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BUILDING A BETTER WORLD

July 18, 2014

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RE: **Pre-Design Studies Report**
Northeast Church Rock Removal Action
McKinley County, New Mexico

Dear Ms. Jacobs and Ms. Norman:

MWH has uploaded the following documents to the Northeast Church Rock (NECR) Remedy Design Team Site for your review, on behalf of United Nuclear Corporation (UNC):

- *Pre-Design Studies, Northeast Church Rock Mine Site Removal Action, Church Rock Mill Site*
- *Pre-Design Studies, Northeast Church Rock Mine Site Removal Action, Northeast Church Rock Mine Site*

The documents are located on the NECR Team Site https://amcollab.mwhglobal.com/sites/necrremedy/default.aspx) in the following location: *Project Documents > Working Documents > Reports > Pre-Design Studies Report.*

The appendices will be uploaded to the Team Site next week. The PDF of the reports and appencies are in an NRC-compliant format. A hard copy of the report and a CD containing the appendices will be mailed to US DOE and NN EPA next week. If you have any questions regarding this letter or the information attached, please feel free to contact me at (970) 871-4361.

Sincerely,
MWH Americas, Inc.

Toby Leeson, P.G.
Removal Action Project Manager

PDS Report transmittal letter.docx

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Pre-Design Studies

Northeast Church Rock Mine Site Removal Action

Northeast Church Rock Mine Site

July 21, 2014

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DRAFT

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
ASA	American Society of Agronomy
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
COPC	Constituent of Potential Concern
cpm	counts per minute
cy	cubic yards
EDRA	East Drainage Removal Action
ELI	Energy Laboratories, Inc.
FSL	Field Screening Level
FSP	Field Sampling Plan
GE	General Electric
HASP	Health and Safety Plan
IRA	Interim Removal Action
mg/kg	milligrams per kilogram
MMD	Mining and Minerals Division
NECR	Northeast Church Rock
NEMSA	non-economic materials storage area
NMMA	New Mexico Mining Act
NNEPA	Navajo Nation Environmental Protection Agency
NRC	Nuclear Regulatory Commission
PACM	Potential asbestos containing materials
pcf	per cubic foot
pCi/g	picoCurie per gram
PDS	Pre-Design Studies
PTW	Principal Threat Waste
QAPP	Quality Assurance Project Plan
Ra-226	Radium 226
RA	Removal Action
RAL	Removal Action Level
RCRA	Resource Conservation and Recovery Act of 1976
ROD	Record of Decision
RSE	Removal Site Evaluation
SAR	Sodium Absorption Ratio
sf	square foot
SPLP	Synthetic precipitation leaching procedure
SRSE	Supplemental Removal Site Evaluation
TCLP	Toxicity characteristic leaching procedure
TPH	Total Petroleum Hydrocarbons
UNC	United Nuclear Corporation
USEPA	United Stated Environmental Protection Agency

1 INTRODUCTION

This Pre-Design Studies Report summarizes the pre-design studies (PDS) conducted at the Northeast Church Rock Mine Site (Mine Site) in preparation for design of the proposed Northeast Church Rock (NECR) Mine Removal Action (RA), which consists of removal of mine soil and waste materials and placement in a repository constructed at the United Nuclear Corporation (UNC) Church Rock Mill Site. The Mine Site is approximately 16 miles northeast of Gallup, NM, as shown on Figure 1-1, *Site Location Map.* A map of the Mine Site is shown on Figure 1-2, *Mine Site Layout.* Figure 1-3, *Regional Map,* shows both the Mill Site and the Mine Site.

The PDS described in the report were conducted in accordance with the *Northeast Church Rock Mine Site Removal Action, Pre-Design Studies Work Plan*, Northeast Church Rock Mine Site (MWH, 2013a), hereafter referred to as the Work Plan. The scope and objectives of the PDS are described in the Work Plan. The goal of the PDS was to collect pre-design data necessary to design the RA in accordance with the proposed performance standards and the United States Environmental Protection Agency Region 9 (USEPA) *Action Memorandum: Request for Non-Time Critical Removal Action at the Northeast Church Rock Mine Site* (Action Memo) (USEPA, 2011a) and the USEPA Region 6 *Proposed Plan* (USEPA, 2012) and *Record of Decision* (ROD)(USEPA, 2013).

1.1 REPORT BACKGROUND

As part of the pre-design data needs evaluation for the RA, MWH identified the major RA design elements and reviewed available site data. The existing data were evaluated for completeness based on the information necessary to design each element of the RA. The Work Plan (MWH, 2013a) identified data needs and presented field sampling plans to obtain the data necessary for design of the RA. This PDS report is one of two separate reports for the NECR RA, and describes results of the PDS conducted at the Mine Site. Results of the PDS conducted at the Mill Site will be submitted separately.

1.2 REPORT OBJECTIVES AND SCOPE

The overall objective of the PDS was to collect data and information necessary to design the RA. The primary objective of this report is to summarize sampling activities and results of the PDS. This report presents descriptions and results of the PDS, as well as a summary of the extensive previous investigations conducted at the Mine Site, primarily related to the Removal Site Evaluation (RSE). Specifically, this report presents:

- A summary of previous investigations conducted at the Mine Site
- A summary of the scope, methods and results of the PDS investigations performed
- A narrative interpretation of PDS data and results

- Resultant design parameters and design criteria
- Conclusions and recommendations for the RA design at the Mine Site

The report contents include the following:

- Section 1 – Background and objectives
- Section 2 – Summaries of previous investigations and interim removal actions
- Section 3 – Description of the scope of the PDS
- Section 4 – Summary of the results of the PDS
- Section 5 – Conclusions and recommendations
- Section 6 – References cited

Laboratory data reports, drilling logs, and field photographs documenting the PDS work are included in the appendices.

2 PRIOR INVESTIGATIONS AND INTERIM REMOVAL ACTIONS

As part of the pre-design data needs evaluation, MWH identified major RA design elements and reviewed available information and data from prior investigations and interim removal actions conducted at the Mine Site to determine what additional data needs remained. MWH reviewed historical information and data including the following:

- mining operations and closeout activities
- numerous field investigations and characterization of the mining impacts
- geophysical and subsurface investigations of mine debris
- geotechnical and agronomic parameter investigations
- shaft and vent assessments
- cultural resources surveys
- vegetation and wildlife surveys
- interim removal actions

Section 2.1 summarizes previous investigations and Section 2.2 summarizes the interim removal actions conducted at the Mine Site.

2.1 PREVIOUS INVESTIGATIONS

2.1.1 2.1.1 Soils Radiological and Metals Characterization

The initial Removal Site Evaluation (RSE) at the Mine Site was conducted in 2007 (MWH, 2007a) to determine the extent of radium-226 (Ra-226) above the field screening level of 2.24 picoCurie per gram (pCi/g) and to evaluate preliminary constituents of potential concern (COPCs): Ra-226, arsenic, molybdenum, selenium, uranium, and vanadium in surface and subsurface soils. Several supplemental RSEs were subsequently conducted through 2011, to refine the characterization of Ra-226 in surface and subsurface soils. The results of the RSEs and supplemental RSEs were presented in the following reports:

- Removal Site Evaluation Report (MWH, 2007a)
- Supplemental Removal Site Evaluation Report (MWH, 2008)
- Removal Site Evaluation Report, Red Water Pond Road (MWH, 2010a)
- Supplemental Removal Site Evaluation Report, East Drainage Area (MWH, 2011a)

The first two RSEs investigated surface and subsurface soils at the Mine Site and SO-1. The two supplemental RSEs conducted in 2010 and 2011 investigated both surface and subsurface soils along Red Water Pond Rd. and the East Drainage Area, east of Red Water Pond Rd. (see Figure 1-2). The locations of the RSE and SRSE subsurface samples are shown in Figure 2-1, *Subsurface Soil Sampling Locations*; surface soil sample locations are presented in Section 3.

Field investigation methods used during the RSEs included scan and static gamma radiation surveys, ex-situ gamma radiation surveys, surface soil sampling, subsurface soil sampling and laboratory analysis. The investigations included over 2,300 static gamma measurements and collection of over 750 surface and subsurface soil samples for laboratory analysis.

The sampling results from the various investigation efforts were compiled to develop a set of tables and figures showing the extent of the mining impacts. These tables and figures were submitted to USEPA in 2008 and have been included in Appendix A.

2.1.2 Investigation of Petroleum-Impacted Soils

During soil excavation activities conducted in 2009 (see Section 2.2), soil and bedrock impacted with petroleum hydrocarbons were observed north of and beneath the northern portion of the NECR-1 pad (MWH, 2010b). Analytical testing of soil samples demonstrated that the material was predominantly diesel-range petroleum hydrocarbons (DROs) and that shallow soils contained both DROs and Ra-226 above the FSL. Soil and bedrock beneath the NECR-1 pad and in SO-1 were then investigated to estimate the extent of total petroleum hydrocarbon (TPH) impacts, as described in the document *Petroleum Investigation Results and Bioventing Pilot Study Plan* (MWH, 2010d). A bioventing pilot study was conducted in 2011 (MWH, 2011d), which demonstrated that DROs could be effectively treated by bioremediation and recommended bioventing, augmented by monitored natural attenuation, and excavation and stockpiling of soils containing DROs and Ra-226. The stockpiled soils containing DROs and Ra-226 will be managed with the mine soils as part of the RA. Approximately 4,000 cubic yards (cy) of TPH-impacted soil were excavated in 2009 and another approximately 3,700 cy were excavated in 2012. The excavated TPH-impacted soils were placed in the TPH Stockpile Area located south of Pond 3, as shown on Figure 1-2.

2.1.3 Geophysical Anomaly Survey and Subsurface Evaluation

A geophysical survey was conducted at the Mine Site in 2006 using magnetic and electromagnetic induction methods, as presented in the memorandum *Results of Geophysical Survey, Northeast Church Rock Mine Site* (MWH, 2007b), which is included in Appendix A. The survey revealed numerous, generally small, anomalies (buried material) within the fuel storage area, magazine area, NECR drainage, NEMSA, Pond 1, Trailer Park, and the Boneyard. All of the anomalies appeared to be small features, such as pieces of buried pipes or metal fencing, with the exception of two anomalies of substantial size in the Boneyard and in Pond 1, as described in Section 4.7.

In 2011 after consultation with former mine workers to attempt to better understand potential locations of subsurface debris, test trenches were excavated at locations of selected geophysical anomalies to visually characterize the types of materials potentially present (MWH, 2011b). One to two locations per area were selected, based on the anomaly strength, size and

location, for a total of 18 test trenches. During trenching, some type of metallic material was observed in each area, with the exception of Vent Holes 3 and 8 where metallic material was not detected. The Boneyard contained a large quantity of metallic material, mostly consisting of hoist cables, empty fire extinguishers, rusted empty barrels, wire mesh, rusted empty one-gallon refrigerant cans, and steel-reinforced cloth. In other areas, metallic objects were primarily single isolated objects or a few small objects together, consisting of hoist cable, electrical cable, iron pipe, wire mesh, rusted barrels, a culvert and other scrap metal. The quantity and size of these materials within each area was generally small.

2.1.4 Soils Geotechnical Characterization

Soils were collected from test pits advanced at the Mine Site in 2011 for testing geotechnical engineering parameters. The data were collected to evaluate densities, remolding parameters and volume changes due to excavation, transport and placement of the soils in the repository. The samples were submitted to an engineering laboratory and tested for Standard Proctor, moisture content, bulk density, volume change parameters and hydraulic properties. The results of this investigation were summarized in the memorandum *Summary of NECR Geotechnical Data Available to Date* (Dwyer, 2012) included in Appendix A and are also summarized in Section 4.6. Sample locations are shown on Figure 2-2, *Geotechnical Soil Sampling Locations.*

2.1.5 Soils Agronomic Characterization

Surface and subsurface soil samples were collected in 2006 during the RSE (MWH, 2007a) for analysis of agronomic parameters and other constituents that could impact plant growth. Sample locations are shown on Figure 2-2. The samples were analyzed for: pH, calcium, magnesium, potassium, sodium, Sodium Absorption Ratio, chlorine, arsenic, molybdenum, Ra-226, selenium, uranium, and vanadium. A table summarizing the results of these analyses is included in Appendix A and the results are described in the RSE report (MWH, 2007a).

2.1.6 Vent and Shaft Assessment

In 2008, UNC conducted a video survey of the accessible vents and shafts at the Mine Site. Holes were drilled into the vent and shaft covers and a video camera was lowered into each void as far as it would go below ground surface. The survey indicated that the vents all have diameters of four feet, except Vent 3 which has a diameter of 8 feet, plus the two shafts, which have 10-ft diameters. Additional information concerning the current surface conditions of the covers is included in Section 4.7 as part of the debris survey information collected during the PDS.

2.1.7 Cultural Resources Surveys

A cultural resource survey of the Mine Site permit area (see Figure 1-2) was conducted in 2005 by Lone Mountain Archeological (Lone Mountain, 2005) as part of the prior State closeout planning. The survey was conducted over the 125-acres that encompass the limits of the Mine Site permit area. A copy of the report for the Mine Site is included in Appendix A. The survey was conducted in accordance with the Navajo Nation Historic Preservation Division guidelines. The survey did not reveal any eligible or significant resources or Traditional Cultural Properties (TCPs). One burial site was reported to have been within the project area and destroyed; no evidence of it was found during the survey.

Two additional cultural resource surveys were conducted by Dinetahdoo Cultural Resource Management (Dinetahdoo) in 2009 and 2011 in the SO-1 and step-out area no. 2 (SO-2) areas, respectively (see Figure 1-2) as part of interim removal actions conducted at the Mine Site (see Section 2.2). Both surveys were conducted in accordance with the Navajo Nation Historic Preservation Division guidelines. Copies of the reports are included in Appendix A. The results were used to develop procedures to protect cultural resources during the interim removal actions.

The 2009 cultural resources survey covered 69 acres within the limits of SO-1 and revealed the presence of one TCP approximately 500 feet to the north of the Mine Site permit boundary (see Appendix A). A second potential TCP was identified on the top of the hillside within SO-1 by one of the local residents during the interim removal action. The site was recorded by Dinetahdoo. The 2011 survey covered 27 acres within the limits of SO-2 and revealed the presence of two archeological sites, one of which was considered eligible for protection under the NRHP. Both of these locations are located north of Red Water Pond Road, greater than 1,200 feet north of the Mine Site permit area. All locations are outside of the Mine Site area and will be protected, as needed, and left undisturbed during the RA.

2.1.8 Vegetation and Wildlife Surveys

Two baseline vegetation and wildlife surveys were conducted in 2009 and 2011 by Cedar Creek Associates as part of interim removal actions conducted north of the Mine Site in SO-1 and SO-2, respectively (see Section 2.2). Copies of Cedar Creek's reports are included in Appendix A. Both surveys were conducted in accordance with standard practices and were designed to determine the: 1) current floral and faunal conditions extant in the vicinity of the survey areas; 2) quality of habitat for indigenous wildlife, and 3) revegetation potential. The baseline surveys were conducted in undisturbed areas and based on the identification of three distinct vegetation communities in the area:

- piñon juniper woodland

- mined-land reclamation and/or disturbance vegetation (ruderal) communities
- grassland (only on Navajo Nation lands to the north of the Mine permit area)

The dominant piñon-juniper woodland ranges between a "savanna" of scattered trees with grassland, to dense woody dominated areas with occasional dense shrubby understory and/or poor herbaceous understory. The piñon-juniper woodland is strongly associated with the rockier, skeletal and shallow soils. The grasslands are herbaceous communities dominated by perennial sod-forming grasses typical of the warm-season group and occasional forbs, and mostly absent of trees and larger shrubs. The survey revealed the presence of a total of 46 taxa including 9 grass or grass-like species, 18 forbs, and 19 trees, shrubs, sub-shrubs, or succulents (see Appendix A). None of these were determined to be rare, threatened or endangered or otherwise protected by statute, and none were identified as noxious weeds (the invasive weed Russian thistle was found in the baseline area, but is not considered problematic).

Cedar Creek conducted faunal (wildlife) surveys while conducting the vegetation surveys, using qualitative techniques of direct observation and evaluation of habitat. All observations of wildlife, either directly or by sign, were recorded in a manner to facilitate an indication of abundance and/or use of project area habitats. In addition to site-specific "incidental" observations during vegetation evaluations, several pedestrian observation transects were extended radially from the central disturbance area approximately one 100 meters to provide a better indication of: 1) wildlife use of the overall vicinity and habitats, 2) any remaining mine-related impacts, and 3) any continuing hazards to wildlife. The wildlife survey revealed the presence of only three habitats for indigenous fauna: piñon juniper woodland (with an occasional Ponderosa pine); shallow canyons with peripheral rock ledges, rim rock and cliffs; and narrow canyon bottoms exhibiting revegetation species or ruderal vegetation. Direct sightings, tracks, scat, nests, or burrows of indigenous wildlife revealed the presence of 29 taxa of mammals, reptiles and birds. According to the New Mexico databases, 19 wildlife taxa that are threatened, endangered or rare have a remote chance of existing within or near the project area; none were observed.

2.2 INTERIM REMOVAL ACTIONS

Based on the results of the RSEs within the area north of NECR-1 (SO-1), USEPA conducted a removal action in 2007 of soils around three of the home sites that showed exceedances of the FSL. The USEPA RA was initially limited to a 0.5-acre area surrounding each home site; however, the extent of excavation was expanded in the field. After the soils were excavated, USEPA conducted a final gamma survey and soil sampling of the excavated areas, and then backfilled the areas with clean soil, where required, and revegetated the areas (Ecology & Environment, 2007). USEPA directed UNC to dispose of approximately 5,000 cy of soil off-site. Soils were transported to U.S Ecology in Grandview, Idaho for final disposal.

The USEPA issued a *Request for a Time-Critical Removal Action* memorandum (USEPA, 2007) to UNC for cleanup of soils exceeding 2.24 pCi/g in SO-1 and in unnamed arroyo no. 1 north of the Mine Site (see Figure 1-2). The IRA was conducted in 2009 and 2010, and surface and subsurface soils containing Ra-226 above 2.24 pCi/g were removed from SO-1 and from unnamed arroyo no. 1 (MWH, 2010b). The results of the IRA were confirmed by a Post-IRA Status Survey of the step-out area and a Final Status Survey of the arroyo consisting of gamma surveying, soil sampling and analysis (MWH, 2010c; MWH, 2011c). As part of the IRA, the NECR-1 pile was regraded to direct runoff from the top surface to Pond 3. Approximately 100,000 cy of soil were removed from the IRA area and stockpiled on the NECR-1 pile. After placement of the excavated soil, the NECR pile was covered with 6 inches of clean soil on the top surface and 12 inches on the slopes, and revegetated (MWH, 2011c).

As part of the design for the 2009 IRA, MWH prepared hydrologic and hydraulic calculations for the design of storm water control and construction of an engineered channel following soils removal from unnamed arroyo no. 1. The calculations included runoff from the hydrologic basin that encompasses the entire Mine Site and were used to calculate peak flows under three separate simulations:

- 100-yr, 24-hr storm event using the pre-IRA topography at the Site
- Back-to-back 100-yr, 24-hr storms to evaluate the possibility of Pond 3 overtopping
- 100-yr, 24-hr storm event using the post-IRA topography at the Site

Based on the results of this evaluation the engineered channel in arroyo no. 1 was constructed to manage a 100-yr, 24-hr storm from the Mine. Evaluating a 100-yr, 24-hour storm event is engineering standard practice. However, additional simulations (e.g., peak flows) and consideration of changes to the Mine Site topography from the RA may need to be considered during the design. A copy of the memorandum describing the calculations and results is included in Appendix A.

Based on the results of the SRSE conducted in the East Drainage area (MWH, 2011a), USEPA issued an Action Memorandum: *Request for a Time-Critical Removal Action at the Northeast Church Rock Mine Site Drainage East of Red Water Pond Road* (SO-2) (USEPA, 2011b) (see Figure 1-2). In response to the Action Memorandum, GE/UNC conducted a removal action of the East Drainage area in 2012, as described in the *Construction Completion Report, Eastern Drainage Removal Action* (MWH, 2013b). Approximately, 30,000 cy of soil were removed from the East Drainage area, and a small area within the previous IRA area, and stockpiled on the NECR-1 pad (soils with Ra-226 only) and the TPH stockpile (soils with commingled TPH and Ra-226). The results of this interim removal action were confirmed by a Post-IRA Status Survey consisting of gamma surveying, soil sampling and analysis (MWH, 2010c)

3 PRE-DESIGN STUDIES

The PDS were conducted at the Mine Site in October and November 2013 and consisted of sampling, field screening and laboratory analysis to further characterize radiological impacts to soils and to characterize mine debris. The PDS were conducted in accordance with the Work Plan, which included a *Field Sampling Plan* (FSP), *Quality Assurance Project Plan* (QAPP), and a *Health and Safety Plan* (HASP). The following tasks were conducted during the PDS:

- Soils radiological sampling and field screening to further assess the volume estimates of potentially clean material and Principal Threat Waste (PTW) and to refine the removal action boundary survey
- A surface debris inventory to further assess the type and volume of debris
- TPH stockpile sampling to assess RCRA hazardous waste characteristics
- Test pitting to evaluate the presence of potential asbestos containing material (ACM)
- Geotechnical characterization to further assess soil properties

The scope of work for each task is summarized in the following sections, including an explanation of any changes from the Work Plan. The results of the PDS are described in Section 4.

3.1 SOILS CHARACTERIZATION

3.1.1 Clean Soils

Soils in some areas of the Mine Site do not contain elevated levels of radionuclides. In order to estimate the extent and volume of clean materials, drilling and sampling was conducted in the following areas to augment the RSE results:

- NECR-1 pad
- NECR-2 pad
- Access road that leads north from the NECR-2 pad
- Berm downstream of Ponds 1 and 2
- Berm downstream of Pond 3
- Boneyard

Additionally, composite sampling was conducted in the eastern end of the NECR-1 pile where soils excavated from the IRA were placed. Sample locations are presented on Figure 2-1.

3.1.2 Principal Threat Waste Soils

In the Action Memo, EPA defined PTW as soils containing either greater than 200 pCi/g of Ra-226 and/or greater than 500 milligrams per kilogram (mg/kg) of total uranium.

The vertical and lateral extent of PTW soils were evaluated in the field by drilling, screening and soil sampling from up to three boreholes adjacent to each of the RSE sampling locations that indicated the presence of PTW and that were accessible during the PDS (MWH, 2013a). Drilling continued to the base of impacted soils as determined by visual observation and/or until gamma screening indicated that the interval of PTW material had been identified. Sample locations are presented on Figure 2-1.

3.1.3 Removal Action Boundary Survey

Static gamma surveys were conducted at the Mine Site in 2007 as part of the initial RSE (MWH, 2007a) and in 2008 during the SRSE (MWH, 2008), as presented in Section 2.1. Copies of the RSE drawings and tables summarizing the results are included in Appendix A. The results of the static gamma surveying were used to identify areas at the Mine Site with Ra-226 concentrations above the FSL of 2.24 pCi/g(MWH, 2007a) and were also used to map the FSL boundary, which represents the lateral extent of surface soils containing Ra-226 above 2.24 pCi/g (MWH, 2008).

In order to confirm and refine the location of the FSL boundary, which will be used for the RA design as the Removal Action Level (RAL) boundary, a gamma scan survey was conducted during the PDS along selected segments of the FSL (RAL) boundary. A value of 5,200 counts per minute (cpm) for the 0.5 inch lead collimated 2x2 NaI detector equivalent to the 2.24 pCi/g Ra-226 RAL was used to screen the RAL boundary using the site-specific updated correlation developed for the for the IRA (MWH, 2010c). The RAL boundary gamma survey consisted of a walk-over survey with a collimated detector and the survey was conducted in a serpentine pattern extending approximately 20 ft along either side of the 2007 FSL boundary. The scan was shifted outside of the FSL boundary until the gamma cpm were observed at or below the RAL. Where the gamma scan cpm were below the RAL, the scan was shifted inside of the 2007 FSL boundary until the scan cpm were observed at the RAL. Detailed methods, procedures and survey results are included in Appendix B, and a summary of the results is included in Section 4.

3.2 SOIL VOLUME ESTIMATES

The volumes of impacted and potentially clean soils were estimated using the following information:

- Previous volume estimates

- Subsurface soil screening and laboratory analytical results
- Comparison of pre-mine and post-mine topography
- Gamma and geophysical surveys
- Institutional knowledge of mining operations and each Mine Site facility

Detailed descriptions of the information and assumptions that were used to calculate the volume of impacted or clean soil for each area are included in Section 4.3. The volumes were estimated using one of two methods:

1. Manual calculation: area of impacts (RAL boundary) times the average depth of impacts.
2. Computer aided calculation: use of elevation surfaces.

Manual calculations were used in areas where only surface soil impacts were detected (e.g., Vents 3 and 8 and the step-out areas). The areas and assumptions used in the manual calculations are described in Section 4.3.

Computer aided calculations were used for areas with subsurface soil impacts that exhibit more complex geometry (i.e., significant variation in topographic elevations and/or thickness of impacts across the area). The following general method was used to estimate volumes using computer aided calculations:

- For 12 of the Mine Site areas with subsurface impacts (e.g., Sediment Pad, NECR-1, etc.) an elevation surface (three-dimensional CAD map layer) was generated that represents the vertical RAL boundary. The vertical RAL boundary was based on the total depth of impacts above 2.24 pCi/g Ra-226 observed in each borehole, including previous RSE boreholes.

- The generated elevation surface (based on the RAL) was extended laterally beyond the outermost boreholes out to the lateral extent of impacts. The lateral extent of impacts was assumed to correspond to the physical edges of each area. The depths of the RAL at the edges or limits of impacts in each area were interpreted based on observations and test results from nearby boreholes, the nature and known operations of the particular area, static gamma survey results, and the ground surface topography.

- The upper elevation surface was defined by the ground surface.

- The volume of the area between the surface and the subsurface layers was then calculated based on the two elevation surfaces, which are combined into one 3D volume.

The subsurface removal action boundary (lower elevation surface) was interpolated as a linear surface between boreholes, and also from the outer boreholes out to the lateral extent of subsurface impacts.

The volume of clean soil was calculated using the manual method, as described above (area times depth). Observations of bedrock or native, in-place soil were used to estimate the depth of clean soil at some locations. In the absence of this information, a minimum depth was assumed for the volume calculations (see Section 4.3).

The Boneyard and Pond 1 contain large volumes of buried debris (scrap metal, concrete blocks, pipe, etc.) presumably with a soil matrix. The volume calculations for the debris are discussed in Section 4.7. These volumes were subtracted from the soil volumes described above.

PTW Soil Volumes

PTW soils in Pond 1 and the Sediment Pad were encountered over limited areas across distinct vertical intervals in some of the PDS boreholes. Therefore, the volume of PTW soils was estimated based on the average thickness of each interval and area around the boreholes in which PTW was encountered across that interval. The lateral extent was interpreted to extend half-way to the next borehole in which PTW was not encountered or to the edge of the facility.

3.3 ENGINEERING PROPERTIES OF MINE SOILS

Soil sampling and testing for geotechnical engineering properties of the soils was conducted at 14 locations at the Mine Site during the PDS. Thirteen locations were drilled with hollow-stem auger drilling methods and one location was hand-augured due to limited access in Pond 3. Drilling and sampling took place in accordance with the Work Plan (MWH, 2013a). Boring locations (MWH, 2013a) are shown on Figure 2-2; locations of some of the proposed borings were moved due to limited access. Two of the geotechnical borings were used for radiological characterization as well.

Continuous (dry-core) samples were collected throughout hollow stem auger drilling. The core samples were logged, placed in labeled core boxes, photographed, and placed in storage. A 2.5 inch (outside diameter) California split-spoon sampler was used to obtain 2-inch diameter California (CA) samples at selected depth intervals and representative bulk samples were also collected during drilling. Hand augering was conducted using a 3-inch hand auger; cuttings were collected for bulk samples and lithologic descriptions. The borehole logs, field notes, photographs of the core, and other representative photographs of drilling operations are provided in Appendix B. Sample results are presented in Section 4.

3.4 MINE DEBRIS INVENTORY

A reconnaissance survey of the Mine Site area was conducted to inventory surface mine debris and structures, such as concrete, building remains, pipes, waste piles, and other scrap material. This included the remains of the magazine building, and other structures made of concrete and/or metal (e.g., vent and shaft openings and auxiliary equipment, tank stands, etc.). A written description, photographic record, estimate of the size, depth and/or quantity, and

location coordinates were recorded for each object or area containing debris that was identified during the PDS. The volume of debris observed during the survey was incorporated with data from the RSEs to develop an estimate of the various types of debris.

During the IRA, debris encountered primarily in NECR-1 (concrete foundation material, miscellaneous metallic debris, and debris from the demolition of buildings that were on NECR-1) were stockpiled just south of Pond 3. These piles were included in the current debris volume estimate, as presented in Section 4.7.

The mine vents, shafts and related structures were also inventoried and their condition was documented. A written description, photographic record and location coordinates were recorded for Vents 3, 6, 7, 8, 9 and 10 and the shaft at the NECR-2 pad. The Shaft 1 at the NECR-1 pad was covered with soil and inaccessible. Vents 1, 2, 4 and 5 no longer exist.

3.5 POTENTIAL RCRA HAZARDOUS WASTE AND ASBESTOS CONTAINING MATERIAL ASSESSMENT

3.5.1 RCRA Hazardous Waste Characteristics

Soil samples were collected from the TPH Stockpile for analysis of RCRA hazardous waste characteristics:

- Toxicity - TCLP extractable metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver
- Ignitability – flash point
- Corrosivity - pH
- Reactivity – reactive cyanide and sulfide

Two samples were collected as 4-point composites and homogenized in the field prior to shipment to the laboratory. Both sets of samples were collected to be representative of the soils present in the stockpile based on visual observation of the soils. Additionally, some of the soils encountered during drilling at four locations in Pond 1 exhibited a strong petroleum odor, and so were sampleds. Consequently, samples were collected and submitted to Energy Laboratories, Inc. Casper, Wyoming (ELI) for analysis of RCRA waste characteristics.

3.5.2 Potential Asbestos Containing Material

Five test pits were advanced in Pond 1 to evaluate the presence of potential ACM in the area where buried vermiculite insulation material was suspected to be present based on anecdotal evidence. Samples of potential ACM were collected and submitted for analysis of bulk asbestos fiber counts by Assaigai Analytical Laboratories of Albuquerque, NM. The results of this task are presented in Section 4.8.

4 SUMMARY OF NECR MINE SITE CHARACTERIZATION

The results of each of the PDS tasks summarized in the sections below.

4.1 CHARACTERIZATION OF SURFACE SOILS

4.1.1 Removal Action Boundary Survey

A scan gamma survey was conducted along the FSL boundary to confirm and define the RAL boundary (the lateral boundary of soils containing Ra-226 above 2.24 pCi/g). The results of the boundary survey are shown on Figure 3-1, *RAL Boundary Survey Results*. Figure 3-1 was adapted from the *Supplemental Removal Site Evaluation Report* (MWH, 2008), and includes the RSE/SRSE static gamma measurements, the original FSL boundary, and the boundary adjusted as a result of the PDS survey. The final boundary is now referred to as the RAL boundary. Minimal adjustments to the previous FSL boundary were required to define the final RAL boundary, including: 1) increased area between NEMSA and Sandfill No. 3; and 2) decreased area in the Boneyard, as shown on Figure 3-1.

The southwestern portion of the Boneyard contains a mix of soil and buried mine debris (see Section 4.7). The results of the RSE and PDS did not indicate the presence of impacted soils in the Boneyard, so the area containing buried debris is not included inside the RAL boundary. However, it is assumed that the debris will be included in the RA and that soils mixed in with the debris may contain Ra-226 above the RAL.

4.1.2 Distribution of COCs in Surface Soil

Surface soils were not sampled during the PDS, but were collected during the RSE (MWH, 2007a) and the SRSE (MWH, 2008). Surface soil sampling analytical results are shown on Figure 3-2, *Surface Soil Analytical Results,* and a tabular summary of the results is included in Appendix A. Surface soil analytical results are included to provide a complete summary of soils characterization data for the RA and to aid in evaluating the distribution and volume of impacted soils at the Mine Site. Surface soil samples (≤ 0.5 ft bgs) were collected from each of the RSE survey areas and analyzed for Ra-226 and total uranium, as well as other analytes, as described in the documents referenced in Section 2.1.

4.2 CHARACTERIZATION OF SUBSURFACE SOILS

4.2.1 Sampling Methods and Locations

Subsurface soil samples (>0.5 ft bgs) were collected from boreholes and hand auger holes advanced throughout the Mine Site as a part of the PDS, as discussed in Section 2.1. Borehole depths were based on field observations and ex-situ gamma screening. Boreholes expected to encounter only unimpacted soils ("clean" boreholes) extended to depths where the field screening values were less than the RAL (if any soils above the RAL were identified),

Boreholes expected to encounter PTW ("PTW" boreholes) continued to depths where the field screening value correlated to a Ra-226 value less than 200 pCi/g.

Soils samples were shipped to the chemical laboratory for analysis of Ra-226 by EPA Method 901.1 and uranium by EPA Method 6020. Laboratory samples for "clean" boreholes were samples with the highest field screening value. For "PTW" boreholes, the sample with the highest field screening value and a sample from a lower interval (to confirm the PTW was accurately delineated) were submitted for laboratory analysis. Samples for analysis of uranium were only submitted to the laboratory where the field screening suggested the presence of PTW. Field duplicate samples were collected at 10 percent of the sample locations.

Locations of each of the subsurface soil sampling locations from the PDS and RSEs are shown on Figure 3-3, *Subsurface Soil Sample Results*. This figure also shows the sample IDs, the vertical depth to unimpacted soil (<2.24 pCi/g Ra-226) and the range of depths to PTW, as applicable.

A summary of the boreholes and test pits advanced during the PDS and RSE is included in Table 3-1, *Subsurface Sampling Summary*. The laboratory analytical results are included in Table 3-2, *Subsurface Soil Analytical Results* and the field screening results are summarized in Table 3-3, *Subsurface Soil Field Screening Results.* Laboratory analytical reports are included in Appendix B. Analytical results were validated in accordance with the QAPP and a copy of the validation report is included in Appendix B. All analytical data are acceptable for their intended use.

Soil samples in which both the field screening value and laboratory concentration (where analyzed) were below the RAL threshold were considered below the RAL. In some cases, Ra-226 concentrations based on laboratory analysis were below the RAL, while the field screening measurements were above the RAL; in these cases, samples were conservatively considered PTW for the purpose of estimating the extent of PTW.

The sampling results will be used during the design to evaluate if it is cost-effective to attempt to segregate clean materials and to develop procedures for potentially segregating clean soils, as well as for removing PTW.

4.2.2 Boneyard

Six subsurface soil samples were collected from two boreholes completed to 15 ft bgs in the southern leg of the Boneyard (See Figure 3-3). No boreholes were advanced in the southwestern leg. Field screening values for all six samples were below the RAL and laboratory results for Ra-226 were less than the RAL. Results of the Boneyard investigation confirm that soils within the southern leg do not contain Ra-226 above the RAL.

4.2.3 NECR-1

Thirty-five subsurface soil samples were collected from 10 boreholes advanced to 8 to 22.5 ft bgs (four to evaluate potential "clean" soil and six to evaluate "PTW") at NECR-1 (see Figure 3-3). Laboratory Ra-226 values were less than the RAL for samples from three of the four "clean" boreholes, however, field screening values were slightly above the RAL, so subsurface soils at all three of these locations could potentially exceed the RAL. One sample from "clean" borehole NECR1-CC10 contained Ra-226 at 70.1 pCi/g.

PTW soils were detected in surface soil samples at NECR-1 during the RSE based on uranium concentrations at two locations: N1-016 and N1-049. Three "PTW" boreholes were advanced to ≥10 ft bgs around each of these two locations during the PDS. The Ra-226 concentrations in the samples from the six PDS boreholes ranged from 2 to 98.7 pCi/g Ra-226, and all screening and laboratory analytical results were below the PTW threshold. The results of the PDS indicated that the soils in NECR-1 above the PTW criteria are limited to the immediate area surrounding the RSE sampling locations. For the purpose of estimating volumes at each the RSE locations in which PTW soils were detected, it was assumed that PTW soils extend to a depth of two ft bgs and extend laterally approximately half way to the nearest sample locations at which PTW was not detected.

As discussed in Section 2, soils excavated during the IRA were consolidated onto the NECR-1 pile. A majority of those soils were placed at the eastern end of NECR-1. In order to assess the average concentration of Ra-226 in those soils, subsurface samples were collected across the upper 0.5 to 5 feet from five boreholes (see NECR1-CC02C on Figure 3-3) and composited into one sample for laboratory analysis. The results of the analysis indicated a concentration of 3.2 pCi/g Ra-226, as shown on Table 3-2.

4.2.4 NECR-2

Fifteen soil samples were collected from seven "clean" boreholes advanced to 4.5 to 24.3 ft bgs in the NECR-2 area. Laboratory analytical results from two of the boreholes contained soils with Ra-226 just above or just below the RAL (1.8 to 3.1 pCi/g). From the other five boreholes the analytical results ranged from 1.7 to 29.4 pCi/g. These results indicated that clean soil exists in NECR-2, but over small, limited areas. Most soils contain Ra-226 above the RAL. PTW was not encountered in NECR-2 during the RSE or the PDS.

4.2.5 Non-Economic Materials Storage Area

Nine soil samples were collected from two boreholes advanced to 11.5 and 25 ft bgs in the NEMSA. Two samples were submitted for laboratory analysis and contained Ra-226 at 1.0 and 82 pCi/g. Field screening suggested the Ra-226 concentrations for eight of the nine samples

were less than 100 pCi/g. The concentration in one sample was less than 200 pCi/g. These results, combined with the RSE results, indicated that the NEMSA does not contain PTW.

4.2.6 Pond 1

Sixty-four subsurface soil samples were collected from 15 boreholes advanced to 10 to 22.5 ft bgs (two "clean", 13 "PTW") in the Pond 1 area. Twelve boreholes were completed within the actual pond and four were completed along the road berm on the north side of the pond (see Figure 3-3). The Ra-226 concentrations for one boring in the pond, P1-CC14, were below the RAL; all others within the pond were above the RAL based on field screening and laboratory test results. The Ra-226 screening values for four boreholes located on the road berm were all above the RAL and the laboratory values ranged from 1.3 to 10.2 pCi/g.

Ten of the 12 boreholes in the actual pond contained at least one interval with soils above the PTW criteria; PTW was not encountered in boreholes P1-CC15 and P1-CC16. The Ra-226 sample concentrations from the PTW boreholes ranged from 205 to 923 pCi/g with co-located uranium concentrations of 209 to 3,190 milligrams per kilogram (mg/kg). The intervals containing PTW in Pond 1 were 5 to 7.5 ft thick from near surface to 12.5 ft bgs (see Figure 3-3). Samples collected below the PTW intervals contained 1.0 to 87.1 pCi/g of RA-226 and 1.1 to 254 mg/kg of uranium, confirming the limits of the impacted soils above the PTW criteria.

A strong petroleum odor was detected between 5 and 15 ft bgs while drilling boreholes P1-CC10 through P1-CC13 (see Figure 3-3). The thickness of TPH-impacted soil varied in individual boreholes between 2.5 and 5 feet. The vertical and lateral extent of TPH was adequately defined in Pond 1, although there is some uncertainty about its lateral extent between borings, which will be determined during execution of the RA. TPH samples were collected from at least one interval in the affected boreholes and submitted to the chemical laboratory to be analyzed for RCRA hazardous waste characteristics in addition to Ra-226 and uranium. These analytical results are further described in Section 4.8.

Results of sampling and testing in the Pond 1 area indicated that Pond 1 contains mostly soils impacted above the RAL, including soils classified as PTW. They also indicated that some soils within Pond 1 contain both PTW and TPH-impacted soils. TPH was not detected in the other boreholes located within Pond 1, which provides an estimate of the lateral extent of TPH impacts within Pond 1.

4.2.7 Pond 2

The bottom of Pond 2 was inaccessible for drilling during the PDS due to the steep ground surface along the pond sides. For reference, one test pit was advanced in Pond 2 during the RSE. Two soil samples collected for laboratory analysis during the RSE had Ra-226 concentrations of 41.3 pCi/g (3 ft bgs) and 6.2 pCi/g (5 ft bgs). It was assumed for the purpose

of the volume estimate that the vertical removal action boundary is at 7 ft bgs in the bottom of Pond 2, based on the RSE results.

Seven soil samples were collected during the PDS from three "clean" boreholes located on the road berm adjacent to the north side of Pond 2 (see Figure 3-3). The total depths of these boreholes ranged from 7.5 to 10 ft bgs. The field screening values for the near surface samples for each of the three boreholes were above the RAL. The Ra-226 concentrations for the laboratory samples ranged from 1.1 to 5 pCi/g. These results indicated impacted soils up to six feet thick overlay unimpacted soils within the road berm.

4.2.8 Pond 3

Eighteen subsurface soil samples were collected from seven boreholes advanced to 5 to 25 ft bgs in the Pond 3 area. Three of the boreholes were advanced on the pond berm ("clean") and four were advanced in the pond itself ("PTW"). Due to soft/wet ground and standing water in the bottom of the pond, only 5 of the 10 boreholes planned in Pond 3 were completed, including the one geotechnical location. Samples collected from the geotechnical borehole, which was hand-augered, were not analyzed or screened for radionuclides. The field screening and laboratory Ra-226 values for two boreholes were below the RAL. Laboratory samples from the four remaining boreholes (i.e., not including the geotechnical borehole) had Ra-226 concentrations that ranged from 1.5 to 21.1 pCi/g, with field screening values above the RAL (see Figure 3-3). These results indicated that impacted soils above the RAL are present in Pond 3, but no PTW soils were present at the locations sampled during the PDS.

During the RSE, PTW was detected in surface soils in Pond 3 based on uranium concentrations at three locations (see Figure 3-2). Due to the wet ground, boreholes were advanced around only two of the RSE locations that encountered PTW. PTW soils were not encountered at any of the PDS locations. For volume calculation purposes, it was assumed that PTW soils are present in Pond 3 at the locations of the three RSE sampling locations, out to a distance of approximately halfway to next boreholes or to the edge of the area.

4.2.9 Road to NECR-2

Four soil samples were collected from three "clean" boreholes each advanced to 10 ft bgs along the road to NECR-2. Three samples were submitted for laboratory analysis and all three had Ra-226 concentrations below the RAL. However, the field screening value from the fourth sample (0-5 ft from ROAD-CC01) exceeded the RAL. These results indicated that the road primarily consists of soils with Ra-226 below the RAL, with the exception of some of the near surface soils at the southwest end of the road closest to NECR-2.

4.2.10 Sediment Pad

Forty-nine subsurface soil samples were collected from 12 "PTW" boreholes advanced to 5 to 22.5 ft bgs in the Sediment Pad. All boreholes contained soil with Ra-226 concentrations above the RAL. The field screening values from five boreholes in the Sediment Pad were above the PTW screening limit; however, the co-located laboratory analyzed soil samples contained Ra-226 at concentrations of 133 to 162 pCi/g (see Tables 3-2 and 3-3). The RSE and the PDS results indicated the presence of two layers of PTW soils with the Sediment Pad, at 0 to 2.5 ft bgs and at 5 to 10 ft bgs.

4.3 VOLUMES OF IMPACTED SOILS

The volumes of impacted soil, including PTW, were estimated as described in Section 3.2. The volumes of PTW were estimated separately from the total volumes of impacted soil, and the volumes of impacted soils are inclusive of the volumes of PTW.

The depth of impacted soils, the lateral RAL, and the vertical removal action boundary depths are shown on Figure 3-3. Average depths to the RAL and areas requiring removal during the RAL are shown on Figure 3-4, *Subsurface Soil Removal Action Boundaries.* The estimated volumes of impacted soils (including PTW) are listed in Table 3-4, *Impacted Soil Volume Estimates* and the volumes of clean (unimpacted) soil are shown on *Table 3-5, Clean Soil Volume Estimates.* The following sections describe the methods and assumptions used for estimating the volumes of impacted and clean soil in each area of the Mine Site out to the lateral extent of impacted surface and subsurface soil.

4.3.1 Volume of Surface Soil Impacts

Areas with impacts only to surface soils (areas with impacts 0.5 to 1 ft bgs) are those areas outside the areas with subsurface impacts (see Section 4.3.2) out to the RAL boundary (see Figure 3-3). These areas are shown as the 0-1 foot Removal Action Depth on Figure 3-4. This includes the intervening areas between each of the areas with subsurface impacts and includes the following:

- Vents 3 and 8
- Sandfill 1 step-out area
- Mine site step-out area, which includes the Trailer Park, Fuel Storage Area, IX Plant, and Magazine area

All other areas of the site contain impacts greater than one foot bgs or contain clean soils only.

Surface soil impacts in these areas were identified based on the static gamma survey results, which are shown on Figure 3-1. The estimated volumes for areas with only surface soil impacts

is conservatively based on an assumed depth of one foot; the actual depth is expected to range from 0.5 to 1 foot, but there may also be limited areas where impacted soil extends slightly deeper than 1 ft bgs. The volume then was estimated by the product of the area times one foot depth. Based on these assumptions, the estimated volume of impacted surface soil is 95,000 cubic yards, as shown on Table 3-4.

4.3.2 Volume of Subsurface Soil Impacts

This section describes the methods and assumptions that were used to estimate the volumes of impacted soils present in each of the areas containing subsurface soil impacts, impacts greater than one foot bgs.

NECR-1

The results of the RSE and the PDS indicated that impacted soils are present in NECR-1 from the base of the clean soil cover constructed during the IRA to depths of 5 to 41 ft bgs (see Figure 3-3). These depths bgs are revised from the depths shown in the RSE (MWH, 2006) to account for the regrade and addition of excavated soils that occurred during the IRA, as well as the soil consolidation pile added during the EDRA. Surface and subsurface sampling was conducted across the whole of NECR-1 during the RSE and PDS and so the lateral and vertical extent of impacts is well defined. The lateral extent of impacts is further defined by the steep slopes of the pile on the north, west and east sides and the steep hillside with outcropping bedrock on the southeastern side. In order to estimate the volume of impacted soil in NECR-1, a CAD layer (elevation surface) was generated for the upper (ground) and the lower (RAL) surfaces. The volume was then estimated in CAD by the volume between the two surfaces. Based on these data and assumptions, the volume of impacted soil within NECR-1 was estimated to be 402,300 cy (see Table 3-4). Of this volume, approximately 100,000 cy was excavated and stockpiled from the IRA and 30,000 cy was excavated and stockpiled form the East Drainage Removal Action.

PTW soils were not detected in NECR-1 during the PDS; however, they were detected during the RSE at two surface soil sampling locations (see N1-016 and N1-049 on Figure 3-2). It was assumed for estimating the volume that PTW soils extended halfway out to the nearest boreholes, which is a diameter of approximately 30 feet around both locations. Based on these assumptions, the cumulative volume of PTW around these two locations was estimated to be approximately 425 cy.

NECR-2

The results of the RSE and the PDS indicated that impacted soils are present in NECR-2 from the ground surface to depths of 2 to 12 ft bgs (see Figure 3-3). PTW soils were not detected in NECR-2. Surface and subsurface sampling was conducted across the whole of NECR-2 during the RSE and PDS and so the lateral and vertical extent of impacts is well defined. The lateral extent of impacts is further defined by boreholes with Ra-226 below the RAL (e.g., SAND2-TP-

019), the steep slopes defining the pile on the north and east sides, and the steep hillside with outcropping bedrock on the west and south sides. The deepest portion of impacted soil is located within the southeastern “leg” of the pile where borehole NECR2-CC03 is located. Impacted soils were encountered in NECR2-CC03 to a depth of 20 ft bgs, and no other boreholes were advanced south of that location. For the purpose of estimating the volume, it was assumed that the impacted subsurface soil extended approximately 100 feet to the south of this location (see Figure 3-3). The volume of impacted soil in NECR-2 was estimated using a CAD layer for the upper (ground) and lower (vertical removal action boundary) surfaces. In order to complete the volume estimate, it was assumed that the depth of impact along the edges was close to the average of the nearby boreholes (e.g., 2.5 feet on the west side, 10 feet adjacent to the NECR2-Drainage, 1 foot on the east side, and 13 feet south of NECR2-CC03). Based on these data and assumptions, the volume of impacted soil within NECR-2 was estimated to be 35,600 cy (see Table 3-4).

NECR-2 Road

The results of the PDS indicated that impacted soils are present in the NECR-2 Road along certain segments, as shown on Figures 3-3 and 3-4. PTW soils were not detected within the road. As shown on Figure 3-4, the road from NECR-2 all the way to the northeastern corner of Pond 1 was divided into segments A through E based on the presence of impacted versus unimpacted (clean) soils along the road. Segments A, C and E were impacted and segments B and D were not. The depth of impacts along Segments A, C and E were between 4 and 8 ft bgs and it was assumed that impacts extended to this depth along the whole length and width of each segment. It should be noted that the impacted soils are likely underlain by unimpacted (clean) soils. Based on these data and assumptions, the volume of impacted soil within the NECR-2 Road (segments A, C and E) was estimated to be 14,200 cy (see Table 3-4).

Pond 1

The results of the RSE and the PDS indicated that impacted soils, including PTW soils, are present in Pond 1 from the ground surface to depths of 5 to 15 ft bgs (see Figure 3-3). The lateral and vertical extent of impacts is well defined by the boreholes, the surrounding steeply sided hillsides, and the road berm to the north. The volume of impacted soil in Pond 1 was estimated using a CAD layer for the upper (ground) and lower (vertical removal action boundary) surfaces. The volume estimated based on the CAD surfaces was 25,500 cy. However, there are approximately 1,000 cy of buried debris located on the east side of the pond, the volume of which was subtracted from the impacted soil volume (see Table 3-4) and included in the debris inventory volume estimate discussed in Section 4.7. Therefore, the net volume of impacted soils in Pond 1, inclusive of PTW, was estimated to be 24,500 cy.

PTW soils were detected in all but a few of the RSE and PDS boreholes (see Figure 3-3). The volume of PTW in Pond 1 was estimated manually by the product of the area times the thickness of PTW in each borehole. PTW was assumed to extend laterally out to the edges of the pond on the west and south sides, to the edge of the berm on the north side, and close to

the boreholes on the east side in which PTW was not detected. These data and assumptions resulted in an estimated volume of PTW of approximately 16,500 cy, depending on the exact location of the assumed lateral extent out from each borehole.

Soils within Pond 1 were also found to be impacted by TPH in boreholes P1-CC10 through P1-CC13 (see Figure 3-3), over thicknesses between 2.5 and 5 feet. The vertical extent was delineated in each borehole. The lateral extent was assumed to extend just beyond the locations of the TPH-impacted boreholes to the west of P1-CC10 and P1-CC11 and to the edge of the pond to the north, east and south of the TPH-impacted boreholes. Based on these data and assumptions, the volume of TPH-impacted soil in Pond 1 was estimated to be approximately 4,500 cy. All intervals of TPH-impacted soils in Pond 1 were coincident with PTW soil.

Pond 2

Since the bottom of Pond 2 was inaccessible for drilling during the PDS, the volume estimate was based on the results of the RSE subsurface locations P2-TP-030, in which impacted soils were detected down to a depth of 7 ft bgs. PTW soils were not detected. It was assumed that impacted soils were present to a depth of 7 ft bgs to the edges of the pond base and then tapered from there to the edges of the pond to depths of 1 foot on the south side and 5 feet on the north side. Based on these data and assumptions, the volume of impacted soil in Pond 2 was estimated to be 4,600 cy.

Pond 3

The results of the RSE and the PDS indicated that impacted soils are present in Pond 3 from the ground surface to depths of 4 to 13 ft bgs (see Figure 3-3). The lateral and vertical extent of impacts is well defined within the base of the pond, but not along the steep sides of the pond, which were inaccessible due to their steepness. The volume of impacted soil in Pond 3 was estimated using a CAD layer for the upper (ground) and lower (vertical removal action boundary) surfaces, based on the RAL depths in the boreholes and assumed depths along the sides of the pond. Along the sides of the pond, the depth to the RAL was assumed to be 1-2 ft bgs around the northeastern end of the pond and 8 ft bgs within the southwestern end of the pond (see Figure 3-4). Based on these data and assumptions, the volume was estimated to be 35,700 cy.

PTW soils were not detected in Pond 3 during the PDS; however they were detected during the RSE at three surface soil sampling locations (see P3-07, P3-014 and P3-029 on Figure 3-2). It was assumed for estimating the volume that PTW soils extended halfway out to the nearest boreholes, which is a diameter of approximately 12-15 feet around P3-007 and P3-029, and to a depth of two ft bgs. Due to access restrictions, it was not possible to collect subsurface samples around P3-014, and it was at least 200 feet away from other subsurface sampling locations. Therefore, it was assumed that PTW soils surrounding P3-014 extended halfway out to the closest boreholes in the northeast and southwest directions, to the axis of the bottom of

the pond to the north, and to the edge of the pond to the south, which is an area of approximately 100 by 200 feet. Based on these assumptions, the cumulative volume of PTW around these three locations was estimated to be approximately 1,550 cy.

Pond 3 Drainage

Impacted soils are present in the Pond 3 Drainage from the ground surface to a depth of 10 ft bgs, which is based on one RSE subsurface soil sampling location (see Figure 3-3). PTW soils were not detected. The area defined as the Pond 3 drainage extends from the edge of the Pond 3 berm down to the upstream boundary of portion of arroyo no. 1 addressed during the IRA, and from the NECR-1 pile over to the portion of arroyo no. 1 that drains out of Pond 3 (see Figures 3-3 and 3-4). For the purpose of estimating the volume of impacted soil, it was assumed that impacts occur to a depth of 10 ft bgs across the whole area. The volume of impacted soil in Pond 3 was estimated using a CAD layer for the upper (ground) and lower (vertical removal action boundary) surfaces. Based on these assumptions, the volume of impacted soil in the Pond 3 Drainage was estimated to be 38,700 cy.

Sandfills 1, 2 and 3

Impacted soils are present in Sandfills 1, 2 and 3 at fairly shallow depths ranging from 2 to 6 ft bgs, based on the RSE results. No PTW was detected in these areas. The edges of the areas are relatively well defined in most areas by the topography of the ground surface and the location of adjacent areas. For Sandfill 1, the southern end of the area is somewhat arbitrary, and assumed to extend approximately 100 feet south of location SAND1-TP-030. In all three areas, there is minimal variation in the depth of impacts where present, and it was assumed for the purpose of estimating volumes that the thicknesses of impacts along the outer boundaries of the areas are similar to the thicknesses at the nearest sample locations. The volumes of impacted soils in the Sandfill areas were estimated using a CAD layer for the upper (ground) and lower (vertical removal action boundary) surfaces. Based on these data and assumptions, the cumulative volume of impacted soil in the Sandfill areas was estimated to be 39,300 cy.

Sediment Pad

The results of the RSE and the PDS indicated that impacted soils, including PTW soils, are present in the Sediment Pad from the ground surface to depths of 3 to 22 ft bgs (see Figure 3-3). The vertical extent of impacts is well defined by the boreholes. The lateral extent of impacts is defined on the west and east ends by the adjacent areas, on the north side by the edge of the unnamed arroyo no. 1 and on the south side by the road and steep topography. The thickness of impacts was assumed to be between 3 and 5 feet on the north side, and between 9 and 12 feet on the south side, based on average thicknesses within the nearby boreholes. The volume of impacted soil in the Sediment Pad was estimated using a CAD layer for the upper (ground) and lower (vertical removal action boundary) surfaces. Based on these data and assumptions, the volume was estimated to be 35,700 cy.

PTW soils were detected in the central portion of the area in both RSE and PDS boreholes in what appear to be two distinct layers at 0 to 2.5 ft bgs and at 5 to 10 ft bgs (see Figure 3-3). The volume of PTW was estimated manually by the product of the area times the thickness of PTW in each borehole. The lateral extent of PTW soils are relatively well defined by nearby boreholes with no PTW. To the south, the PTW soils were assumed to extend to the edge of the area. Based on these data and assumptions, the volume of PTW was estimated to be approximately 700 cy.

NEMSA

The results of the RSE and the PDS indicated that impacted soils are present in the NEMSA from the ground surface to depths of 3 to 18 ft bgs (see Figure 3-3). PTW soils were not detected in the NEMSA. The lateral extent of impacts is relatively well defined by boreholes and the surrounding topography. The thicknesses at the edges were assumed to be similar to the thicknesses within the nearby boreholes, ranging from 5 to 8 feet at the southern end, 2 to 3 feet on the east and west sides, and 6 feet at the northern end. Based on these data and assumptions, the volume of impacted soils in the NEMSA was estimated to be approximately 50,000 cy.

Boneyard

The results of the RSE and PDS investigations indicated that there are no impacted soils in the Boneyard. However, there is a large volume of buried debris in the southwestern leg of the Boneyard that is likely mixed with soil. The volume of mixed debris and soil in the Boneyard is included in the estimated volume of buried debris, as presented in Section 4.7.

4.3.3 Summary of Impacted Soil Volumes

The total volume of soils with Ra-226 above the RAL, as presented in the Sections 4.3.1 and 4.3.2, is estimated to be 783,000 cy, as shown on Table 3-4. These impacted soils are within the RAL boundary shown on Figure 3-4 and are distributed between surface and subsurface soils as follows (see Table 3-4):

- Surface soils (areas with impacts 0.5 to 1 ft bgs) = 95,000 cy
- Subsurface soils (areas with impacts >1 ft bgs) = 688,000 cy

These volumes represent the current in-place volume and do not account for a reduction in volume due to compaction when placed on the repository. Section 4.6 below discusses the geotechnical properties of the soils at the Mine Site, and concludes that if the mine soils are placed in the repository at 90 percent of the maximum Proctor values, it would result in an average volume reduction of eight percent. This would reduce the total volume from 783,000 cy to 720,000 cy.

Within the areas containing impacted soils, soils meeting the PTW criteria were detected in four areas, as follows:

- Sediment Pad: 700 cy
- Pond 1: 16,500 cy
- Pond 3: 1,550 cy
- NECR-1: 425 cy

The total in-place volume of PTW estimated based on the PDS and RSE results is approximately 19,000 cy (see Table 3-4).

4.4 VOLUME OF CLEAN SOILS

Clean soils (i.e., soils disturbed and placed during mining as fill) were only detected in limited areas within the following areas, as shown on Figures 3-3 and 3-4:

- Boneyard (southern leg only)
- NECR-2 drainage
- Pond 3 berm
- NECR-2 Road (segments B and D)

In each of these areas, the soils are either native in-place soils, or if they were placed in their current locations as fill, they overlay native in-place soils. Soil within the road berm (NECR-2 Road) from NECR-2 over to Ponds 1 and 2 are clean from the ground surface to some depth within segments B and D (see Figure 3-4). Across segments A, C and E, there are impacted soils from the ground surface to depth (i.e., 4-8 ft bgs) with clean soils underlying the impacted soil. In most cases, subsurface sampling did not reach bedrock, and so the depth of clean soil can only be assumed. For each of the areas where clean soil is present, a minimum depth of clean soil was assumed, based on the topography of the area. The minimum depths for each area that were used for the volume estimates are shown on Table 3-5.

Based on the results of the PDS and RSE, the estimated volume of clean soils is approximately 35,000 cy (see Table 3-5). This volume represents clean soils in distinct areas where they could be easily segregated during construction. There were some other areas, such as around the shaft at NECR-1 (see locations NECR1-CC09 and N1-SB408) and the clean soil cover on NECR-1 that would not be easily segregated. Although the design will evaluate methods to segregate clean soils, to provide a conservative estimate of the volume of soil that will be placed in the repository, the volumes of clean soil in these areas are included in the impacted soil volume presented in Section 4.3. There may be additional clean soil at the base of the berms below Ponds 1, 2 and 3 within the pre-mine drainage channels or other areas of the site that are not included here.

4.5 POST-REMOVAL ACTION TOPOGRAPHY

An initial design cut surface was developed based on the vertical removal action boundary out to the lateral RAL boundary for each area. The cut depths (based on the RAL) for each borehole or test pit are shown on Figure 3-3 and were used to generate the bottom elevation surfaces discussed in Section 4.3. The elevation contours that represent the rough, initial cut surface based on removal of soils above 2.24 pCi/g (RAL) are shown on shown on Figure 3-5, *RAL Cut Surface*. The elevation contours shown on Figure 3-5 represent the surface topography after impacted soils have been removed. It does not include additional cut, fill or regrading that may be required to ensure erosional stability and positive run-off of surface water, and which will be determined during the RA design. A regrading plan and determination of borrow requirements for the Mine Site will be conducted during the RA design.

4.6 SOILS GEOTECHNICAL CHARACTERIZATION

Geotechnical borings were advanced at 14 locations during the PDS to depths of 3.2 to 24.4 ft bgs and a total of 24 samples were collected for geotechnical testing, as described in Section 3.3. Boring locations are shown on Figure 2-2 and test results are listed in Table 3-6, *Geotechnical Test Results*. The results indicated the following:

- Gravimetric water content: 2 to 20%, average 8.1% (n=24)
- Dry density: 83.5 to 110.6 lb/ft^3, average 97 lb/ft^3 (n=23)
- Specific gravity: 2.6 to 2.7 g/cm^3, average 2.7 g/cm^3 (n=8)
- Max. dry density: 102 to 125 lb/ft^3 at optimum water contents of 9.8 and 20.6% (n=12)

The results were similar to results from the 2011 geotechnical testing, described in Section 2.1, during which seven soil samples were collected (Dwyer, 2012). The average water content was slightly higher at 13.2 percent and the maximum dry density was slightly lower at 91.8 per cubic foot (pcf) at optimum water content of 12.6 percent. Average dry density was 101.7 pcf. Specific gravity was not tested in 2011. A detailed presentation of the 2011 results are included in Appendix A (Dwyer, 2012).

No grain size analyses were conducted at the Mine Site during the PDS investigation, but grain size was qualitatively evaluated based on visual soil classification methods during the PDS and the RSE. Detailed lithologic logs are included in Appendix A (RSE) and Appendix B (PDS). Soils encountered during drilling and sampling consisted mostly of sand, silt, and some clay with occasional minor amounts of gravel. The predominant lithology is light brown and gray silty sand. Typically the gravel encountered was less than 1" diameter and 1 to 20 percent by volume. Gravel was most prevalent in Ponds 1, 2, and 3 and in the roadways. Gray to brown, high plasticity clay was also observed in both Pond 1 and in the very southeastern lobe of NECR-2. These lithologies are consistent with the results of grain size analyses conducted on the seven 2011 geotechnical samples, which indicated 12 to 34 percent fines and 0 to 5 percent

gravel (Dwyer, 2012). Additionally, occasional angular fragments of rock, and non-native materials were observed in NECR-1 and NECR-2, including small pieces of wood, concrete, brick, electrical wire and rubber. Large pieces of rock or concrete were generally not encountered; however, there were a few boreholes drilled during the RSE (MWH, 2007a) that met refusal above the top of bedrock that based on the depth may be waste rock or concrete. Procedures will be developed for managing any large material during the RA design.

The 2011 geotechnical investigation also evaluated volume changes due to compaction during construction. The dry densities of the samples collected at NECR-1, NECR-2, Sandfill 3, NEMSA, and the Sediment Pad ranged between 69 and 89 percent of their respective Proctor maximum dry densities. The average compaction values for each Mine Site area ranged from 76 to 84 percent of the maximum Proctor values. If the mine soils are placed in the repository at 90 percent of the maximum Proctor values, this would result in a volume reduction ranging from about 6 to 14 percent. A weighted average, using the estimated volumes of soil in the five areas listed above, would result in an approximately 8 percent reduction in the volume of soil from the five areas above, once placed in the repository at 90 percent of the maximum Proctor density.

4.7 DEBRIS INVENTORY

4.7.1 Debris Inventory

The mine debris inventory survey was conducted during the PDS, as described in Section 3.4. Field notes and photographs taken during the survey are included in Appendix B. A summary of the debris observed, including location, material type, size, and whether it was fixed to the surface or not is included in Table 3-7, *Summary of Mine Debris Inventory* and shown on Figure 3-6, *Mine Debris Inventory Map*. Appendix B contains additional detail, including maps with identification numbers for each piece or pile of debris and a detailed debris inventory table with corresponding identification numbers. The inventory table included in Appendix B indicates whether the object(s) is fixed or not, the dominant material type, whether or not it is compressible, and what needs to be done to the object prior to removal and placement in the repository. The types of materials that were observed include metal, concrete, plastic, wood, and rubber.

4.7.2 Debris Volumes

An estimate of the volume of material present for each item included in the debris inventory was made based on field observation and, in some cases, the length or area of the item. Many items contained more than one type of material (e.g., a foundation structure that contains both metal and concrete); the volume of these types of items was included in only one material classification type. Generally, only materials visible on the surface were used in the volume calculations, with the exception of the following:

- A depth of two ft bgs was used for surface materials that extend deeper into the subsurface, such as the hoist foundations at Vent Hole 3.
- The Boneyard and Pond 1 contain large volumes of buried debris, the volumes of which are included here, as described below.

The Boneyard was included in the 2007 geophysical survey (see Section 2.1), which showed that a large portion of the southwestern leg of the Boneyard contained buried debris (MWH, 2007b). Test pits advanced in the Boneyard (see Section 2.1) confirmed a large volume of debris is buried there (e.g., general trash, metal, scrap wood and other debris). The surface area of the major geophysical anomaly in the Boneyard was calculated to be 40,000 sf. Test pits, subsurface sampling, and comparisons of pre-mine to post-mine topography suggest that the depths to native soil in the southwestern leg of the Boneyard ranges from 5 to 10 ft. An average depth of 8 ft was used to calculate the volume of buried debris and an average depth of 4 ft (clean soil) was used over the remaining Boneyard area, including the southern leg.

Test pits were also completed in Pond 1 as part of the PDS, as described in Section 4.8. Information from these test pits assisted with delineating the location and estimating the volume of buried debris in Pond 1. Buried debris observed in Pond 1 included wood, plastic, concrete, and metal. The surface area of the debris area was calculated to be 5,400 sf and an average depth of 5 ft was used to estimate the volume of buried debris.

Table 3-7 summarizes the estimated volume of debris based on the dominant material types, or mixed in the case of the Boneyard and Pond 1. The dominant material type overall at the Mine Site is metal. The second largest volume of material on the Mine Site is concrete, including concrete pads, foundations, and vent casing structures. The total estimated volume of mine debris at the Mine Site is 25,600 cy as follows:

- Surface debris = 12,800 cy
- Buried debris at Boneyard = 11,800 cy
- Buried debris at Pond 1 = 1,000 cy

These volumes represent partial consolidation (50%) of specific items (e.g., concrete culverts). For large items such as buildings and large tanks, the volumes exclude the void spaces within those structures. A reduction in volume was not assumed for the volume estimates of the smaller or non-compressible/crushable items.

There is additional surface debris located in the Shaft Construction Yard located just west of the UNC offices and at the Mill Site (see Figure 1-2). The results of the debris surveys from these areas are included the report *Pre-Design Studies Report, Church Rock Mill Site* (MWH, 2014).

4.7.3 Vent and Shaft Cover Assessment

The debris survey included the mine vents and shafts, the locations of which are shown on Figure 1-2. The locations of Vents 3, 6, 7, 8, and the NECR-2 mine shaft are shown on Figure 3-6 and the photos in Appendix B. The locations of Vents 9 and 10 are shown on Figure 1-2. Appendix B includes location information, photographs, and descriptions of the covers for the Mine Site vents, and the shaft at the NECR-2 pad. Shaft 1 is covered with soil from the Interim Removal Actions, and so was not observed during the PDS. All observed vent covers and the Shaft 2 cover appeared visually to be in place and in good condition with no signs of damage or disrepair.

4.8 MINE WASTE CHARACTERIZATION

This section describes the nature and quantity of waste materials at the Mine Site that will be included in the RA, including Ra-226 and TPH-impacted soils and potential ACM. The following sections describe the results of the PDS, as well as pertinent information from previous investigations (RSE and SRSEs). The location and volume of PTW is discussed in Section 4.3.

4.8.1 TPH-Impacted Soil

Samples of the TPH Stockpile were collected and analyzed for RCRA hazardous waste characteristics (toxicity, ignitability, corrosivity, and reactivity) according to the Work Plan (MWH, 2013a). The analyzed samples consisted of two 4-point composite samples that were homogenized in the field. The TPH-stockpile was covered with heavyweight plastic sheeting beneath a clean soil cover that ranged in thickness from 4 to 30 inches. The samples were collected from hand-excavated holes advanced to 4 to 17 inches below the bottom of the cover.

The two composite samples were sent to ELI for analysis. The results are shown in Table 3-8, *TPH Soil Analytical Results* and the laboratory analytical reports are included in Appendix B. The results for the two samples indicated the following:

- pH values of 7.74 and 7.81 s.u.
- Flash point greater than 140°F for both samples.
- Reactive cyanide and sulfide concentrations were both non-detect.
- Extractable metals were all non-detect

These results indicated that the TPH-impacted soils present within the TPH-stockpile are not classified as a RCRA hazardous waste. The volume of the TPH-stockpile is approximately 7,500 cy and is included with the impacted soil volume estimate.

Soil with a strong petroleum odor was also encountered while drilling four boreholes in Pond 1 (P1-CC10 through P1-CC13), as presented in Section 4.2.6. The intervals over which TPH-impacted soil was detected in Pond 1 generally coincided with the location of PTW in Pond 1 (see borehole locations shown on Figures 2-1 and 3-3). Four samples were collected from

impacted intervals in Pond 1 (one from each borehole) for analysis of ignitability, corrosivity, reactivity (sulfide and cyanide) and toxicity (TCLP extractable metals arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) and submitted to the chemical laboratory for analysis. The laboratory analytical reports are included in Appendix B and the results indicated the following for the four samples:

- Corrosivity-pH: 7.5 to 8.6 s.u.
- Flash Point (Ignitability): >140°F for all but one sample at 90°F
- Reactivity (cyanide): non-detect (<0.050 mg/kg)
- Reactivity (sulfide): non-detect (<20 mg/kg) up to 30 mg/kg.
- TCLP-Extractable Metals: barium was detected at 2 mg/L in one sample (the regulatory level for barium is 100 mg/L). All other metals concentrations were non-detect.

These results indicated that the TPH soils would not be classified as hazardous waste (see 40 CFR §261.23), with the possible exception of the one sample in which the flash point was less than 140°F. Sample TPH-P1-CC12-004 exhibits the RCRA ignitability characteristic because the sample flash point was 90°F. However, this sample is not considered to be a representative of all the impacted soil sample since it is only one out of five samples collected. Additional characterization of soils at this location will be conducted during implementation of the RA. The TPH impacted soils are commingled with soils containing Ra-226 above the RAL, the volume of these commingled soils is included with the estimate of impacted soil from Pond 1.

4.8.2 Potential Asbestos Containing Materials

Five test pits were advanced in the northeastern corner of Pond 1 to evaluate the presence potential ACM, such as building insulation material made of vermiculite. Test pit locations are identified on Figure 3-6 and test pit logs are included in Appendix B. The test pits were excavated 10 to 25 ft in length and 3 to 4 ft deep and generally ran northeast to southwest. Buried vermiculite was not encountered in any of the test pits. However, one small piece of what appeared to be vermiculite material (~5 mm) was observed on the ground surface near PACM-Pit 4. Large amounts of debris were encountered in the test pits, including cinder blocks, plastic piping, rotten and/or burned wood, fiberglass insulation, building floor tiles, and pieces of concrete.

Prior to excavation of the test pits, floor tile pieces were observed scattered on the ground surface (some tiles were also encountered in test pit PACM-Pit 1). Communication with UNC staff suggested the floor tiles were potential ACM, and therefore, two tile samples were collected and shipped to Assaigai Analytical Laboratories (Albuquerque, NM). Floor tile pieces were off-white in color with black mastic on one side and generally less than 8 inches in diameter. Pieces were generally flexible and not friable. Laboratory sample analyses indicated the white material contains 2% chrysotile asbestos and the black mastic contains 3% percent chrysotile asbestos. USEPA guidance states that any material containing in excess of 1%

asbestos is considered an ACM (USEPA, 1990). The OSHA regulation 29 CFR 1910 provides permissible exposure limits (PEL) for friable asbestos applicable to onsite workers, which will be addressed in the design for removal, transport and placement of friable ACM.

5 CONCLUSIONS

The PDS were conducted at the NECR Mine Site in preparation for design of the NECR Mine Site Removal Action. The goal of the PDS was to collect pre-design data and information necessary to design the RA in accordance with the proposed performance standards and the USEPA Region 9 *Action Memorandum: Request for Non-Time Critical Removal Action at the Northeast Church Rock Mine Site* (Action Memo) (USEPA, 2011a) and the USEPA Region 6 *Proposed Plan* (USEPA, 2012) and *Record of Decision* (ROD)(USEPA, 2013). The tasks that were conducted during the PDS consisted of the following:

- Removal action level (RAL) boundary survey
- Soils radiological characterization of clean (unimpacted) and PTW soils
- Estimates of the volumes of clean and impacted soils, including PTW soils
- Soils geotechnical characterization
- Debris inventory
- Evaluation of potential hazardous waste and potential ACM

The PDS were used to refine the vertical and lateral extent of clean (unimpacted) and PTW soils within the areas containing subsurface impacts. The results of the PDS and RSE were then used to estimate the volume of impacted soils (surface and subsurface) that will be placed in the repository, as well as the volume of clean (unimpacted) soils. The total volume of soils with Ra-226 above the RAL was estimated to be 783,000 cy, distributed between surface and subsurface soils, as follows:

- Surface soils (areas with impacts 0.5 to 1 ft bgs) = 95,000 cy
- Subsurface soils (areas with impacts >1 ft bgs) = 688,000 cy

These volumes represent the current in-place volume and do not account for a reduction in volume due to compaction when placed in the repository. The results of geotechnical testing of the soils at the Mine Site indicated that if the mine soils are placed in the repository at 90 percent of the maximum Proctor values, it would result in an average volume reduction of eight percent, which would reduce the total volume from 783,000 cy to 720,000 cy.

The PDS also included an inventory of surface debris and an estimate of the volume of debris to be placed in the repository. The mine debris inventory indicated that scrap metal, concrete, plastic, wood, and rubber is present at the surface in many locations at the Mine site. Additionally, a large volume of buried debris is located in Pond 1 and in the Boneyard. The total volume of mine debris at the Mine Site was estimated to be 25,600 cy, which includes 12,800 cy of surface debris plus 12,800 cy of buried debris in Pond 1 and the Boneyard. These volumes represent partial compaction (50%) of specific items (e.g., concrete culverts) and, for large items such as buildings and large tanks; the volumes exclude the void space within those structures.

The volumes for the smaller or non-compressible/crushable items assumed no reduction in volume.

There is additional surface debris located in at the Mill Site and at the Shaft Construction Yard located just west of the UNC offices and at the Mill Site. The results of the debris surveys from these areas are included the report *Pre-Design Studies Report, Church Rock Mill Site* (MWH, 2014). The total volume of debris inventoried at these two locations was 6,780 cy.

Based on the volume estimates presented above, the aggregate volume of impacted soil plus mine debris from both the Mine Site and the Mill Site, not including compaction, is expected to be approximately 815,000 cy. Assuming an 8% reduction in soil volume due to compaction once placed in the repository, the net volume to be placed in the repository is expected to be approximately 752,000 cy. This volume assumes partial consolidation (50%) of specific debris items, as discussed above. During the design, adding a contingency to the capacity of the repository will be considered.

The combined results of the RSE, supplemental RSEs, and PDS were comprehensive, and there are no significant data gaps for the RA design. However, as part of the RA design and execution of the RA, it may be necessary to conduct the following tasks:

- Confirm the absence of RCRA hazardous waste in Pond 1.
- Further evaluate the presence of PTW in the Sediment Pad.
- Further assess the potential reduction in volume of the compressible debris.

Additionally, the rough cut surface that was generated based on the RSE and PDS results will need to be refined during the design process in order to determine the final regrade and borrow requirements. This may result in minor adjustments to the volume of soils to be placed in the repository and the total volume of clean soil that can be segregated during construction.

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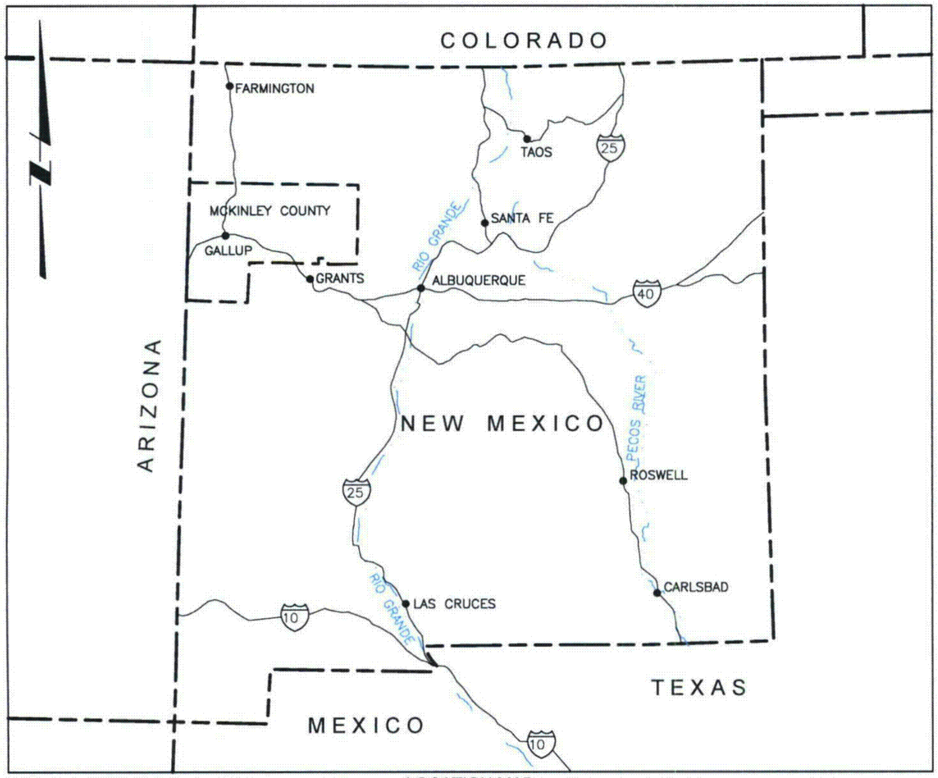
FIGURES

D:\004-Blocks\10504918 figure 1-1



LOCATION MAP

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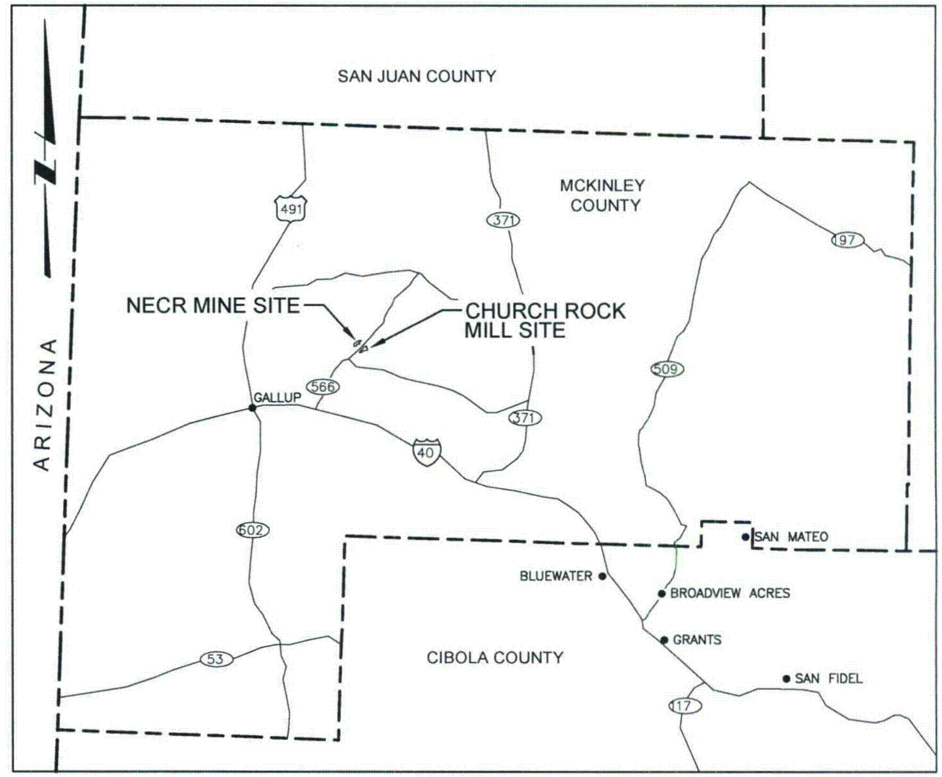

VICINITY MAP

NOT TO SCALE

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DRAWN BY	C FOWLER	07/18/14
CHECKED BY	T LEESON	07/18/14
APPROVED BY	T LEESON	07/18/14
PROJECT MANAGER	T LEESON	07/18/14
CLIENT APPROVAL		
CLIENT REFERENCE NO		

PROJECT LOCATION
MCKINLEY COUNTY, NEW MEXICO

PROJECT
NORTHEAST CHURCH ROCK MINE
PRE-DESIGN STUDIES REPORT

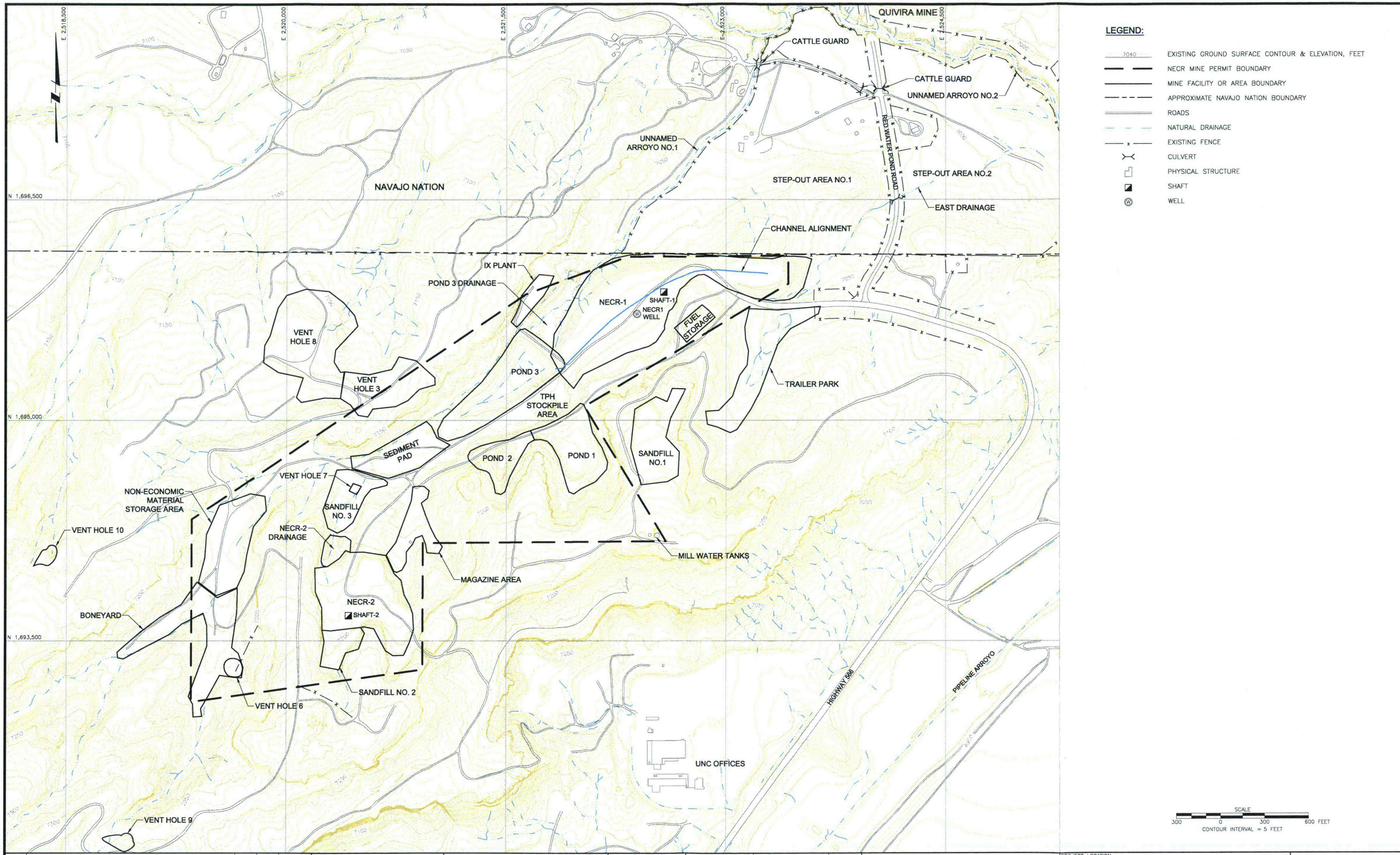
TITLE
SITE LOCATION MAP

MWH

FIGURE 1-1

REVISION A

FILE NAME 10504918 figure 1-1



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1. ORIGINAL SURFACE TOPOGRAPHY GENERATED FROM AERIAL PHOTOGRAPHS DATED MAY 2007 BY COOPER AERIAL SURVEYS CO. AND USGS 10m DIGITAL ELEVATION MODELS (DEM).
2. NECR-1, STEP-OUT NO.1 AND NO.2 REGRADE TOPOGRAPHY SURVEY DATA PROVIDED BY MORRIS SURVEYING ENGINEERING, LLC; DATED MAY 2010 AND DEC 2012.

PROJECTION: STATE PLANE COORDINATES
ZONE: NEW MEXICO WEST
DATUM: NAD 83
UNITS: US FEET

DESIGNED BY	T LEESON	05/15/14
DRAWN BY	C FOWLER	05/15/14
CHECKED BY	T LEESON	05/15/14
APPROVED BY	T LEESON	05/15/14
PROJECT MANAGER	T LEESON	05/15/14
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO
PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT
TITLE: NECR MINE SITE LAYOUT
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FILE NAME: 10504918 figure 1-2

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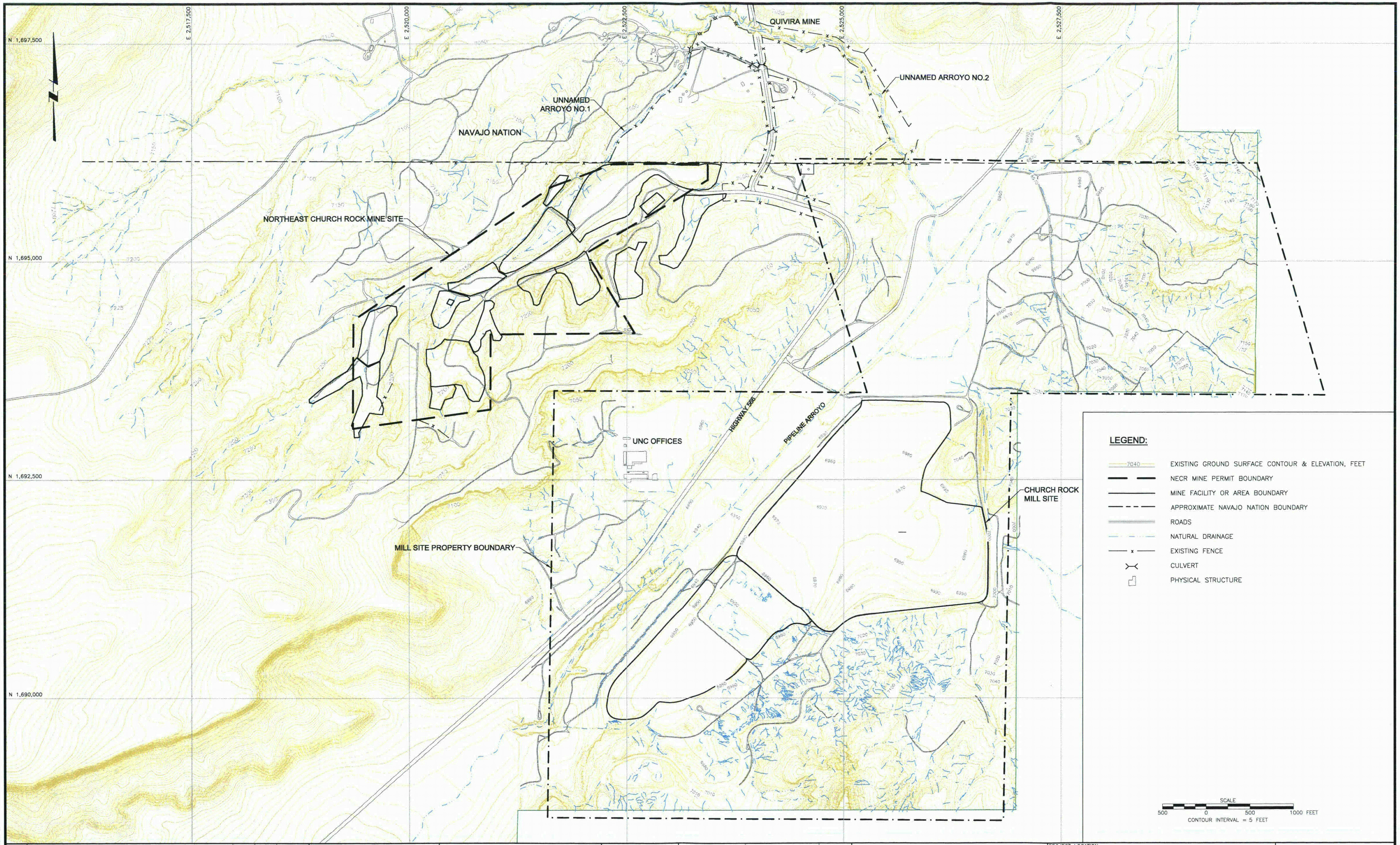

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PROJECTION: STATE PLANE COORDINATES
ZONE: NEW MEXICO WEST
DATUM: NAD 83
UNITS: US FEET

DESIGNED BY	T LEESON	05/15/14
DRAWN BY	C FOWLER	05/15/14
CHECKED BY	T LEESON	05/15/14
APPROVED BY	T LEESON	05/15/14
PROJECT MANAGER	T LEESON	05/15/14
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO
PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT
TITLE: REGIONAL MAP

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FIGURE: 1-3
REVISION: A
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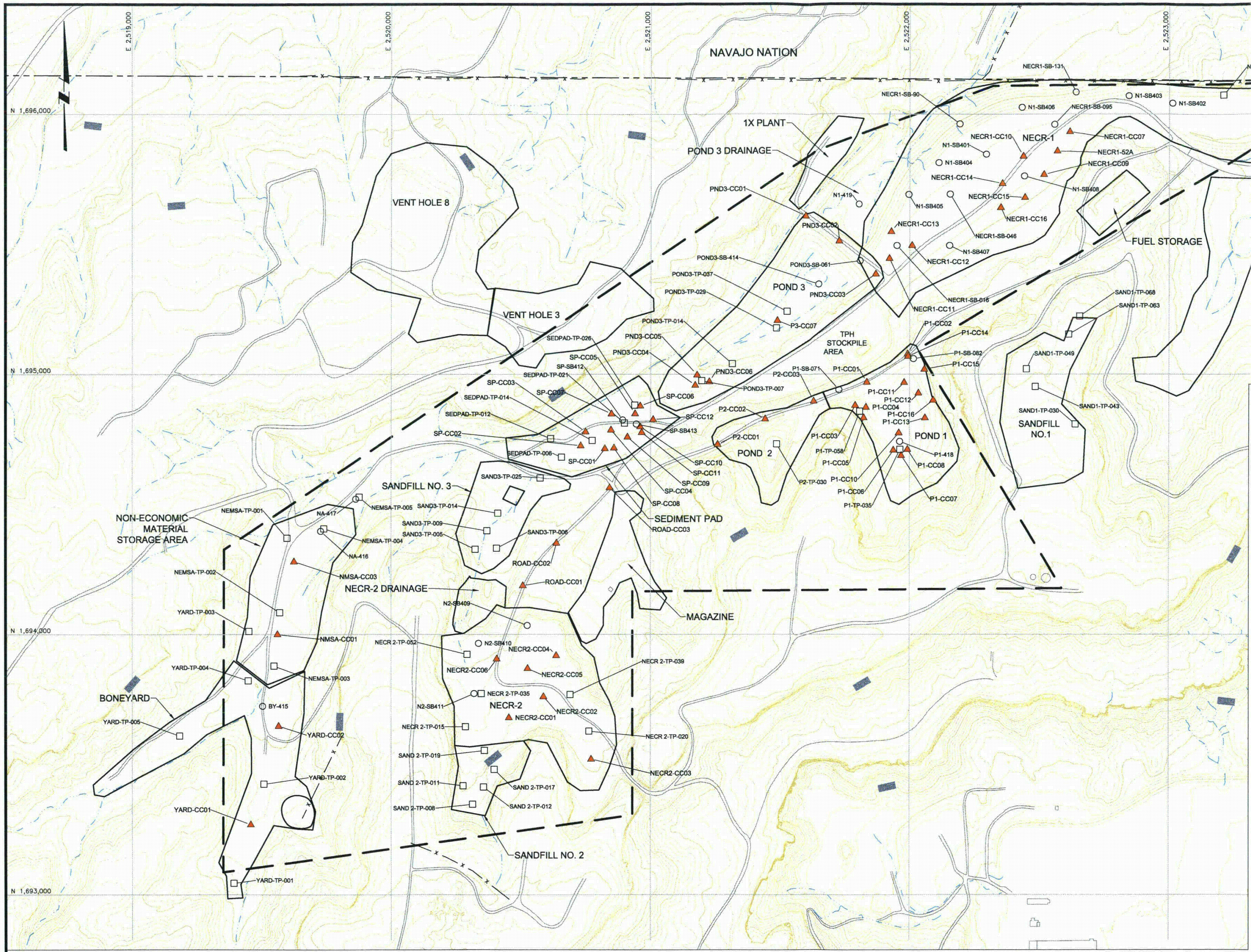

PLAN

SCALE 200 0 200 400 FEET

CONTOUR INTERVAL = 5 FEET

LEGEND:

7040	EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
	NECR MINE PERMIT BOUNDARY
	APPROXIMATE NAVAJO NATION BOUNDARY
	MINE FACILITY OR AREA BOUNDARY
	ROADS
	NATURAL DRAINAGE
x	EXISTING FENCE
	PHYSICAL STRUCTURE
	RSE TEST PIT LOCATION
	RSE SOIL BORING LOCATION
SP-SB413	RSE LOCATION ID
	PDS SOIL BORING LOCATION
P1-CC08	PDS SOIL BORING LOCATION ID

NOTES:

1. PDS LOCATIONS SAMPLED 2013.
2. RSE LOCATIONS SAMPLED 2007 AND 2008.

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PROJECTION: STATE PLANE COORDINATES
ZONE: NEW MEXICO WEST
DATUM: NAD 83
UNITS: US FEET

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APPROVED BY	T LEESON	05/15/14
PROJECT MANAGER	T LEESON	05/15/14
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

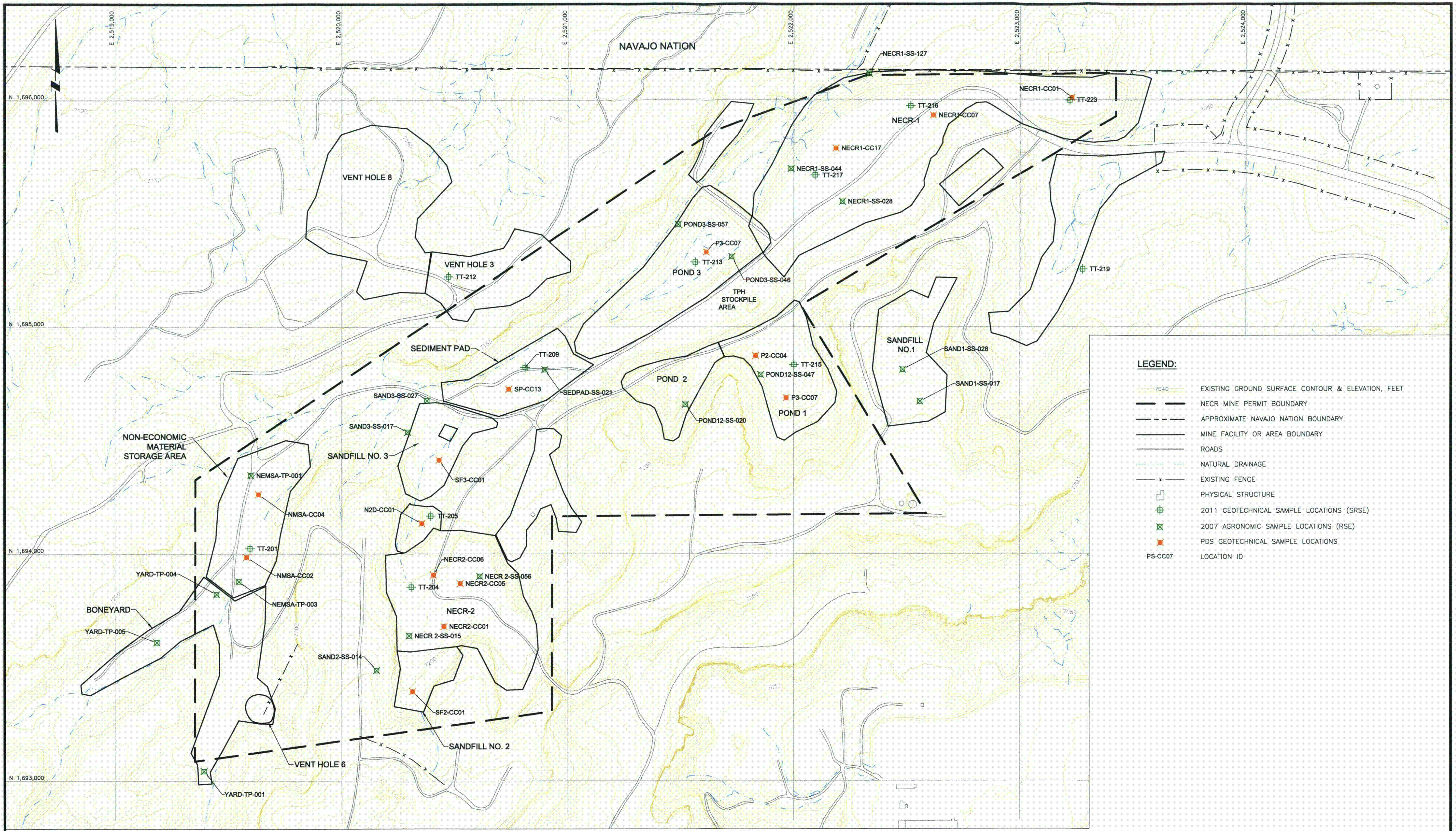
PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: SUBSURFACE SOIL SAMPLING LOCATIONS

FIGURE: 2-1 REVISION: A

FILE NAME: 10504918 figure2-1

D:\004-Blocks\10504918 figure2-1



PLAN

SCALE

200 0 200 400 FEET

CONTOUR INTERVAL = 5 FEET

ISSUE REV	DESCRIPTION	TECH	ENG	DATE
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CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: GEOTECHNICAL SOIL SAMPLING LOCATIONS

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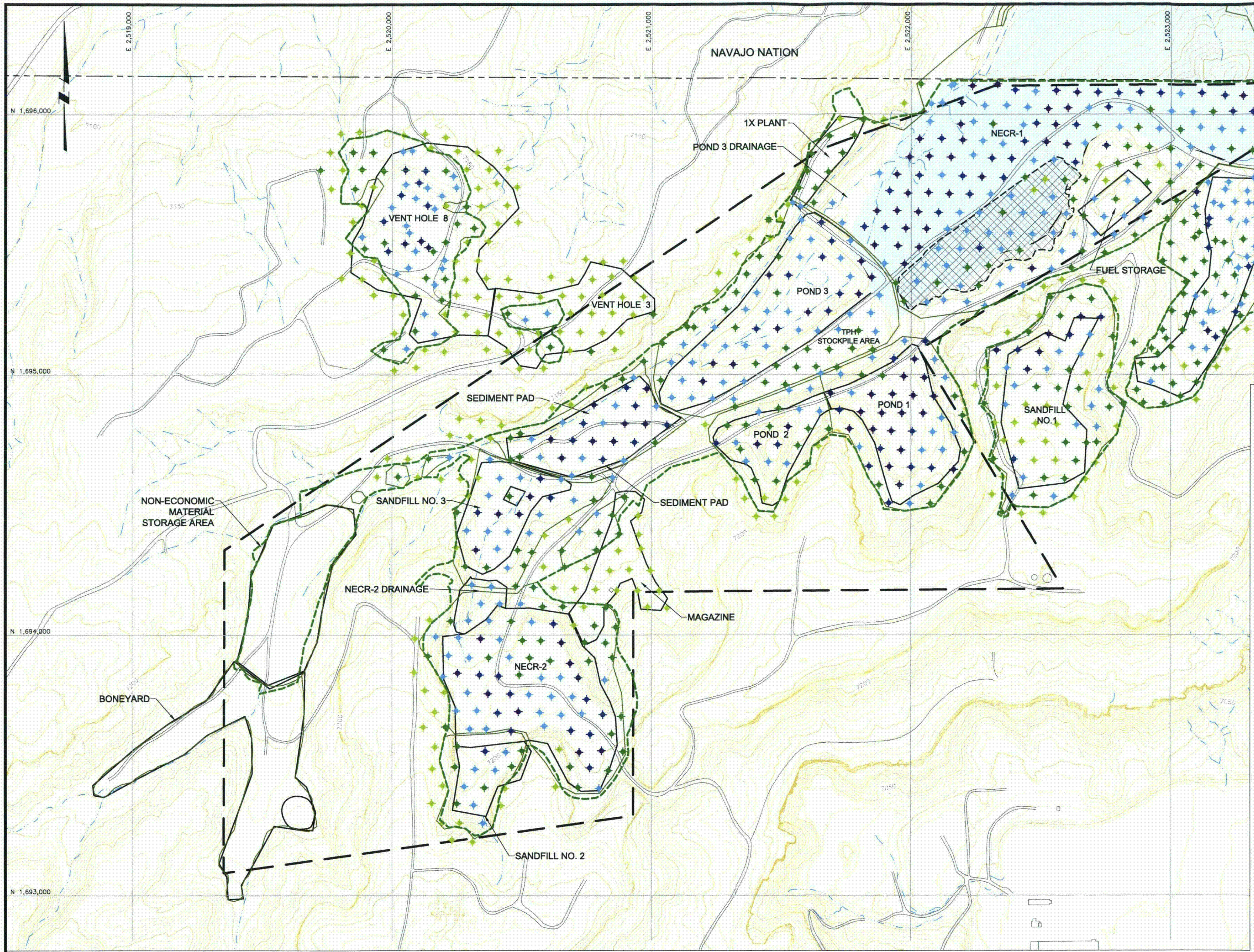
FIGURE: 2-2 REVISION: A

FILE NAME: 10504918 figure 3-5

D: U04-Blocks\10504918 figure 3-5



LEGEND:

7040	EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
	NECR MINE PERMIT BOUNDARY
	APPROXIMATE NAVAJO NATION BOUNDARY
	MINE FACILITY OR AREA BOUNDARY
	RAL BOUNDARY
	FSL BOUNDARY
	INTERIM REMOVAL ACTION AREA (NECR-1 PAD WAS REGRADED AND COVERED WITH UP TO 20 FEET OF IMPACTED SOIL AND 6" - 12" OF IMPORTED SOIL)
	EDRA SOIL CONSOLIDATION AREA
	ROADS
	NATURAL DRAINAGE
	PHYSICAL STRUCTURE

RSE STATIC GAMMA MEASUREMENT LOCATIONS SHOWING EQUIVALENT RA-226 (PCI/G) CONCENTRATION

- < 2.2
- 2.2 ~ 6.0
- 6.1 ~ 22.4
- 22.4 ~ 50
- >50

NOTE:

RAL BOUNDARY IS AN UPDATE TO THE FIELD SCREENING LEVEL (FSL) BOUNDARY FROM THE RSE BASED ON A SCAN SURVEY OF THE BOUNDARY DURING THE PDS.

PLAN

SCALE 200 0 200 400 FEET

CONTOUR INTERVAL = 5 FEET

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ZONE: NEW MEXICO WEST
DATUM: NAD 83
UNITS: US FEET

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CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

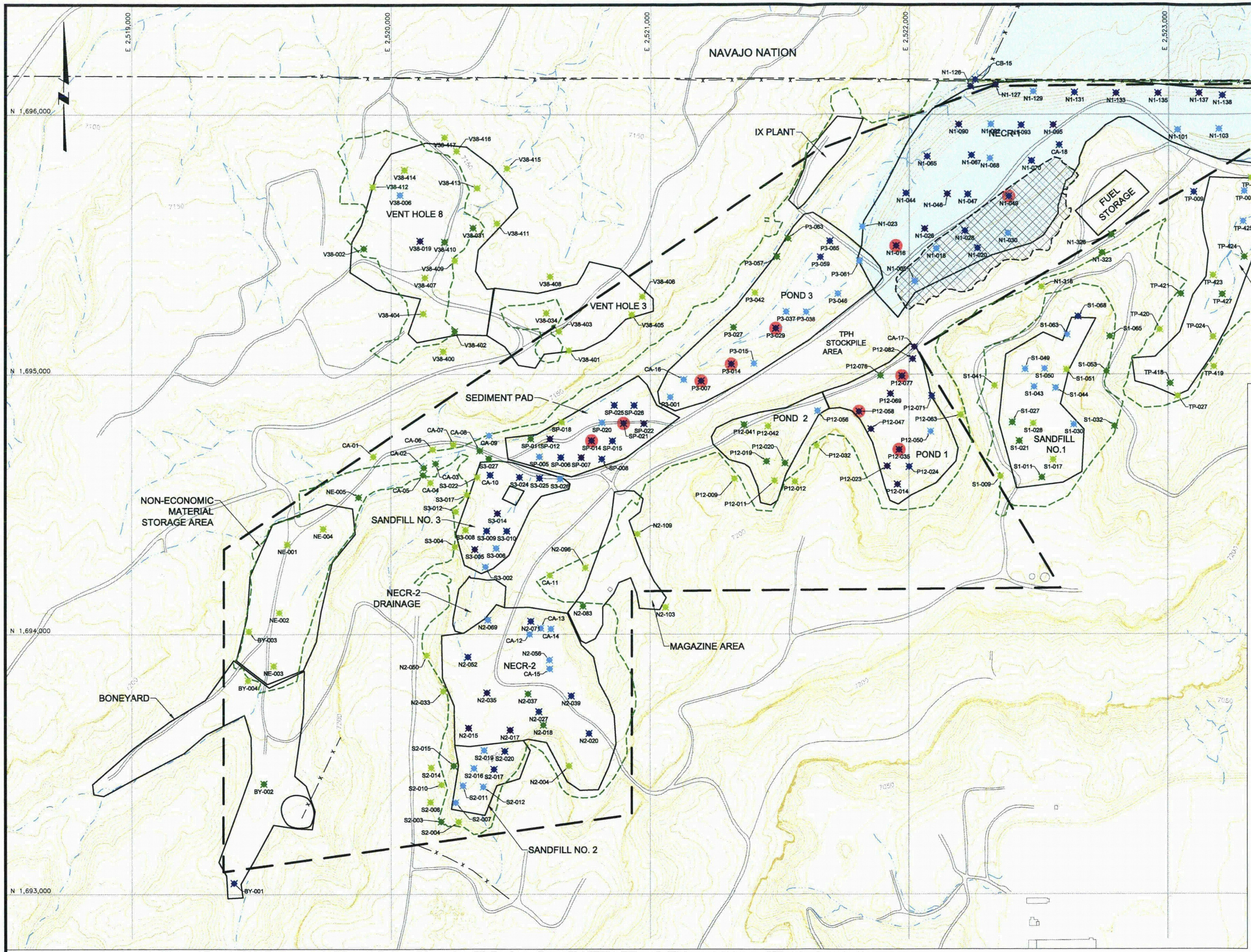
PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: RAL BOUNDARY SURVEY RESULTS

FIGURE: 3-1 REVISION: A

FILE NAME: 10504918 figure 3-1

D:\004-Blocks\10504918 figure 3-1



PLAN

SCALE: 200 0 200 400 FEET

CONTOUR INTERVAL = 5 FEET

LEGEND:

- 7040 — EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- NECR MINE PERMIT BOUNDARY
- APPROXIMATE NAVAJO NATION BOUNDARY
- MINE FACILITY OR AREA BOUNDARY
- RAL BOUNDARY
- INTERIM REMOVAL ACTION AREA. NECR-1 PAD WAS REGRADED AND COVERED WITH UP TO 20 FEET OF IMPACTED SOIL AND 6" – 12" OF IMPORTED SOIL.
- EDRA SOIL CONSOLIDATION AREA
- ROADS
- NATURAL DRAINAGE
- EXISTING FENCE
- PHYSICAL STRUCTURE
- TP-423 — SURFACE SOIL SAMPLE LOCATION ID

RSE SURFACE SOIL SAMPLE LOCATIONS SHOWING RA-226 LABORATORY RESULTS (pCi/g)

- < 2.2
- 2.2 ~ 6.0
- 6.1 ~ 22.4
- 22.4 ~ 50
- > 50
- PTW (BASED ON Ra OR U CONCENTRATION DURING RSE, SEE FIGURE 3-3 FOR SUBSURFACE RESULTS)

NOTES:

1. SAMPLES COLLECTED DURING 2007 RSE AND 2008 SRSE, AND ANALYZED BY ELI USING EPA 901.1.
2. SEE APPENDIX A FOR DETAILED RESULTS.
3. PTW = PRINCIPAL THREAT WASTE
4. PTW WAS DETECTED IN SURFACE SOIL DURING THE RSE.

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CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: RSE SURFACE SOIL ANALYTICAL RESULTS

MWH

FIGURE: 3-2
REVISION: A
FILE NAME: 10504918 figure 3-2

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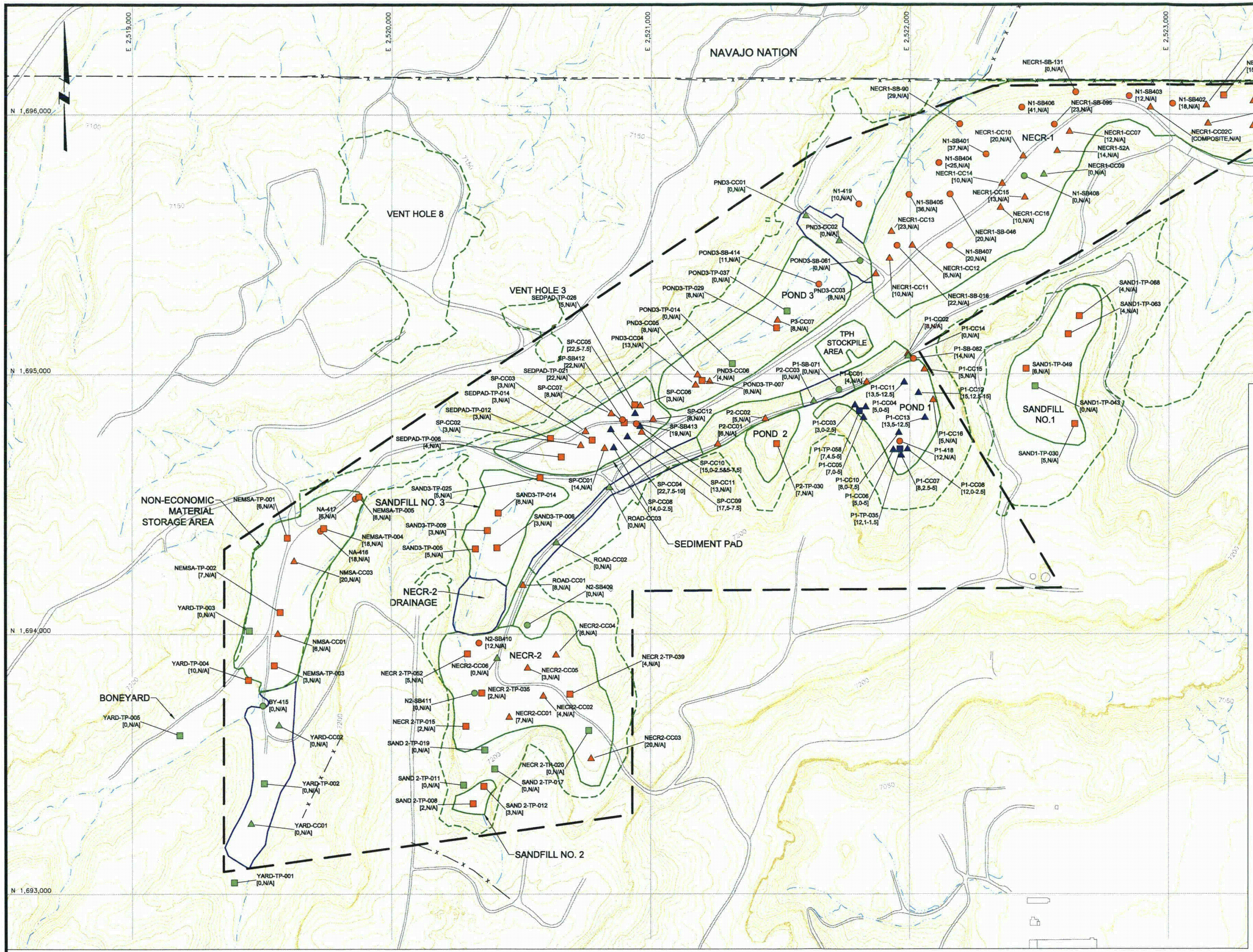

LEGEND:

7040	EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
	NECR MINE PERMIT BOUNDARY
	APPROXIMATE NAVAJO NATION BOUNDARY
	RAL BOUNDARY
	SUBSURFACE SOIL REMOVAL ACTION BOUNDARY
	NON-IMPACTED SOIL
	ROADS
	NATURAL DRAINAGE
	EXISTING FENCE
	PHYSICAL STRUCTURE
	RSE TEST PIT LOCATION
	RSE SOIL BORING LOCATION
	PDS SOIL BORING LOCATION
SP-SB413	LOCATION ID
[12, 1-1.5]	PTW DEPTH RANGE (ft bgs) / DEPTH TO RAL (ft bgs)

SUBSURFACE SOIL ANALYTICAL OR SCREENING RESULTS:

- < 2.24
- 2.24 – 200
- > 200 (PTW CRITERIA)

NOTES:

1. SURFACE SOIL WAS NOT SAMPLED DURING THE PDS.
2. PTW = PRINCIPAL THREAT WASTE.
3. ONE SOIL SAMPLE WAS COLLECTED FROM EACH OF THE FIVE NECR1–CC02C LOCATIONS AND COMPOSITED INTO ONE SAMPLE FOR LAB ANALYSIS.

PLAN

SCALE 200 0 200 400 FEET

CONTOUR INTERVAL = 5 FEET

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CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: SUBSURFACE SOIL SAMPLE RESULTS

MWH

FIGURE 3-3 REVISION A

FILE NAME 10504918 figure 3-3

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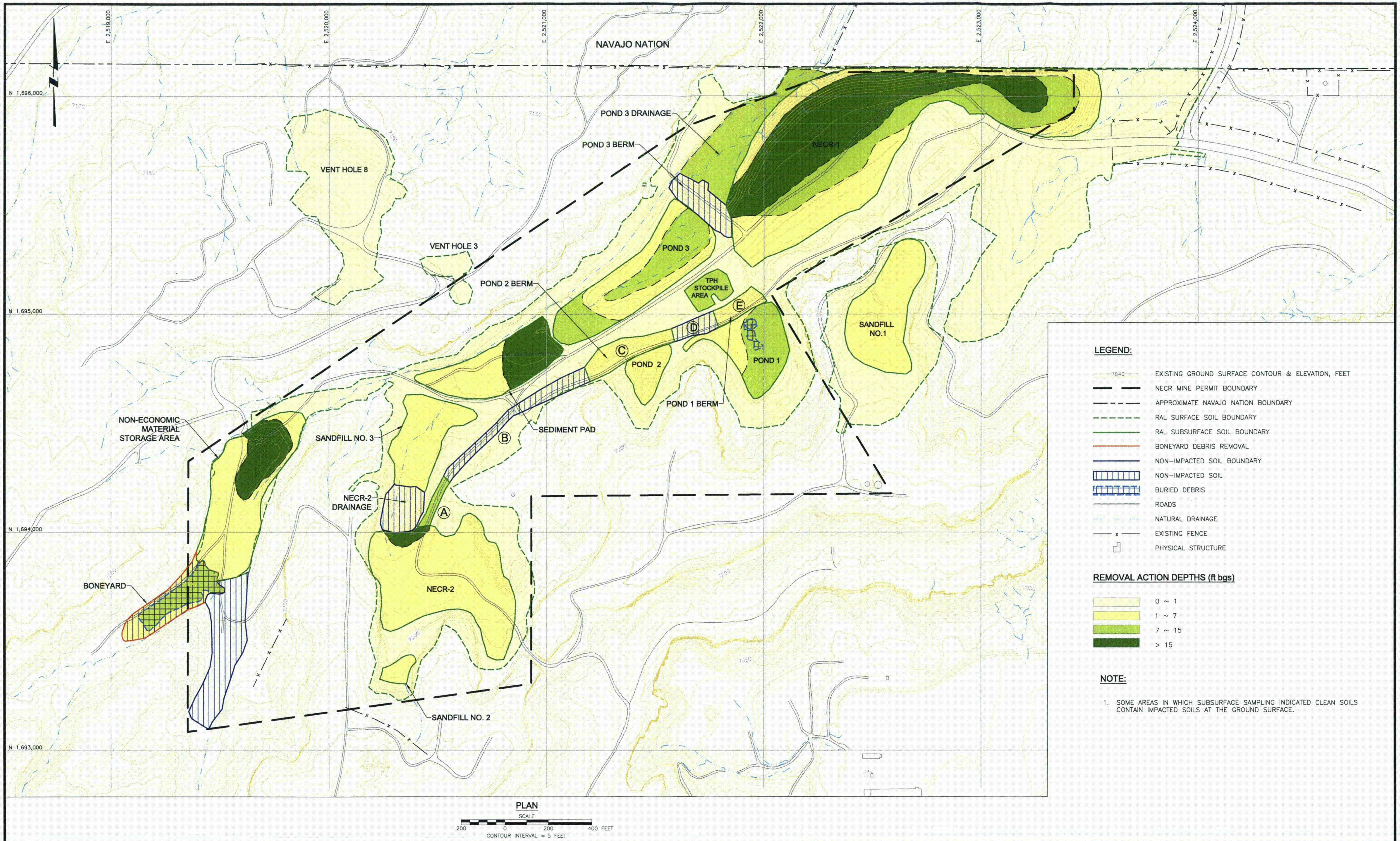

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PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: SUBSURFACE SOIL REMOVAL ACTION BOUNDARIES

MWH

FIGURE: 3-4
REVISION: A
FILE NAME: 10504918 figure 3-4

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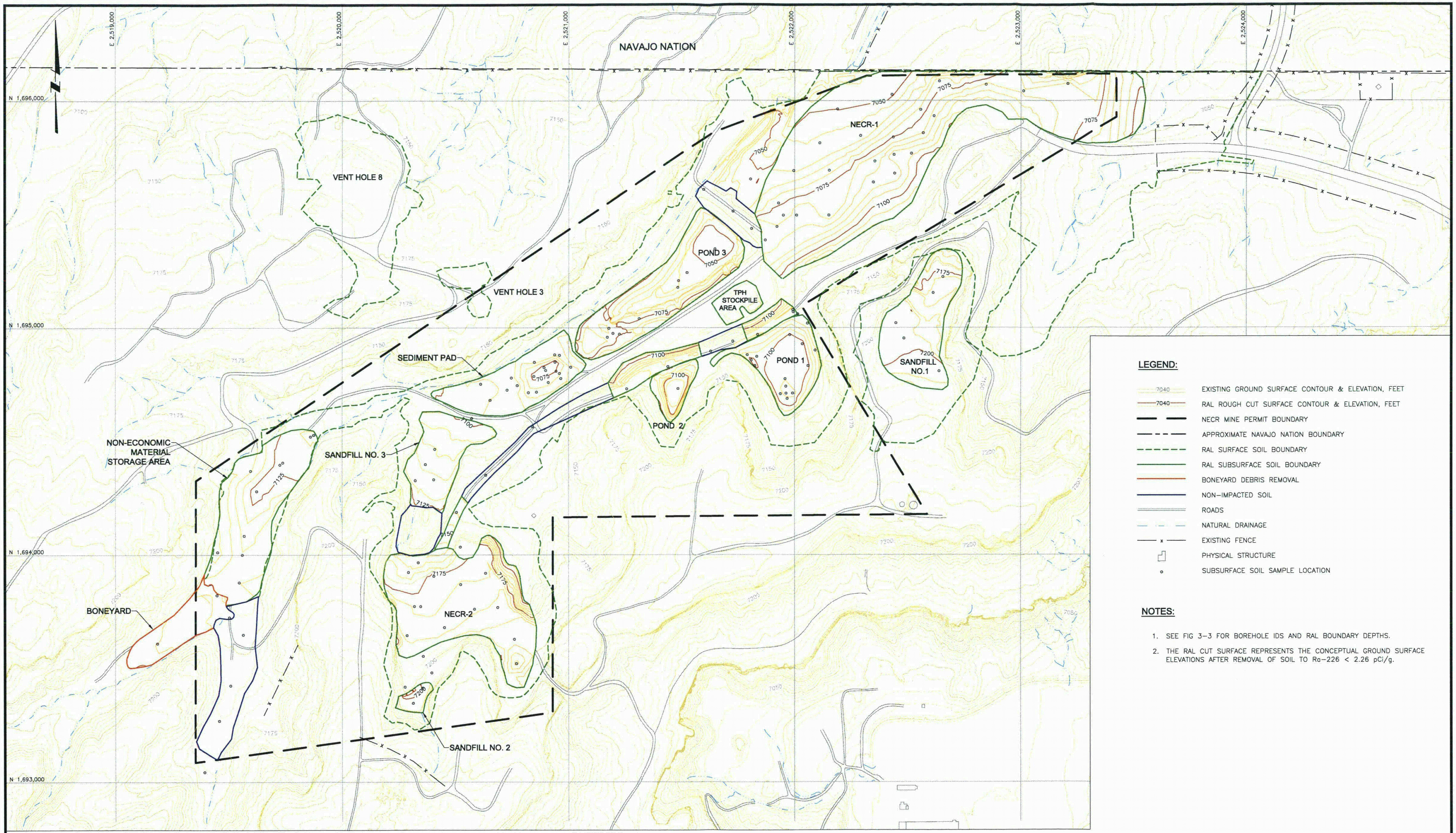

LEGEND:

- 7040 EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- 7040 RAL ROUGH CUT SURFACE CONTOUR & ELEVATION, FEET
- NECR MINE PERMIT BOUNDARY
- APPROXIMATE NAVAJO NATION BOUNDARY
- RAL SURFACE SOIL BOUNDARY
- RAL SUBSURFACE SOIL BOUNDARY
- BONEYARD DEBRIS REMOVAL
- NON-IMPACTED SOIL
- ROADS
- NATURAL DRAINAGE
- EXISTING FENCE
- PHYSICAL STRUCTURE
- SUBSURFACE SOIL SAMPLE LOCATION

NOTES:

1. SEE FIG 3-3 FOR BOREHOLE IDS AND RAL BOUNDARY DEPTHS.
2. THE RAL CUT SURFACE REPRESENTS THE CONCEPTUAL GROUND SURFACE ELEVATIONS AFTER REMOVAL OF SOIL TO Ra-226 < 2.26 pCi/g.

PLAN

SCALE 200 0 200 400 FEET

CONTOUR INTERVAL = 5 FEET

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CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: RAL CUT SURFACE

FIGURE: 3-5 REVISION: A

FILE NAME: 10504918 figure 3-7-1

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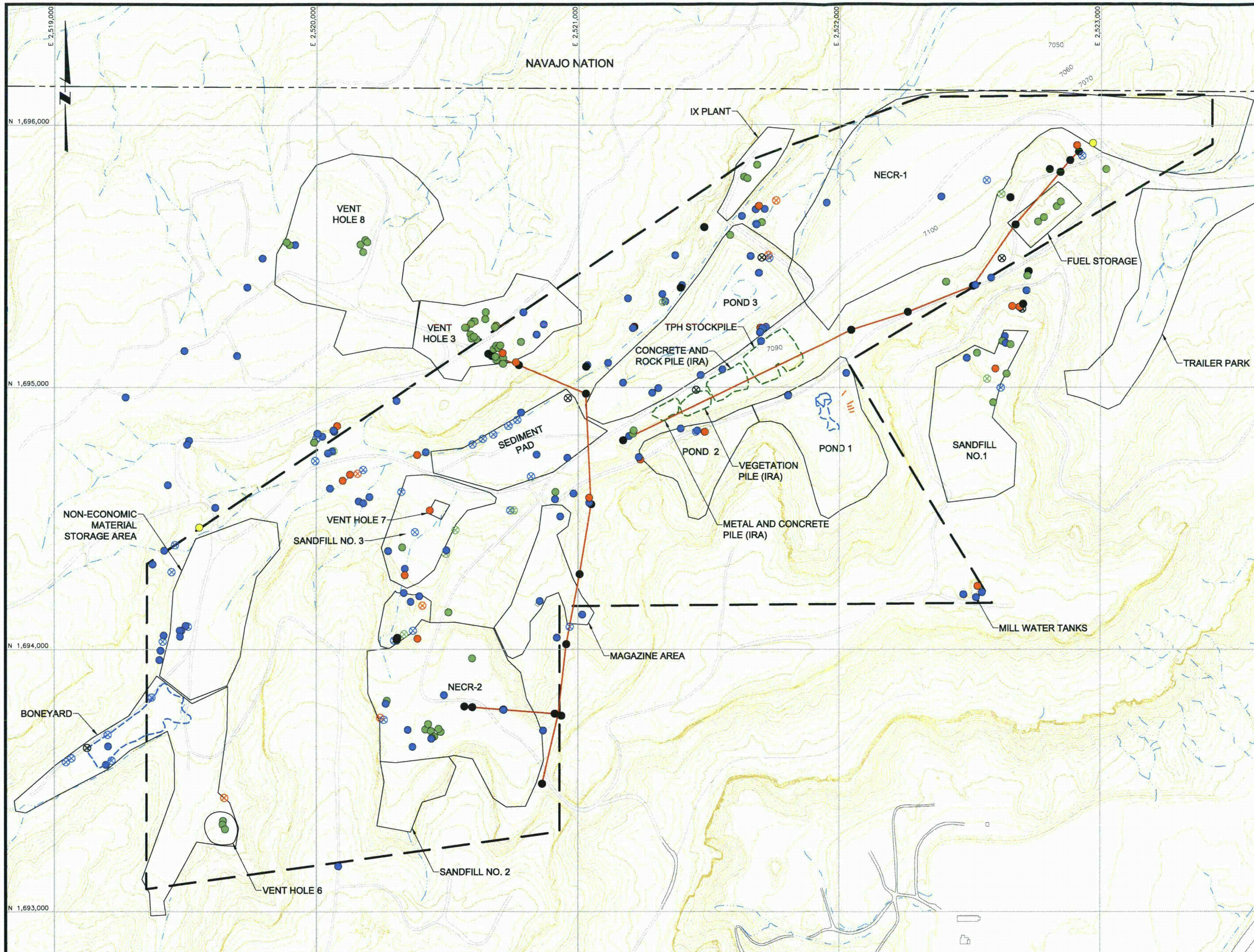

PLAN

SCALE

200 0 200 400 FEET

CONTOUR INTERVAL = 5 FEET

LEGEND:

- 7040 EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
- NECR MINE PERMIT BOUNDARY
- FACILITY BOUNDARY
- APPROXIMATE NAVAJO NATION BOUNDARY
- ROADS
- NATURAL DRAINAGE
- METALLIC DEBRIS
- MIXED METALLIC AND NON-METALLIC DEBRIS
- TELEPHONE LINES
- PACM TRENCHES
- PHYSICAL STRUCTURE

DEBRIS GROUP:

- METAL
- CONCRETE
- PLASTIC
- WOOD
- OTHER
- FIXED (COLOR CODED BY TYPE)
- NON FIXED (COLOR CODED BY TYPE)

NOTES:

1. SEE APPENDIX B OF PRE-DESIGN STUDIES REPORT FOR DETAILED MAPS AND SUMMARY TABLES OF DEBRIS INVENTORY.
2. SEE FIGURE 1-2 FOR LOCATION OF VENT HOLES 9 AND 10.
3. PACM = POTENTIAL ASBESTOS CONTAINING MATERIAL
4. IRA = 2009 INTERIM REMOVAL ACTION

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CLIENT REFERENCE NO.		

PROJECT LOCATION: MCKINLEY COUNTY, NEW MEXICO

PROJECT: NORTHEAST CHURCH ROCK MINE PRE-DESIGN STUDIES REPORT

TITLE: MINE DEBRIS INVENTORY MAP

MWH

FIGURE: 3-6 REVISION: A

FILE NAME: 10504918 figure 3-6-1

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TABLES

Table 3-1 Subsurface Sampling Summary

Area	Boreholes/Test Pits[1]	Total Depths (ft bgs)	Subsurface Samples	Boreholes <RAL	Boreholes >RAL, <PTW	Boreholes >PTW
Pre-Design Studies Boreholes						
Boneyard	2	15	6	2	0	0
NECR1	10	8 – 22.5	35	0	10	0
NECR2	7	4.5 – 24.3	15	1	6	0
NEMSA	2	11.5, 25	9	0	2	0
Pond 1	15	10 – 22.5	64	1	4	10
Pond 2	3	7.5 – 10	7	0	3	0
Pond 3	7	5 – 25	18	2	5	0
NECR-2 Road	3	10	4	2	1	0
Sediment Pad	12	5 – 22.5	49	0	7	5
Removal Site Evaluation Boreholes and Test Pits						
Boneyard	6	1.5 - 10	13	5	1	0
NECR1	15	3.5 - 46.5	44	3	12	0
NECR2	8	1 - 13	12	2	6	0
NEMSA	7	1.5 - 20	17	0	7	0
Ponds 1&2	7	1 - 22	14	1	4	2
Pond 3	6	3 - 26.5	16	3	3	0
Sediment Pad	7	1 - 20.5	12	0	7	0
Sandfill 1	5	2 - 6	9	1	4	0
Sandfill 2	5	1 - 2	5	3	2	0
Sandfill 3	5	1 - 2	7	0	5	0
Totals	**132**	**--**	**356**	**26**	**89**	**17**

Notes:

RAL=Removal Action Level; PTW=Principal Threat Waste

1. Borehole/test pit counts exclude geotechnical holes where Ra-226 was not monitored.

2. Within the Sediment Pad, during the PDS, the field screening values from five of the boreholes indicated the presence of PTW, while the laboratory values were less than PTW criteria.

Table 3-2 Subsurface Soil Analytical Results

Area	Loc ID[1]	Depth (ft bgs)	Ra-226 (pCi/g)[2]	Uranium (mg/kg)[2]
BONEYARD	YARD-CC01	0-5	1.1	--
	YARD-CC02	0-5	1.1	--
NECR-1	NECR1-52A	16.6-19.1	1.2	--
	NECR1-CC02C	-	3.2	--
	NECR1-CC07	12-15	1.2	--
	NECR1-CC09	5-8.8	2.1	--
	NECR1-CC10	9.5-15	70.1	--
	NECR1-CC11	3-5	98.7	--
	NECR1-CC12	2.5-5	147	--
	NECR1-CC13	10-12.5	60.8	--
	NECR1-CC13	10-12.5	57.6	--
	NECR1-CC14	12-15	1.2	--
	NECR1-CC15	5-10	2	--
	NECR1-CC16	7.5-10	6.9	--
NECR-2	NECR2-CC05	5-8	1.7	--
	NECR2-CC06	0-2.5	1.8	--
	NECR2-CC1	5-7	2.3	--
	NECR2-CC2	0-2.5	29.4	--
	NECR2-CC3	15-20	13.2	--
	NECR2-CC4	0-5	3.1	--
NEMSA	NMSA-CC01	5.5-7.5	1	--
	NMSA-CC03	5-7.5	82	--
POND 1	P1-CC01	5-10	1.2	--
	P1-CC02	5-8	10.2	--
	P1-CC03	0-2.5	504	906
	P1-CC03	2.5-5	1.8	254
	P1-CC04	2.5-5	372	2110
	P1-CC04	5-7.5	1.3	176
	P1-CC05	2.5-5	205	284
	P1-CC05	5-7	23.5	174
	P1-CC06	2.5-5	399	498
	P1-CC06	5-7.5	1.1	--
	P1-CC07	2.5-5	322	209
	P1-CC07	5-7.5	87.1	183
	P1-CC08	0-2.5	492	434
	P1-CC08	2.5-5	27.7	70.7
	P1-CC10	5-7.5	168	1220
	P1-CC10	7.5-10	1	1.1
	P1-CC11	12.5-15	1.9	12.2
	P1-CC11	7.5-10	887	3190
	P1-CC12	12.5-15	199	393
	P1-CC12	15-17.5	1.3	1.8
	P1-CC13	12.5-14	1.3	51.2
	P1-CC13	5-7.5	923	1330
	P1-CC14	22.5-25	0.9	--
	P1-CC15	15-17.5	1.3	--
	P1-CC16	12.5-15	2.2	--
	TPH-P1-CC10	5-7.5	211	197
	TPH-P1-CC11	10-12.5	473	1310
	TPH-P1-CC11	7.5-10	895	2940
	TPH-P1-CC12	12.5-15	152	72.7
	TPH-P1-CC13	7.5-10	592	1090

Table 3-2 Subsurface Soil Analytical Results

Area	Loc ID[1]	Depth (ft bgs)	Ra-226 (pCi/g)[2]	Uranium (mg/kg)[2]
POND 2	P2-CC01	0-5	5	--
	P2-CC02	5-10	1.1	--
	P2-CC03	0-5	2	--
POND 3	P3-CC07	0-5	12.7	--
	PND3-CC01	0-5	1.2	--
	PND3-CC02	5-10	1.5	--
	PND3-CC03	10-20	1.4	--
	PND3-CC04	5-10	21.1	--
	PND3-CC05	5-7.5	12	--
	PND3-CC06	0-2.5	18.2	--
ROAD	ROAD-CC01	5-10	1	--
	ROAD-CC02	0-5	1.1	--
	ROAD-CC03	0-5	1.2	--
SEDIMENT PAD	SP-CC01	0-5	98.9	--
	SP-CC02	2.5-5	1.7	--
	SP-CC03	2.5-5	2.1	--
	SP-CC04	10-12.5	65.3	48.1
	SP-CC04	7.5-10	162	108
	SP-CC05	5-7.5	140	69.2
	SP-CC05	7.5-10	158	82.4
	SP-CC06	2.5-5	2	--
	SP-CC07	2.5-5	78.6	--
	SP-CC08	0-2.5	150	231
	SP-CC08	2.5-5	119	184
	SP-CC09	5-7.5	135	192
	SP-CC09	7.5-10	145	166
	SP-CC10	11-15	3.6	--
	SP-CC10	15-17.5	1.8	--
	SP-CC10	15-17.5	1.6	--
	SP-CC10	5-7.5	144	104
	SP-CC10	5-7.5	133	99.6
	SP-CC11	0-2.5	157	199
	SP-CC11	2.5-4.5	118	206
	SP-CC12	0-2	106	--

Notes:
1. Samples collected in October-December 2013 during the Pre-Design Studies.
2. Samples analyzed by Energy Laboratories using EPA Methods 901.1 and 6020.
3. NECR1-CC02C is a composite sample collected from five boreholes in NECR-1 (see Figure 3-3).
4. Shaded cells indicate concentrations above the Principal Threat Waste crteria (Ra-226=200 pCi/g and U=500 mg/kg).

Table 3-3 Subsurface Soil Field Screening Results

Area	Location ID	Investigation Phase	Depth (ft bgs)	Gamma Measurements (CPM)		
				Subsurface Sample	200 pCi/g Reference	2 pCi/g Reference
BONEYARD	BY-415	RSE	5	18,852	--	--
	BY-415	RSE	10	17,938	--	--
	BY-415	RSE	15	17,863	--	--
	YARD-CC01	PDS	0-5	327	--	393
	YARD-CC01	PDS	6-10	302	--	393
	YARD-CC01	PDS	10-15	313	--	393
	YARD-CC02	PDS	0-5	338	--	393
	YARD-CC02	PDS	5-10	287	--	393
	YARD-CC02	PDS	10-15	317	--	393
NECR-1	N1-419	RSE	2	84,000	--	--
	N1-419	RSE	5	75,326	--	--
	N1-419	RSE	10	72,758	--	--
	N1-419	RSE	15	n/a	--	--
	N1-SB401	RSE	10	54,548	--	--
	N1-SB401	RSE	20	53,847	--	--
	N1-SB402	RSE	10	55,566	--	--
	N1-SB402	RSE	5	55,312	--	--
	N1-SB403	RSE	5	27,059	--	--
	N1-SB404	RSE	30	49,050	--	--
	N1-SB405	RSE	30.5	69,851	--	--
	N1-SB405	RSE	15	82,250	--	--
	N1-SB405	RSE	20	79,393	--	--
	N1-SB405	RSE	25	80,543	--	--
	N1-SB406	RSE	10	53,972	--	--
	N1-SB406	RSE	25	48,854	--	--
	N1-SB406	RSE	30	48,055	--	--
	N1-SB406	RSE	16	52,596	--	--
	N1-SB406	RSE	22	51,880	--	--
	N1-SB407	RSE	10	27,653	--	--
	N1-SB408	RSE	5	36,433	--	--
	NECR1-52A	PDS	14.1-16.6	450	--	441
	NECR1-52A	PDS	16.6-19.1	419	--	441
	NECR1-52A	PDS	9.1-14.1	654	--	441
	NECR1-CC02	PDS	-	618	--	--
	NECR1-CC07	PDS	9-11	667	--	419
	NECR1-CC07	PDS	12-15	416	--	419
	NECR1-CC09	PDS	5-8.8	760	--	417
	NECR1-CC10	PDS	9.5-15	12,344	--	417
	NECR1-CC11	PDS	3-5	14,984	17,877	--
	NECR1-CC11	PDS	12.5-15	411	17,877	--
	NECR1-CC11	PDS	5-7.5	3,779	17,877	--
	NECR1-CC11	PDS	7.5-10	577	17,877	--
	NECR1-CC12	PDS	0-2.5	1,593	17,877	--
	NECR1-CC12	PDS	2.5-5	14,451	17,877	--
	NECR1-CC12	PDS	5-7.5	347	17,877	--
	NECR1-CC12	PDS	7.5-10	339	17,877	--
	NECR1-CC13	PDS	10-12.5	7,650	17,877	--
	NECR1-CC13	PDS	12.5-15	7,831	17,877	--
	NECR1-CC13	PDS	2.5-5	2,919	17,877	--
	NECR1-CC13	PDS	5-7.5	9,110	17,877	--
	NECR1-CC13	PDS	7.5-10	8,003	17,877	--
	NECR1-CC14	PDS	12-15	458	17,735	--
	NECR1-CC14	PDS	1.5-5	1,311	17,735	--
	NECR1-CC14	PDS	15-17.5	329	17,735	--

Table 3-3 Subsurface Soil Field Screening Results

Area	Location ID	Investigation Phase	Depth (ft bgs)	Gamma Measurements (CPM)		
				Subsurface Sample	200 pCi/g Reference	2 pCi/g Reference
	NECR1-CC14	PDS	17.5-20	395	17,735	--
	NECR1-CC14	PDS	7.5-10	631	17,735	--
	NECR1-CC15	PDS	5-10	607	17,735	--
	NECR1-CC15	PDS	10-12	1,412	17,735	--
	NECR1-CC15	PDS	15-17.5	372	17,735	--
	NECR1-CC15	PDS	20-22.5	324	17,735	--
	NECR1-CC16	PDS	10-15	341	17,735	--
	NECR1-CC16	PDS	16-18	360	17,735	--
	NECR1-CC16	PDS	18-20	242	17,735	--
	NECR1-CC16	PDS	2.5-5	503	17,735	--
	NECR1-CC16	PDS	7.5-10	1,182	17,735	--
NECR-2	N2-SB409	RSE	5	16,560	--	--
	N2-SB410	RSE	10	75,264	--	--
	N2-SB410	RSE	5	78,173	--	--
	N2-SB411	RSE	5	25,117	--	--
	NECR1-CC07	PDS	5-9	6,771	--	419
	NECR2-CC01	PDS	5-7	523	--	--
	NECR2-CC01	PDS	0-5	4,491	--	--
	NECR2-CC02	PDS	4-9	380	--	493
	NECR2-CC02	PDS	0-2.5	2,673	--	493
	NECR2-CC03	PDS	4-5	1,899	--	493
	NECR2-CC03	PDS	5-7	1,013	--	493
	NECR2-CC03	PDS	0-4	6,822	--	493
	NECR2-CC03	PDS	14-15	4,508	--	493
	NECR2-CC03	PDS	15-20	2,027	--	493
	NECR2-CC03	PDS	20-22.5	452	--	493
	NECR2-CC04	PDS	0-5	498	--	493
	NECR2-CC05	PDS	5-8	404	--	493
	NECR2-CC05	PDS	0-2.5	958	--	493
	NECR2-CC06	PDS	0-2.5	361	--	475
NEMSA	NA-416	RSE	5	50,573	--	--
	NA-416	RSE	10	37,417	--	--
	NA-416	RSE	15	44,685	--	--
	NA-416	RSE	20	31,452	--	--
	NA-417	RSE	2	23,570	--	--
	NA-417	RSE	5	23,531	--	--
	NMSA-CC01	PDS	1.5-5	7,095	16,229	--
	NMSA-CC01	PDS	5.5-7.5	304	16,229	--
	NMSA-CC01	PDS	7.5-10	300	16,229	--
	NMSA-CC01	PDS	11-12.5	349	16,229	--
	NMSA-CC01	PDS	16.5-20	410	16,229	--
	NMSA-CC01	PDS	20-25	400	16,229	--
	NMSA-CC03	PDS	2.5-5	7,933	16,229	--
	NMSA-CC03	PDS	5-7.5	9,989	16,229	--
	NMSA-CC03	PDS	7.5-10	8,443	16,229	--
	P1-418	RSE	2	226,493	--	--
	P1-418	RSE	5	226,202	--	--
	P1-418	RSE	10	229,405	--	--
	P1-CC01	PDS	5-10	556	--	515
	P1-CC01	PDS	0-3	2,608	--	515
	P1-CC02	PDS	5-8	1,982	--	515
	P1-CC02	PDS	8-15	517	--	515
	P1-CC02	PDS	0-5	1,206	--	515
	P1-CC03	PDS	5-10	683	17,973	--

Table 3-3 Subsurface Soil Field Screening Results

Area	Location ID	Investigation Phase	Depth (ft bgs)	Gamma Measurements (CPM)		
				Subsurface Sample	200 pCi/g Reference	2 pCi/g Reference
POND 1	P1-CC03	PDS	0-2.5	36,475	17,973	--
	P1-CC03	PDS	2.5-5	1,217	17,973	--
	P1-CC04	PDS	0-2.5	44,517	17,973	--
	P1-CC04	PDS	2.5-5	34,976	17,973	--
	P1-CC04	PDS	5-7.5	523	17,973	--
	P1-CC04	PDS	7.5-10	467	17,973	--
	P1-CC05	PDS	5-7	3,146	17,973	--
	P1-CC05	PDS	7-10	433	17,973	--
	P1-CC05	PDS	0-2.5	25,845	17,973	--
	P1-CC05	PDS	2.5-5	21,621	17,973	--
	P1-CC06	PDS	0-2.5	22,741	17,973	--
	P1-CC06	PDS	2.5-5	33,215	17,973	--
	P1-CC06	PDS	5-7.5	371	17,973	--
	P1-CC06	PDS	7.5-10	362	17,973	--
	P1-CC07	PDS	0-2.5	7,657	17,884	--
	P1-CC07	PDS	2.5-5	33,212	17,884	--
	P1-CC07	PDS	5-7.5	9,977	17,884	--
	P1-CC07	PDS	7.5-10	411	17,884	--
	P1-CC08	PDS	5-10	603	17,884	--
	P1-CC08	PDS	0-2.5	36,385	17,884	--
	P1-CC08	PDS	2.5-5	4,210	17,884	--
	P1-CC10	PDS	0-2.5	30,076	17,884	--
	P1-CC10	PDS	2.5-5	18,558	17,884	--
	P1-CC10	PDS	5-7.5	35,315	17,884	--
	P1-CC10	PDS	7.5-10	324	17,884	--
	P1-CC11	PDS	0-2.5	6,146	17,884	--
	P1-CC11	PDS	10-12.5	50,824	17,884	--
	P1-CC11	PDS	12.5-15	578	17,884	--
	P1-CC11	PDS	2.5-5	9,579	17,884	--
	P1-CC11	PDS	5-7.5	23,697	17,884	--
	P1-CC11	PDS	7.5-10	67,660	17,884	--
	P1-CC12	PDS	5-10	6,555	17,884	--
	P1-CC12	PDS	0-2.5	6,353	17,884	--
	P1-CC12	PDS	12.5-15	18,704	17,884	--
	P1-CC12	PDS	15-17.5	523	17,884	--
	P1-CC12	PDS	2.5-5	12,371	17,884	--
	P1-CC13	PDS	0-5	16,587	17,884	--
	P1-CC13	PDS	10-12.5	35,459	17,884	--
	P1-CC13	PDS	12.5-14	654	17,884	--
	P1-CC13	PDS	5-7.5	61,684	17,884	--
	P1-CC13	PDS	7.5-10	57,736	17,884	--
	P1-CC14	PDS	20-22.5	408	18,104	--
	P1-CC14	PDS	22.5-25	386	18,104	--
	P1-CC14	PDS	25-27.5	381	18,104	--
	P1-CC14	PDS	27.5-30	417	18,104	--
	P1-CC15	PDS	5-10	466	18,104	--
	P1-CC15	PDS	0-5	2,184	18,104	--
	P1-CC15	PDS	10-12.5	412	18,104	--
	P1-CC15	PDS	12.5-15	457	18,104	--
	P1-CC15	PDS	15-17.5	402	18,104	--
	P1-CC15	PDS	17.5-20	472	18,104	--
	P1-CC15	PDS	20-22.5	424	18,104	--
	P1-CC16	PDS	0-5	897	18,104	--
	P1-CC16	PDS	10-12.5	463	18,104	--

Table 3-3 Subsurface Soil Field Screening Results

Area	Location ID	Investigation Phase	Depth (ft bgs)	Gamma Measurements (CPM)		
				Subsurface Sample	200 pCi/g Reference	2 pCi/g Reference
	P1-CC16	PDS	12.5-15	532	18,104	--
	P1-CC16	PDS	15-17.5	468	18,104	--
	P1-CC16	PDS	5-7.5	430	18,104	--
	P1-CC16	PDS	7.5-10	409	18,104	--
POND 2	P2-CC01	PDS	0-5	1,084	--	515
	P2-CC01	PDS	5.5-7.4	487	--	515
	P2-CC01	PDS	7.4-10	490	--	515
	P2-CC02	PDS	0.5-5	584	--	515
	P2-CC02	PDS	5-10	465	--	515
	P2-CC03	PDS	0-5	533	--	515
	P2-CC03	PDS	5.3-7.5	486	--	515
POND 3	P3-414	RSE	2	74,081	--	--
	P3-414	RSE	5	73,993	--	--
	P3-414	RSE	10	66,348	--	--
	P3-414	RSE	15	65,897	--	--
	PND3-CC04	PDS	0-3	2,025	17,519	--
	PND3-CC04	PDS	5-10	3,406	17,519	--
	PND3-CC04	PDS	12.5-15	484	17,519	--
	PND3-CC04	PDS	15-20	373	17,519	--
	PND3-CC04	PDS	22-25	371	17,519	--
	P3-CC07	PDS	0-5	1,745	--	--
	PND3-CC05	PDS	0-2.5	1,006	17,519	--
	PND3-CC05	PDS	5-7.5	2,116	17,519	--
	PND3-CC05	PDS	7.5-10	543	17,519	--
	PND3-CC06	PDS	0-2.5	2,443	17,519	--
	PND3-CC06	PDS	5-10	350	17,519	--
	PND3-CC02	PDS	1-5	371	--	417
	PND3-CC02	PDS	5-10	405	--	417
	PND3-CC02	PDS	15-20	375	--	417
	PND3-CC01	PDS	0-5	328	--	417
	PND3-CC01	PDS	11.5-15	378	--	417
	PND3-CC03	PDS	1-5	705	--	417
	PND3-CC03	PDS	10-20	417	--	417
ROAD	ROAD-CC01	PDS	0-5	719	--	475
	ROAD-CC01	PDS	5-10	349	--	475
	ROAD-CC02	PDS	0-5	335	--	475
	ROAD-CC03	PDS	0-5	391	--	475
	SP-SB412	RSE	20	72,173	--	--
	SP-SB412	RSE	15	90,490	--	--
	SP-SB413	RSE	15	107,193	--	--
	SP-SB413	RSE	20	100,752	--	--
	SP-SB413	RSE	5	117,041	--	--
	SP-SB413	RSE	10	118,953	--	--
	SP-CC02	PDS	0-2.5	3,032	17,810	--
	SP-CC02	PDS	2.5-5	545	17,810	--
	SP-CC02	PDS	7.5-10	412	17,810	--
	SP-CC04	PDS	0-2.5	11,532	17,810	--
	SP-CC04	PDS	2.5-5	13,474	17,810	--
	SP-CC04	PDS	5-7.5	13,807	17,810	--
	SP-CC04	PDS	7.5-10	21,702	17,810	--
	SP-CC04	PDS	10-12.5	11,365	17,810	--
	SP-CC04	PDS	15-17.5	12,238	17,810	--
	SP-CC07	PDS	0-2.5	7,199	19,032	--
	SP-CC07	PDS	2.5-5	12,425	19,032	--

Table 3-3 Subsurface Soil Field Screening Results

Area	Location ID	Investigation Phase	Depth (ft bgs)	Gamma Measurements (CPM)		
				Subsurface Sample	200 pCi/g Reference	2 pCi/g Reference
SEDIMENT PAD	SP-CC07	PDS	5-7.5	639	19,032	--
	SP-CC07	PDS	7.5-10	510	19,032	--
	SP-CC05	PDS	0-2.5	10,225	17,810	--
	SP-CC05	PDS	2.5-5	16,466	17,810	--
	SP-CC05	PDS	5-7.5	17,941	17,810	--
	SP-CC05	PDS	7.5-10	15,893	17,810	--
	SP-CC05	PDS	10-12.5	4,923	17,810	--
	SP-CC05	PDS	12.5-15	632	17,810	--
	SP-CC05	PDS	15-20	850	17,810	--
	SP-CC05	PDS	20-20.5	699	17,810	--
	SP-CC01	PDS	5-10	2,728	17,810	--
	SP-CC01	PDS	0-5	11,923	17,810	--
	SP-CC03	PDS	0-2.5	1,783	17,810	--
	SP-CC03	PDS	2.5-5	414	17,810	--
	SP-CC03	PDS	5-10	373	17,810	--
	SP-CC08	PDS	0-2.5	19,089	19,032	--
	SP-CC08	PDS	2.5-5	16,043	19,032	--
	SP-CC08	PDS	6-8.5	1,267	19,032	--
	SP-CC08	PDS	12.5-15	640	19,032	--
	SP-CC09	PDS	0-2.5	18,120	19,032	--
	SP-CC09	PDS	2.5-5	12,009	19,032	--
	SP-CC09	PDS	5-7.5	19,393	19,032	--
	SP-CC09	PDS	7.5-10	15,469	19,032	--
	SP-CC09	PDS	10.5-12.5	2,855	19,032	--
	SP-CC10	PDS	0-2.5	19,048	19,032	--
	SP-CC10	PDS	2.5-5	17,954	19,032	--
	SP-CC10	PDS	5-7.5	19,423	19,032	--
	SP-CC10	PDS	11-15	2,837	19,032	--
	SP-CC10	PDS	15-17.5	1,413	19,032	--
	SP-CC11	PDS	0-2.5	18,345	19,032	--
	SP-CC11	PDS	2.5-4.5	11,967	19,032	--
	SP-CC11	PDS	5-7.5	1,492	19,032	--
	SP-CC12	PDS	0-2	13,203	19,032	--
	SP-CC12	PDS	2.5-5	730	19,032	--
	SP-CC06	PDS	0-2.5	4,016	19,032	--
	SP-CC06	PDS	2.5-5	434	19,032	--
	SP-CC06	PDS	5-7.5	456	19,032	--
	SP-CC06	PDS	7.5-10	534	19,032	--

Notes:

CPM=counts per minute; RSE=Removal Site Evaluation; PDS= Pre-Design Studies

1. Field soil screening for Ra-226 consisted of ex-situ gamma radiation meaurements using a 3x3 NaI scintillation detector and a lead shielded counting chamber.
2. Shaded cells indicated exceedance of either the 200 pCi/g or 2 pCi/g reference values.

Table 3-4 Impacted Soil Volume Estimates

Area Name	Areas and Volumes				
	Area (sq ft)	Depths (ft bgs)	Calculation Method[3]	PTW Volume	Total Volume (cy)
Impacted Subsurface Soils (>1 ft bgs)					
NECR-1[1]	701,717	2 - 31	CAD	425	402,300
NECR-2	268,443	1 - 13	CAD	0	35,600
NECR-2 Road (segs. A,B,C)	67,160	5 - 8	CAD	0	14,200
Pond 1[2]	91,496	7 - 15	CAD	16,500	24,500
Pond 2	33,241	2 - 7	CAD	0	4,600
Pond 3	185,470	6 - 13	CAD	1,550	35,700
Pond 3 Drainage	108,677	11	CAD	0	38,700
Sandfill 1	135,501	4 - 5	CAD	0	21,500
Sandfill 2	15,177	2 - 3	CAD	0	1,200
Sandfill 3	102,122	3 - 6	CAD	0	16,600
Sediment Pad	116,227	3 - 20	CAD	700	35,700
NEMSA	201,780	3 - 18	CAD	0	50,000
TPH Stockpile	27,530	≤15	Manual	0	7,500
			s/t	**19,175**	**688,000**
Impacted Surface Soils (0.5-1 ft bgs)					
Sandfill 1 step-out	199,196	1	Manual	0	7,400
Vent 3	29,870	1	Manual	0	1,100
Vent 8	281,160	1	Manual	0	10,400
Mine Site Step-out Area[5]	2,048,842	1	Manual	0	75,900
			s/t	**0**	**95,000**
Total Volume of Impacted Soil				**19,175**	**783,000**

Notes:

1. Soils excavated from the Unnamed Arroyo No. 1, Step-out Area No. 2 and East Drainage during the 2009 IRA and 2012 EDRA were placed on the NECR-1 pile. The volume of these soils is included here.

2. Pond 1 contains buried debris over ~5,400 sf area; the volume of the debris is subtracted from the soil volume shown here. The volume of mixed debris within the Boneyard is include in the debris volume estimate and not included above.

3. The calculation method applies to the total impacted volume estimates only. PTW volume estimates were all calculated manually.

4. PTW = Principal Threat Waste. To provide a conservative estimate, these volumes are included in the total impacted volumes in the next column. PTW was detected in the Sediment Pad and Pond 1 during the PDS and RSE, but only during the RSE in Pond 3 and NECR-1.

5. The Trailer Park, Fuel Storage Area, IX Plant and Magazine are included in Mine site step-out area.

Table 3-5 Clean Soil Volume Estimates

Area Name	Areas and Volumes[1]			
	Area (sq ft)	Min. Depths (ft bgs)	Calculation Method	Volume (cy)
Boneyard (southern leg only)	150,760	4	Manual	22,300
NECR-2 Drainage	35,908	4	Manual	5,300
Pond 3 Berm	40,925	15	Manual	22,700
NECR-2 Road (segs. B & D)[2]	50,000	4	Manual	7,400
			Volume of Clean Soil:	**35,000**

Notes:

1. The volume for these areas were estimated manually by the area times assumed minimum depth.
2. There are presumably clean (native) soils beneath the impacted soils within segments A, C and E; a volume for these soils is not included here. This area includes the Pond 1 and 2 berms.

sq ft = square feet; ft bgs = feet below ground surface, cy = cubic yards

Table 3-6 Geotechnical Test Results

Sample ID[1]	Sample Location	Sample Type	Sample Depth Interval		Gravimetric Water content	Dry Density	Specific gravity	Standard Proctor	
		Units:	top (ft bgs)	bottom (ft bgs)	(% by mass)	(pcf)	(g/cm^3)	max. dry density (pcf)[3]	optimum water content (%)
NECR1-CC01	NECR-1	Bulk	10	20			2.68	120.7	11.9
NECR1-CC17		CA[2]	5.5	6	4.9	92.3			
NECR1-CC17		CA	10.5	11	6.2	96.5			
NECR1-CC17		CA	15.5	16	2	106.7			
NECR1-CC17		CA	20.5	21	19.1	95.8			
NECR1-CC17		Bulk	0	10				120.3	11.3
NECR1-CC17		Bulk	10	20				125.1	10
NECR2-CC05	NECR-2	Bulk	0	10				118.8	11.9
NECR2-CC07		Bulk	0	10			2.71	117.8	11.6
NECR2-CC05		CA	2.5	3	8.1	93.7			
NECR2-CC05		CA	5	5.5	10	D[3]			
NECR2-CC06		CA	3.5	4	4.7	101.1			
NECR2-CC07		CA	6	6.5	2.7	101			
NECR2-CC07		CA	5.5	6	4.5	101.3			
NECR2-CC07		CA	10	10.5	4.1	97.1			
NECR2-CC01		CA	5.5	6	7.4	99.1			
NECR2-CC06		CA	3	3.5	5	103.4			
N2D-CC01	NECR-2 Drainage	Bulk	0	10				115.6	13.4
N2D-CC01		CA	3.5	4	8.6	91.2			
N2D-CC01		CA	6	6.5	4.7	87.2			
N2D-CC01		CA	11	11.5	4	91.8			
NMSA-CC02	NEMSA	CA	3	3.5	8.1	110.6			
NMSA-CC02		CA	6	6.5	20	97.5			
NMSA-CC02		CA	10.5	11	15	86.6			
NMSA-CC04		Bulk	0	15			2.66	125.2	9.8
P2-CC04	Pond 2	Bulk	0	3			2.66	102.0	20.6
P3-CC07	Pond 3	Bulk	0	5			2.63	109.7	13.7
SF2-CC01	Sandfill 2	Bulk	0	10			2.65	121.5	10.5
SF3-CC01	Sandfill 3	Bulk	0	10			2.68	121.7	11.1
SF3-CC01		CA	3.5	4	17	99.3			
SF3-CC01		CA	6	6.5	10.5	96.4			
SF3-CC01		CA	11	11.5	8.2	83.5			
SP-CC13	Sediment Pad	CA	5.5	6	10.2	101.4			
SP-CC13		CA	11	11.5	3.5	100.8			
SP-CC13		CA	15.5	16	6.9	97.5			
SP-CC13		Bulk	0	15			2.62	120.6	11.5

Notes:

pcf=pounds per cubic foot

1. Samples collected October-December 2013 during the Pre-Design Studies
2. CA = 2-inch diameter California sample, Bulk = 5-gallon bucket sample
3. Maximum dry density listed includes rock correction
4. D = Disturbed, moisture content only

Table 3-7 Summary of Mine Debris Inventory

Material Type	Volume (cubic yards)[1,2]
Mixed/Buried - Boneyard[3]	11,800
Mixed/Buried - Pond 1[3]	1,000
Concrete	8,200
Wood	2,600
Metal	2,000
Rubber	<10
Plastic	<10
Total Debris Volume	**25,600**

Notes:

1. A volume of 2 cu. ft. was used for all small materials expected to be less than 2 cu. ft.
2. Values rounded to the nearest 100 cy.
3. Mixed/buried material includes buried debris of all types within the Boneyard and Pond 1.

Table 3-8 TPH Soil Analytical Results

Analysis	Units	Reporting Limit	TPH-01	TPH-02
Corrosivity-pH	s.u.	0.01	7.74	7.81
Flash Point (Ignitability)	deg. F	60	> 140	> 140
Sulfide Reactivity	mg/kg	20	ND	ND
Cyanide Reactivity	mg/kg	0.05	ND	ND
Arsenic	mg/L	0.2	ND	ND
Barium	mg/L	1	ND	ND
Cadmium	mg/L	0.1	ND	ND
Chromium	mg/L	0.2	ND	ND
Lead	mg/L	0.2	ND	ND
Mercury	mg/L	0.02	ND	ND
Selenium	mg/L	0.1	ND	ND
Silver	mg/L	0.02	ND	ND

Notes:
TPH=total petroleum hydrocarbons
s.u.=standard units
ND=Not detected at the reporting limit.

APPENDICES

(ON CD)