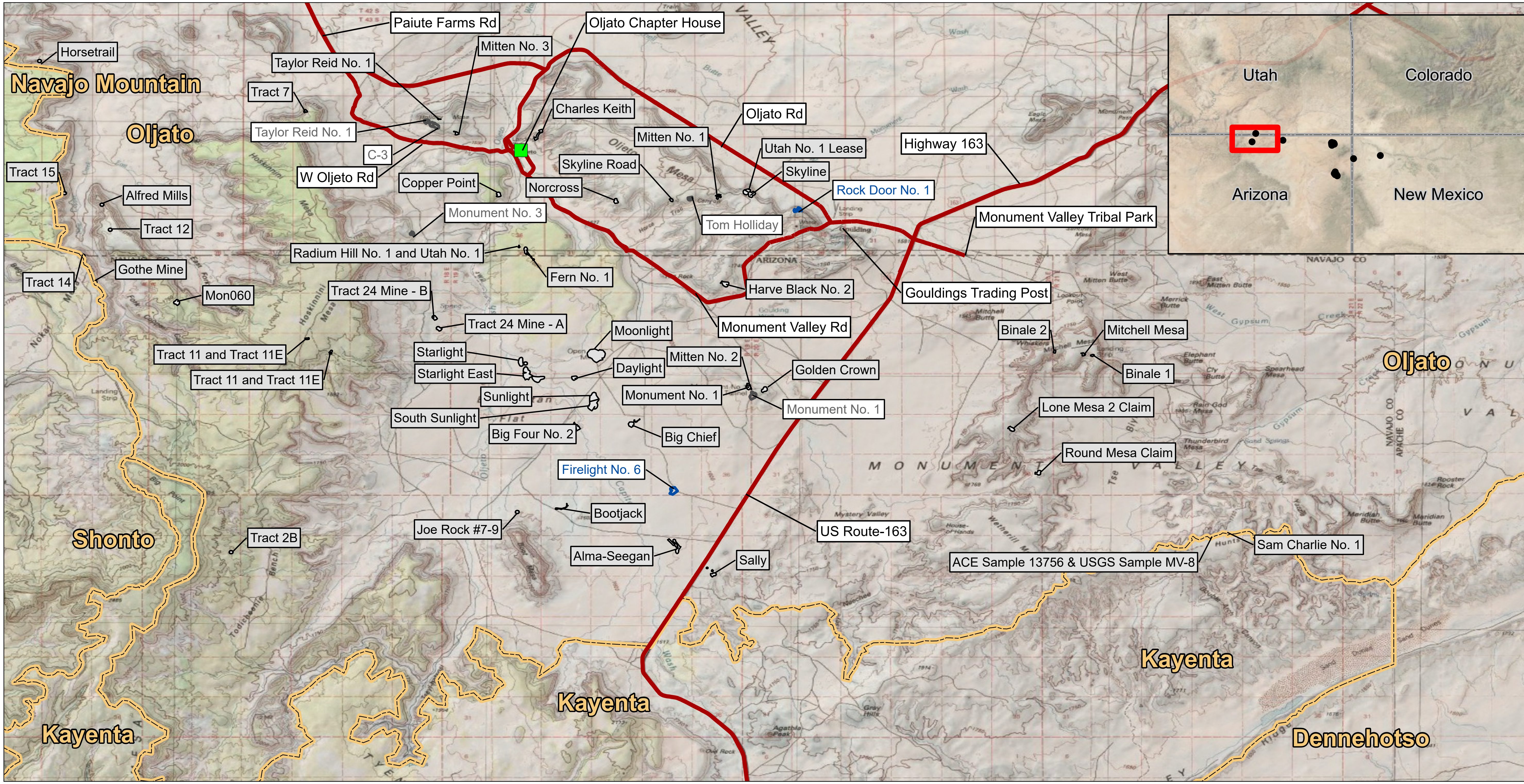


Figure 1-1. Superfund Process on the Navajo Nation
Rock Door No. 1
Removal Site Evaluation Report



LEGEND

- Oljato Chapter House
- Major Roads
- Group One Mine Boundary
- Consent Decree Mine Boundary
- Non-Consent Decree Mine Boundary
- Navajo Nation Chapter 2015

N

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Feet
1:156,000 1 inch = 13,000 feet

Coordinate System: NAD 83 UTM Zone 12N;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online, USA Topo Map

Figure 1-2. Regional Location Map
Rock Door No. 1
Removal Site Evaluation Report

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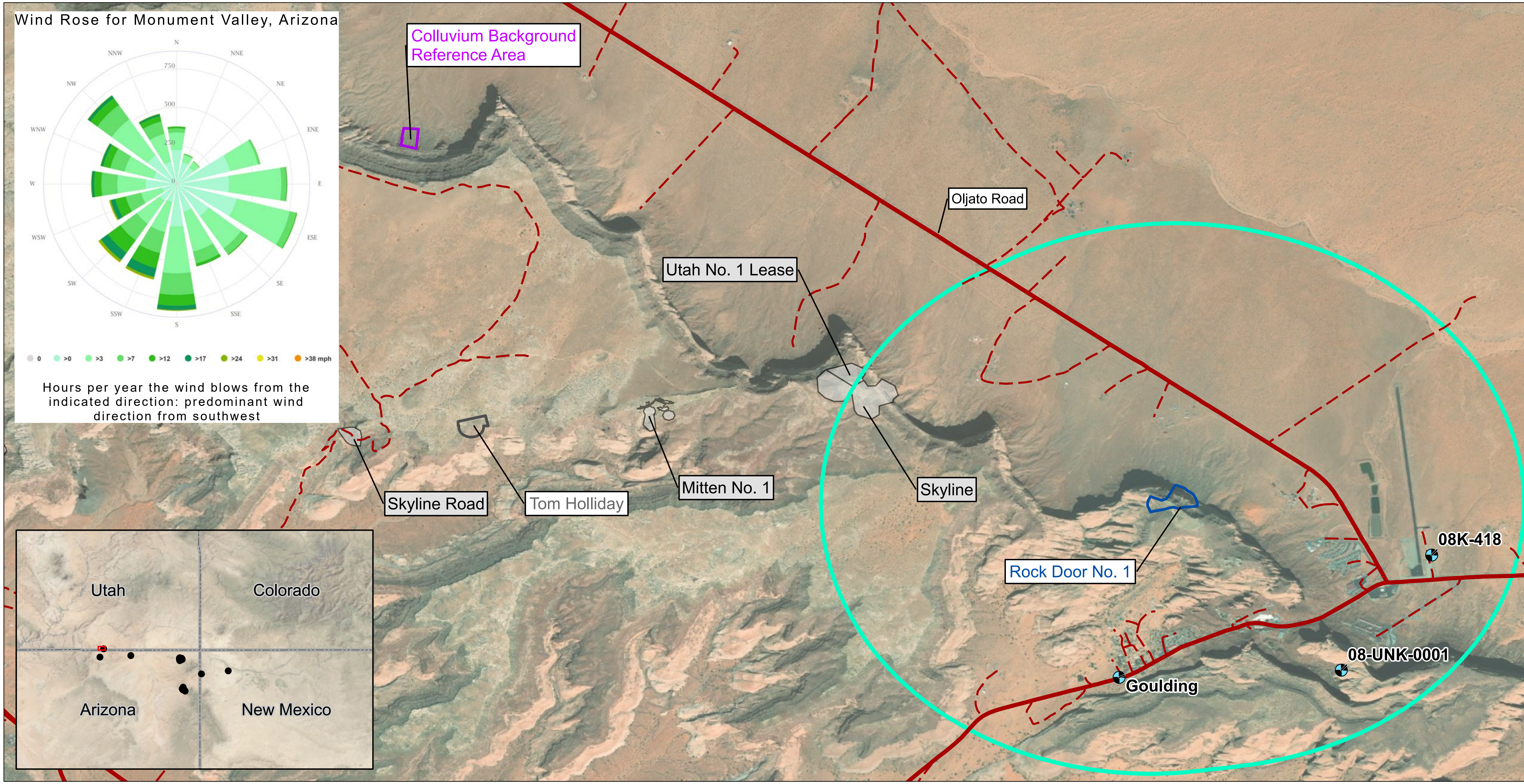

LEGEND

- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria
- Group One Mine Boundary
- Consent Decree Mine Boundary
- Non-Consent Decree Mine Boundary
- Background Reference Area
- 1-Mile radius around Mine Site
- Major Roads
- Unpaved / Local Road

Notes:
Water wells and surface water features meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and sampling was attempted.
CH2M = CH2M HILL Engineers, Inc.
NDWR = Navajo Nation Department of Water Resources
RSE = removal site evaluation

Sources:
1. Navajo Nation Department of Water Resources Water Management Branch Well Database. Accessed online August 2017.
2. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites.* October.
3. Wind Rose Source:
https://www.meteoblue.com/en/weather/forecast/modelclimate/monument-valley-navajo-tribal-park_united-states-of-america_5305400

N

0 1,000 2,000 4,000
Feet
1:24,000 1 inch = 2,000 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 1-3. General Location Map
Rock Door No. 1
Removal Site Evaluation Report

JACOBS

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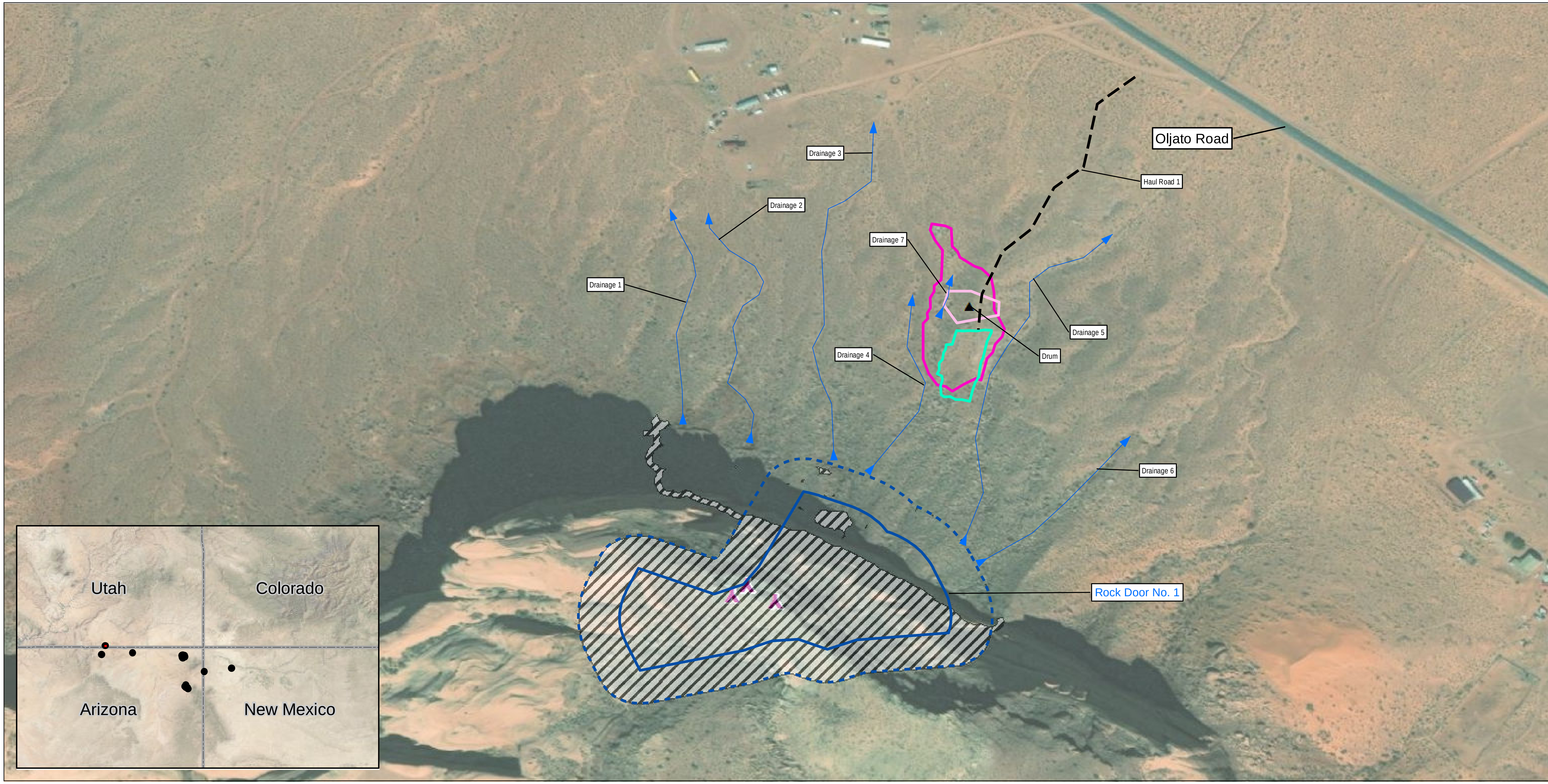

LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drum
- Drainage
- Former Haul Road
- 100-foot Mine Buffer
- Group One Mine Boundary
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump
- Interim Action Fence

Notes:
Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
Jacobs = Jacobs Engineering Group Inc.

N

0 150 300 600
Feet
1:3,658
1 inch = 304.84 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 2-1. Site Layout
Rock Door No. 1
Removal Site Evaluation Report

JACOBS

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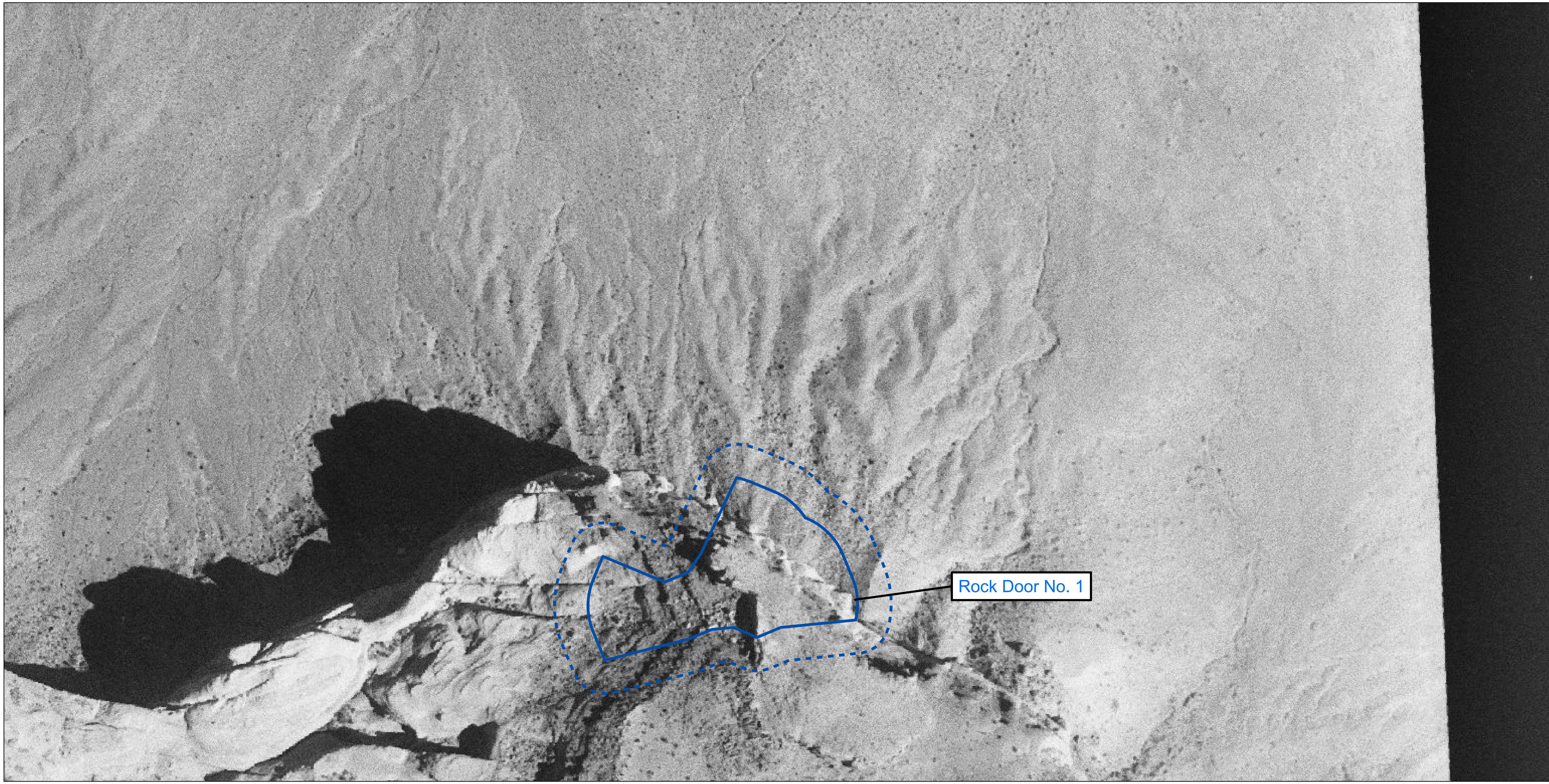

LEGEND

100-foot Mine Buffer

Group One Mine Boundary

N

0 150 300 600

Feet

1:3,600 1 inch = 300 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: Earth Data Analysis Center Univeristy of New Mexico 2016

Figure 2-2. Historical Aerial Photo from 1950
Rock Door No. 1
Removal Site Evaluation Report

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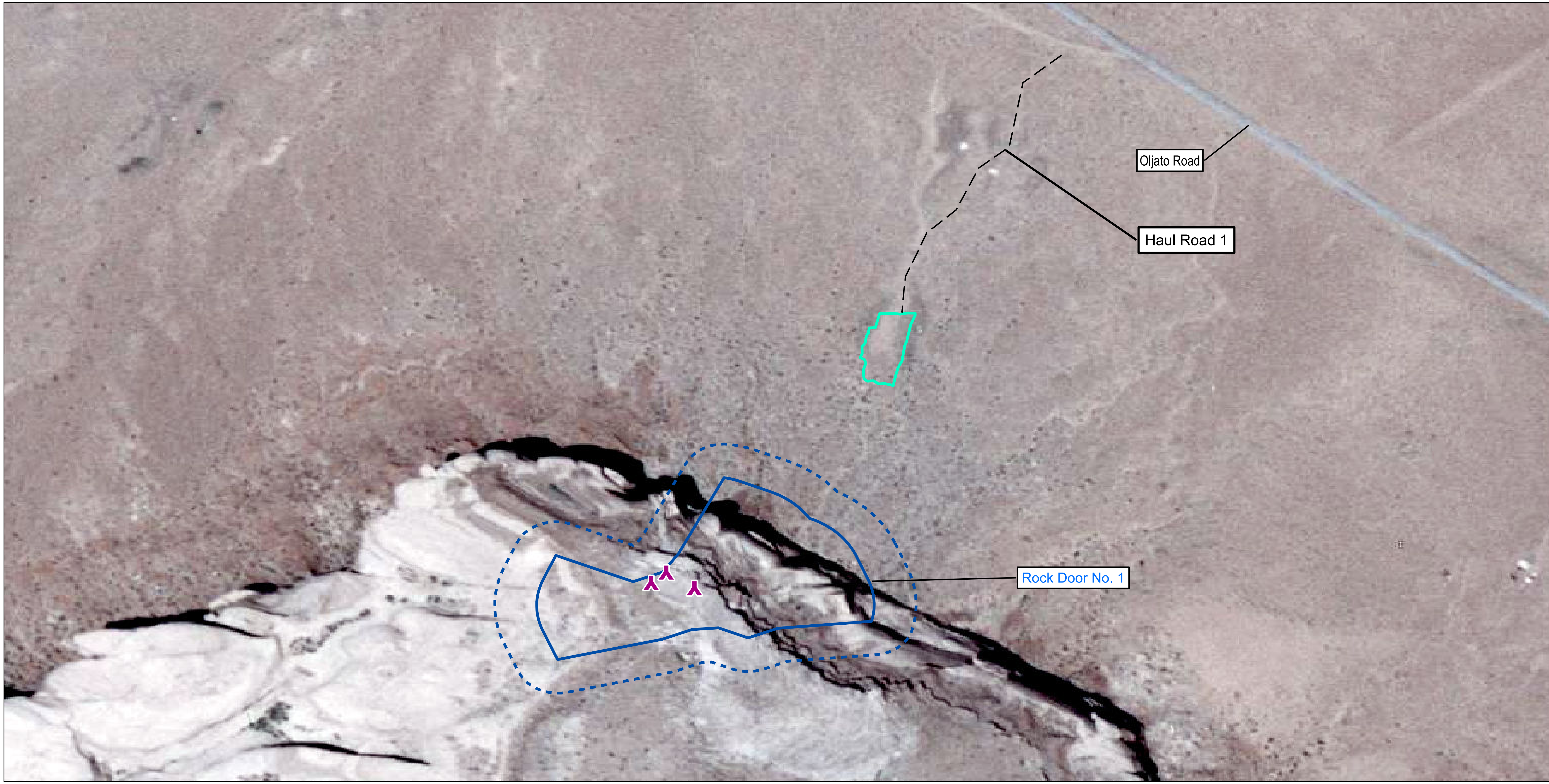
Notes:
Jacobs = Jacobs Engineering Group Inc.



LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Former Haul Road
- Rock Door No. 1 Loadout Area
- 100-foot Mine Buffer
- Group One Mine Boundary

Notes:
Jacobs = Jacobs Engineering Group Inc.

N

0 150 300 600
Feet
1:3,600 1 inch = 300 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: United States Geological Survey 2018

Figure 2-3. Historical Aerial Photo from 1980
Rock Door No. 1
Removal Site Evaluation Report

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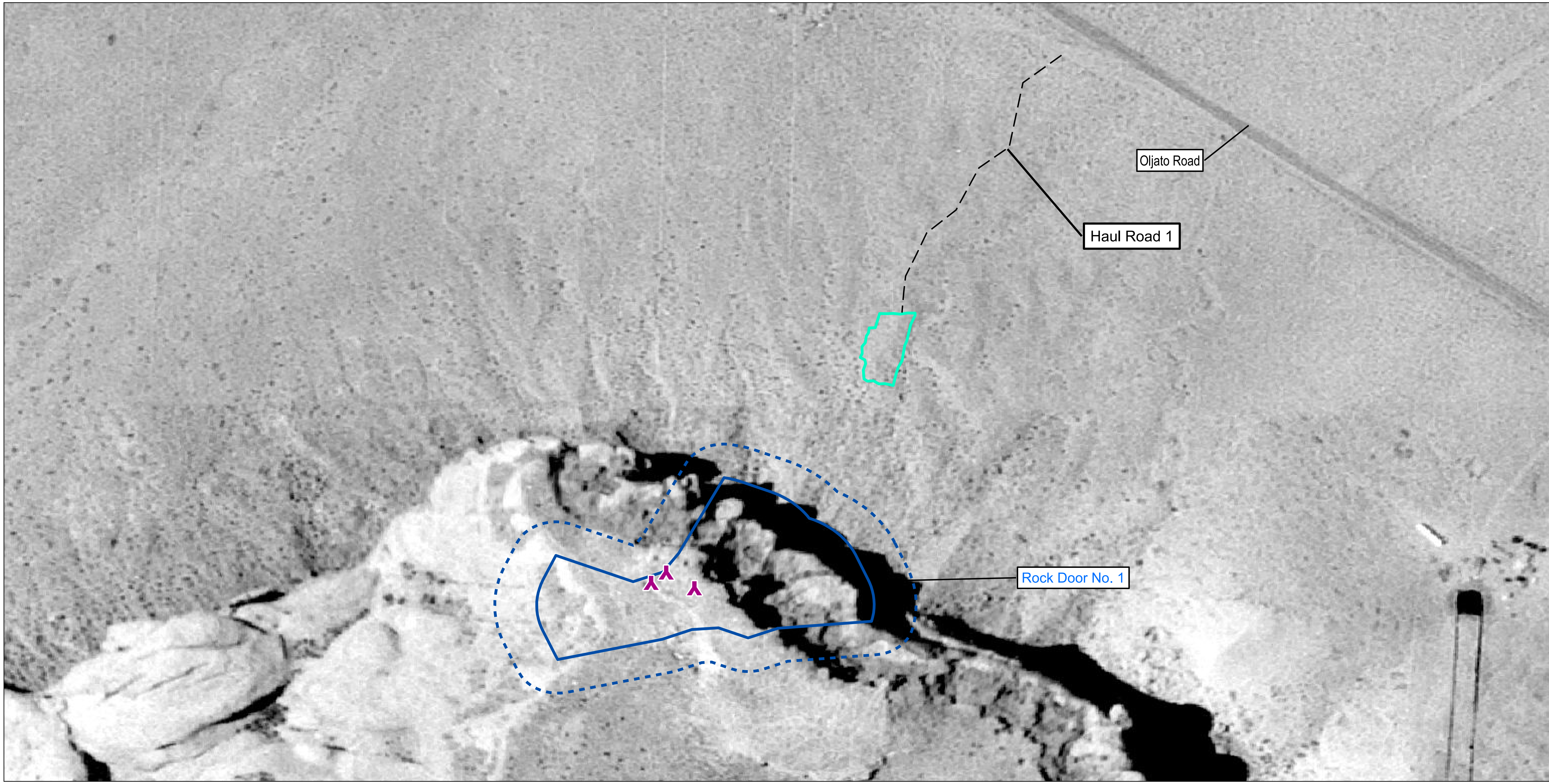

LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Former Haul Road
- Rock Door No. 1 Loadout Area
- 100-foot Mine Buffer
- Group One Mine Boundary

Notes:
Jacobs = Jacobs Engineering Group Inc.

N

0 150 300 600
Feet
1:3,600 1 inch = 300 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: United States Geological Survey 2018

Figure 2-4. Historical Aerial Photo from 1993
Rock Door No. 1
Removal Site Evaluation Report

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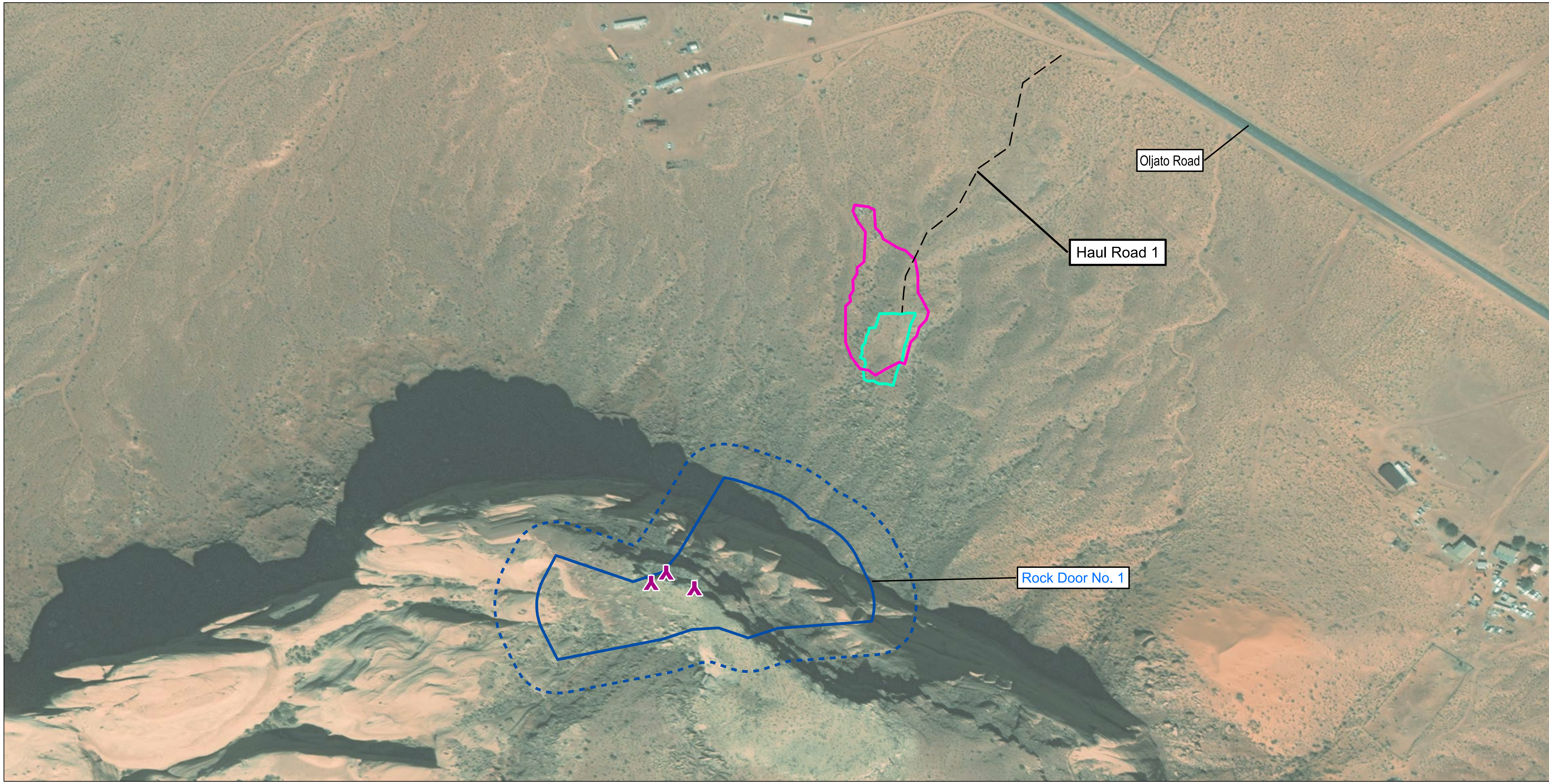

LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Former Haul Road
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump
- 100-foot Mine Buffer
- Group One Mine Boundary

Notes:
Jacobs = Jacobs Engineering Group Inc.

N

0 150 300 600
Feet
1:3,600 1 inch = 300 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 2-5. Satellite Imagery from 2019
Rock Door No. 1
Removal Site Evaluation Report

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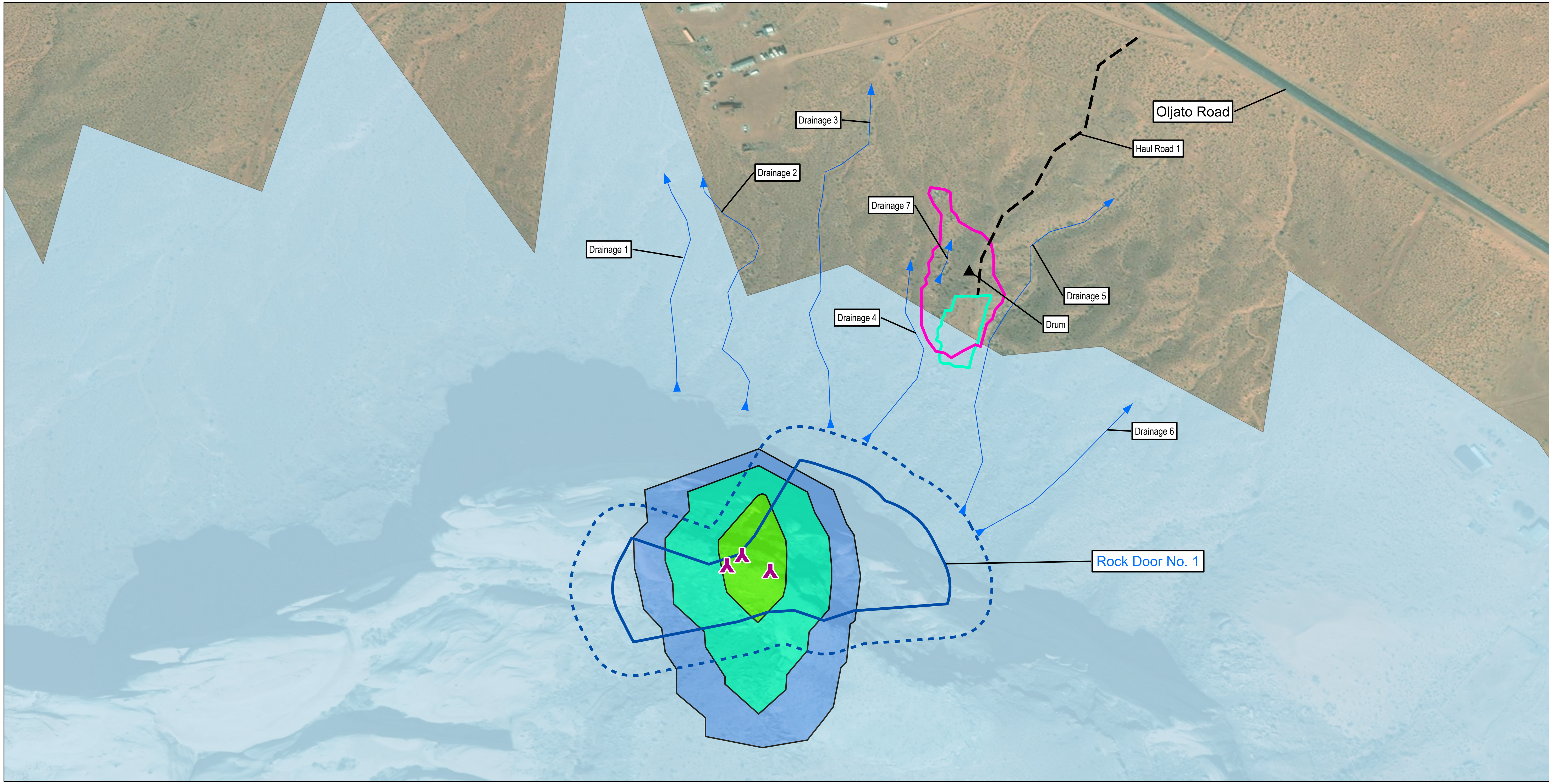

LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drum
- Drainage
- Former Haul Road
- 100-foot Mine Buffer
- Group One Mine Boundary
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump

Ground Surface Exposure Rate (in μR/hr)

- 0 - 2.4
- 2.4 - 3.5
- 3.5 - 5.2
- 5.2 - 7.4

Notes:
1. US EPA Region 9 and US Department of Energy excess bismuth-214 data collected from October 1994 to October 1999.
2. Ground surface exposure rate is estimated from excess bismuth-214 readings in counts per minute based upon the 1764keV photopeak. Bismuth-214 is based upon measured minus expected bismuth-214 times a per flight determined constant equal to a ratio of statistically most likely values.
3. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).

Notes: (cont)
μR/hr = microroentgen per hour
AUM = Abandoned Uranium Mines
Jacobs = Jacobs Engineering Group Inc.
USEPA = United States Environmental Protection Agency

Source:
U.S. Environmental Protection Agency (U.S. EPA). 2007. Abandoned Uranium Mines and the Navajo Nation, Navajo Nation AUM Screening Assessment Report and Atlas with Geospatial Data. August.

N

0 150 300 600
Feet
1:3,600 1 inch = 300 feet

Figure 2-6. Ground Surface Exposure Rate Map
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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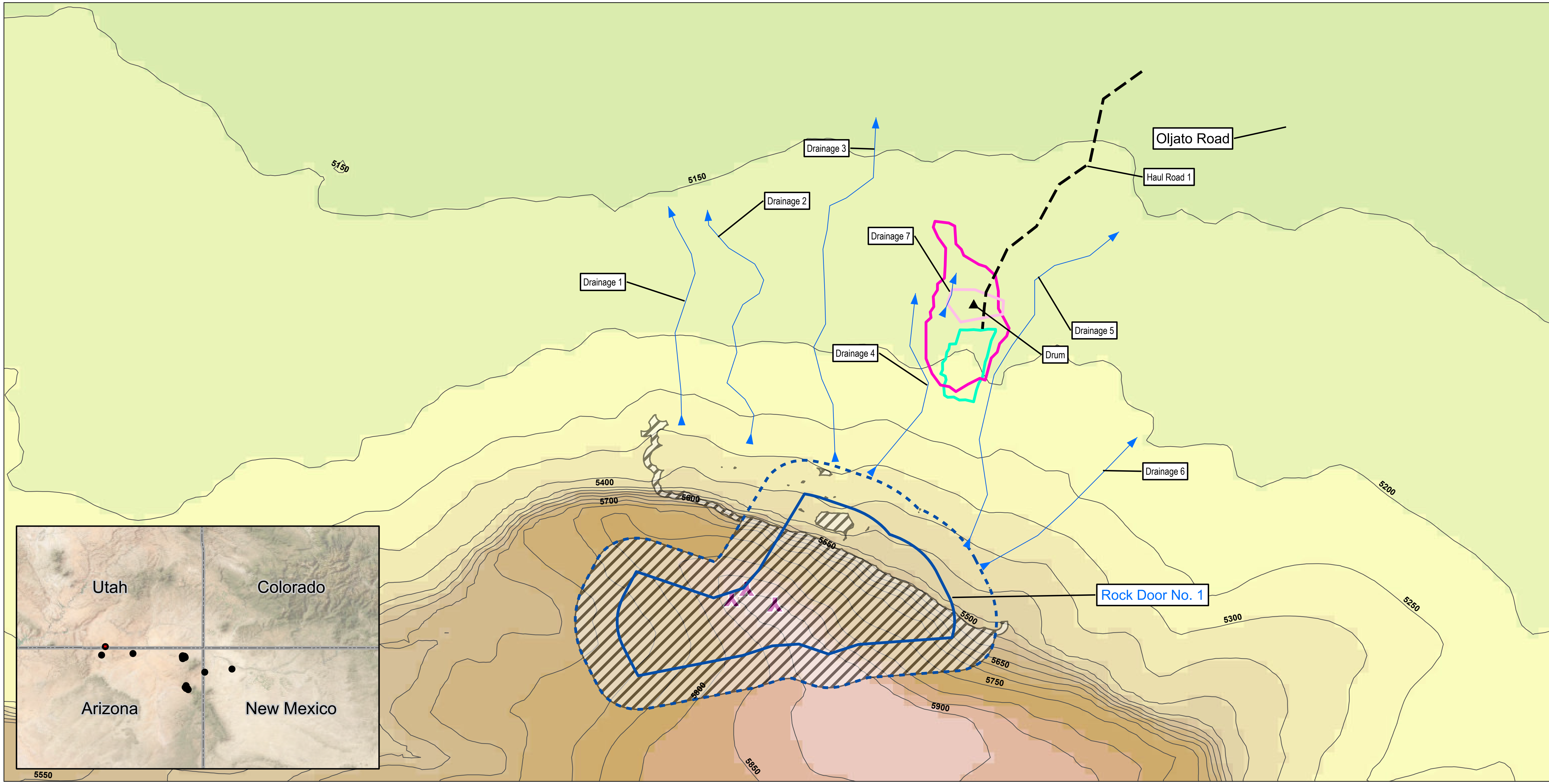

LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drum
- Drainage
- Former Haul Road
- Contour (50 foot interval)
- 100-foot Mine Buffer
- Group One Mine Boundary
- Consent Decree Mine Boundary
- Non-Consent Decree Mine Boundary
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump
- Interim Action Fence

Elevation in feet

5,100 - 5,150	5,400 - 5,450	5,750 - 5,800
5,150 - 5,200	5,450 - 5,500	5,800 - 5,850
5,200 - 5,250	5,500 - 5,550	5,850 - 5,900
5,250 - 5,300	5,550 - 5,600	5,900 - 5,950
5,300 - 5,350	5,600 - 5,650	
5,350 - 5,400	5,650 - 5,700	
	5,700 - 5,750	

Notes:
1. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
2. Contours and Elevation data are based on USGS 1/3rd arc-second Digital Elevation Model raster data: USGS_13_n38w111_20211215.tif
Jacobs = Jacobs Engineering Group Inc.

N

0 150 300 600
Feet
1:3,600 1 inch = 300 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;

Figure 2-7. Site Layout Topographic Background
Rock Door No. 1
Removal Site Evaluation Report

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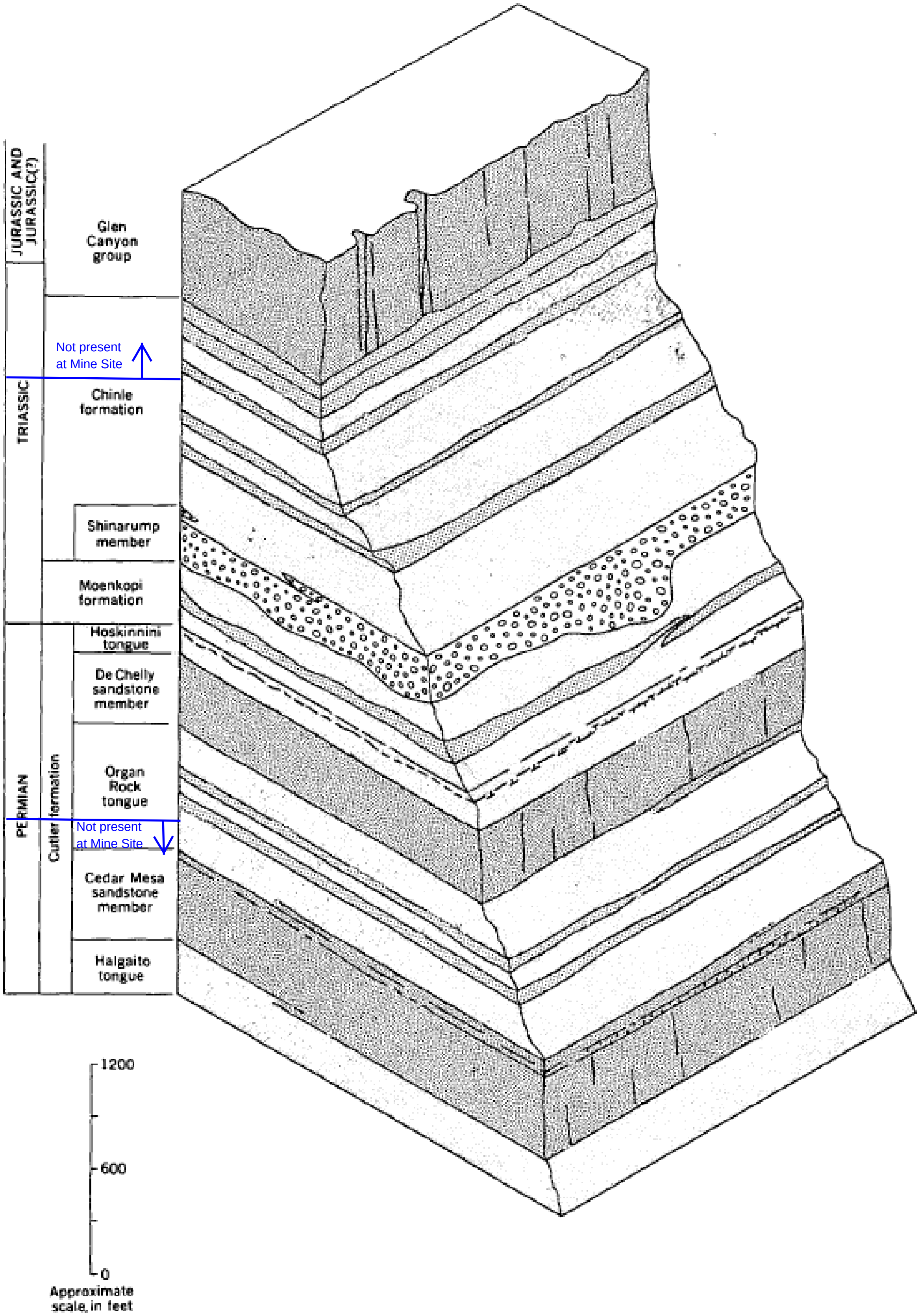
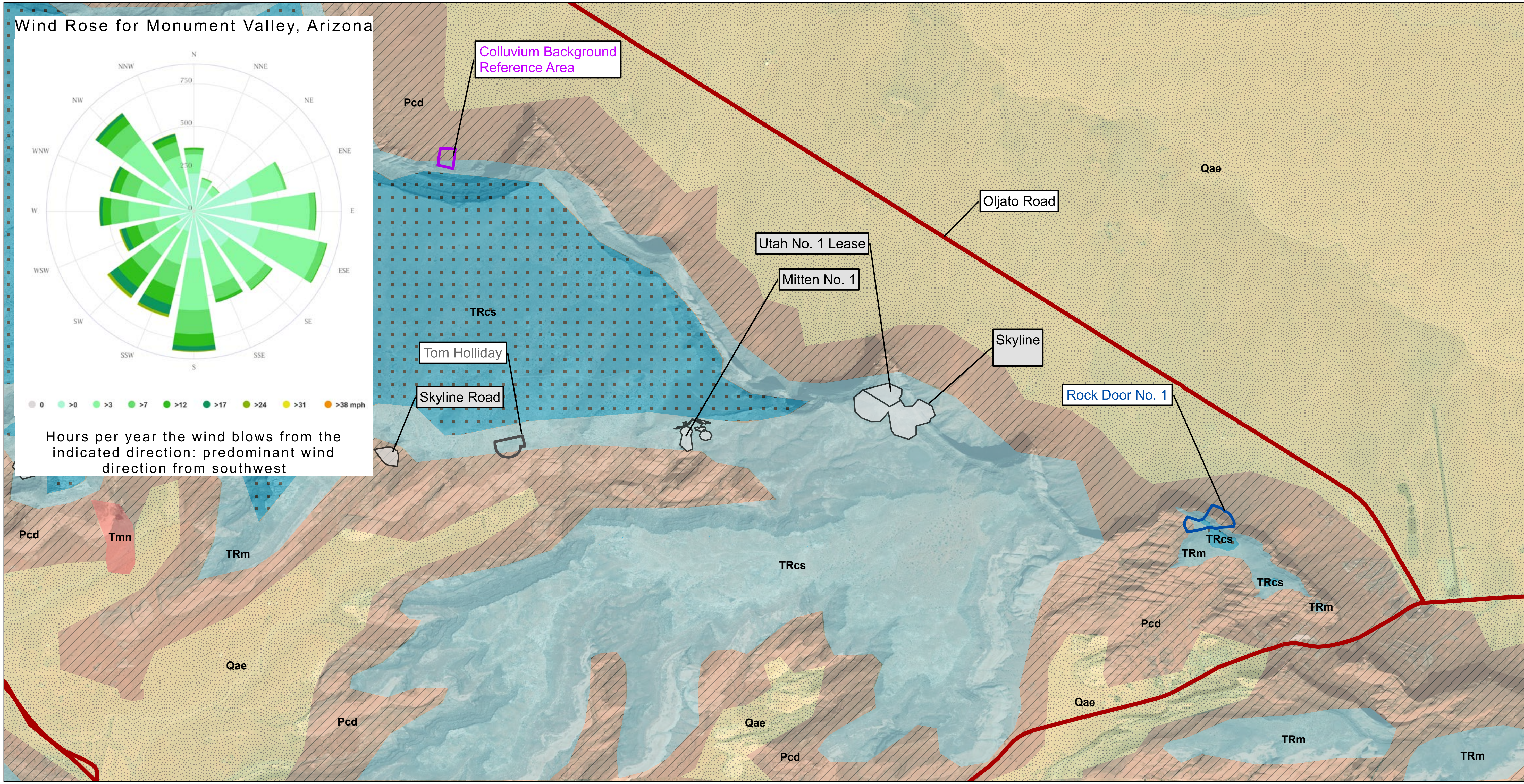


Source: Modified from Lewis R. Q. and Trimble D. E. 1959. Geology and Uranium Deposits of Monument Valley San Juan County, Utah. Geological Survey Bulletin 1087-D. United States Department of the Interior, Geological Survey.

Figure 2-8 **Monument Valley Stratigraphic Column**
Rock Door No. 1
Removal Site Evaluation Report



LEGEND

- Group One Mine Boundary
- Consent Decree Mine Boundary
- Non-Consent Decree Mine Boundary
- Background Reference Area
- Major Roads

SITE GEOLOGY

HOLOCENE

Qae: Alluvial and (or) eolian deposits, reworked by water.

TERTIARY

Tmn: Minette, intrusive basaltic rock composed of diopside, biotite-phlogopite, sanidide, and accessory minerals.

TRIASSIC

TRcs: Shinarump Member of the Chinle Formation. Moderate-orange and yellowish-gray sandstone, siltstone, conglomerate, and sandy shale.

TRIASSIC (CONT.)

TRm: Moenkopi Formation. Reddish-brown, even-bedded ripple-marked sandstone and shaley siltstone.

PERMIAN

Pcd: De Chelly Sandstone Member of the Cutler Formation. Grayish-yellow to tan fine-grained massive cross-bedded eolian sandstone. Forms vertical cliffs and steep rounded slopes; 300 - 500 feet thick; thins to the west.

Sources:
1. Geology adapted from Hackman, R.J., and Wyant, D.G. (1973). Geology, structure, and uranium deposits of the Escalante quadrangle, Utah and Arizona. Miscellaneous Geologic Investigations Map I-744
I-744.1:250,000. https://ngmdb.usgs.gov/Prodesc/proddesc_9498.htm
2. Wind Rose Source:
https://www.meteoblue.com/en/weather/forecast/modelclimate/monument-valley-navajo-tribal-park_united-states-of-america_5305400

N

0 1,000 2,000 4,000
Feet
1:24,000 1 inch = 2,000 feet

Figure 2-9. Geologic Map with Wind Direction
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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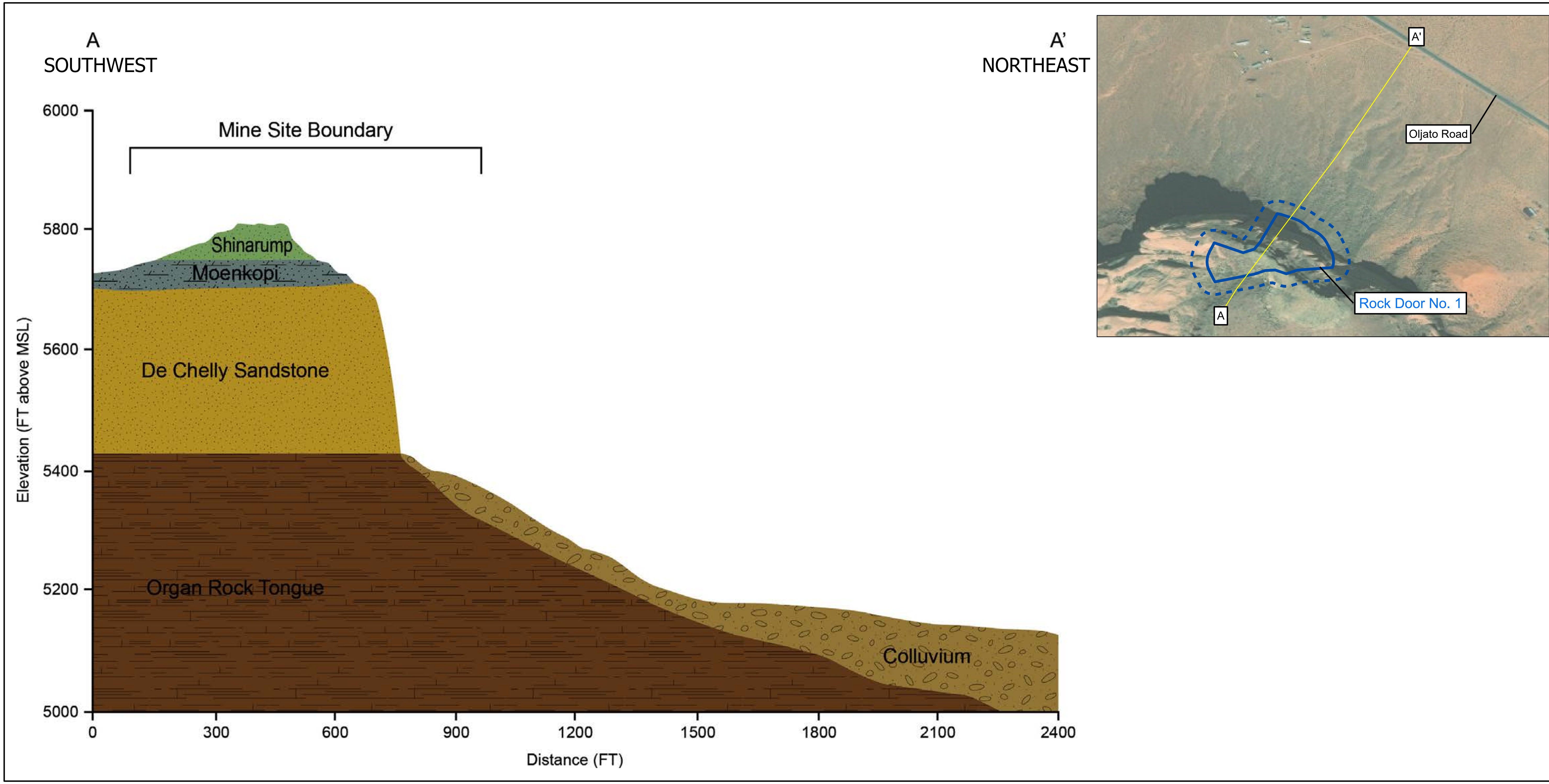

LEGEND

- A-A' line
- 100-foot Mine Buffer
- Group One Mine Boundary

Notes:
Figure is not drawn to scale
FT = Feet
MSL = Mean Sea Level
Jacobs = Jacobs Engineering Group Inc.

N
0 400 800 1,600
Feet
1:9,600 1 inch = 800 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 2-10. Geologic Cross Section
Rock Door No. 1
Removal Site Evaluation Report

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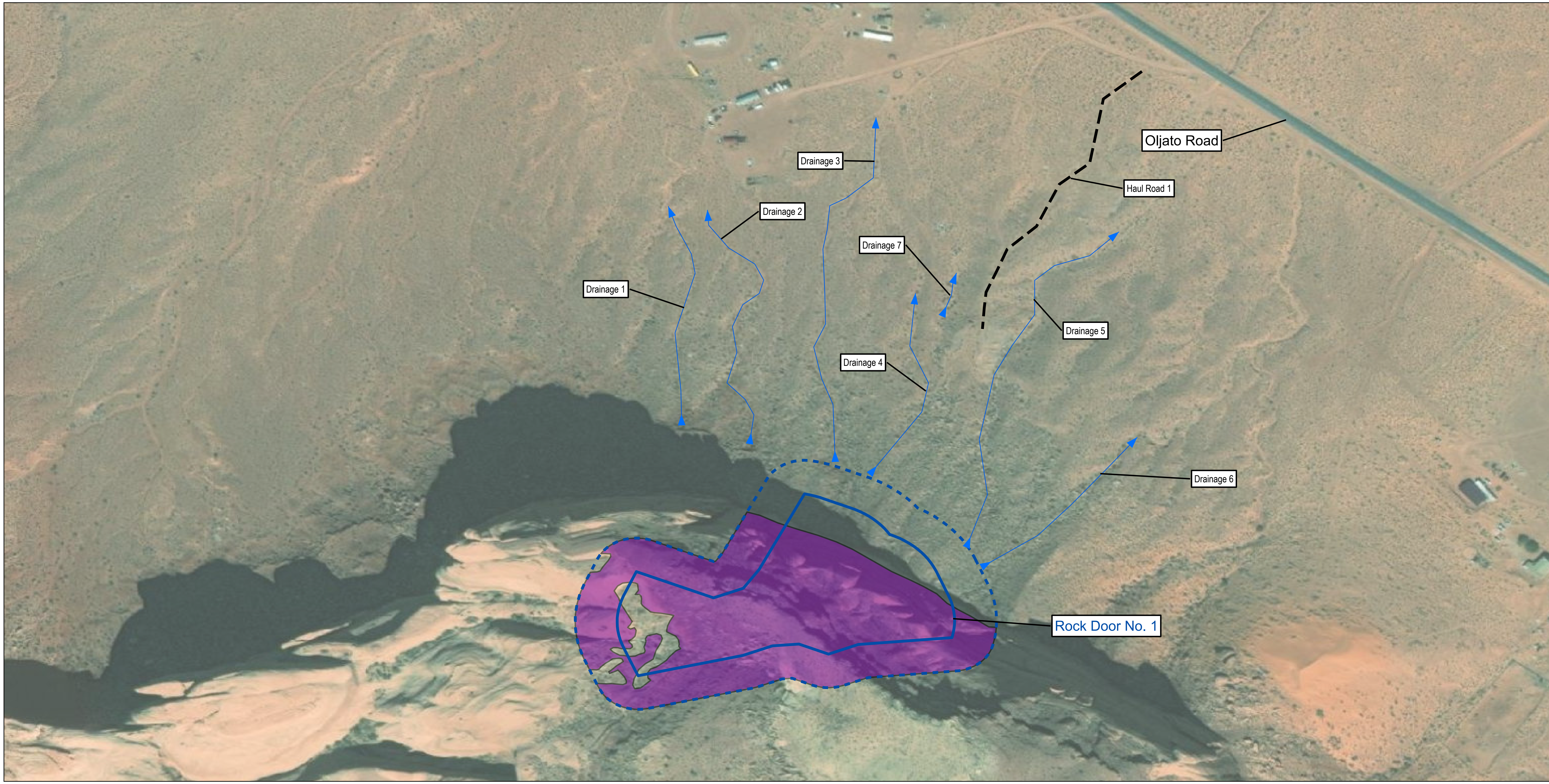

LEGEND

- Drainage
- Former Haul Road
- 100-foot Mine Buffer
- Group One Mine Boundary
- Shallow Bedrock

Notes:
1. Shallow bedrock mapping is an approximation of areas where bedrock is exposed or less than 6 inch soil depths. Areas of soil profiles deeper than 6 inches may exist locally within the mapped areas.
2. Exposed or shallow bedrock may exist outside of areas where it has been mapped.
3. Shallow bedrock was not mapped outside areas where gamma scanning occurred.

N

0 150 300 600
Feet
1:3,600 1 inch = 300 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 2-11. Shallow Bedrock Mapping
Rock Door No. 1
Removal Site Evaluation Report

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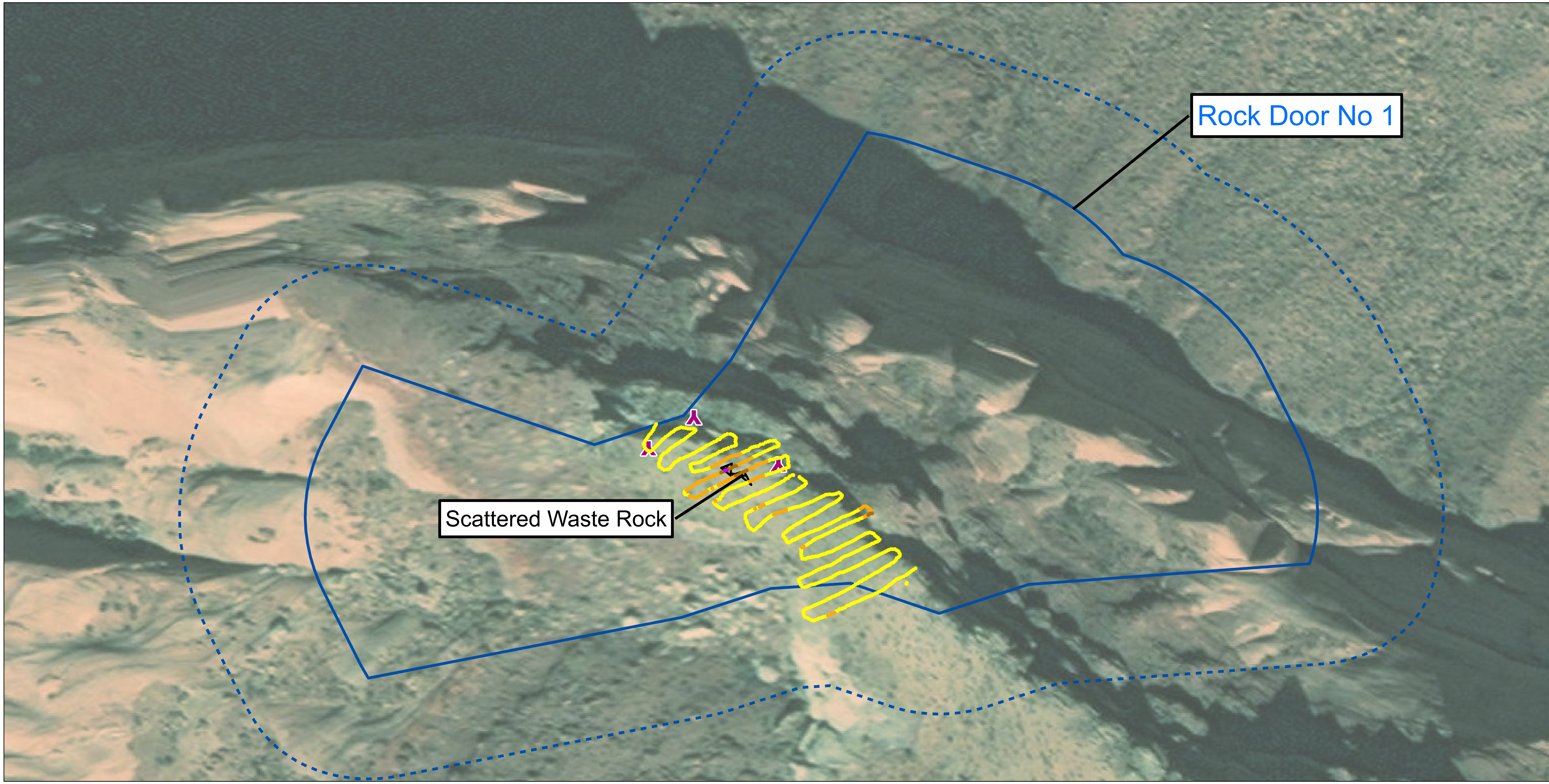

LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- 100-foot Mine Buffer
- Group One Mine Boundary
- Cyprus Amax/Jacobs Observed Scattered Waste Rock

Colluvium Gamma (cpm)

- 10263 - 25000
- 25001 - 50000
- 50001 - 100000
- 100001 - 110298

Notes:
1. This data is for screening purposes only and was not collected using the methodology set forth in the approved Removal Site Evaluation Work Plan
2. Gamma BTV for Colluvium is 14400 cpm.
BTV = background threshold value
cpm = counts per minute
Jacobs = Jacobs Engineering Group Inc.

N

0 50 100 200
Feet
1:1,200 1 inch = 100 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 3-1. Top of Mesa Gamma Scan Survey
Rock Door No. 1
Removal Site Evaluation Report

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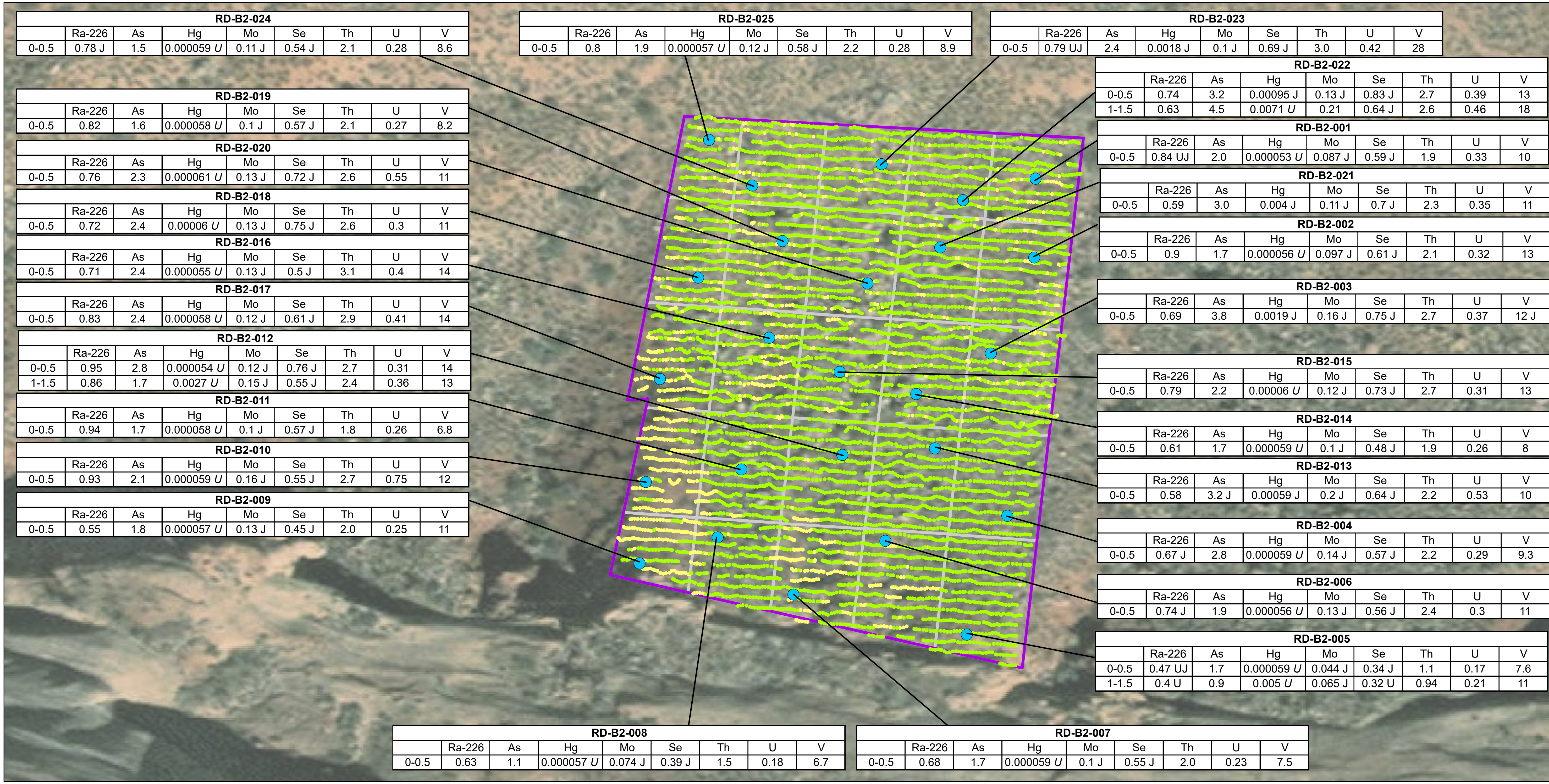

RD-B2-024

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.78 J	1.5	0.000059 *U*	0.11 J	0.54 J	2.1	0.28	8.6

RD-B2-025

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.8	1.9	0.000057 *U*	0.12 J	0.58 J	2.2	0.28	8.9

RD-B2-023

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.79 UJ	2.4	0.0018 J	0.1 J	0.69 J	3.0	0.42	28

RD-B2-022

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.74	3.2	0.00095 J	0.13 J	0.83 J	2.7	0.39	13
1-1.5	0.63	4.5	0.0071 *U*	0.21	0.64 J	2.6	0.46	18

RD-B2-019

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.82	1.6	0.000058 *U*	0.1 J	0.57 J	2.1	0.27	8.2

RD-B2-001

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.84 UJ	2.0	0.000053 *U*	0.087 J	0.59 J	1.9	0.33	10

RD-B2-020

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.76	2.3	0.000061 *U*	0.13 J	0.72 J	2.6	0.55	11

RD-B2-021

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.59	3.0	0.004 J	0.11 J	0.7 J	2.3	0.35	11

RD-B2-018

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.72	2.4	0.00006 *U*	0.13 J	0.75 J	2.6	0.3	11

RD-B2-002

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.9	1.7	0.000056 *U*	0.097 J	0.61 J	2.1	0.32	13

RD-B2-016

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.71	2.4	0.000055 *U*	0.13 J	0.5 J	3.1	0.4	14

RD-B2-017

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.83	2.4	0.000058 *U*	0.12 J	0.61 J	2.9	0.41	14

RD-B2-003

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.69	3.8	0.0019 J	0.16 J	0.75 J	2.7	0.37	12 J

RD-B2-012

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.95	2.8	0.000054 *U*	0.12 J	0.76 J	2.7	0.31	14
1-1.5	0.86	1.7	0.0027 *U*	0.15 J	0.55 J	2.4	0.36	13

RD-B2-015

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.79	2.2	0.00006 *U*	0.12 J	0.73 J	2.7	0.31	13

RD-B2-011

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.94	1.7	0.000058 *U*	0.1 J	0.57 J	1.8	0.26	6.8

RD-B2-014

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.61	1.7	0.000059 *U*	0.1 J	0.48 J	1.9	0.26	8

RD-B2-010

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.93	2.1	0.000059 *U*	0.16 J	0.55 J	2.7	0.75	12

RD-B2-013

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.58	3.2 J	0.00059 J	0.2 J	0.64 J	2.2	0.53	10

RD-B2-009

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.55	1.8	0.000057 *U*	0.13 J	0.45 J	2.0	0.25	11

RD-B2-004

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.67 J	2.8	0.000059 *U*	0.14 J	0.57 J	2.2	0.29	9.3

RD-B2-006

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.74 J	1.9	0.000056 *U*	0.13 J	0.56 J	2.4	0.3	11

RD-B2-005

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.47 UJ	1.7	0.000059 *U*	0.044 J	0.34 J	1.1	0.17	7.6
1-1.5	0.4 U	0.9	0.005 *U*	0.065 J	0.32 U	0.94	0.21	11

RD-B2-008

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.63	1.1	0.000057 *U*	0.074 J	0.39 J	1.5	0.18	6.7

RD-B2-007

	Ra-226	As	Hg	Mo	Se	Th	U	V
0-0.5	0.68	1.7	0.000059 *U*	0.1 J	0.55 J	2.0	0.23	7.5

LEGEND

- Sample Location for Primary COPCs
- Background Reference Area
- Background Sampling Grid

Gamma cpm

- 6206 - 10000
- 10001 - 14374

	Colluvium IL
Radium (Ra)-226	1.01 pCi/g
Arsenic (As)	3.91 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	3.62 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg

Notes:
1. Background reference area is 2.0 acres
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV is the 95% USL, Gamma BTV = 11100.
BTV = background threshold value
COPCs = contaminants of primary concern
cpm = counts per minute
IL = Investigation Level
J = estimated concentration
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram

Notes: continued
RSLs = regional screening levels
U = non-detect
UJ = estimated concentration below detection limit
USL = upper simultaneous limit

N

0 37.5 75 150
Feet
1:900 1 inch = 75 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 4-1. Colluvium Background Reference Area Gamma Survey Scan and Soil Sample Results
Rock Door No. 1
Removal Site Evaluation Report

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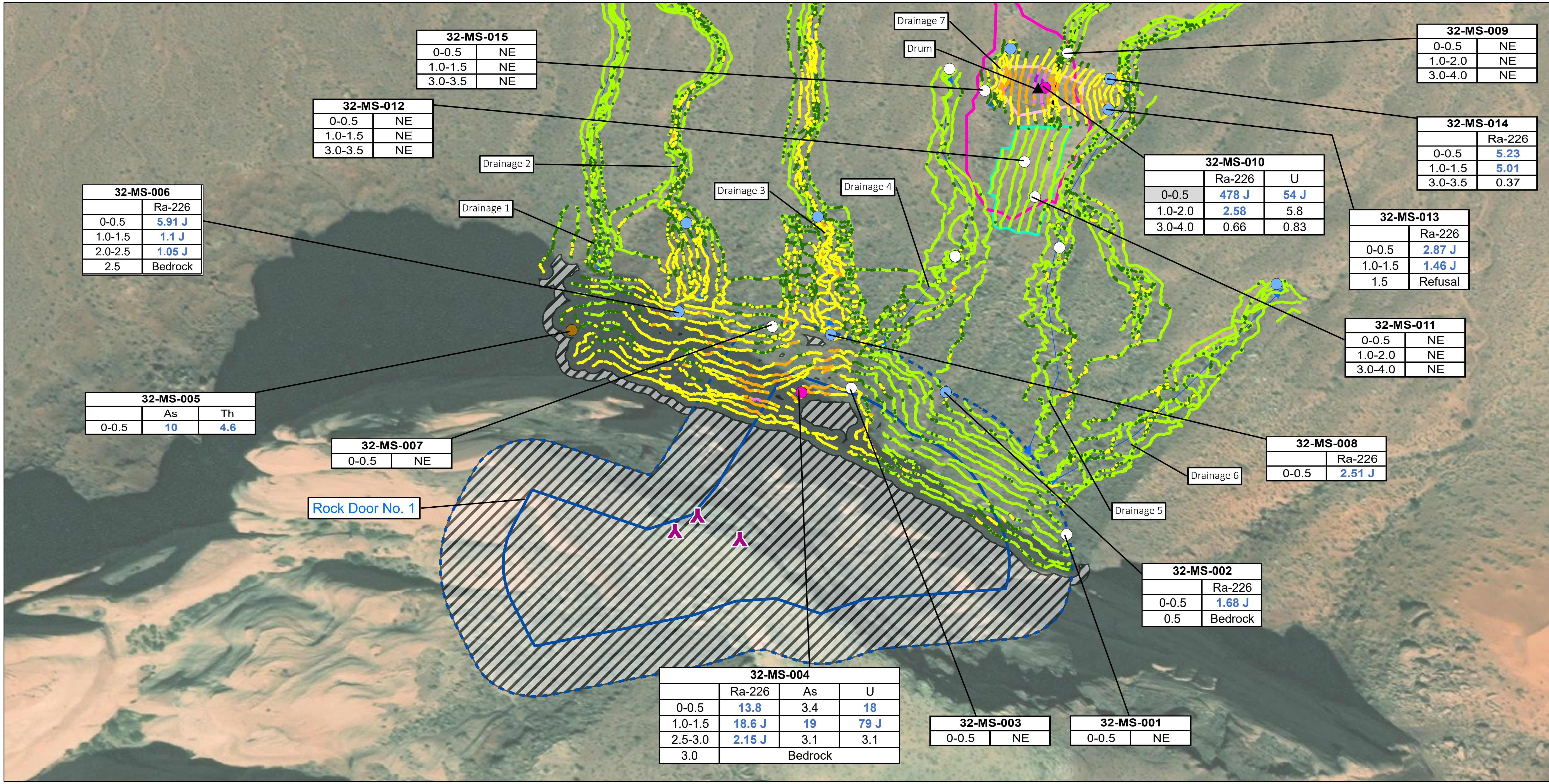

LEGEND

Sample Location
- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drum

- Drainage
- 100-foot Mine Buffer
- Group One Mine Boundary
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Extent of Observed Non-Mining Related Trash Dump
- Interim Action Fence

Colluvium Gamma (cpm)
- 5475 - 11100
- 11101 - 12600
- 12601 - 22200
- 22201 - 55500
- 55501 - 111000
- 111001 - 481300

Notes:
1. Results are only shown for those COPCs that have one exceedance in a boring.
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV for Colluvium is 11100 cpm.
4. Blue and Bold = Exceedance of IL
5. Nomenclature for Surface Soil (0.0-0.5) samples includes an SS at the beginning of the Sample ID
6. Nomenclature for Subsurface Soil (>0.5) samples includes an SB at the beginning of the Sample ID
7. Metal and Ra-226 exceedances are based on the prior BRA. New ILs will be determined upon laboratory analysis and data validation.
8. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
9. Secondary COCPs collected at 32-MS-004 were less than RSLs
10. Mine site accessible area = 4.15 acres
11. Distance of former haul roads surveyed = 0.17 miles

Notes: continued
12. Distance of drainage surveyed = 0.94 miles
Grey Shading = waste rock observed in sample interval. See table 4-5 for full interval
> = greater than
BTV = background threshold value
BRA = Background reference area
COPCs = contaminants of potential concern
cpm = counts per minute
IL = Investigation Level
J = estimated concentration
Jacobs = Jacobs Engineering Group Inc.
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
NE = No Exceedance
pCi/g = picocuries per gram
RSLs = regional screening levels

	Colluvium IL
Radium (Ra)-226	1.01 pCi/g
Arsenic (As)	3.91 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	3.62 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg

N

0 100 200 400
Feet
1:2,400 1 inch = 200 feet

Figure 4-2. Mine Site Gamma Scan Survey and Soil Sampling Results Map
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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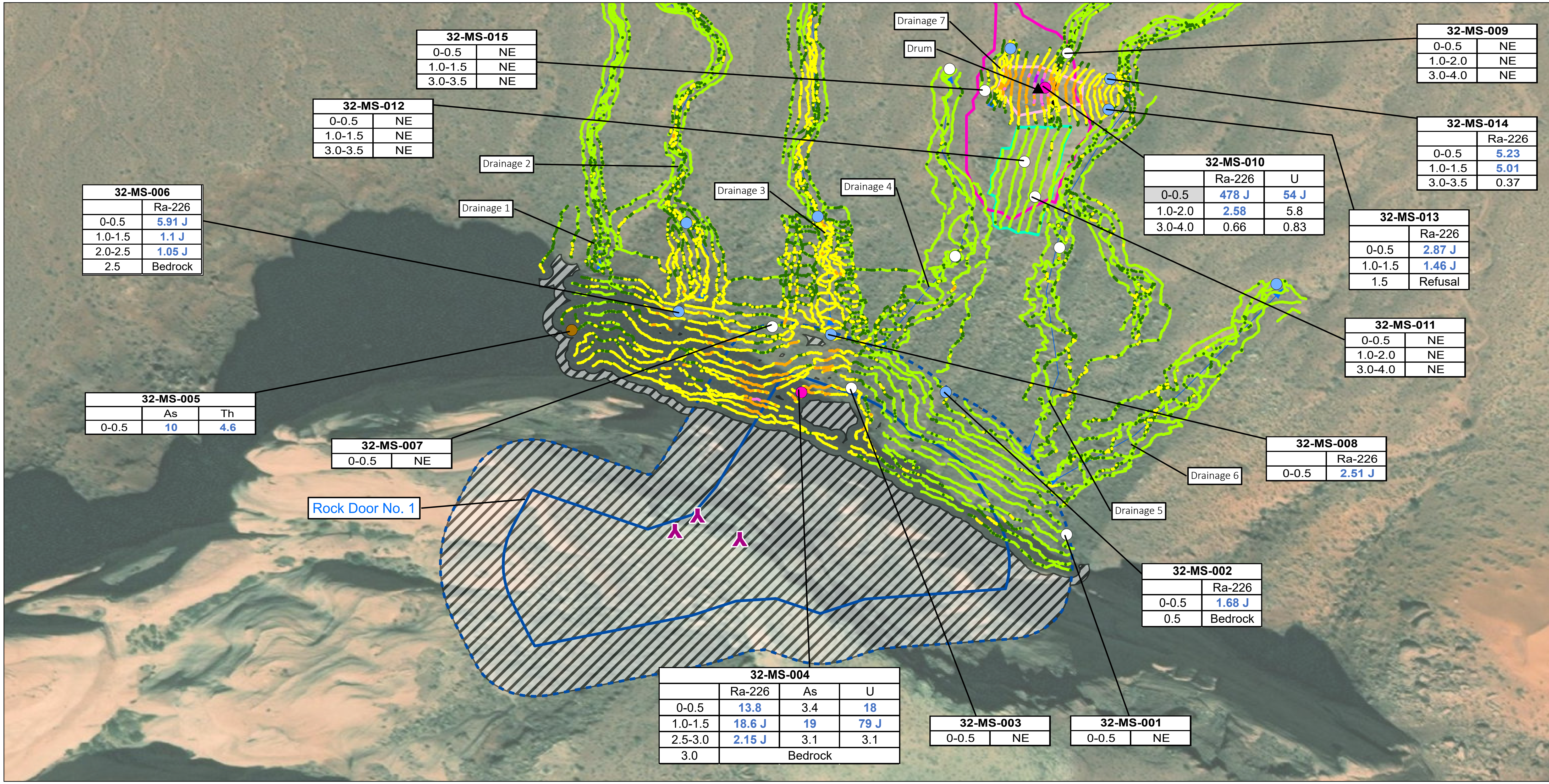

LEGEND

Sample Location

- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drum

- Drainage
- 100-foot Mine Buffer
- Group One Mine Boundary
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Extent of Observed Non-Mining Related Trash Dump
- Interim Action Fence

Colluvium Gamma (cpm)

- 5475 - 11100
- 11101 - 12600
- 12601 - 22200
- 22201 - 55500
- 55501 - 111000
- 111001 - 481300

Notes:
1. Results are only shown for those COPCs that have one exceedance in a boring.
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV for Colluvium is 11100 cpm.
4. Blue and Bold = Exceedance of IL
5. Nomenclature for Surface Soil (0.0-0.5) samples includes an SS at the beginning of the Sample ID
6. Nomenclature for Subsurface Soil (>0.5) samples includes an SB at the beginning of the Sample ID
7. Metal and Ra-226 exceedances are based on the prior BRA. New ILs will be determined upon laboratory analysis and data validation.
8. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
9. Secondary COCPs collected at 32-MS-004 were less than RSLs
10. Mine site accessible area = 4.15 acres
11. Distance of former haul roads surveyed = 0.17 miles

Notes: continued
12. Distance of drainage surveyed = 0.94 miles
* = Waste rock observed in sample.
See table 4-5 for full interval
> = greater than
BTV = background threshold value
BRA = Background reference area
COPCs = contaminants of potential concern
cpm = counts per minute
IL = Investigation Level
J = estimated concentration
Jacobs = Jacobs Engineering Group Inc.
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
NE = No Exceedance
pCi/g = picocuries per gram
RSLs = regional screening levels

	Colluvium IL
Radium (Ra)-226	1.01 pCi/g
Arsenic (As)	3.91 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	3.62 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg

N

0 100 200 400
Feet
1:2,400 1 inch = 200 feet

Figure 4-2. Mine Site Gamma Scan Survey and Soil Sampling Results Map
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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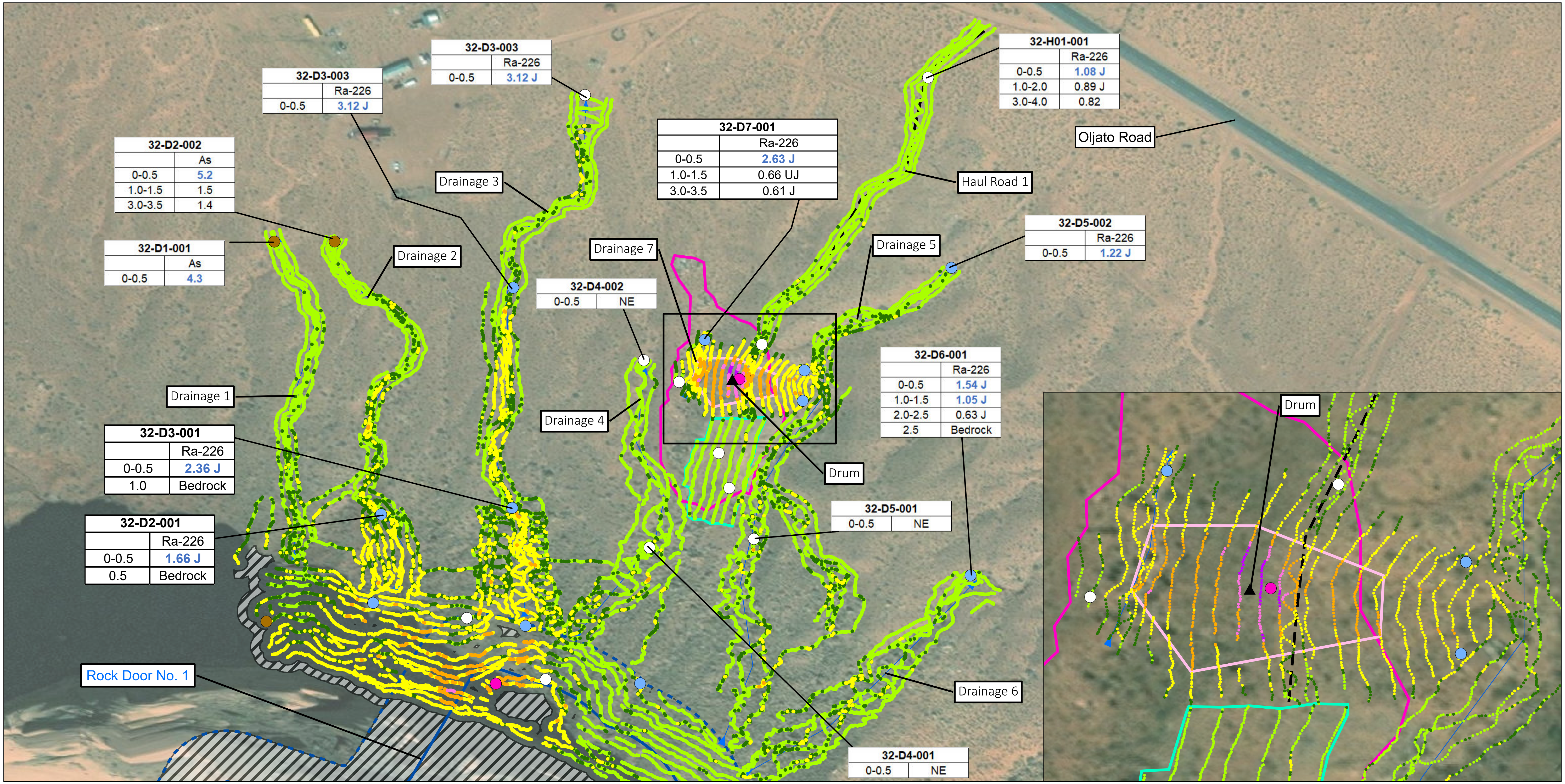

LEGEND

Sample Location
- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Drum
- Drainage

- Former Haul Road
- 100-foot Mine Buffer
- Group One Mine Boundary
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump
- Interim Action Fence

Colluvium Gamma (cpm)
- 5475 - 11100
- 11101 - 12600
- 12601 - 22200
- 22201 - 55500
- 55501 - 111000
- 111001 - 481300

	Colluvium IL
Radium (Ra)-226	1.01 pCi/g
Arsenic (As)	3.91 mg/kg
Mercury (Hg)	11 mg/kg
Molybdenum (Mo)	390 mg/kg
Selenium (Se)	390 mg/kg
Thorium (Th)	3.62 mg/kg
Uranium (U)	16 mg/kg
Vanadium (V)	390 mg/kg

Notes:
1. Results are only shown for those COPCs that have one exceedance in a boring.
2. Ra-226 is reported in pCi/g; metals are reported in mg/kg.
3. Gamma BTV for Colluvium is 11100 cpm.
4. Blue and Bold = Exceedance of IL
5. Nomenclature for Surface Soil (0.0-0.5) samples includes an SS at the beginning of the Sample ID
6. Nomenclature for Subsurface Soil (>0.5) samples includes an SB at the beginning of the Sample ID
7. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
8. Mine site accessible area = 4.15 acres
9. Distance of former haul roads surveyed = 0.17 miles
10. Distance of drainage surveyed = 0.94 miles

> = greater than
BTV = background threshold value
COPCs = contaminants of potential concern
cpm = counts per minute

Notes: continued
IL = Investigation Level
J = estimated concentration
mg/kg = milligrams per kilogram
NAML = Navajo Abandoned Mine Lands
NE = No Exceedance
pCi/g = picocuries per gram
UJ = estimated concentration below detection limit

N

0 100 200 400
Feet
1:2,400 1 inch = 200 feet

Figure 4-3. Drainage and Haul Road Gamma Scan Survey and Soil Sampling Results Map
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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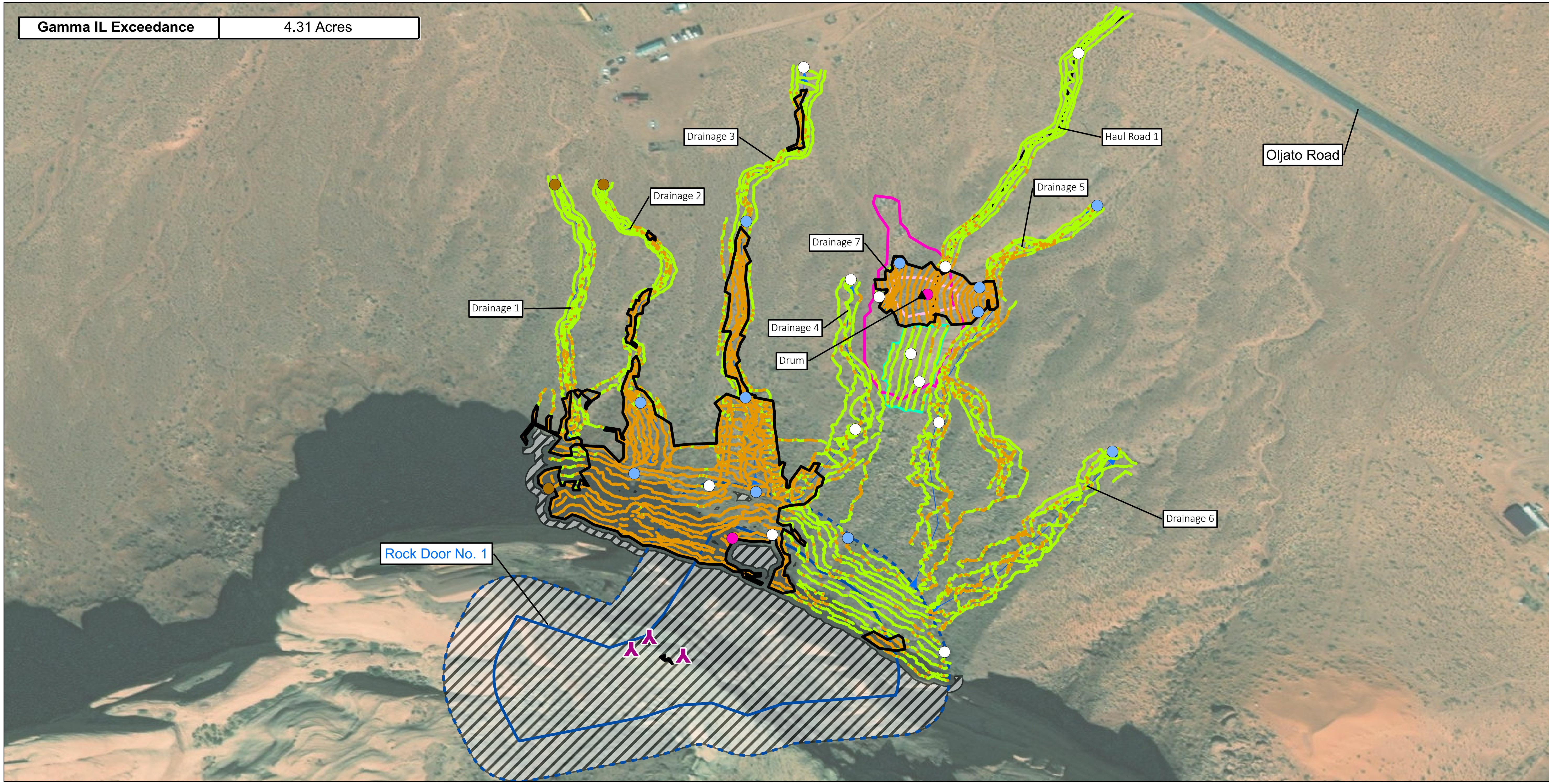

LEGEND

- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Drainage
- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drum
- Former Haul Road
- 100-foot Mine Buffer
- Group One Mine Boundary
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump
- Interim Action Fence
- Gamma Exceedance

Colluvium Gamma (cpm)

- 5475 - 11100
- 11101 - 481300

Notes:
1. BTV and IL for Colluvium gamma scan data is 11100 cpm
2. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Calculated area that exceeds the IL includes mine site, haul roads, and drainages.
BTV = background threshold value
cpm = counts per minute
IL = Investigation Level
Jacobs = Jacobs Engineering Group Inc.

0 125 250 500
Feet
1:3,000 1 inch = 250 feet

Figure 4-4. Gamma Exceedance Area Map
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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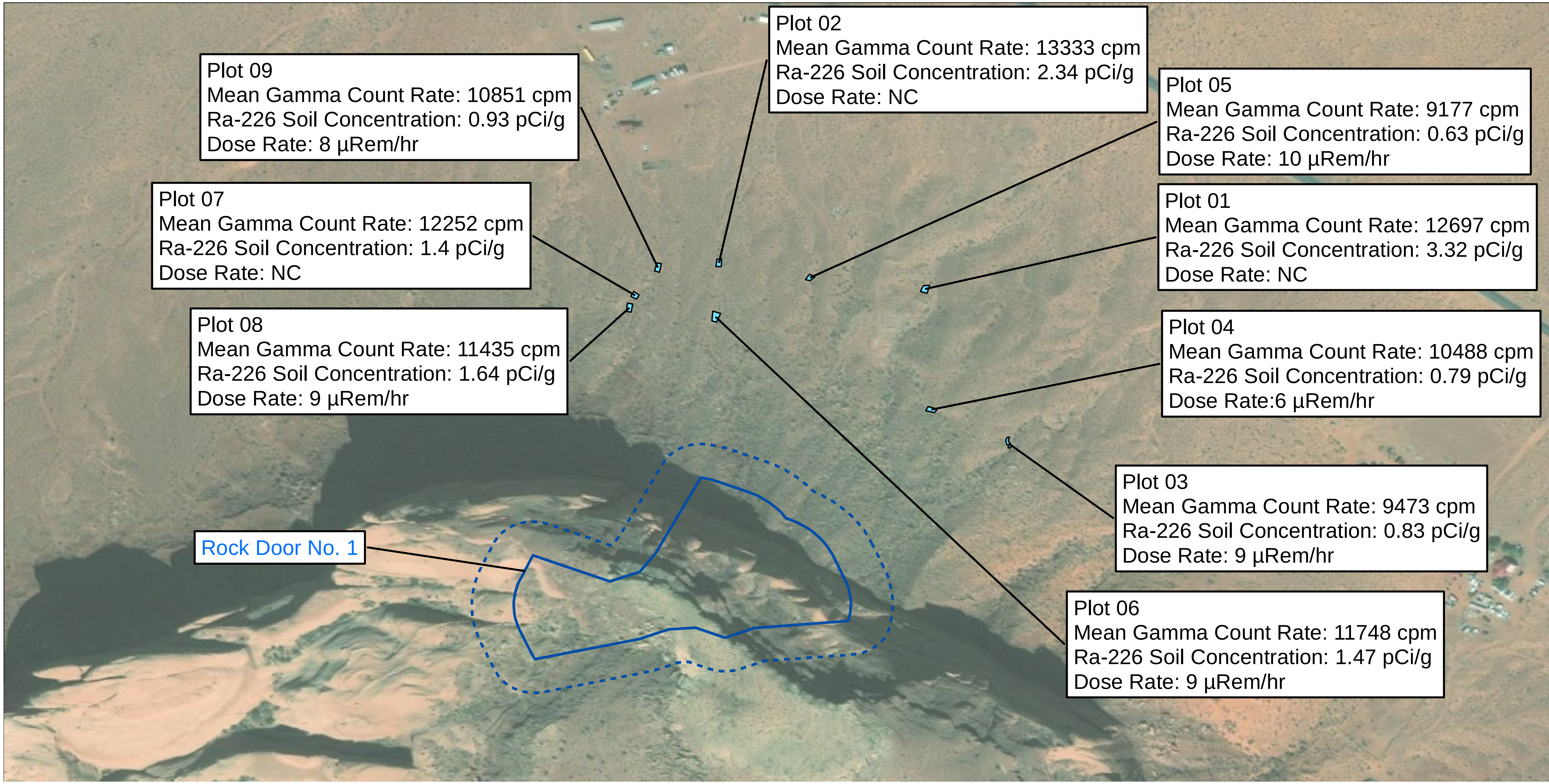

LEGEND

- Correlation Plots
- 100-foot Mine Buffer
- Group One Mine Boundary

Notes:
1. The Bicron MicroREM instrument used for dose rate measurements does not have the resolution required for measurements at low dose rate conditions (less than approximately 15 µRem/hr) and requires reliance on analog interpretation by the field operator. This instrument is appropriate only for its intended use as a health and safety tool.
2. Top of mesa at Rock Door is inaccessible for health and safety reasons.
cpm = counts per minute
µRem/hr = microrems per hour
NC = not collected
pCi/g = picocuries per gram
Ra = Radium

N
0 150 300 600
Feet
1:3,600 1 inch = 300 feet

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 4-5. Correlation Plot Map
Rock Door No. 1
Removal Site Evaluation Report

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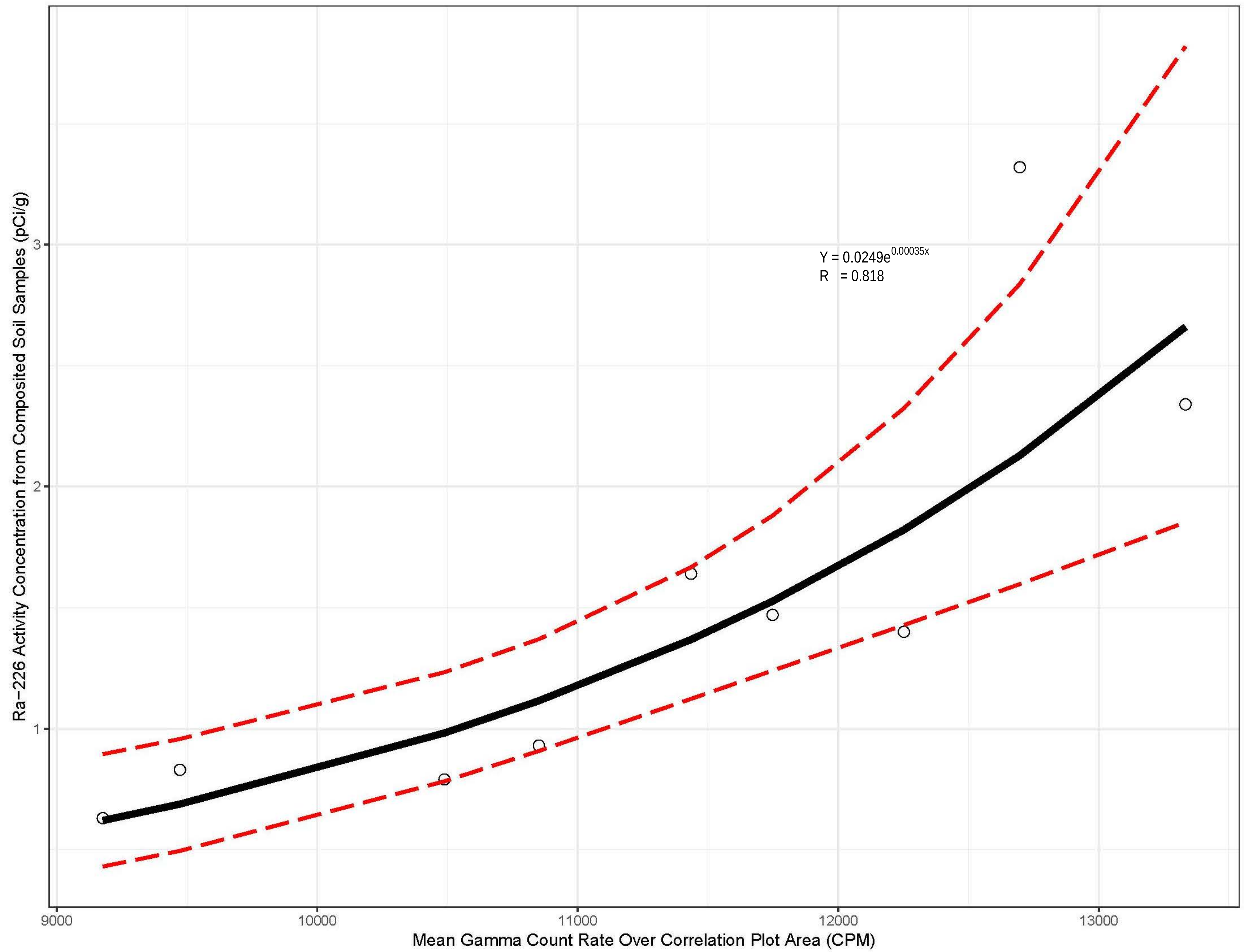
SLC \\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\MONUMENT_VALLEY\ROCK_DOOR_RSE_REPORT\FIGURE 4-5_ROCK_DOOR_CORRELATION_PLOTS_MAP.MXD TARROWOO 3/24/2020 17:29:57



LEGEND

Sample Location

Predicted pCi/g

95% Confidence interval

Notes:
CPM = counts per minute
pCi/g = picocuries per gram
Ra = Radium

Figure 4-6.
Correlation of Mean Gamma Count Rate (cpm)
to Ra-226 Soil Concentration (pCi/g)
Rock Door No. 1
Removal Site Evaluation Report

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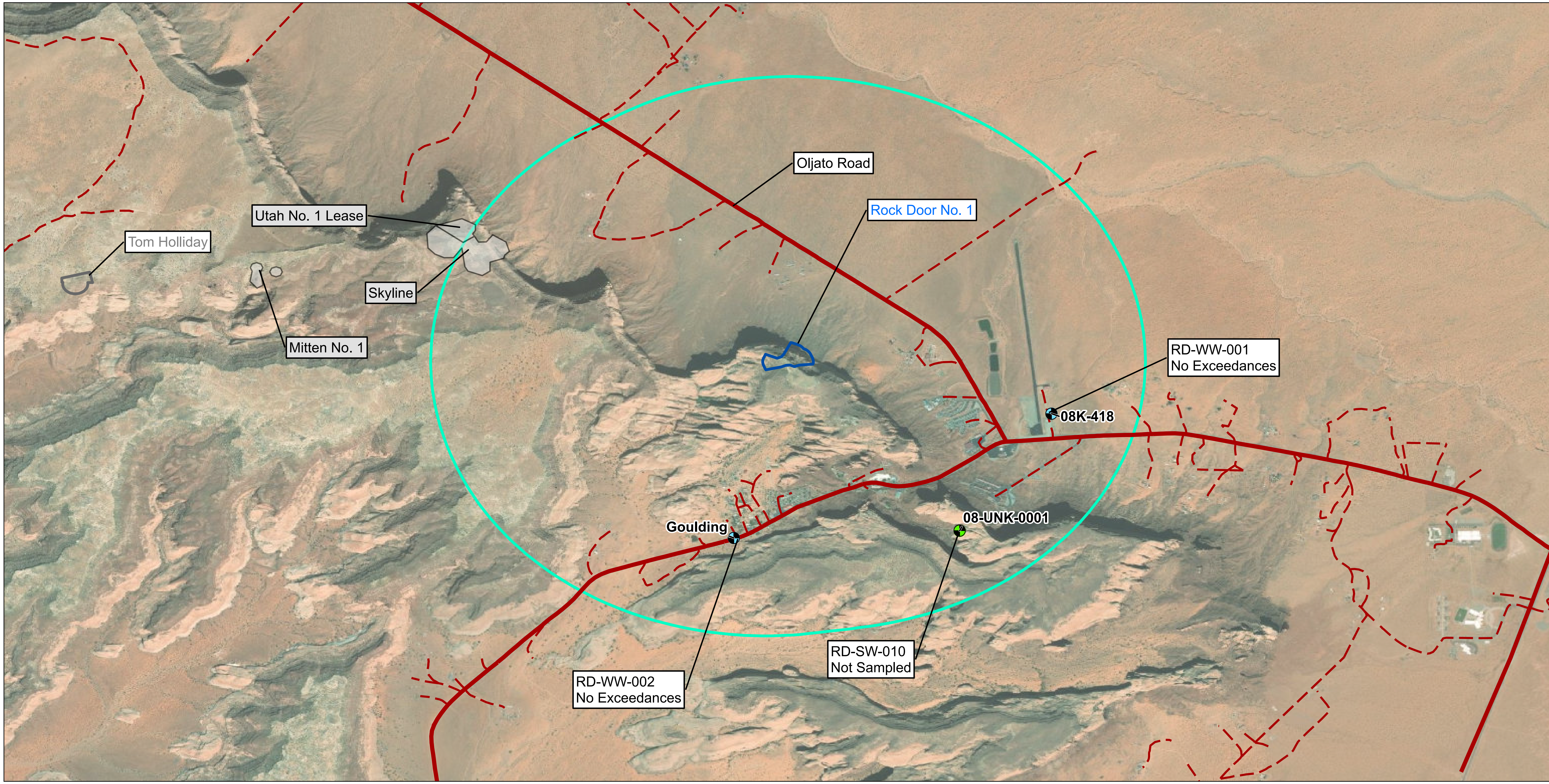

LEGEND

- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria - Not Sampled
- NDWR Well Database Location Meeting RSE Work Plan Sampling Criteria - Sampled
- 1-mile radius around Mine Site
- Group One Mine Boundary
- Consent Decree Mine Boundary
- Non-Consent Decree Mine Boundary
- Major Roads
- Unpaved / Local Road

Notes:
1. Top of mesa at Rock Door is inaccessible for health and safety reasons.
2. Water wells meeting the RSE Work Plan sampling criteria (CH2M, 2017) are shown in blue and green sampling was attempted.
CH2M = CH2M HILL Engineers, Inc.
NDWR = Navajo Nation Department of Water Resources
RSE = removal site evaluation

Sources:
1. Navajo Nation Department of Water Resources Water Management Branch Well Database. Accessed online August 2017.
2. CH2M, 2017. *Removal Site Evaluation Work Plan for Consent Decree Sites*. October.

N

0 1,000 2,000 4,000
Feet
1:24,000 1:24,000

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

Figure 4-7. Water Well and Surface Water Results Map
Rock Door No. 1
Removal Site Evaluation Report

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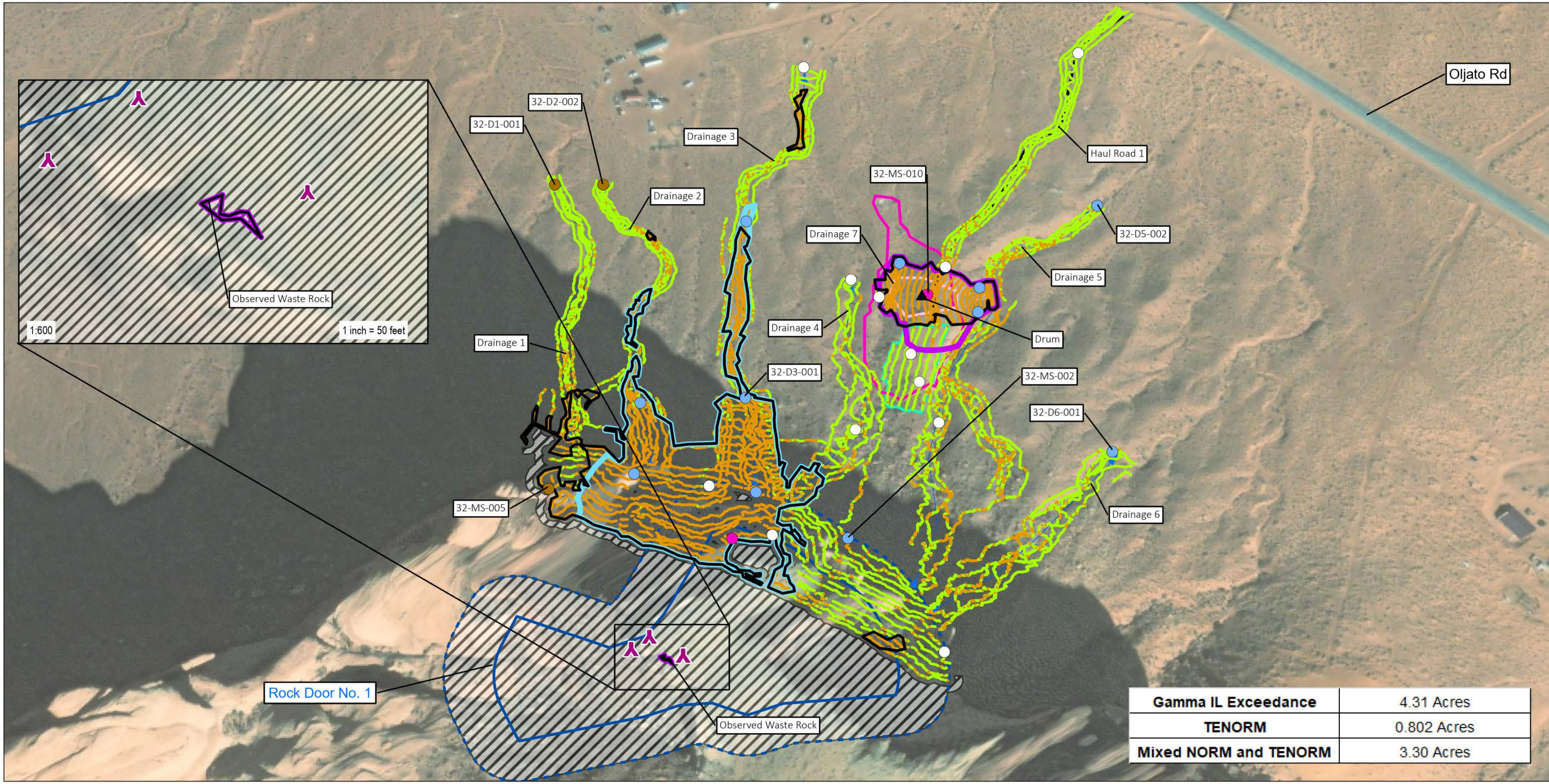

Gamma IL Exceedance	4.31 Acres
TENORM	0.802 Acres
Mixed NORM and TENORM	3.30 Acres

LEGEND

- Ra-226 exceedance
- Metals exceedance
- Metals and Ra-226 exceedance
- No exceedance
- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drum
- Drainage
- Former Haul Road
- 100-foot Mine Buffer
- Group One Mine Boundary
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump
- Interim Action Fence

Colluvium Gamma (cpm)

- 5475 - 11100
- 11101 - 481300

CSM Mining Impacted Areas

- Gamma Exceedance
- TENORM Area
- Mixed NORM and TENORM

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Notes:
1. BTV and IL for Colluvium gamma scan data is 11100 cpm
2. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
3. Total calculated area of TENORM includes the entire Mine Site and all the haul roads and drainages.
BTV = background threshold value
cpm = counts per minute
CSM = Conceptual Site Model
IL = Investigation Level
Jacobs = Jacobs Engineering Group Inc.
NORM = Naturally-Occurring Radioactive Material
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

0 125 250 500
Feet
1:3,000
1 inch = 250 feet

Figure 5-1. Gamma Exceedance and TENORM Area Map
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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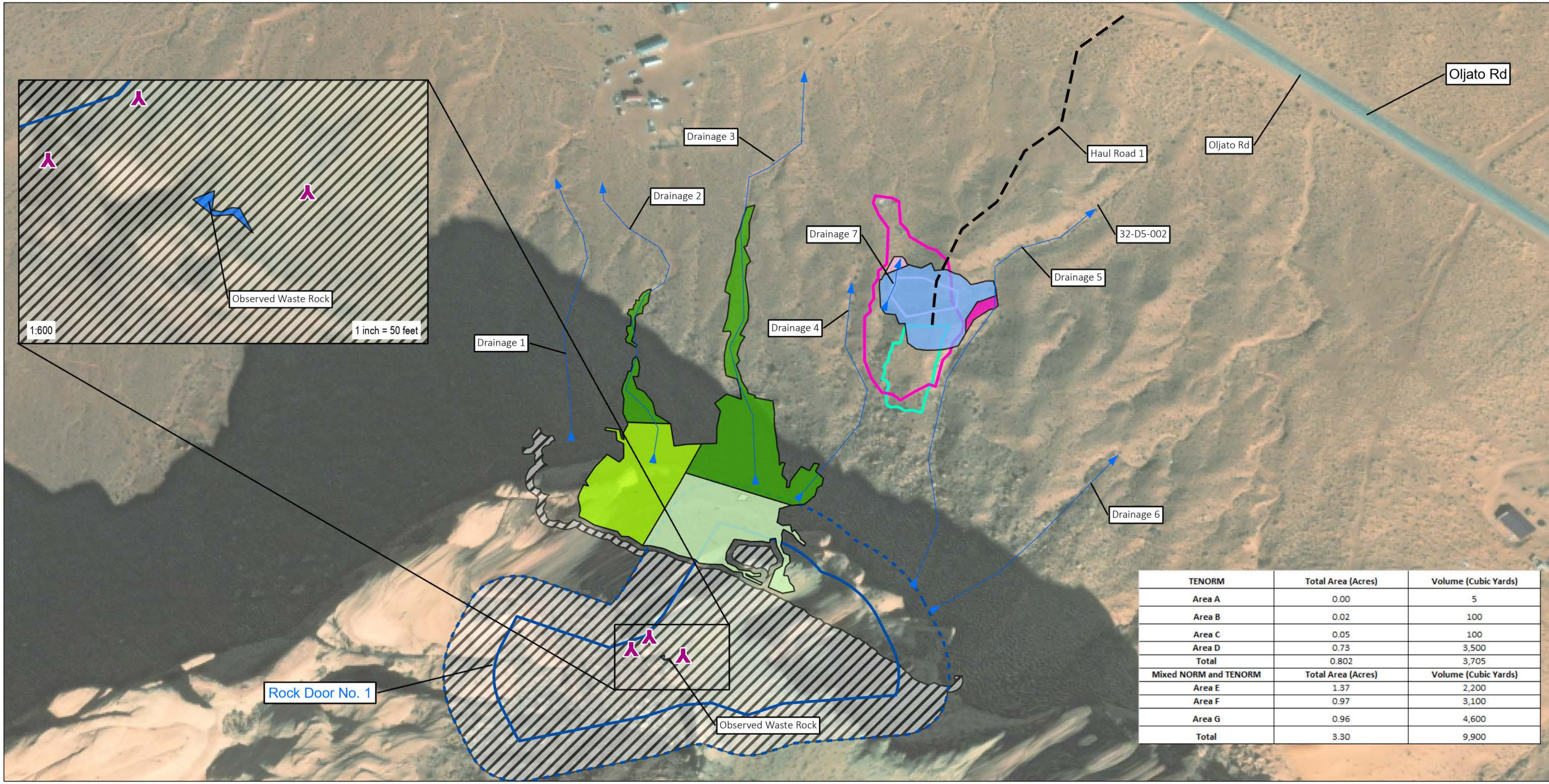

TENORM	Total Area (Acres)	Volume (Cubic Yards)
Area A	0.00	5
Area B	0.02	100
Area C	0.05	100
Area D	0.73	3,500
Total	0.802	3,705
Mixed NORM and TENORM	**Total Area (Acres)**	**Volume (Cubic Yards)**
Area E	1.37	2,200
Area F	0.97	3,100
Area G	0.96	4,600
Total	3.30	9,900

LEGEND

- Cyprus Amax/Jacobs Approximate Mine Portal Location
- Drainage
- Group One Mine Boundary
- Former Haul Road
- 100-foot Mine Buffer
- Inaccessible Area
- Rock Door No. 1 Loadout Area
- Non-Mining Related Trash Dump
- Interim Action Fence
- Area A- TENORM - 0-0.5 ft bgs
- Area B- TENORM - 0-1.0 ft bgs
- Area C- TENORM - 0-1.5 ft bgs
- Area D- TENORM - 0-3.0 ft bgs
- Area E- Mixed NORM and TENORM - 0-1.0 ft bgs
- Area F- Mixed NORM and TENORM - 0-2.0 ft bgs
- Area G- Mixed NORM and TENORM - 0-3.0 ft bgs

Notes:
1. Roads are not identified as disturbed areas, as these areas are well established to be from anthropogenic activities (although not necessarily related to historical mining activities).
ft bgs = feet below ground surface
Jacobs = Jacobs Engineering Group Inc.
NORM = Naturally-Occurring Radioactive Material
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

0 100 200 400
Feet
1:3,000 1 inch = 250 feet
N

Figure 5-2. TENORM Depth and Area Map
Rock Door No. 1
Removal Site Evaluation Report

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Mine Locations CH2M Hill Engineers, Inc. 2016;
Aerial Imagery: ESRI ArcGIS online

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Appendix A
Mine Site Mining Reclamation and Regulatory History
(Provided Under Separate Cover)

Appendix B
Regulatory Correspondence and Permit Compliance
(Provided Under Separate Cover)

Appendix C
Field Documentation
(Provided Under Separate Cover)

Appendix D
Data Quality Evaluation Summary and Analytical Laboratory Reports

(Provided Under Separate Cover)

Appendix E
Statistical Documentation
(Provided Under Separate Cover)

Appendix F
Evaluation of Correlation at the Rock Door No. 1 Mine Site
(Provided Under Separate Cover)