UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

MEMORANDUM

DATE: August 28, 2018

SUBJECT: Request for Concurrence on Proposed Nationally Significant or Precedent-Setting Removal at the Tronox Mesa V Haul Shaft Site, Cove, Arizona, Navajo Nation Indian Reservation

FROM: Enrique Manzanilla, Director
Superfund Division (SFD)

Partnership, Land Revitalization & Cleanup Branch, Region 9

TO: Reggie Cheatham, Acting Director
Office of Emergency Management

The purpose of this memorandum is to request your concurrence on the proposed time-critical removal action at the Tronox Mesa V Haul Shaft Site, Cove, Arizona, Navajo Nation Indian Reservation. Redelegation of Authority in R-14-2 gives the Director of the Office of Emergency Management the authority to concur on nationally significant or precedent-setting removals.[1] This removal action is estimated to cost $186,000 in direct extramural expenditures and to take 6 months. As a result, contingent upon your concurrence, I will approve the Action Memorandum in order to avert the ongoing exposures to unsafe levels of uranium contamination that are occurring at the Site.

Region 9 staff for the Tronox Mesa V Haul Shaft Site has discussed this proposed removal with staff for the Office of Emergency Management's Preparedness and Response Operations Division (PROD). PROD has advised that this removal is considered nationally significant or precedent setting because it is a removal of radioactive mining waste from a site located in Indian country. As has been the case with all of Region 9's uranium waste removal actions on the Navajo Nation, Region 9 has conducted extensive government to government consultation with the Navajo Nation and community involvement activities with local residents regarding the Tronox Mesa V Haul Shaft Site and the proposed removal action.

[1] See September 2009 Superfund Removal Guidance on Preparing Actions Memoranda ("2009 Guidance"). removals in Indian Country generally require OEM concurrence (see p. 45).

The proposed removal action would mitigate the exposure to the release or threat or release of hazardous substances that is causing a threat to public health or welfare or the environment by taking steps to prevent exposure to the radon gas located in the Tronox Mesa V haul shaft. EPA and Navajo Nation has received information indicating that Navajo residents and livestock may be utilizing this haul shaft as temporary shelter. The proposed action would post signs warning the public/community of the hazards associated with entering the Site and construct a physical barricade designed to prevent entry into the haul shaft. The action is expected to take approximately 6 months.

The Tronox Mesa V haul shaft Action Memorandum is attached for your review. My approval awaits your concurrence.

Concur:

Rebecca Clark 10/18/18

for Reggie Cheatham, Acting Director
Office of Emergency Management
Date

According to the redelegation, authority to non-concur remains with the Assistant Administrator. If you choose not to concur on this action, please forward this memorandum to the Assistant Administrator.

Non-Concur:

Reggie Cheatham, Acting Director
Office of Solid Waste and Emergency Response
Date

Attachment A:
Action Memorandum: Request for a Time-Critical Removal Action at the Tronox Mesa V Haul Shaft Site, Cove, Arizona, Navajo Nation Indian Reservation

cc: Gilberto Irizarry, U.S. EPA, OEM, HQ
Jean Schumann, U.S. EPA, OEM, HQ

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

MEMORANDUM

DATE:

SUBJECT: Request for a Time-Critical Removal Action at the Tronox Mesa V Haul Shaft Site, Cove, Arizona, Navajo Nation Indian Reservation

FROM: Kenneth B. Rhame, On-Scene Coordinator
Chip Poalinelli, Remedial Project Manager
Tribal Lands Clean-Up Section (SFD 6-2)

THROUGH: Will C. Duncan, III, Assistant Director (SFD-6)

TO: Enrique Manzanilla, Director
Superfund Division (SFD)

I. PURPOSE

The purpose of this Action Memorandum is to request and document approval to spend up to $186,000 in direct extramural costs to mitigate threats to human health and the environment posed by a release into the environment of hazardous substances at the Tronox Mesa V Haul Site (the Site) located in Cove, Apache County, Arizona. The Site consists of an open mine haul shaft that is accessible by the public and livestock (cattle). U.S. EPA and the Navajo Nation are concerned that unrestricted access to the Site poses an exposure and health risk to the public that may utilize this haul shaft as temporary shelter. Hazardous substances at the Site include a pile of uranium mining waste rock that is emanating radon at 81.9 picocuries per liter (pCi/L), which is twenty times the residential-specific dose action level of 4.0 pCi/L.

If approved, this Action Memorandum will serve to document the authorization of expenditures required for U.S. EPA to take the actions described herein to address a release, or threat of release, of hazardous substances that pose a danger to human health and the environment. The proposed time-critical removal action would be undertaken pursuant to Section 104(a)(1) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. § 9604(a)(1), and Section 300.415 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR § 300.415

II. SITE CONDITIONS AND BACKGROUND

Site Status: Non-NPL
Category of Removal: Time-Critical
CERCLIS ID:

SITE ID: A9BJ

A. Site Description

1. Physical Location

The Site is located within the Navajo Nation Indian Reservation in Arizona. The Site is located in the Cove Mesa, Apache County, Arizona; above the Navajo Nation Chapter known as Cove (See Attachment II).

2. Site Characteristics

Portions of the Navajo Nation are located on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore on Navajo Nation tribal lands for national defense and energy purposes led to a legacy of abandoned uranium mine (AUM) sites. The Site is believed to have been used as part of the Tronox Mesa V Mine Site operation. The Tronox Mesa V mine site is classified as tribal trust land. Historical documents indicate that the operator of Tronox Mesa V mine was Kerr-McGee from 1953 to 1955. No other historical ownership / lease information has been identified. The Tronox Mesa V haul shaft appears to be a man-made opening that was accessed by the mining company to transport uranium ore from the Tronox Mesa V mine site. U.S. EPA and the Navajo Nation are concerned that unrestricted access to the Site may be a potential public/human exposure pathway to radon gas released into the environment from exposed uranium ore and waste. The Tronox Mesa V haul shaft consists of a short passageway to a small excavated room approximately 16 feet by 20 feet with a ceiling height of approximately 10 feet. Just inside the haul shaft is a vertical shaft that extends up toward the surface of the mesa. There is a large pile of rock and sand just inside the entrance and below the vertical shaft. The shaft is estimated to extend upward approximately 100 feet.

3. Removal Site Evaluation

During the summer and fall of 2015 the U.S. EPA and their contractors (START) completed the Mine Category Assessment Protocol (MCAP) project to identify sites requiring time-critical actions and prioritize other sites for Removal Site Evaluations. The project entailed reconnaissance efforts within a 180-square mile area containing 120 mine claims. The purpose of the MCAP project was to develop and implement a systematic method for assessing and surveying abandoned uranium mine sites and other potential contributions of uranium material areas to assist ranking areas for Removal Site Evaluations. The MCAP report identifies the Site as "Tronox Mesa V Mine" and gives the Site the highest priority for further investigation (see Mine Category Assessment Protocol (MCAP) Summary Report Navajo Nation, Apache County, Arizona in Attachment IV). During the week of June 18-23, 2017, representatives from the National Center for Radiation Field Operations (NCRFO), on behalf of U.S. EPA, monitored the ambient levels of radon gas at the Site, inside and at the entrance of the Tronox Mesa V haul shaft. Three calibrated Saphymo AlphaGuard passive radon monitors were placed at two different locations within the haul shaft and left to measure radon concentrations, statistical measurement error, temperature, pressure and humidity

at 10-minute intervals for a period of 72 hours. One sampler was placed approximately 30 feet inside the haul shaft entrance near the top of the debris pile, the other two samplers were co-located inside and toward the rear of the inner chamber and were placed six feet apart and oriented in different directions. The results are illustrated in the tables below.

Table 1. Interior Room ^{222}Rn Measurements (co-located AlphaGUARDS)

	Average (pCi/L)	Std. Dev. (pCi/L)	Min. (pCi/L)	Max. (pCi/L)	Screening Level (pCi/L)
SN 1147 - All Data Points	80.5	9.0	30.9	106.6	4.0
SN 1147 - Minus First 4 hrs.	81.9	9.2	59.2	106.6	
SN 1036 - All Data Points	79.4	9.0	15.5	104.2	
SN 1036 - Minus First 4 hrs.	80.5	9.2	63.0	104.2	

Table 2. Haul Shaft Entrance Rn-222 concentration over time

	Average (pCi/L)	Std. Dev. (pCi/L)	Min (pCi/L)	Max (pCi/L)	Screening Level (pCi/L)
All Data	3.15	0.97	0.41	10.43	4.0

The radon sampling results from the rear interior room of the Tronox Mesa V haul shaft were approximately twenty times the screening level of 4 pCi/L. The screening level is the U.S. EPA action level for radon gas in residential scenarios. The residential screening level was selected because of evidence that the haul shaft has been used by herders and trespassers as shelter. The average concentration of radon gas measured from the rear interior room was approximately 80 pCi/L; the highest concentration measured was 106.6 pCi/L. These results indicate that uranium waste rock located within the Tronox Mesa V haul shaft related to the uranium mining operation poses an exposure and health risk to the public that may utilize this haul shaft as temporary shelter. There is also a threat of release into the environment because of radon progeny's charged state and solid nature, they rapidly attach to clothing and can be transported outside of the haul shaft by trespassers. The report, Tronox Mesa V Radon Sampling Project, dated July 7, 2017, is provided as part of the administrative record for this action memo (see Attachment III).

4. Release or threatened release into the environment of a hazardous substance, or pollutant or contaminant

Uranium Waste

Uranium mining at the Site resulted in releases of uranium and progeny, such as radon, to the environment. Uranium and radon are CERCLA hazardous substances, listed in the National Contingency Plan at Appendix B to 40 C.F.R. Section 302.4 (Radionuclides). Based on field observations and the radon assessment data collected, it is evident that mining waste containing hazardous substances is present at the Site and poses a threat of release into the environment. As noted above, because of radon progeny's charged state and solid nature, they rapidly attach to clothing and can be transported outside of the haul shaft by trespassers. It is known that people in the Cove Community and their livestock frequent the haul shaft.

5. NPL status

The Site is not on the National Priorities List (NPL) nor is it proposed to be on the NPL. Current conditions at the Site pose an imminent and substantial endangerment (see Sections III and IV) to the surrounding community that enter the haul shaft seeking shelter. The proposed removal action will not complete all work at the Site but is intended as an interim action that will restrict access until a final action is selected and implemented.

B. Other Actions to Date

No other response actions have occurred at the Site to date.

C. State and Local Authorities' Roles

1. State and local actions to date

No state or tribal actions have taken place at the Site. Formal consultations with the Navajo Nation for a broad range of AUM-related issues have been ongoing for several years. Formal consultation for this removal action have been initiated with the Navajo Abandoned Mine Lands Program (AML). These discussions constitute state and tribal consultation.[1]

III. THREATS TO PUBLIC HEALTH OR WELFARE OR THE ENVIRONMENT, AND STATUTORY AND REGULATORY AUTHORITIES

Current Site conditions include ongoing releases into the environment and the threat of future releases of hazardous substances, namely: uranium and its progeny (i.e., radium-226) and ionizing gamma and alpha radiation associated with that progeny. The likelihood of direct human exposure, via ingestion and/or close proximity to the hazardous substances, and the threat of future releases and migration of those substances, pose an imminent and substantial endangerment to public health or welfare or the environment based on the factors set forth in the NCP, 40 CFR § 300.415(b)(2).

These factors include:

---

[1] EPA Policy on consultation and coordination with Indian Tribes, May 4, 2011. See http://www.epa.gov/tp/pdf/cons-and-coord-with-indian-tribes-policy.pdf

1. Actual or potential exposure to nearby populations, animals, or the food chain from hazardous substances or pollutants or contaminants

As described in Section II.A.4, elevated levels of radon related to historical uranium mining operations have been detected inside at the Site. U.S. EPA has determined that the unrestricted access and part-time occupants of the haul shaft risk elevated exposure to radon, at levels greater than U.S. EPA residential screening levels and health risk thresholds. These exposures pose an unacceptable excess cancer risk.

The U.S. EPA has set a guideline for radon in air inside homes of 4 picocuries per liter (4 pCi/L) of air. Persons exposed to radon concentrations greater than 4 pCi/L also face increased cancer risks. Radon is a naturally occurring radioactive gas that is formed from the radioactive decay of uranium. Indoor radon levels are affected by the radium and uranium levels in soil, the porosity of the soil, and the ventilation rate of the room. People exposed to high levels of radon have an increased incidence of lung cancer (ATSDR 1999b). U.S. EPA's use of area-specific background levels is intended to verify that removal actions are taken in response to mine-related releases of radiation, rather than naturally-occurring radiation in area soils.

The Tronox Mesa V haul shift was used to support uranium mining in the vicinity of the Site. Uranium is found in small amounts in most rocks and soil. It slowly breaks down to its progeny including radium and radon. Radium and radon enter the environment from the soil, and from uranium mines and sometimes other types of mines. Uranium occurring in a subsurface vein is brought to the surface during mining activities. Thorium is also often present in uranium ore.

The elevated radon levels at the Site are likely to result in human exposure via inhalation. Persons occupying, traversing the Site or seeking temporary shelter may be exposed to elevated radon via inhalation.

One of the radioactive properties of uranium is its half-life, or the time it takes for half of the isotope to give off its radiation and change into another substance. The half-life of uranium is very long (between 200,000 years and 5 billion years). This is why uranium still exists in nature and has not all decayed away and does not itself emit high levels of ionizing radiation. Inhalation and ingestion of uranium can result in kidney damage. The radiation damage from exposure to high levels of natural uranium is not known to cause cancer (ATSDR 1999c).

Radium is formed when uranium and thorium break down in the environment. Two of the main radium isotopes found in the environment are radium-226 and radium-228. During the decay process, alpha, beta, and gamma radiation are released. Radium may be found in air and water. Radium in the soil may be absorbed by plants.

Acute inhalation exposure to high levels of radium can cause adverse effects to the blood (anemia) and eyes (cataracts). It also has been shown to affect the teeth, causing an increase in broken teeth and cavities. Exposure to high levels of radium results in an increased incidence of bone, liver, and breast cancer. The BEIR V report has also stated that radium is a known human carcinogen (ATSDR, 1999a). Inhalation of radium contaminated particulates is of particular concern. Radium emits alpha radiation,

which, when inhaled, becomes a source of ionizing radiation in the lung and throat, possibly leading to toxic effects (See ATSDR ToxFAQ Attachment V).

2. The availability of other appropriate federal or state response mechanisms to respond to the release

Navajo Nation EPA has informed U.S. EPA that it does not have the funding to address the Site. U.S EPA is utilizing Navajo Nation Abandoned Mines Lands resources to implement the Tronox Mesa V haul shaft project through a grant.

3. Weather conditions that may cause hazardous substances to migrate or be released

Rainfall events and hot/cold temperatures, including extreme weather such as monsoons, would lead to a trespasser seeking shelter in the haul shaft, which increase the threat of release into the environment. In addition, contaminants may migrate during high wind events due to the propensity for contaminants to adhere to windborne dust particles.

IV. ENDANGERMENT DETERMINATION

Actual or threatened releases of pollutants and contaminants from this site, if not addressed by implementing the response action selected in this Action Memorandum, may present an imminent and substantial endangerment to public health, or welfare, or the environment.

V. PROPOSED ACTIONS AND ESTIMATED COSTS

A. Proposed Actions

1. Proposed action description

U.S. EPA proposes to mitigate the release or threat or release of hazardous substances into the environment that is causing a threat to public health or welfare or the environment by taking steps to prevent exposure to the radon gas located in the Tronox Mesa V haul shaft. The removal action will include the following objectives to prevent direct human exposure to radon gas emitting from mine related waste:

- Post Signs Warning the Public/Community of the hazards associated with entering the Site.
- Construct a physical barricade designed to prevent entry into the haul shaft.
- Inspect the site once a year to assure the barricade is still protective.

2. Contribution to remedial performance

This removal action is being conducted in concert with future removal plans. The OSC is coordinating the work being done at this Site with the remedial project manager assigned to the Mesa V Haul Shaft Site in an effort to maximize the chance that the action

will compliment future actions to address the contamination at the Site. As noted above, the Site is currently not on the NPL nor proposed for the NPL.

It is expected that this removal action will mitigate release or threat of release of hazardous substances and the public health risk associated with the inhalation of hazardous substances at the Site. As discussed below, U.S. EPA expects to conduct subsequent assessments of other mine waste sites and AUMs located throughout the Navajo Nation to determine what additional response actions may be necessary.

Sources of the contamination may require long-term cleanup. In future actions, these sources may include individual Navajo AUM site cleanups. U.S. EPA will continue to coordinate with N.N.EPA to evaluate the risk of human health effects based on mine waste exposure pathways that may be present at these other AUM sites.

The construction of a physical barrier will act as an interim action to reduce the risk of exposure and warn the nearby community of the hazards associated with entering the Site and should reduce the threats described in Section III.

3. Applicable or relevant and appropriate requirements (ARARs)*

Section 300.415(j) of the NCP provides that removal actions must attain ARARs to the extent practicable considering the exigencies of the situation.

Section 300.5 of the NCP defines applicable requirements as cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations promulgated under Federal environmental or State environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances at a CERCLA site.

Section 300.5 of the NCP defines relevant and appropriate requirements as cleanup standards, standards of control and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that, while not "applicable" to a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site and are well-suited to the particular site.

Pursuant to CERCLA section 121(e), CERCLA on-site response actions do not require permitting; only substantive requirements are considered as possible ARARs. Administrative requirements such as approval of, or consultation with administrative bodies, issuance of permits, documentation, reporting, record keeping and enforcement are not ARARs for the CERCLA actions confined to the site.

Federal ARARs determined to be practicable for the Site are:

- Uranium Mill Tailings Radiation Control Act (40 CFR Part 192.12 subparts B and C) requirements for residential cleanup levels of tailings sands.
- Native American Graves Protection and Repatriation Act, 25 USC Section 3001 *et seq.* and its implementing regulations, 43 CFR Part 10.

- National Historic Preservation Act, 16 USC Section 470 *et seq.* and its implementing regulations, 36 CFR Part 800.
- Archeological Resources Protection Act of 1979, 16 USC Section 47000 *et seq.* and its implementing regulations, 43 CFR Part 7.
- American Indian Religious Freedom Act, 42 USC Section 1996 *et seq.*

Additional Federal policy and guidance to be considered:

- U.S. EPA Directive, Radiation Risk Assessment at CERCLA Sites: Q&A, OSWER Directive 9200$ 3,540,000.4-40, May 2014. *See* https://nepis.epa.gov/Exe/ZyPDF.cgi/P100K3TC.PDF?Dockey=P100K3TC.PDF
- U.S. EPA Directive on Protective Cleanup Levels for Radioactive Contamination at CERCLA sites. Directive 9200.4040, EPA 540-R-012-13, May 2014.

*To date, the Navajo Nation has not identified additional ARARs.

4. Project schedule

It is estimated that it will take approximately 6 months to complete the construction of the physical barrier. Permanent disposal will not be included in this Action Memorandum's Scope of Work.

B. Estimated Extramural Costs

Tronox Special Account Costs	
Abandoned Mine Lands Program (AML)	$ 155,000
Extramural Costs Not Funded from the Regional Allowance	
START Contractor	$ 0
Extramural Subtotal	$ 155,000
Extramural Costs Contingency (20% of $155,000 Subtotal)	$ 31,000
TOTAL Removal Action Extramural Direct Cost Project Ceiling	**$ 186,000**

VII. EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN

Given the Site conditions, the nature of the hazardous substances documented on-site, and the potential exposure pathways to the general public and livestock seeking shelter described in Sections III and IV above, actual or threatened releases of hazardous substances from the Site, if not addressed by implementing the response actions selected in this Action Memorandum, may continue to present a threat to public health or welfare or the environment.

VIII. OUTSTANDING POLICY ISSUES

There are no outstanding policy issues with respect to the Site that have been identified at this time.

IX. ENFORCEMENT

This removal action is being funded with Tronox settlement funding.

Estimated EPA costs for this Removal Action

U.S. EPA Direct Costs[2] (Direct Extramural [$186,000] + Direct Intramural [$ 103,000])	$ 186,000
U.S. EPA Indirect Costs: (59.70% of Direct Spending)	$ 172,533
TOTAL	$ 461,533

The total U.S. EPA extramural and intramural costs for this removal action are estimated to be $461,533.

X. U.S. EPA RECOMMENDATION

This decision document represents the selected removal action for the Tronox Mesa V Haul Shaft Site, developed in accordance with CERCLA and is not inconsistent with the NCP. This decision is based on the Administrative Record for the Site.

Because conditions at the Site meet the NCP Section 300.415(b) criteria for a removal, EPA staff recommends the approval of the removal action proposed in this Action Memorandum. The total project ceiling if approved will be $461,533 will be funded by Tronox Special Account (A9BJ – Tronox Mesa V). Approval may be indicated by signing below.

---

[2] Direct costs include direct extramural costs and direct intramural costs. Indirect costs are calculated based on an estimated indirect cost rate expressed as a percentage of site-specific direct costs, consistent with the full cost accounting methodology effective October 2, 2000. These estimates do not include pre-judgment interest, do not take into account other enforcement costs, including Department of Justice costs, and may be adjusted during the course of a removal action. The estimates are for illustrative purposes only and their use is not intended to create any rights for responsible parties. Neither the lack of a total cost estimate nor deviation of actual costs from this estimate will affect the United States' right to cost recovery.

Approve: _____ _____
Enrique Manzanilla, Director Date
Superfund Division

Disapprove: _____ _____
Enrique Manzanilla, Director Date
Superfund Division

Attachments:

I. Index to the Administrative Record
II. Site Location Map – Tronox Mesa V Mine Site
III. Tronox Mesa V Radon Report
IV. MCAP Report
V. ATSDR ToxFAQ (Radon, Uranium, and Radium)

cc: Tim Grier, U.S. EPA, HQ OEM
Dr. Donald Benn, Navajo Nation Environmental Protection Agency
Harrison Karr, Navajo Nation Department of Justice
Madeline Roanhorse, Navajo Nation Abandoned Mines Lands

bcc: H. Allen, SFD-9
W. Duncan, SFD-9
E. Poalinelli, SFD-6-2
L. Williams, ORC-3
C. Temple, SFD-9-2
Site File

ATTACHMENT I
INDEX TO THE ADMINISTRATIVE RECORD

1. Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs, Radium CAS#7440-14-4. ATSDR. July 1999a.

2. Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs, Radon CAS#14859-67-7. ATSDR. September 1999b.

3. Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs, Ionizing Radiation. ATSDR. September 1999c.

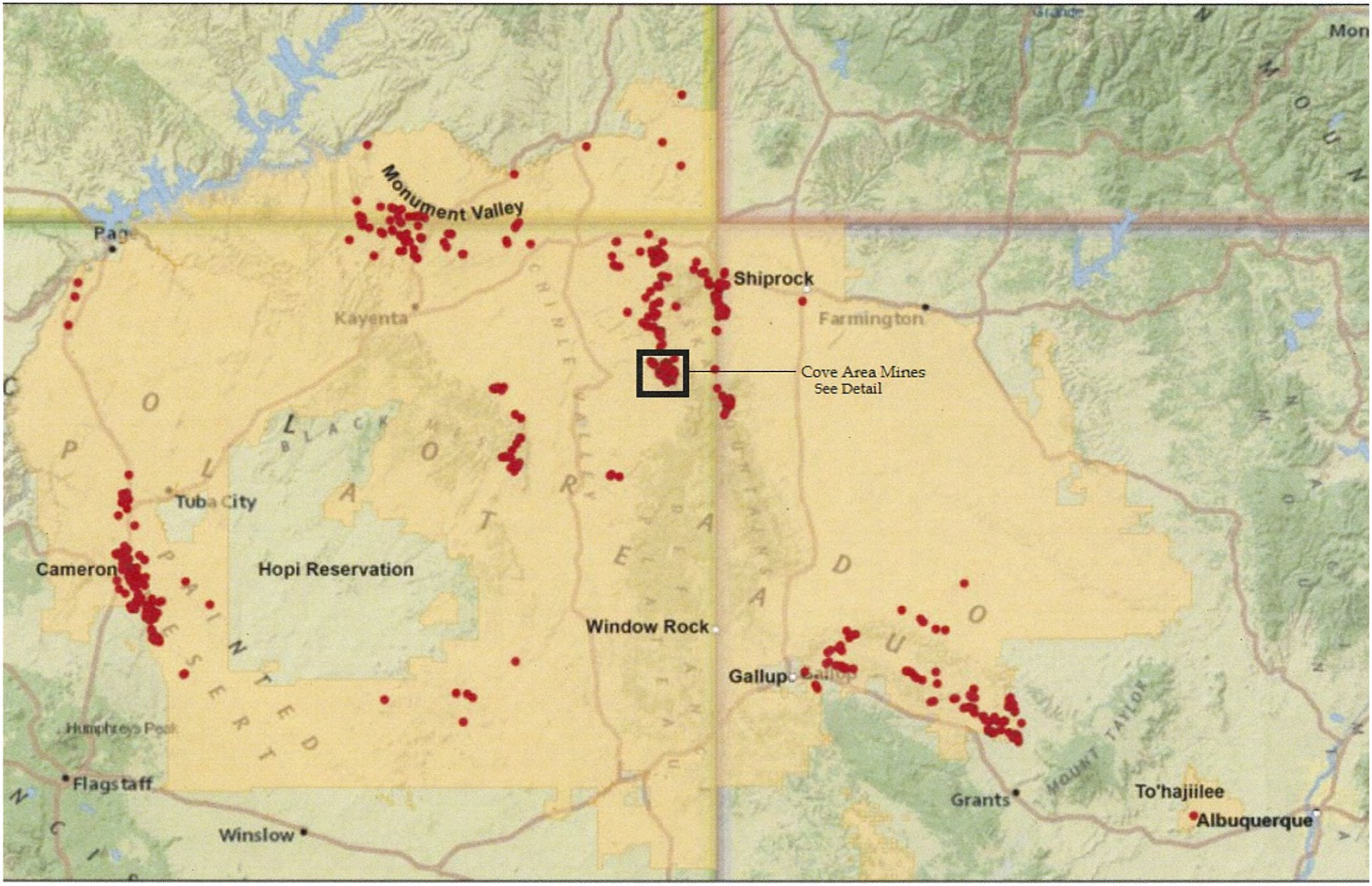
4. Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs, Uranium CAS#7440-61-1. ATSDR. September 1999d.

5. Tronox Mesa V Mine Radon Sampling Project, EPA Office of Radiation & Indoor Air, National Center for Radiation Field Operations, August 7, 2017.

6. Mine Category Assessment Protocol (MCAP) Summary Report Navajo Nation, Apache County, Arizona, Weston, December 9, 2016.

7. Site Location Map – Tronox Mesa V Mine Site

ATTACHMENT II
SITE LOCATION MAP – TRONOX MESA V MINE SITE



Abandoned Uranium Mines on and Near Navajo Nation

Abandoned Uranium Mine

Navajo Nation Boundary

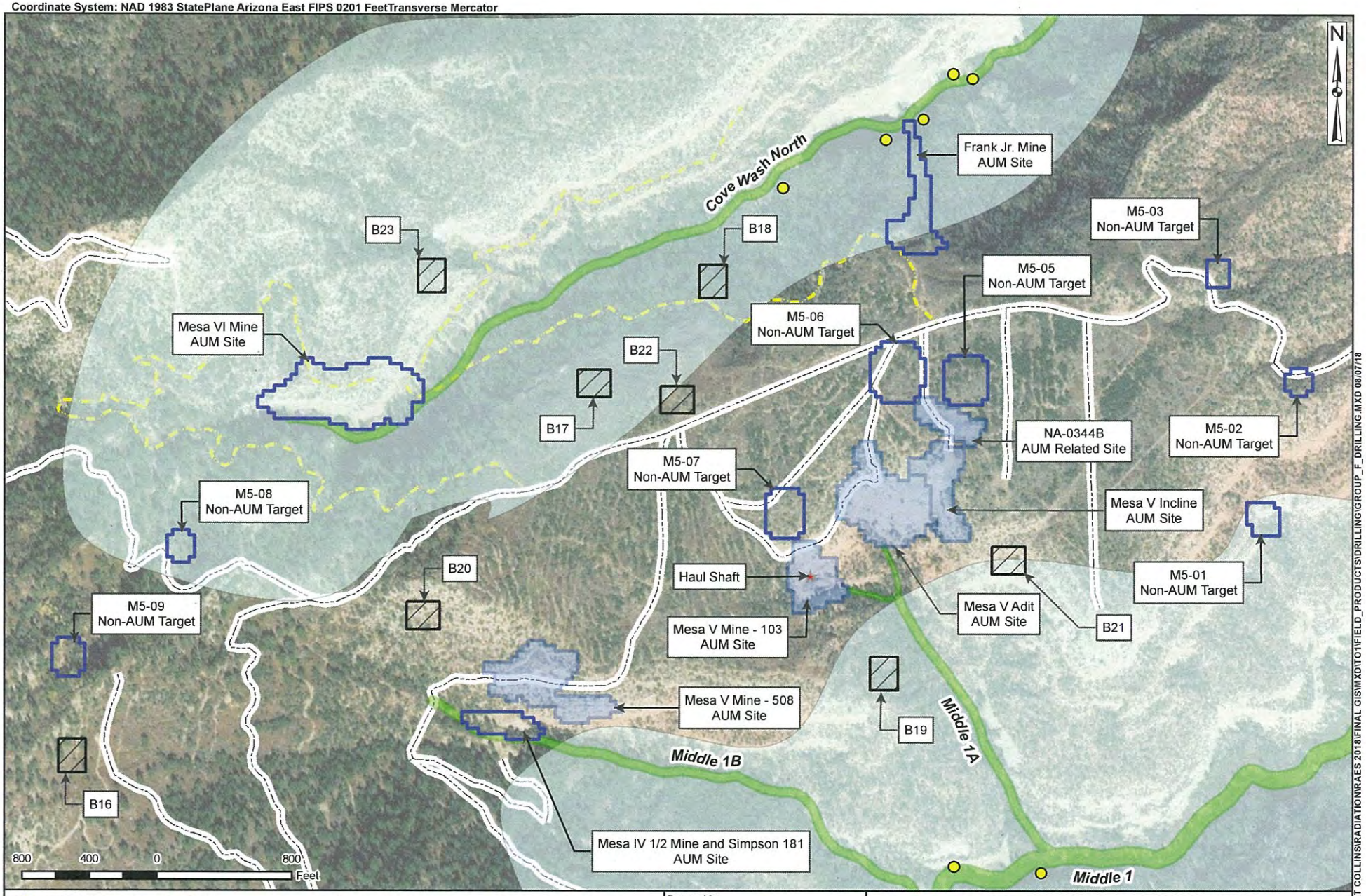
0 25 50 100 Miles

N W E S

EPA Region 9 GIS Center

SFD 1902325 March 30, 2016

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 FeetTransverse Mercator



- MSO Observation site - 2018
- Protected Activity Center (2018)
- Project Area Drill Location
- Survey Area - No Drilling
- Drainage Survey Area
- Background Sample Location
- Access Route - Foot
- Access Route - Vehicular

Notes:
1) Boring frequency - 10 borings per acre to 20 feet bgs.
2) Boring rate - 5 borings per 8 hour day.
3) All drainages will be sampled using a hand auger to a maximum depth of 5 feet bgs.

Prepared for:

Prepared By:
TETRA TECH
1999 Harrison Street, Suite 500
Oakland, CA 94612

MESA V HAUL SAFT LOCATION FIGURE
C O V E CHAPTER

Task Order No.:	Contract No.:	Figure No.:
TO 001	EP-S9-17-03	
Location: COVE CHAPTER NAVAJO NATION	Date: 8/7/2018	

T:\LOCAL OPERATIONS\FORT COLLINS\RADIATION\RAES 2018\FINAL GIS\MXD\T01\FIELD_PRODUCTS\DRILLING\GROUP_F_DRILLING.MXD 08/07/18

ATTACHMENT III
TRONOX MESA V RADON REPORT

Mesa V Mine Radon Sampling Project

08/07/2017
DCN: REP-Mesa V
Revision: 00

Prepared by:
US Environmental Protection Agency
Office of Radiation and Indoor Air
National Center for Radiation Field Operations
4220 S. Maryland Parkway, Building C
Las Vegas, NV 89119

Prepared for:

US Environmental Protection Agency, Region 9
Superfund Division
Tribal Lands Clean-up Section
75 Hawthorne Street
San Francisco, CA 94105

This page is intentionally blank

Table of Contents

Table of Figures

Table of Tables

1 INTRODUCTION

Portions of the Navajo Nation are located on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore on Navajo Nation tribal lands for national defense and energy purposes led to a legacy of abandoned uranium mine (AUM) sites. During the summer and fall of 2015, EPA Region 9 and EPA's START contractors completed the Mine Category Assessment Protocol (MCAP) for the prioritization of Removal Site Evaluations within the Navajo Nation in Apache County Arizona. One location of particular concern is located in the Cove Mesa, AZ area and is identified as "Mesa V Mine", which is the highest scoring site in the MCAP. See Figures 1 and 2 below for maps of the adit location.

The Mesa V Mine site consists of an open mine adit that is accessible by the public and possibly livestock (cattle) as well. EPA Region 9 and the Navajo Nation are concerned that unrestricted access to the site may be a potential public/human exposure pathway to radon gas emitted from exposed uranium ore or waste.

During the week of June 18-23, 2017, National Center for Radiation Field Operations (NCRFO), on behalf of EPA Region 9, monitored the ambient levels of radon gas within the Mesa V Mine adit. The following sections present the investigation methods and results.

Measurement data collected by NCRFO and presented in this report is intended to be used by U.S. EPA Region 9 and the Navajo Nation to evaluate/assess doses/risks to persons that may enter the adit.

Figure 2. Map of AUMs on the Navajo

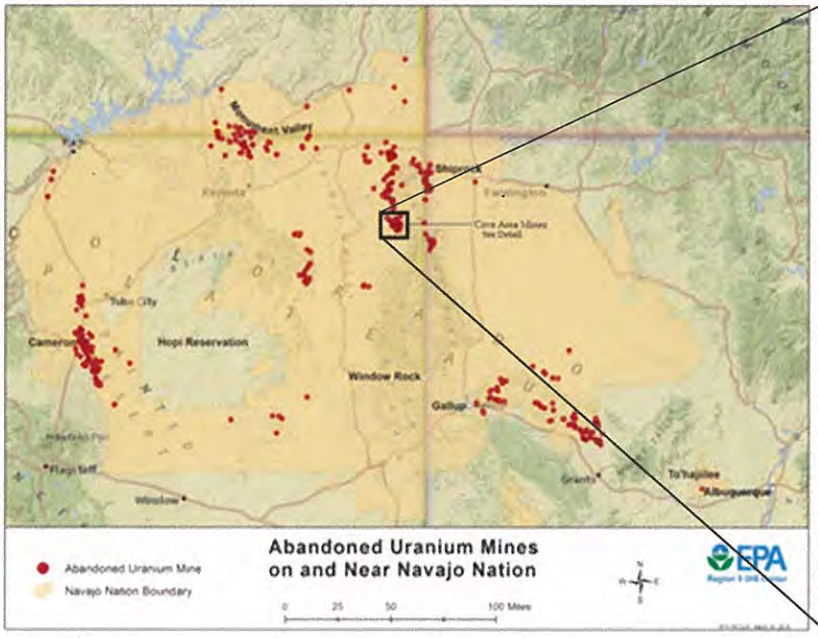
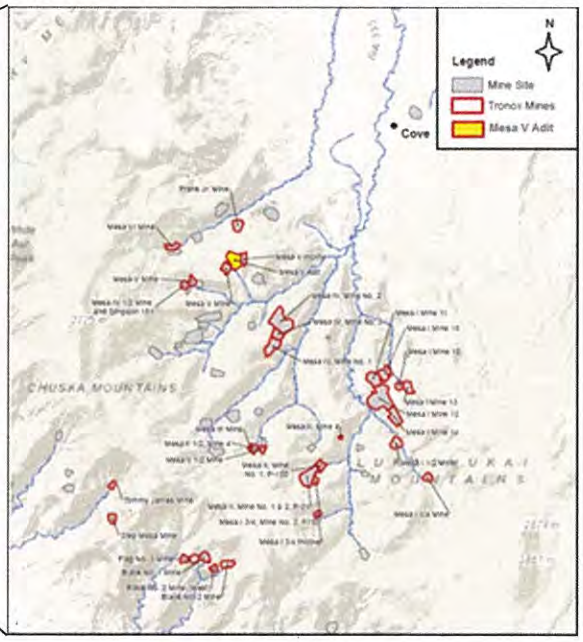


Figure 1. Detail of map of Cove and Mesa V



2 FIELD OBSERVATIONS

Upon arrival at the adit site, the team discovered that the full extent of the mineshaft consisted of a short passageway downslope to a small excavated room approximately 16 feet by 20 feet with a ceiling height of approximately 10 feet. Just inside the adit entrance, a vertical shaft extends up toward the surface of the mesa. There is a large pile of debris (rock and sand) just inside the entrance and below the vertical shaft. The shaft is estimated to extend upward approximately 100 feet. It is unknown if there are any side tunnels going out from this vertical shaft. There appeared to be timber material covering the entrance to the shaft at the top, but some light could be seen entering through or around the cover. The top entrance to this shaft was not investigated by the field team. No other indications of mining or excavations existed beyond these immediate areas. There was evidence of animal droppings within the adit and inner chamber.

3 SUMMARY OF METHODS

Since the field team found that the adit and mineshaft configuration was not as expected and described in the SAP, adjustments were made to the planned monitoring locations. All other monitoring activities for the project were performed in accordance with the Sampling Analysis Plan (SAP) for the Mesa V Mine Radon Sampling Project, dated May 24, 2017.

Consistent with the SAP, three calibrated Saphymo AlphaGUARD passive radon monitors were placed at two different locations within the adit and left to measure ^{222}Rn concentrations, statistical measurement error, temperature, pressure and humidity at 10 minute intervals for a period of 72 hours. The initial location for one sampler was to be at the entrance of the adit. Due to a large debris pile consisting of sand and rock directly inside the entrance, the field team decided to place AlphaGUARD SN 1756 approximately 30 feet inside of the adit entrance near the top of the debris pile for stability, yet allowing for adequate mixing with the outside air. The remaining two samplers, AlphaGUARD SN 1036 and 1147, were co-located inside and toward the rear of the inner chamber and were placed six feet apart and oriented in different directions

for unbiased duplicate monitoring of the radon gas concentration within the chamber. With the exception of the distance to the ground surface in the vertical shaft, the adit did not extend to a distance of 100 feet as assumed in the SAP. Thus the samplers were placed in the inner most reaches of the adit.

4 MONITORING RESULTS

4.1 Adit Inner Chamber Results

AlphaGUARD SN 1147 and SN 1036 were placed inside and near the back of the adit inner chamber. Both monitors were started 06/19/2017 at 1140 Pacific Daylight Time (PDT) and turned off and retrieved 06/22/2017 at 1150 PDT. The instruments recorded data at 10 minute intervals resulting in a total of 433 sequential measurements.

Measured concentrations of ^{222}Rn over time are plotted in the chart in Figure 3. It is clear from the plot that the two samplers inside of the inner chamber did not reach full equilibrium until approximately four hours after placement. This was likely caused by the lack of air exchange or air movement within the space. The measurements remained stable once the monitors reached equilibrium. This can also be seen in the temperature, humidity and atmospheric pressure measurements described in section 4.3. The three-day average ^{222}Rn measurement data for the co-located monitors in the inner chamber is summarized in Table 1 below. The average measurement results provided in Table 1 are for the total number of measurements and for measurements with the first four hours of data removed (24 measurements). The latter value is a more accurate representation of the average radon concentrations in the inner chamber over the monitoring period. Measurement standard deviation was calculated internally for each 10-minute sampling period. The average of the standard deviation measurements is provided in Table 1. The screening level listed in Table 1 is the U.S. EPA action level for radon gas in residential scenarios. Refer to Section 5 for a discussion of measurement quality including the relative percent difference between the collocated samples.

Figure 3. Plot of inner chamber Rn-222

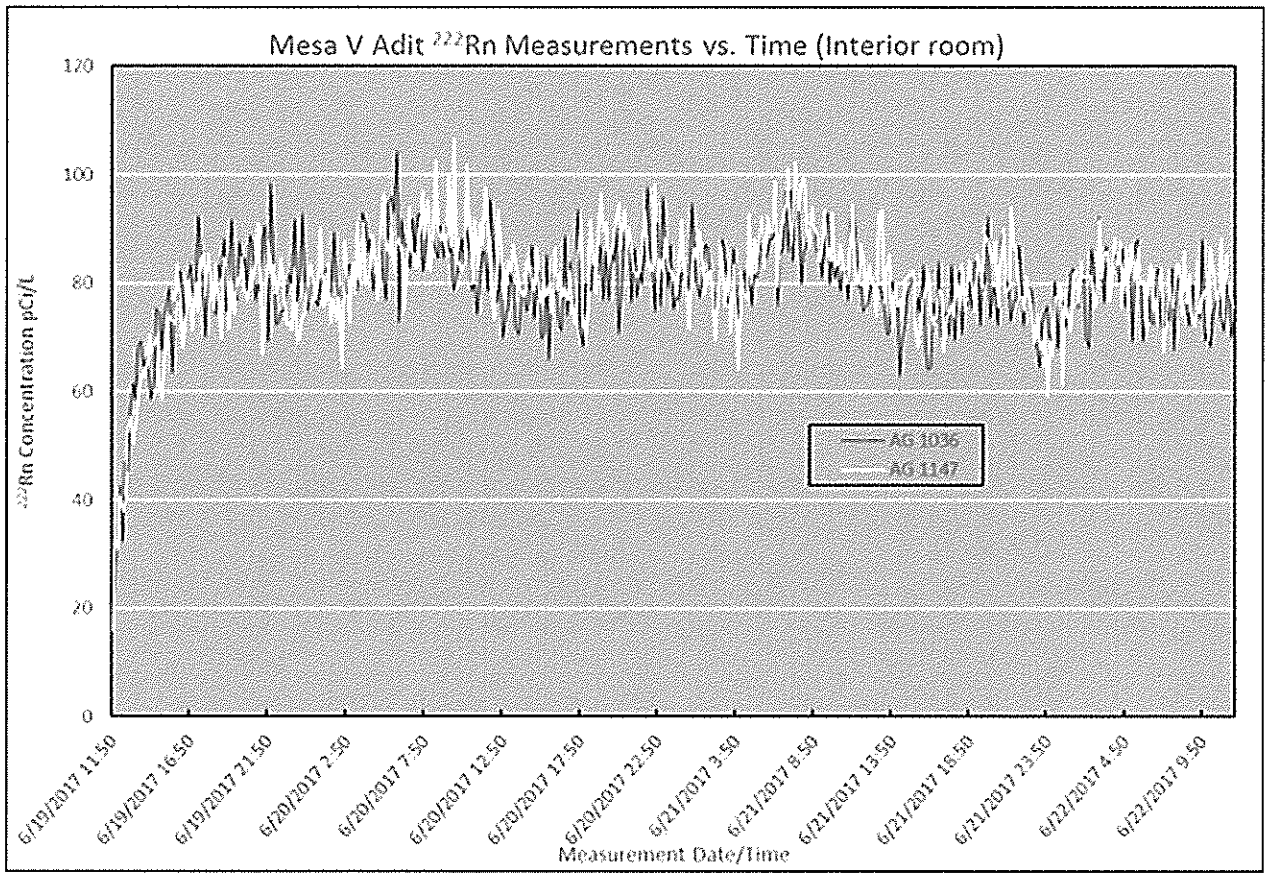


Table 1. Interior Room ^{222}Rn Measurements (co-located AlphaGUARDS)

	Average (pCi/L)	Std. Dev. (pCi/L)	Min. (pCi/L)	Max. (pCi/L)	Screening Level (pCi/L)
SN 1147 – All Data Points	80.5	9.0	30.9	106.6	4.0
SN 1147 – Minus First 4 hrs.	81.9	9.2	59.2	106.6	
SN 1036 – All Data Points	79.4	9.0	15.5	104.2	
SN 1036 – Minus First 4 hrs.	80.5	9.2	63.0	104.2	

4.2 Adit Entrance Area ^{222}Rn Results

AlphaGUARD SN 1756 was placed inside the adit entrance and started 06/19/2017 at 1130 PDT and turned off and retrieved 06/22/2017 at 1150 PDT. The instrument was set

to record the average ^{222}Rn concentration, standard deviation, temperature, pressure and humidity at 10 minute intervals, resulting in a total of 434 sequential measurements. Data from this instrument showed significantly lower concentrations of ^{222}Rn but had greater variability than the two monitors in the inner chamber. Air exchange at the adit entrance was higher than in the inner chamber resulting in quicker equilibrium of the passive samplers. The data was plotted over time and clearly shows diurnal variation. See the chart in Figure 4, below. Table 2 below is a summary of the data averages for the entire 72-hour measurement period. Peak radon concentrations, typically 4 – 6 pCi/L, occurred during the late evening and overnight periods with the lowest concentrations, averaging less than 2 pCi/L, occurring during the middle of the day.

Figure 4. Plot of Adit Rn-222 concentration over time

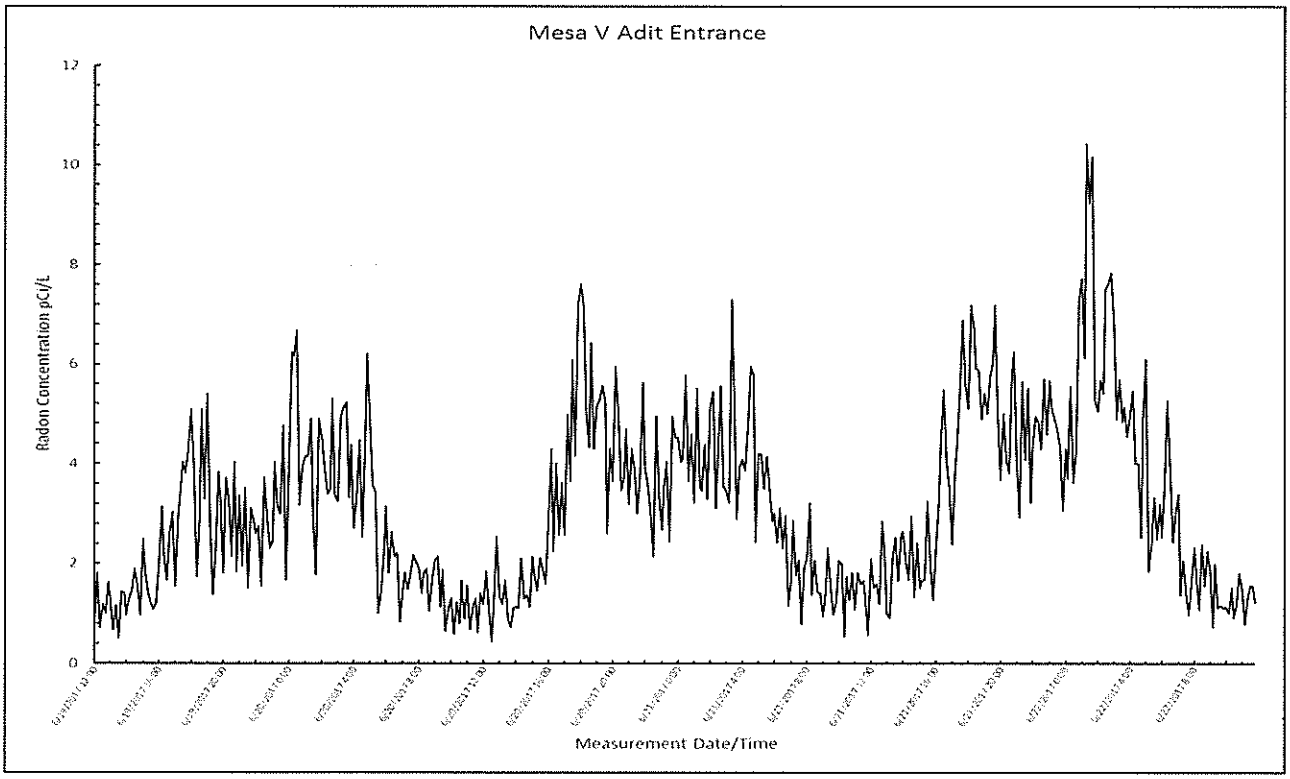


Table 2. Adit Rn-222 concentration over time

	Average (pCi/L)	Std. Dev. (pCi/L)	Min (pCi/L)	Max (pCi/L)	Screening Level (pCi/L)
All Data	3.15	0.97	0.41	10.43	4.0

Of the 433 total measurements, 430 (99.3%) were less than 7.84 pCi/L. Three peak measurements greater than 9.2 pCi/L occurred overnight at 0120 to 0140 PDT on the third sampling day, June 22, 2017.

4.3 Environmental conditions

During the radon measurement process, the AlphaGUARDs also recorded ambient temperature, pressure and relative humidity. Table 3 below is a summary of the conditions measured by the three samplers.

Table 3. Environmental conditions summary *

	Avg. Pressure inHg	Minimum Pressure inHg	Maximum Pressure inHg
AG1036 (inside room)	23.6	23.6	23.6
AG1147 (inside room)	23.6	23.6	23.6
AG1756 (Adit Entrance)	23.6	23.6	23.6
	Avg. Humidity %	Minimum Humidity %	Maximum Humidity %
AG1036 (inside room)	80.4	62.3	83.5
AG1147 (inside room)	84.0	65.0	88.0
AG1756 (Adit Entrance)	43.1	31.1	71.5
	Avg.Temperature °F	Minimum Temp. °F	Maximum Temp. °F
AG1036 (inside room)	50.6	50.0	52.3
AG1147 (inside room)	50.3	49.8	51.6
AG1756 (Adit Entrance)	63.3	56.3	71.4

*data after monitor stabilization ~ 4 hours

The monitors in the inside room took several hours to stabilize to the room temperature, but once stabilized, the room temperature did not show variation more than 1 degree during the entire 72-hour measurement period. Temperature at the adit entrance varied between 56 °F at night to 72 °F during the daytime. The humidity was stable in the inner

room showing a slight increase in humidity over the three-day measurement period. The humidity at the adit entrance changed with the same diurnal variation as the temperature and radon concentration, ranging from as low as 31% during the day and over 70% during early morning hours. The atmospheric pressure was very stable over the entire sampling period in the inner room and at the adit entrance. All three monitors show no observable change in the ambient pressure. Refer to Figure 5 for a time plot of the temperature, pressure and humidity in the inner chamber. The plot in Figure 6 is for the adit entrance monitor placement.

Figure 5. Environmental measurements, inner chamber

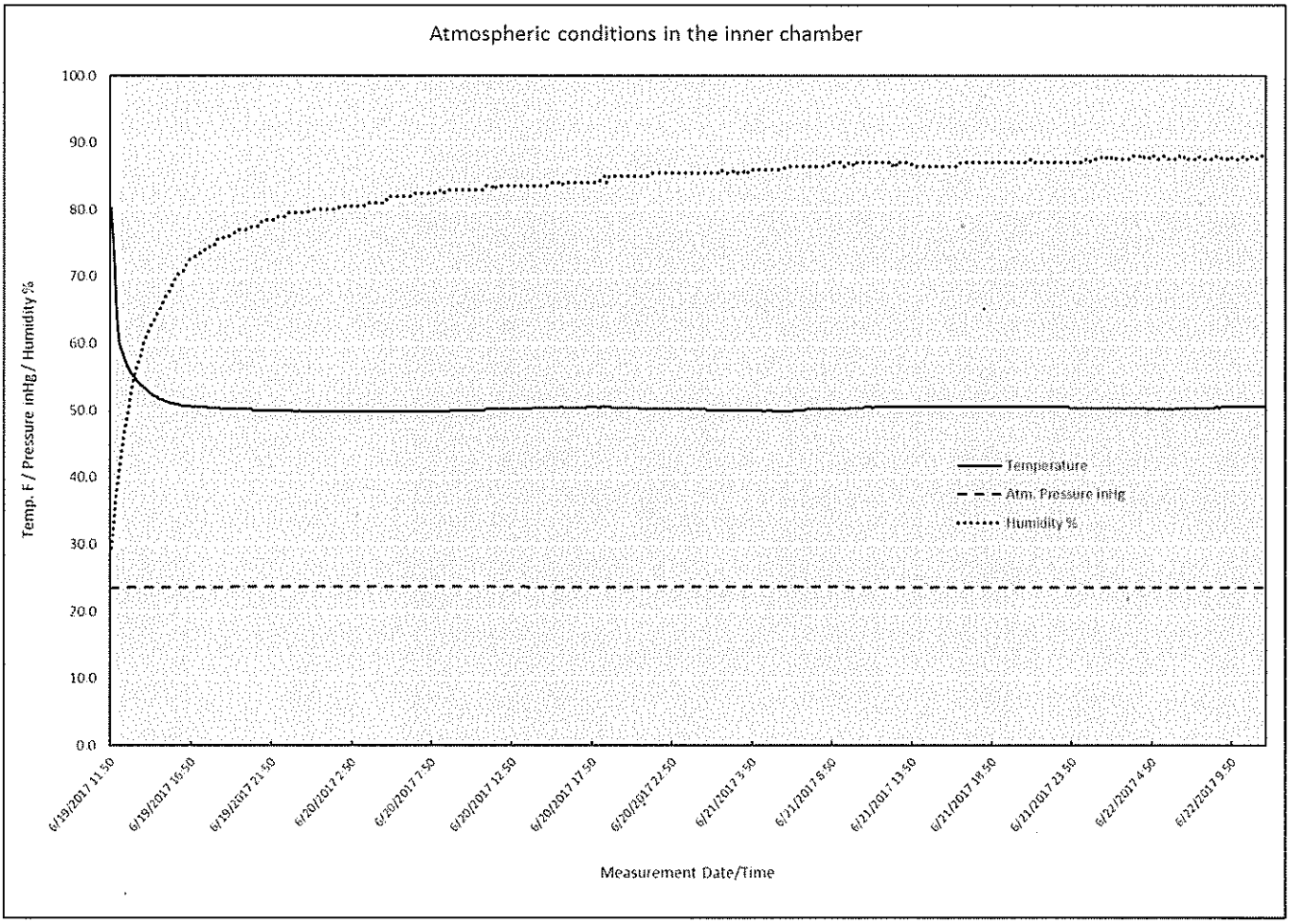
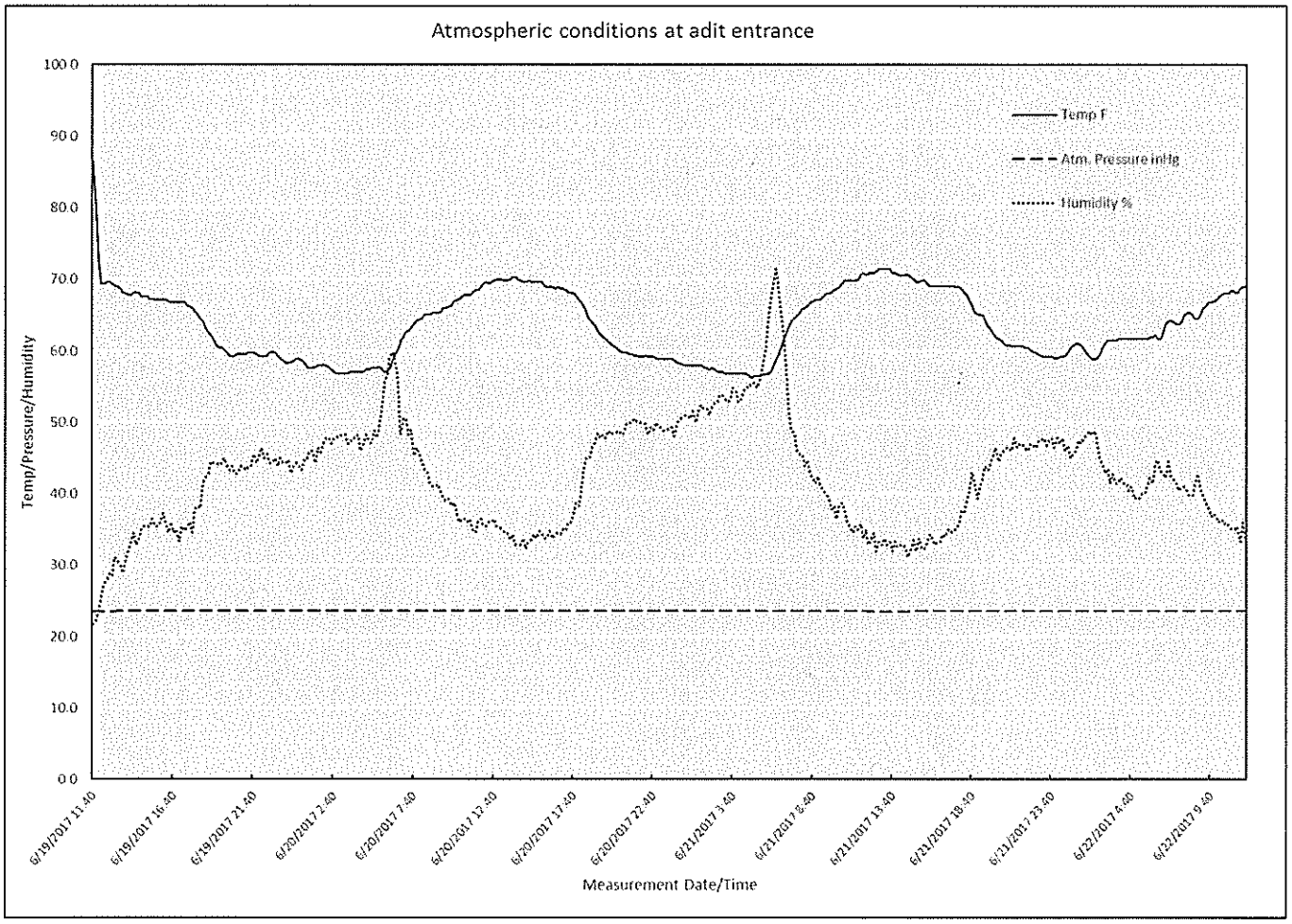


Figure 6. Environmental measurements, Adit

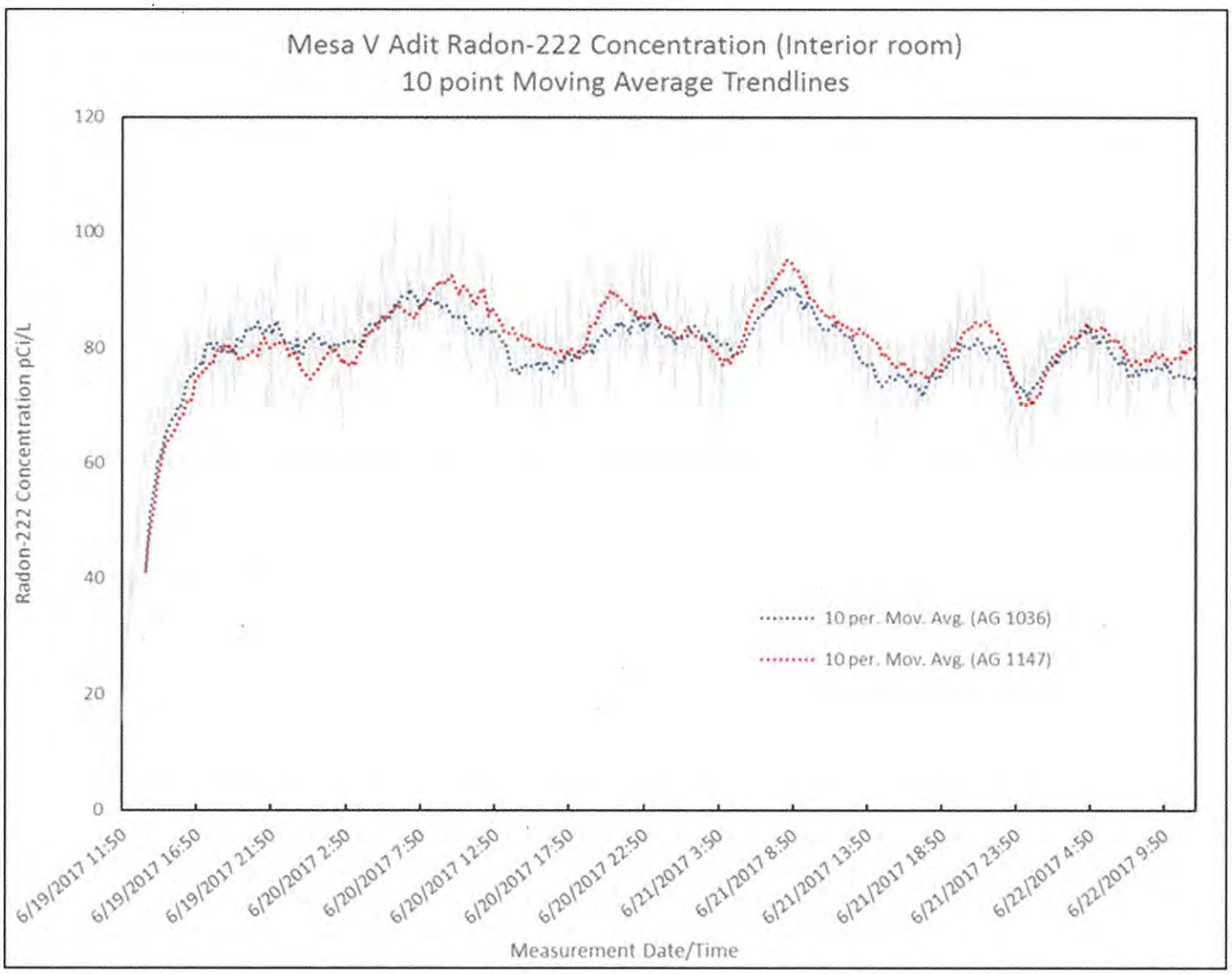


5 MEASUREMENT QUALITY

Data completeness was 100% with no data lost from the measurement phase or during transfer of the data for all three monitors. The Relative Percent Difference (RPD) for the measurement run was determined for each 10-minute measurement period, and for the overall averages on the co-located samplers in the inner chamber. The RPD for the overall ^{222}Rn averages was 1.40%, well within the goal of 25% stated in the SAP. The average RPD for individual ^{222}Rn measurements was 7.86%, ranging from 0.0% to 30.0%. Of the 433 measurements, only five measurements had an RPD of greater than 25% and 90% of the measured RPDs were 15% or less. The RPDs for all of the

individual temperature, pressure and humidity measurements were less than 1%. A plot of the data for the two instruments inside the inner room was generated with 10-point trailing average trend lines. The plot shows excellent agreement between the two instruments over the entire 72-hour sampling period. See Figure 7, below.

Figure 7. Timeplot of radon trendlines from inner chamber



6 CONCLUSIONS

While the measured levels of ^{222}Rn are at or exceed screening levels based on residential scenarios, listed in tables 1 and 2 and the SAP, those screening levels are based on continuous or

near continuous exposures that occur for many years (>25 years). Thus, when comparing them to adit ^{222}Rn levels, they would significantly overestimate risks to recreational and short-term worker receptors. The exposure receptors for the site (i.e., adit) are expected to have significantly shorter exposure time, frequency and duration due to the remoteness and accessibility of the adit. However, background exposures (e.g., at home) to radon and representativeness of the monitoring data (i.e., snapshot in time) should be considered in the evaluation and addressment of potential exposure pathways.

This event is only a snapshot in time of the radon concentrations. The diurnal variations in ^{222}Rn concentration at the adit entrance indicate that there is an increased exchange of radon during the overnight hours. The atmospheric pressure in the area was high and stable so it is unknown if the radon concentrations inside the excavation would increase with changes in weather and a drop in the atmospheric pressure.

7 REFERENCES

No references cited.

8 APPENDICES

8.1 Project Acceptance Form/Customer Request

8.2 Photographs of the Mesa V mine adit entrance and inner chamber

Appendix 8.1, Project Acceptance Form

NATIONAL CENTER FOR RADIATION FIELD OPERATIONS (NCRFO)

PROJECT ACCEPTANCE FORM

The purpose of this document is to provide NCRFO an abridgment, to ensure that all requests can be delivered while meeting quality assurance objectives. This document is not a contract. It's an internal quality control approach to ensure that NCRFO can deliver environmental radiological services, so we can meet the needs of our customer. The customer must be aware that in the event of an emergency, NCRFO resources may be redirected from your activity.

I. REQUESTER CONTACT INFORMATION

Organization: USEPA Region 9

Contact Person: Edwin "Chip" Poalinelli

Phone: 415-972-3390 Cell: 415-301-1573

Email: poalinelli.edwin@epa.gov

Signature: Edwin Poalinelli Date: 2/27/2017

II. SITE BILLING CODE (IF REQUIRED) FOR SITE SUPPORT

Certifying Officer: _____

BFY: _____

FUND/Appropriation: _____

Budget Org: _____

PRC: _____

Site Project: _____

III. PROJECT INFORMATION

Please provide a detailed site and project description including known or suspected hazards.

Site Program Type: ☑ Regional ☑ Superfund ☐ Other

Site Name: Mesa V Navajo Nation Tronox

Site Location: _____

Appendix 8.1, Project Acceptance Form, cont'd

Site History or Weblink/URL (if Available)

Proposed Project Start Date: 3/20/2017

Proposed Project End Date: 9/29/2017

Customer Proposal:

See Attachment

IV. Samples Collected by NCRFO? ☑ **YES** (Laboratory Sample Acceptance Form Needed) ☐ **NO**

V. PROPOSED APPROACH (to be completed by NCRFO personnel)

Please note that the proposed target date may change due to emergency and operational commitments.

Proposed Date: _____

Comments:

Appendix 8.1, Project Acceptance Form, cont'd

VI. NCRFO APPROVAL (to be completed by NCRFO personnel)

NCRFO Project Manger MARK D. SECUS

☒ Approved ☐ Disapproved Reason for Disapproval: _____

Comments:

Signature: _____ Date: 3/08/2017

CRPR/CPT Center Director Jeremy D. Johnson

☒ Approved ☐ Disapproved Reason for Disapproval: _____

Comments:

Signature: _____ Date: 3/8/2017

NCRFO QA Manager Emilio B Braganza

☒ Approved ☐ Disapproved Reason for Disapproval: _____

Comments:

Signature: _____ Date: 3/9/2017

NCRFO Laboratory Director Edward L. Wilds Jr

☒ Approved ☐ Disapproved Reason for Disapproval: _____

Comments:

Signature: _____ Date: 3/9/17

NCRFO PAF Rev. 5, April 03, 2014

Page 3 of 3

Appendix 8.1, Project Acceptance Form, cont'd

NCRFO will assist EPA Region 9 in developing and implementing a radon investigation of an adit located on the Mesa V Navajo Nation Tronox site. More specifically, NCRFO (in coordination with EPA Region 9 and Navajo Nation) will develop a work plan (including a QAPP/SAP) to sample and measure the ambient levels of radon in the adit, which will be used to evaluate/assess doses/risks to people and animals that enter or are near the adit opening. Exposure rate monitoring may also be performed to more fully characterize the adit and immediate vicinity during the radon investigation. The work plan (including QAPP/SAP) will include, but is not limited to the development of a conceptual site model, data quality objectives, and screening levels (to assess risks/doses).

During the development of the work plan, NCRFO staff will visit the site at least once for the purposes of gaining more complete understanding of site conditions and field work limitations. In addition, NCRFO and EPA Region 9 staff will hold regular meetings (at least monthly) to discuss work plan elements and objectives and other project related issues (analytical needs, Health and Safety).

EPA Region 9 also proposes that a small NCRFO field team implement the work plan, with RPM oversight. Upon completion of the investigation and analysis of samples, NCRFO will develop and provide a report to EPA Region 9 on the findings of the investigation. Region 9 will provide the overall approval of all work plans/QAPPs/investigation reports.

EPA Region 9 will make arrangements with a contract lab to perform sample analysis and supplying the data to NCRFO.

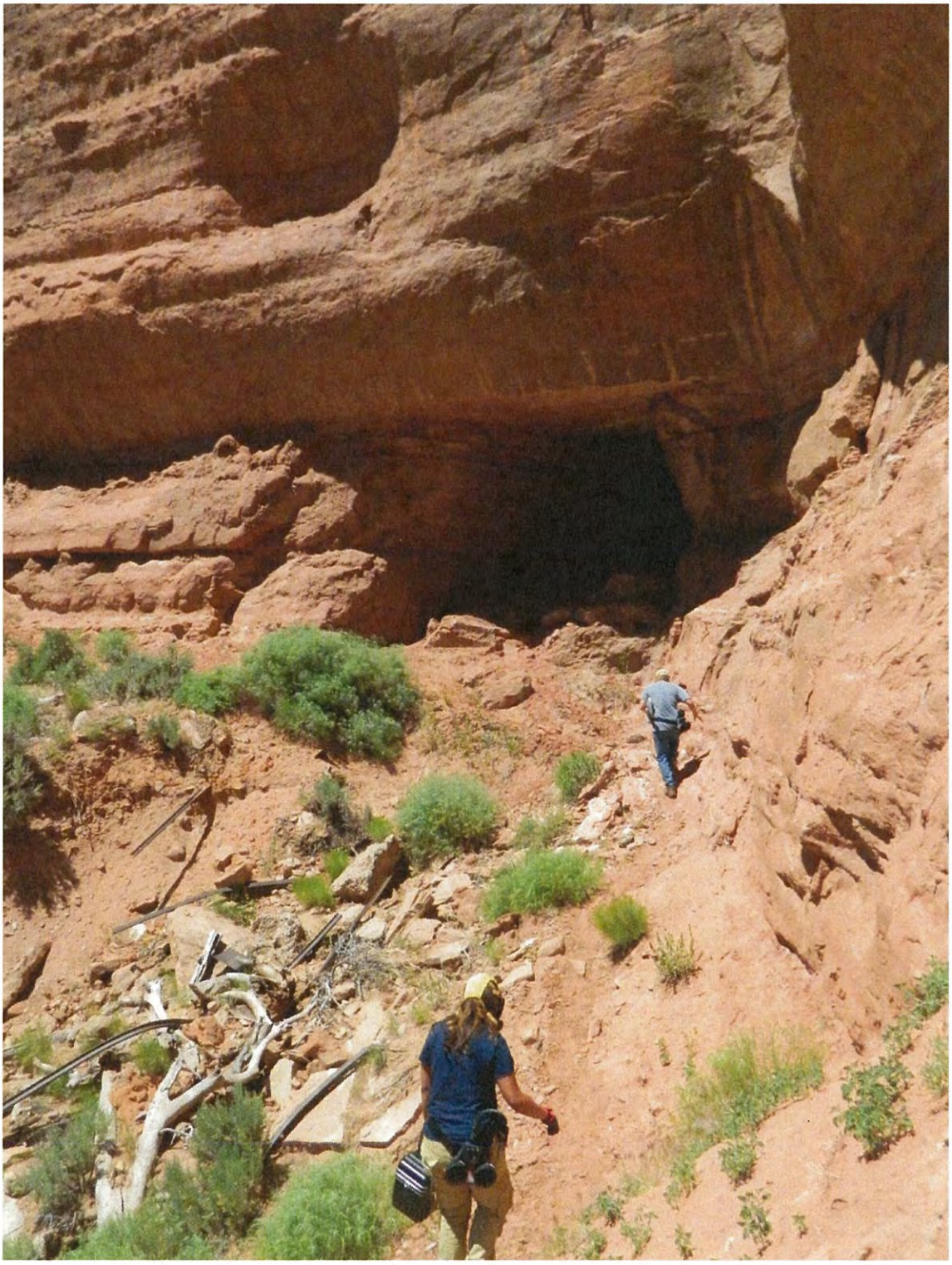
EPA Region 9 will also provide NCRFO all site coding/billing information along with all relevant site background information and health and safety plans

Appendix 8.2, Photos of Mesa V Adit

Mesa V adit in the distance (approach on foot)

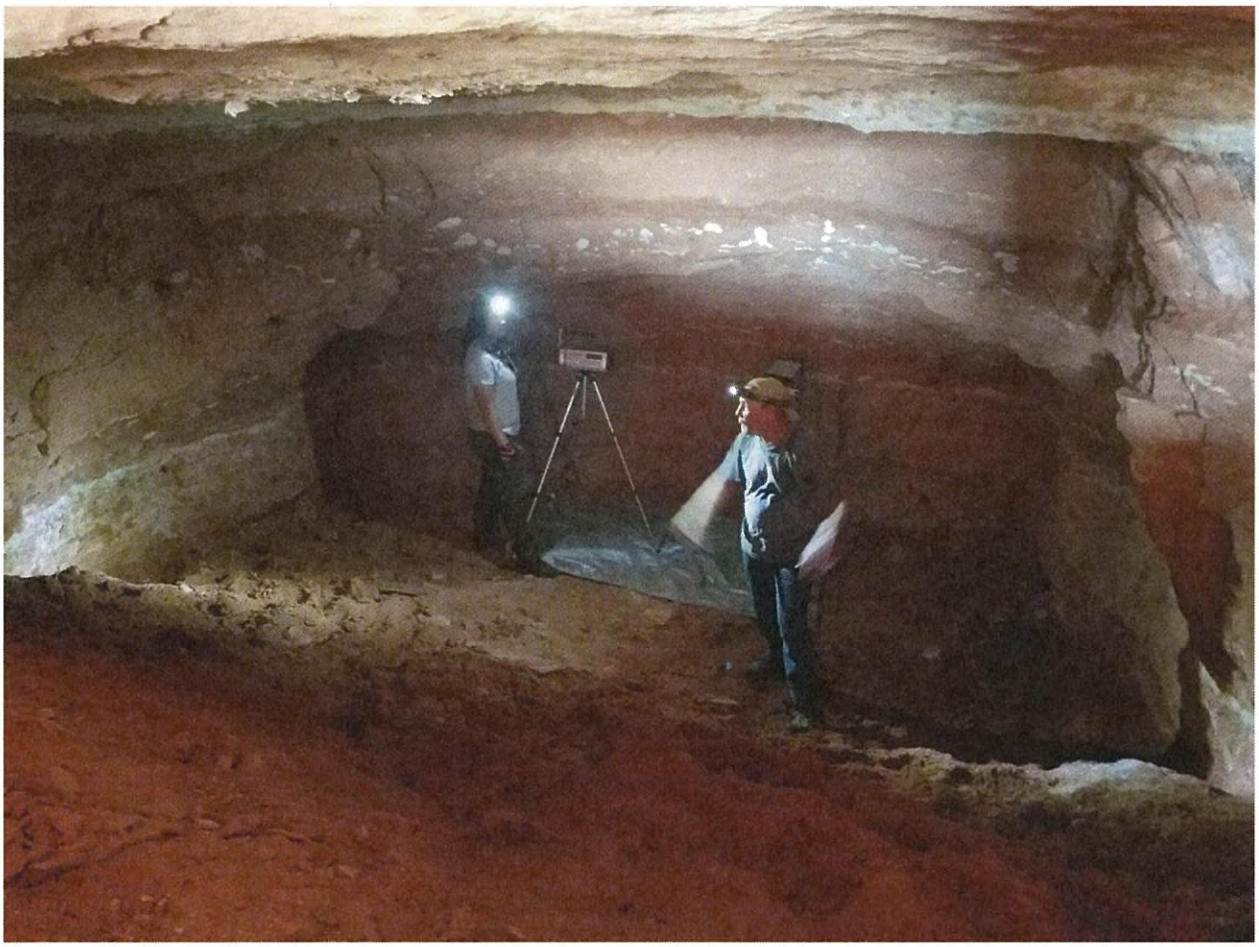
Appendix 8.2, Photos of Mesa V Adit, cont'd

Team arrival at the Mesa V adit



Appendix 8.2, Photos of Mesa V Adit, cont'd

Monitoring in the Mesa V inner chamber



ATTACHMENT IV
MCAP REPORT

MCAP SUMMARY REPORT

TO: Edwin Poalinelli. United States Environmental Protection Agency, Region 9, Remedial Project Manager

FROM: Alex Grubb, Weston Solutions, START Project Manager

DATE: December 9, 2016

SUBJECT: Mine Category Assessment Protocol (MCAP) Summary Report
Navajo Nation, Apache County, Arizona
TDD No.: 24-1512001 (0024/1302-T24-R9-15-12-0001)

PROJECT BACKGROUND

The U.S. Environmental Protection Agency (EPA) tasked Weston Solutions, Inc.'s (WESTON®) Superfund Technical Assessment and Response Team (START) to develop and implement the Mine Category Assessment Protocol (MCAP) in support of the Tronox settlement.

There are more than 500 abandoned uranium mine (AUM) claims spread across six distinct mining regions of the Navajo Nation. The MCAP project is concentrated on assessing 26 Tronox mines, as well as six potential Tronox mines, referred to as "other Tronox mines", located within the Northern Agency of the Navajo Nation. As shown on **Figure 1** the MCAP area of interest is divided between two ranges of the Northern Agency:

- The Lukachukai Mountains: The MCAP target sites are spread over approximately 30 square miles of high peaks and mesas, south of Cove, Arizona.

- The Northwest Carrizo Mountains: The MCAP target sites are spread over approximately 1.5 square miles near the Toh Atin Mesa anticline, southeast of Red Mesa, Arizona.

The MCAP effort has also been applied to any additional mines within a half mile radius of the Tronox mines, and other non-mine areas of concern as identified in MCAP Target List. Development of the MCAP is intended to establish a systematic method for assessing and surveying abandoned uranium mine sites and other potential contributions of uranium material areas to determine and evaluate removal factors impacting future site work, and to develop ranking system for prioritizing forthcoming Removal Site Evaluations. This systematic approach will includes ranking each mine claim area based on a historical review as well as creating a Target List, made up of the Tronox mine sites and other nearby mines sites.

MCAP TARGET LIST

The initial phase of developing the MCAP process was to determine the list of target sites to be assessed. The MCAP effort has also been applied to any additional mines and non-mine areas of concern within a half-mile radius of the Tronox mines, where mine waste and contamination is likely to have comingled or have potentially been impacted by the operations at the Tronox mines. As shown on **Figure 2**, **Figure 3**, and **Table 1**, the following targets were identified:

Tronox AUMs, including

- 26 AUMs in the Lukachukai Mountains comprised of 33 individual mining sites
- 1 AUM in the Northwest Carrizo Mountains

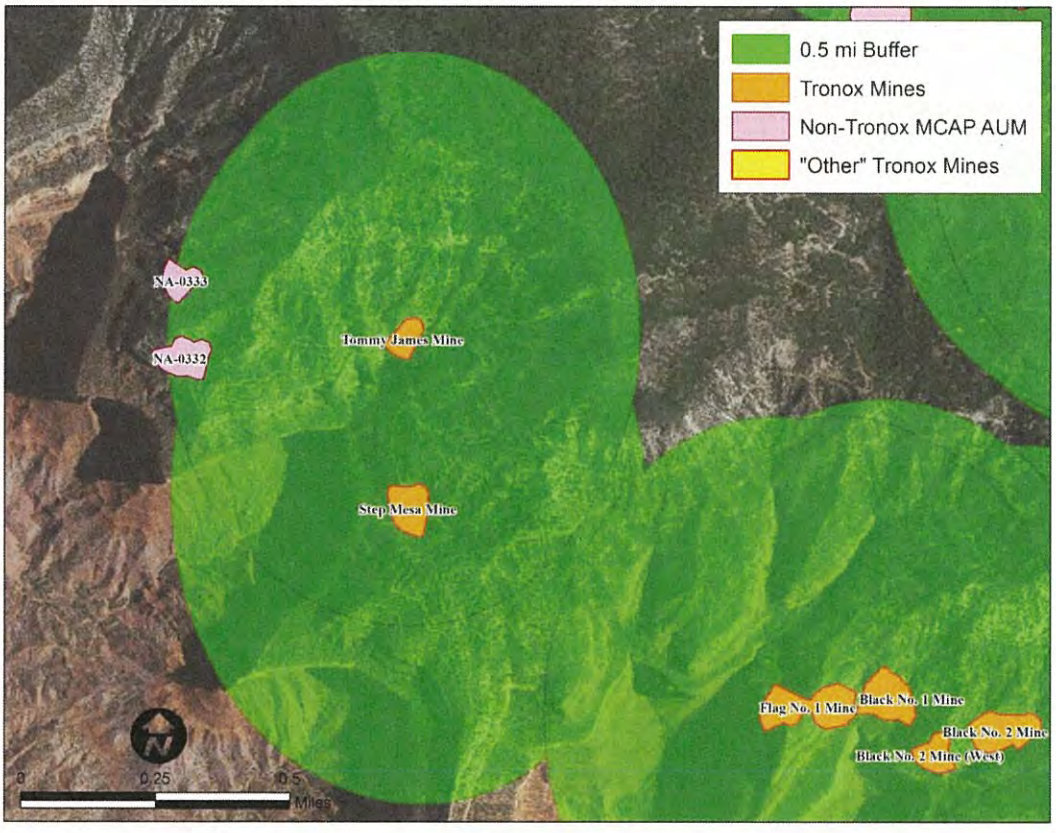
"Other" Tronox AUMs, including:

- 5 AUMs in the Lukachukai Mountains
- 1 AUM in the Northwest Carrizo Mountains

Non-Tronox AUMs:

- 20 AUMs in the Lukachukai Mountains comprised of 21 individual mining sites

0.5 Mile Buffer of Tronox AUMs



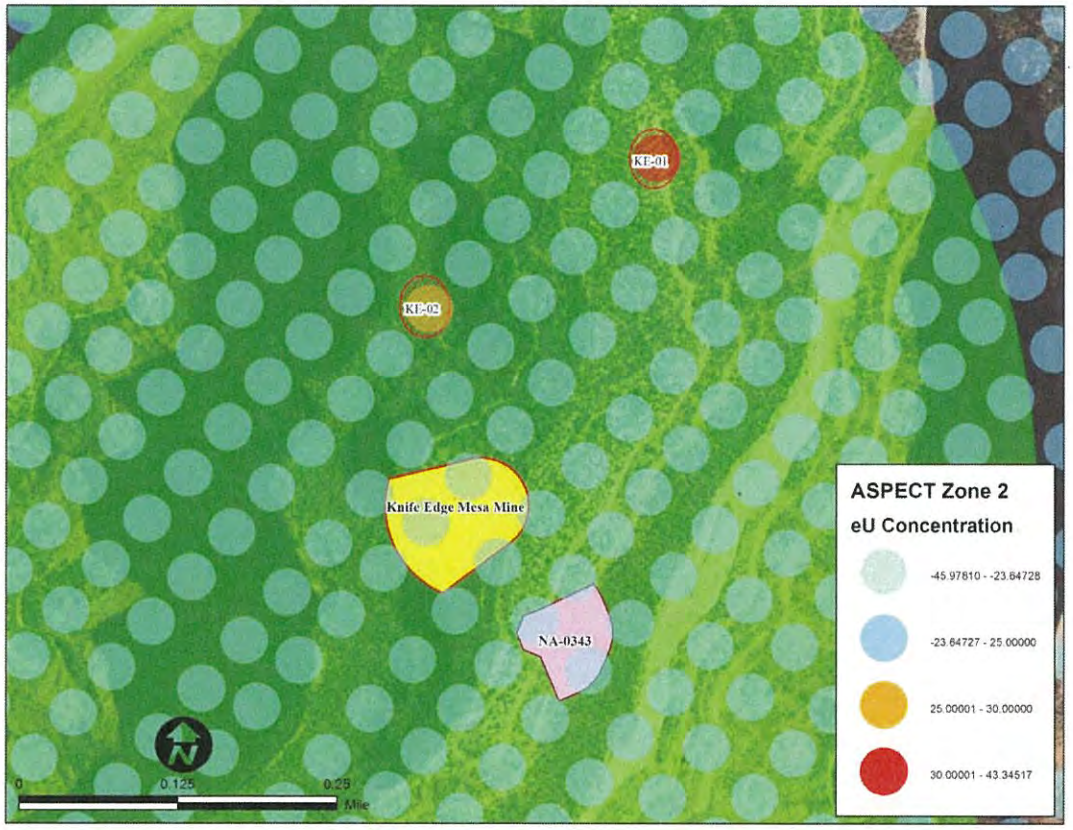
Non-Mine Target Areas:

Non-AUM target sites included locations determined by an analysis of the 2014-2015 aerial radiological survey conducted by EPA's Airborne Spectral Photometric Environmental Collection Technology (ASPECT) program. Data anomalies and elevated outliers revealed during the analysis of the ASPECT gamma spectrometry results within a half-mile radius from a Tronox AUM were evaluated. A summary of the results are described in the draft ASPECT Survey Report, included as **Attachment B-1.**

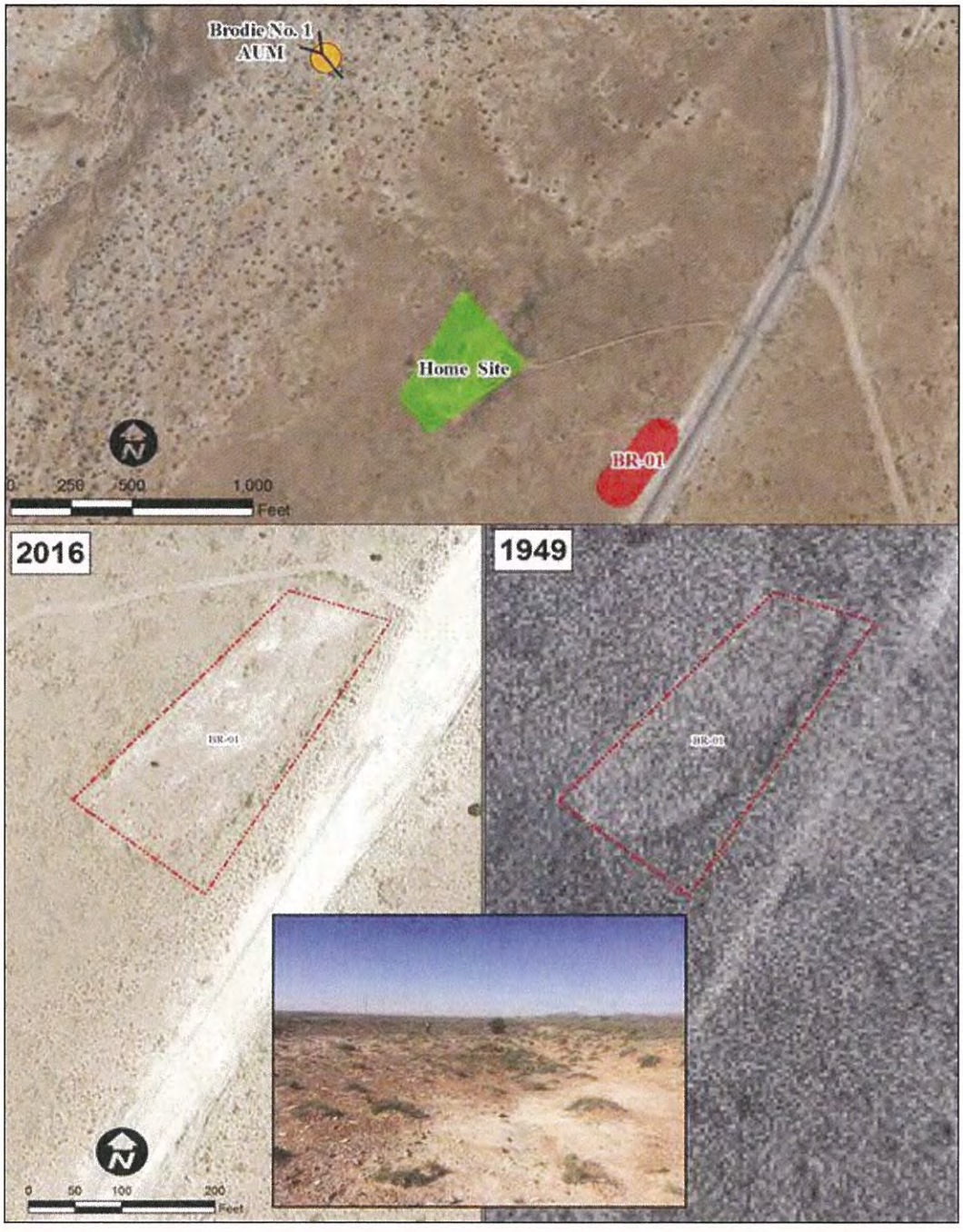
A review of historical documentation and historical aerial photographs was also conducted to identify areas of concern. The historical documents are included in **Appendix A** and **B**, and aerial photographs are included in **Appendix C**. These newly defined areas have been identified, provided a name and mapped. The non-AUM target sites include:

- 27 sites in the Lukachukai Mountains
- 8 sites in the Northwest Carrizo Mountains

Non-AUM Targets (KE-01 & KE-02) as Determined by ASPECT eU Concentration Anomalies



Non-AUM Target (BR-01) as Determined by Historical Aerial Photographs



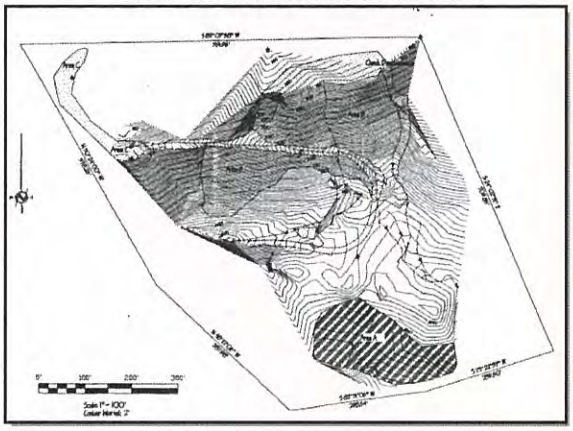
HISTORICAL DOCUMENT REVIEW

Prior to the MCAP site reconnaissance field deployment, START assimilated historical site reports and documentation from as many sources as possible, in order to gather site specific knowledge.

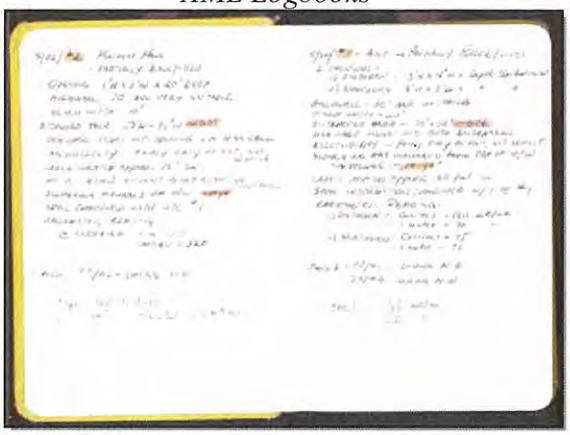
- ASPECT Survey Data
- Previous Gamma Scanning Results and Reports, and Investigations
- Historic Aerial Imagery
- Navajo Abandoned Mine Lands Reclamation Program (AML) Logbooks and Sketches
- AML Reclamation technical specifications and site plans
- Existing GIS Data
- Historical Geological Reports

The document review was conducted using site-specific data, included in **Appendix A**, and regional data, included in **Appendix B**.

AML Reclamation Site Plans



AML Logbooks



Production Records

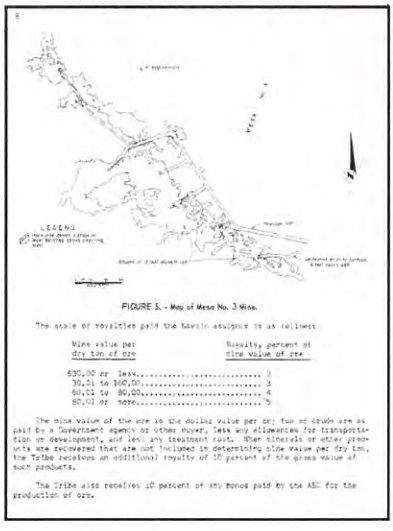


FIGURE 5. - Map of Mesa No. 3 Mine.

The scale of royalties paid the Navajo assignor is as follows:

Mine value per dry ton of ore	Royalty, percent of mine value of ore
$30.00 or less	3
30.01 to $60.00	4
60.01 to $90.00	4
90.01 or more	5

The mine value of the ore is the dollar value per dry ton of crude ore as paid by a Government agency or other buyer, less any allowances for transportation or development, and less any treatment costs. When minerals or other products are recovered that are not included in determining mine value per dry ton, the Tribe receives an additional royalty of 10 percent of the gross value of such products.

The Tribe also receives 10 percent of any bonus paid by the ASC for the production of ore.

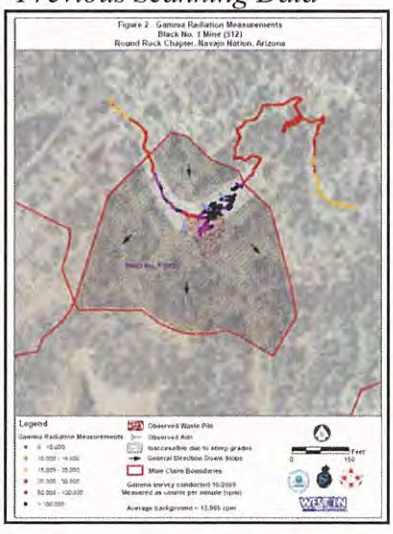
Historic Reports

are partitioned with stulls and logging, making the ore chutes about 5 by 5 feet.

For most of their lengths, the 7- by 7-foot haulageways penetrate red sandstone, which underlies the ore sandstone. The sandstone air-slakes and sloughs easily, falling from the back and sides until a natural arch is formed. Even though a good arch is formed, the back often will continue to slough unless it is stopped by a sandstone parting or held by timber. Sloughing of the sides often will continue as long as it does at the back. To control

FIGURE 8. - Mesa No. 2 Mine Portals.

Previous Scanning Data



MCAP RECONNAISANCE

Two site reconnaissance field deployments were conducted from 18-27 April, 2016, and from 14-29 September, 2016. The site personnel included eight members of Weston's START team, as well as three representatives from USEPA Region IX. Prior to the field mobilization, START generated a table based field form to be deployed in the field, as well as an online map viewer loaded with previous site screening data.

Gamma Scanning:

In order to document the radiological measurements throughout the deployment, and and delineate the extent of the contaminated areas, the field teams used Ludlum 22-41 gamma rate meters with 2" x 2" sodium-iodide scintillation detectors, linked to a Trimble GeoXTs. The gamma radiation measurements are displayed in the removal site evaluation priority maps as indexed on **Table 5**.

Gamma Scanning and Display of Gamma Measurements

Site Comparison Level

During the MCAP site reconnaissance field effort, more than 200,000 gamma radiation measurements were collected and logged, ranging from approximately 4,000 counts per minute (cpm) to nearly 1,000,000 cpm. In order to determine the relative levels of gamma radiation measurements collected throughout the MCAP field deployment, a "Comparison Level" (CL) was selected based by calculating the median gamma level over the entire deployment. The CL of approximately 8,000 cpm was used during the implementation of the MCAP priority ranking scenario, used as an arbitrary evaluation criteria to prioritize and compare scanning results across the target sites. The gamma scanning maps are symbolized using multiples of two-times (2x), 5x, 10x, 25x, and greater than 25x the CL.

Site Access:

Limited vehicle access as well as poor and changing road and weather conditions made accessing some target sites a challenge. The primary access roads leading to many of the sites were blocked by heavy snowpack, fallen trees, and rockslides. Specialized vehicles such as ATVs, UTVs, and Jeeps were necessary to gain closer access to many of the targets. Hiking paths leading to many of the more remote target sites have also washed out and eroded to the point of impassability. Attempts were made to access the Target Sites from alternative directions, but in total 7 AUM targets and 4 non-AUM target sites were not accessed during the field deployment, as described on **Table 2**. Information gathered during previous investigations was used to determine many of the priority factors assessed during MCAP.

Access Challenges

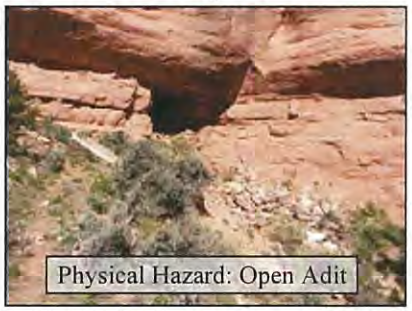
PRIORITY TARGET DETERMINATION

Based on the findings of the MCAP site reconnaissance, START developed the Priority Ranking Scenario and identified evaluation factors in order to systematically select the priority Removal Site Evaluation (RSE) candidates. The MCAP ranking scenario differs from standard ranking systems, such as the EPA Hazardous Ranking System (HRS) largely as it is intended to differentiate similar sites within a relatively close proximity, where typical factors, such as precipitation or sensitive environments is expected to be consistent throughout the project area. More site-specific factors were included in the MCAP ranking scenario.

Target Site Priority Ranking Scenario

The following factors were evaluated in order to determine the MCAP Priority sites:

1. Physical Hazards - Immediate physical hazards observed (i.e. accessible open shaft, un-reclaimed pits or other hazards attributable to mining or reclamation)
2. Surface Area of Impacted Material - Estimated surface area of significantly impacted soils/waste material, where gamma radiation was measured greater than 5-times the Comparison Level, or where likely impacted materials appeared to be present in areas inaccessible to ground scanning
3. Impacted Material Characteristics - Mobility potential of elevated/waste material to the surface water, groundwater, and air, based on structure/texture of affected media
4. Migration to Surface Water - Potential of contaminated material migrating off-site into a known surface water body
5. Residential Exposure - Proximity of inhabited or potentially inhabited structures/home compounds
6. Public Exposure - Potential for public to visit the site for non-residential purposes (such recreation, livestock herding, hunting, etc)
7. Accessibility - Ease of gaining access to the site
8. Reclamation - Condition of any historical mine reclamation


Physical Hazard: Open Adit


Residential Exposure


Reclamation - Erosion

The specific numeric values associated with each priority factor is detailed on **Table 3**, and the scores and overall priority ranking and rationale for all of the MCAP target sites is shown on **Table 4**.

While each of the target sites was assigned individual priority ranking score values, it may be appropriate for future Removal Site Evaluations to encompass multiple target sites geographically clustered in close proximity. The targets determined in need of further evaluation have been grouped into 17 "Removal Site Evaluation Priority Groups", as shown on **Figures 7 and 8**. The RSE groups were ranked into four categories, based on the highest individual target site value within each group. Evaluation recommendations are based on the RSE groups, rather than individual Target Sites. The RSE groups and associated target sites are listed on **Table 5**, and shown on the figures indexed on **Table 5**.

Priority Removal Site Evaluation Groups

Five of the 17 Assessment Areas were determined to achieve the maximum priority ranking, these areas include the following:

M5 South – **Figures 19A**, **19B** and **19C** show the proposed M5 South RSE Group

- An un-reclaimed open adit was observed at AUM 103, which poses a potential and significant physical hazard. More than a mile of underground mine workings were once operational at the site, and it is current extent of the underground chambers is unknown. Cattle were observed entering the portal, so it appears the underground tunnel networks is still at least partially intact
- Waste below the adit, as well as throughout other Mesa V area AUMs, was characterized by fine grain soils, which are likely to be highly mobile.
- Observed contamination has been documented in the surface water pathway drainages downstream from Mesa V

M2 South – **Figures 13A**, **13B** and **13C** show the proposed M2 South RSE Group

- Mesa II Mines 1 & 2 P-21 was the most productive mine in the Lukachukai Mountains, producing nearly five time the volume of the second largest operation
- Large quantities of fine grained and highly mobile contaminated material is found throughout the area
- Reclamation performed at the site has become highly eroded and compromised
- Water and sediment samples collected from a spring originating within the waste area were found to contain the highest levels of contamination in the Lukachukai Mountains.

M1 North – **Figures 10A, 10B** and **10C** show the proposed M1 North RSE Group

- Observed waste piles and mine debris has been documented in the stream and wetlands below the AUMs.
- Some waste below the former adits was characterized by fine grain soils, which are likely to be highly mobile
- A frequently travelled road bisects the Mesa I area

Brodie - **Figures 24A, 24B** and **24C** show the proposed Brodie RSE Group

- An unknown and undocumented recessed pit area at BR-01 with elevated levels of gamma radiation was identified within a close proximity of an occupied residence. The pit area pre-dates the earliest obtained aerial imagery (1949), and its origin remains unclear.
- The AUM boundaries identified in AUM Atlas at Brodie No. 1 were located in the wrong the location, so the reclaimed adit area has yet to be properly assessed.
- Soil samples collected during the ASPECT Survey showed highly elevated levels of contamination present at the site

M3– **Figures 14A, 14B** and **14C** show the proposed M3 RSE Group

- Water and sediment samples collected from a seep originating below the sealed adit were found to contain high levels of contamination
- An unoccupied structure is located on Mesa III, which is reportedly used as part of a sheep camp
- Fine grained and highly mobile contaminated material is found above the drainages leading offsite
- Elevated levels of gamma radiation have been documented continuously downstream

RECOMMENDATIONS

Recommendations for the MCAP target Removal Site Evaluations and further characterization are largely impacted and attributable to the access limitations present throughout the project area. Ideally, Removal Site Evaluations should include surface characterization of 100% of the assessment areas, as well as subsurface investigations and volumetric calculations, however the within the context of the inhibiting geography, the following recommendations are contingent upon the actual site conditions:

- Completion of cultural resource and archaeological surveys at areas of potential disturbance
- Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas
- Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites
- Further site access route reconnaissance may be needed at selected areas
- Road improvement evaluations to determine removal alternatives
- Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas
- Detailed aerial site surveys may be warranted to estimate waste volumes
- Underground surveys of open and exposed adits
- Surface sampling of waste and cover material to confirm scanning data
- Subsurface sampling with limited access drilling equipment, at accessible locations
- Historic records and document review, including reclamation specifications and drawings
- Review of historical aerial imagery and land-use / land-cover analysis

Site-specific recommendations are included on **Table 5**, including the primary recommended task, which addresses the most significant objective for each priority RSE group.

TABLES

FIGURES

18B M5 North Removal Site Evaluation Group - Gamma Radiation
18C M5 North Removal Site Evaluation Group - Waste Material
19A M5 South Removal Site Evaluation Group - Layout
19B M5 South Removal Site Evaluation Group - Gamma Radiation
19C M5 South Removal Site Evaluation Group - Waste Material
20A M6 Removal Site Evaluation Group - Layout
20B M6 Removal Site Evaluation Group - Gamma Radiation
20C M6 Removal Site Evaluation Group - Waste Material
21A Knife Edge Mesa Removal Site Evaluation Group - Layout
21B Knife Edge Mesa Removal Site Evaluation Group - Gamma Radiation
21C Knife Edge Mesa Removal Site Evaluation Group - Waste Material
22A Flag Mesa Removal Site Evaluation Group - Layout
22B Flag Mesa Removal Site Evaluation Group - Gamma Radiation
22C Flag Mesa Removal Site Evaluation Group - Waste Material
23A Step Mesa Removal Site Evaluation Group - Layout
23B Step Mesa Removal Site Evaluation Group - Gamma Radiation
23C Step Mesa Removal Site Evaluation Group - Waste Material
24A Brodie Removal Site Evaluation Group - Layout
24B Brodie Removal Site Evaluation Group - Gamma Radiation
24C Brodie Removal Site Evaluation Group - Waste Material
25A Block K Removal Site Evaluation Group - Layout
25B Block K Removal Site Evaluation Group - Gamma Radiation

ATTACHMENTS

Appendix A *- Site Specific Documents*

The following site specific documents are included in Appendix A, and accessible through the attached MS Access MCAP Document Index Database:

- Photographic Logs
- NAMLRP Reclamation Logbooks
- NAMLRP Reclamation Contracts
- NAMLRP Reclamation Sketches
- NAMLRP Reclamation Maps
- NAMLRP Technical Specifications
- Weston Pre-CERCLIS Screening Reports
- Historic Geologic Reports
- Historic Production Reports
- Previous Investigation Reports
- Historic Mining Permits

Appendix B *– Regional Historic Documents*

The following region-wide documents are included in Appendix B, and accessible through the attached MS Access MCAP Document Index Database:

B-1 USEPA - ASPECT Navajo Nation Survey Report Summary Report, 2015
B-2 ARIZONA BUREAU OF MINES – Radioactive Occurrences in Arizona, 1981
B-3 ARIZONA GEOLOGIC SURVEY – Uranium Production in the Lukachukai Mountains, 1988
B-4 ARIZONA GEOLOGIC SURVEY – Uranium Production in the Northern and Western Carrizo Mountains, 1985
B-5 BUREAU OF MINES – Kerr McGee Uranium Mining in the Lukachukai Mountains, 1961

Appendix C *– Data Package*

Digital data files are provided in the attached data package, including full resolution historical aerial photograph GeoTiffs, and ESRI ArcGIS Shapefiles.

Historic aerial photographs were acquired from the USGS Earth Resources Observation and Science Center (EROS), National Aerial Photography Program (NAPP), and the National High Altitude Photography Program (NHAP).

The following photographs were acquired and reviewed during the MCAP process:

Range	Date	Scale	Source
Lukachukai NE	11/13/1949	1:20000	USGS-EROS
Lukachukai SE	11/13/1949	1:20000	USGS-EROS
Lukachukai NW	11/13/1949	1:20000	USGS-EROS
Lukachukai W	11/13/1949	1:20000	USGS-EROS
Lukachukai E	11/13/1949	1:20000	USGS-EROS
NW Carrizo BR	11/13/1949	1:20000	USGS-EROS
NW Carrizo BK	11/13/1949	1:20000	USGS-EROS
NW Carrizo	6/11/1950	1:47200	USGS-EROS
Lukachukai	6/11/1950	1:47200	USGS-EROS
Lukachukai S	10/8/1952	1:20000	USGS-EROS
Lukachukai SE	10/8/1952	1:20000	USGS-EROS
Lukachukai SW	10/27/1952	1:20000	USGS-EROS
NW Carrizo	4/1/1953	1:54000	USGS-EROS
Lukachukai NE	4/1/1953	1:54000	USGS-EROS
Lukachukai SE	4/1/1953	1:54000	USGS-EROS
Lukachukai N	9/20/1953	1:37400	USGS-EROS
Lukachukai NE	9/20/1953	1:37400	USGS-EROS
Lukachukai SW	9/20/1953	1:37400	USGS-EROS
NW Carrizo	10/22/1955	1:60000	USGS-EROS
Lukachukai NE	9/17/1968	1:12000	USGS-EROS
NW Carrizo BR	6/25/1976	1:30000	USGS-EROS
NW Carrizo BK	6/25/1976	1:30000	USGS-EROS
Lukachukai N	6/25/1976	1:30000	USGS-EROS
Lukachukai S	6/25/1976	1:30000	USGS-EROS
NW Carrizo BK	4/3/1992	1:20000	NAPP
NW Carrizo BR	4/6/1992	1:20000	NAPP
Lukachukai NE	9/30/1992	1:20000	NAPP
Lukachukai SW	9/30/1992	1:20000	NAPP
NW Carrizo BK	10/14/1997	1:20000	NAPP
NW Carrizo BR	10/14/1997	1:20000	NAPP
Lukachukai NE	10/13/1997	1:20000	NAPP
Lukachukai SW	10/13/1997	1:20000	NAPP
NW Carrizo	6/10/1981	1:58000	NHAP
NW Carrizo	6/13/1981	1:58000	NHAP
Lukachukai	6/10/1981	1:80000	NHAP

The following GIS Shapefiles were utilized or developed during the MCAP process:

Shapefile	Source
ASPECT Gamma Survey Zone 1	EPA
ASPECT Gamma Survey Zone 2	EPA
ASPECT Gamma Survey Zone 3	EPA
ASPECT Gamma Survey Zone 6	EPA
MCAP Target Sites	Weston
MCAP AUMs	AUM Atlas
RSE Groups	Weston
Tronox Buffers	Weston
MCAP Gamma Scanning Data	Weston
Cove Watershed Gamma Scanning Data	Weston
Pre-CERCLIS Screening Gamma Scanning Data	Weston
MCAP Waste Material	Weston
Mine Portals	AUM Atlas
Site Access Routes	Weston
Reclamation Boundaries	AUM Atlas
Drainages	AUM Atlas
Lukachukai Mesas	Weston

Table 1. MCAP Target List

AUM / Target Site	Site ID	Target Justification
Black No. 1 Mine	512	Tronox Mine
Black No. 2 Mine	205	Tronox Mine
Black No. 2 Mine (West)	206	Tronox Mine
Block K	64	Tronox Mine
Flag No. 1 Mine	511	Tronox Mine
Frank Jr. Mine	421	Tronox Mine
Mesa I 1/2 Mine	419	Tronox Mine
Mesa I 1/4 Mine	423	Tronox Mine
Mesa I 3/4 Incline	95	Tronox Mine
Mesa I 3/4, Mine No. 2, P150	600	Tronox Mine
Mesa I, Mines 10 - 15	654	Tronox Mine
	93	Tronox Mine
	655	Tronox Mine
	94	Tronox Mine
	656	Tronox Mine
	657	Tronox Mine
Mesa II 1/2 Mine	603	Tronox Mine
Mesa II 1/2, Mine 4	604	Tronox Mine
Mesa II, Mine 4	285	Tronox Mine
Mesa II, Mine No. 1 & 2, P-21	601	Tronox Mine
Mesa II, Mine No. 1, P-150	602	Tronox Mine
Mesa III Mine	605	Tronox Mine
Mesa IV 1/2 Mine and Simpson 181	506	Tronox Mine
Mesa IV, Mine No. 1	606	Tronox Mine
Mesa IV, Mine No. 2	607	Tronox Mine
Mesa IV, Mine No. 3	608	Tronox Mine
Mesa V Adit	609	Tronox Mine
Mesa V Incline	610	Tronox Mine
Mesa V Mine	103	Tronox Mine
	508	Tronox Mine
Mesa VI Mine	611	Tronox Mine
Step Mesa Mine	204	Tronox Mine
Tommy James Mine	203	Tronox Mine
Brodie 1	191	"Other" Tronox Mine
Henry Phillips Mine	286	"Other" Tronox Mine
Knife Edge Mesa Mine	428	"Other" Tronox Mine
Mesa I 1/2, West Mine	288	"Other" Tronox Mine
Mesa II Pit	287	"Other" Tronox Mine
Mesa IV, West Mine	101	"Other" Tronox Mine
Cato No. 1 Pit	426	1/2 mile of Tronox Mine
Cato No. 2	104	1/2 mile of Tronox Mine
Cov000	425	1/2 mile of Tronox Mine
Cov068	420	1/2 mile of Tronox Mine
Cov087	507	1/2 mile of Tronox Mine
East Portal, Frank No. 1 Mine	509	1/2 mile of Tronox Mine
Frank No. 2	510	1/2 mile of Tronox Mine
Mesa II 1/4 Mine	96	1/2 mile of Tronox Mine
Mesa III, Northwest Mine	424	1/2 mile of Tronox Mine
Mesa III, West Mine	417	1/2 mile of Tronox Mine
Mesa IV, East Side	416	1/2 mile of Tronox Mine
NA-0313	660	1/2 mile of Tronox Mine
NA-0316	107	1/2 mile of Tronox Mine
NA-0318	99	1/2 mile of Tronox Mine
NA-0319	469	1/2 mile of Tronox Mine

Table 1. MCAP Target List

AUM / Target Site	Site ID	Target Justification
NA-0319	612	1/2 mile of Tronox Mine
NA-0332	202	1/2 mile of Tronox Mine
NA-0333	201	1/2 mile of Tronox Mine
NA-0343	207	1/2 mile of Tronox Mine
North Portal, Frank No. 1 Mine	505	1/2 mile of Tronox Mine
South Portal, Frank No. 1 Mine	106	1/2 mile of Tronox Mine
BK-01	*N/A*	Adjacent to Home Compound, S of Block K AUM
BK-02	*N/A*	Road N of Block K AUM
BR-01	*N/A*	Potential Pit Area adjacent to road, SE of Brodie No. 1 AUM
BR-02	*N/A*	Adit Area, W of Brodie No. 1 AUM
BR-03	*N/A*	Open area E of Brodie No. 1 AUM
BR-04	*N/A*	Cliff Area, NE of Brodie AUM
BR-05	*N/A*	Road, NE of AUM
BR-06	*N/A*	Clearing below cliff, NE of AUM
CT-01	*N/A*	Road N of Cove Transfer Station
CT-02	*N/A*	Road SW of Cove Transfer Station
CT-03	*N/A*	Residnetial Area S of Cove Transfer Station
KE-01	*N/A*	Slope E of ridge, north of AUMs
KE-02	*N/A*	Slope W of ridge, norht of AUMs
M1-01	*N/A*	Clearing along trail
M1-02	*N/A*	Rocks N/W of Road
M1-03	*N/A*	Slope S of Road
M1-04	*N/A*	Waste in Drainage
M1-05	*N/A*	Waste in Drainage
M1-06	*N/A*	Waste in Drainage
M1-07	*N/A*	Below trail
M1-08	*N/A*	Drainage below trail
M2-01	*N/A*	Trail
M4-01	*N/A*	Cleared/Access Area Above AUMs
M4-02	*N/A*	Road
M4-03	*N/A*	Slope W of AUMs/Road
M4-04	*N/A*	Cleared Area W of AUMs
M5-01	*N/A*	Possible Mine Area, Ravine E of Road
M5-02	*N/A*	S Side of Road
M5-03	*N/A*	N Site of Road
M5-04	*N/A*	Area betweem NA-0138 & Mesa V Incline AUMs
M5-05	*N/A*	Clearing between road and Mesa V Incline AUM
M5-06	*N/A*	Clearing between road and Mesa V Adit AUM
M5-07	*N/A*	Clearing between road and Mesa V AUM
M5-08	*N/A*	Slope below road
M5-09	*N/A*	Slope below trail

Table 2. MCAP Target Site Access

Target Site	Site ID	Range	Access Comments
Targets Accessed			
Black No. 1 Mine	512	Lukachukai	Hiking Access
Black No. 2 Mine	205	Lukachukai	Hiking Access
Black No. 2 Mine (West)	206	Lukachukai	Hiking Access
Block K	64	NW Carrizo	Car Access
Brodie 1	191	NW Carrizo	Car Access
Cato No. 1 Pit	426	Lukachukai	Jeep Access
Cato No. 2	104	Lukachukai	Hiking Access
Cov000	425	Lukachukai	Jeep Access
Cov068	420	Lukachukai	ATV Access
Cov087	507	Lukachukai	Jeep Access
East Portal, Frank No. 1 Mine	509	Lukachukai	Jeep Access
Flag No. 1 Mine	511	Lukachukai	Hiking Access
Frank Jr. Mine	421	Lukachukai	Hiking Access
Frank No. 2	510	Lukachukai	Jeep Access
Knife Edge Mesa Mine	428	Lukachukai	Hiking Access
Mesa I 1/4 Mine	423	Lukachukai	Hiking Access
Mesa I 3/4 Incline	95	Lukachukai	Hiking Access
Mesa I 3/4, Mine No. 2, P150	600	Lukachukai	Hiking Access
Mesa I Mine 10	654	Lukachukai	Jeep Access
Mesa I Mine 11	93	Lukachukai	Jeep Access
Mesa I Mine 12	655	Lukachukai	Jeep Access
Mesa I Mine 13	94	Lukachukai	Jeep Access
Mesa I Mine 14	656	Lukachukai	Jeep Access
Mesa I Mine 15	657	Lukachukai	Jeep Access
Mesa II 1/2 Mine	603	Lukachukai	ATV Access
Mesa II 1/2, Mine 4	604	Lukachukai	ATV Access
Mesa II 1/4 Mine	96	Lukachukai	Jeep Access
Mesa II Pit	287	Lukachukai	Jeep Access
Mesa II, Mine 4	285	Lukachukai	Hiking Access
Mesa II, Mine No. 1 & 2, P-21	601	Lukachukai	ATV Access
Mesa II, Mine No. 1, P-150	602	Lukachukai	ATV Access
Mesa III Mine	605	Lukachukai	ATV Access
Mesa III, Northwest Mine	424	Lukachukai	Jeep Access
Mesa III, West Mine	417	Lukachukai	Jeep Access
Mesa IV 1/2 Mine and Simpson 181	506	Lukachukai	Jeep Access
Mesa IV, East Side	416	Lukachukai	Jeep Access
Mesa IV, Mine No. 1	606	Lukachukai	Jeep Access
Mesa IV, Mine No. 2	607	Lukachukai	Jeep Access
Mesa IV, Mine No. 3	608	Lukachukai	Jeep Access
Mesa IV, West Mine	101	Lukachukai	Jeep Access
Mesa V Adit	609	Lukachukai	Jeep Access
Mesa V Incline	610	Lukachukai	Jeep Access
Mesa V Mine	103	Lukachukai	Jeep Access
Mesa V Mine	508	Lukachukai	Jeep Access
Mesa VI Mine	611	Lukachukai	Hiking Access
NA-0313	660	Lukachukai	ATV Access
NA-0316	107	Lukachukai	Jeep Access
NA-0318	99	Lukachukai	Jeep Access
NA-0319	612	Lukachukai	Hiking Access
NA-0319	469	Lukachukai	Hiking Access
NA-0343	207	Lukachukai	Hiking Access
North Portal, Frank No. 1 Mine	505	Lukachukai	Jeep Access

Table 2. MCAP Target Site Access

Target Site	Site ID	Range	Access Comments
South Portal, Frank No. 1 Mine	106	Lukachukai	Jeep Access
BK-01	N/A	NW Carrizo	Car Access
BK-02	N/A	NW Carrizo	Car Access
BR-01	N/A	NW Carrizo	Car Access
BR-02	N/A	NW Carrizo	Jeep Access
BR-03	N/A	NW Carrizo	Jeep Access
BR-04	N/A	NW Carrizo	Jeep Access
BR-05	N/A	NW Carrizo	Car Access
BR-06	N/A	NW Carrizo	Jeep Access
CT-01	N/A	Lukachukai	Car Access
CT-02	N/A	Lukachukai	Car Access
CT-03	N/A	Lukachukai	Car Access
KE-01	N/A	Lukachukai	Hiking Access
KE-02	N/A	Lukachukai	Hiking Access
M1-01	N/A	Lukachukai	ATV Access
M1-02	N/A	Lukachukai	ATV Access
M1-03	N/A	Lukachukai	ATV Access
M1-04	N/A	Lukachukai	Hiking Access
M2-01	N/A	Lukachukai	Hiking Access
M4-01	N/A	Lukachukai	ATV Access
M4-02	N/A	Lukachukai	Jeep Access
M4-03	N/A	Lukachukai	ATV Access
M4-04	N/A	Lukachukai	ATV Access
M5-01	N/A	Lukachukai	ATV Access
M5-02	N/A	Lukachukai	Jeep Access
M5-03	N/A	Lukachukai	ATV Access
M5-04	N/A	Lukachukai	ATV Access
M5-05	N/A	Lukachukai	ATV Access
M5-06	N/A	Lukachukai	ATV Access
M5-07	N/A	Lukachukai	ATV Access
M5-08	N/A	Lukachukai	ATV Access
M5-09	N/A	Lukachukai	ATV Access
Targets Not Accessed			
Henry Phillips Mine	286	Lukachukai	Cliffs, vegetation preventing access
Mesa I 1/2 Mine	419	Lukachukai	Cliffs, vegetation preventing access
Mesa I 1/2, West Mine	288	Lukachukai	Cliffs, vegetation preventing access
NA-0332	202	Lukachukai	Potential hiking access from north, ATV access blocked 2 miles north of site
NA-0333	201	Lukachukai	Potential hiking access from north, ATV access blocked 2 miles north of site
Step Mesa Mine	204	Lukachukai	Potential hiking access from north, ATV access blocked 2 miles north of site
Tommy James Mine	203	Lukachukai	Potential hiking access from north, ATV access blocked 2 miles north of site
M1-05	N/A	Lukachukai	Waterfalls preventing access
M1-06	N/A	Lukachukai	Waterfalls preventing access
M1-07	N/A	Lukachukai	Potential hiking access from south, cliffs and vegetation preventing access
M1-08	N/A	Lukachukai	Potential hiking access from south, cliffs and vegetation preventing access

Table 3. MCAP Priority Ranking Scoring Scenario

Priority Factor	Description	Scoring Scenario	
Physical Hazards	Immediate physical hazards observed (open shafts, un-reclaimed pits or adits, etc)	Yes	10
		No	0
Surface Area of Impacted Material	Estimated surface area of significantly impacted soils/waste material, where gamma radiation was measured greater than 5-times the Comparison Level, or where likely impacted materials appeared to be present in areas inaccessible to ground scanning	Greater than 2.0 acres	10
		1.0 to 2.0 acres	8
		0.5 to 1.0 acres	6
		Less than 0.5 acres	4
		None	2
Impacted Material Characteristics	Mobility potential of elevated/waste material to the surface water, groundwater, and air, based on structure/texture of affected media	High Mobility (fine) > 1 acre	10
		High Mobility (fine) < 1 acre	6
		Moderate Mobility (medium to large grained)	4
		Low Mobility (large rocks)	2
		None	0
Migration to Surface Water	Potential of contaminated material migrating off-site into a known surface water body	Documented onsite source	10
		Documented offsite waste	8
		Likely (mobile material or surface water within 200 ft)	6
		Potential (surface water within 0.25 mi)	4
		Unlikely (based on distance/material)	2
		None	0
Residential Exposure	Proximity of inhabited or potentially inhabited structures/home compounds	Inhabited within 0.25 mi	10
		Inhabited within 0.5 mi	8
		Potential within 0.25 mi	6
		Inhabited within 1 mi; potential within 0.5 mi	4
		Potential within 1 mi	2
		None	0
Public Exposure	Potential for public to visit the site for non-residential purposes (such recreation, livestock herding, hunting, etc)	Known	10
		Likely	8
		Potential	5
		Unlikely	2
Accessibility	Ease of gaining access to the site	Well maintained road within 200 ft	10
		4WD/unmaintained road within 200 ft	8
		Potenital ATV/speciality offroad vehicle path within 200 ft	6
		Hiking trail within 1000 ft	4
		Hiking trail greater than 1000 ft	2
Reclamation Status	Condition of any historical mine reclamation	Unreclaimed, Contamination Present	10
		Reclamation insufficient /deteriorating	8
		Unknown (waste inaccessible)	5
		Reclamation effective	2
		Reclamation not needed	0

Table 4. MCAP Target Site Priority Ranking

Target Site	Site ID	AUM/Non-AUM	Tronox Status	Range	Removal Site Evaluation Group	Physical Hazard		Impacted Area		Material Characteristics		Migration to Surface Water		Residential Exposure		Public Exposure		Accessibilty		Reclamation Status		Total Score
						Rationale	Score	Acres	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	
Mesa V Mine	103	AUM	Tronox	Lukachukai	M5 South	Open Adit	10	3.43	10	Fine (~1.3 acres) to Large	10	Elevated in Drainage	8	None	0	Pinon gathering	10	Jeep Road	8	Additional Reclamation Needed	8	64
Mesa II, Mine No. 1 & 2, P-21	601	AUM	Tronox	Lukachukai	M2 South	Major Erosion Channel	10	4.54	10	Fine (~1.7 acres) to Large	10	Seep/Spring in Waste Area	10	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Offroad Trail	6	Additional Reclamation Needed	8	61
Mesa V Adit	609	AUM	Tronox	Lukachukai	M5 South	None	0	6.95	10	Fine (~3 acres) to Large	10	Elevated in Drainage	8	None	0	Pinon gathering	10	Jeep Road	8	Additional Reclamation Needed	8	54
Mesa I Mine 12	655	AUM	Tronox	Lukachukai	M1 North	None	0	15.84	10	Fine (~1.3 acres) to Large	10	Elevated in Stream	8	None	0	Near frequented road	8	Jeep Road	8	Additional Reclamation Needed	8	52
BR-01	N/A	Non-AUM	Attributable to Other Tronox	NW Carrizo	Brodie	None	0	1.86	8	Medium to Large	4	Drainage > 0.25 mi	2	Occupied < 0.25 mi	10	Near occupied residence	10	Paved Road	10	Unrelaimed Non-AUM	6	50
Mesa II 1/2, Mine 4	604	AUM	Tronox	Lukachukai	M3	None	0	1.92	8	Fine (~0.2 acres) to Large	6	Elevated in Drainage	8	Unoccupied < 0.25 mi	6	Sheep camp	8	Offroad Trail	6	Additional Reclamation Needed	8	50
CT-02	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	Cove	None	0	0.02	4	Medium to Large	4	Drainage < 0.25 mi	4	Occupied < 0.25 mi	10	Within Cove	10	Paved Road	10	Unrelaimed Non-AUM	6	48
Mesa III Mine	605	AUM	Tronox	Lukachukai	M3	None	0	0.56	6	Medium to Large	4	Seep at Adit	10	Unoccupied < 0.25 mi	6	Sheep camp	8	Offroad Trail	6	Additional Reclamation Needed	8	48
Mesa III, Northwest Mine	424	AUM	Within 1/4 Mile	Lukachukai	M3	None	0	0.55	6	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 0.25 mi	6	Sheep camp	8	Jeep Road	8	Unreclaimed	10	48
Mesa III, West Mine	417	AUM	Within 1/4 Mile	Lukachukai	M3	None	0	0.78	6	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 0.25 mi	6	Sheep camp	8	Jeep Road	8	Unreclaimed	10	48
Frank Jr. Mine	421	AUM	Tronox	Lukachukai	M5 North	None	0	4.89	10	Medium to Large	4	Elevated in Drainage	8	Unoccupied < 1 mi	2	Pinon gathering	10	Offroad Trail	6	Additional Reclamation Needed	8	48
South Portal, Frank No. 1 Mine	106	AUM	Within 1/2 Mile	Lukachukai	M4 West	None	0	13.51	10	Fine (~0.8 acres) to Large	6	Elevated in Drainage	8	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	47
Mesa I Mine 11	93	AUM	Tronox	Lukachukai	M1 North	None	0	4.42	10	Medium to Large	4	Elevated in Drainage	8	None	0	Near frequented road	8	Jeep Road	8	Additional Reclamation Needed	8	46
Mesa I Mine 13	94	AUM	Tronox	Lukachukai	M1 North	None	0	4.55	10	Medium to Large	4	Elevated in Drainage	8	None	0	Near frequented road	8	Jeep Road	8	Additional Reclamation Needed	8	46
Mesa I Mine 14	656	AUM	Tronox	Lukachukai	M1 North	None	0	9.89	10	Medium to Large	4	Elevated in Drainage	8	None	0	Near frequented road	8	Jeep Road	8	Additional Reclamation Needed	8	46
Mesa I Mine 15	657	AUM	Tronox	Lukachukai	M1 North	None	0	7.71	10	Medium to Large	4	Elevated in Drainage	8	None	0	Near frequented road	8	Jeep Road	8	Additional Reclamation Needed	8	46
Cato No. 1 Pit	426	AUM	Within 1/4 Mile	Lukachukai	M5 North	None	0	3.66	10	Medium to Large	4	Drainage < 0.25 mi	4	Unoccupied < 1 mi	2	Pinon gathering	10	Jeep Road	8	Additional Reclamation Needed	8	46
Mesa IV, Mine No. 2	607	AUM	Tronox	Lukachukai	M4 North	None	0	11.37	10	Fine (~0.2 acres) to Large	6	Elevated in Drainage	8	None	0	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	45
BR-02	N/A	Non-AUM	Attributable to Other Tronox	NW Carrizo	Brodie	None	0	0.13	4	Medium to Large	4	Drainage < 0.25 mi	4	Occupied < 0.5 mi	8	Near occupied residence	10	Offroad Trail	6	Additional Reclamation Needed	8	44
Mesa V Incline	610	AUM	Tronox	Lukachukai	M5 South	None	0	1.08	8	Medium to Large	4	Drainage < 200 ft	6	None	0	Pinon gathering	10	Jeep Road	8	Additional Reclamation Needed	8	44
NA-0318	99	AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	4.09	10	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Pinon gathering	10	Jeep Road	8	Additional Reclamation Needed	8	44

Table 4. MCAP Target Site Priority Ranking

Target Site	Site ID	AUM/Non-AUM	Tronox Status	Range	Removal Site Evaluation Group	Physical Hazard		Impacted Area		Material Characteristics		Migration to Surface Water		Residential Exposure		Public Exposure		Accessibilty		Reclamation Status		Total Score
						Rationale	Score	Acres	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	
Mesa I 3/4 Incline	95	AUM	Tronox	Lukachukai	M2 South	None	0	8.12	10	Fine (~0.4 acres) to Large	6	Elevated in Drainage	8	None	0	Accessible, visitation rare	5	Offroad Trail	6	Additional Reclamation Needed	8	43
Mesa II 1/4 Mine	96	AUM	Within 1/4 Mile	Lukachukai	M2 South	None	0	0.72	10	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	43
East Portal, Frank No. 1 Mine	509	AUM	Within 1/2 Mile	Lukachukai	M4 West	None	0	3.88	10	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	43
NA-0316	107	AUM	Within 1/2 Mile	Lukachukai	M4 West	None	0	3.51	10	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	43
Cov087	507	AUM	Immediately Adjacent	Lukachukai	M5 South	None	0	1.24	8	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Unreclaimed	10	43
Mesa II 1/2 Mine	603	AUM	Tronox	Lukachukai	M3	None	0	0.68	6	Medium to Large	4	Elevated in Drainage	8	Unoccupied < 1 mi	2	Sheep camp	8	Offroad Trail	6	Additional Reclamation Needed	8	42
NA-0319	612	AUM	Immediately Adjacent	Lukachukai	M6	None	0	2.02	10	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Pinon gathering	8	Along trail	4	Additional Reclamation Needed	8	42
Mesa I 3/4, Mine No. 2, P150	600	AUM	Tronox	Lukachukai	M2 South	None	0	1.38	10	Fine (~0.6 acres) to Large	6	Elevated in Drainage	8	None	0	Accessible, visitation rare	5	Along trail	4	Additional Reclamation Needed	8	41
Mesa II, Mine No. 1, P-150	602	AUM	Tronox	Lukachukai	M2 South	None	0	0.76	6	Fine (~0.2 acres) to Large	6	Elevated in Drainage	8	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Offroad Trail	6	Additional Reclamation Needed	8	41
Cov068	420	AUM	Within 1/4 Mile	Lukachukai	M4 North	None	0	2.44	10	Medium to Large	4	Drainage < 200 ft	6	None	0	Accessible, visitation rare	5	Offroad Trail	6	Unreclaimed	10	41
Mesa IV, Mine No. 1	606	AUM	Tronox	Lukachukai	M4 North	None	0	2.03	10	Medium to Large	4	Drainage < 0.25 mi	4	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	41
Mesa IV, East Side	416	AUM	Within 1/2 Mile	Lukachukai	M4 South	None	0	0.86	6	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Unreclaimed	10	41
North Portal, Frank No. 1 Mine	505	AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	1.8	8	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	41
BR-04	N/A	Non-AUM	Within 1/4 Mile	NW Carrizo	Brodie	None	0	0.05	4	Medium to Large	4	Drainage < 0.25 mi	4	Occupied < 0.5 mi	8	Near occupied residence	8	Offroad Trail	6	Unreclaimed Non-AUM	6	40
Brodie 1	191	AUM	Other Tronox	NW Carrizo	Brodie	None	0	0	2	Medium to Large	4	Drainage < 0.25 mi	4	Occupied < 0.5 mi	8	Near occupied residence	10	Maintained Road	10	Reclamation Effective	2	40
Mesa I Mine 10	654	AUM	Tronox	Lukachukai	M1 North	None	0	0.39	4	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Near frequented road	8	Jeep Road	8	Unreclaimed	10	38
NA-0313	660	AUM	Immediately Adjacent	Lukachukai	M3	None	0	0.36	4	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Pinon gathering	8	Offroad Trail	6	Additional Reclamation Needed	8	38
Mesa IV, Mine No. 3	608	AUM	Tronox	Lukachukai	M4 North	None	0	1.94	8	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	37
Frank No. 2	510	AUM	Within 1/2 Mile	Lukachukai	M4 West	None	0	0.05	4	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	37
Mesa V Mine	508	AUM	Tronox	Lukachukai	M5 South	None	0	0.14	4	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	37
M5-02	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	0.07	4	Medium to Large	4	Drainage > 0.25 mi	2	Unoccupied < 1 mi	2	Pinon gathering	10	Jeep Road	8	Unreclaimed Non-AUM	6	36
M5-04	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	0.65	6	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Pinon gathering	10	Offroad Trail	6	Unreclaimed Non-AUM	6	36

Table 4. MCAP Target Site Priority Ranking

Target Site	Site ID	AUM/Non-AUM	Tronox Status	Range	Removal Site Evaluation Group	Physical Hazard		Impacted Area		Material Characteristics		Migration to Surface Water		Residential Exposure		Public Exposure		Accessibilty		Reclamation Status		Total Score
						Rationale	Score	Acres	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	
Mesa VI Mine	611	AUM	Tronox	Lukachukai	M6	None	0	0.23	4	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Pinon gathering	8	Along trail	4	Additional Reclamation Needed	8	36
Mesa II Pit	287	AUM	Other Tronox	Lukachukai	M2 North	None	0	0.68	6	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Accessible, visitation rare	5	Jeep Road	8	Additional Reclamation Needed	8	35
Block K	64	AUM	Tronox	NW Carrizo	Block K	None	0	0	2	None	0	None	0	Occupied < 0.25 mi	10	Near occupied residence	10	Maintained Road	10	Reclamation Effective	2	34
M5-05	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	0.06	4	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Pinon gathering	10	Offroad Trail	6	Unreclaimed Non-AUM	6	34
M1-02	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M1 North	None	0	0.22	4	Medium to Large	4	Drainage > 0.25 mi	2	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Offroad Trail	6	Unreclaimed	10	33
M4-04	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M4 North	None	0	0.57	6	Medium to Large	4	Drainage < 0.25 mi	4	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Offroad Trail	6	Unreclaimed Non-AUM	6	33
BK-02	N/A	Non-AUM	Within 1/4 Mile	NW Carrizo	Block K	None	0	0	2	None	0	None	0	Occupied < 0.25 mi	10	Near occupied residence	10	Maintained Road	10	Not Needed	0	32
CT-01	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	Cove	None	0	0	2	None	0	None	0	Occupied < 0.25 mi	10	Within Cove	10	Paved Road	10	Not Needed	0	32
CT-03	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	Cove	None	0	0	2	None	0	None	0	Occupied < 0.25 mi	10	Within Cove	10	Paved Road	10	Not Needed	0	32
Black No. 1 Mine	512	AUM	Tronox	Lukachukai	Flag Mesa	None	0	2.68	10	Medium to Large	4	Drainage < 200 ft	6	None	0	Difficult Access	2	Difficult Hike	2	Additional Reclamation Needed	8	32
Black No. 2 Mine	205	AUM	Tronox	Lukachukai	Flag Mesa	None	0	3.94	10	Medium to Large	4	Drainage < 200 ft	6	None	0	Difficult Access	2	Difficult Hike	2	Additional Reclamation Needed	8	32
NA-0343	207	AUM	Within 1/4 Mile	Lukachukai	Knife Edge Mesa	None	0	4.02	10	Medium to Large	4	Drainage < 0.25 mi	4	Unoccupied < 1 mi	2	Difficult Access	2	Difficult Hike	2	Additional Reclamation Needed	8	32
M1-04	N/A	Non-AUM	Attributable to Tronox	Lukachukai	M1 North	None	0	2.38	10	Medium to Large	4	Elevated in Stream	8	None	0	Difficult Access	2	Long Stream Hike	2	Unreclaimed Non-AUM	6	32
BK-01	N/A	Non-AUM	Within 1/4 Mile	NW Carrizo	Block K	None	0	0	2	None	0	None	0	Occupied < 0.5 mi	8	Near occupied residence	10	Maintained Road	10	Not Needed	0	30
Black No. 2 Mine (West)	206	AUM	Tronox	Lukachukai	Flag Mesa	None	0	1.40	8	Medium to Large	4	Drainage < 200 ft	6	None	0	Difficult Access	2	Difficult Hike	2	Additional Reclamation Needed	8	30
Flag No. 1 Mine	511	AUM	Tronox	Lukachukai	Flag Mesa	None	0	3.77	10	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Difficult Access	2	Difficult Hike	2	Additional Reclamation Needed	8	30
Knife Edge Mesa Mine	428	AUM	Other Tronox	Lukachukai	Knife Edge Mesa	None	0	1.10	8	Medium to Large	4	Drainage < 0.25 mi	4	Unoccupied < 1 mi	2	Difficult Access	2	Difficult Hike	2	Additional Reclamation Needed	8	30
BR-05	N/A	Non-AUM	Within 1/4 Mile	NW Carrizo	Brodie	None	0	0	2	None	0	None	0	Occupied < 0.5 mi	8	Near occupied residence	8	Maintained Road	10	Not Needed	0	28
Mesa I 1/4 Mine	423	AUM	Tronox	Lukachukai	M1 South	None	0	0	2	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Difficult Access	2	Difficult Hike	2	Unreclaimed	10	28
Cov000	425	AUM	Within 1/4 Mile	Lukachukai	M3	None	0	0	2	Medium to Large	4	Drainage < 0.25 mi	4	Unoccupied < 1 mi	2	Sheep camp	8	Jeep Road	8	Not Needed	0	28
Mesa IV, West Mine	101	AUM	Other Tronox	Lukachukai	M4 South	None	0	0.00	2	Medium to Large	4	Drainage < 0.25 mi	4	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Reclamation Effective	2	27
Mesa IV 1/2 Mine and Simpson 181	506	AUM	Tronox	Lukachukai	M5 South	None	0	0	2	Medium to Large	4	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Not Needed	0	27
BR-03	N/A	Non-AUM	Within 1/4 Mile	NW Carrizo	Brodie	None	0	0	2	None	0	None	0	Occupied < 0.25 mi	10	Near occupied residence	8	Offroad Trail	6	Not Needed	0	26
M1-05	N/A	Non-AUM	Attributable to Tronox	Lukachukai	M1 North	None	0	0.38	4	Medium to Large	4	Elevated in Stream	8	None	0	Difficult Access	2	Long Stream Hike	2	Unreclaimed Non-AUM	6	26

Table 4. MCAP Target Site Priority Ranking

Target Site	Site ID	AUM/Non-AUM	Tronox Status	Range	Removal Site Evaluation Group	Physical Hazard		Impacted Area		Material Characteristics		Migration to Surface Water		Residential Exposure		Public Exposure		Accessibilty		Reclamation Status		Total Score
						Rationale	Score	Acres	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	
M1-06	N/A	Non-AUM	Attributable to Tronox	Lukachukai	M1 North	None	0	0.31	4	Medium to Large	4	Elevated in Stream	8	None	0	Difficult Access	2	Long Stream Hike	2	Unreclaimed Non-AUM	6	26
Cato No. 2	104	AUM	Within 1/4 Mile	Lukachukai	M6	None	0	0.87	6	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Difficult Access	2	Difficult Hike	2	Additional Reclamation Needed	8	26
Mesa I 1/2 Mine	419	AUM	Tronox	Lukachukai	M1 South	None	0	0.59	6	Medium to Large	4	Drainage < 200 ft	6	None	0	Difficult Access	2	Inaccessible	2	Unknown	5	25
Tommy James Mine	203	AUM	Tronox	Lukachukai	Step Mesa	None	0	0.79	6	Medium to Large	4	Drainage < 200 ft	6	None	0	Difficult Access	2	Inaccessible	2	Unknown	5	25
KE-01	N/A	Non-AUM	Within 1/2 Mile	Lukachukai	Knife Edge Mesa	None	0	0.61	6	Medium to Large	4	Drainage > 0.25 mi	2	Unoccupied < 1 mi	2	Difficult Access	2	Difficult Hike	2	Unreclaimed Non-AUM	6	24
NA-0319	469	AUM	Within 1/4 Mile	Lukachukai	M6	None	0	0	2	None	0	Drainage < 200 ft	6	Unoccupied < 1 mi	2	Pinon gathering	8	Along trail	4	Reclamation Effective	2	24
NA-0333	201	AUM	Within 1/2 Mile	Lukachukai	Step Mesa	None	0	0.15	4	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Difficult Access	2	Inaccessible	2	Additional Reclamation Needed	8	24
NA-0332	202	AUM	Within 1/2 Mile	Lukachukai	Step Mesa	None	0	1.27	8	Medium to Large	4	Drainage > 0.25 mi	2	None	0	Difficult Access	2	Inaccessible	2	Unknown	5	23
BR-06	N/A	Non-AUM	Within 1/4 Mile	NW Carrizo	Brodie	None	0	0	2	None	0	None	0	Occupied < 0.25 mi	10	Accessible, visitation rare	5	Along trail	4	Not Needed	0	21
Mesa II, Mine 4	285	AUM	Tronox	Lukachukai	M2 North	None	0	0	2	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Difficult Access	2	Along trail	4	Unknown	5	21
Step Mesa Mine	204	AUM	Tronox	Lukachukai	Step Mesa	None	0	0.49	4	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Difficult Access	2	Inaccessible	2	Unknown	5	21
KE-02	N/A	Non-AUM	Within 1/2 Mile	Lukachukai	Knife Edge Mesa	None	0	0	2	Medium to Large	4	Drainage > 0.25 mi	2	Unoccupied < 1 mi	2	Difficult Access	2	Difficult Hike	2	Unreclaimed Non-AUM	6	20
M5-01	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	0	2	None	0	None	0	Unoccupied < 1 mi	2	Pinon gathering	10	Offroad Trail	6	Not Needed	0	20
M5-03	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	0	2	None	0	None	0	Unoccupied < 1 mi	2	Pinon gathering	10	Offroad Trail	6	Not Needed	0	20
Henry Phillips Mine	286	AUM	Other Tronox	Lukachukai	M1 South	None	0	0	2	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Difficult Access	2	Inaccessible	2	Unknown	5	19
Mesa I 1/2, West Mine	288	AUM	Other Tronox	Lukachukai	M1 South	None	0	0	2	Medium to Large	4	Drainage < 0.25 mi	4	None	0	Difficult Access	2	Inaccessible	2	Unknown	5	19
M5-06	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	0	2	None	0	None	0	None	0	Pinon gathering	10	Offroad Trail	6	Not Needed	0	18
M5-07	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M5 South	None	0	0	2	None	0	None	0	None	0	Pinon gathering	10	Offroad Trail	6	Not Needed	0	18
M5-08	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	N/A	None	0	0	2	None	0	None	0	Unoccupied < 1 mi	2	Pinon gathering	8	Offroad Trail	6	Not Needed	0	18
M5-09	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	N/A	None	0	0	2	None	0	None	0	Unoccupied < 1 mi	2	Pinon gathering	8	Offroad Trail	6	Not Needed	0	18
M4-02	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	N/A	None	0	0	2	None	0	None	0	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Jeep Road	8	Not Needed	0	17
M4-01	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M4 West	None	0	0	2	None	0	None	0	Unoccupied < 1 mi	2	Accessible, visitation rare	5	Offroad Trail	6	Not Needed	0	15
M1-01	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M1 North	None	0	0	2	None	0	None	0	None	0	Accessible, visitation rare	5	Offroad Trail	6	Not Needed	0	13
M1-03	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M1 North	None	0	0	2	None	0	None	0	None	0	Accessible, visitation rare	5	Offroad Trail	6	Not Needed	0	13
M2-01	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M3	None	0	0	2	None	0	None	0	Unoccupied < 1 mi	2	Difficult Access	2	Difficult Hike	2	Unknown	5	13
M4-03	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	M4 North	None	0	0	2	None	0	None	0	None	0	Accessible, visitation rare	5	Offroad Trail	6	Not Needed	0	13
M1-07	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	N/A	None	0	0	2	None	0	None	0	None	0	Difficult Access	2	Difficult Hike	2	Not Needed	0	6
M1-08	N/A	Non-AUM	Within 1/4 Mile	Lukachukai	N/A	None	0	0	2	None	0	None	0	None	0	Difficult Access	2	Difficult Hike	2	Not Needed	0	6

Table 5. MCAP Priority Assessment Areas and Recommendations

Removal Site Eval. Group	Target Site	Site ID	Figures No.	Recommendation - Type	Recommendation - Primary Task	Recommendation - Detail	Area Priority
Cove	CT-01	N/A	9A, 9B	RSE	Assessment of elevated target areas within community	• Gamma scanning should be performed of 100% of the elevated Target Sites, roads, and other potentially disturbed areas • Gamma scanning of school, ponds, and nearby residents • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	High
	CT-02	N/A					
	CT-03	N/A					
M1-North	Mesa I Mine 11	93	10A, 10B, 10C	RSE	Characterization of waste material pushed off bench and documented in the drainage	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Road improvement evaluations to determine removal alternatives • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	Moderate
	Mesa I Mine 13	94					
	Mesa I Mine 10	654					
	Mesa I Mine 12	655					
	Mesa I Mine 14	656					
	Mesa I Mine 15	657					
	M1-01	N/A					
	M1-02	N/A					
	M1-03	N/A					
	M1-04	N/A					
	M1-05	N/A					
	M1-06	N/A					
M1 South	Henry Phillips Mine	286	11A, 11B, 11C	Road Assessment	Inaccessible, further reconnaissance to determine if any access routes exist	• Further site access route reconnaissance is needed to complete Removal Site Evaluation • Historic records and document review, including reclamation specifications and drawings • Review of historical aerial imagery and land-use / land-cover analysis	Medium
	Mesa I 1/2, West Mine	288					
	Mesa I 1/2 Mine	419					
	Mesa I 1/4 Mine	423					
M2 North	Mesa II, Mine 4	285	12A, 12B, 12C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	Medium
	Mesa II Pit	287					
M2 South	Mesa I 3/4 Incline	95	13A, 13B, 13C	RSE	Evaluation of fine-grained reclamation areas	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Assessment of reclamation erosion area • Road improvement evaluations to determine removal alternatives • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	Moderate
	Mesa II 1/4 Mine	96					
	Mesa I 3/4, Mine No. 2, P150	600					
	Mesa II, Mine No. 1 & 2, P-21	601					
	Mesa II, Mine No. 1, P-150	602					

Table 5. MCAP Priority Assessment Areas and Recommendations

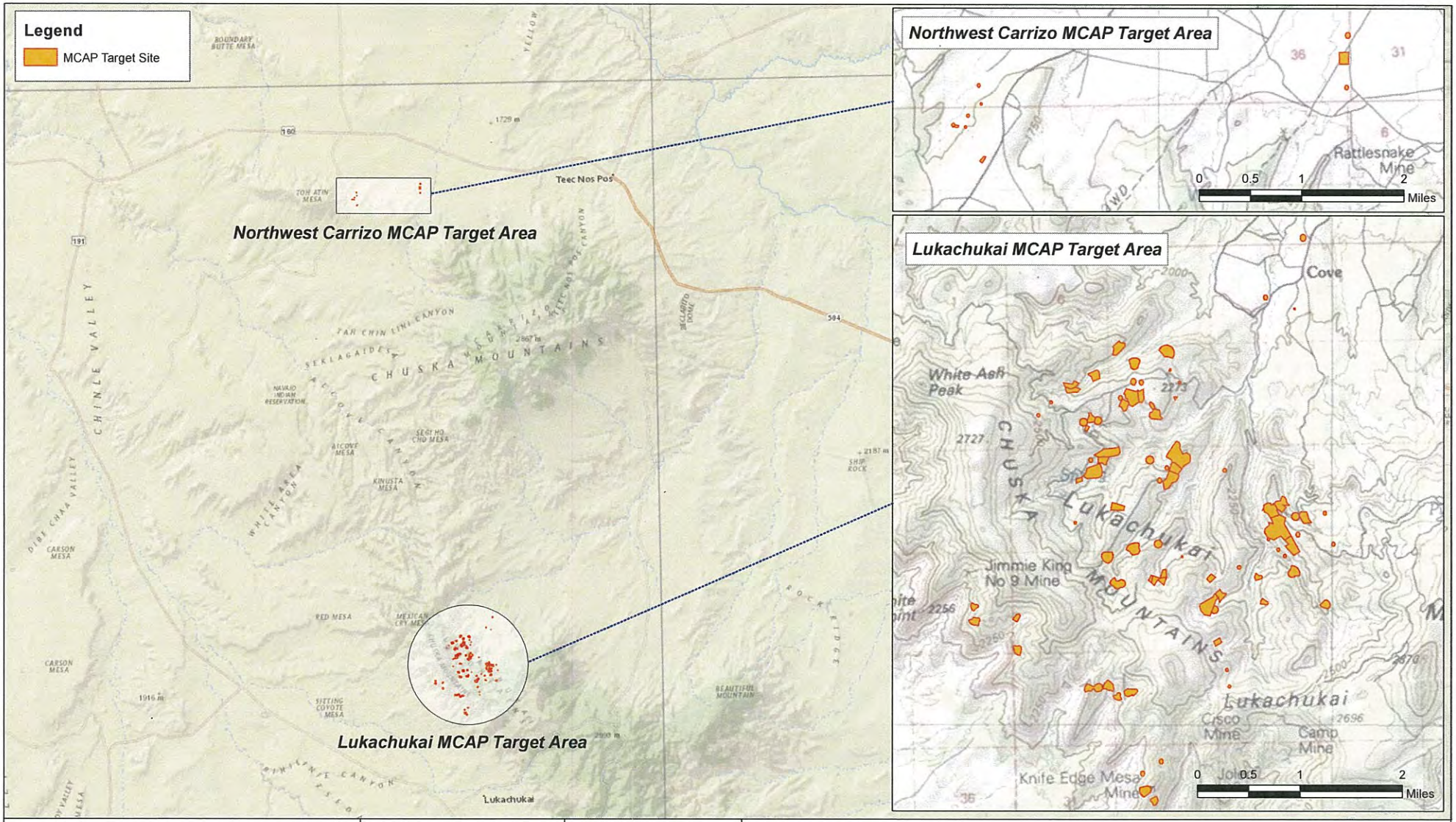
M3	Mesa III, West Mine	417	14A, 14B, 14C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	Moderate
	Mesa III, Northwest Mine	424					
	Cov000	425					
	Mesa II 1/2 Mine	603					
	Mesa II 1/2, Mine 4	604					
	Mesa III Mine	605					
	NA-0313	660					
	M2-01	N/A					
M4 North	Cov068	420	15A, 15B, 15C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	High
	Mesa IV, Mine No. 1	606					
	Mesa IV, Mine No. 2	607					
	Mesa IV, Mine No. 3	608					
	M4-03	N/A					
	M4-04	N/A					
M4 South	Mesa IV, West Mine	101	16A, 16B, 61C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	High
	Mesa IV, East Side	416					
M4 West	South Portal, Frank No. 1 Mine	106	17A, 17B, 17C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	High
	NA-0316	107					
	East Portal, Frank No. 1 Mine	509					
	Frank No. 2	510					
	M4-01	N/A					
M5 North	Frank Jr. Mine	421	18A, 18B, 18C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Further site access route reconnaissance may be needed at selected areas • Road improvement evaluations to determine removal alternatives • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	High
	Cato No. 1 Pit	426					

Table 5. MCAP Priority Assessment Areas and Recommendations

M5 South	NA-0318	99	19A, 19B, 19C	RSE	Survey of open and accessible adit, and additional waste characterization, extent, and pathways	• Underground surveys of open and exposed adits • Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Further site access route reconnaissance may be needed at selected areas • Road improvement evaluations to determine removal alternatives • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	Maximum
	Mesa V Mine	103					
	North Portal, Frank No. 1 Mine	505					
	Mesa IV 1/2 Mine and Simpson	506					
	Cov087	507					
	Mesa V Mine	508					
	Mesa V Adit	609					
	Mesa V Incline	610					
	M5-01	N/A					
	M5-02	N/A					
	M5-03	N/A					
	M5-04	N/A					
	M5-05	N/A					
	M5-06	N/A					
	M5-07	N/A					
M6	Cato No. 2	104	20A, 20B, 20C	RSE	Additional waste characterization, extent, and pathways, and possible survey of inaccessible but open adits	• Underground surveys of open and exposed adits • Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Further site access route reconnaissance may be needed at selected areas • Road improvement evaluations to determine removal alternatives • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	High
	NA-0319	469					
	Mesa VI Mine	611					
	NA-0319	612					
Knife Edge Mesa	KE-01	N/A	21A, 21B, 21C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Further site access route reconnaissance may be needed at selected areas • Road improvement evaluations to determine removal alternatives • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data	Medium
	KE-02	N/A					
	NA-0343	207					
	Knife Edge Mesa Mine	428					
Flag Mesa	Black No. 2 Mine	205	22A, 22B, 22C	RSE	Additional waste characterization, extent, and pathways	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Further site access route reconnaissance may be needed at selected areas • Road improvement evaluations to determine removal alternatives • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Detailed aerial site surveys may be warranted to estimate volumes • Surface sampling of waste and cover material to confirm scanning data	Medium
	Black No. 2 Mine (West)	206					
	Flag No. 1 Mine	511					
	Black No. 1 Mine	512					

Table 5. MCAP Priority Assessment Areas and Recommendations

Step Mesa	NA-0333	201	23A, 23B, 23C	Road Assessment	Inaccessible, further reconnaissance to determine if any access routes exist	• Further site access route reconnaissance is needed to complete Removal Site Evaluation • Historic records and document review, including reclamation specifications and drawings • Review of historical aerial imagery and land-use / land-cover analysis	Low
	NA-0332	202					
	Tommy James Mine	203					
	Step Mesa Mine	204					
Brodie	Brodie 1	191	24A, 24B, 24C	RSE	Assessment of BR-01 Target Site, pit area near residence	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	Moderate
	BR-01	N/A					
	BR-02	N/A					
	BR-04	N/A					
Block K	Block K	64	25A, 25B	Confirmation Scanning / Sampling	Confirmation scanning and sampling to determine if site is adqueately remediated	• Gamma scanning should be performed of 100% of safely-accessible areas within the AUMs, Target Sites, roads, and other potentially disturbed areas • Gamma scanning transects (distances to be determined) of areas between AUMs and Target Sites • Waste volume estimates at accessible and inaccessible impacted areas, such and lower bench areas • Surface sampling of waste and cover material to confirm scanning data • Subsurface sampling with limited access drilling equipment, at accessible locations	Medium

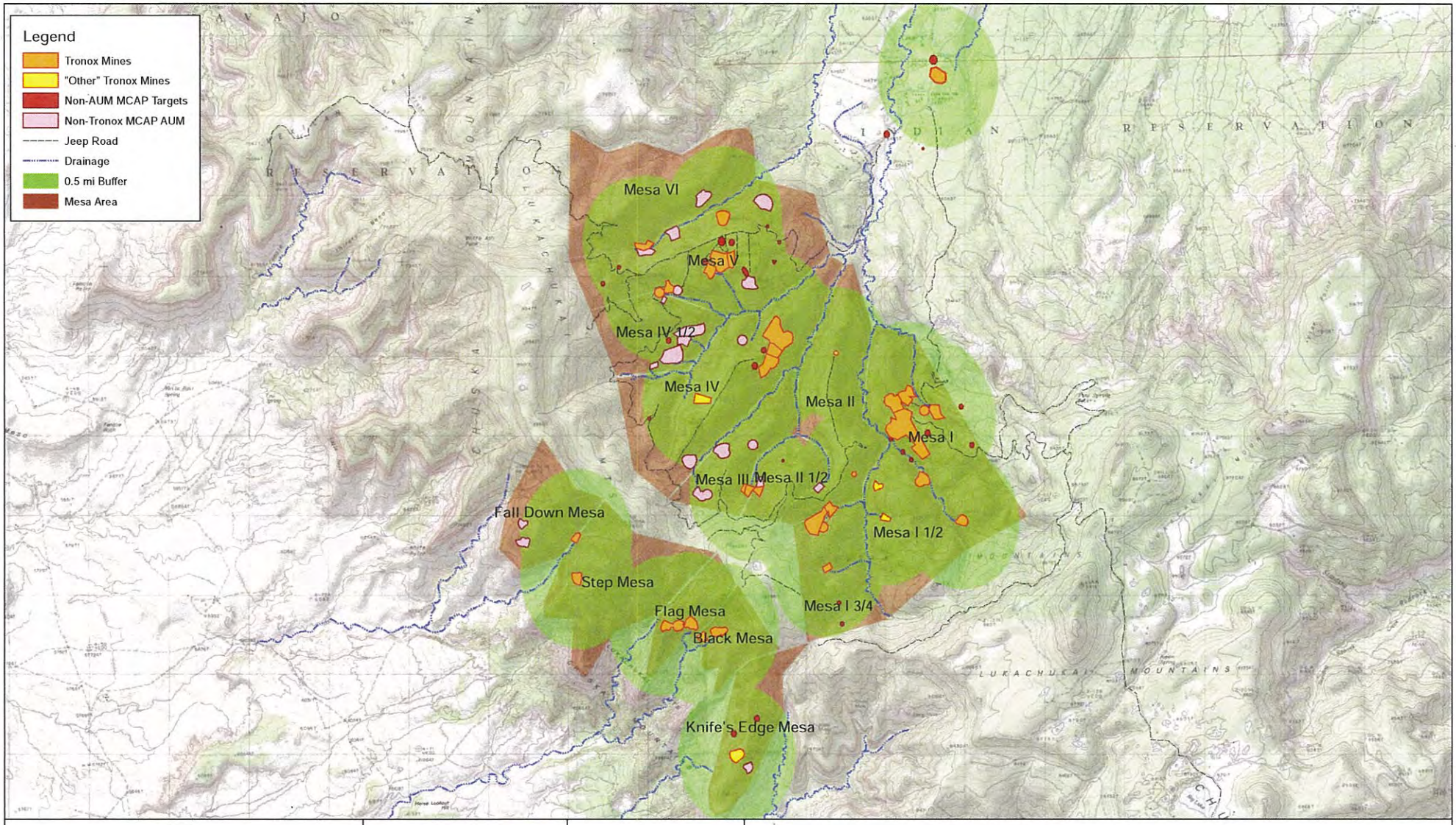


0 3.75 7.5 15
Miles

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

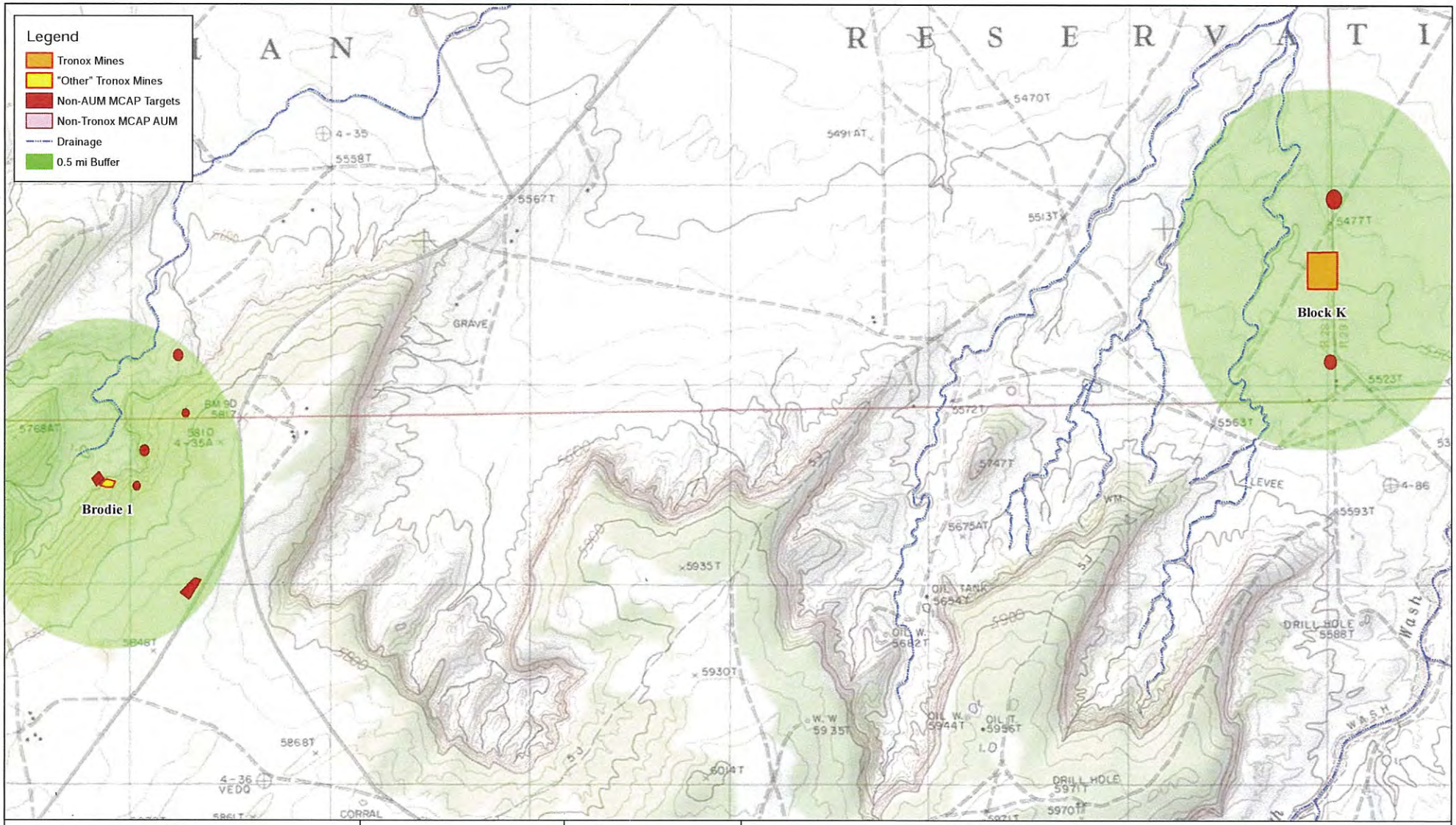
Figure 1
MCAP Target Areas
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

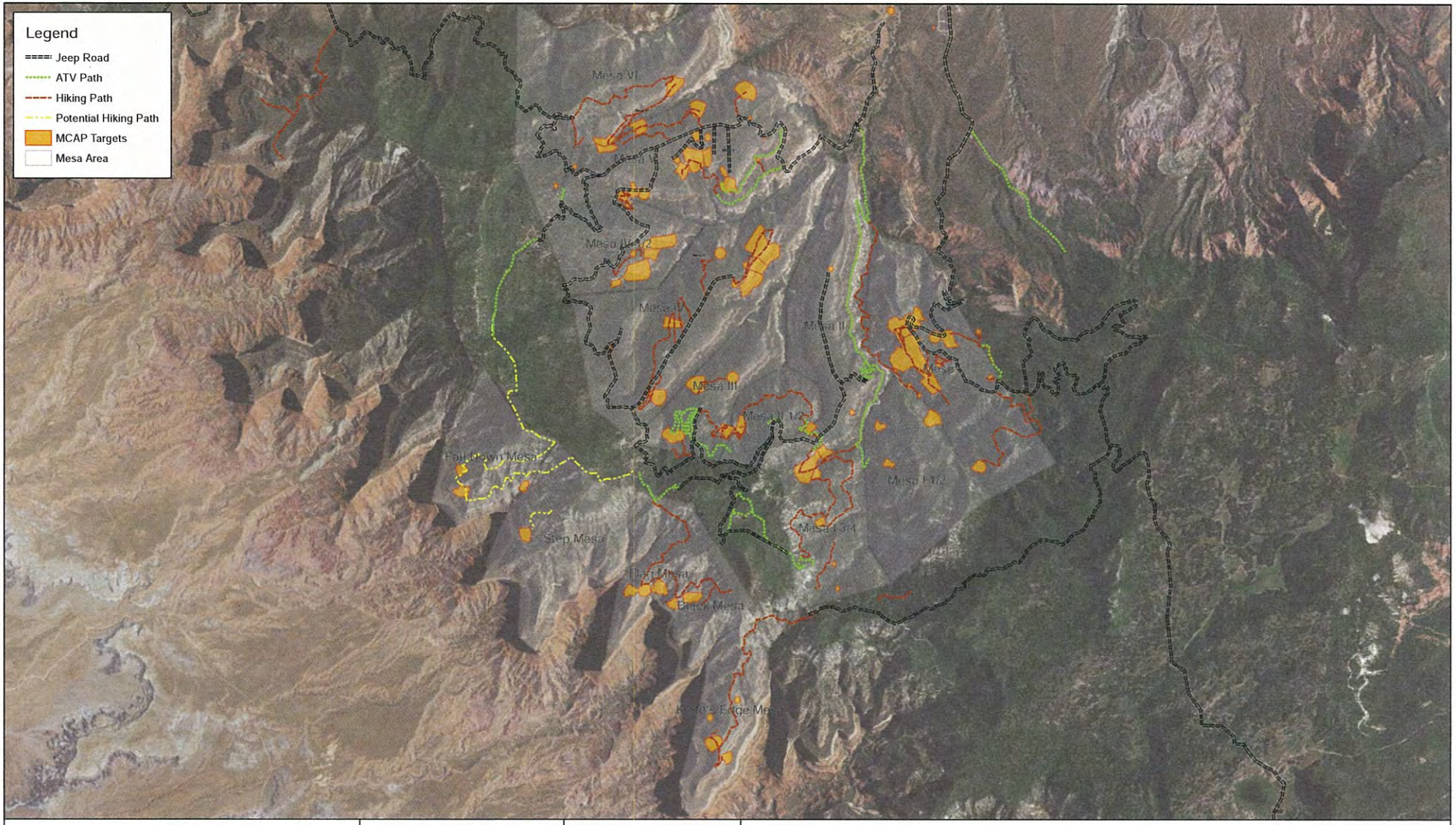
Figure 2
Lukachukai Target Sites
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

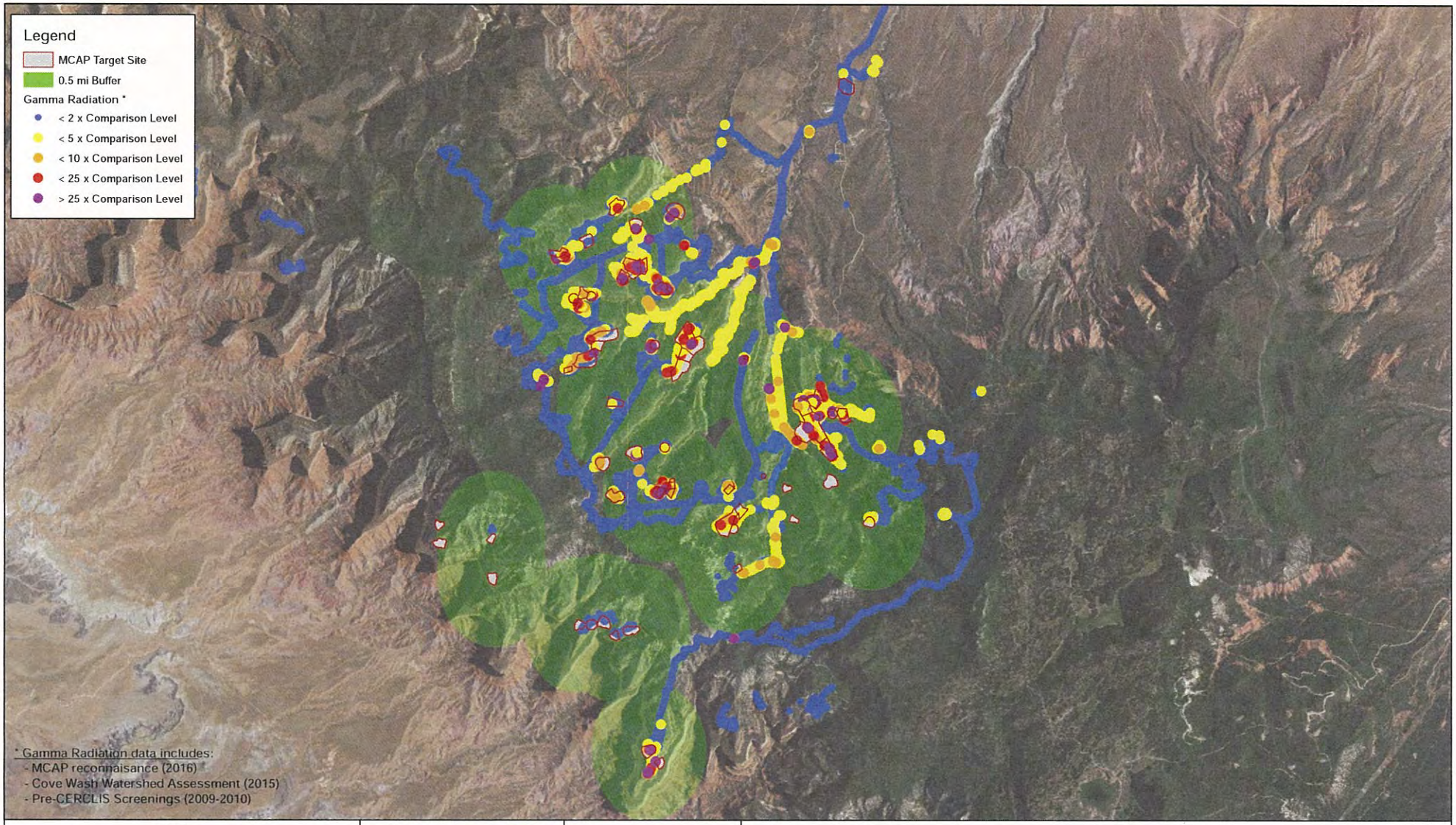
Figure 3
Northwest Carrizo Target Sites
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

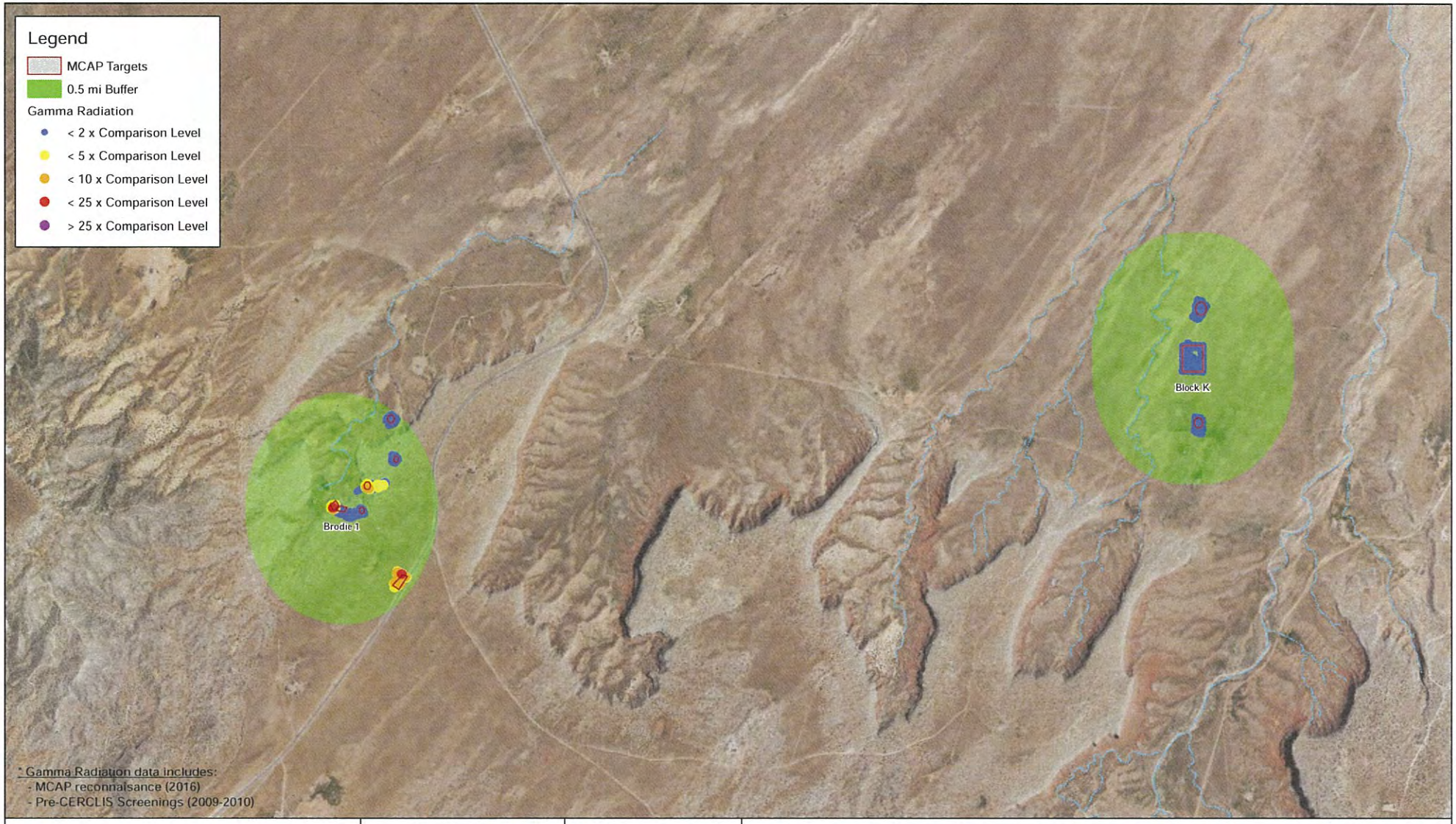
Figure 4
Lukachukai Access Routes
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

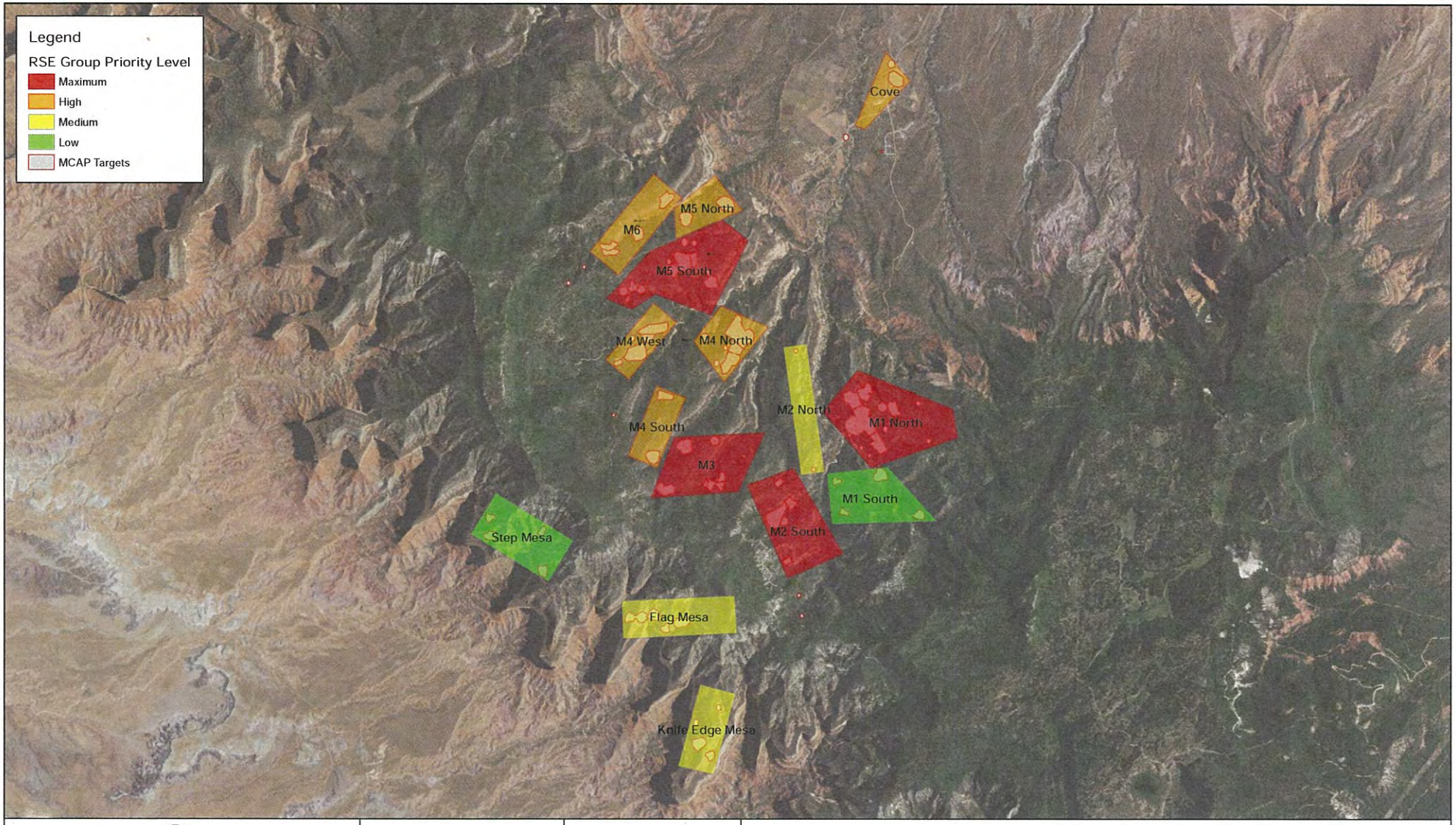
Figure 5
Lukachukai Gamma Radiation Scanning
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 6
Northwest Carrizo Gamma Radiation Scanning
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 7
Lukachukai Priority Removal Site Evaluation Groups
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 8
Northwest Carrizo Priority Removal Site Evaluation Groups
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

N

0 0.1 0.2 Mile

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

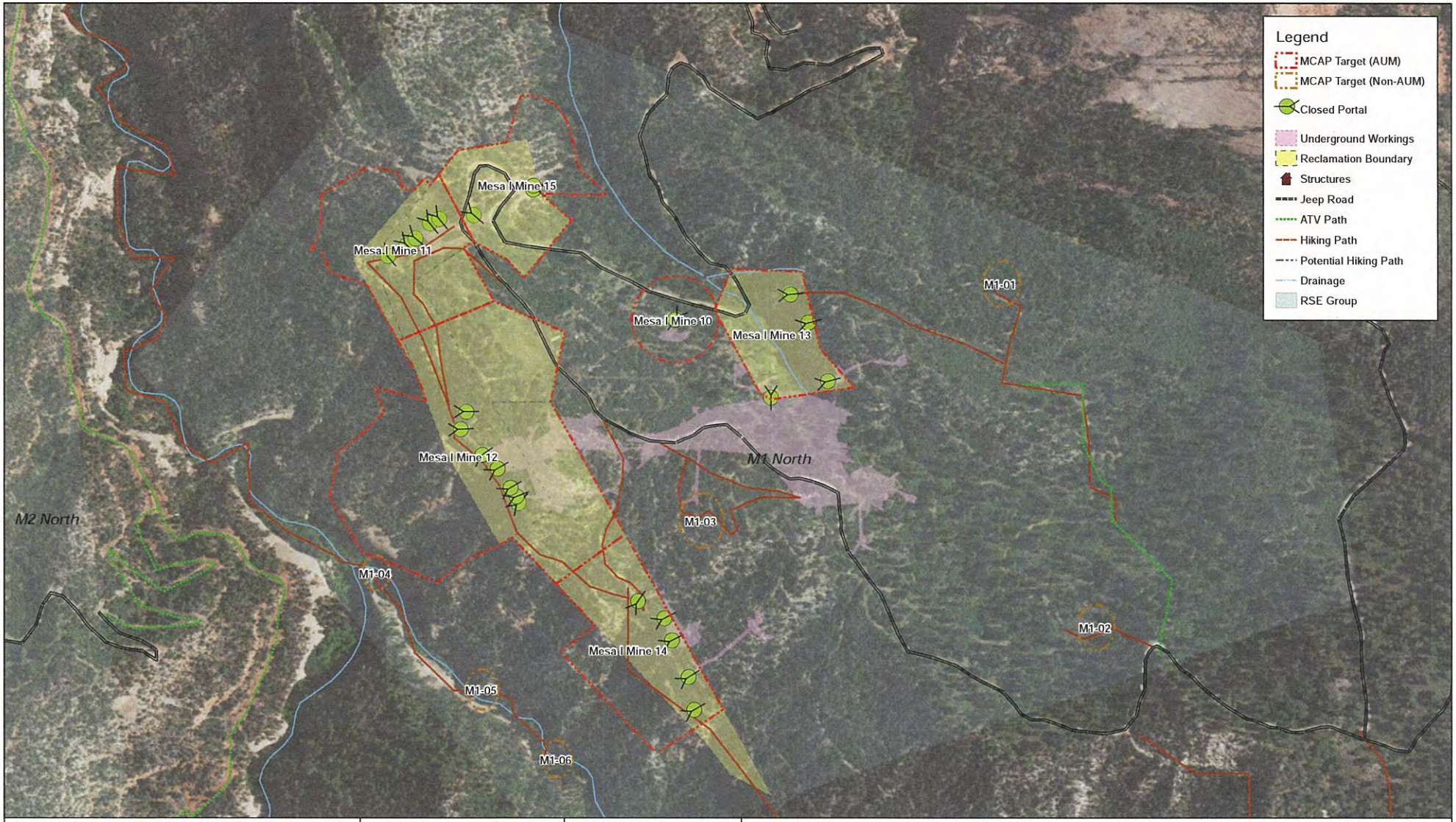
Figure 9 A
Cove Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

0 0.1 0.2 Mile

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

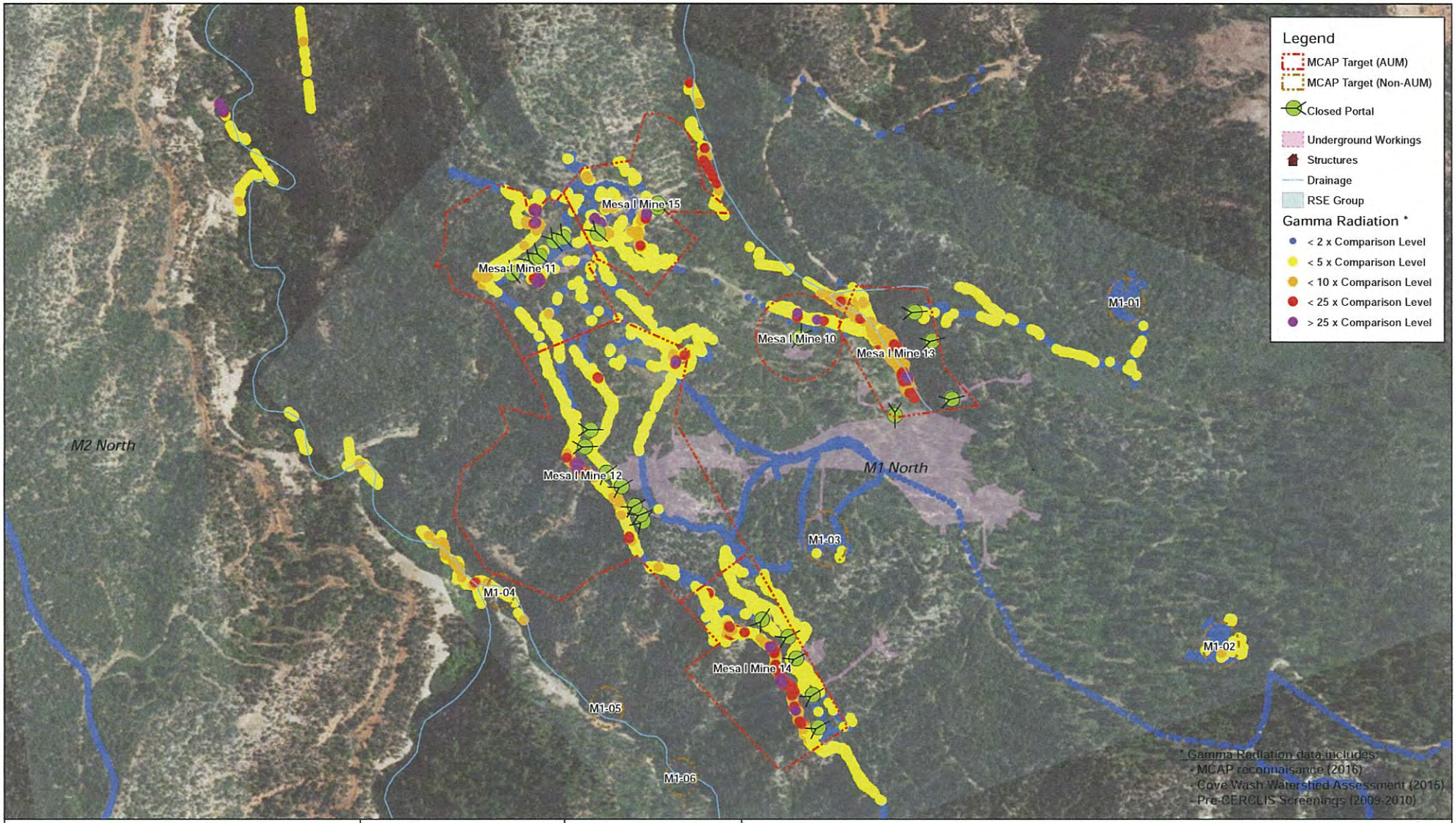
Figure 9 B
Cove Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 10 A
M1 North Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

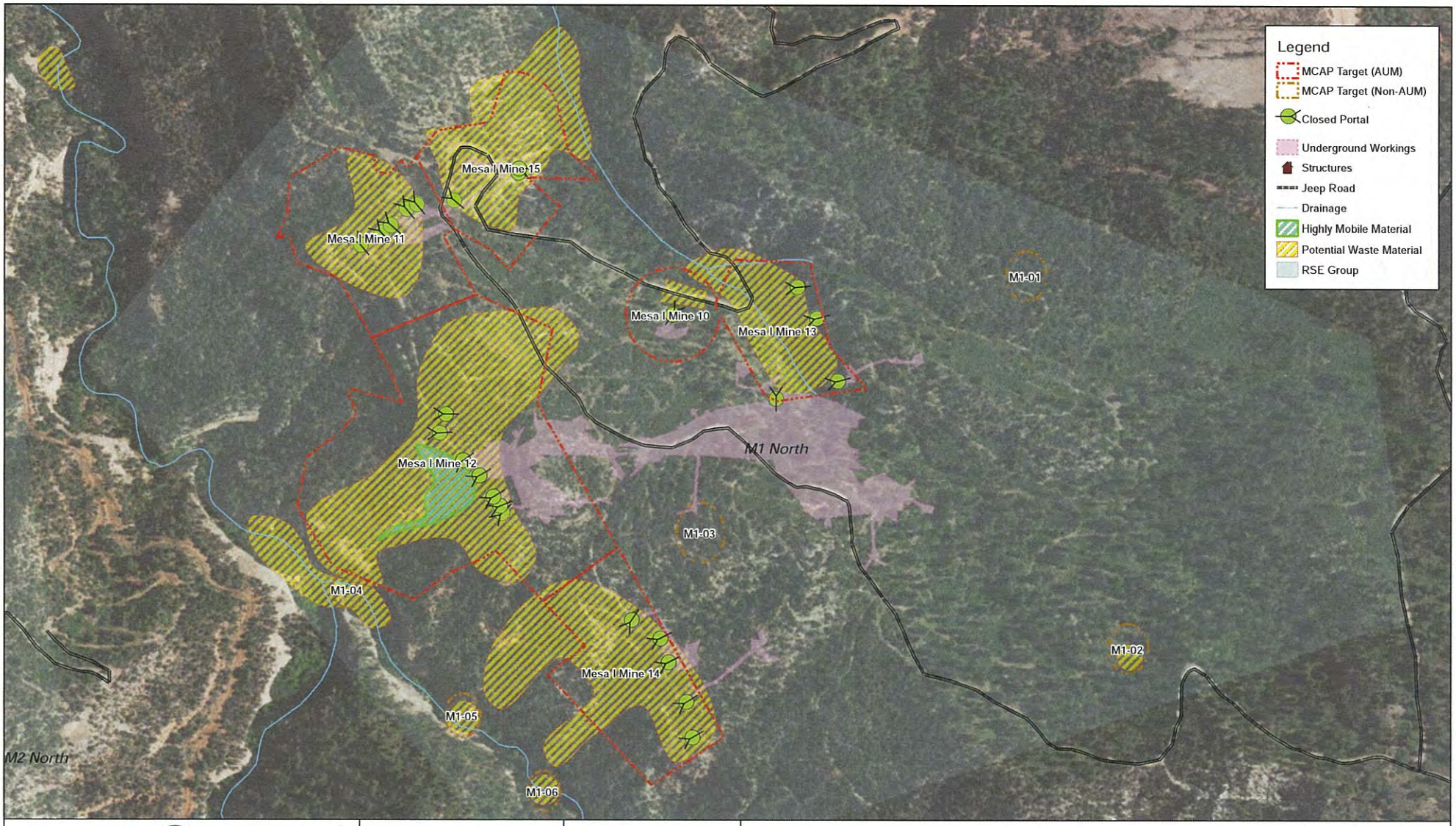


0 0.125 0.25 Mile

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 10 B
M1 North Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

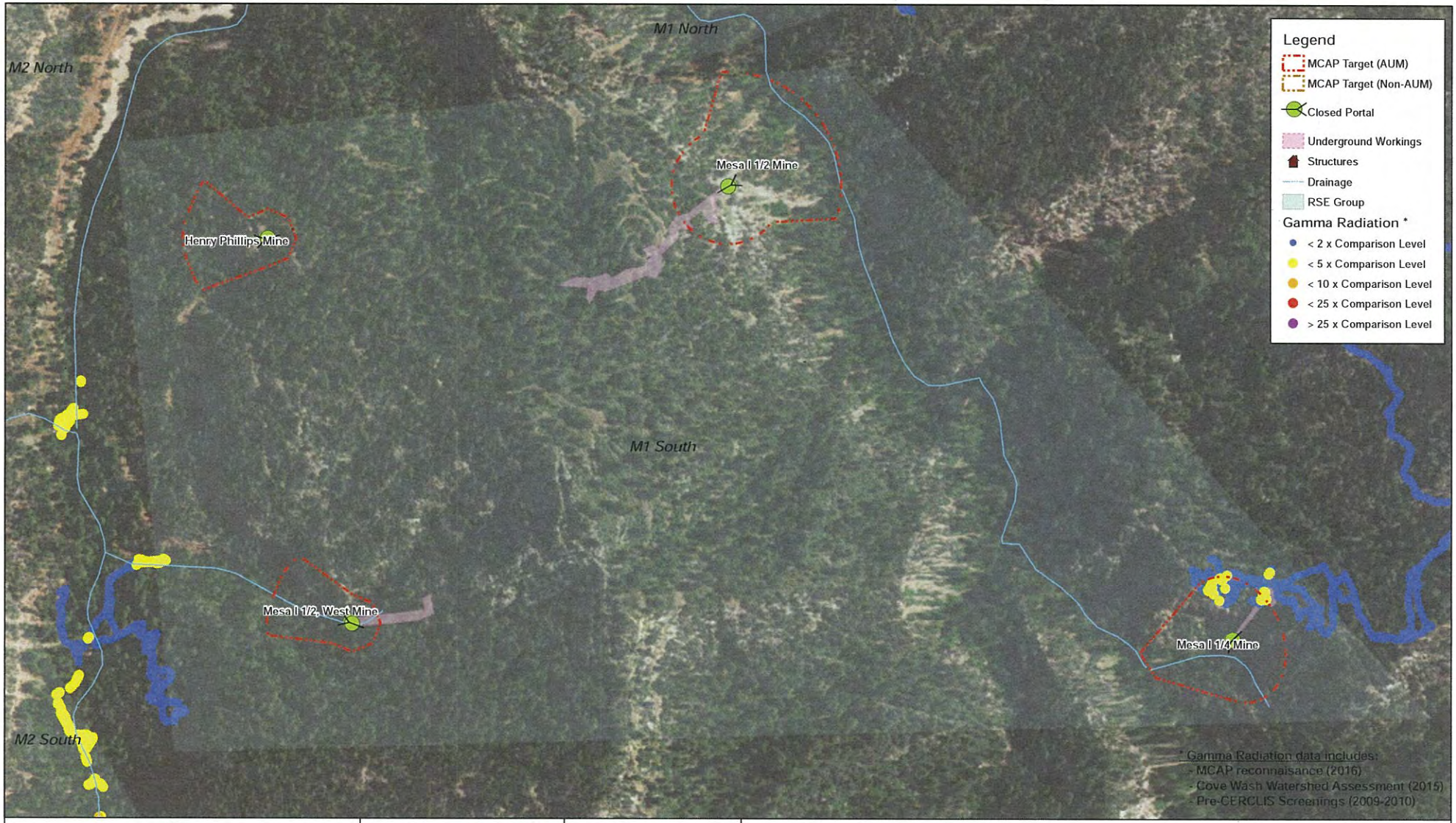
PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 10 C
M1 North Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 11 A
M1 South Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

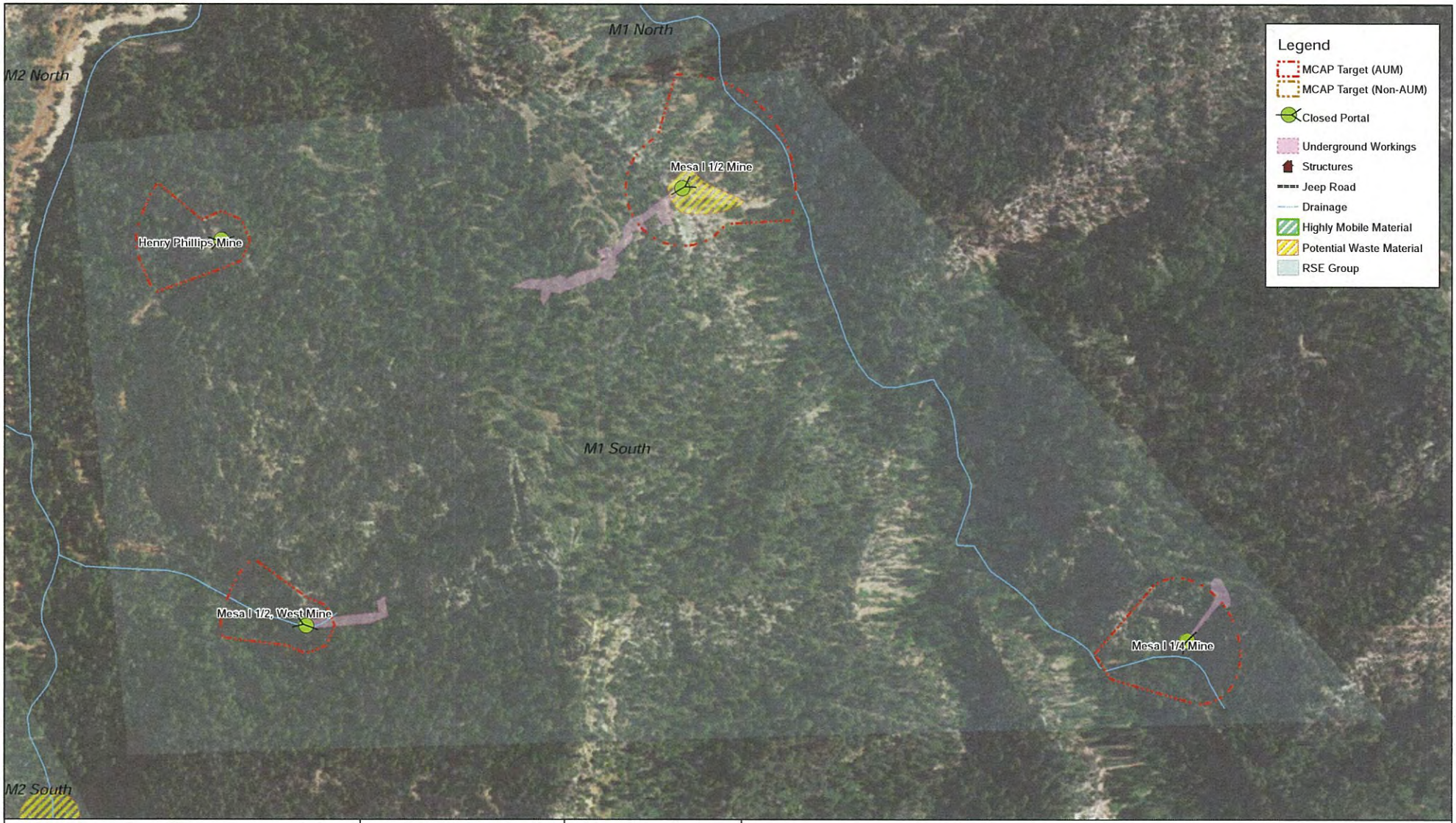


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

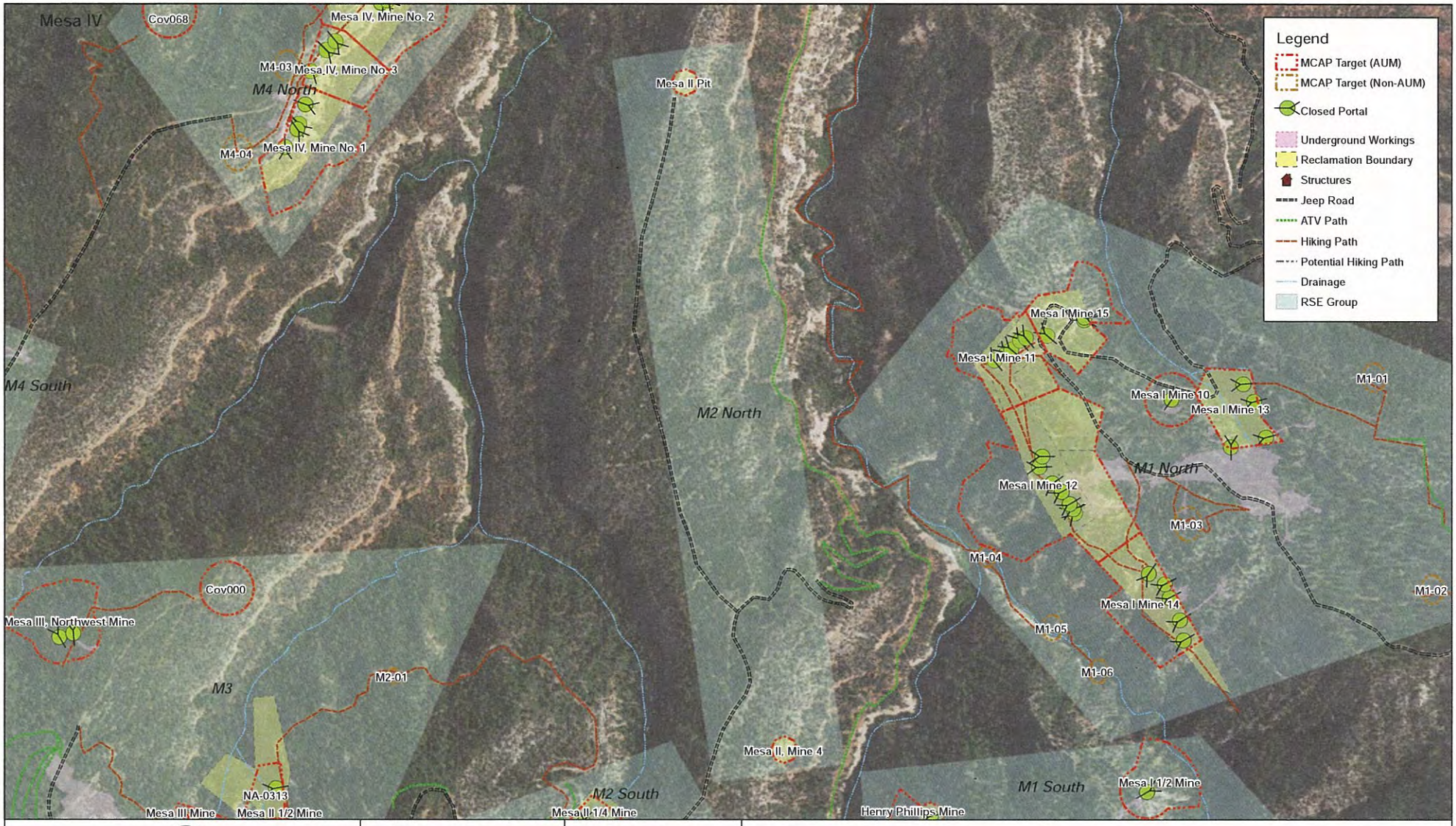
Figure 11 B
M1 South Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

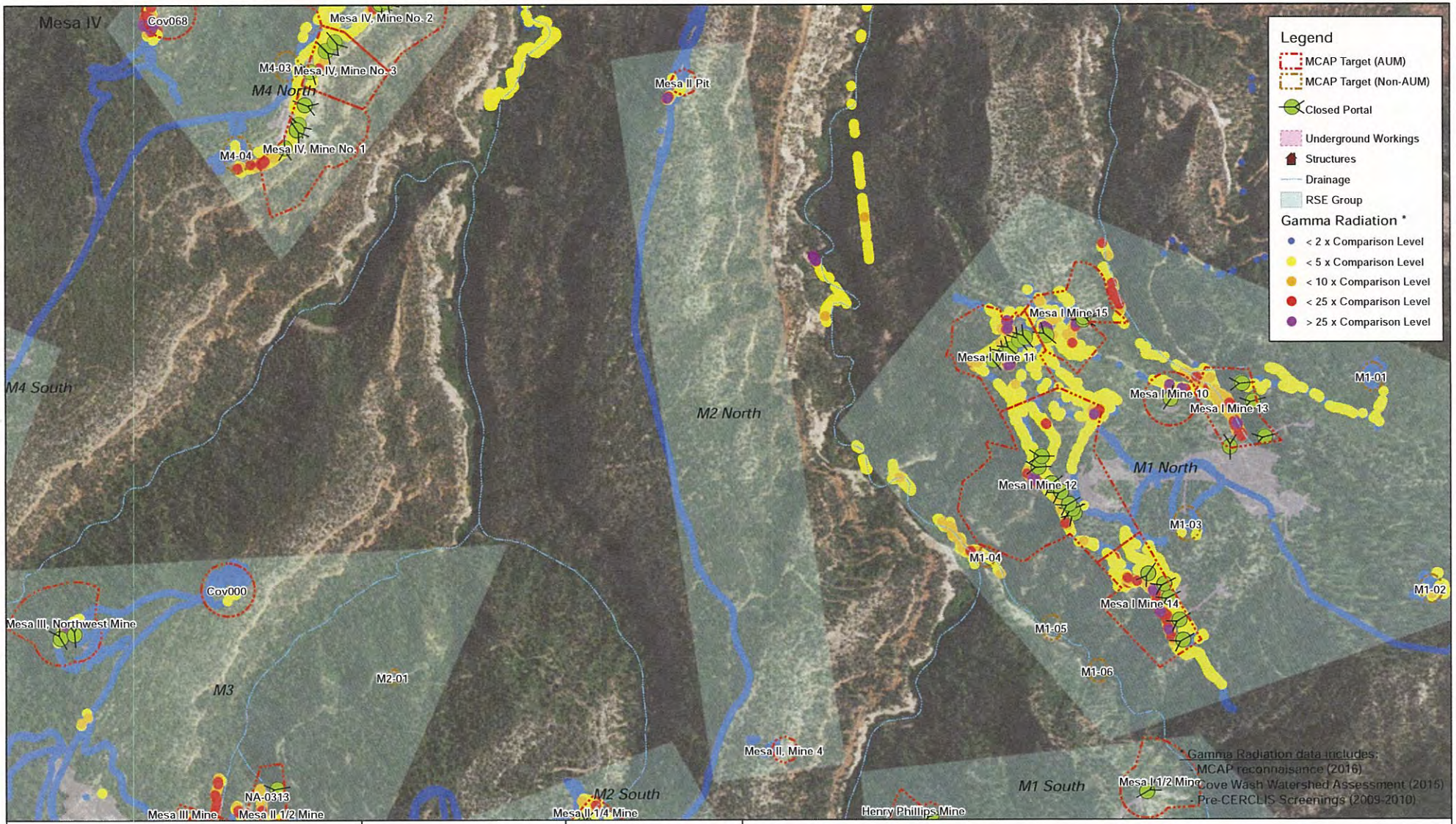
Figure 11 C
M1 South Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

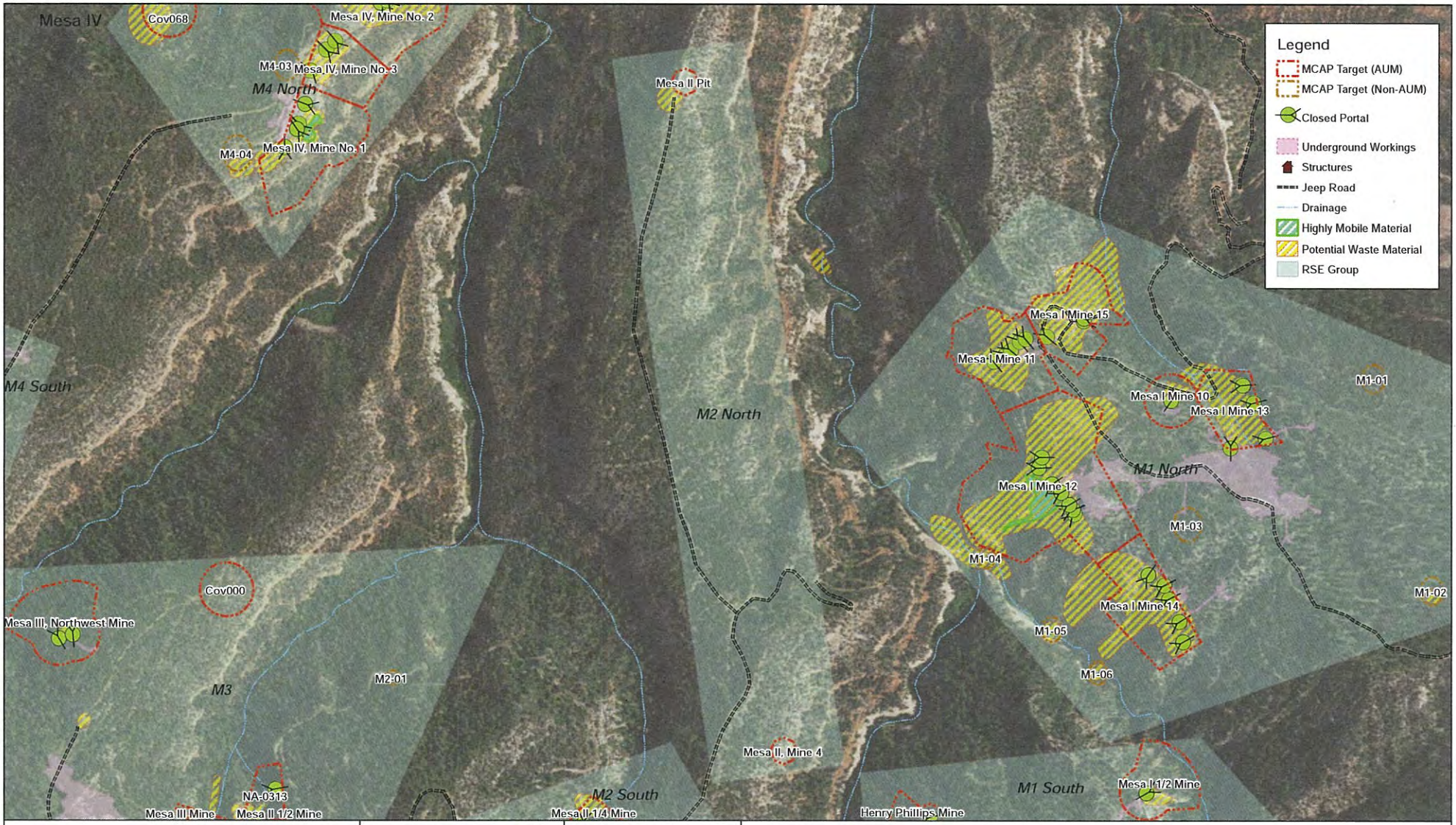
Figure 12 A
M2 North Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

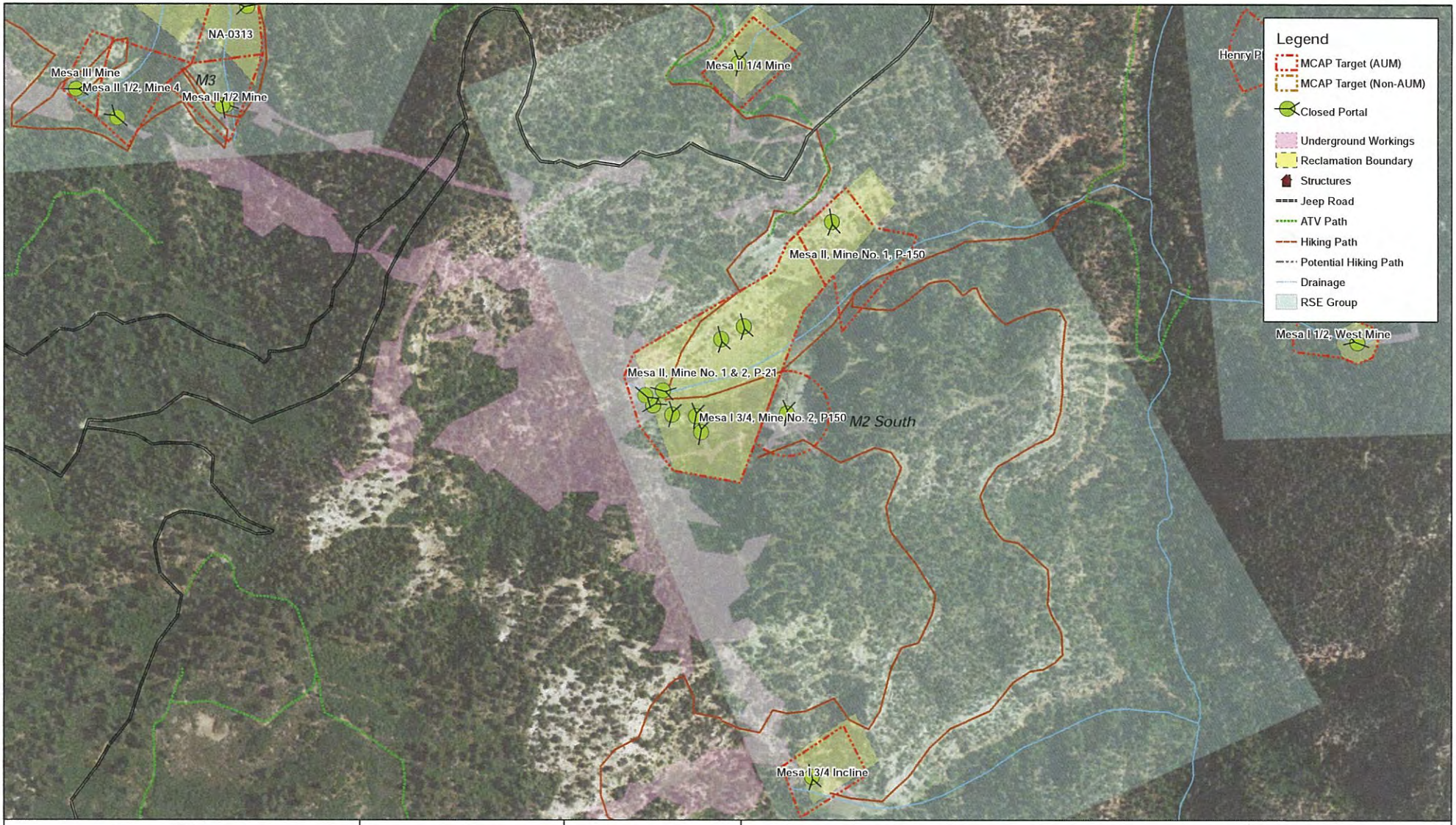
Figure 12 B
M2 North Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 12 C
M2 North Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

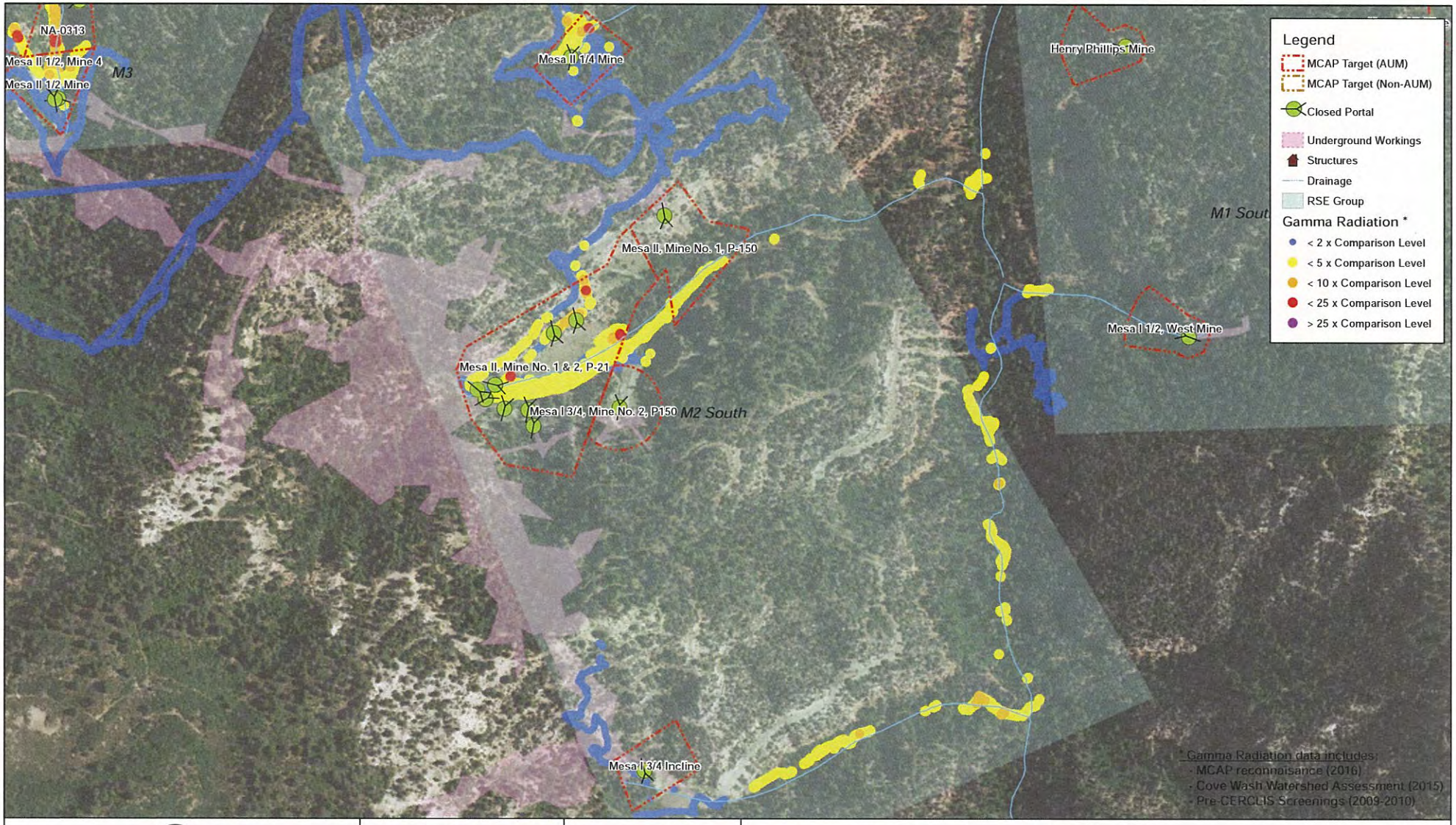


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 13 A
M2 South Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

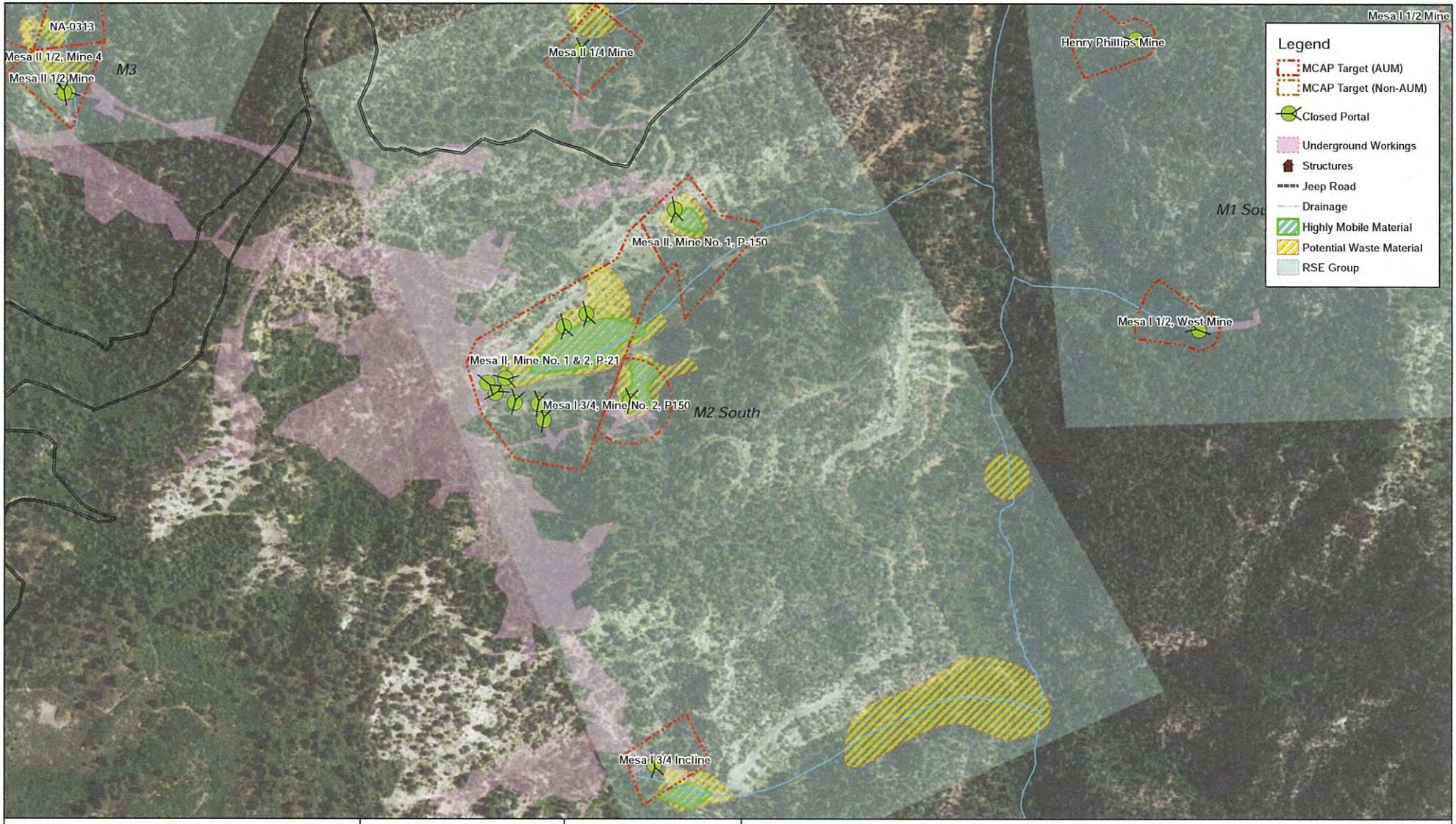


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

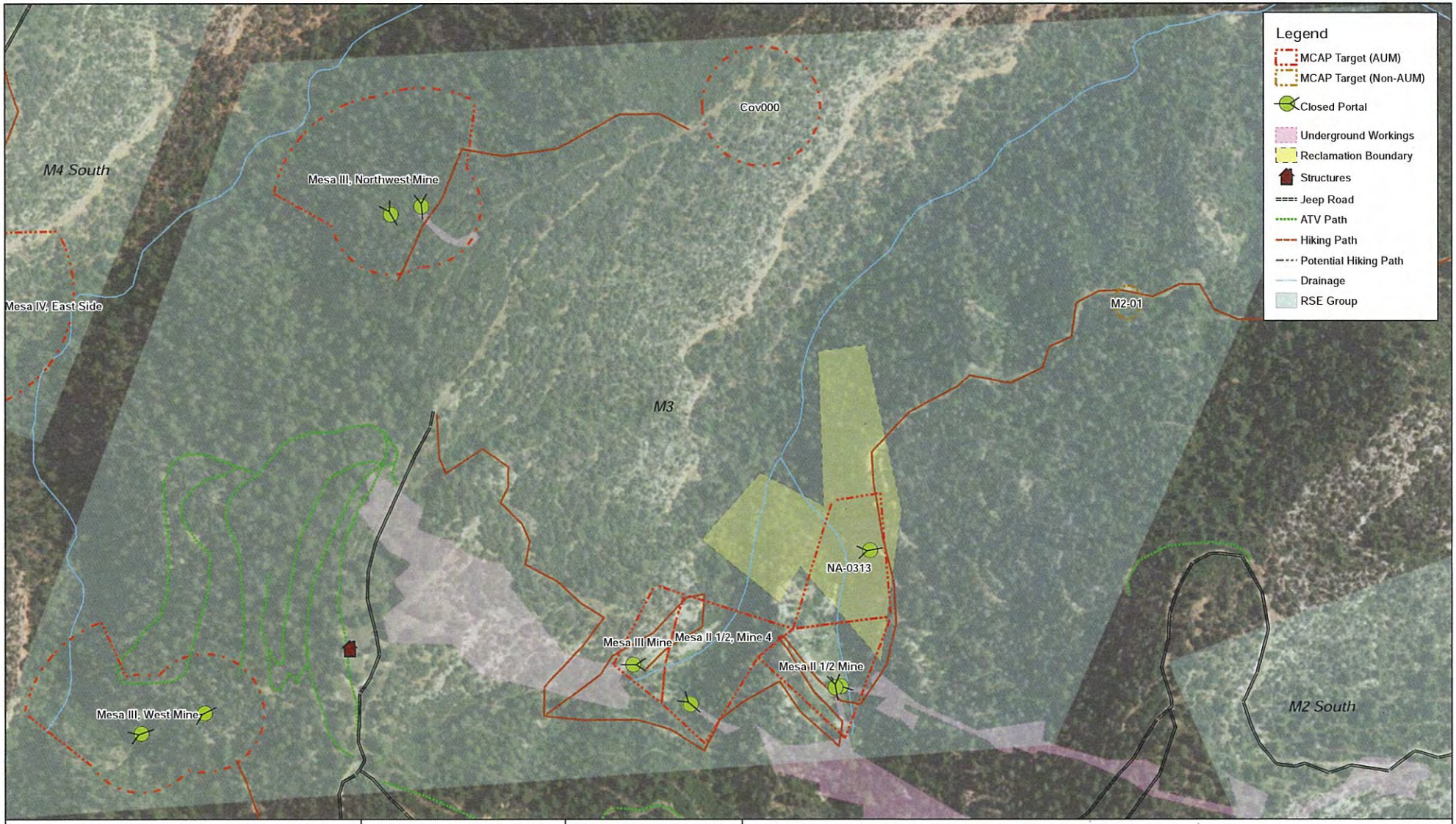
Figure 13 B
M2 South Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

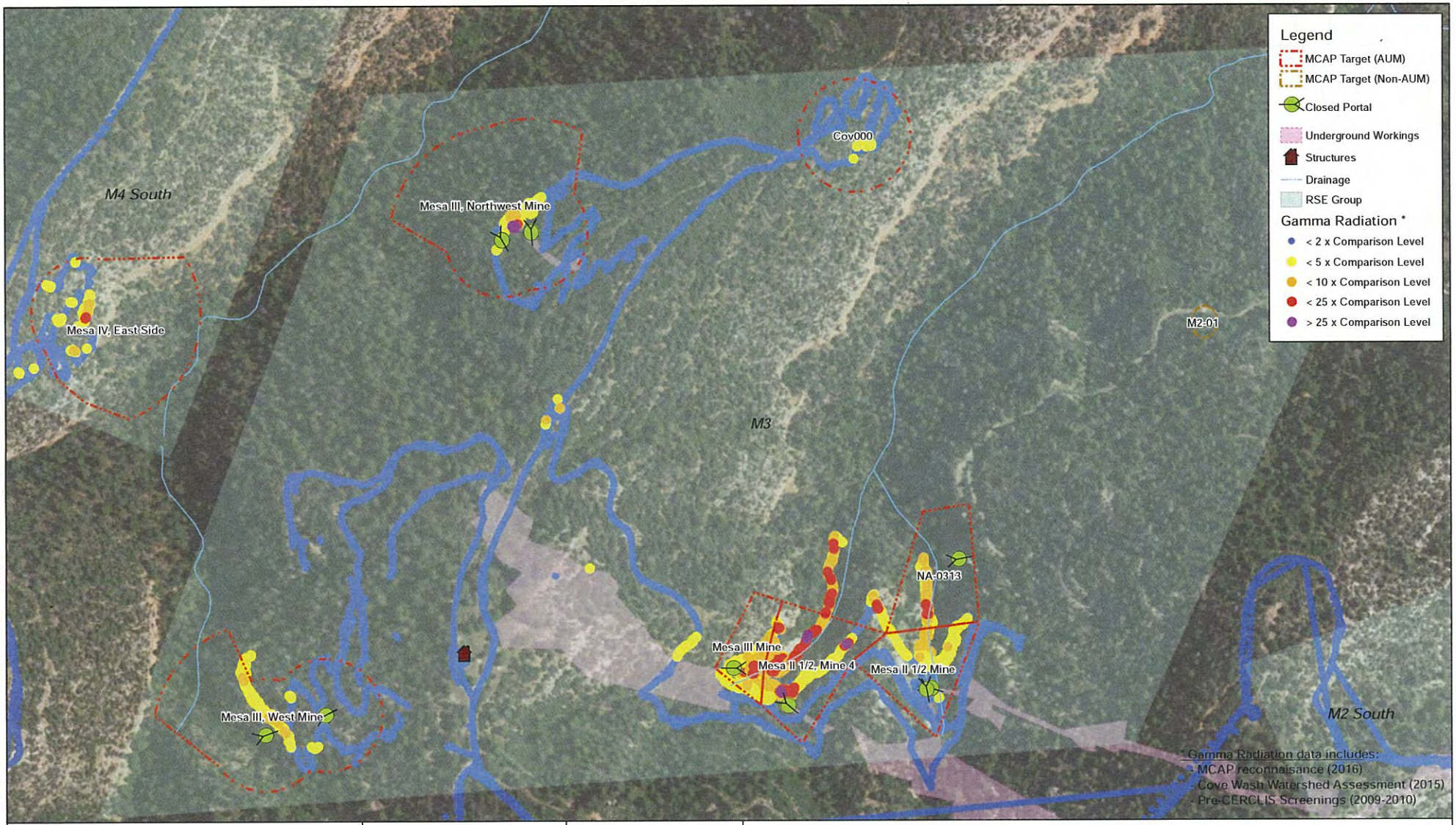
Figure 13 C
M2 South Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

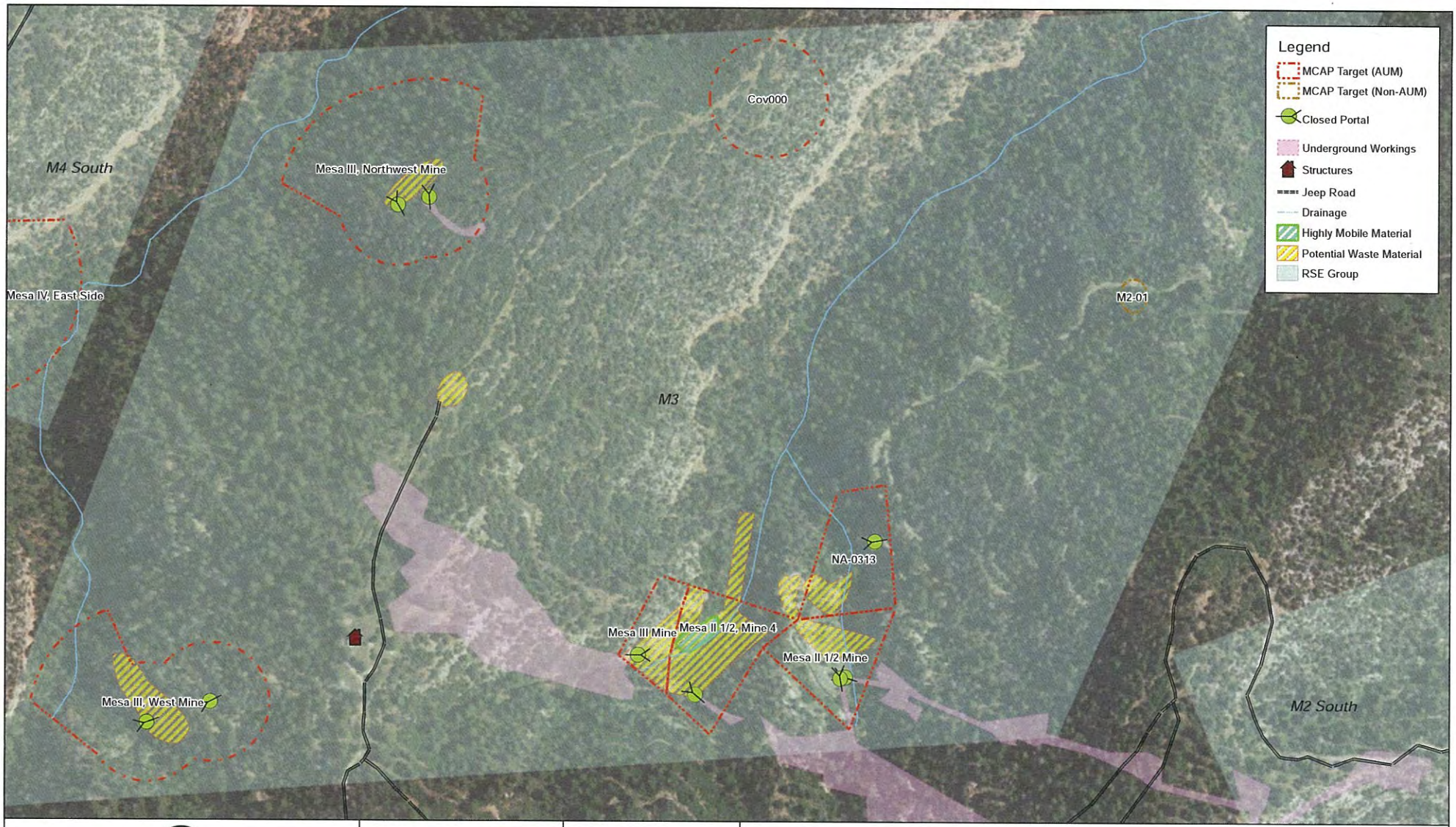
Figure 14 A
M3 Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

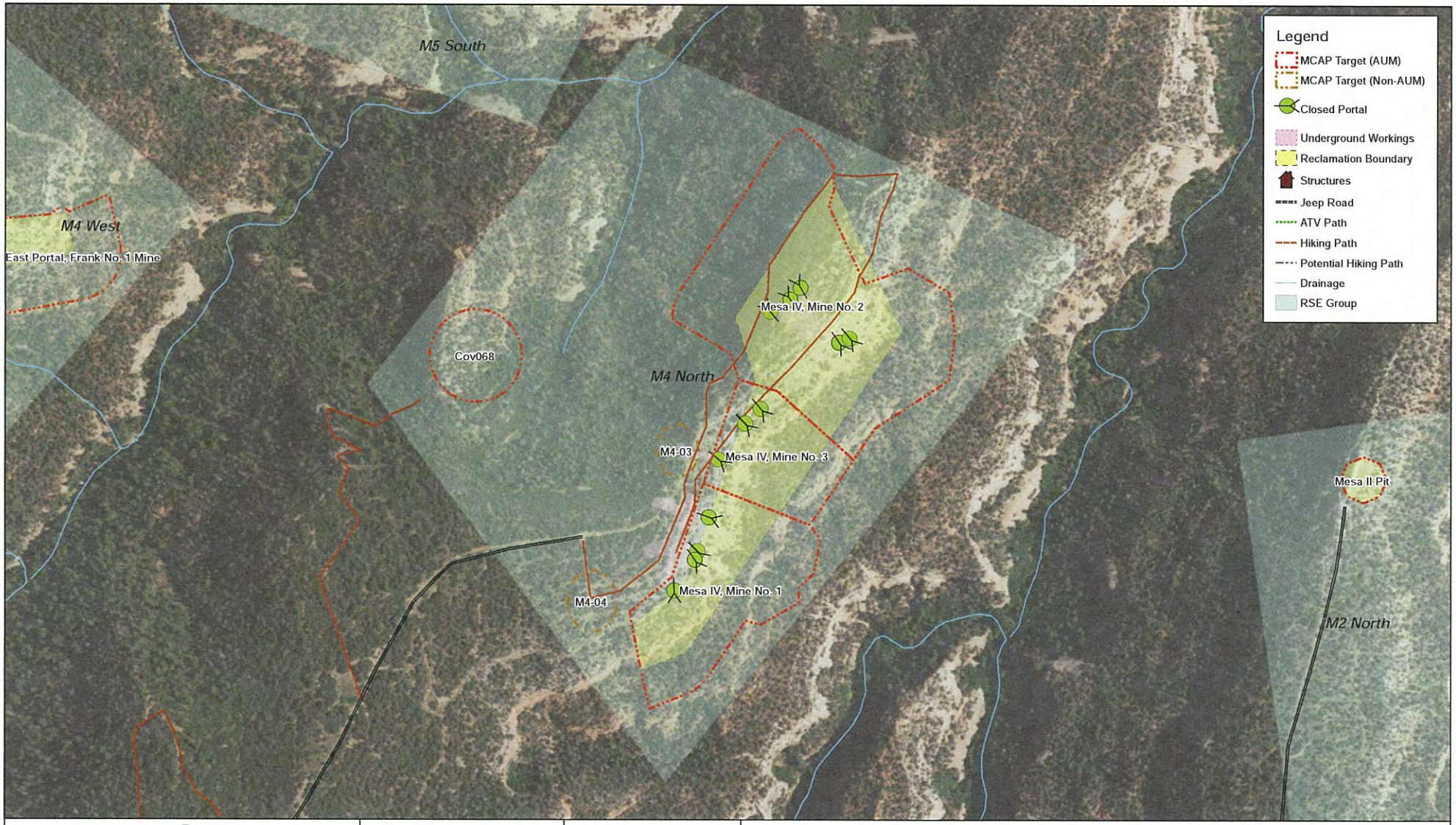
Figure 14 B
M3 Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

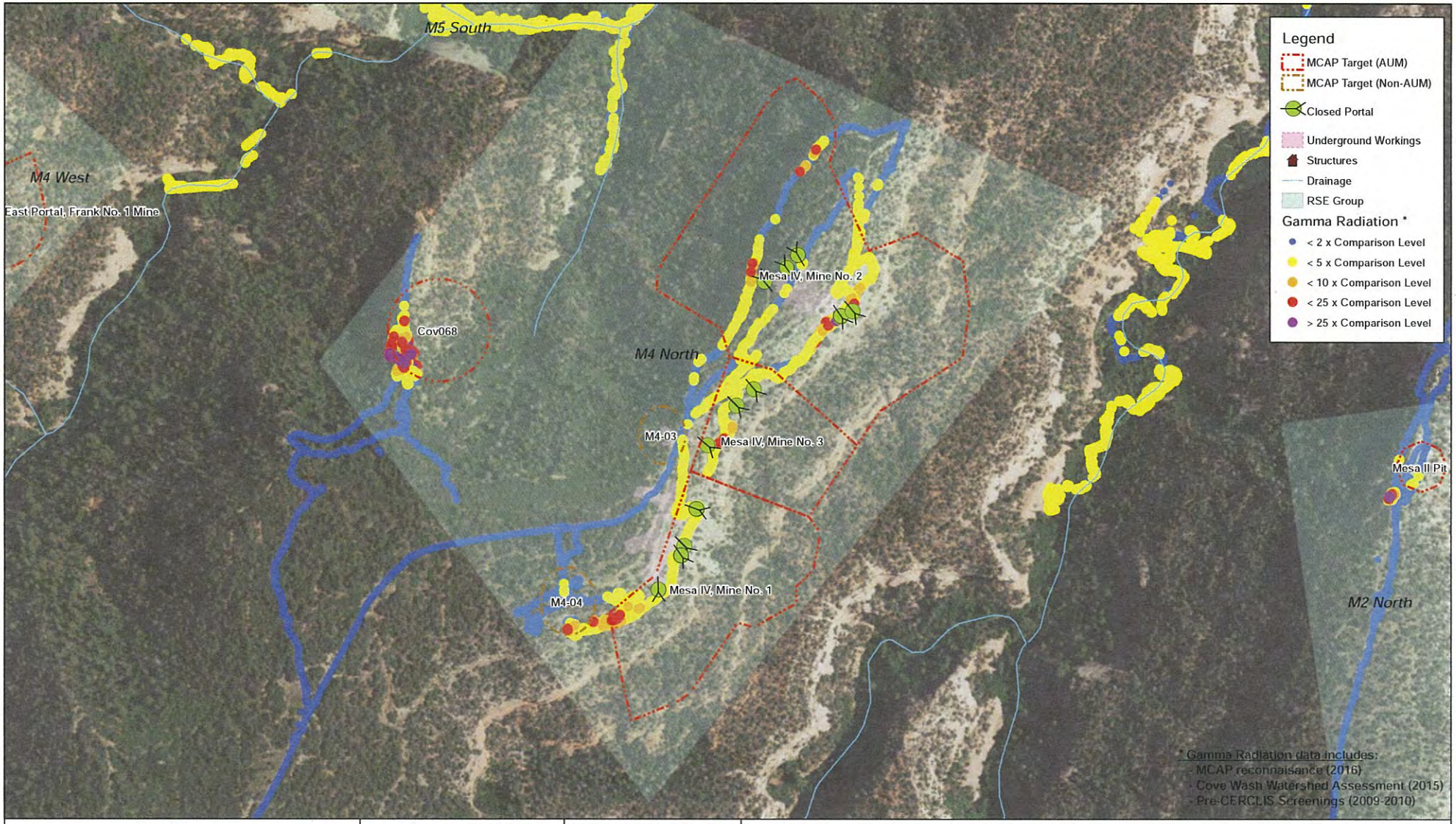
Figure 14 C
M3 Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 15 A
M4 North Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

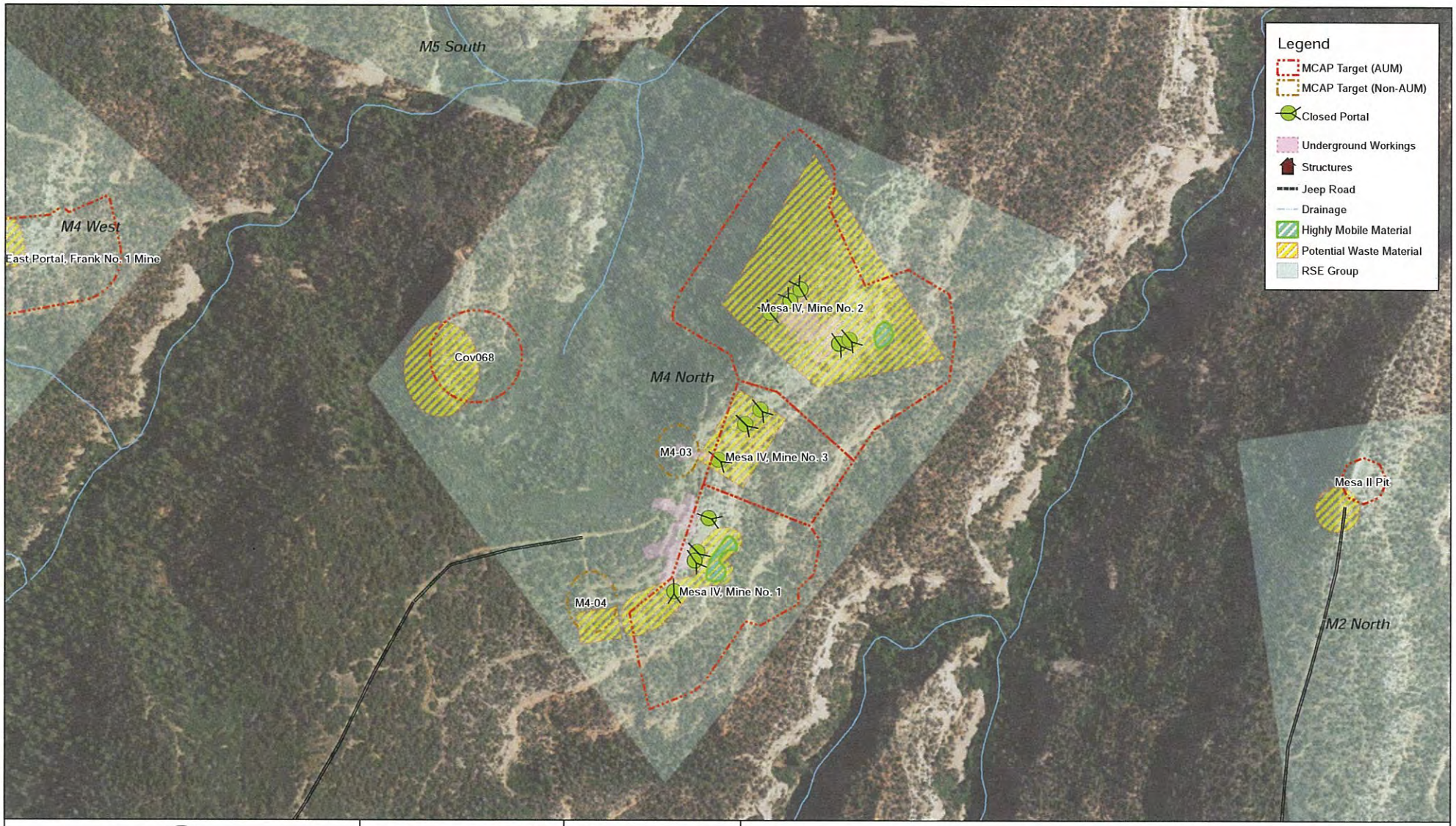


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

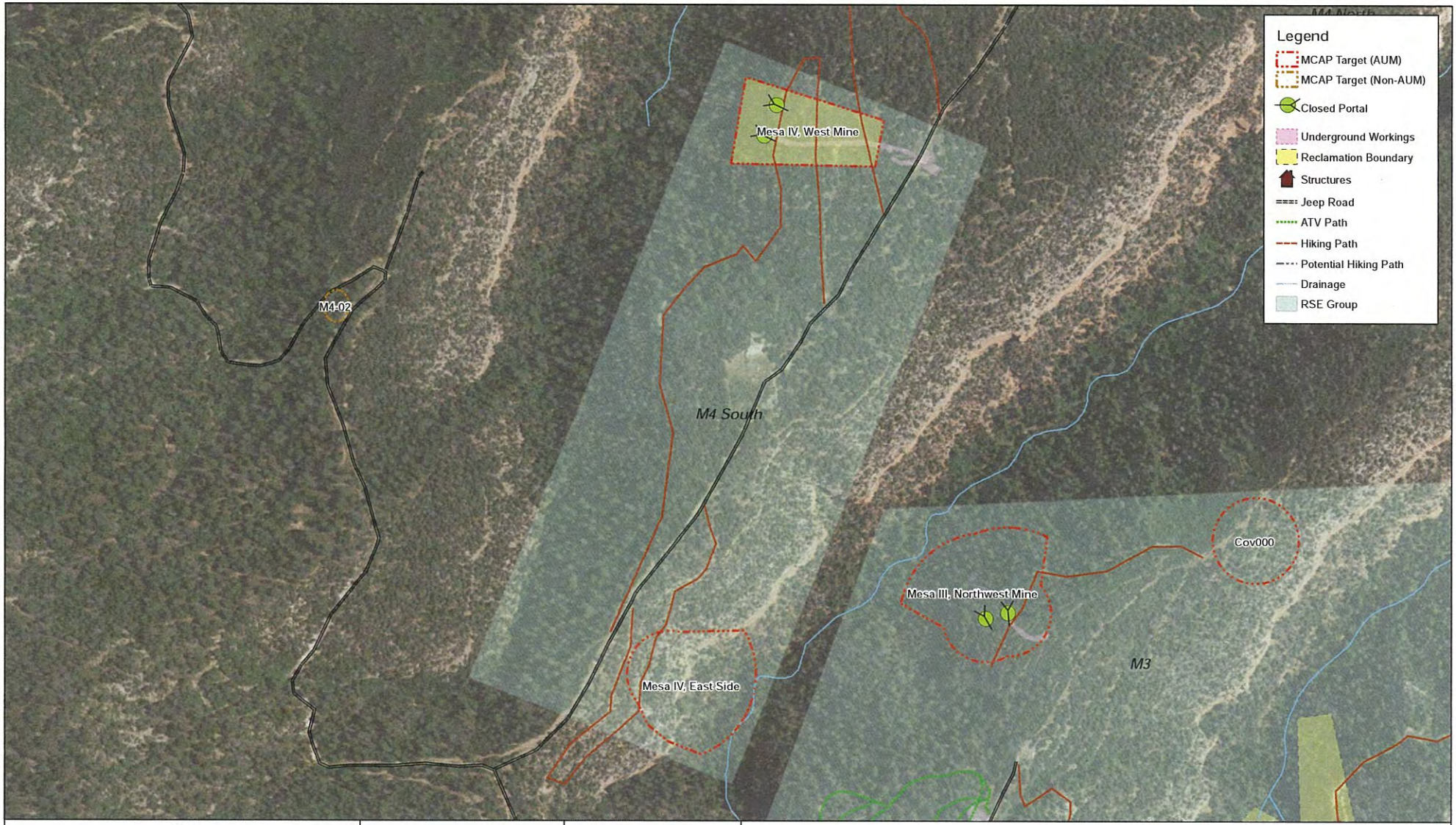
Figure 15 B
M4 North Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

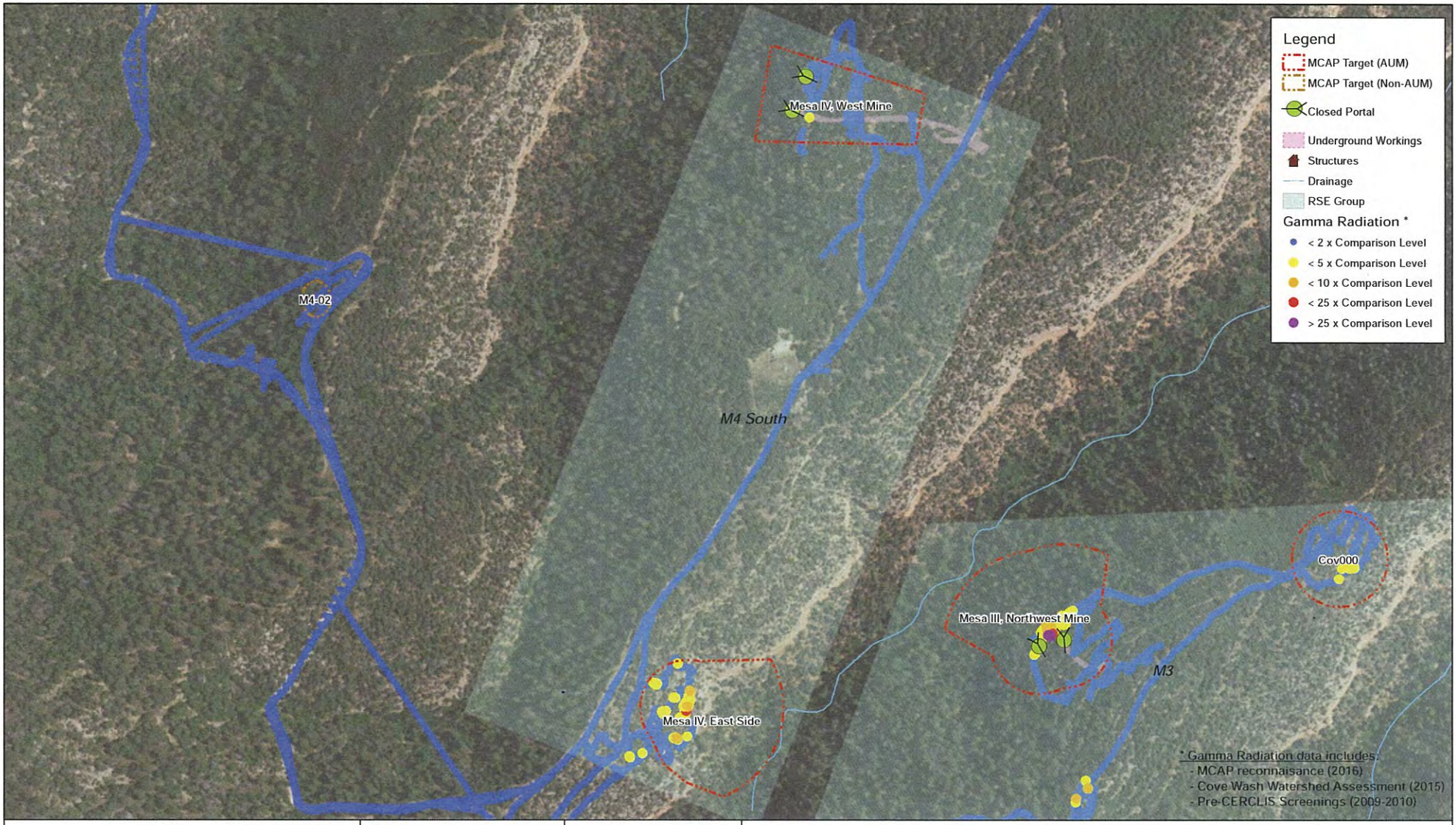
Figure 15 C
M4 North Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 16 A
M4 South Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

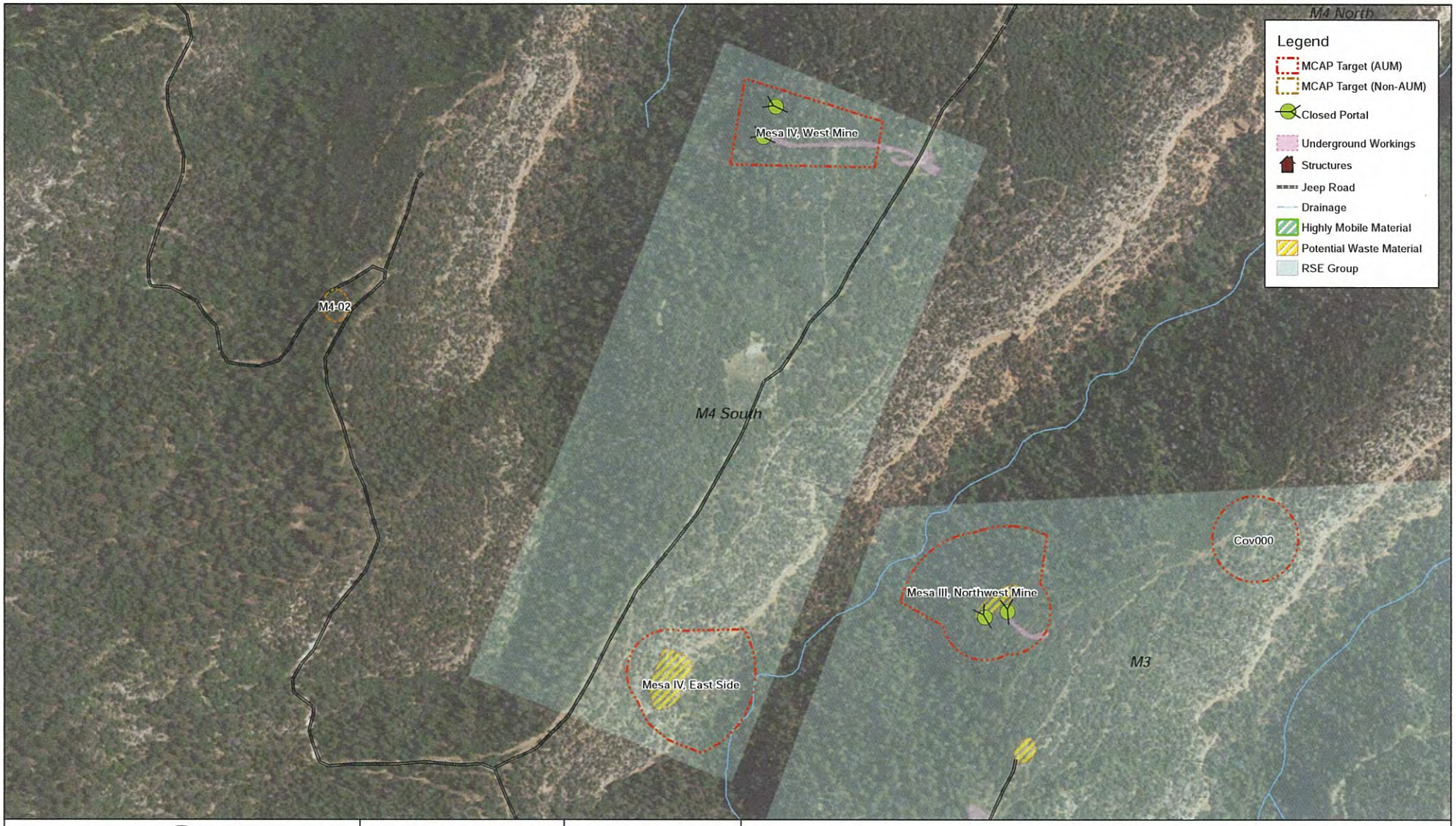


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 16 B
M4 South Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

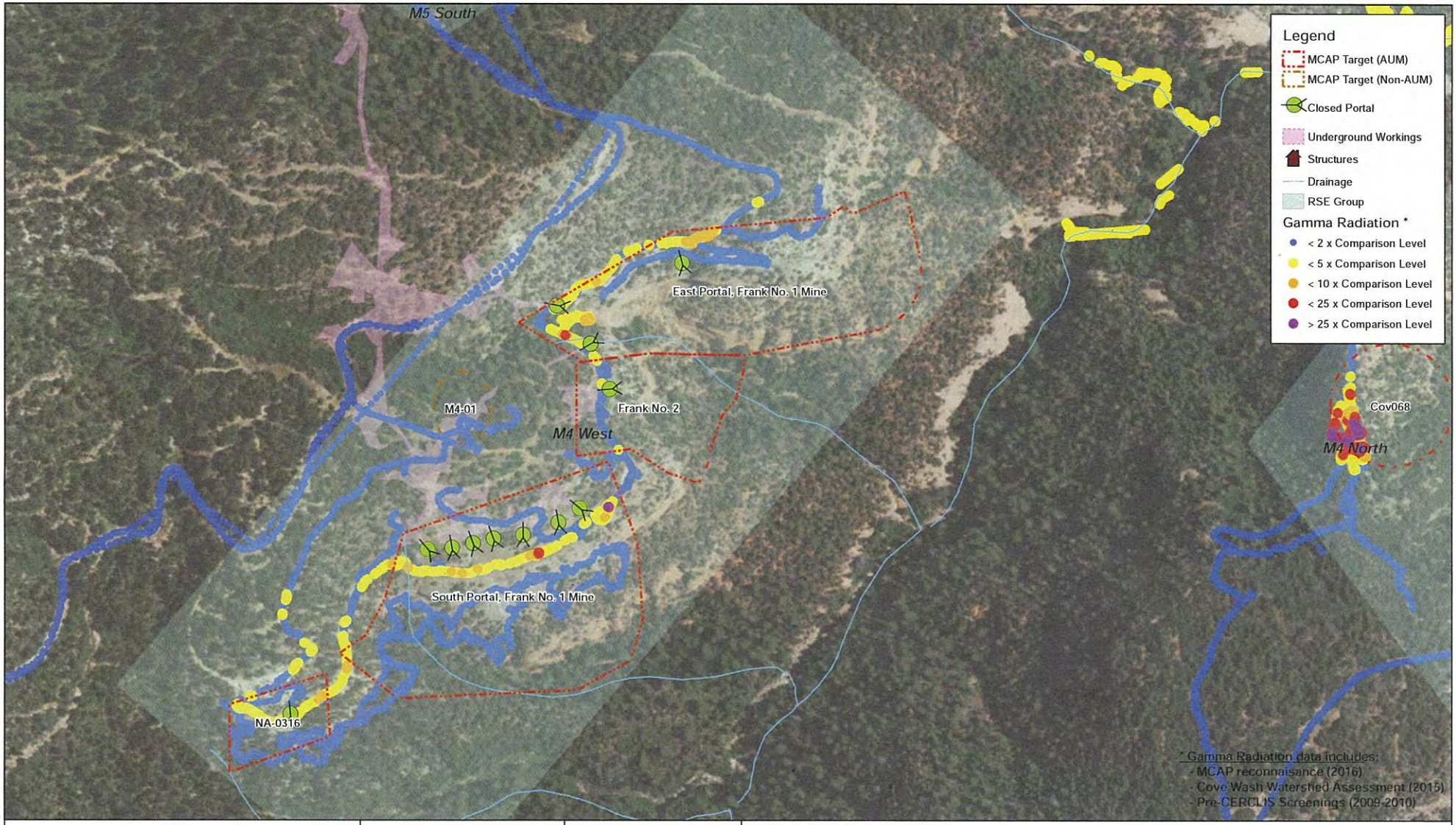
PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 16 C
M4 South Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

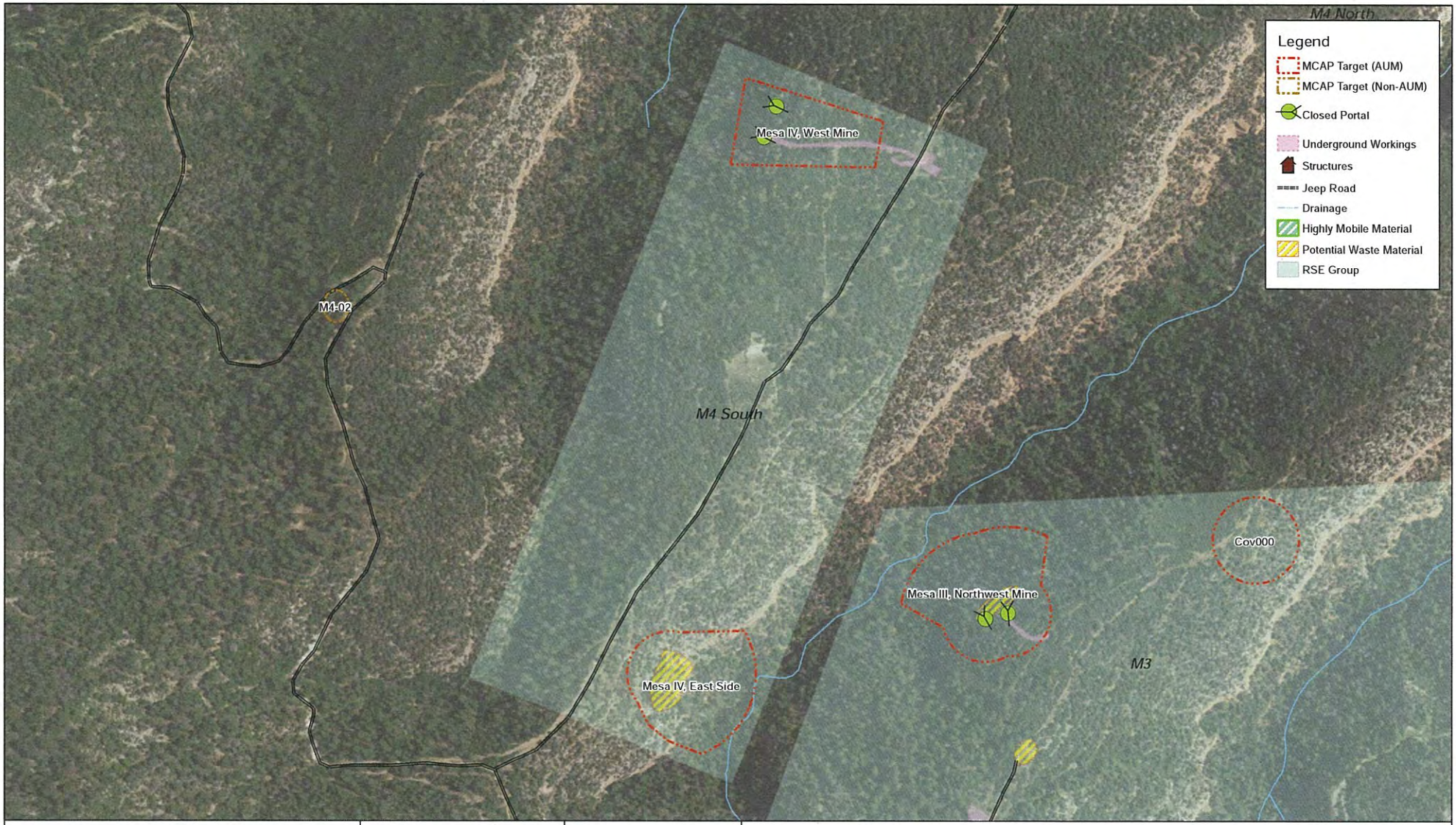
Figure 17 A
M4 West Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

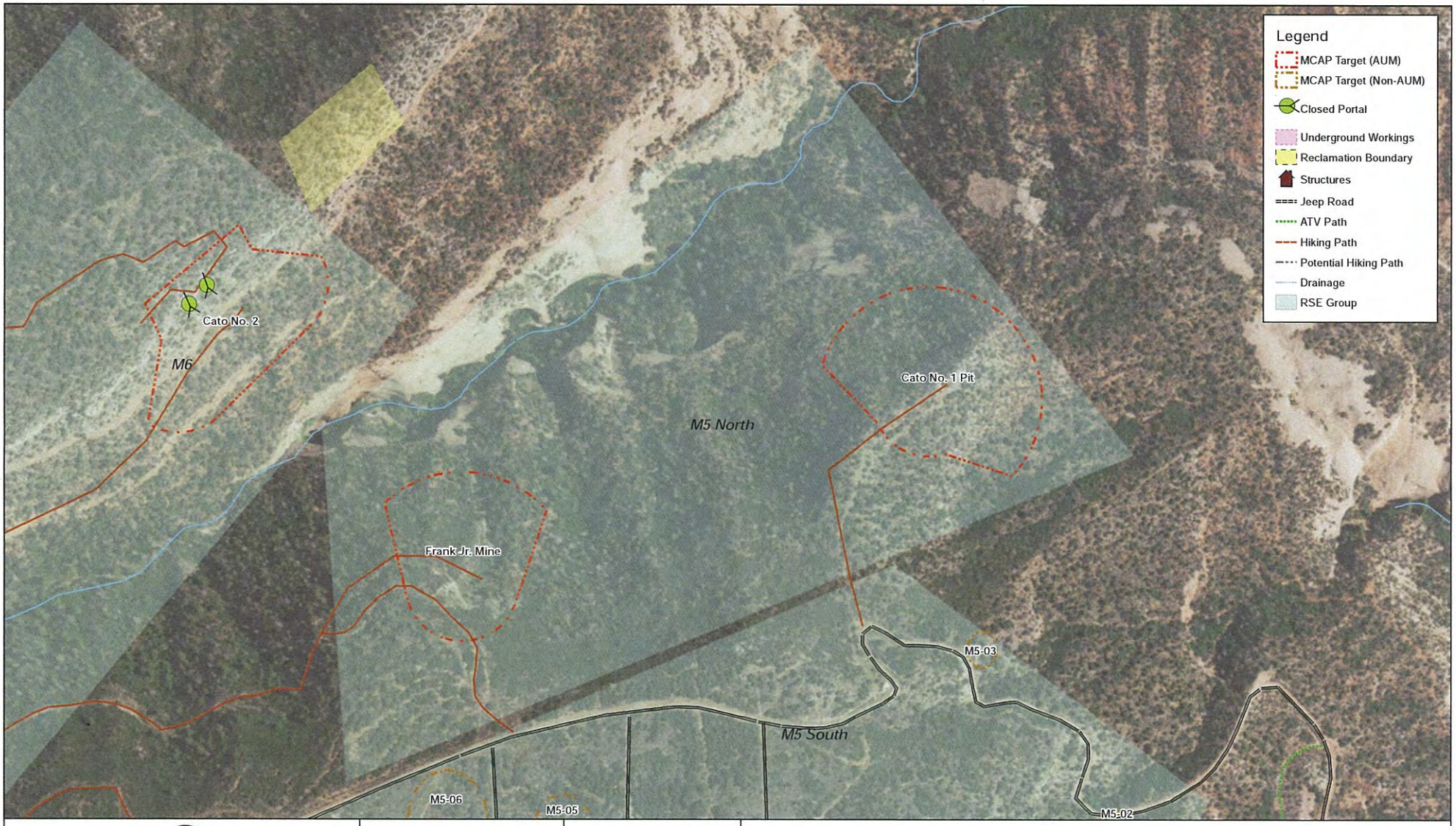
Figure 17 B
M4 West Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 17 C
M4 West Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

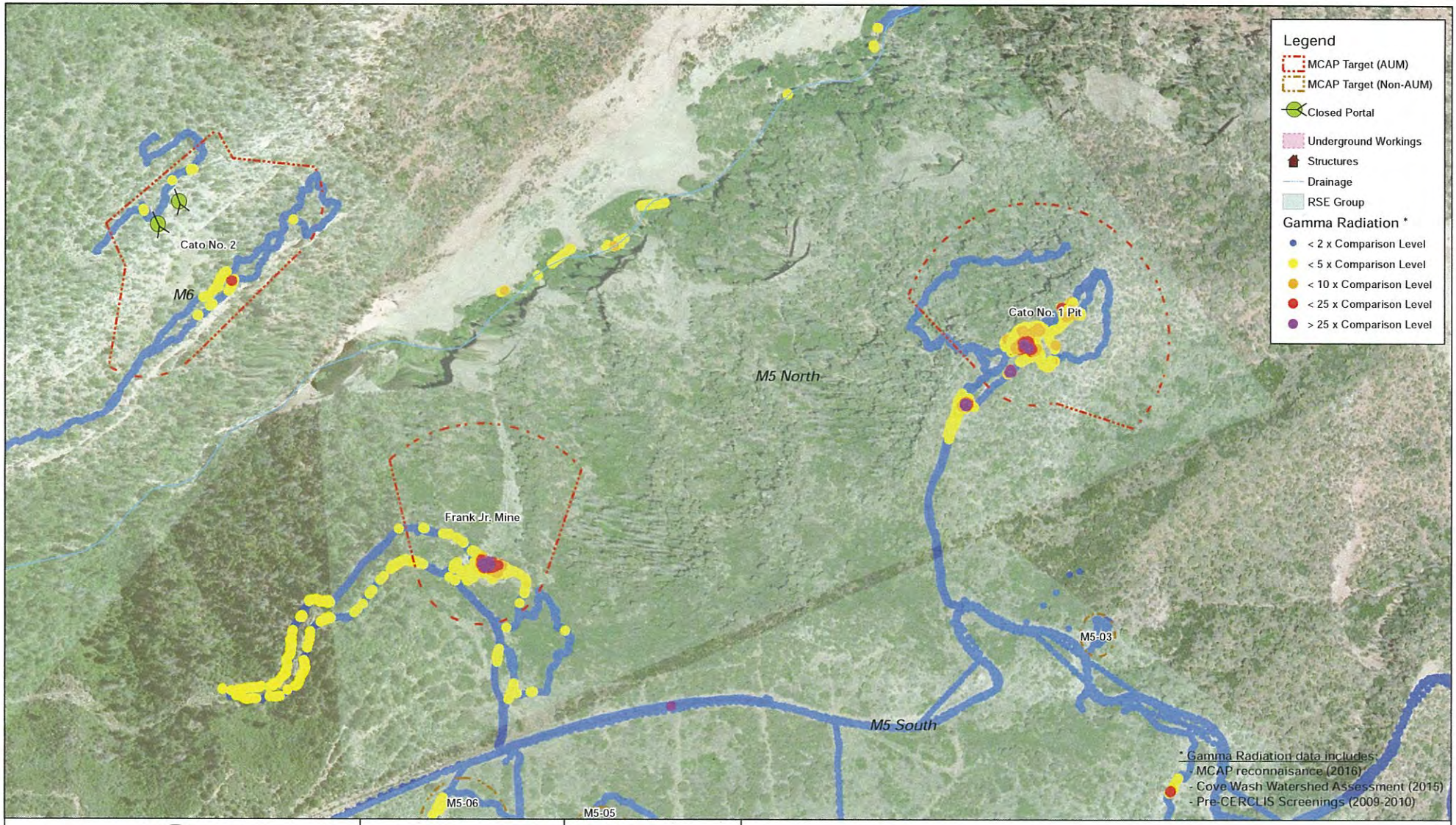


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 18 A
M5 North Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

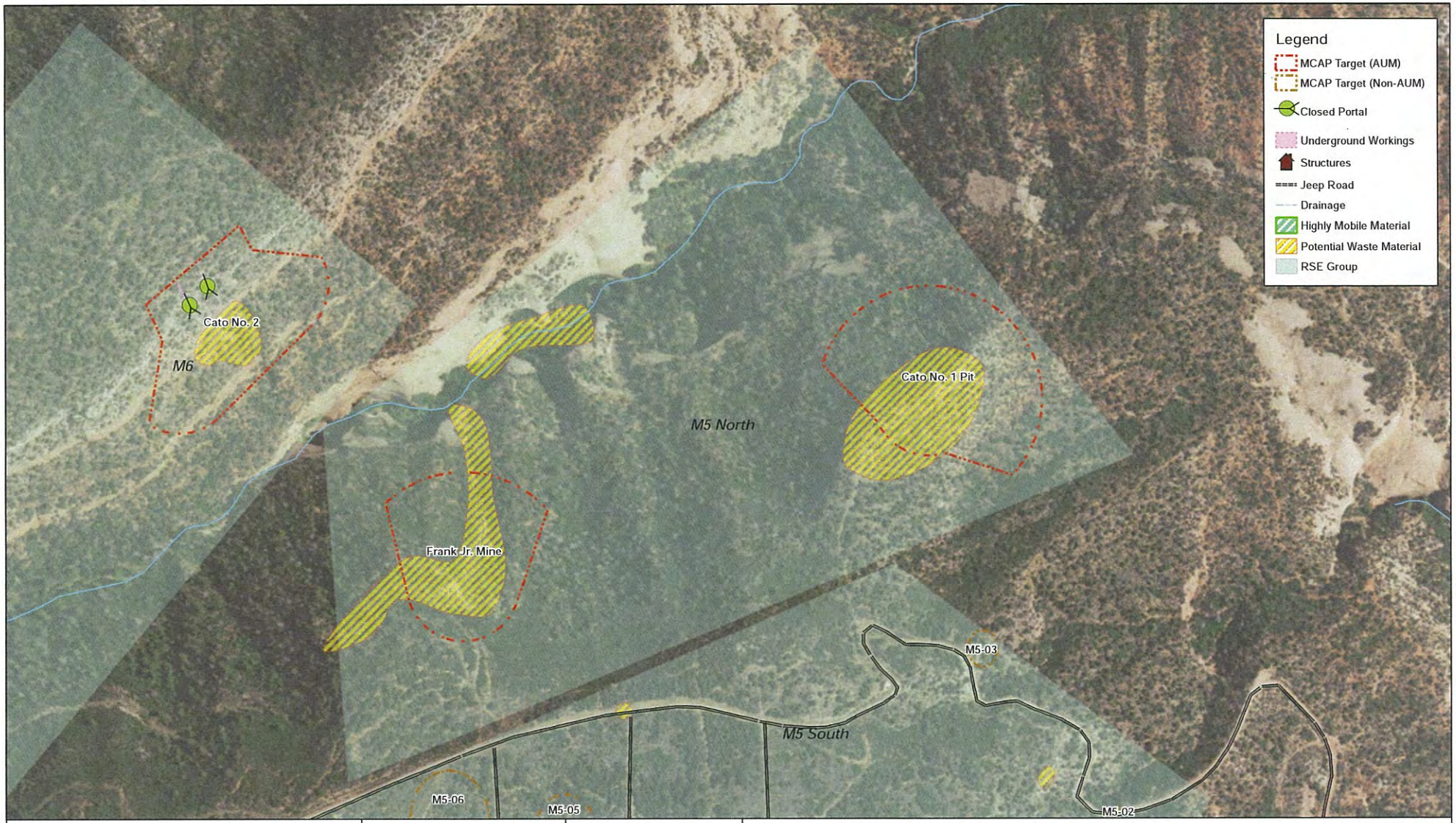


0 250 500 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 18 B
M5 North Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

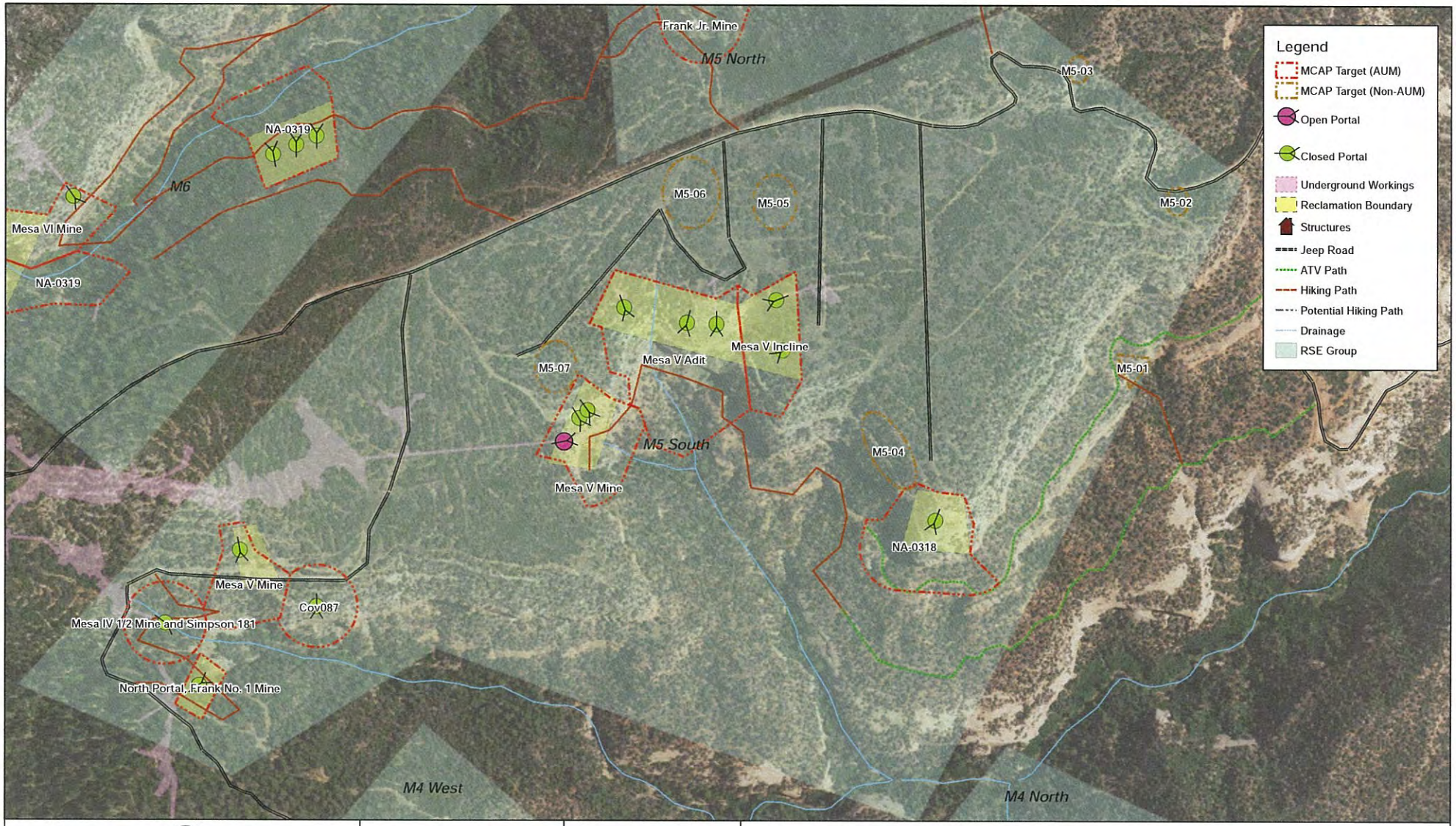


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 18 C
M5 North Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

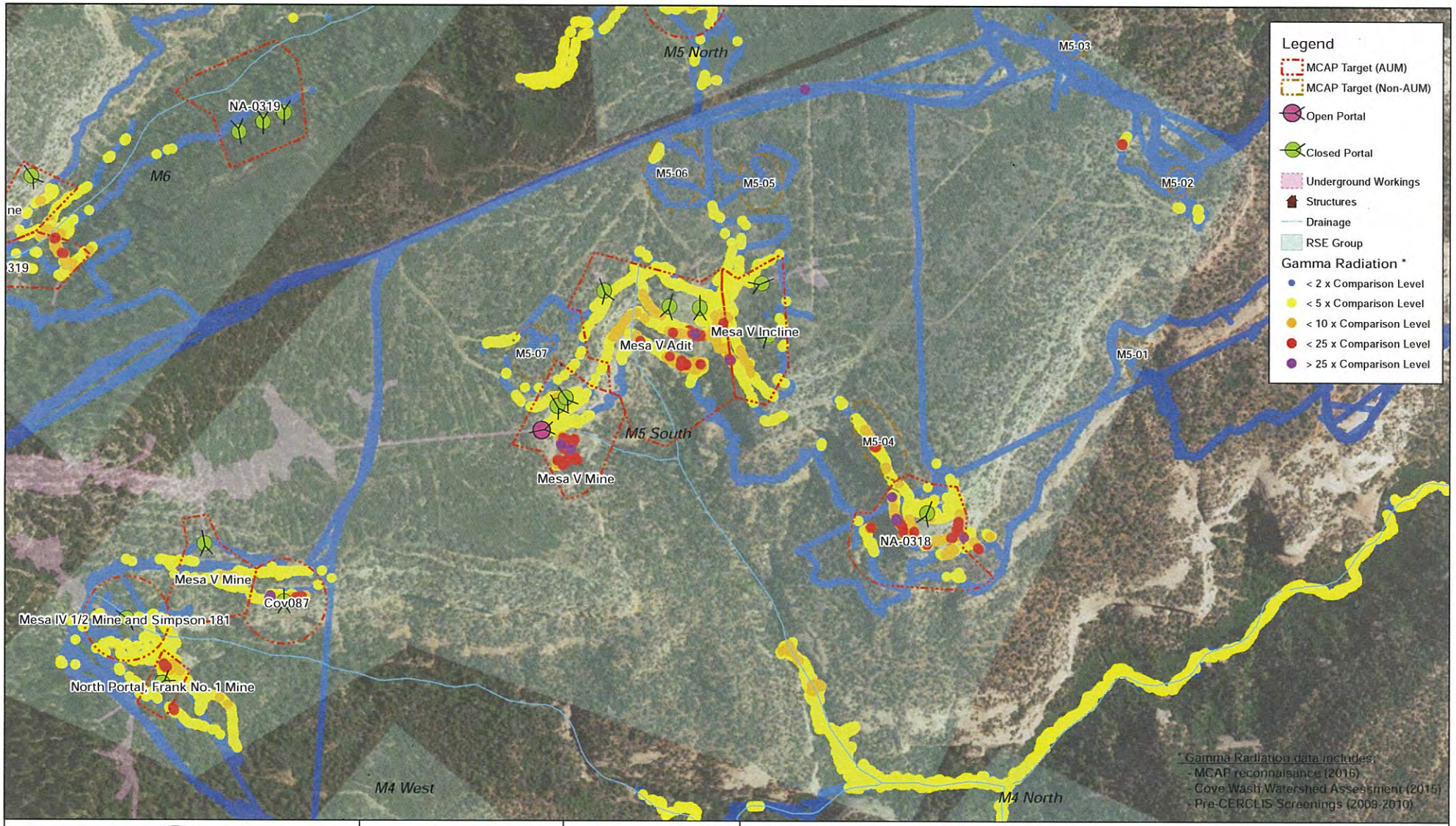


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 19 A
M5 South Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

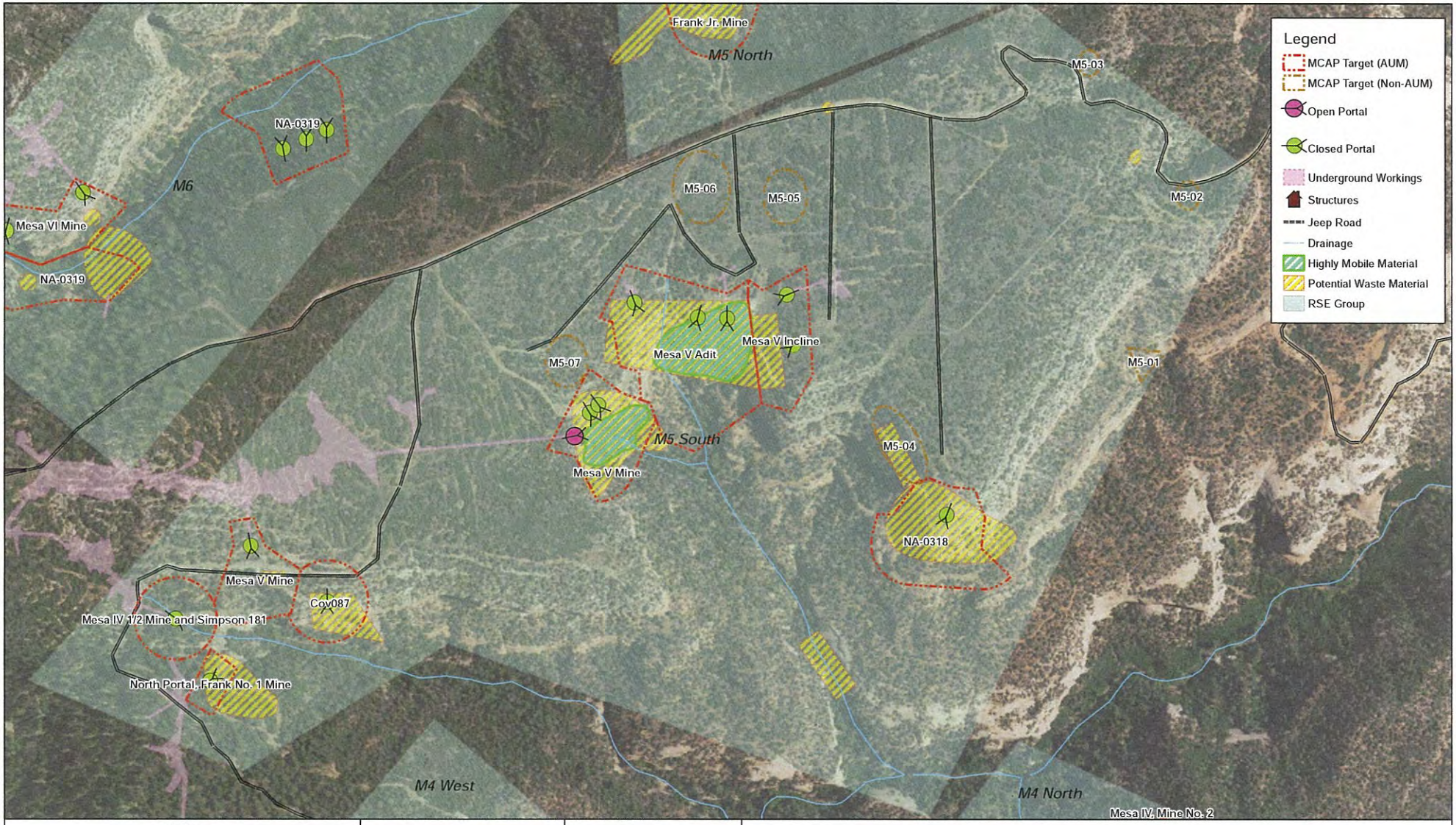


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

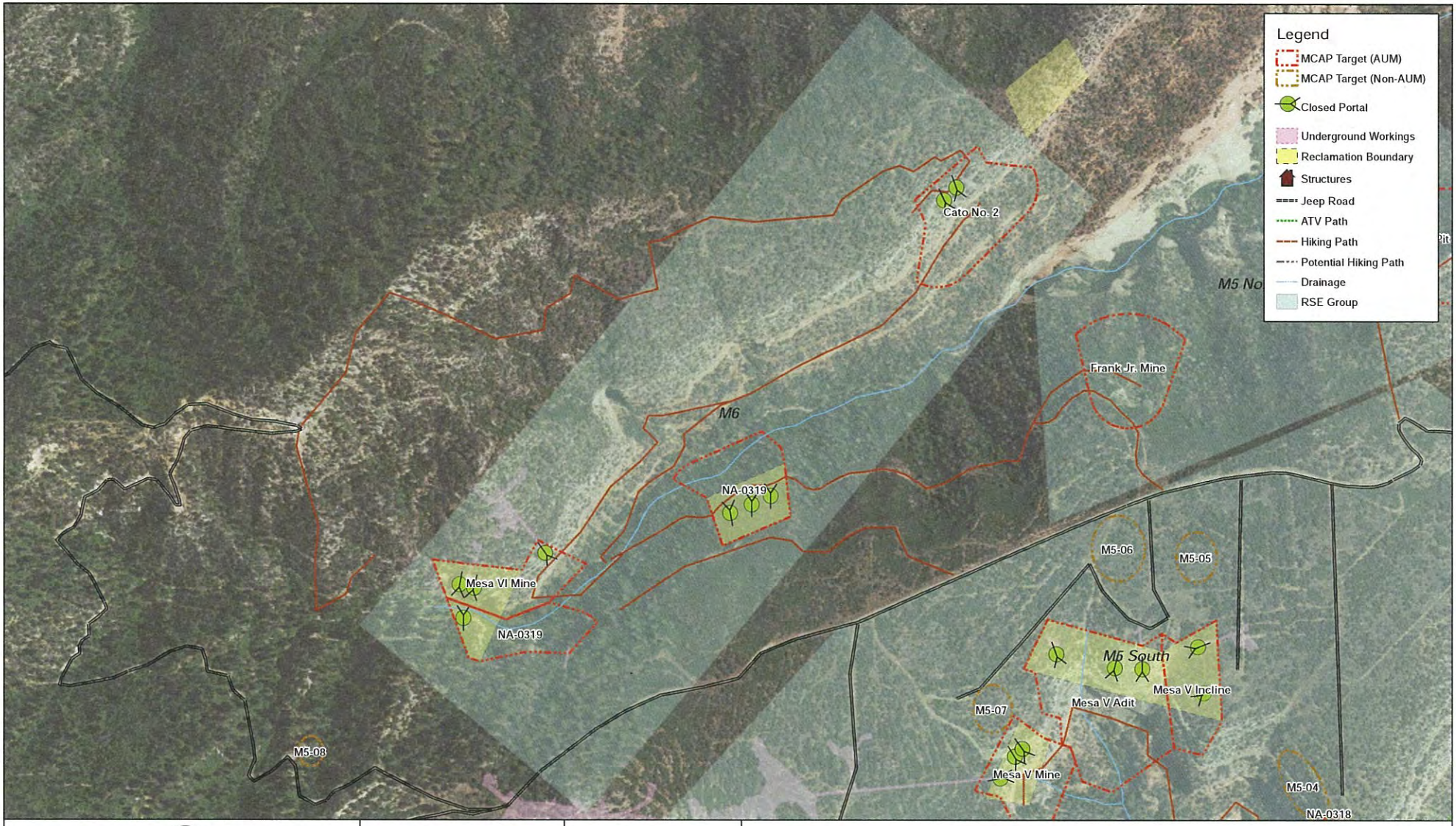
Figure 19 B
M5 South Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

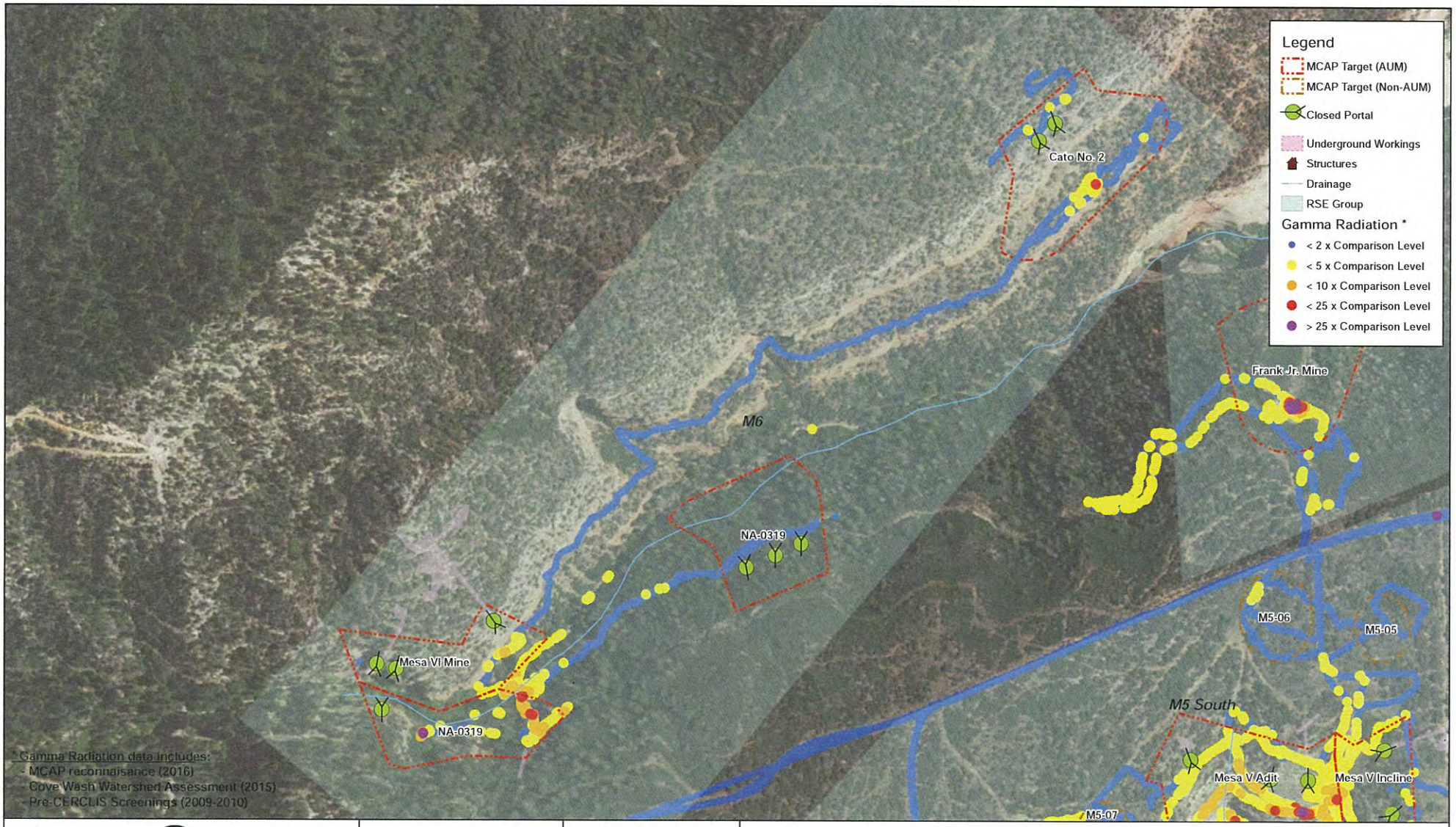
Figure 19 C
M5 South Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

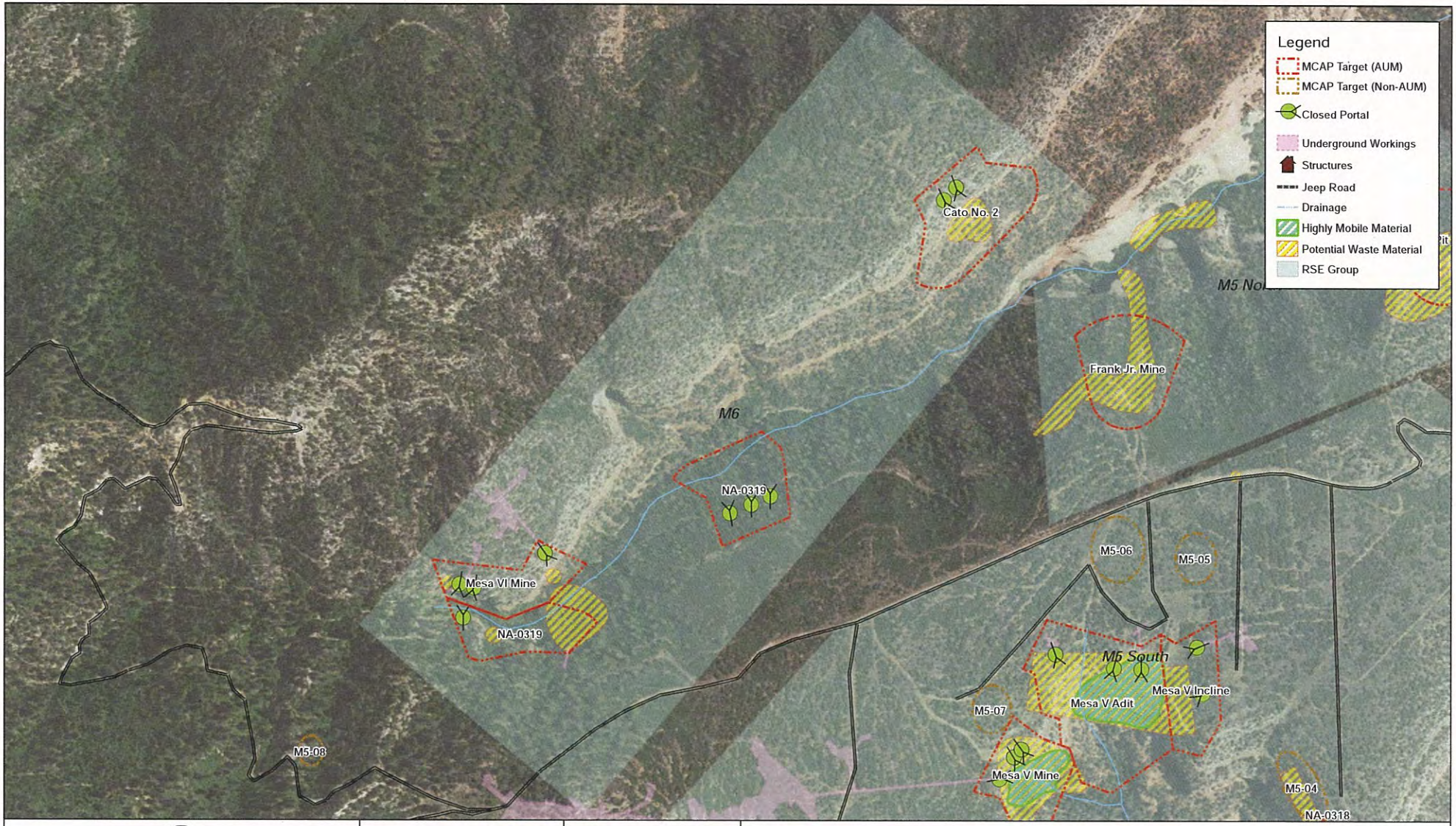
Figure 20 A
M6 Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 20 B
M6 Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

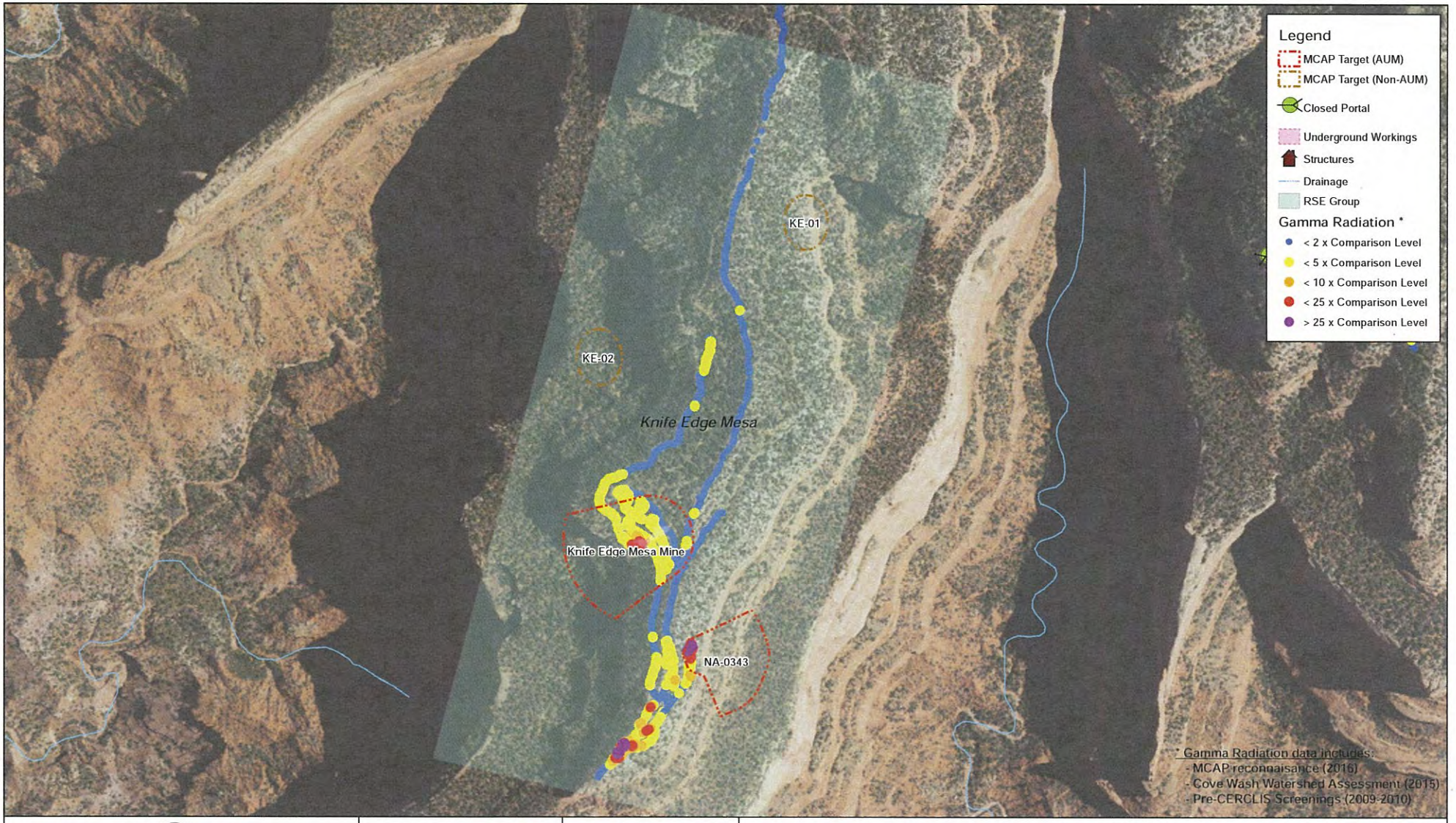
Figure 20 C
M6 Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 21 A
Knife Edge Mesa Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



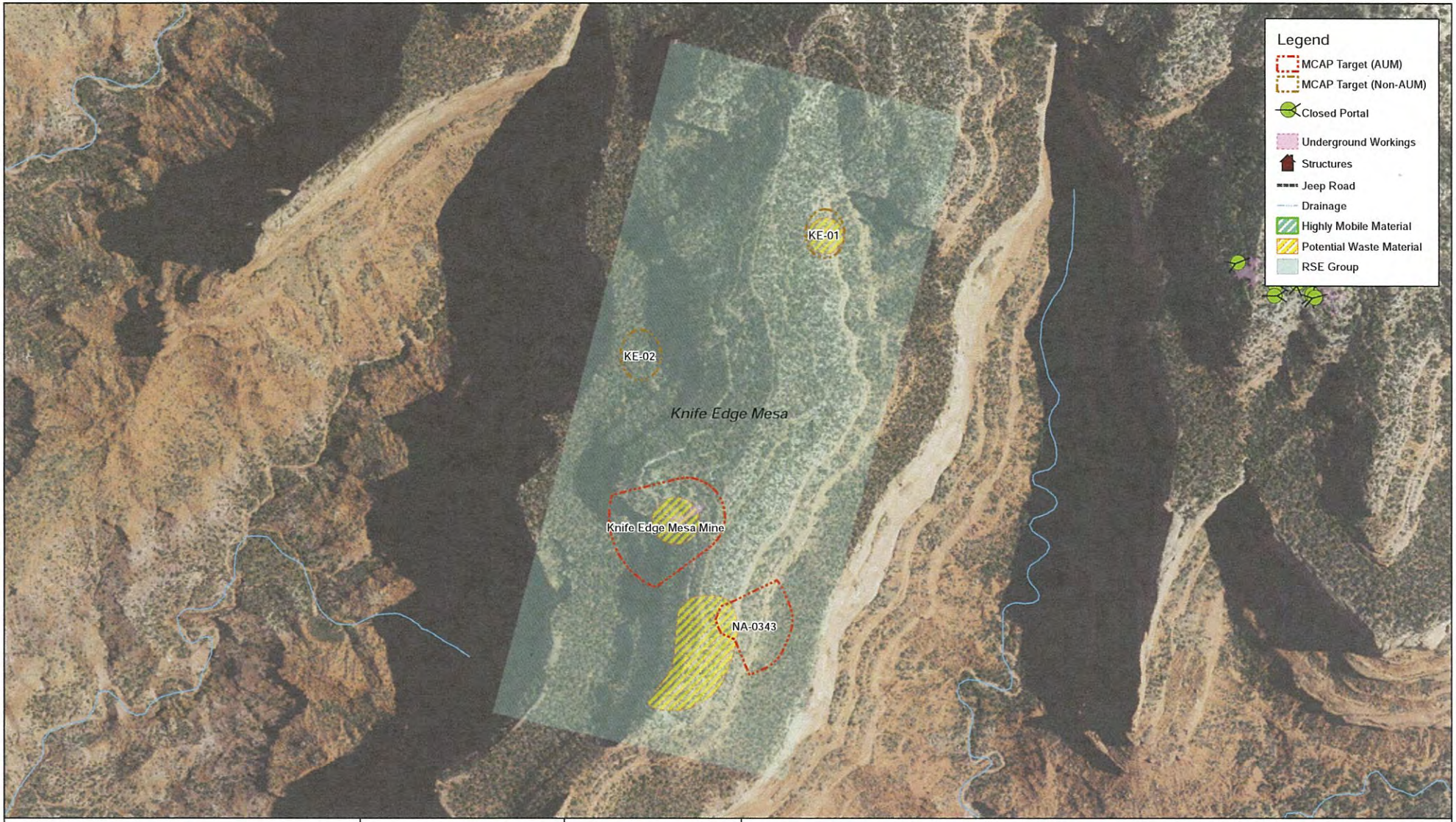
N

0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 21 B
Knife Edge Mesa Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

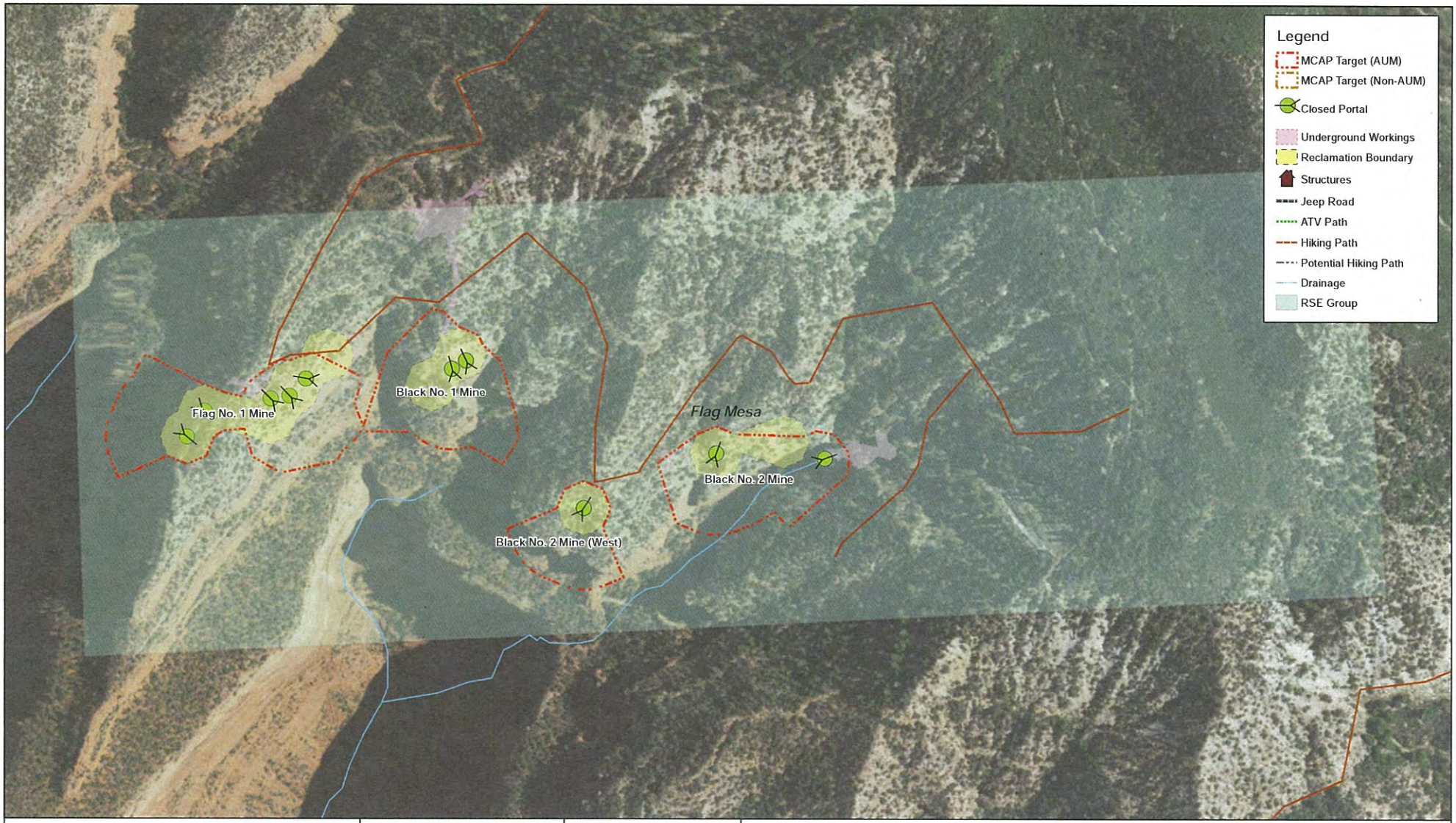


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

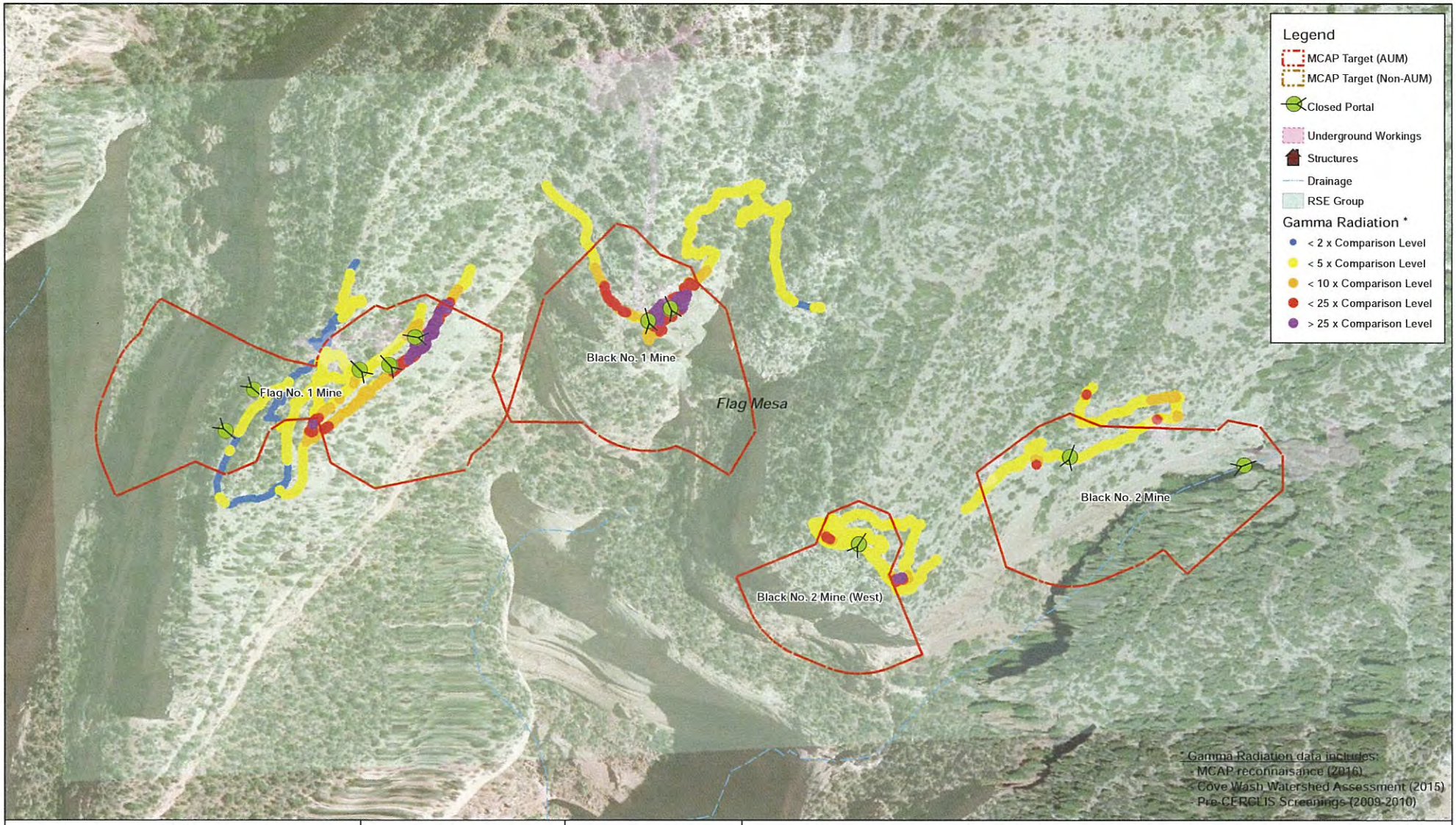
Figure 21 C
Knife Edge Mesa Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 22 A
Flag Mesa Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



0 250 500 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

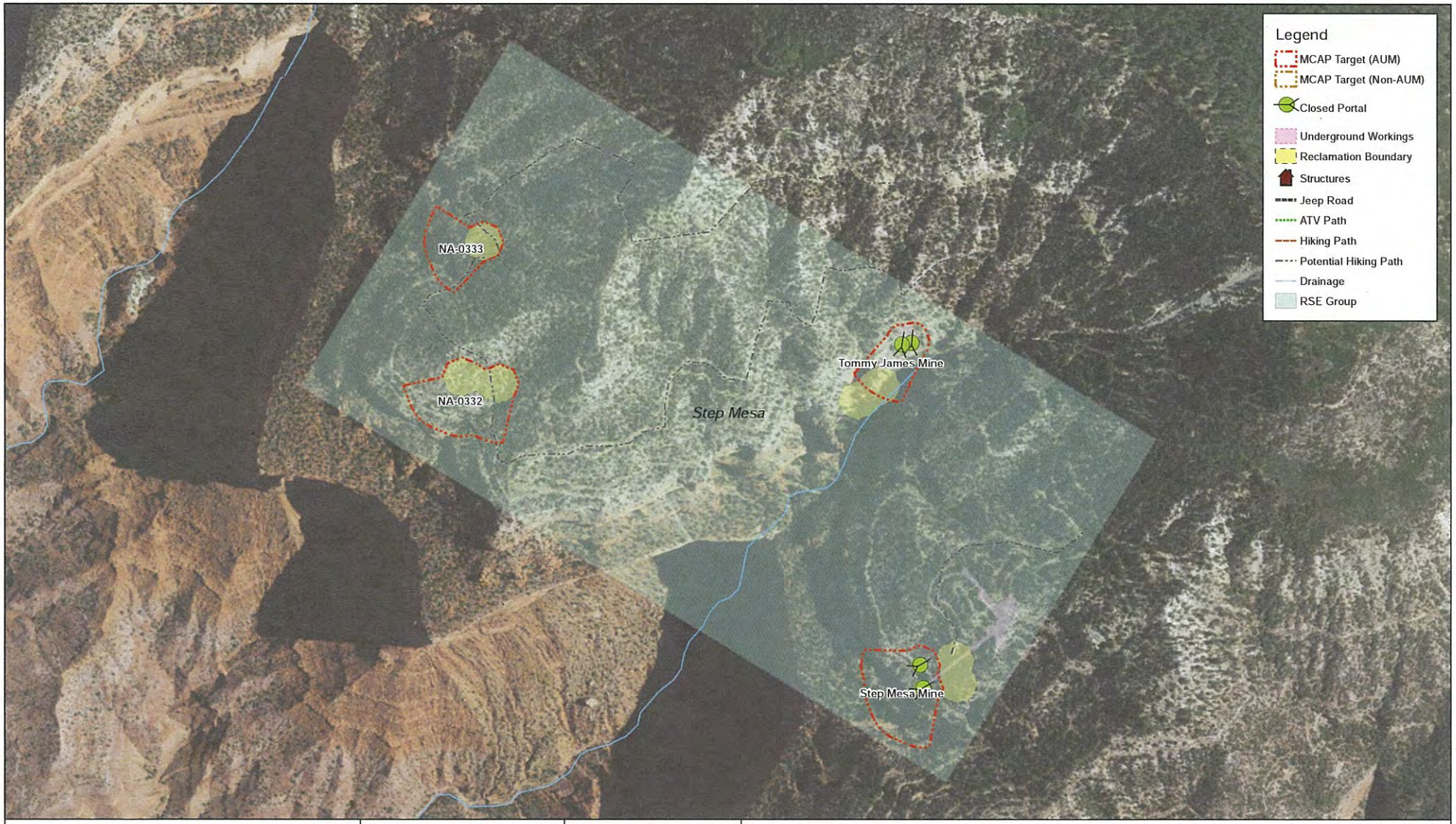
PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 22 B
Flag Mesa Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

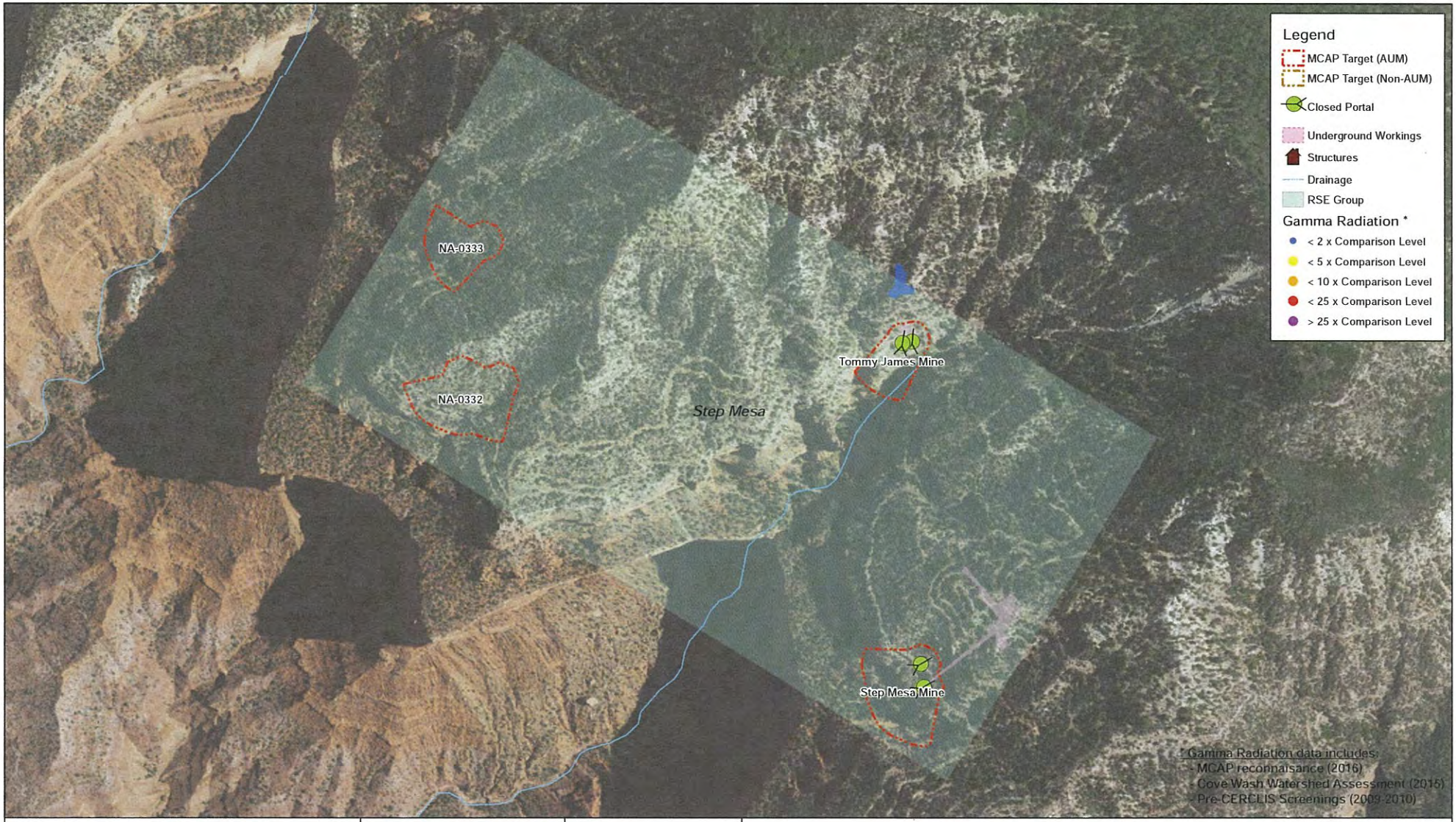
Figure 22 C
Flag Mesa Removal Evaluation Group - Waste Material Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 23 A
Step Mesa Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

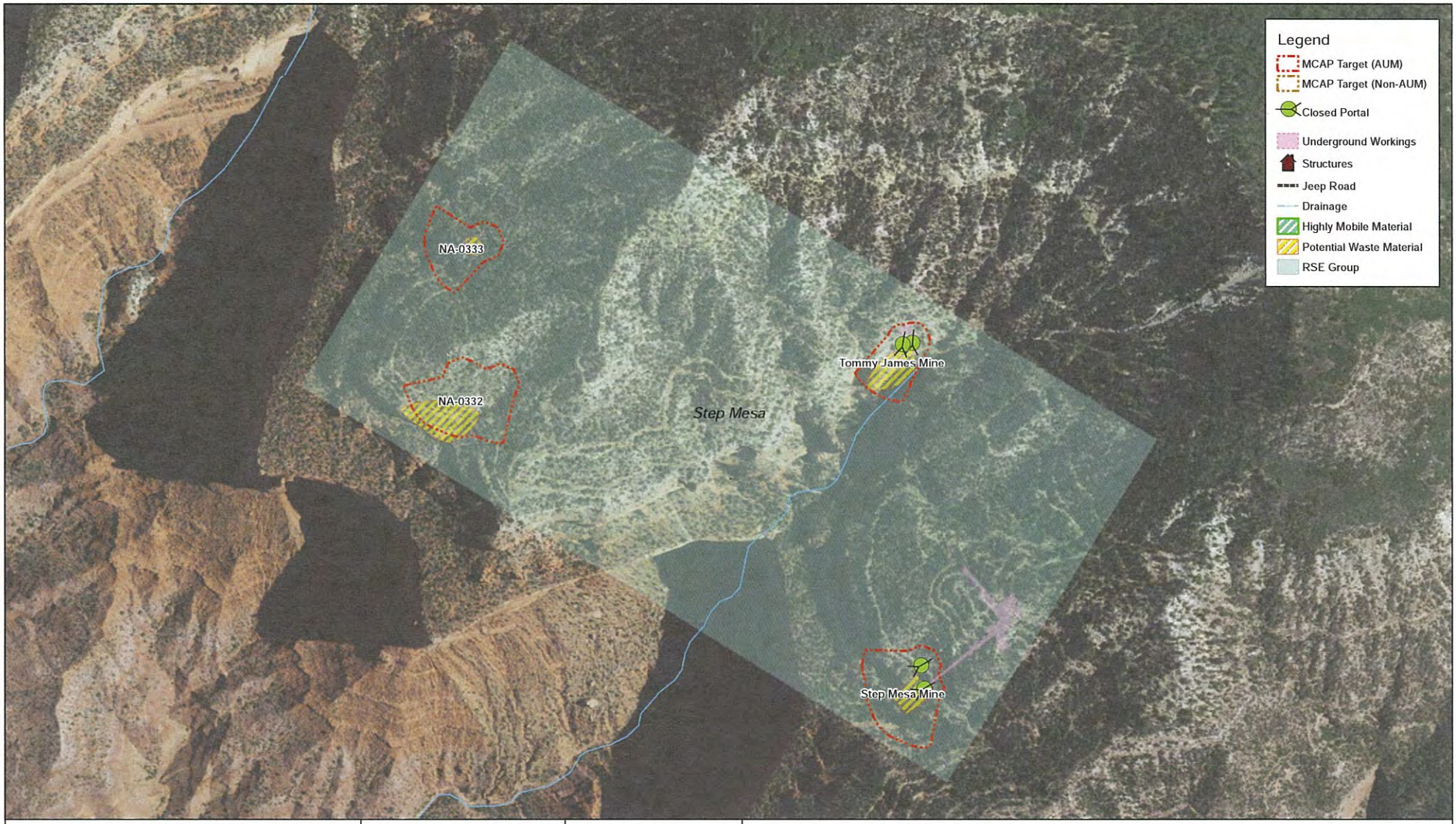


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 23 B
Step Mesa Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

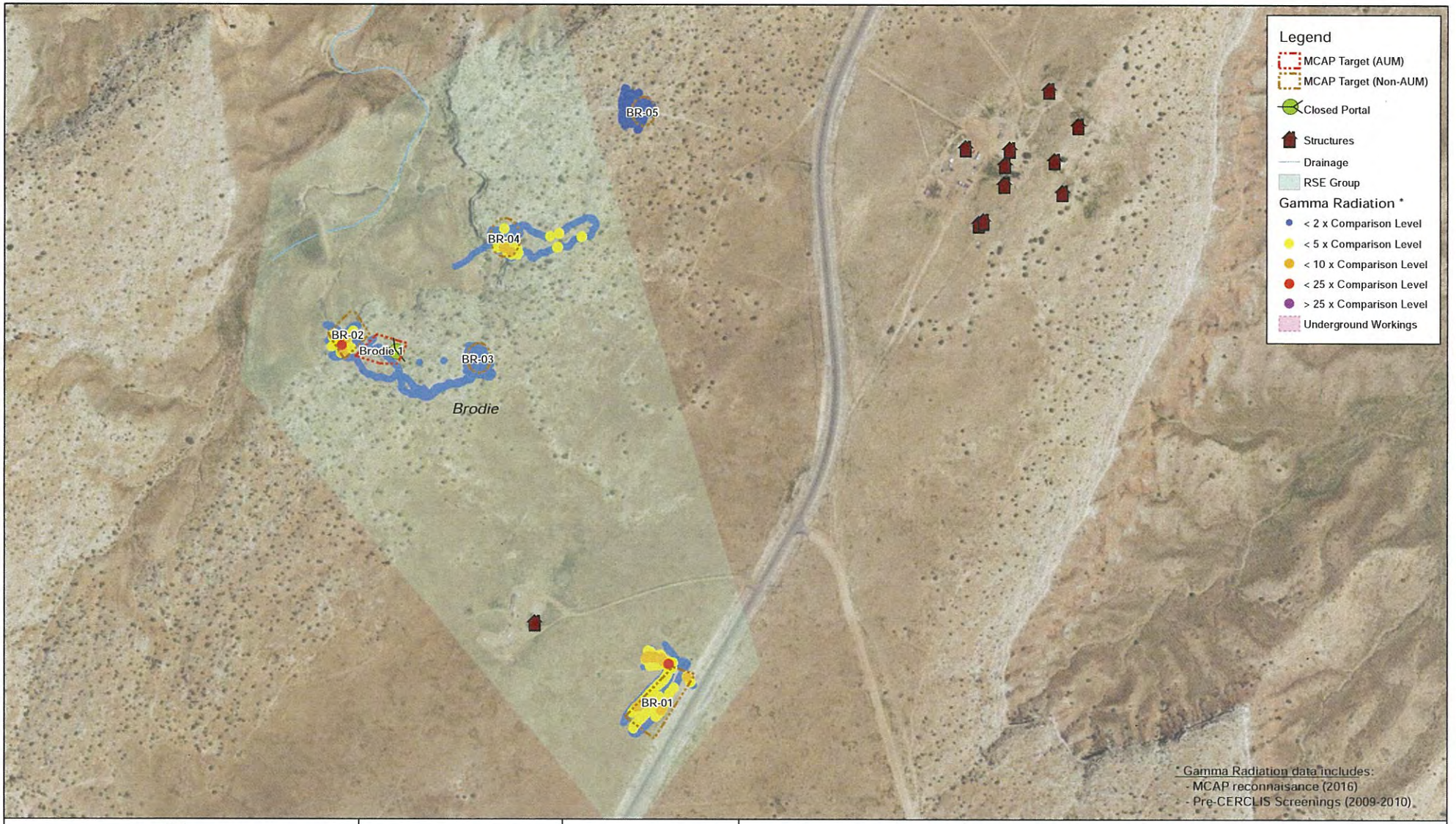
PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 23 C
Step Mesa Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

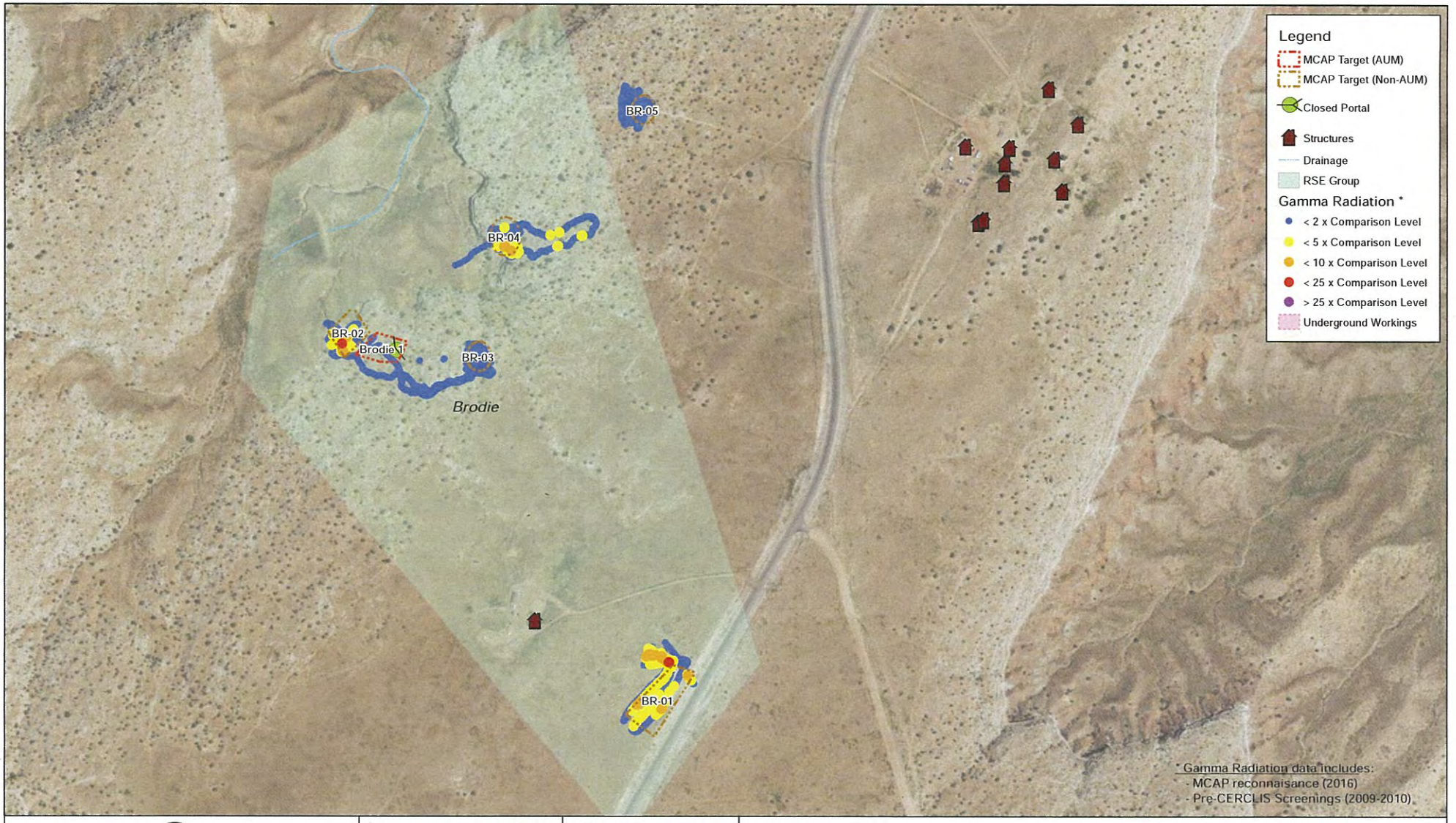
Figure 24 A
Brodie Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 24 B
Brodie Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

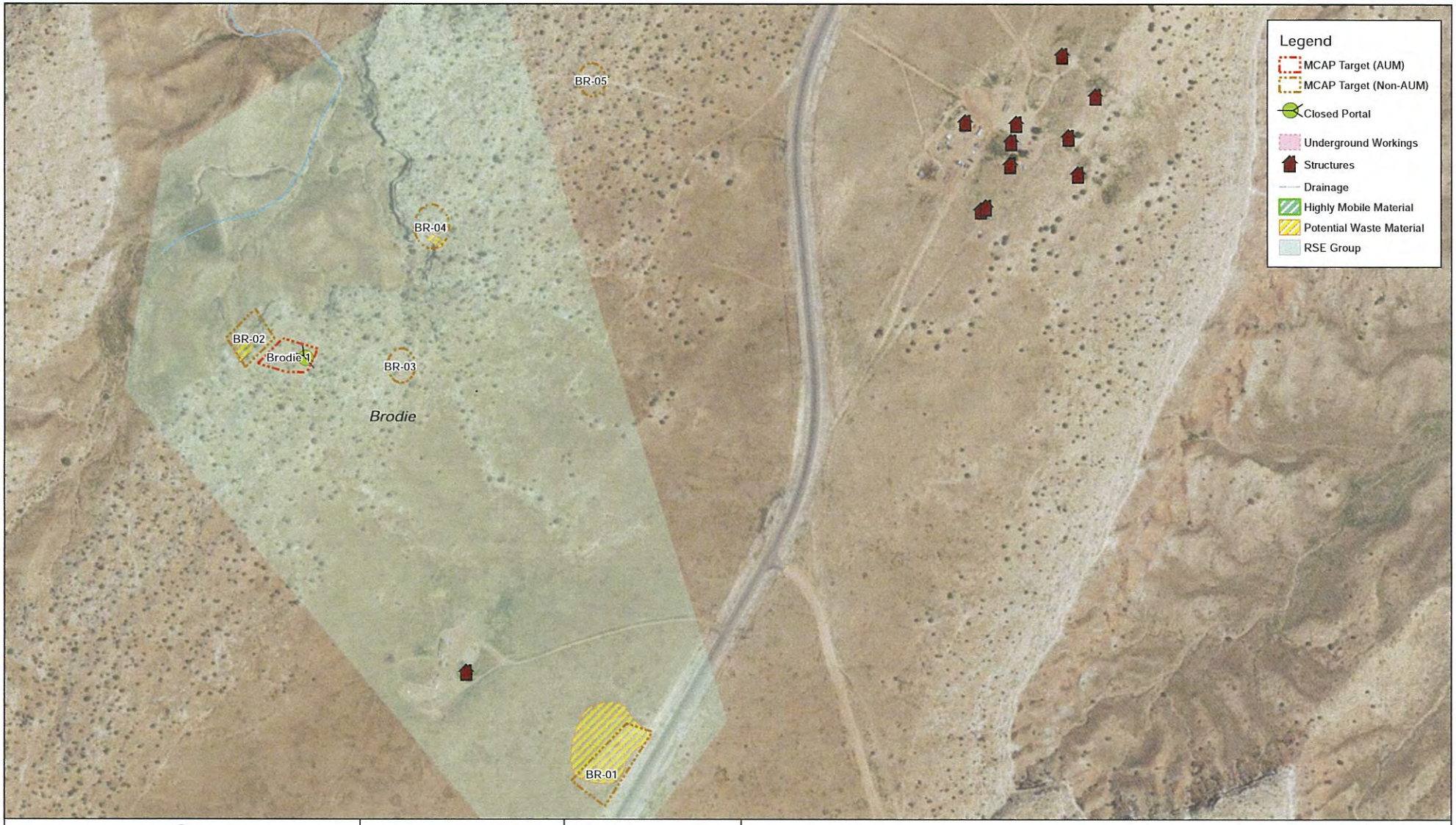


0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 24 B
Brodie Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

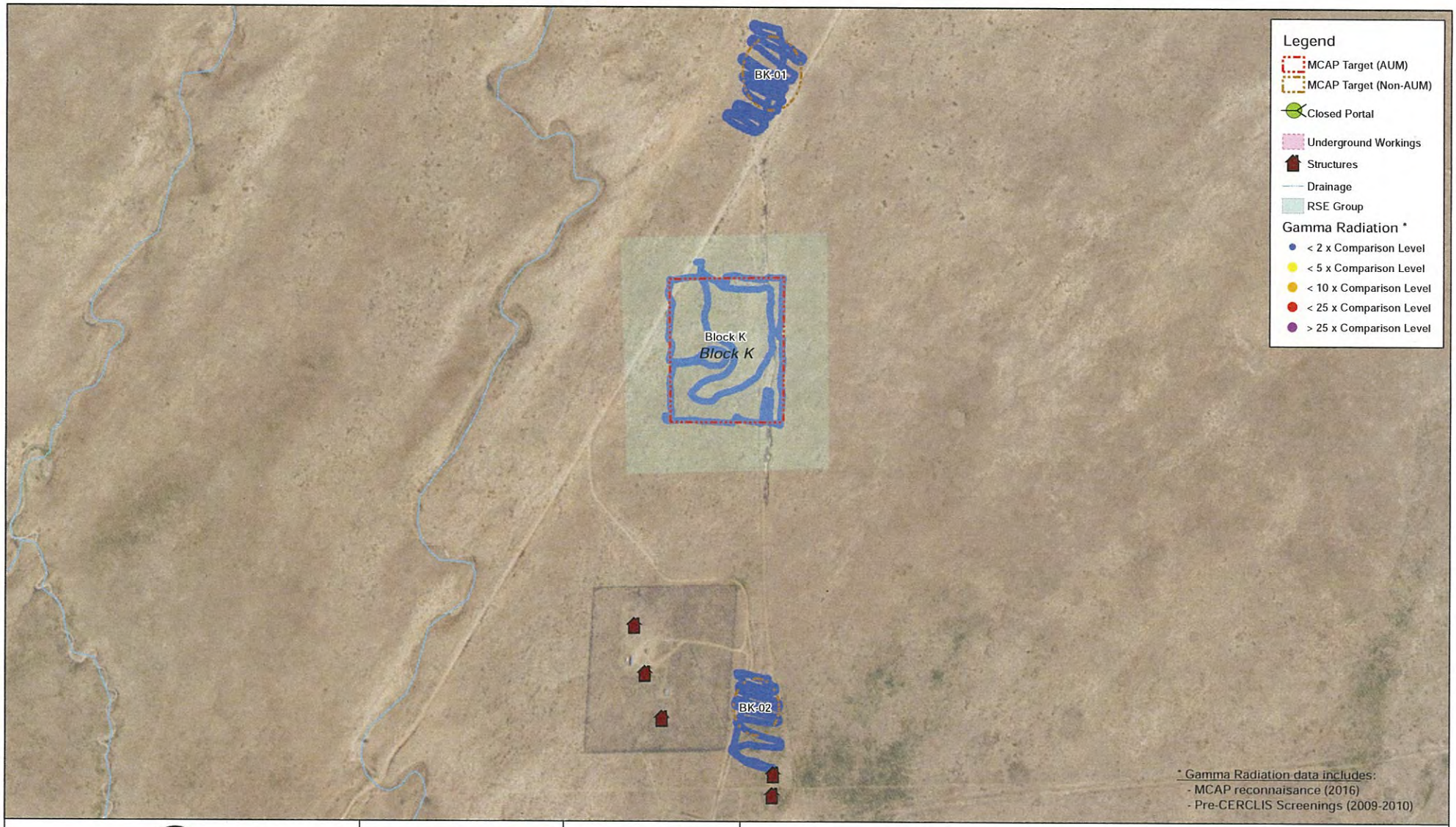
Figure 24 C
Brodie Removal Evaluation Group - Waste Material
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

0 250 500 1,000 Feet

PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 25 A
Block K Removal Evaluation Group - Layout
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ



PREPARED BY:
Region 9, START
Weston Solutions, Inc.
1340 Treat Blvd, Ste 210
Walnut Creek, CA 94597

PREPARED FOR:
EPA Region 9
Pacific
Southwest

Figure 25 B
Block K Removal Evaluation Group - Elevated Gamma Radiation
Mine Category Assessment Protocol
Apache County, Navajo Nation, AZ

ATTACHMENT V
ATSDR ToxFAQ (Radon, Uranium, and Radium)

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

RADIUM
CAS # 7440-14-4

This fact sheet answers the most frequently asked health questions (FAQs) about radium. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Radium is a radioactive substance formed from the breakdown of uranium and thorium. Exposure to high levels results in an increased risk of bone, liver, and breast cancer. This chemical has been found in at least 18 of the 1,177 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is radium?

(Pronounced rā′dē-əm)

Radium is a naturally occurring silvery-white radioactive metal that can exist in several forms called isotopes. Radium is formed when uranium and thorium break down in the environment. Uranium and thorium are found in small amounts in most rocks and soil. Two of the main radium isotopes found in the environment are radium-226 and radium-228.

Radium undergoes radioactive decay. It divides into two parts—one part is called radiation and the other part is called a daughter. The daughter, like radium, is not stable, and it also divides into radiation and another daughter. The dividing of daughters continues until a stable, nonradioactive daughter is formed. During the decay process, alpha, beta, and gamma radiation are released. Alpha particles can travel only a short distance and cannot travel through your skin. Beta particles can penetrate through your skin, but they cannot go all the way through your body. Gamma radiation can go all the way through your body.

Radium has been used as a radiation source for treating cancer, in radiography of metals, and combined with other metals as a neutron source for research and radiation instrument calibration. Until the 1960s, radium was a component of the luminous paints used for watch and clock dials, intrument panels in airplanes, military instruments, and compasses.

What happens to radium when it enters the environment?

- ❑ Radium is constantly being produced by the radioactive decay of uranium and thorium.
- ❑ Radium is present at very low levels in rocks and soil and may strongly attach to those materials.
- ❑ Radium may also be found in air.
- ❑ High concentrations are found in water in some areas of the country.
- ❑ Uranium mining results in higher levels of radium in water near uranium mines.
- ❑ Radium in the soil may be absorbed by plants.
- ❑ It may concentrate in fish and other aquatic organisms.

How might I be exposed to radium?

- ❑ Everyone is exposed to low levels of radium in the air, water, and food.

- Higher levels may be found in the air near industries that burn coal or other fuels.
- It may be found at higher levels in drinking water from wells.
- Miners, particularly miners of uranium and hard rock, are exposed to higher levels of radium.
- It may also be found at radioactive waste disposal sites.

How can radium affect my health?

Radium has been shown to cause effects on the blood (anemia) and eyes (cataracts). It also has been shown to affect the teeth, causing an increase in broken teeth and cavities. Patients who were injected with radium in Germany, from 1946 to 1950, for the treatment of certain diseases including tuberculosis were significantly shorter as adults than people who were not treated.

How likely is radium to cause cancer?

Exposure to high levels of radium results in an increased incidence of bone, liver, and breast cancer. The EPA and the National Academy of Sciences, Committee on Biological Effects of Ionizing Radiation, has stated that radium is a known human carcinogen.

Is there a medical test to show whether I've been exposed to radium?

Urine tests can determine if you have been exposed to radium. Another test measures the amount of radon (a breakdown product of radium) in exhaled air. Both types of tests require special equipment and cannot be done in a doctor's office. These tests cannot tell how much radium you were exposed to, nor can they be used to predict whether you will develop harmful health effects.

Has the federal government made recommendations to protect human health?

The EPA has set a drinking water limit of 5 picocuries per liter (5 pCi/L) for radium-226 and radium-228 (combined).

The EPA has set a soil concentration limit for radium-226 in uranium and thorium mill tailings of 5 picocuries per gram (5 pCi/g) in the first 15 centimeters of soil and 15 pCi/g in deeper soil.

The federal recommendations have been updated as of July 1999.

Glossary

Anemia: A decreased ability of the blood to transport oxygen.

Carcinogen: A substance that can cause cancer.

CAS: Chemical Abstracts Service.

National Priorities List: A list of the nation's worst hazardous waste sites.

Picocurie (pCi): A unit used to measure the quantity of radioactive material.

rem: A unit used to measure radiation dose.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. Toxicological profile for radium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

Radon - ToxFAQs™

CAS # 10043-92-2 and 14859-67-7

This fact sheet answers the most frequently asked health questions (FAQs) about radon. For more information, call the CDC Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Radon is an odorless, colorless, tasteless, naturally-occurring radioactive gas formed from the breakdown of uranium and thorium. Exposure to high levels results in an increased risk of lung cancer.

What is radon?

Radon is a naturally occurring, radioactive, noble gas that is odorless, colorless, and tasteless. It is formed as part of three radioactive decay chains that begin with uranium or thorium. These elements are found in small amounts in most rock, soil, and water. Each atom of uranium or thorium decays or transforms about a dozen times, each time expelling radiation and forming a different element with different radioactive properties. Radium and then radon are formed midway through these decay chains.

Since radon is a noble gas, it releases from any chemical bonds that attach it, and it may travel far enough to reach groundwater or the air.

Radon progeny is the term given to those radioactive atoms with short half-lives into which radon quickly decays. Air, soil, and water contain many atoms that are at various points in these decay chains. A sample of any one is expected to contain a mixture of these radioactive elements or radionuclides, including radon and radon progeny.

What happens to radon when it enters the environment?

- Radon gas released from rocks and soil can move to air, groundwater, and surface water.
- Radon-222 has a radioactive half-life of about 4 days; this means that one-half of a given amount of radon will decay to radon progeny every 4 days.
- Radon progeny are solid particles that can be trapped inside the earth or, if in the air when radon decays, can attach to dust and other particles and move with the air. Radon progeny that are attached to dust can be removed by air filters.

How might I be exposed to radon and radon progeny?

- Radon is normally found at very low levels in outdoor air.
- Radon progeny are often attached to dust; you are exposed to them primarily by breathing them in.
- Radon and radon progeny are normally found at higher levels in indoor air in homes, schools, and office buildings.
- Concrete construction materials or cracks in the basement or foundation of a home may allow higher levels of radon and radon progeny inside the home.
- Elevated levels of radon and radon progeny can be found in areas with elevated levels of uranium or thorium. This can include most any mining or milling operation involving metals or phosphates.
- Radon and radon progeny are normally found in surface and groundwater and are expected to be in drinking water from these sources. They are also found in drinking water from wells that contain radon. Radon in water can become airborne especially when the water is used for cooking or showering.

How can radon and radon progeny affect my health?

When radon or radon progeny undergo radioactive decay, some of the decays expel high-energy alpha particles, which are the main source of health concerns. The main isotope of health concern is radon-222 (^{222}Rn).

Many scientists believe that the alpha radiation dose from long-term exposure to elevated levels of radon progeny

CAS # 10043-92-2 and 14859-67-7

in air increases your chance of getting lung cancer. Cigarette smoking greatly increases your chance of developing lung cancer if you are exposed to radon and radon progeny at the same levels as people who do not smoke.

How likely are radon and radon progeny to cause cancer?

The Department of Health and Human Services (DHHS), International Agency for Research on Cancer (IARC), and the Environmental Protection Agency (EPA) consider radon to be a human carcinogen. The greater your exposure to radon, especially if you smoke cigarettes, the greater your chance of developing lung cancer.

How can radon and radon progeny affect children?

Smaller lungs and faster breathing rates may result in higher radiation doses to the lungs of children relative to adults. However, limited information from children employed as miners in China do not provide evidence of increased susceptibility to the effects of exposure to radon.

How can families reduce the risk of exposure to radon and radon progeny?

Indoor radon and radon progeny levels can be reduced by methods that include sealing the pathways through which radon can enter a building and installing a ventilation system that routes air from underneath the building (either under the slab or in the crawl space) to outdoor air. For more information, contact your state radon office, a professional radon testing and mitigation firm, the National Environmental Health Association's National Radon Proficiency Program, or the National Radon Safety Board.

Is there a medical test to determine whether I've been exposed to radon and radon progeny?

Radon in human tissues is not detectable by routine medical testing. Some radon progeny can be detected in urine and in lung and bone tissue. These tests cannot tell how much radon you were exposed to, nor can they be used to predict whether you will develop harmful health effects. Radon exposure is estimated by measuring radon levels in the air.

Has the federal government made recommendations to protect human health?

The EPA recommends fixing your home if measured indoor levels of radon are 4 or more picocuries per liter of air (4 pCi/L). The EPA also notes that radon levels less than 4 pCi/L still pose a health risk and can be reduced in many cases. If indoor radon levels need to be reduced, the EPA recommends using a certified radon mitigation specialist to ensure that appropriate methods are used to reduce radon levels.

The Mine Safety and Health Administration (MSHA) has adopted an exposure limit of 4 Working Level Months (WLM) per year for people who work in mines (WLMs basically combine the concentration of radon progeny in mine air with length of exposure inside the mine).

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological Profile for Radon. Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information?

For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, 1600 Clifton Road NE, Mailstop F-57, Atlanta, GA 30329-4027.

Phone: 1-800-232-4636 FAX: 770-488-4178.

ToxFAQs™ Internet address via WWW is http://www.atsdr.cdc.gov/toxfaqs/index.asp.

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

Natural & Depleted Uranium - ToxFAQs™

CAS # 7440-61-1

This fact sheet answers the most frequently asked health questions (FAQs) about natural and depleted uranium. For more information, call the CDC Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Natural uranium is a naturally occurring chemical substance that is mildly radioactive. Depleted uranium is an adjusted mixture of natural uranium isotopes that is less radioactive. Everyone is exposed to low amounts of uranium through food, water, and air. Exposure to high levels of natural or depleted uranium can cause kidney disease. Uranium has been found in at least 67 of 1,699 National Priorities List (NPL) sites identified by the Environmental Protection Agency (EPA).

What is uranium?

Uranium is a naturally occurring radioactive element. It is naturally present in nearly all rocks, soils, and air; can be redistributed in the environment through wind and water erosion; and more can be released into the environment through volcanic eruptions. Natural uranium is a mixture of three isotopes: ^{234}U,235U, and ^{238}U. The most common isotope is ^{238}U; it makes up over 99% of natural uranium. All three isotopes behave the same chemically, but they have different radioactive properties. The half-lives of uranium isotopes (the amount of time needed for half of the isotope to give off its radiation and change into a different element) is very long. The least radioactive isotope is ^{238}U with a half life of 4.5 billion years. Depleted uranium is a mixture of the same three uranium isotopes except that it has very little ^{234}U and ^{235}U. It is less radioactive than natural uranium. Enriched uranium is another mixture of isotopes that has more ^{234}U and ^{235}U than natural uranium. Enriched uranium is more radioactive than natural uranium.

Uranium is almost as hard as steel and much denser than lead. Natural uranium is used to make enriched uranium; depleted uranium is the leftover product. Enriched uranium is used to make fuel for nuclear power plants. Depleted uranium is used as a counterbalance on helicopters rotors and airplane control surfaces, as a shield to protect against ionizing radiation, as a component of munitions to help them penetrate enemy armored vehicles, and as armor in some parts of military vehicles.

What happens to uranium when it enters the environment?

- Natural and depleted uranium that exist in the dust in the air settle onto water, land, and plants. Uranium deposited on land can be reincorporated into soil, washed into surface water, or stick to plant roots. Uranium in air, surface water, or groundwater can be transported large distances.

How might I be exposed to uranium?

- Food and drinking water are the primary sources of intake for the general public. Very low levels of uranium are found in the air.
- Root crops such as potatoes, parsnips, turnips, and sweet potatoes contribute the highest amounts of uranium to the diet. Because uranium in soil can stick to these vegetables, the concentrations in these foods are directly related to the concentrations of uranium in the soil where the foods are grown.
- In most areas of the United States, low levels of uranium are found in the drinking water. Higher levels may be found in areas with elevated levels of naturally occurring uranium in rocks and soil.
- People may be exposed to higher levels of uranium if they live near uranium mining, processing, and manufacturing facilities. People may also be exposed if they live near areas where depleted uranium weapons are used.

How can uranium enter and leave my body?

Most of the uranium you breathe or ingest is not absorbed and leaves the body in the feces. Absorbed uranium is deposited throughout the body. The highest levels are found in the bones, liver, and kidneys; 66% of the uranium in the body is found in your bones. It can remain in the bones for a long time; the half-life of uranium in bones is 70–200 days. Most of the uranium that is not in bones leaves the body in the urine in 1–2 weeks.

How can uranium affect my health?

Natural uranium and depleted uranium have the identical chemical effect on your body. Kidney damage has been seen in humans and animals after inhaling or ingesting

CAS # 7440-61-1

uranium compounds. However, kidney damage has not been consistently found in soldiers who have had uranium metal fragments in their bodies for several years. Ingesting water-soluble uranium compounds will result in kidney effects at lower doses than following exposure to insoluble uranium compounds.

Studies in animals have shown that inhalation exposure to insoluble uranium compounds can result in lung damage. In male rats and mice, exposure to uranium has been shown to decrease fertility. Uranium compounds on the skin caused skin irritation and mild skin damage in animals.

Health effects of natural and depleted uranium are due to chemical effects and not to radiation.

How likely is uranium to cause cancer?

Neither the National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC) nor the EPA have classified natural uranium or depleted uranium with respect to carcinogenicity.

How can uranium affect children?

The health effects seen in children from exposure to toxic levels of uranium are expected to be similar to the effects seen in adults.

Exposure of animals to high levels of uranium during pregnancy, which caused toxicity in the mothers, has induced early deaths and birth defects in the young. It is not clear if this can happen in the absence of effects on the mother. We do not know whether uranium can cause birth defects in people. There are some studies that suggest that exposure to depleted uranium increased the frequency of birth defects, but the studies are deficient to allow valid conclusions.

How can families reduce the risk of exposure to uranium?

- Avoid eating root vegetables grown in soils with high levels of uranium. Consider washing fruits and vegetables grown in that soil and discard the outside portion of root vegetables.
- Consider having your water tested if you suspect that your drinking water might have elevated levels of uranium; if elevated levels are found, consider using bottled water.

Is there a medical test to determine whether I've been exposed to uranium?

Natural uranium is in your normal diet, so there will always be some level of uranium in all parts of your body. If depleted uranium is present, it adds to the total uranium level. Uranium can be measured in blood, urine, hair, and body tissues. Most tests are for total uranium; however, expensive tests are available to estimate the amounts of both natural and depleted uranium that are present.

Has the federal government made recommendations to protect human health?

The government has made recommendations for uranium which apply to natural and depleted uranium combined.

The EPA established a maximum drinking water contaminant level of 0.03 mg/L.

The Occupational Safety and Health Administration (OSHA) has limited workers' exposure in air to an average of 0.05 mg U/m^3 for soluble uranium and 0.25 mg U/m^3 for insoluble uranium over an 8-hour workday.

The National Institute for Occupational Safety and Health (NIOSH) recommends workers exposure be limited to 0.05 mg U/m^3 of air for soluble uranium and 0.2 mg U/m^3 for insoluble uranium averaged over a 10-hour workday and recommends that exposure to soluble uranium not exceed 0.6 mg U/m^3 for more than 15 minutes.

The Nuclear Regulatory Commission (NRC) has established air concentration limits for uranium and its individual isotopes that apply to occupational exposure and releases from facilities.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2013. Toxicological Profile for Uranium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, 1600 Clifton Road NE, Mailstop F-57, Atlanta, GA 30329-4027.

Phone: 1-800-232-4636.

ToxFAQs™ Internet address via WWW is http://www.atsdr.cdc.gov/toxfaqs/index.asp.

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.