Northeast Church Rock 30% Design Report

Appendix I:
Mill Site Stormwater Controls

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LIST OF ACRONYMS / ABBREVIATIONS

ADWR	Arizona Department of Water Resources
amsl	above mean sea level
AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
CFR	Code of Federal Regulations
CY	cubic yards
D_{50}	median stone diameter
fps	feet per second
ft/ft	feet per foot
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NDC	North Diversion Channel
NECR	Northeast Church Rock
NRC	US Nuclear Regulatory Agency
PCA	Portland Cement Association
PMF	probable maximum flood
PMP	probable maximum precipitation
RAO	Remedial Action Objective
RCC	roller compacted concrete
ROD	Record of Decision
TDA	Tailings Disposal Area
USEPA	United States Environmental Protection Agency
WRCC	Western Regional Climate Center

I.1 BACKGROUND

This appendix presents the design of permanent stormwater controls for the repository to be constructed at the Church Rock Mill Site (Mill Site). The intent of the stormwater controls is to divert stormwater upgradient of the proposed repository from impacting the repository and to capture and convey runoff from the repository in a way that limits long-term scour at the edge of the repository. The design also proposes improvements to existing channels and other measures that will reduce sediment accumulation in channels.

This appendix includes evaluation and designs for items requested by the US Nuclear Regulatory Commission (NRC, 2003) and the United States Environmental Protection Agency (USEPA, 2016):

- An evaluation of the hydrology and hydraulics of the Pipeline Arroyo upgradient of, and adjacent to, the repository area. The evaluation assesses the existing buried rock "jetty" constructed during the previous reclamation of the Tailings Disposal Area (TDA) (Canonie, 1991), analyzes alternatives to the jetty for stabilizing the arroyo against of lateral migration into the TDA, and presents a preliminary design of the recommended alternative.
- Improvements to the drainage of the alluvial floodplain area north of the North Cell of the TDA, and improvements to the North Cell Drainage Channel located north of the North Cell of the TDA(see Section 9 Drawings).
- Improvements to the channel located upstream and along the east side of the TDA.

I.2 TASK-SPECIFIC PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (ROD; USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table I.2-1 presents performance standards related to the Mill Site stormwater controls and explains how the design accomplishes these standards.

Table I.2-1: Performance Standards Applicable to Mill Site Stormwater Controls

Location of Performance Standard Requirement	Performance Standard	Comments
10 CFR 61.23(g)	10 CFR §61.23(e) Standards for issuance of a license. Refer to www.ecfr.gov.	Stormwater controls for the repository are designed to provide capacity and erosional stability for the probable maximum flood (PMF). The design also includes measures to improve the sediment transport competency of the East Repository Channel to minimize maintenance requirements.
2011 Action Memo, Table A-1; 2013 ROD Table 1 and Sections 2.9.2 and 2.9.5	40 CFR 192.02(d) Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites. Refer to www.ecfr.gov.	Stormwater controls for the repository are designed to provide capacity and erosional stability for the PMF. The design also includes measures to improve the sediment transport competency of the East Repository Channel to minimize maintenance requirements. The design uses natural materials that will meet quality specifications and minimize future maintenance requirements.
2013 ROD, Table 1	10 CFR 40, Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content - Criterion 1. Refer to www.ecfr.gov.	The stormwater controls for the repository include a large diversion channel to divert stormwater from upgradient catchments away from the repository and perimeter channels to capture stormwater runoff from the repository and convey it in a stable manner. This section also proposes a conceptual design for an upgrade to the rock jetty that will improve the long-term stabilization of the Pipeline Arroyo to mitigate the risk of lateral migration of the arroyo toward the repository area.
2013 ROD, Table 1	10 CFR 40, Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content - Criterion 4. Refer to www.ecfr.gov.	The proposed stormwater controls for the Mill Site call for improvements to the North Diversion Channel which functions to reduced run-on from upgradient catchments. The siting of the repository was predetermined by the location of the existing tailings impoundment. The remaining parts of Criterion

Location of Performance Standard Requirement	Performance Standard	Comments
		4 are addressed in Appendix G.
2013 ROD, Table 1	10 CFR §61.41 Protection of the general population from releases of radioactivity. Refer to www.ecfr.gov.	The proposed stormwater controls are designed to provide erosional stability in the Mill site channels for storm events up to the PMF.
2013 ROD, Table 1	10 CFR §61.44 Stability of the Disposal Site after Closure. Refer to www.ecfr.gov.	Stormwater controls for the repository are designed to provide capacity and erosional stability for the PMF. The design also includes measures to improve the sediment transport competency of the East Repository Channel in order to minimize maintenance requirements.
2013 ROD, Table 1	10 CFR §61 51(a)(1), 10 CFR §61 51(a)(4), 10 CFR §61 51(a)(5), and 10 CFR §61 51(a)(6) Technical Requirements for Land Disposal Facilities. Refer to www.ecfr.gov.	Stormwater controls for the repository are designed to provide capacity and erosional stability for the PMF. The design also includes measures to improve the sediment transport competency of the East Repository Channel in order to minimize maintenance requirements.
2013 ROD, Table 1 and Section 2.9.5, Cap Design Criteria, Bullets 3 and 4	40 CFR §264.228(b)(4) Closure and Post-Closure Care. Refer to www.ecfr.gov.	Stormwater controls for the repository are designed to provide capacity and erosional stability for the PMF.
2013 ROD, Table 1 and Sections 2.9.2 and 2.9.5	40 CFR §192.32(b) Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended. Refer to www.ecfr.gov.	Stormwater controls for the repository are designed to provide capacity and erosional stability for the PMF. The design also includes measures to improve the sediment transport competency of the East Repository Channel to minimize maintenance requirements.
2015 AOC SOW, Paragraph 28 – Long-term Stormwater Management	Long-Term Stormwater Management. In the Design, Respondents shall include detailed plans and specifications for long-term Stormwater management for the restored NECR Site and for the UNC Site.	Stormwater controls for the repository are designed to provide capacity and erosional stability for the PMF. The design also includes measures to improve the sediment transport competency of the East Repository Channel in order to minimize maintenance requirements. Permanent stormwater controls for the Northeast Church Rock Mine Site (Mine Site) are described in Appendix F.
2015 AOC SOW, Paragraph 29 – Green Remediation Best Management Practices	Respondents shall incorporate applicable Best Management Practices for Green Remediation listed in ASTM-E2893-13 consistent with EPA's policy Superfund Green Remediation Strategy (2010), found at http://www.epa.gov/superfund/greenremediation/sf-gr-strategy.pdf.	Green and Sustainable Remediation considerations are outlined in Section I.10.

I.3 ENGINEERING DESIGN DRAWINGS

The engineering design drawings are contained in Volume II – Design Drawings (Section 9). Drawings related to the Mill Site Stormwater Controls are listed in Table I.3-1.

Table I.3-1: Engineering Design Drawings

Drawing No.	Drawing Title
9-01	Existing Condition
9-02	Final Condition
9-03	Repository Channel Profiles
9-04	Details
9-05	North Diversion Channel Improvements
9-06	Stormwater Controls Dilco Hill Channel Confluence
9-07	Alluvial Floodplain Improvements
9-08	Reconstructed Rock Jetty with Weir
9-09	Rock Jetty with Rock Weir Sections

I.4 DESIGN BASIS MILL SITE STORMWATER CONTROLS

The design basis for the Mill Site excavation and final grading plan is provided in Table I.4-1. The individual design basis items comply with regulatory requirements and/or generally accepted engineering practice and meet the overall project design criteria as provided in the Design Work Plan (MWH, 2016).

Table I.4-1: Mill Site Stormwater Controls

Design Category	Design Basis	Design Reference
Channel capacity	PMF	10 CFR §61.44
Channel erosional stability	PMF	10 CFR §61.44
Pipeline Arroyo stabilization	200-year flood	10 CFR §61.44 , 40 CFR §192.32(b)

Note: See Attachment I-1, I-2, and I-5 for computed PMF and 200-year flood values at specific locations.

I.5 STORMWATER HYDROLOGY

I.5.1 Site Hydrologic Setting

The Northeast Church Rock (NECR) Mine is approximately 17 miles northeast of Gallup, New Mexico and was operated from 1967 until 1982 by the United Nuclear Corporation. The elevation of the Northeast Church Rock Mine Site (Mine Site) is approximately 7,100 feet (ft) above mean sea level (amsl) and the Mill Site is approximately 6,970 ft amsl. The climate for the region, as summarized by measurements taken at the Gallup Municipal Airport and reported by the Western Regional Climate Center (WRCC, 2016) has an average annual precipitation of 11.08 inches, with the heaviest precipitation falling as thunderstorms during July, August, and September. Pan evaporation rates obtained at the Gallup Ranger Station between 1966 and 1975 show as average annual evaporation approaching 62.46 inches, approximately six times greater than the current annual average precipitation (WRCC, 2016). Although the site receives an average of 30.6 inches of snowfall, average monthly snow depths are typically one inch or less.

Both the Mine Site and the Mill Site are contained within the Pipeline Arroyo watershed, which is approximately 18 square miles and is comprised of upland mesas and buttes that flow steeply over rock outcrops into alluvial valley bottoms that form ephemeral channels. Mesas and hillslopes are vegetated with a mixture of grasses, shrubs, and trees. Alluvial drainages show limited vegetation. The mesas and buttes are comprised of sandy clay loam to loamy soils with medium to high runoff potential. Transitions from mesas and buttes to valley floors are dominated by rock outcrop and limited soil cover consisting of sandy clays. These regions have significant slopes and have very high runoff potential. The alluvium valley floor that forms the ephemeral channels "consists of fine sand interfingered with layers of silty clay" that "overlies sedimentary bedrock" (USGS, 1994).

The general stormwater responses for regions like the Mine Site are typically dominated by intense, short-duration storms that occur between summer and early fall months. As described by Sabol et al. (1982), typical New Mexico thunderstorms have three phases: (1) a short-duration, low-intensity phase, (2) a higher intensity period, and (3) a longer, low-intensity period. The initial low intensity period fills potential rainfall loss reservoirs such as interception, depression storage in soils, and reducing the water storage capacity of soils. In extreme rainfall events, the short-duration, high-intensity rainfall often exceeds the infiltration capacity of the soil.

I.5.2 Design Discharge

Stormwater controls for the Mine Site and Mill Site are designed on the basis of a design flood event. The design event for the Mill Site stormwater controls and cover erosion protection is the probable maximum flood (PMF). The practical design event for the Pipeline Arroyo Stabilization is the 200-year flood (see Section I.7.2). Both align with the NRC guidance to "…be effective for one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years…" (40 CFR §192.32). MWH estimated the design flood event by simulating runoff hydrographs for a corresponding design storm event, where the design storm event was developed as a center peaking rainfall distribution that included the peak rainfall intensity for every duration from 5 minutes to 24 hours for design storm frequency, or the probable maximum precipitation (PMP) intensity for all durations from 10 minutes to 6 hours. The development of the design flows incorporates methods developed since the hydrology analysis was previously performed for the reclamation plan for the TDA(Canonie, 1991). In particular, the development of the PMP depth and distribution use the recently-developed PMP estimation tool prepared for the Arizona Department of Water Resources (ADWR). The Mine Site is located within the watersheds included in the Arizona tool. The ADWR PMP (ADWR, 2013) study used a similar approach to the Hydrometeorological Reports, but adds more data and improved analytical techniques. The tool produces gridded PMP values using a grid spacing of approximately 2.5 square miles to allow site-specific estimation of precipitation depths. Similarly, the development of the 200-year storm and other frequency-based storm hyetographs incorporate site-specific precipitation intensity-duration information in the hyetograph as recommended in the recent National Engineering Handbook (NRCS, 2015). Finally, the updated design discharge estimates compute rainfall losses using the Green-Ampt method which provides a physically-based estimate of losses over difference storm intensities and durations.

MWH estimated the PMF at locations relevant for the Mill Site stormwater controls using a numerical rainfall-runoff model (HEC-HMS 4.1). The model development methods and simulation results for the Mill Site stormwater hydrology are presented in Attachment I.1. Attachment I.1 also presents results for the peak 2-year flows, which MWH used as a significant, but frequently occurring event, to evaluate the designed channel improvements related to sediment movement efficiencies.

I.6 REPOSITORY STORMWATER CONTROLS

The proposed stormwater controls for the Mill Site repository use existing swales and channels constructed for the TDA with improvements and supplemental controls where necessary to conform to performance standards. These stormwater controls, as shown on Drawing 9-01 and 9-02 and discussed in this section, are the following:

- North Diversion Channel
- East Repository Channel and related sediment controls
- Repository South and West Side Drainage

The evaluation of the Pipeline Arroyo and proposed improvements to the area of the existing rock jetty are discussed in the following section.

I.6.1 North Diversion Channel

The North Diversion Channel (NDC) is an existing earthen conveyance channel that intercepts stormwater runoff from native upgradient watersheds to the south and east of the TDA and diverts it to the alluvial floodplain area north of the TDA. The upper and middle reaches of the NDC have a mild slope (approximately 0.005 feet per foot [ft/ft]) and are constructed with an earthen embankment on the left channel bank (i.e., between the channel and the TDA). The lower (northernmost) portion of the channel is cut through Dilco Hill and has steeper channel slopes (approximately 0.03 ft/ft). The NDC has some areas of minor aggradation, but overall appears to function according to its design intent.

Hydraulic modeling of the PMF through the NDC shows that the NDC, in its current condition, can convey the PMF with no overtopping (see Attachment I.2); however, an area of concern for long-term loss of channel capacity is near where the channel turns from running east to running north. In this location, the channel embankment is breached by a dirt road that crosses the channel. The dirt road is causing sediment deposition where it crosses the bottom of the channel. The proposed improvements will re-grade the road to allow the channel embankment to be reconstructed and to maintain a constant channel invert slope (see Section 9 Drawings). With the proposed improvements, the model simulations show that the NDC will maintain more than 1 foot of freeboard during the PMF under the estimated condition of future vegetation overgrowth in the channel.

The design also includes two rock check dams on the right (south) bank in the east-west portion of the NDC (see Section 9 Drawings). The purpose of the check dams is to trap sediment at the outlets of two tributary catchments to the NDC that have historically delivered sediments to the NDC.

The hydraulic model simulations predict that the PMF flow will be sub-critical in all but the lower NDC reach; however, the predicted PMF velocities in all reaches of the NDC are high (over 10 feet per second [fps]), and channel and bank scour is possible during extreme flood events. The depth of scour is, however, unlikely to compromise the embankment, which is over 80 feet wide at the base. The model predicts super-critical flows with velocities up to 29 fps for the lower reach of the NDC that is cut through Dilco Hill, but excessive scour in the reach is not expected because the channel is cut through rock.

I.6.2 East Repository Channel and Related Sediment Controls

The proposed East Repository Channel will be constructed using the existing Branch Swale C and runs along the south and east perimeter of the repository. Stations 0+00 to 34+60 of the proposed East Repository Channel follow the current alignment of the existing Drainage Swale C and Stations 34+60 to 41+39 are aligned with the existing upper reach of the North Cell Drainage Channel (see Section 9 Drawings). The design objectives for the East Repository Channel are to provide capacity and scour protection against the PMF, and pass sediment delivered to the channel.

I.6.2.1 East Repository Channel Capacity and Scour Protection

The hydraulic calculations (see Attachment I.3) show the following requirements for the East Repository Channel to conform to performance standards:

- Stations 0+00 to 18+30 - No improvements are required to the existing Drainage Swale C.
- Stations 18+50 to 28+30 – The required median (D_{50}) riprap size is 3.0 inches. The existing D_{50} riprap size in this reach of Drainage Swale is 1.5 inches. Thus a larger riprap size is required and excavation of some material below the riprap layer will be necessary to accommodate the larger riprap.
- Stations 28+30 to 34+60 (downstream of the confluence with existing Drainage Swale B) – The required D_{50} median riprap size is 9.0 inches.
- Station 34+60 to 41+39 - The required D_{50} median riprap size is 9.0 inches. The design also includes modifying the cross-section of the existing channel in this reach to increase the sediment transport capacity of the channel (see discussion in Section I.6.2.2).

The existing Drainage Swale C between approximately Stations 0+00 and 18+30 is constructed over tailings and radon barrier. Because no channel improvements are required in this reach, the radon barrier will not be impacted by the proposed design for the East Repository Channel. Filter compatibility calculations show that a single bedding layer will meet filter criteria for the subgrade and the various riprap sizes (Attachment I.3). These calculations assume subgrade soil conditions based on gradations reported in the Tailings Reclamation Plan (Canonie, 1991). Actual subgrade conditions will be verified prior to final design of the channels.

I.6.2.2 East Repository Channel Sediment Control Features

Sediment accumulation along the reach in the existing Drainage Swale C that runs along the base of the south side of Dilco Hill created localized high points in the swale that reduce the swale capacity and are promoting further sediment deposition. Sediment also accumulated in the upper reach of the North Cell Drainage Channel where an erosional feature from Dilco Hill empties into the channel. The apparent sources of the sediment are bare areas on the south side of Dilco Hill and an erosional feature on the east side of Dilco Hill. The reaches of concern and the apparent sediment source areas are shown in Figure I.6-1.

The RAdesign for the East Repository channel proposes several controls to reduce sediment delivery to the East Repository Channel and to increase the sediment transport capacity of the channel:

- Two interceptor channels will be constructed on Dilco Hill. The interceptor channels will reduce sediment delivery from Dilco Hill by cutting the overland flow length. The interceptor channels will also divert stormwater runoff and sediment from Dilco Hill into the lower reach of the East Repository Channel, which is designed for improved sediment transport capacity.
- A rock check dam will be constructed at the base of the erosional feature where it empties into the East Repository Channel. The check dam will decrease sediment loading to the lower reach of the East Repository Channel.
- The lower reach of the East Repository Channel will be constructed to modify the base of the existing channel cross-section from flat to triangular (see Section 9 Drawings). The triangular section is estimated to improve the sediment transport capacity of the channel by nearly three times and to have sufficient capacity to pass sediment delivered from the two Dilco Hill interceptor channels (Attachment I.4).

I.6.3 Repository South and West Side Drainage

This design includes no new drainage channels or swales on the west side of the repository. Instead, the repository cover will be extended to the existing north-flowing portion of the existing runoff control ditch that runs along the west side of the TDA.

The north portion of the runoff control ditch will be extended south to capture drainage from the south-west side of the repository. Hydraulics calculations indicate that the existing runoff control ditch has sufficient capacity to convey the post-repository PMF flow but that the riprap size will need to be increased to a D_{50} of 2 inches (see Attachment I.3) to maintain erosional stability during the PMF. Appendix G describes the repository cover design.

The design also includes no new channels or swales on the southwest side of the repository (west of the proposed head of the East Repository Channel). Stormwater draining from the southwest side of the repository will drain to the existing Branch Swale H (see Section 9 Drawings). Currently, Branch Swale H has no outlet point. Branch Swale H was originally designed to drain to the south and tie into the South Diversion Channel. The alignment of the tie-in reach of Branch Swale H is through the existing evaporation ponds; thus, it will be completed following removal of the ponds. The hydraulic calculations show that when the full length of Branch Swale H is constructed to its tie in with the South Diversion Channel, the existing reach of Branch Swale H is sufficiently sized to convey the PMF flow with the repository in place (see Attachment I.3).

I.7 PIPELINE ARROYO STABILIZATION

The Pipeline Arroyo is an existing ephemeral arroyo that runs along the northwest side of the TDA. Stability of the Pipeline Arroyo is important for long-term viability of the repository and the TDA, as lateral southeastward migration of the arroyo could create embankment erosion, with potential for significant erosion to threaten the integrity of the TDA. An area of particular concern along the Pipeline Arroyo is the rock outcrop (nick point) and riprap "jetty" that was constructed as part of the prior TDA reclamation (Canonie, 1991). Progressive scour and undermining of the jetty led to ongoing concerns that loss of the jetty will result in uncontrolled lateral scour in the arroyo toward the tailings embankment. In a 2003 inspection, the NRC noted damage to the jetty and headcutting toward the jetty that could pose a risk of uncontrolled erosion, with the potential for tailings exposure and downstream migration (NRC, 2003). The USEPA also expressed concern with the potential flood level in the Pipeline Arroyo north of the TDA North Cell and requested that this be assessed during the preliminary RA design (USEPA, 2016).

This section provides an assessment, alternatives evaluation, and preliminary design for the Pipeline Arroyo stabilization. This section also gives a preliminary estimate of the floodplain extent of the Pipeline Arroyo near the repository.

I.7.1 Assessment of the Existing Rock Jetty

The assessment of the existing rock jetty is based on MWH's review of the historical images of the Pipeline Arroyo, observations made on a recent (February 2016) site tour, a review of available information on bedrock depths, and on preliminary hydraulic calculations.

I.7.1.1 Historical Images of the Pipeline Arroyo

Aerial images from as early as 1954, included in Attachment I.5, show the historical development of the Pipeline Arroyo in the limits of the TDA:

- In 1954 (Figure I.7-1), the Pipeline Arroyo does not appear to be influenced by mining or other anthropogenic activities. Two branches of the arroyo are evident. The main branch of the arroyo originates to the east of the current alignment of the arroyo upstream of the rock outcrop and converges to the current alignment near the rock outcrop. Downstream of the rock outcrop, the arroyo runs in a nearly straight alignment that is offset to the southeast of the post-reclamation (1991) alignment and aligns with the current head-cut erosional feature downstream of the rock jetty. The arroyo downstream of the rock outcrop shows significant down-cutting; whereas, little or no down-cutting is evident above the rock outcrop, indicating that the rock outcrop (referred in earlier documents as the nick point) has historically provided upstream grade control. The tributary branch of the Pipeline Arroyo runs under the present-day TDA and combines with the main branch downstream of the TDA.
- By 1962 (Figure I.7-2), a water control dam had been constructed across both branches of the Pipeline Arroyo near the location of the rock outcrop. Alluvial deposits are apparent upstream of the dam. Downstream of the dam, the alignment and headcutting appears unchanged from 1954.
- By 1978 (Figure I.7-3), the water control dam had been removed. Upstream of the rock outcrop, the alignment of the Pipeline Arroyo had been shifted to the west compared to its 1954 alignment, and the north cell of the TDA had been constructed over the 1954 alignment. Downstream of the rock outcrop, the arroyo had cut back to its 1954 alignment.
- By 1981 (Figure I.7-4), the Pipeline Arroyo downstream of the rock outcrop had been engineered to a channel approximately 100 feet to 150 feet to the northwest, and the topography in the area of the original (1954) alignment had been graded to slope away from the TDA.
- In 1991 (Figure I.7-5), the Pipeline Arroyo continued to follow the engineered alignment but with evidence of some downcutting and widening in the arroyo channel.
- By 1997 (Figure I.7-6), the rock jetty had been constructed that keyed into the rock outcrop. The jetty appears to be effective in controlling the upstream grade. Downstream of the outcrop and rock jetty was evidence of significant

downcutting and widening of the engineered arroyo channel, but little lateral movement of the engineered arroyo channel. A large headcut is also apparent near the southern end of the South Cell of the TDA that extends from the engineered arroyo channel toward the original (1954) alignment of the Pipeline Arroyo. A less-developed headcut is also apparent approximately 475 feet downstream of the rock outcrop and jetty.

- By 2005 (Figure I.7-7), a drainage cut is apparent that runs from the rock jetty to where the headcut downstream of the rock jetty is apparent in 1997. The drainage cut appears to be caused by stormwater avulsing the engineered arroyo channel at the rock jetty and flowing perpendicular to the rock jetty (southeast toward the TDA). The cut follows the approximate location of the original Pipeline Arroyo alignment for about 475 feet (at the location of the headcut apparent in 1997) where it makes a 90 degree bend and reconnects with the engineered arroyo channel.
- The 2009, 2011, and 2014 images (Figure I.7-8 to I.7-10) show continued development of the drainage cut apparent in 2005. No lateral migration of the channel is apparent upstream of the rock jetty or downstream of the drainage cut.

I.7.1.2 Site Tour

MWH toured the Pipeline Arroyo near the rock jetty on February 18, 2016. During the tour, MWH observed that flows across the rock jetty have preferentially pushed away from the rock outcrop and cut into softer fill material in front of the rock jetty. This has created progressive downcutting and an erosional flow pathway parallel to the downstream side of the jetty that is undercutting the jetty and fill on the southeast side of the jetty (Photo I.7-1). The cutting of the southeast side fill material has left an overhang that appears on the verge of collapse, which could lead to further lateral movement of the cut. The undercutting has exposed the downstream face of the jetty, although a large displacement of jetty rockfill is not apparent (Photo I.7-2). Downstream of the jetty the erosional flow pathway runs parallel to the engineered arroyo channel and appears to have either cut down to bedrock or to the stable channel slope, with downcutting depths ranging from about 20 feet to 40 feet (Photos I.7-3 and I.7-4). The banks of the erosional pathway are vertical with some overhangs and areas of soil cracking.

I.7.1.3 Review of Bedrock Depths and Quality

Information collected from drilling for the original design of the tailings dam, from TDA reclamation work (Canonie 1991), and from cone penetration testing for the Pre-Design Studies for the RA (MWH, 2014) indicate that the bedrock surface dips steeply to the southeast in the area of the rock jetty. Depths to bedrock appear to increase between the Pipeline Arroyo and the TDA dam, with a maximum depth of over 100 feet likely (Figure I.7-11).

The exposed sandstone bedrock along the existing portion of the Pipeline Arroyo at the location of the rock outcrop is highly weathered and friable, with severe scour into the sandstone bedrock created by flood events (Photo I.7-5). If the underlying bedrock is of similar quality as the exposed outcrop, then it will be expected to show substantial scour after a series of annual peak floods. The bedrock underlying the exposed outcrop may be more competent and durable.

I.7.1.4 Preliminary Hydraulic Calculations

Preliminary hydraulic calculations show flood flows greater than about the 5-year return interval flood will begin to overtop the jetty. Under extreme flood events, flow will overtop a significant length of the jetty. PMF flows will overtop the jetty with a flow depth of about 5 feet (see Attachment I.6).

I.7.1.5 Assessment Summary

The severe undercutting of the downstream side of the jetty has exposed the jetty rockfill and threatens to progressively or abruptly fail the toe of the jetty (Photo I.7-1). The undercutting is at the head of an "erosional pathway" headcut that appears to have originated some 450 feet downstream and has created a preferential flow pathway away from the engineered section of the Pipeline Arroyo over the rock outcrop (Figure I.7-12). Based on the review of historical images and the site tour, the cause of the erosional pathway appears to be flood waters pushing away from the rock outcrop and into the softer fill material behind the jetty in an alignment that closely follows the alignment the pre-mine Pipeline Arroyo. The headcut has scoured to the rock near the toe of the jetty, and future flooding through the erosional pathway will likely dislodge the jetty rock from the toe, leading to collapse of the jetty sometime in the future. A failure of the jetty will not put the TDA embankment at immediate risk

of failure, but instead could result in a loss of grade control at the rock outcrop, leading to episodic head-cutting of the Pipeline Arroyo upstream from the location of the existing jetty.

The rock sizes observed in the jetty and shown in the as-built documents also indicate that the jetty was not designed as a weir structure. The median design rock size is 6 inches (Canonie, 1991). Preliminary hydraulic calculations suggest that floods with an annual return interval of about 10 years or greater could exceed the capacity of the upstream arroyo channel. In such a flood event, flood waters will overtop the jetty and a breach-type failure of the jetty would be likely. Thus an eventual failure of the jetty - either by undercutting or overtopping - is likely.

If the jetty were to fail, lateral migration of the Pipeline Arroyo upstream of the rock outcrop is possible, though not certain. Under a failure scenario, the downcutting that has occurred below the rock outcrop could progress upstream; although, historically, the rock outcrop appears to have provided grade control against upstream headcutting so that upstream headcutting and lateral migration might be slow and limited. More information on the rock depths at and near the rock outcrop are needed to further assess its effectiveness at grade control without the jetty in place.

Regardless of the failure scenarios presented above, currently the jetty is functional, and the Pipeline Arroyo upstream of the jetty appears stable, with no evidence of scour or lateral migration of the channel. Other than the erosional pathway, the Pipeline Arroyo downstream of the jetty also appears to be stable (based on aerial imagery), with some historical deepening and widening, but with no lateral movement. How far the erosional pathway might migrate further toward the TDA is difficult to predict. Historical images show only deepening of the pathway with no lateral movement in the last decade, but the further downcutting in the pathway and undercutting of the banks could cause episodic bank failures and pathway shifting toward the TDA. It appears unlikely that the pathway would shift far enough to the east to threaten the TDA embankment however, the available bedrock information indicates that migration will not be limited by a bedrock control. Besides the erosional pathway, the engineered arroyo channel between the jetty and the southern end of the TDA has been stable with no meandering since at least 1981, although, similar to the erosion pathway, lateral migration will not be limited by bedrock. A large meander bend in the Pipeline Arroyo does exist just downstream of the TDA.

I.7.2 Alternatives for Pipeline Arroyo Stabilization

MWH considered the following alternatives for stabilization of the Pipeline Arroyo:

- Alternative 1: Monitor and Repair
- Alternative 2: Re-constructed Jetty
- Alternative 3: Re-constructed Channel
- Alternative 4: Stepped Energy Dissipation Structure
- Alternative 5: Rock-Cut Chute

These alternatives are described and evaluated below. MWH evaluated these alternatives for both the PMF event and a 200-year storm. Based on preliminary design flows for the PMF, riprap on the order of 48-inch median diameter will be required to maintain stability under flow velocities from the PMF. Due to the anticipated volume of rock required, and the difficulties in consistently sourcing durable rock in these sizes, as well as the local quarries' abilities to produce the needed volumes of large rock and anticipated challenges in properly placing rock this large; a design solution for the PMF in this location is not considered practical. Therefore, the design alternatives are presented for 200-year storm flows in the Pipeline Arroyo. This is consistent with NRC design guidance in 10 CFR 40 Appendix A, Criterion 6(1).

I.7.2.1 Alternative 1: Monitor and Repair

This alternative consists of leaving the existing rock jetty in place and providing long-term maintenance funding as needed. This option would not require further disturbance of the Pipeline Arroyo, at least in the near term. However, it would require monitoring and maintenance in perpetuity and potentially future engineering interventions after other remediation activities are

completed. A possibility exists of a sudden failure of the jetty during a single large flood event if (1) flood waters overtop the jetty or (2) flood waters displace the rock from the back-side of the jetty, leading to a slope failure of the jetty. A failure of the jetty will not put the TDA embankment at immediate risk of failure. A failure of the jetty could result in a loss of grade control at the rock outcrop, leading to episodic head-cutting of the Pipeline Arroyo backward from the location of the existing jetty. The headcut could then advance upstream of the existing Pipeline Arroyo alignment above the current jetty location (upper Pipeline Arroyo). Over time, the new headcut channel could form meanders toward the TDA. In addition, slope failures at the current jetty location could shift the arroyo cut at the current jetty location toward the TDA. Channel meandering or a shift in the arroyo cut that encroached on the TDA seems improbable; however, the available borehole information indicates that bedrock depths increase between the Pipeline Arroyo and the TDA such that lateral migration as far as the TDA will not be limited by a bedrock control (Figure I.7-11). Consequently, post-flood monitoring and repairs would be required to prevent loss of grade control at the rock outcrop that could result in the need to perform extensive repairs.

I.7.2.2 Alternative 2: Re-constructed and Re-designed Jetty with Riprap Weir

This alternative consists of replacing the existing rock jetty with a new jetty with larger rock sized to handle overtopping flows. The downstream side of the jetty would be a large embankment armored with riprap revetment (Figure I.7-13). Alternative 2 would be an upgrade to the existing jetty because it would be designed to handle overtopping flow events. The new jetty embankment would then provide improved grade control for the upper Pipeline Arroyo. With this grade control in place, future lateral migration or head-cutting of the upper Pipeline Arroyo is not expected. Similar to the existing jetty, the new jetty would not provide bank stabilization or channel migration protection downstream of the jetty. Although, lateral migration of the arroyo toward the TDA downstream of the jetty (lower Pipeline Arroyo) would not be limited by bedrock or other natural controls, the historical images show that the arroyo alignment has been stable for decades.

The size and quantity of the rock requirement for this alternative to handle the PMF is problematic. The design would require about 44,000 cubic yards (CY) of median 48-inch stone and about 8,000 CY of rock bedding and granular filter materials. Developing the quantity of this size of rock that meets the rock durability requirements may be difficult as would transporting and placing this material in a way that does not lead to flow concentrations. Further, the design equations for sizing the rock are extrapolated beyond the empirical limits of applicability. Therefore, a design for the PMF may not be practical for this option. In comparison, protection against the 200-year flood (6,460 cubic feet per second) would require a median 24-inch diameter rock.

I.7.2.3 Alternative 3: Reconstructed Arroyo Channel

This alternative consists of removing the existing rock jetty and re-constructing the Pipeline Arroyo within the limits of the TDA to be a constant slope channel with armoring on the left (east) bank (Figure I.7-14). The length of the re-constructed channel would be approximately 6,000 feet, and the slope of the re-constructed arroyo channel would be 1.5 percent, which is about the same as the slope of the Pipeline Arroyo downstream of the existing rock jetty. The cross-section of the re-constructed channel would be trapezoidal with a low-flow channel, and riprap armoring along the left bank (adjacent to the TDA embankment). Hydraulic calculations indicate that, for protection against the PMF, a riprap with a median diameter (D_{50}) of 24 inches would be required to a vertical height of 4 feet along the left bank with 12 inch diameter riprap to a vertical depth of 5 feet above the 24-inch riprap to prevent scour of the left bank during the PMF. The riprap would be keyed-in at 10 feet, which is below the estimate PMF scour depth on the left bank, to protect against undermining of the left bank during flood events. The median riprap could be reduced to 12 inches for protection against the 200-year flood.

This alternative is the only alternative of those considered that would provide explicit hard-armor protection against lateral movement of the left (east) bank of both the upper and lower Pipeline Arroyo. Over time, the low flow channel would likely meander, but the riprap armoring would prevent it from cutting into the left channel bank. Further, because no lateral migration of the lower Pipeline Arroyo – at a slope of 1.5 percent – has occurred over decades, a slope of 1.5 percent is likely to be at, or near, the channel "stable" slope. This alternative is also the only alternative that provides a gradual drop from the upper to lower Pipeline Arroyo and thus would not have an abrupt dissipation of energy.

The disadvantage of this alternative is that it would have a large disturbance area in the Pipeline Arroyo compared to the other alternatives. The excavation for this alternative would be nearly 700,000 CY, compared to less than 160,000 CY for the other alternatives, and the excavation limits would extend near the TDA embankment. This alternative also would require approximately 65,000 CY of 24-inch (D_{50}) riprap, about 12,000 CY of 12-inch riprap, and over 11,000 CY of granular bedding and filter materials, which would be difficult to source. In comparison, riprap and filter quantities would be approximately half for protection against the 200-year flood.

I.7.2.4 Alternative 4: Roller Compacted Concrete Stepped Spillway

This alternative would replace the rock jetty with a stepped spillway structure as shown in Figure I.7-15. The stepped spillway would have a series of step drops with step lengths of 15 feet and sloping drops with heights of 3 feet over 3 feet for an overall slope of 17 percent. The spillway structure would be formed from roller compacted concrete (RCC) and keyed into the sandstone bedrock outcrop on the right (west) bank and below the potential scour hole depth at the toe. The lateral extents of the spillway would be sufficient to capture the floodplain of the PMF and funnel it to the base of the dissipation structure.

RCC stepped spillways are becoming common for rehabilitation of existing embankment dams and new dam construction (PCA, 2000; Abdo and Adaska, date unknown) and have been designed and constructed for overtopping flows in dams and rivers for extreme events up to, and including the PMF (PCA, 2000). The increased use of RCC is due to its efficiency in construction and high abrasion resistance. Several studies demonstrated that RCC overtopping structures have excellent abrasion resistance, even compared to conventional concrete of higher strength and RCC structures are functional after several decades in operation (Abdo and Adaska, date unknown). Still, the historical record is insufficient to confirm the long-term reliability (greater than several decades) of these structures under sediment- and debris-laden flows. Accordingly, and RCC stepped spillway structure cannot be shown to have a design life of 200 years, and a life of 1,000 years is unlikely. Additionally, differential settlement of the structure, due to variable bearing conditions (rock to soil) would be a concern that would need to be addressed in the design.

I.7.2.5 Alternative 5: Rock-Cut Chute

This alternative would replace the rock jetty with a chute cut into the existing sandstone bedrock (Figure I.7-16). The chute would have a slope of 10 percent, dropping approximately 10 feet in 100 feet. As shown in Figure I.7-16, the Pipeline Arroyo would be re-aligned near the chute so that the chute would be formed entirely into the existing sandstone bedrock except for the left (east) bank, which would be cut from the native soil and armored with riprap with a key-in below the sandstone chute.

By being cut into the native rock outcrop, this alternative would not require sourcing large quantities of large diameter riprap, although 60-inch boulders would be required along the left channel bank for protection against the PMF (24-inch for protection against the 200-year flood). The viability of this alternative depends on (1) the depth to and location of the bedrock, and (2) the quality and abrasion resistance (durability) of the bedrock. The design of the rock-cut chute shown in Figure I.7-16 assumes a bedrock surface topography based on visible outcrops. This interpretation of the bedrock surface is contradicted by the bedrock surface developed from the limited number of previous boreholes (Figure I.7-11). The top of rock surface developed from the boreholes indicates that the dip of the bedrock could be much steeper than shown in Figure I.7-16, in the vicinity of the existing rock jetty. If the dip of the bedrock is as indicated in the developed surface, a rock-cut chute is not a viable alternative. Also, observations of exposed bedrock in the vicinity of the existing rock jetty suggest the rock is highly weathered, friable, and would potentially be subject to significant scour from flood flows (Photo I.7-5). Scour of the rock-cut chute could fail the chute if the scour depth on the left bank exceeded the key-in depth of the riprap and thus exposed the left bank to lateral erosion.

As shown in Figure I.7-16, this option also would require modifications to the Pipeline Arroyo at the rock outcrop and upstream of the rock outcrop. The modifications at the rock outcrop would be to cut into the outcrop to construct the rock chute. This would effectively shift the alignment of the arroyo to the right (west) at the location of the outcrop. The modifications upstream of the rock outcrop would be to fill portions of the left (east) arroyo floodplain to funnel arroyo flows to the shifted alignment. The area of fill would create a flood backwater and raise the flood levels against the TDA.

I.7.2.6 Alternatives Evaluation

MWH qualitatively evaluated the five alternatives for the Pipeline Arroyo Stabilization based on (1) robustness and durability, (2) protection against lateral arroyo migration, (3) constructability, and (4) disturbance area. From this evaluation, and discussions with General Electric/United Nuclear Corporation, MWH made the following determinations:

- Alternative 1 (Monitor and Repair) - Dismiss. Although the probability that lateral migration of the Pipeline Arroyo – even under a failure of the existing jetty – would occur to the extent that it would pose an imminent geotechnical or erosional threat to the TDA is uncertain and could be low, the alternative to monitor and repair does not provide a long-term solution to stabilize the arroyo and mitigate the risks of impacts to the TDA. Under this alternative, future repairs would be likely and could be extensive.
- Alternative 2 (Reconstructed and Redesigned Jetty with Riprap Weir) – Retain with qualifications. This alternative provides a robust solution for grade control and stabilization without the immense area of disturbance of re-engineering the entire arroyo along the length of the TDA (Alternative 3). A disqualifying factor for this alternative would be the difficulties in sourcing, transporting, and placing the large quantity of riprap; however the riprap requirements would be more practical if the structure were designed for the 200-year flood event. Hydraulic calculations show that a at median (D_{50}) stone size of 24 inches would be sufficient to convey the 200-year flood on a 12 percent slope or flatter. This alternative would be less dependent on the depth to rock in the area, however additional subsurface characterization would still be required for final design.
- Alternative 3 (Reconstructed Channel) – Dismiss. Although this alternative would provide stabilization of the arroyo along the entire length of the TDA, the large disturbance area and the amount of excavation and riprap required make this alternative impractical.
- Alternative 4 (Stepped Energy Dissipation Structure) – Dismiss. Although this alternative would be expected to be robust and likely the most constructible, NRC's aversion to the use of concrete as a long-term erosion control solution and concerns for differential settlement make an RCC structure unsuitable for this application.
- Alternative 5 (Rock Cut Chute) - Retain with qualifications. This alternative would potentially stabilize the Pipeline Arroyo by providing grade control at the rock outcrop, but the unknowns related to the bedrock topography and quality make assessing the constructability and durability of this alternative uncertain. Also uncertain would be the impacts of shifting the arroyo alignment on the upstream flood levels and downstream scour and lateral migration. This alternative was, therefore, retained until better characterization of the bedrock is obtained and until more sophisticated hydraulic calculations can be performed.

I.7.3 Preliminary Stabilization Design

The Section 9 Drawings show a conceptual design for the reconstructed rock jetty with riprap weir. As shown on the Drawings, the re-constructed jetty is designed for floods up to the 200-year event. The protection provided by the rock-cut chute alternative is uncertain until a detailed characterization of the bedrock is completed. Future designs of either of these structures would also provide more detailed evaluation and design related to energy dissipation at the base of the structure (if required) and upstream channel adjustments (if required).

I.7.4 Work Required to Progress Design of the Preferred Alternative

The Section 9 Drawings show a 30% design of the preferred alternative for Pipeline Arroyo Stabilization. At this time, a future study is needed to characterize the existing bedrock in the proposed location for depths and durability. This characterization should include borehole and/or geophysical methods to determine the bedrock depth with sufficient detail to produce an accurate map of the bedrock surface in the area. The characterization should also include rock sampling to test rock hardness, durability, and degree and depth of weathering. A work plan for this evaluation will be submitted to USEPA for approval following submittal of the 30% design.

I.8 PIPELINE ARROYO FLOOD EXTENTS

The Pipeline Arroyo watershed above the TDA is approximately 18 square miles in area. The estimated PMF in the arroyo reach that runs along the TDA is 27,600 cubic feet per second (see Attachment I.1). Figure I.8-1 shows the floodplain extents for the PMF and the 100-year and 5-year floods, estimated with a one-dimensional hydraulic model (HEC-RAS) (see Attachment I-6). The simulated flood extents show that the 5-year storm will be contained in the Pipeline Arroyo, but that the 100-year flood and the PMF will overtop the arroyo. The estimated flood plain extents for the 100-year flood and PMF include the Pipeline Canyon Road that parallels the arroyo, north of the TDA. The estimated PMF flood plain extents are also estimated to encroach on the north edge of the TDA and the base of the repository. The PMF evaluation reported in Canonie (1991) predicted similar PMF flood extents (also shown in Figure I.8-1). Note that PMF flood extents predicted by Canonie do not account for the repository; whereas the flood extents estimated in this study do. The flood plain extents shown in Figure I.8-1 must be qualified by noting the limitations of the 1-dimensional HEC-RAS model. Flow in the flood plain will be two-dimensional; thus, many of the flow dynamics cannot be represented by a one-dimensional model. Consequently, the estimated flood extends computed in HEC-RAS must be considered preliminary.

I.9 ALLUVIAL FLOODPLAIN AND NORTH CELL DRAINAGE CHANNEL

The alluvial floodplain is an open area north of the North Cell of the TDA. The alluvial floodplain may become inundated by flow discharged from the North Upstream Diversion or by flooding in the Pipeline Arroyo. The current topography in the alluvial floodplain includes a depressed area. Currently, an earthen channel is cut from the depressed area to the Pipeline Arroyo, but the highpoint in the channel invert prevents complete drainage of the alluvial floodplain.

The North Cell Drainage Channel is an existing large drainage swale on the north side of the North Cell of the TDA. A dirt access road cutting across the west end of the channel has created a localized high point in the channel that prevents complete drainage of the channel and is a cause for sediment accumulation in the channel.

Included in the 30% Design is a new channel to drain the alluvial floodplain area, and improvements to the North Cell Drainage Channel to provide better drainage in that location. The new channel and improvements are shown on the Section 9 Drawings. The new channel in the alluvial floodplain will have a slope of 0.3 percent. The improvements to the North Cell Drainage Channel will include re-grading the access road so that the road will not create a high point in the channel.

I.10 BEST MANAGEMENT PRACTICES FOR GREEN REMEDIATION

The design implements Green and Sustainable Remediation practices by limiting the length of new channels to be constructed and makes use of the existing channels already in place at the site. Non-contaminated on site materials will be used for rip-rap, filters and clean fill as much as possible. Using local materials decreases transportation costs, dust emissions and fossil fuel emissions. It also encourages reusing existing material. Construction equipment will be correctly sized to avoid utilizing oversized or undersized equipment, which can result in higher greenhouse gas and dust emissions. Segregating contaminated water from non-impacted water through the use of temporary stormwater controls during the Mine Site Removal Activities (as explained in Appendix E and shown in the Section 5 Drawings) encourages recycling/reusing existing on-site materials, since non-impacted water may be used for dust suppression or other construction activities. It also decreases greenhouse gases by decreasing the amount of water that must be trucked into the site for construction. Temporary seeding, erosion control mats, silt fences and other best management practices will be used to protect disturbed slopes during construction and minimize dust emissions.

I.11 REFERENCES

Abdo, F.Y. and W.S. Adaska date unknown. Performance Review of RCC Spillways and Overtopping Protection. Portland Cement Association.

Arizona Department of Water Resources (ADWR), 2013. Probable Maximum Precipitation Study for Arizona.

Canonie Environmental (Canonie), 1991. Tailings Reclamation Plan as Approved by NRC March 1, 1991. License No. SUA-1475. August.

MWH, Inc. (MWH), 2014. Pre-Design Studies Northeast Church Rock Mine Site Removal Action, Church Rock Mill Site. October 31.

MWH, Inc. (MWH), 2016. Design Work Plan, Northeast Church Rock Mine Site Removal Action. March 17.

Natural Resource Conservation Service (NRCS). 2015. National Engineering Handbook, Part 630: Hydrology; Chapter 4: Storm Rainfall Depth and Distribution (Draft). September.

Portland Cement Association (PCA). 2000. Vegas Doesn't Gamble with Dam Safety. RCC Newsletter. Winter 2000-2001.

Sabol, G.V., T.J. Ward, and A.D. Seiger. 1982. Rainfall Infiltration of Selected Soils in the Albuquerque Drainage Area for the Albuquerque Metropolitan Arroyo Flood Control Authority", Civil Engineering Department, New Mexico State University, Las Cruces, New Mexico.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. September 29.

US Environmental Protection Agency (USEPA) Region 6, 2013. Record of Decision, United Nuclear Corporation Site, McKinley County, New Mexico. Operable Unit OU2: Surface Soil Operable Unit. March 29.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, Appendix D: Statement of Work. April 27.

United States Environmental Protection Agency (USEPA), 2016. Comments on Design Work Plan, Northeast Church Rock Mine Site Removal Action. Excel Spreadsheet.

United States Geological Survey (USGS), 1994. Radioactivity in the Environment - A Case Study of the Puerco and Little Colorado River Basins, Arizona, and New Mexico. Water-Resources Investigations Report 94--4192.

US Nuclear Regulatory Commission (NRC), 2003. Erosion Protection Design Concerns Identified at Recent Site Visit (TAC No. L52459).

Western Regional Climate Center (WRCC). 2016. Climate Summary for Gallup Municipal Airport, New Mexico (COOP ID 293422). Access online www.wrcc.dri.edu. March.

FIGURES

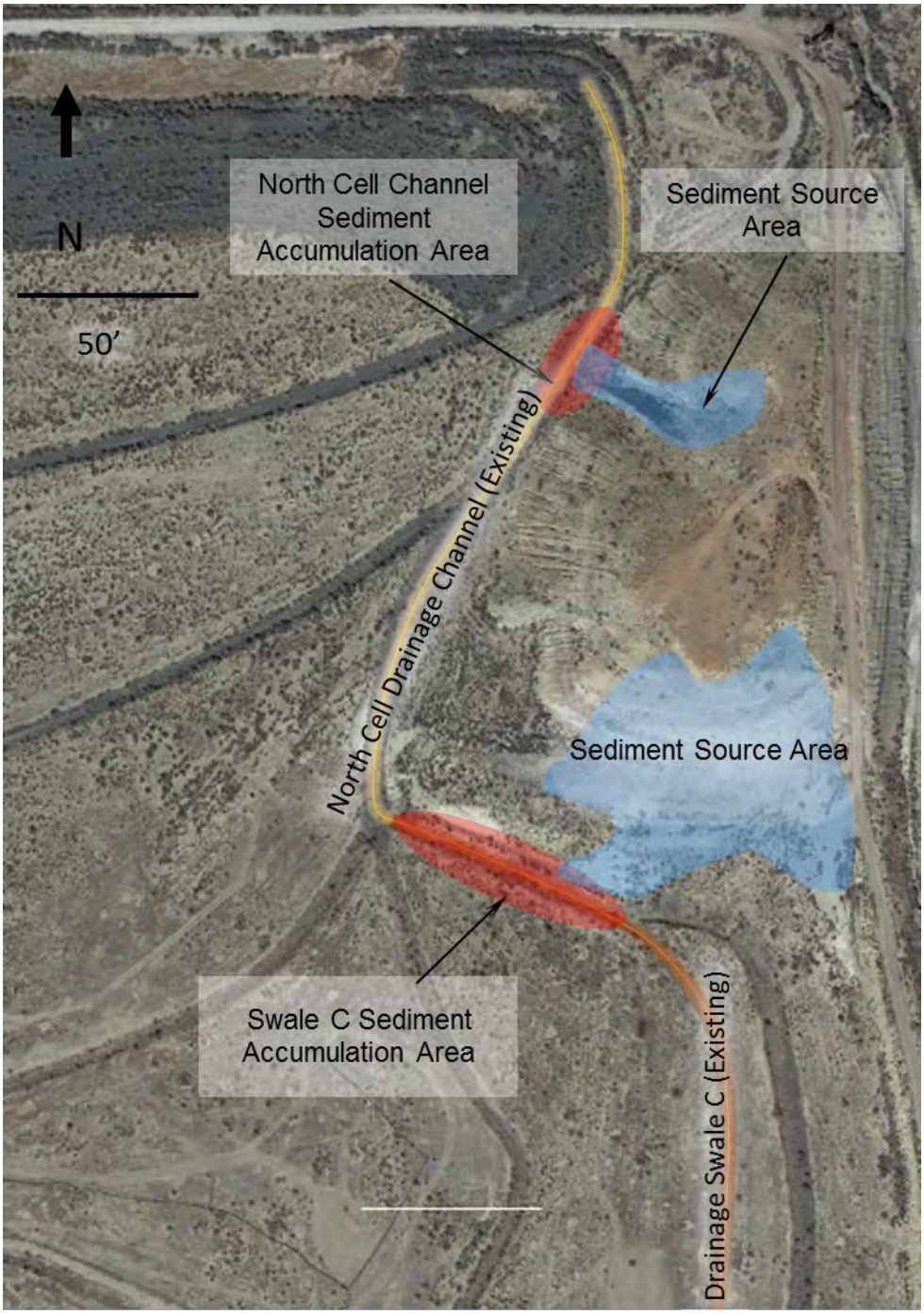
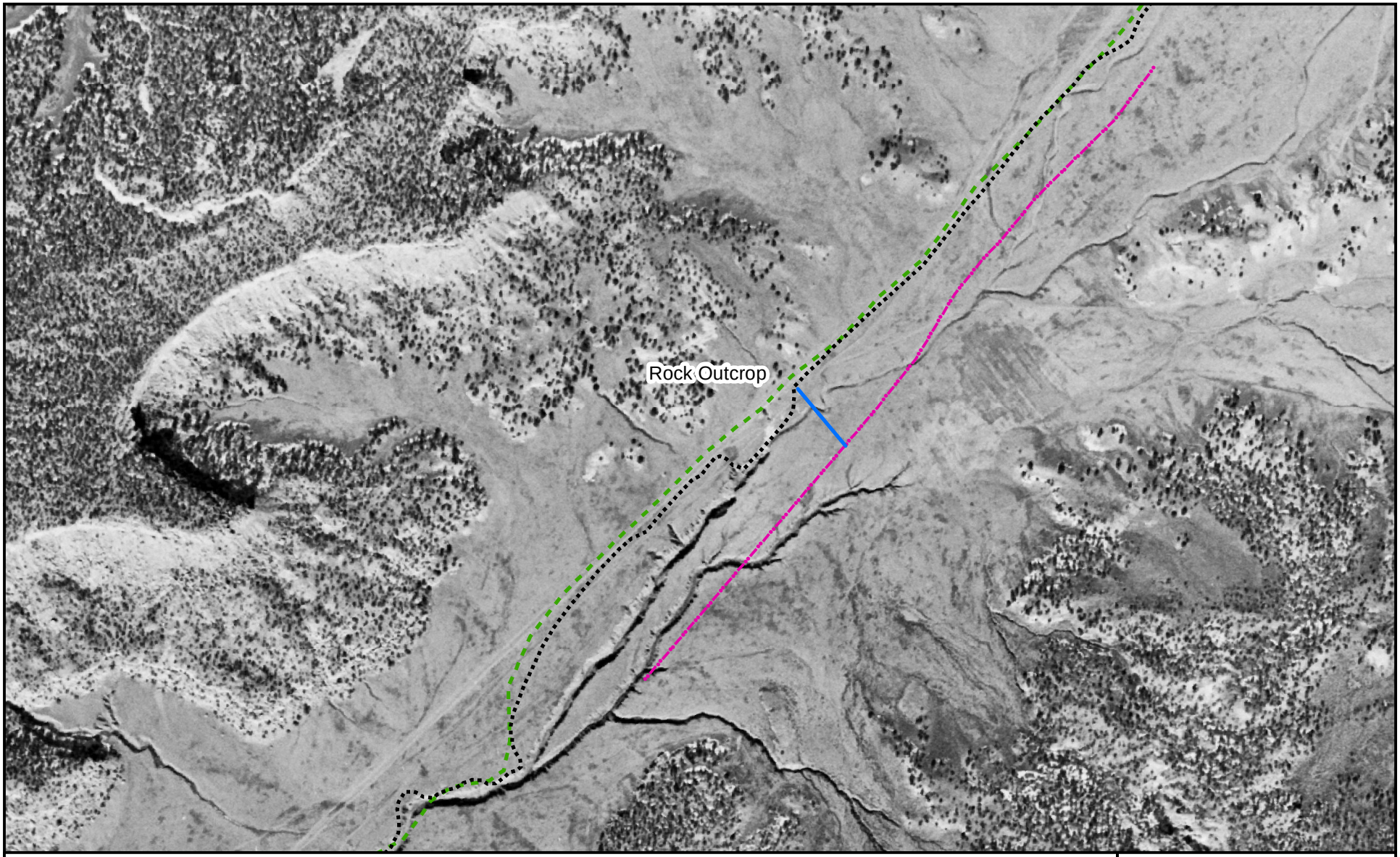


Figure I.6-1: Sediment Source Areas for the East Repository Channel



Legend

- 2014 Pipeline Arroyo Centerline
- 1991 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) East Limit of Tailings

N
W E
S

0 500 1,000 1,500 Feet

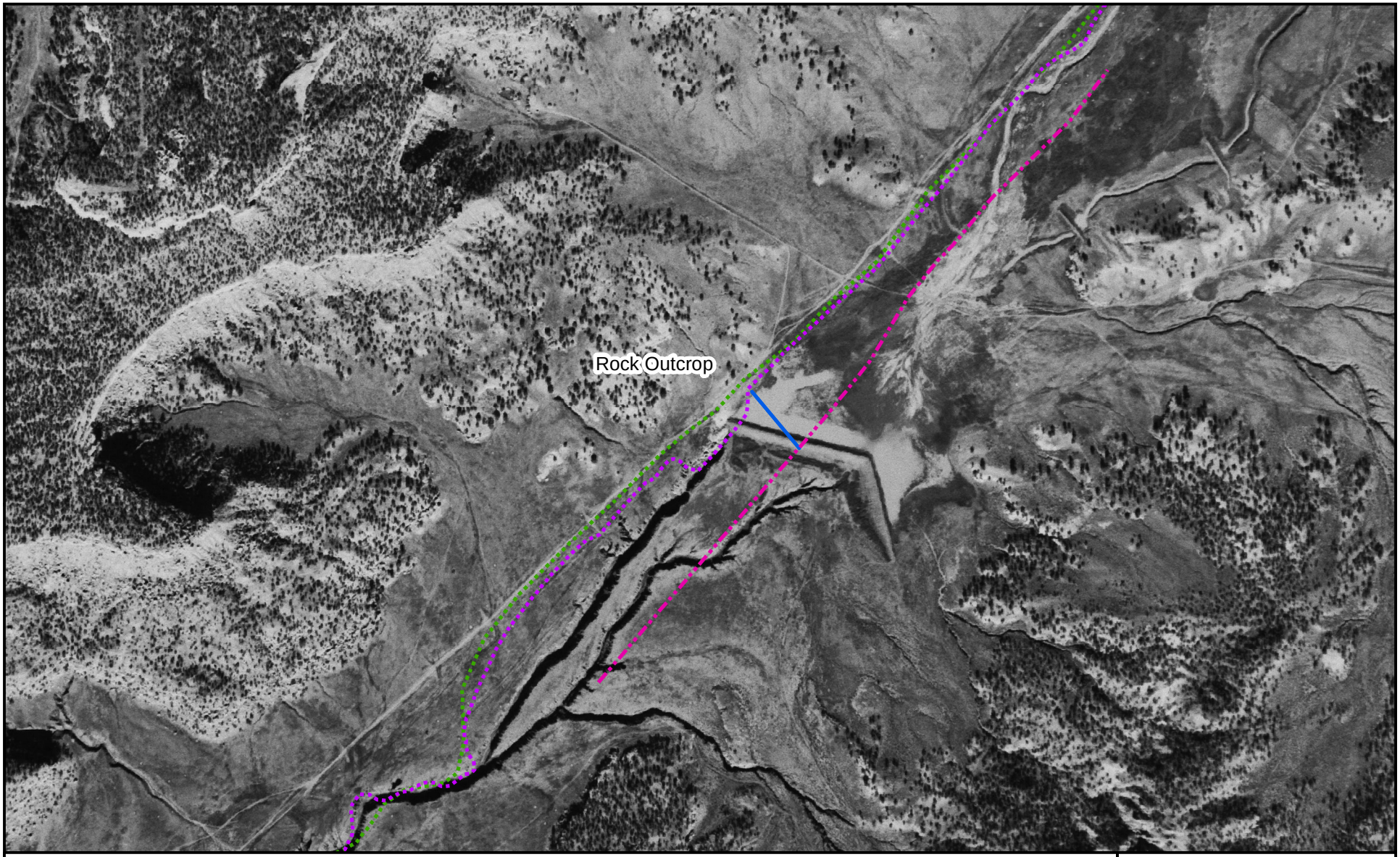
Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-1:
Pipeline Arroyo
February 1954

Northeast Church Rock

Date Revised: 5/18/2016

MWH



Legend

- 1991 Pipeline Arroyo Centerline
- 2014 Pipelne Arroyo Centerline
- Existing (2016) East Limits of Tailings
- Existing (2016) Rock Jetty

N
W E
S

0 500 1,000 1,500 Feet

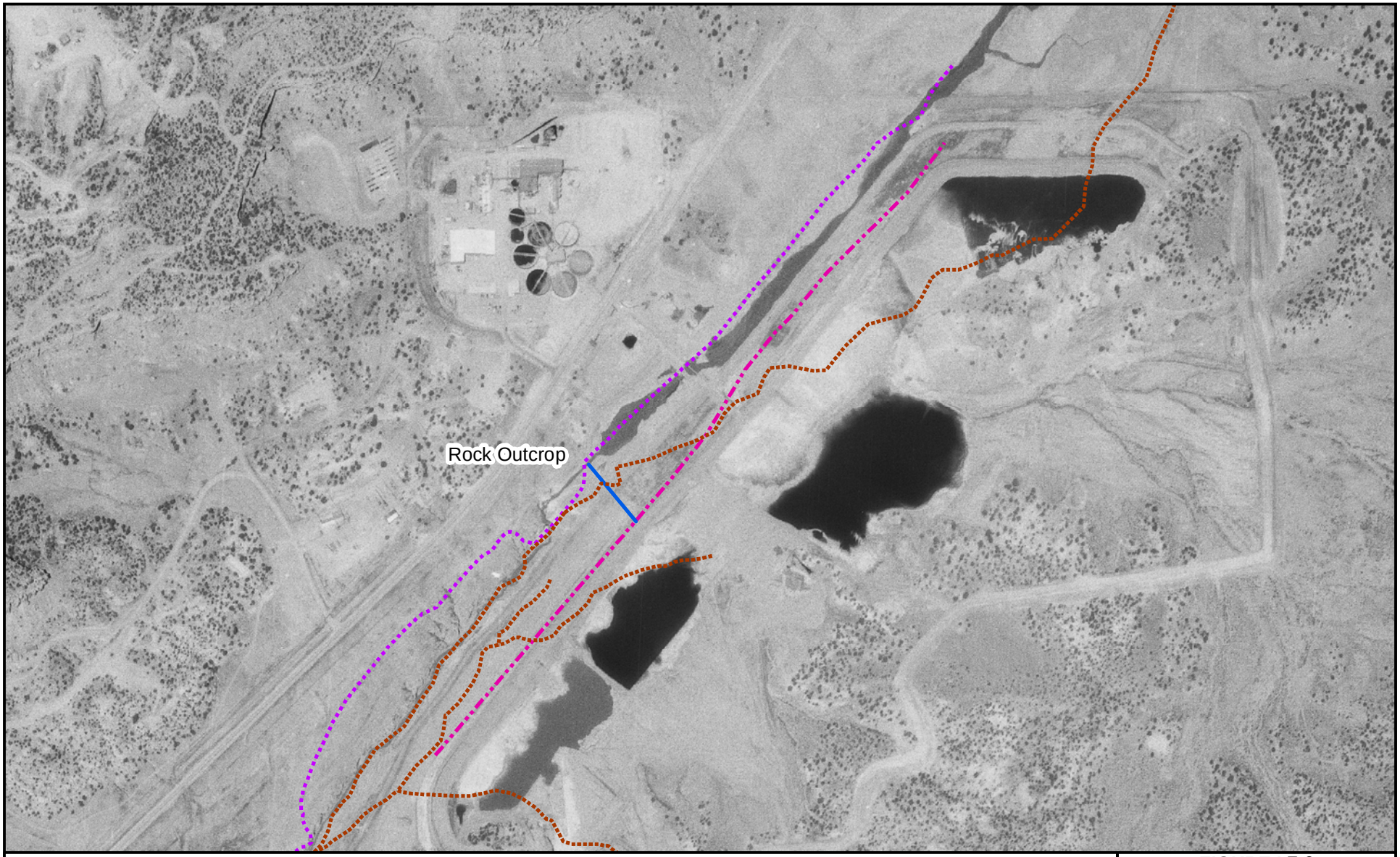
Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-2:
Pipeline Arroyo
November 1962

Northeast Church Rock

Date Revised: 5/18/2016

MWH



Legend

- 1954 Pipeline Arroyo
- 2014 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) Eat Limit of Tailings

N
W E
S

0 500 1,000 1,500 Feet

Coordinate System: NAD83 UTM zone 12N

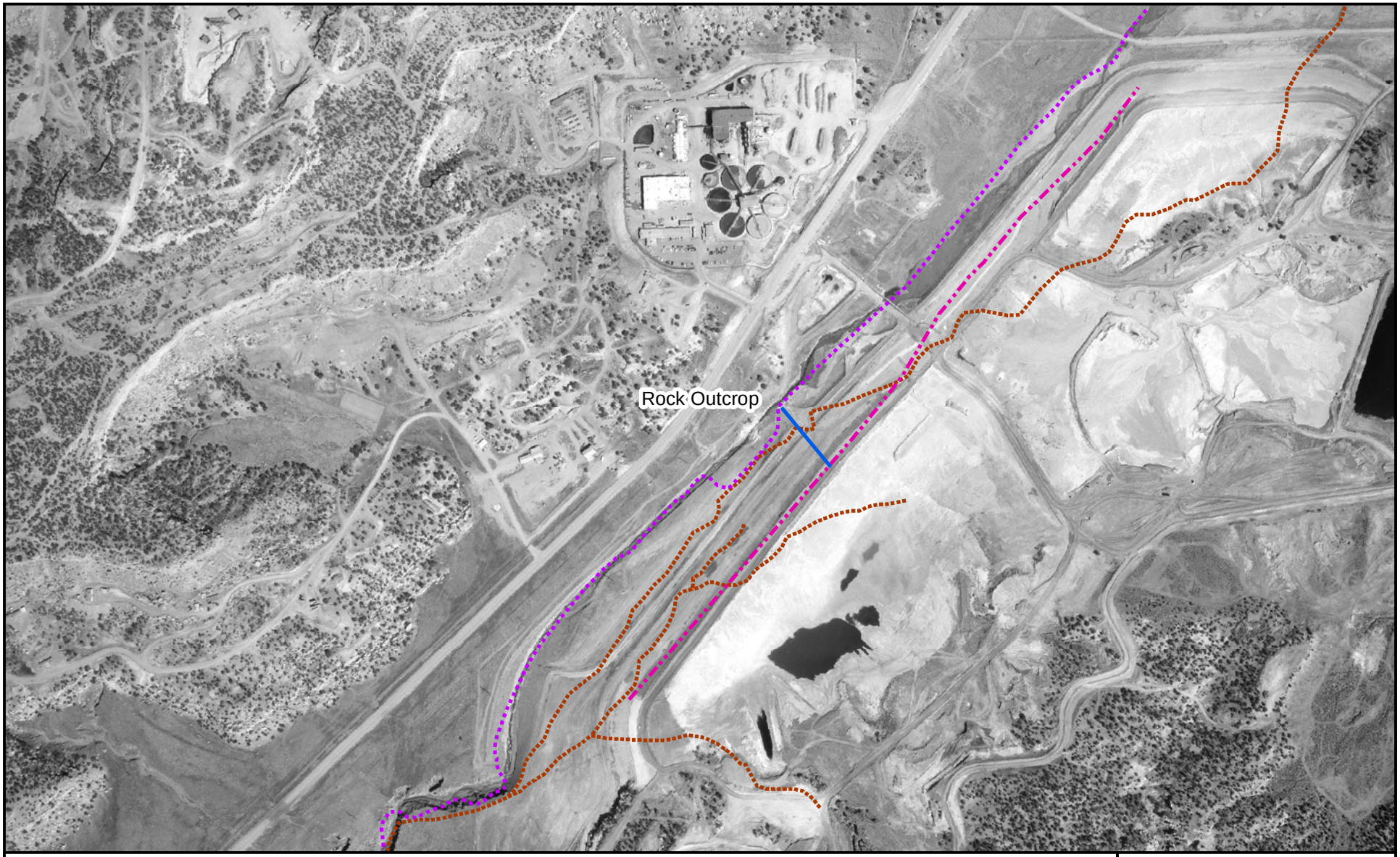
FIGURE I.7-3:

Pipeline Arroyo
April 1978

Northeast Church Rock

Date Revised: 5/18/2016

MWH



Legend

- 1954 Pipeline Arroyo
- 2014 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) East Limit of Tailings

N
W E
S

0 500 1,000 1,500 Feet

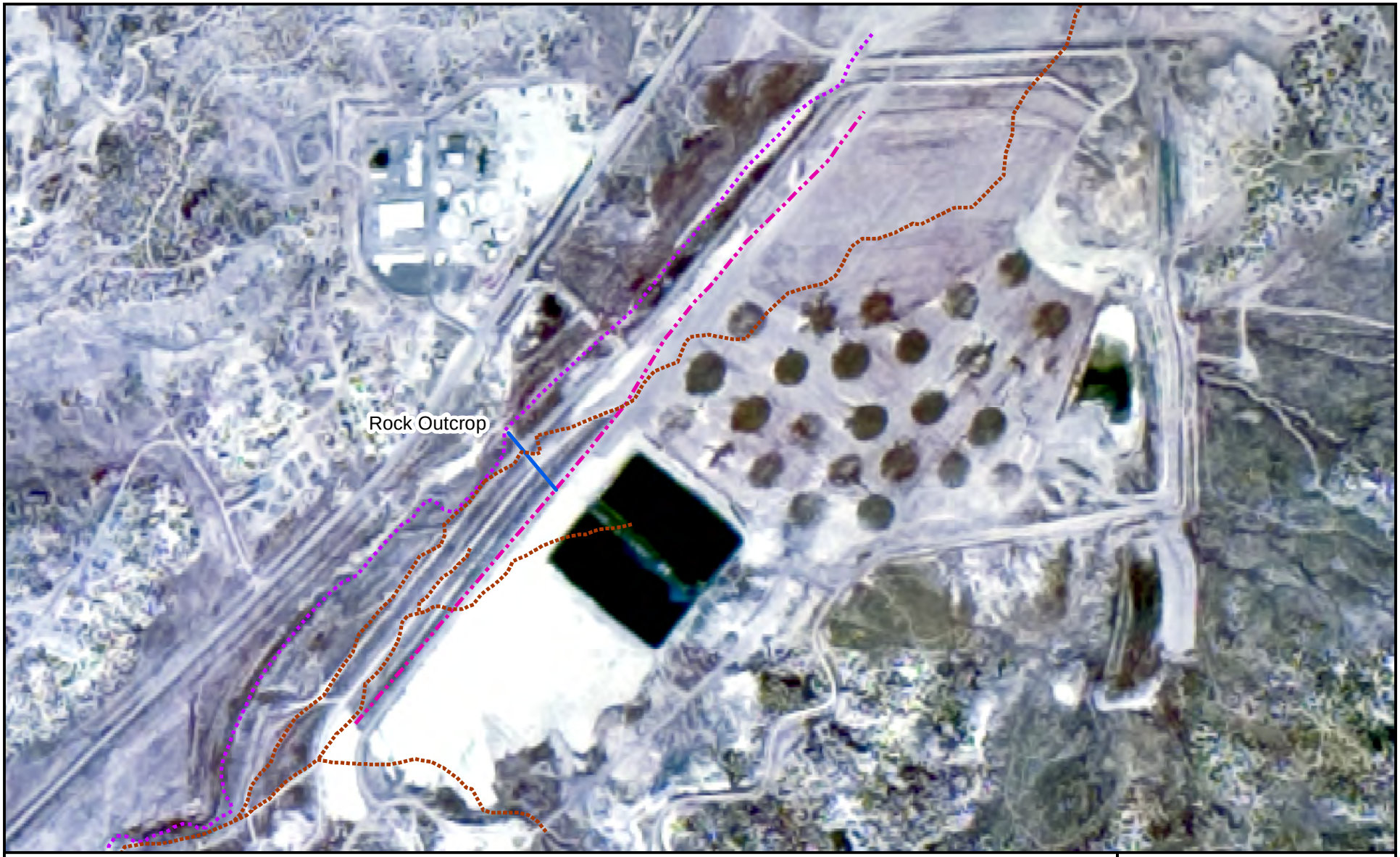
Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-4:
Pipeline Arroyo
April 1981

Northeast Church Rock

Date Revised: 5/18/2016

MWH



Legend

- 1954 Pipeline Arroyo Centerline
- 2014 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) East Limit of Tailings

N
W E
S

0 500 1,000 1,500 Feet

Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-5:
Pipeline Arroyo
June 1991

Northeast Church Rock

Date Revised: 5/18/2016

MWH

Legend

- 1954 Pipeline Arroyo
- 2014 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) East Limits of Tailings

N
W E
S

0 500 1,000 1,500 Feet

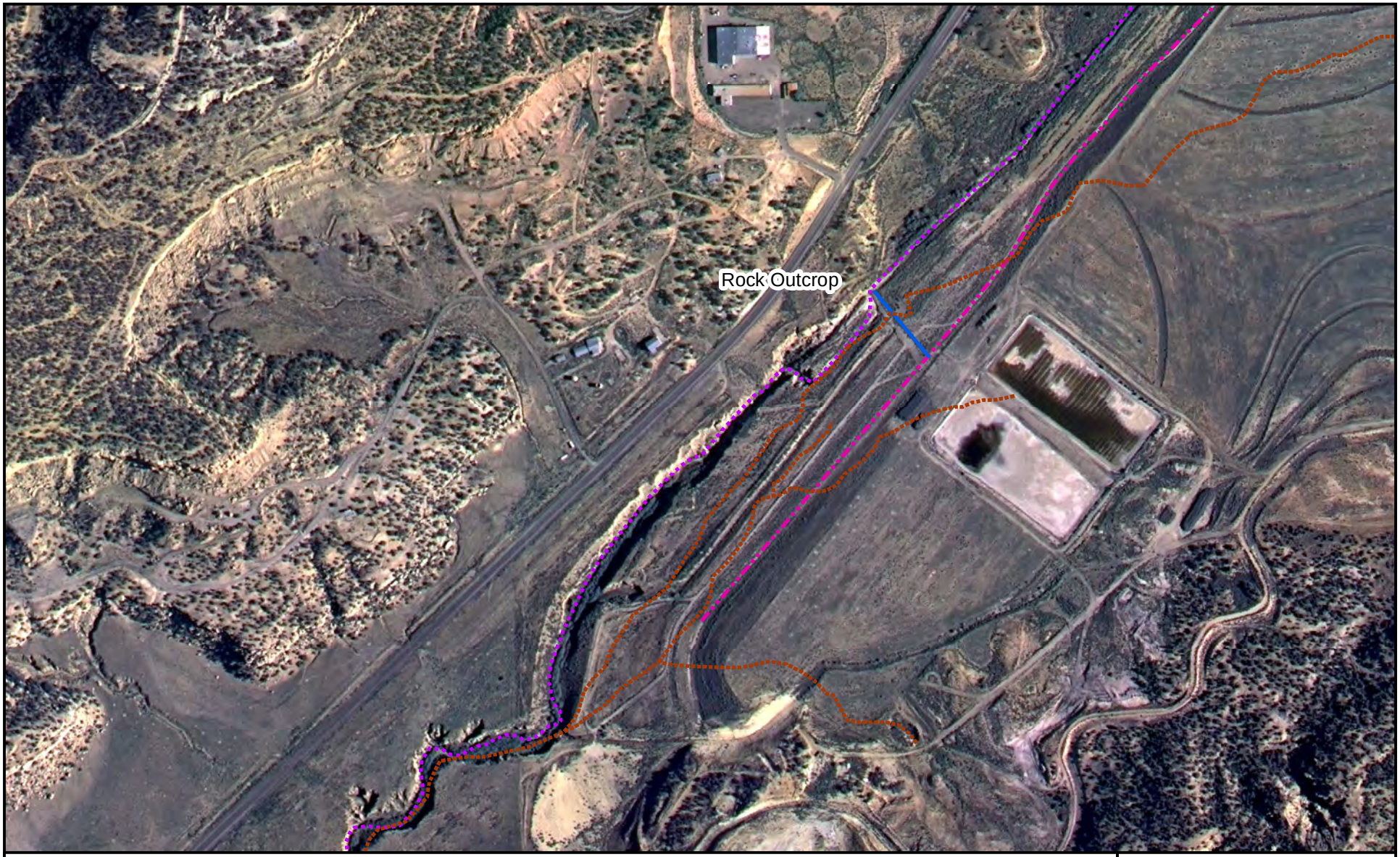
Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-6:
Pipeline Arroyo
October 1997

Northeast Church Rock

Date Revised: 5/18/2016

MWH



Legend

- 1954 Pipeline Arroyo
- 2014 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) East Limit of Tailings

N
W E
S

0 500 1,000 1,500 Feet

Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-7:
Pipeline Arroyo
July 2005

Northeast Church Rock

Date Revised: 5/18/2016

MWH

Legend

- 1954 Pipeline Arroyo
- 2014 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) East Limit of Tailings

N
W E
S

0 250 500 750 1,000 Feet

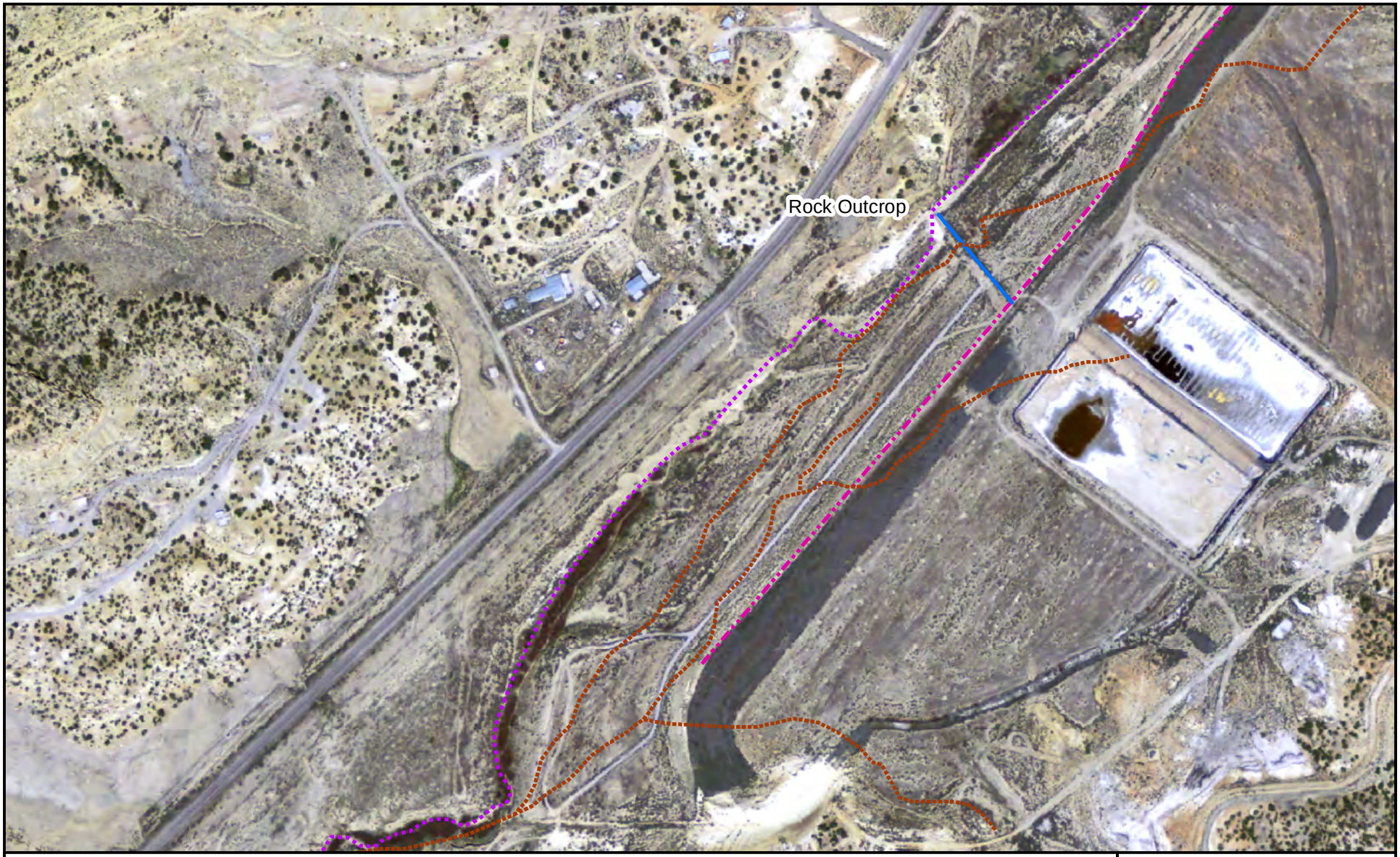
Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-8:
Pipeline Arroyo
May 2009

Northeast Church Rock

Date Revised: 5/18/2016

MWH



Legend

- 1954 Pipeline Arroyo
- 2014 Pipeline Arroyo Centerline
- Existing (2016) Rock Jetty
- Existing (2016) East Limit of Tailings

N
W E
S

0 250 500 750 1,000 Feet

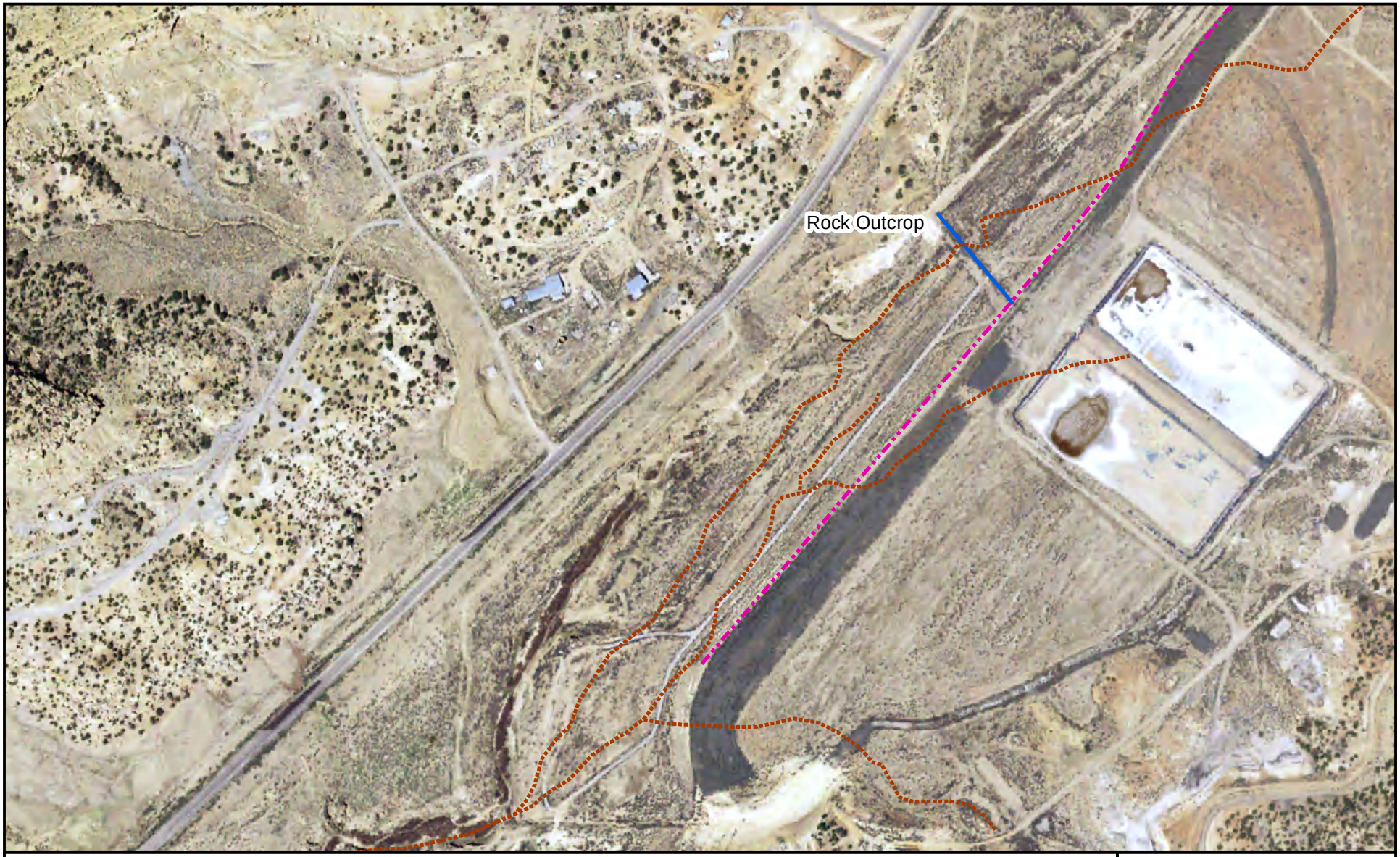
Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-9:
Pipeline Arroyo
May 2011

Northeast Church Rock

Date Revised: 5/18/2016

MWH



Legend

- 1954 Pipeline Arroyo
- Existing (2016) Rock Jetty
- Existing (2016) East Limit of Tailings

N
W E
S

0 250 500 750 1,000 Feet

Coordinate System: NAD83 UTM zone 12N

FIGURE I.7-10:
Pipeline Arroyo
June 2014

Northeast Church Rock

Date Revised: 5/18/2016

MWH

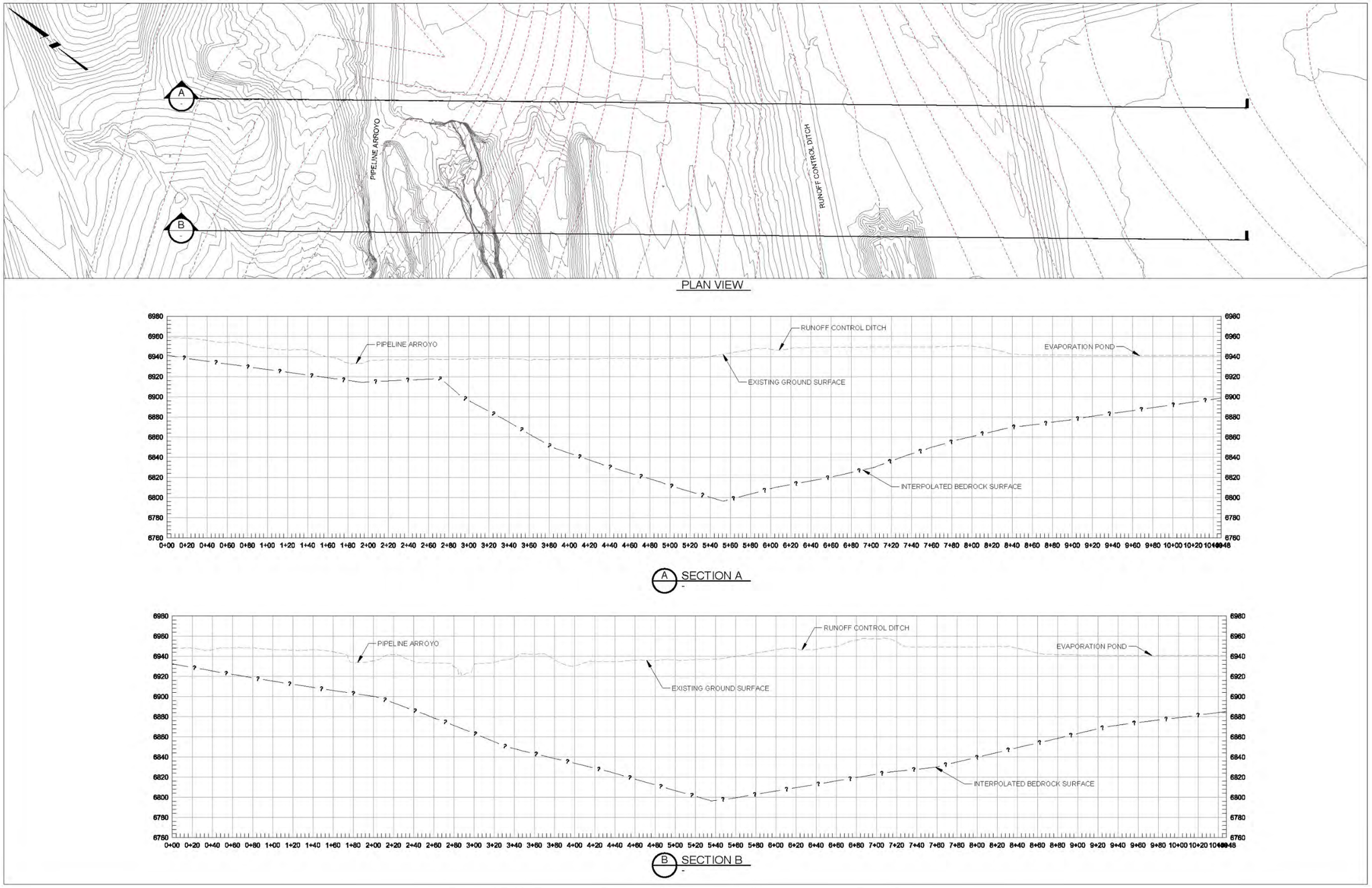
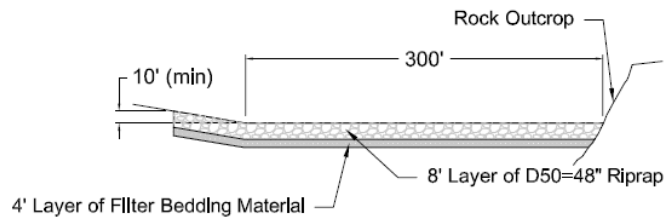
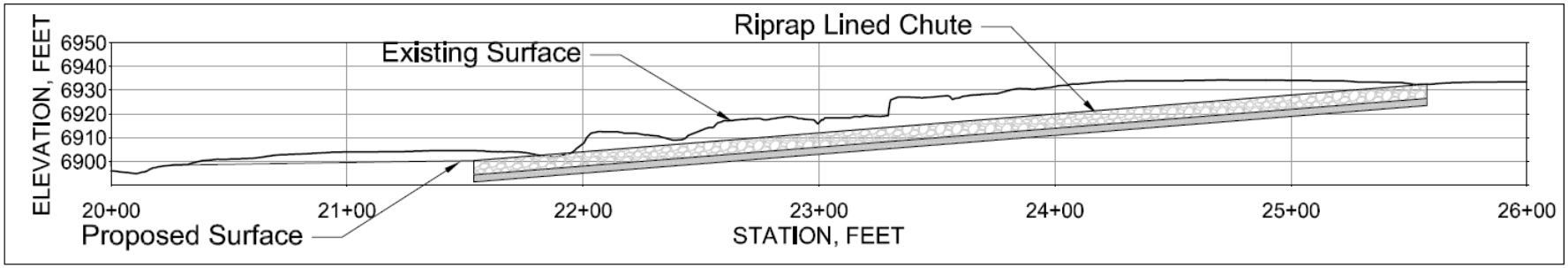


Figure I.7-11: Estimated Bedrock Surface along Section near the Rock Jetty

Figure I.7-12: Pipeline Arroyo in the Vicinity of the Rock Jetty.

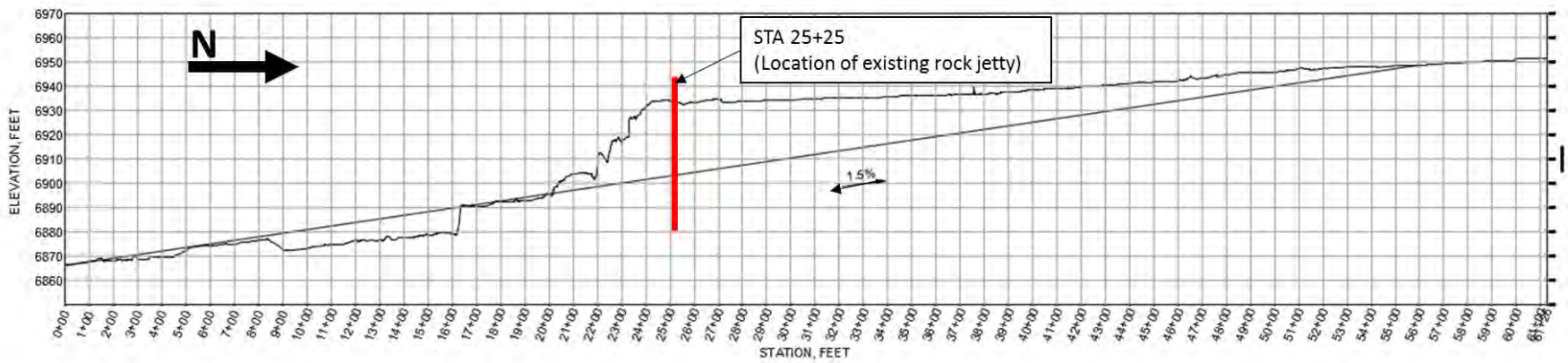


Section B-B



Section A-A

Figure I.7-13: Concept for Re-constructed Jetty Alternative



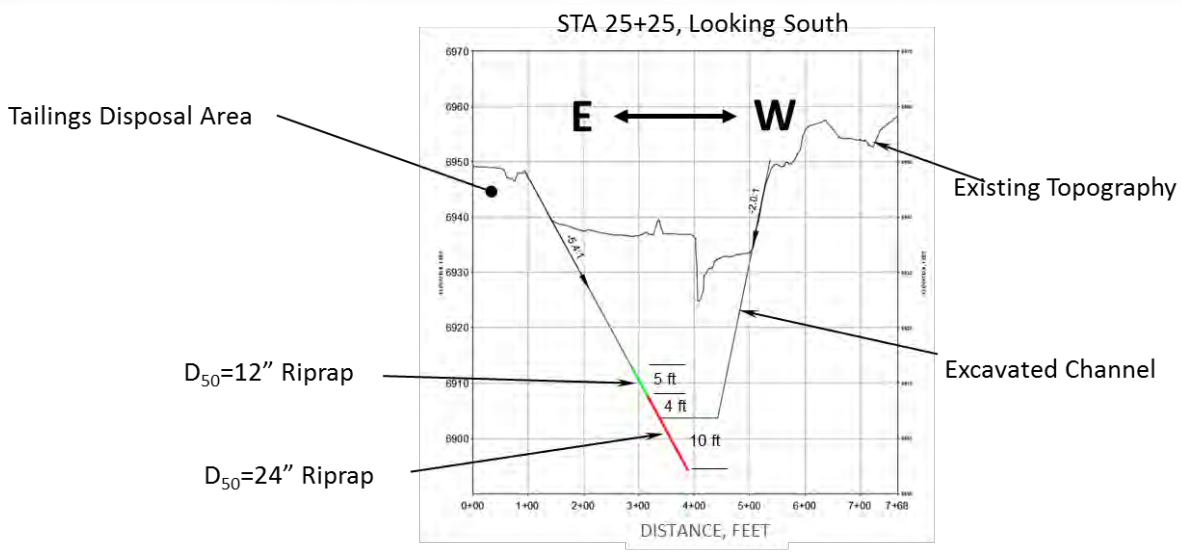


Figure I.7-14: Concept (Plan and Section) for Re-constructed Channel Alternative

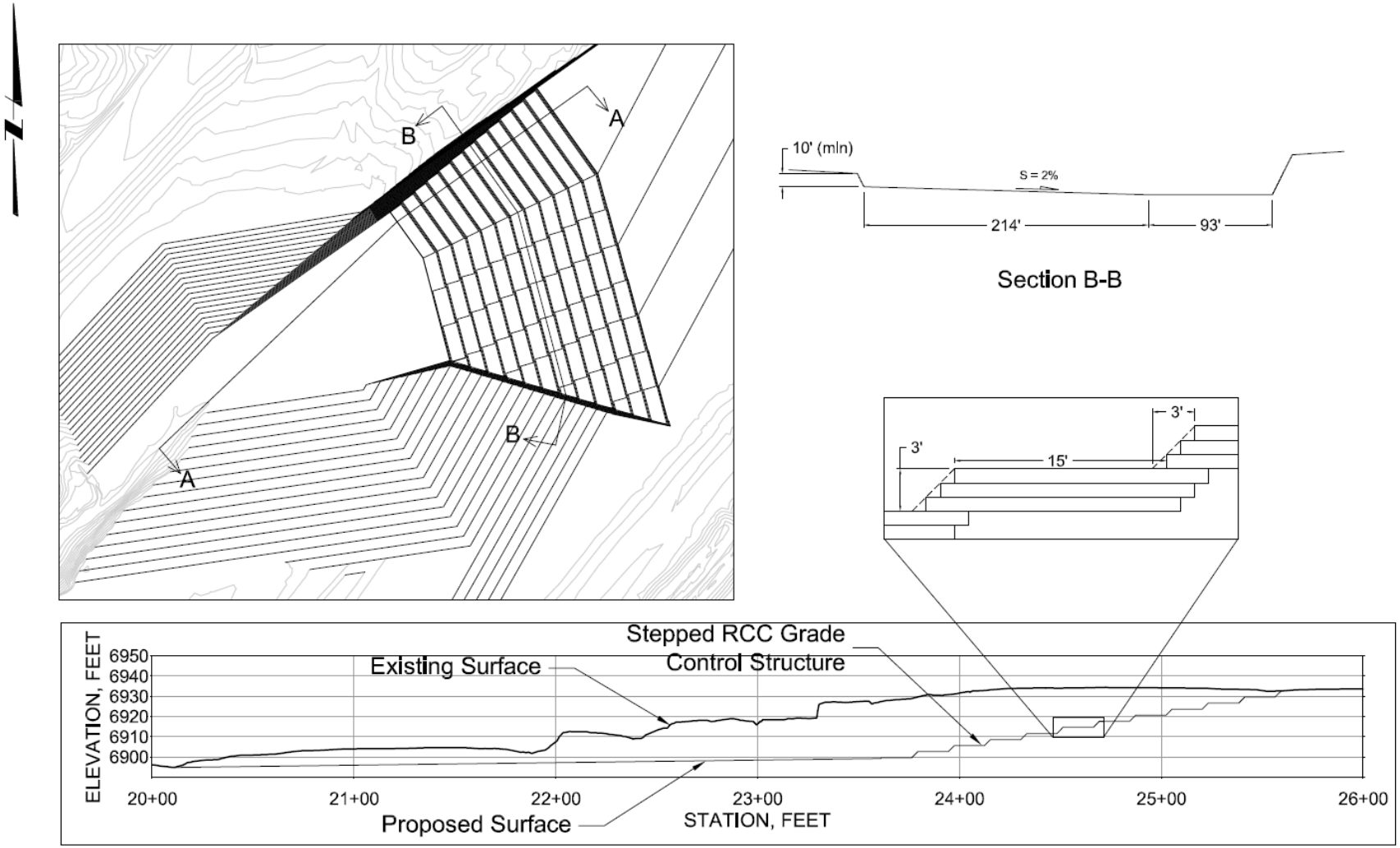


Figure I.7-15: Concept for Roller Compacted Concrete Spillway Alternative

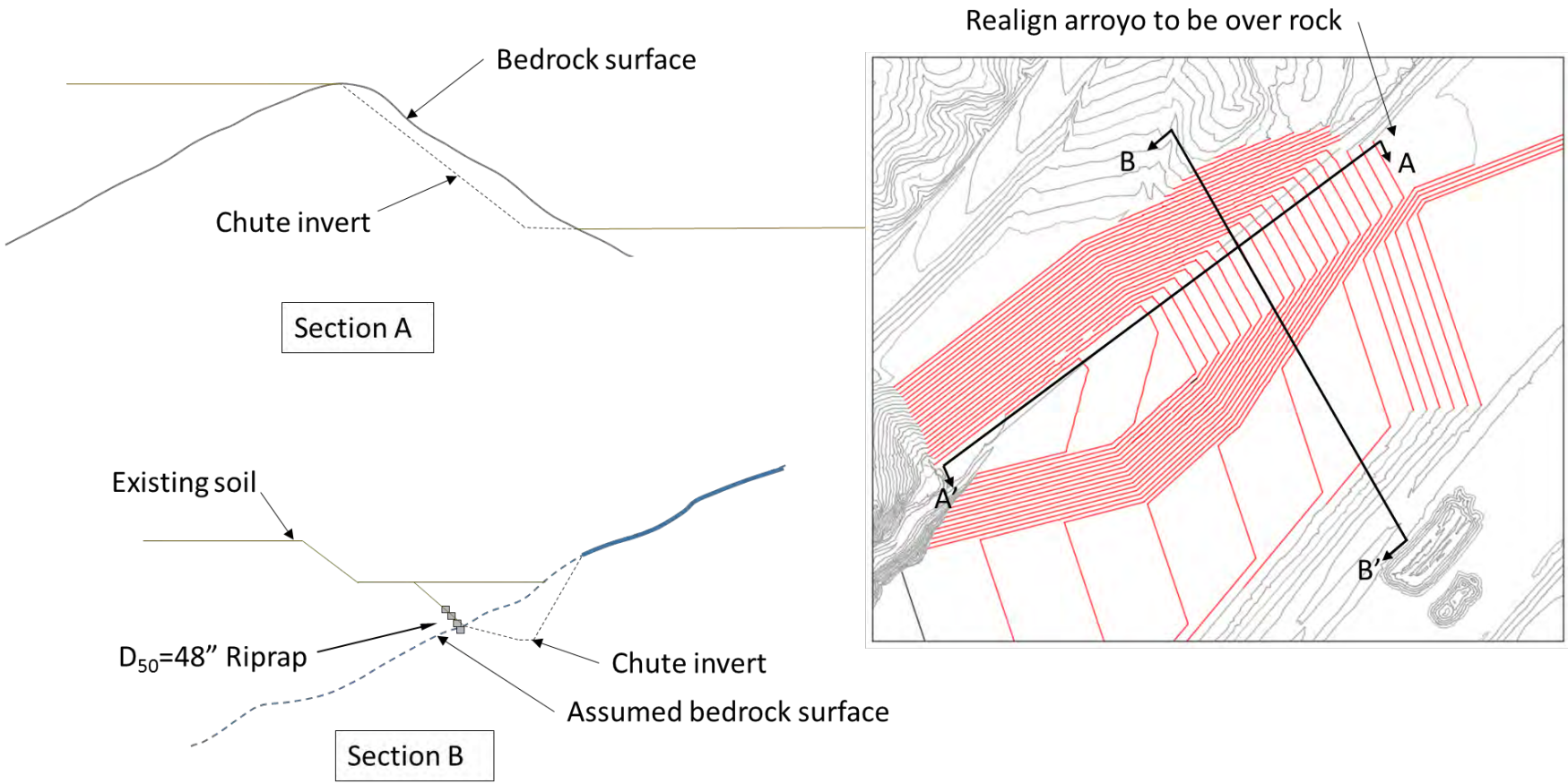
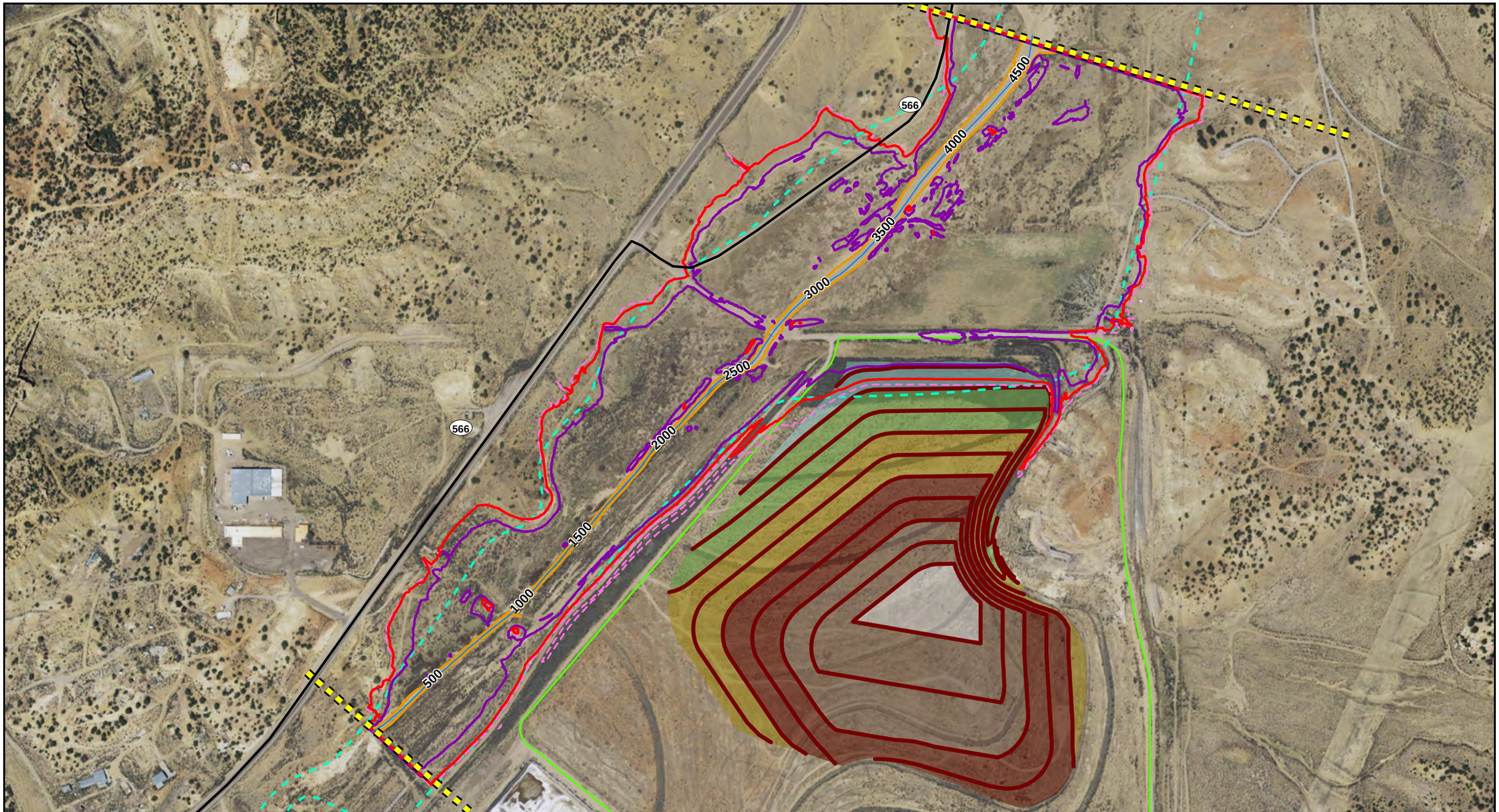


Figure I.7-16: Concept for Rock-Cut Chute Alternative



Legend

- Proposed Repository Area (5' Contour Interval)
- Upper & Lower Extents of Study
- Pipeline Road
- Upper Pipeline Arroyo Thalweg
- PMF Flood Extents from Canonie (1991)
- TDA-North Cell
- PMF Flood Extents
- 100 Year Event Flood Extents
- 5 Year Event Flood Extents
- PMF Flood Extents (Maximum Roughness)

N
W E
S

0 250 500 1,000 1,500 Feet

FIGURE I.8-1:

Estimated Pipeline Arroyo Flood Extents

Northeast Church Rock

Date Revised: 5/18/2016

MWH

PHOTOS

Photo I.7-1: Downstream Side of Rock Jetty (February 18, 2016)

Photo I.7-2: Undercutting of Downstream Side of Rock Jetty

Photo I.7-3: Drainage Cut Approximately 150 Feet Downstream of the Rock Jetty

Photo I.7-4: Drainage Cut Approximately 300 Feet Downstream of the Rock Jetty

Photo I.7-5: Existing Pipeline Arroyo Channel at the Location of the Rock Outcrop

ATTACHMENT I.1

Estimation of Flood Flows for Design of Interim and Final Surface Water Controls for the Removal Action at the NECR Mine Site and Church Rock Mill Site

ATTACHMENT I.1: ESTIMATION OF FLOOD FLOWS FOR DESIGN OF INTERIM AND FINAL SURFACE WATER CONTROLS FOR THE REMOVAL ACTION AT THE NORTHEAST CHURCH ROCK MINE SITE AND CHURCH ROCK MILL SITE

Revisioning

Rev.	Date	Description	By	Checked	Date
0	*5/27/2015*	*Preliminary (30%) Design*	*A. Edstrom*	*Z. Elliot*	*4/15/2016*

Revisions

Issue Date	Description
--	--

Location and Format

Electronic copies of these calculations are located in the project team site.

The following calculations were generated using the following software:

- United States Army Corps of Engineers (USACE) Hydrologic Engineering Center's – Hydrologic Modeling System (HEC-HMS) version 4.1, build 1542
- AutoCAD Civil 3D 2015
- ESRI ArcMAP 10.2.2
- Microsoft Excel 2013

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Objective

The objective of these calculations is to estimate flood flows for the following design elements:

- Pipeline Arroyo at the location of the "nickpoint" rock outcrop and upstream of the tailings disposal area (TDA) after removal of Northeast Church Rock (NECR) Mine waste materials, their placement in the designated Mill repository, revegetation of the engineered cover on the repository, and after the Mine Site is graded to not retain water (post-removal action [RA] conditions).
- North Diversion Channel at locations in the south and east reaches.
- At locations within the West Repository Channel and tributary channels (Swale B and proposed Dilco Hill channels), and the Runoff Control Ditch under post-RA conditions (see Section 9 Drawings).
- In the engineered channel protecting the unnamed arroyo at the outfall of the Mine Site under post-RA conditions.
- At various locations within the NECR Mine Site relevant to stormwater controls during implementation of the RA (during construction).
- Downstream of the Mine Site under existing and post-RA conditions.

These locations are shown in Figure 1.

Background

The Selected Remedy under the Administrative Settlement Agreement and Order on Consent (AOC) requires that NECR Mine Site waste that contain concentrations of uranium and Ra-226 in excess of Action Levels be excavated and transported to a Repository. Excavation at the Mine Site will continue until confirmation sample results from excavated areas are below the Action Levels. The Selected Remedy further requires design of a repository at the Mill Site to contain mine waste from the Mine Site.

Surface water channels protecting the TDA are designed to prevent erosion or overtopping of the channels during the design storm. Included in the RA is an evaluation of the buried jetty and design of improvements to protect the TDA from flows in the Pipeline Arroyo during the design storm event. The design storm event for the surface water channels for the Mill Site, including the Pipeline Arroyo, is the Probable Maximum Flood (PMF). These calculations also estimate the peak 200-year flow in the Pipeline Arroyo and peak flows for lesser floods (100-year and 2-year) for use in analysis of hydraulics and design of sediment control measures.

The engineered channel protecting the unnamed arroyo at the outlet of the Mine Site was designed to have capacity and erosional stability for the 100-year flood event. These calculations estimate the 100-year flood flow entering and leaving the engineered channel under post-RA conditions to evaluate the as-built channel performance. The calculations also estimate 2-year peak flows at the Mine Site locations shown in Figure 1 for Phase 3 removal. Phase 3 removal provides the maximum peak flow and volume to each control structure during soil and waste removal from the Mine Site.

MWH developed four hydrological models to facilitate estimation of flood flows at the various locations and conditions:

1. Pipeline Arroyo Watershed Model for Existing Conditions (Pipeline Arroyo Existing Condition Model)
2. Pipeline Arroyo Watershed Model for Post-RA Conditions (Pipeline Arroyo Post-RA Model)

3. Mill Site Sub-Catchments Model for Post-RA Conditions (Mill Site Model)
4. Mine Site Sub-Catchments Model for Construction Phases (Mine Site Model)

Applicable Codes and Standards

The calculation methods are consistent with the following codes and standards:

- Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site (AOC; USEPA, 2015)
- Design of Erosion Protection for Long-Term Stabilization (Johnson, 2002)
- Hydraulic Analysis for Dams (NMOSE, 2008)

Methods

Analysis Model

United States Army Corps of Engineers (USACE) Hydrologic Engineering Center's – Hydrologic Modeling System (HEC-HMS) version 4.1, build 1542.

Watershed Delineations and Model Element Construction

Watershed delineations and the model element construction within HEC-HMS for the three hydrologic models are shown in Attachment A. MWH selected the delineations for the sub-watershed to capture major hydrologic features in the Mill Site and Mine Site, to break out major tributaries to the Pipeline Arroyo upstream of the nickpoint, and to have approximately consistent upstream catchments.

Hyetograph Development

Frequency-Based Storms

MWH developed the 2-year, 100-year, and 200-year hyetographs using the center-peaking alternative block technique with the depth-duration frequency curve built from the National Oceanic and Atmospheric Association (NOAA) Precipitation Data Frequency Server (PDFS) (Bonnin et al, 2011).

The PDFS provides storm depths for return periods ranging from 1-year to 1,000-years and for storm durations of 5-minutes to 60-days. Table 1 shows the PDFS annual maximum series, median confidence interval storm depths for a point located at the south side of the Mill Site (35.6455˚ latitude and -108.5056˚ longitude).

MWH fit the depth-duration values given in the PDF to the analytical intensity-duration-frequency (IDF) shown in Equation 1 (Chow et al. 1988):

$$i = \frac{c}{T_d^e + f} \quad \textbf{[Eq.1]}$$

Where:

i	=	The design rainfall intensity (mm/hr)
T_d	=	The storm duration of the specific return period (15 minutes to 4320 minutes)

c, e, f = Fitting parameters

Table 2 gives the fitting parameters for the IDF curve, and Figure 2 shows the analytical IDF curves with the PDFS depth-duration points.

Finally, MWH constructed the alternating block hyetograph from the analytical IDF curves. Figure 3 shows the cumulative hyetographs for the 2-year and 100-year storm events. Fitting and rounded error inherent in the analytical IDF curves tended to produce cumulative 24-hour rainfall depths greater than reported in the NOAA PDFS, and the cumulative hyetographs were truncated at the 24-hour depth reported by NOAA.

Probable Maximum Precipitation Storm

MWH developed the PMP storm depths and distributions using the Arizona Department of Water Resources (ADWR) PMP Evaluation Tool (ADWR, 2013). The PMP evaluation tool, completed in 2013, was developed to supersede Hydrometeorological Report (HMR) 49. The ADWR PMP study used a similar approach to the HMRs, but adds more data and improved analytical techniques. The tool produces gridded PMP values using a grid spacing of approximately 2.5 square miles to allow site-specific estimation of precipitation depths. The Pipeline Arroyo watershed, including the Mine Site and Mill Site, is within the ADWR PMP study boundaries (Figure 4).

The PMP tool provides PMP depths and distributions for three different storm types: (1) local convective storms, (2) remnant tropical storms, and (3) general frontal storms. These calculations use local convective storms because they produce the most intense rainfall of the three storm types, and will generate the peak flood flows for design of surface water controls. The PMP tool provides PMP depths for the local convective storm PMP (hereafter referred to as PMP), depths at 1-hour intervals for storm durations between 1 hour and 6 hours. MWH computed area-weighted PMP depths for the Pipeline Arroyo Watershed model and for the Mill Site Sub-Catchments model from the gridded PMP depths. These area-weighted averages are shown in Table 3.

The ADWR PMP study also developed a standard hyetograph for the 6-hour PMP on 10-minute time steps. The hyetograph was developed using a center-peaking distribution, similar to the development of the frequency-based storm hyetographs described above and which is an accepted storm distribution method given by the New Mexico Office of the State Engineer for the hydrologic analysis of dams (NMOSE, 2008). Because the response times for the Mill Site and Pipeline Arroyo watersheds are estimated to be much less than 6 hours, a 6-hour storm distribution may not produce peak runoff compared to shorter, more intense PMP durations. Consequently, MWH developed distributions for 1-hour to 5-hour storms from the 6-hour PMP storm by scaling the relative intensities for the most intense period of the 6-hour PMP distribution to the ratio of the total 6-hour PMP depth and the total depth of the other storm durations. Figure 5 shows the cumulative hyetographs of storms of durations between 1 hour and 6 hours.

PMP depths and distributions for the Pipeline Arroyo Watershed were slightly different than for the Mill Site watershed, owing to the difference in watershed areas and averaging of the PMP tool grid cells (Figure 6).

The PMP and frequency-based storm hyetographs are presented in Attachment B.

Rainfall Losses

The hydrologic models compute rainfall losses from depression storage and infiltration (Green-Ampt). Final values for rainfall loss parameters for each catchment in the models are provided in Attachment C.

Depression Storage

MWH specified a depression storage value of 0.15 inches for all areas excluding the tailings disposal area and mine waste repository. This value is mid-range of the values recommended for alluvial plains near Albuquerque, New Mexico (Sabol et al., 1982a). MWH specified a depression storage value of 0.05 inches for the TDA, including the repository area, to account for lower storage that is expected on the engineered cover compared to the native alluvial plains. A value of 0.20 was applied for the Mine Site construction phase model to estimate roughness produced by roughening the surface of the RA impacted areas.

Infiltration Losses

The hydrologic models use the Green and Ampt (1911) method to simulate losses due to infiltration. MWH specified Green and Ampt parameters for individual catchments based on information in the United States Department of Agriculture (USDA) National Resources Conservation Service (NRCS) gridded Soil Survey Geographic (gSSURGO) database for the state of New Mexico, with adjustments made for vegetation coverage. The gSSURGO database shows three general groups of soils within the Pipeline Arroyo watershed: (1) upland mesas composed of shallow sandy clay loam to loamy soils with medium to high runoff potential, (2) steep transition zones dominated with rock outcrops and limited soil cover consisting of sandy clays, and (3) alluvium valley floors with primarily deep fine sand with mixed silty clay layers overlying sedimentary bedrock. The gSSURGO database further maps soils into 20 soils groups (excluding a “Uranium Mined Land” group). MWH assigned representative bare ground saturated hydraulic conductivity (Ksat) values to each of the 20 groups by approximating a harmonic average of the soil horizons within the upper 30 centimeters. The assigned bare ground Ksat values are listed in Table 4 and the bare ground Ksat distribution for the Pipeline Arroyo Watershed is shown in Figure 7. MWH compared these assigned values to measured values for similar New Mexico soils (Sabol et al., 1982a, 1982b) and found them consistent. MWH assigned Ksat values for “Uranium Mined Lands” based on visual observations and previous site characterization reports (Canonie, 1991; MWH, 2014).

After determining the individual soil unit polygon bare ground Ksat values; MWH computed the catchment-composite bare ground Ksat using the area-weighted logarithmic expression shown in Equation 2:

$$\overline{K}_{S,BG} = 10^{\wedge}\left(\frac{\sum_i^n A_i * \log(K_{S,BG,i})}{A_t}\right) \qquad \textbf{[Eq.2]}$$

Where:

$\overline{K}_{S,BG}$	=	The composite bare ground saturated hydraulic conductivity for each soil map unit
$K_{S,BG,i}$	=	The soil subarea bare ground saturated hydraulic conductivity that intersects the watershed
A_i	=	The subarea
A_i	=	The size of the watershed (composite) area

MWH adjusted the bare ground Ksat values to account for impacts of vegetation using the conductivity ratio calculated in Equation 3 (ADWR, 2007):

$$V_c \geq 10;\ \ C_k = \frac{(V_c - 10)}{90} + 1.0 \qquad \textbf{[Eq.3]}$$

$$V_c < 10;\ \ C_k = 1.0$$

Where:

C_k	=	Conductivity ratio of vegetated to bare ground Ksat
V_c	=	Vegetation cover (%)

MWH approximated vegetation coverage using the 2011 National Land Cover Database (NLCD; see Homer et al., 2015) from the USDA-NRCS Geospatial Data Gateway website. The vegetation over the Pipeline Arroyo Watershed extents is shown in Figure 8.

MWH only considered the regions coded as Evergreen Forest to determine the percentage of vegetation cover. The percent vegetation coverage for the individual watersheds of the existing condition Pipeline Arroyo are shown in Figure 9.

MWH adjusted the percent vegetation coverage from the listed NCLD values for the Mine Site model and for the post RA Mill Site area. For the Mine Site model, MWH set the vegetation percentage to zero for areas selected for soil removal during the RA. MWH specified a 25 percent vegetation cover for the watersheds located on the TDA and just outside of the TDA.

MWH used the relationship shown in Figure 10 to relate the composite bare ground Ksat values to soil moisture deficit and soil suction values.

Hydrograph Transform

The hydrologic model uses the synthetic Clark Unit Hydrograph (UH) to transform rainfall excess to a runoff hydrograph at a catchment outlet. The Clark UH requires estimation of two parameters: the time of concentration, Tc, and the storage coefficient, R, which represent the time translation and attenuation of a flood wave within a watershed.

Time of Concentration

Tc values were estimated using two different methods: (1) the empirically based Sabol (1993) Tc equation for native catchments, and (2) the velocity-based method (McCuen et al., 2002) for catchments with drainage dominated by engineered channels (i.e., the catchments containing the lower Mine Site and the tailings repository). These approaches are described in following sections, and worksheets for the calculation of the Tc and R values are provided in Attachment D.

Sabol Tc Method

The Sabol (1993) time of concentration, developed specifically for the desert southwest, is calculated as shown in Equation 4:

$$T_c = 2.4 * A^{0.1} * L^{0.25} * {L_{ca}}^{0.25} * S^{-0.2} \qquad \textbf{[Eq.4]}$$

Where:

T_c	=	Time of concentration (hours)
A	=	Area (square miles)
L	=	Hydraulically most distant length (miles)
L_{ca}	=	Length along the longest flow path from centroid (miles)
S	=	Slope along the longest flow path (ft/mile)

Velocity-Based Method

The velocity-based method computes the Tc as the sum of (1) the sheet flow travel time, (2) shallow concentrated flow travel time, and (3) open channel flow travel time, shown by Equation 5 (McCuen et al., 2002):

$$T_c = T_{sf} + T_{sc} + T_{oc} \qquad \textbf{[Eq.5]}$$

Where:

T_c	=	Time of concentration (hours)
T_{sf}	=	Sheet flow travel time (hours)
T_{sc}	=	Shallow concentrated flow travel time (hours)
T_{oc}	=	Open channel flow travel time (hours)

The following subsections describe methods used to estimate sheet flow, shallow concentrated flow, and open channel flow parameters.

Sheet Flow Travel Time, T_{sf}

The sheet flow travel time, T_{sf}, was calculated using Equation 6 (McCuen et al., 2002):

$$T_{sf} = \frac{0.93}{i^{0.4}}\left(\frac{nL}{\sqrt{S_{sf}}}\right)^{0.6} / 60 \qquad \textbf{[Eq.6]}$$

Where:

T_{sf}	=	Sheet flow travel time (hours)
i	=	Rainfall intensity for storm of Tc duration (inches/hour)
n	=	Manning's roughness coefficient
S_{sf}	=	Surface slope along the flow path length (feet/feet)
L_{sf}	=	Flow path length (feet) with a maximum distance of 100 feet or nL/S^0.5
60	=	Conversion from minutes to hours

MWH estimated values for L_{sf} and S from available site topography. Manning's n values were estimated from roughness coefficients presented by McCuen et al. (2002, Table 2.1). The roughness values used in the hydrologic analysis are shown in Table 5.

The sheet flow calculation uses iterative computations to solve for storm intensity and the sheet flow travel time. MWH related storm intensities to travel time using the analytical IDF relationships developed for the 2-year and 100-year storms. MWH also developed an analytical IDF relationship for the 1-hour PMP storm.

Shallow Concentrated Flow Travel Time, T_{sc}

The shallow concentrated flow travel time, T_{sc}, was calculated using Equation 7 and Equation 8 (McCuen et al., 2002):

$$T_{sc} = \frac{L_{sc}}{V_{sc} * 3600} \qquad \textbf{[Eq.7]}$$

Where:

T_{sc}	=	Time of concentration (hours)
L_{sc}	=	Shallow concentrated flow path length (feet)
V_{sc}	=	Shallow concentrated flow velocity (feet per second)
3600	=	Conversion from seconds to hours

$$V_{sc} = 33 * k * \sqrt{S_{sc}} \qquad \textbf{[Eq.8]}$$

Where:

V_{sc}	=	Shallow concentrated flow velocity (feet per second)

k	=	Velocity-slope relationship constant
S_{sc}	=	Surface slope along the flow path length (feet/feet)

MWH estimated values for L_{sc} and S from the available site topography and then computed the shallow concentrated flow coefficient, k, using McCuen (2009, Table 2.2). The values selected for hydrologic analysis are shown in Table 6.

Open Channel (Concentrated Flow) Travel Time, T_{oc}

The open channel flow travel time, T_{oc}, was calculated Equation 9:

$$T_{oc} = \frac{L_{oc}}{V_{oc} * 3600} \qquad \textbf{[Eq.9]}$$

Where:

T_{oc}	=	Open channel travel time (hours)
V_{oc}	=	Open channel flow velocity (feet per second)
3600	=	Conversion from seconds to hours (seconds/hour)

Open channel flow velocity is calculated using Manning's equation as given in Equation 10:

$$V_{oc} = \frac{1.486}{n} * Rh^{2/3} * {S_{oc}}^{0.5} \qquad \textbf{[Eq.10]}$$

Where:

V_{oc}	=	Open channel flow velocity (feet per second)
n	=	Manning's roughness coefficient
Rh	=	Hydraulic radius of the cross sectional flow area (feet)
S_{oc}	=	Surface slope along the flow path length (feet/feet)

Values for L_{sc} and S were estimated from the available site topography. Manning's roughness coefficient values, n, were determined from (Chow et al., 1988). The values selected for hydrologic analysis are shown in Table 7.

Manning's equation was solved iteratively to find a flow depth (and hydraulic radius) that satisfied the overall Tc. The representative flow used to compute the depth in the equations was 2/3 of the simulated peak flow at catchment outlet (NMDOT, 1995).

<u>Clark Unit Hydrograph Storage Coefficient (R Parameter)</u>

The Clark UH R parameter was computed using the Sabol (1993) equation as shown in Equation 11:

$$R = 0.37 * {T_c}^{1.11} * L^{0.80} * A^{-0.57} \qquad \textbf{[Eq.11]}$$

Where:

R	=	Clark UH storage coefficient (hours)
T_c	=	Time of concentration as calculated in Section 5.1 or 5.2 (hours)
L	=	Length of the longest hydraulic flow path (miles)
A	=	Area (square miles)

Channel Routing

The hydrologic models use the Muskingum-Cunge method to simulate routing through natural and engineered channels between catchment outlet points. The Muskingum-Cunge method couples the Manning formula and the convective-diffusion equation to compute the hydrograph travel time and hydrograph peak attenuation through a channel reach. No additional losses were applied to the channel reaches; therefore, only minor attenuation of the peak flows were observed, indicating that channel reach specifications have a limited impact on the modeled peak flows.

For completeness, channel dimensions were estimated using aerial survey data or using the design topography for the RA. These channel dimensions are simplified versions of the actual channel geometry (which again, have limited impact on the estimated peak flow values). Channel roughness of 0.04 were assigned to most reaches; however, the North Diversion Channel segment ND02, ND04, and ND05 were adjusted to correspond more closely with the HEC-RAS model. Routing parameters for the Pipeline Arroyo watershed model, Mill Site model, and Mine Site model are listed in Attachment E.

Reservoir Routing

The models route stormwater through the Mine Site ponds (for the Mine Site model) using the Modified Puls (level-pool) routing method. MWH computed the stage-area curve relationships using site topographic files and the average-end-area method. Stage-area-storage values for existing Mine Site Pond 1, Pond 2, Pond 3, Pond 4, and Pond 5 are provided in Attachment F. With the exception of Pond 3, none of the existing Ponds have controlled outlets. Pond 3 has an existing box culvert that acts as an emergency overflow. Otherwise, as the volume of the ponds is exceeded, flow passes downstream by overflowing the pond embankment. Table 8 shows how overflows were simulated in HEC-HMS. MWH also developed a stage-area-storage relationship for the temporary channel “plug” proposed for the Mine Site construction RA phases (see Section 3 Drawings). This stage-area-storage relationship is also given in Attachment F. The model assumes that the plug retains water up to an elevation of 7,088 ft above mean sea level (amsl) and then overtops as a broad-crested weir. The design parameters for the broad-crested weir are given in Table 8.

Assumptions

Assumptions used in these calculations are described with the explanation of methods.

Calculations

Input parameters for the hydrologic models are provided in Attachments.

Results

The simulated peak flows for the locations shown on Figure 1 are listed in Table 9. Tables in Attachment G list peak flow results at the outlet of model elements.

Conclusions

Results shown in Table 9 are for use in design of channels and other stormwater controls for the Northeast Church Rock RA.

Attachments

- Attachment A – Watershed Delineation Maps, HEC-HMS Element Construction, Watershed Area Tables
- Attachment B – Storm Hyetograph Tables
- Attachment C – Rainfall Loss Parameters Tables
- Attachment D – Clark Unit Hydrograph Parameter Calculation Tables
- Attachment E – Channel Routing Parameters Tables
- Attachment F – Reservoir Stage-Area-Storage Tables
- Attachment G – HEC-HMS Model Results

References

Arizona Department of Water Resources (ADWR), 2007. State Standard for Hydrologic Modeling Guidelines. Report No. SS10-07. Accessed online February 2016 at: http://www.azwater.gov/azdwr/surfacewater/floodmanagement/documents/Hydrology_State_Standard.pdf

Arizona Department of Water Resources (ADWR), 2013. Probable Maximum Precipitation Study for Arizona

Bonnin, G.M., D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley, 2011. Precipitation-Frequency Atlas of the United States. NOAA Atlas 14, Volume 1, Version 5.0: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah). Accessed online February 2016 at: http://www.nws.noaa.gov/oh/hdsc/PF_documents/Atlas14_Volume1.pdf

Canonie, 1991. Tailings Reclamation Plan. License No. SUA – 1475.

Chow, V.T., D.R. Maidment, and L. W. Mays, 1988. Applied Hydrology.

Green, W.H. and G. Ampt, 1911. Studies of soil physics, part I – the flow of air and water through soils. J. Ag. Sci. 4:1-24.

Homer, C.G., J.A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N.D. Herold, J.D. Wickham, and K. Megown, 2015. Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

McCuen, R.H., P. A. Johnson, and R.M. Ragan, 2002. Highway Hydrology: Hydraulic Design Series Number 2, Second Edition. Federal Highway Administration. Report No. FHWA-NHI-02-001, HDS-2. Accessed online February 2016 at: https://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=2&id=6

New Mexico Office of the State Engineer (NMOSE), 2008. Dam Safety Bureau – Hydrologic Analysis for Dams. August 15.

MWH, Inc. (MWH), 2014a. Pre-Design Studies Northeast Church Rock Mine Site Removal Action: Church Rock Mill Site. October 31.

MWH, Inc. (MWH), 2014b. Pre-Design Studies Northeast Church Rock Mine Site Removal Action; Northeast Church Rock Mine Site. October 31.

New Mexico Department of Transportation (NMDOT), 1995. Drainage Manual, Volume 1, Hydrology. Prepared by C.S. Philips, C.M. Easterling, R.J. Heggen, and J.D. Schall.

New Mexico Office of the State Engineer (NMOSE), 2008. Hydraulic Analysis for Dams.

Sabol, G.V., T.J. Ward, and A.D. Seiger, 1982a. Phase II – Rainfall Infiltration of Selected Soils in the Albuquerque Drainage Area. Accessed online February 2016 at: http://www.fcd.maricopa.gov/pub/library.aspx

Sabol, G.V., T.J. Ward, and A.D. Seiger, 1982b. Phase II – Arroyo Transmission Losses. Civil Engineering Department, New Mexico State University, Las Cruces, New Mexico. Accessed online February 2016 at: http://www.fcd.maricopa.gov/pub/library.aspx

Sabol. G.V., 1993. Arizona Department of Transportation Highway Drainage Design Manual Final Report.

US Environmental Protection Agency (USEPA), 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site. . April 27.

US Nuclear Regulatory Agency (NRC), 2002. Design of Erosion Protection for Long-Term Stabilization.

TABLES

Table 1: NOAA PDFS Depth-Duration Values for 2-year and 100-year Return Interval Storms

Duration (Minute)	Depth (inches)		
	2-year storm	100-year storm	200-year storm
5	0.21	0.61	0.69
10	0.31	0.92	1.04
15	0.39	1.14	1.29
30	0.52	1.54	1.75
60	0.65	1.91	2.16
120	0.77	2.28	2.6
180	0.83	2.35	2.67
300	0.95	2.50	2.81
720	1.10	2.69	3
1440	1.17	2.99	3.34

Table 2: Fitting Parameters for the 100-year and 2-year, 24-hour Distributions

Storm	c	e	f
200-year, 24-hour	88.52978	0.865771	6.701886
100-year, 24-hour	78.29110794	0.866661056	6.695777805
2-year, 24-hour	22.76860156	0.830917394	5.261281148

Table 3: Area-Weighted Averaged PMP Depths for the Pipeline Arroyo Watershed and Mill Site Sub-Catchments Models

Storm Duration (hour)	Total Depth (inches)	
	Mill Site	Pipeline Arroyo
1	6.18	6.14
2	6.49	6.45
3	6.51	6.46
4	6.51	6.46
5	6.51	6.46
6	6.51	6.47

Table 4: Assigned Bare Ground Saturated Hydraulic Conductivity Values

Name	MUKEY	State	Runoff Class	$K_{S,BG}$ (in/hr)
Sparank-San Mateo-Zia Complex 0-3 percent slopes	57984	AZ	Medium	1.12
Sparank-San Mateo-Zia Complex 0-3 percent slopes	57234	NM	Medium	1.12
Toldohn-Vessilla-Rock Outcrop Complex 8-to-35% Slope	57987	AZ	Very High	0.46
Toldohn-Vessilla-Rock Outcrop Complex 8-to-35% Slope	57260	NM	Very High	0.46
Evpark_Arabrab complex, 2 to 6 percent slopes	58103	AZ	High	0.41
Evpark_Arabrab complex, 2 to 6 percent slopes	57255	NM	High	0.41
Buckle fine sandy loam, 1 to 8 percent	57322	NM	Low	1.65
Doakum fine sandy loam, 2 to 8 percent slopes	58071	AZ	Low	1.65
Vessilla-Rock Outcrop complex, 2 to 15 percent slopes	57269	NM	Medium	1.21
Rock outcrop-Eagleye-Teesto family complex, 35 to 70 percent slopes	58091	AZ	High	0.24
Rock outcrop-Eagleye-Atchee complex, 35 to 70 percent slopes	57332	NM	High	0.24
Rock outcrop-Techado-Stozuni complex, 5 to 60 percent slopes	57281	NM	High	0.24
Parkelei sandy loam, 1 to 8 percent slopes	57248	NM	Low	1.44
Mentmore loam, 1 to 8 percent slopes	57328	NM	Medium	1.00
Parkelei family-Evpark complex, 2 to 8 percent slopes	58065	AZ	High	0.50
Parkelei-Evpark fine sandy loams, 2 to 8 percent slopes	57313	NM	High	0.50
Parkelei family-Fraguni complex, 1 to 8 percent slopes	58066	AZ	Very Low	2.15
Parkelei-Fraguni complex, 1 to 8 percent slopes	57253	NM	Very Low	2.15
Parkelei family-Hosta complex, 3 to 8 percent slopes	57986	AZ	High	0.50
Uranium mined lands	57239	NM	<null>	<varies>

Table 5: Sheet Flow Roughness Values

n	McCuen Description	NECR Land Surface
0.015 [1]	Roughened asphalt	Asphalt surface
0.05	Fallow (no residue)	Bare/roughened dirt surface
0.06	Cultivated; Residue cover <= 20%	Surface with limited vegetation
0.13	Range (natural)	Vegetated surface or expected vegetation

1. Estimated from available table values presented by McCuen et al. (2002).

Table 6: Shallow Concentrated Flow Coefficients

k	McCuen Description	NECR Land Surface
0.213	Short grass pasture (overland flow)	Vegetated surface or expected vegetation
0.305	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions	Little vegetation, gradual slope
0.491	Unpaved (shallow concentrated flow)	Little vegetation, steep slope

Table 7: Manning Coefficients Selected for Open Channel Flow

n	Description
0.03	Clean, straight stream
0.04	Clean, winding stream
0.05	Light brush and weeds
0.07	Dense brush

Table 8: Pond Outlets Specified for Hydrologic Modeling

Pond	Structure	HEC-HMS Inputs Specified
Pond 1	Dam Top	Elevation: 7123 feet; Length: 20 feet; Coefficient: 2.64
Pond 2	Dam Top	Elevation: 7123 feet; Length: 40 feet; Coefficient: 2.64
Pond 3	Culvert Dam Top	Shape: Box; Chart 10; Scale 1; Length: 40 feet; Rise: 4 feet; Span: 10 feet; Entrance Coefficient: 0.8; Outlet Elevation: 7077 feet; Exit Coefficient: 0.8; Manning's n: 0.004 Elevation: 7123 feet; Length: 20 feet; Coefficient: 2.64
Pond 4	Dam Top	Elevation: 7054 feet; Length: 40 feet; Coefficient 2.64
Pond 5	Dam Top	Elevation: 7050 feet; Length: 40 feet; Coefficient 2.64
Temporary Plug	Broad Crested Weir Spillway	Elevation: 7088 feet; Length: 4 feet; Coefficient 1.5

Table 9: Simulated Peak Flows at Locations of Interest for the Remedial Design

Location	Model Element ID	Model	Peak Flow (cubic feet per second)		
			PMP	100-year	2-year
Nick Point, Existing conditions	Outlet/R15ds	Pipeline Arroyo, Existing Conditions	26,764.4	4,766.2	3.2
Nick Point, Post-RA conditions	Outlet/R15ds	Pipeline Arroyo, Post-RA Conditions	27,573.0	4,957.0	3.4
North Diversion Channel, Outlet	J-ND01ds	Mill Site (Post-RA)	3,116.8	792.1	0.0
North Diversion Channel, Lower	J-ND02ds	Mill Site (Post-RA)	2,850.4	761.8	0.0
North Diversion Channel, Middle	J-ND02us	Mill Site (Post-RA)	2,777.9	752.7	0.0
North Diversion Channel, Upper	J-ND04us	Mill Site (Post-RA)	972.5	225.5	0.0
Swale B Outlet	J-RC05ds	Mill Site (Post-RA)	72.7	18.7	0.5
Dilco Hill Channel A Outlet	02	Mill Site (Post-RA)	14.3	4.4	0.1
Dilco Hill Channel B Outlet	01	Mill Site (Post-RA)	8.5	2.3	0.0
West Repository Channel Outlet	05	Mill Site (Post-RA)	177.2	57.6	2.4
East Repository Channel STA 18+50	J-SCus	Mill Site (Post-RA)	97.7	23.7	0.7
East Repository Channel STA 28+30	J-SCds	Mill Site (Post-RA)	140.2	32.9	2.8
East Repository Channel STA 34+60	J-RC04ds	Mill Site (Post-RA)	227.5	52.2	3.4
East Repository Channel STA 41+39	J-RC03ds	Mill Site (Post-RA)	274.0	66.0	3.8
Mine Site to Unnamed Arroyo Outlet, Existing	J-R16us	Pipeline Arroyo, Existing Conditions	353.6	42.9	0.0
Mine Site to Unnamed Arroyo Outlet, RA-Phase 3	Outlet	Mine Site (Construction, RA-Phase 3)	-	-	1.6
Unnamed Arroyo Outlet, Post-RA	J-R16ds	Pipeline Arroyo, Post-RA Conditions	1,038.2	217.9	0.0
Unnamed Arroyo Outlet, Existing	J-R16ds	Pipeline Arroyo, Existing Conditions	352.0	42.3	0.0
Native Drainage downstream of Unnamed Arroyo Outlet, Existing	J-R04us	Pipeline Arroyo, Existing Conditions	9,132.8	1,846.1	0.0
Native Drainage downstream of Unnamed Arroyo Outlet, Post-RA	J-R04us	Pipeline Arroyo, Post-RA Conditions	9,973.9	2,030.2	0.0
Diversion Berm Upstream of Pond 3, RA-Phase 3	R-J3ds/Berm1	Mine Site (Construction, RA-Phase 3)	-	-	0.6
Diversion Berm Near Haul Road, RA-Phase 3	J-Berm2	Mine Site (Construction, RA-Phase 3)	-	-	0.0
Diversion Berm/Attenuation Pond Near Haul Road, RA-Phase 3	Const_Pond	Mine Site (Construction, RA-Phase 3)	-	-	0.0
Pond 3 Diversion Plug	R-J3ds/Berm1	Mine Site (Construction, RA-Phase 3)	-	-	0.6

FIGURES

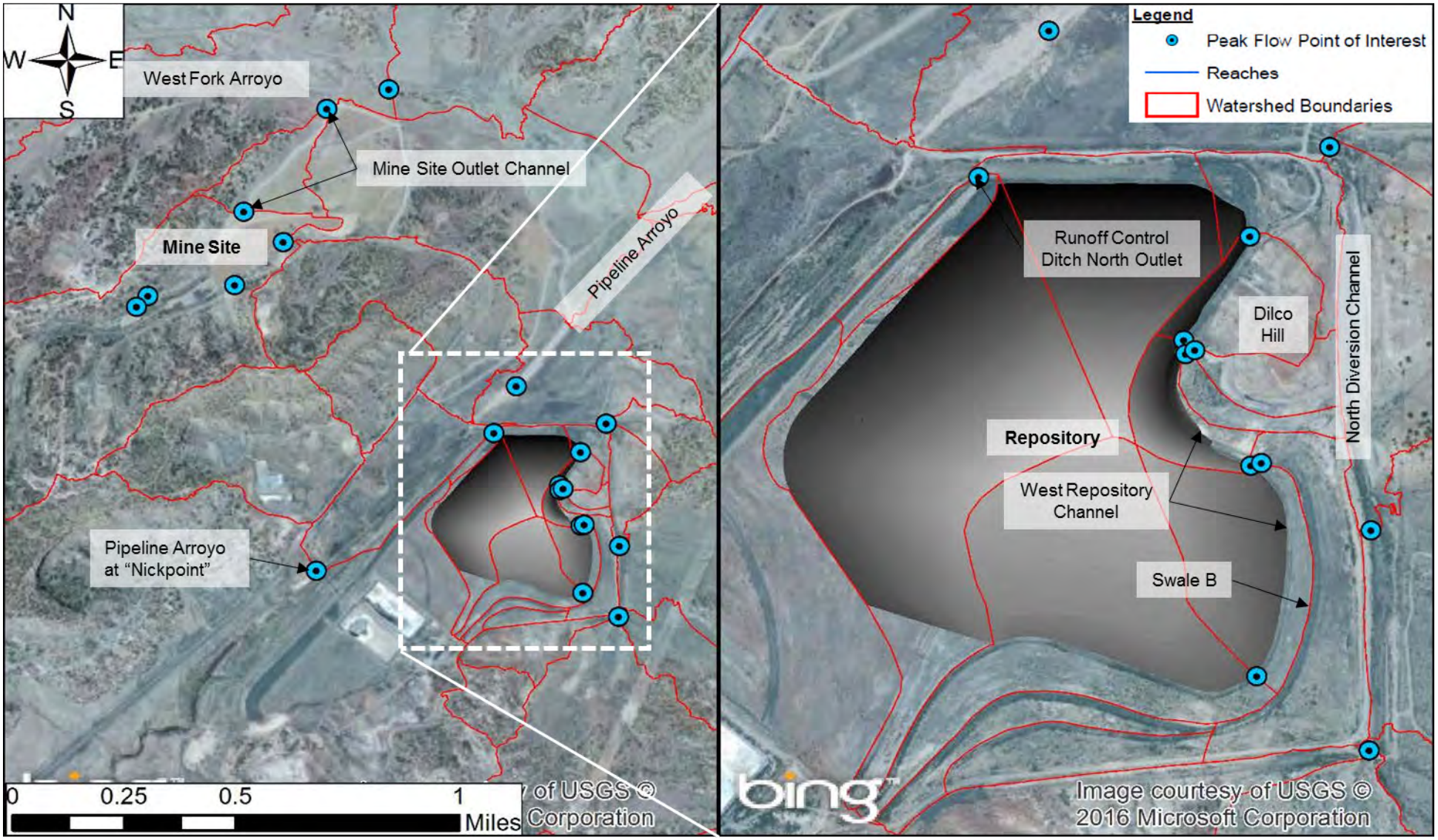

Figure 1: Hydrology Model Outlet Locations

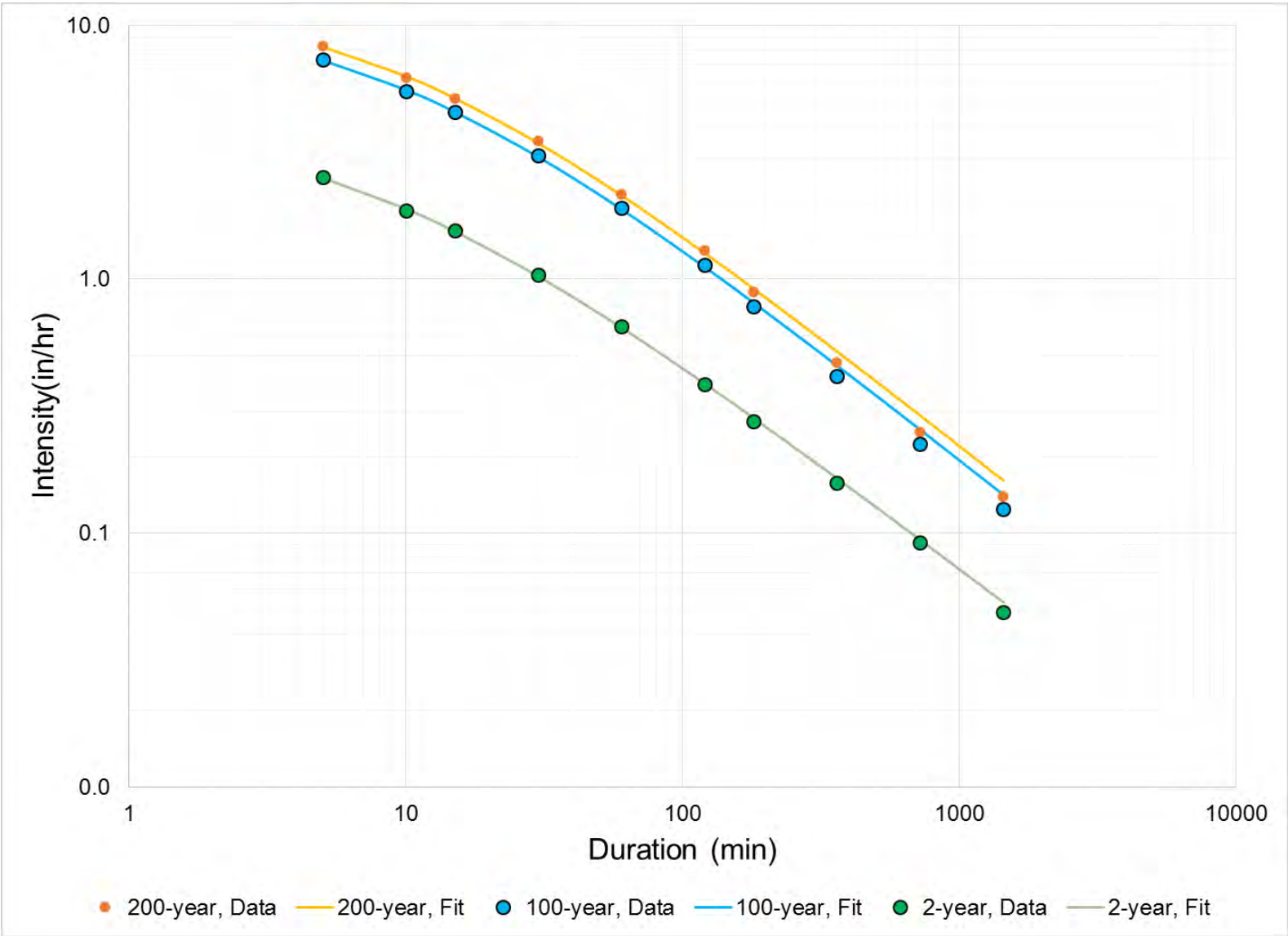

Figure 2: Analytical (fit) Depth-Duration-Frequency Curves Compared to NOAA PDFS Values for 200-Year, 100-Year, and 2-Year Return Intervals

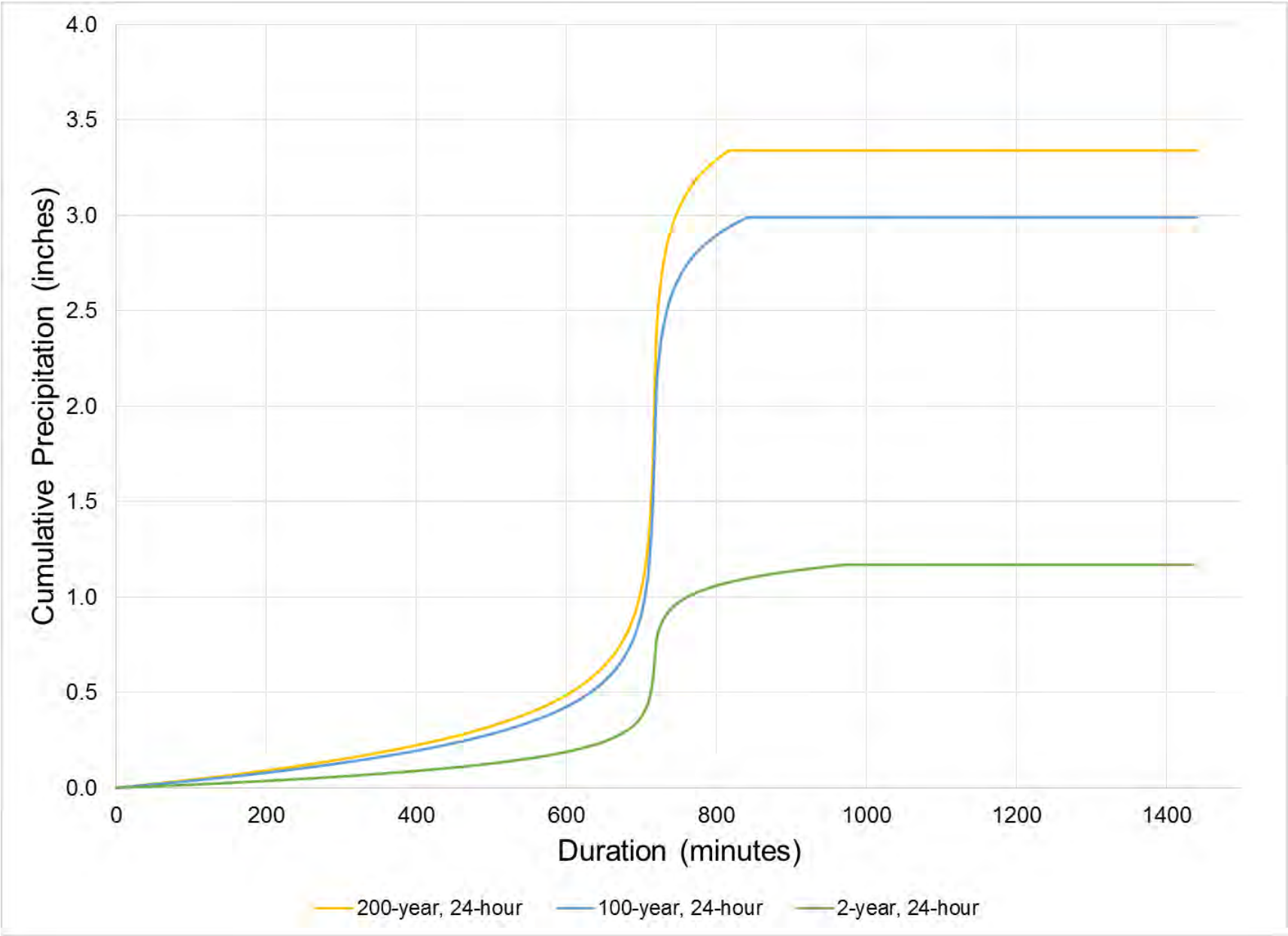

Figure 3: Cumulative Hyetographs for 200-Year, 100-Year, and 2-Year Storm Events

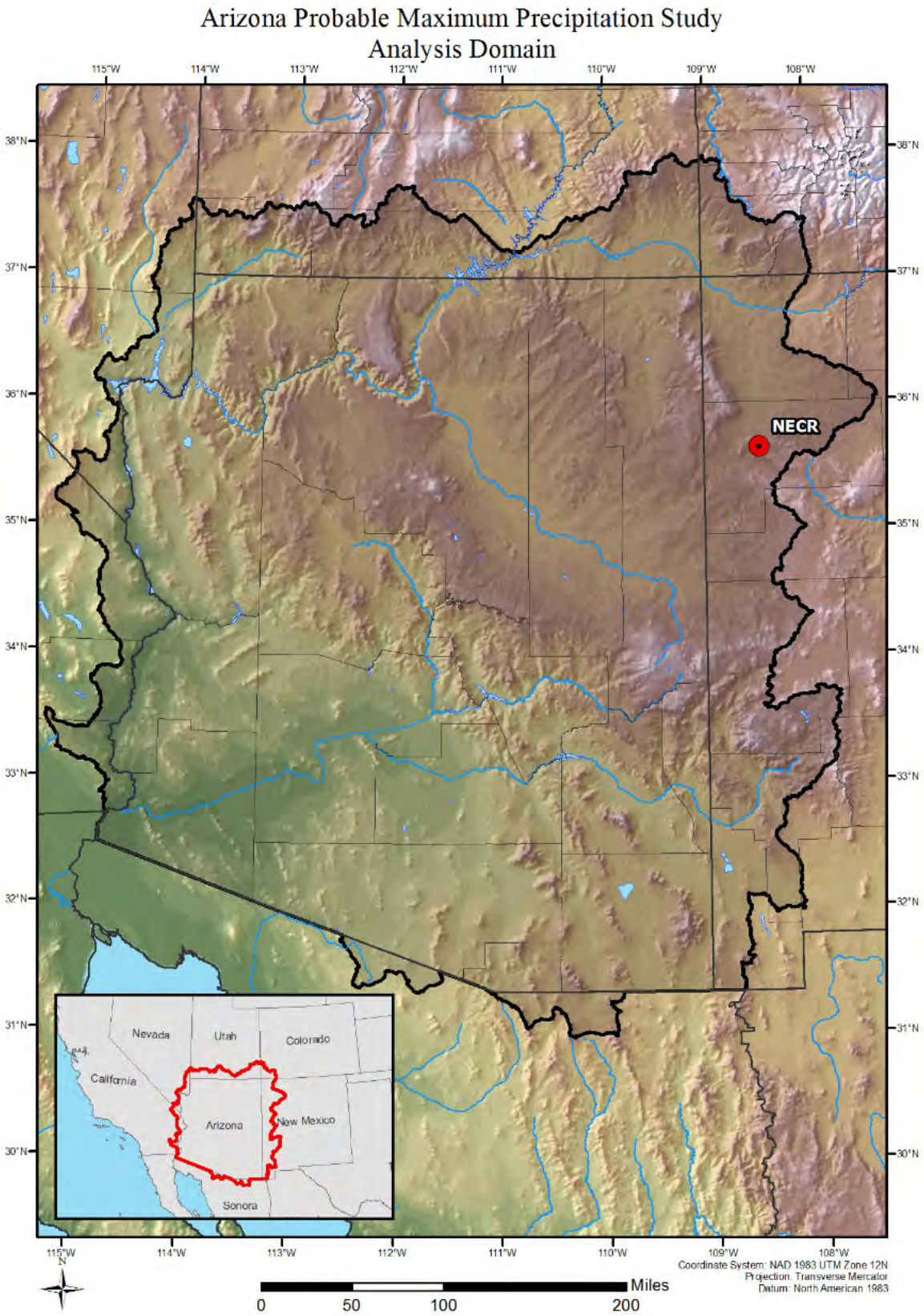

Figure 4: Location of Northeast Church Rock mine in Relation to the Arizona PMP Study Domain

(Source: Applied Weather Associates)

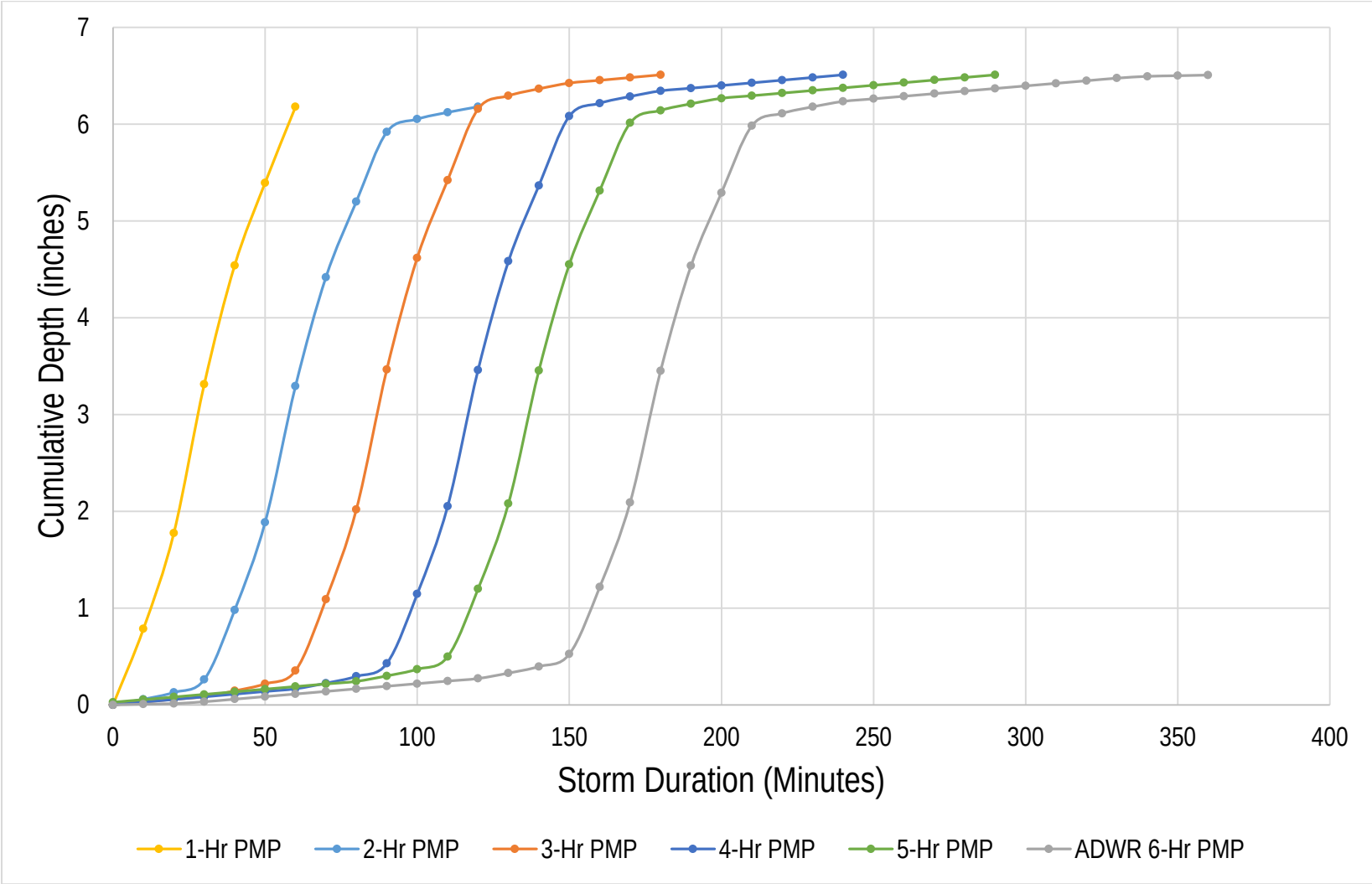

Figure 5: PMP storms for Durations of 1-Hour to 6-Hour PMP for the Pipeline Arroyo Watershed

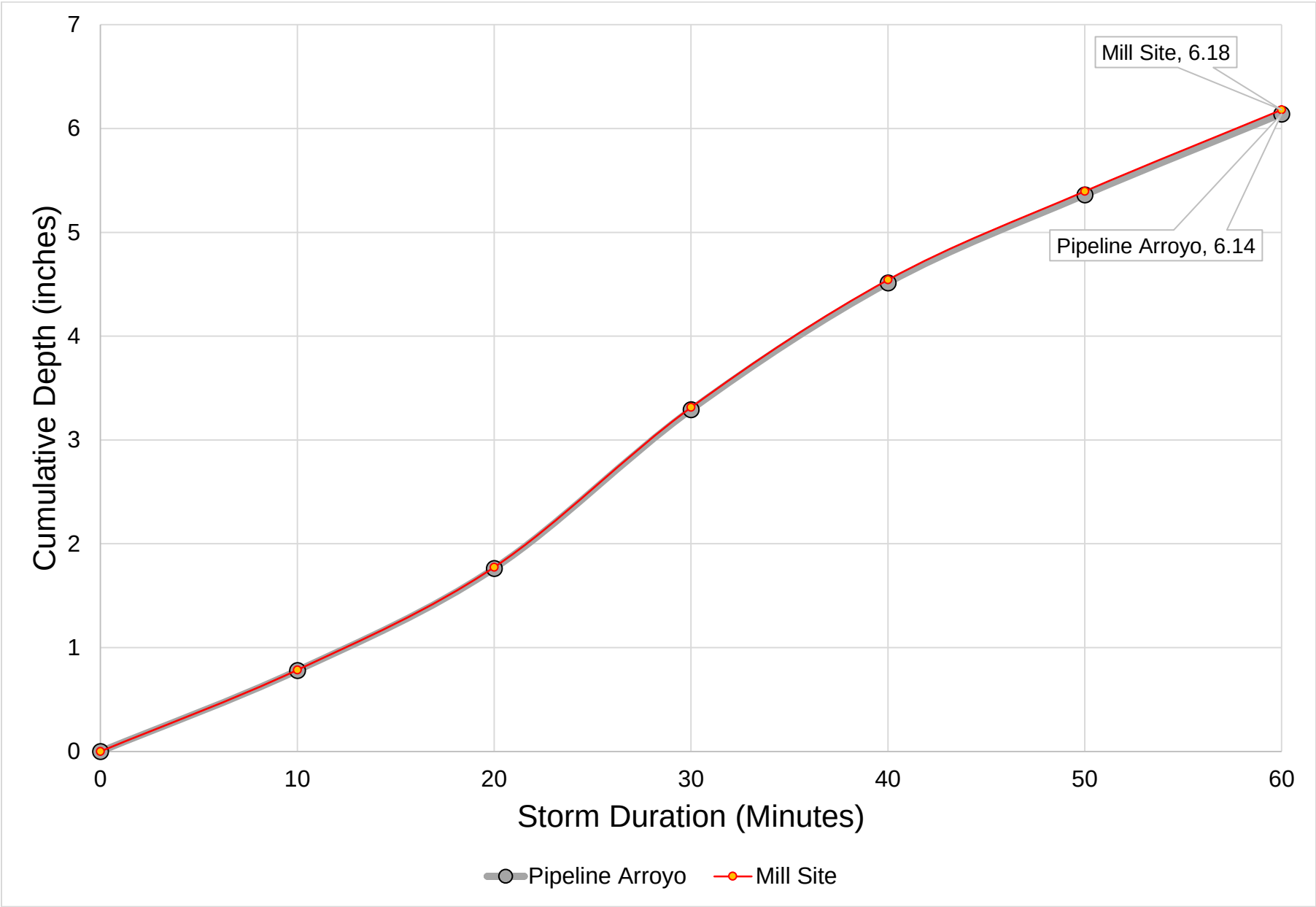

Figure 6: 1-Hour PMP Distributions for the Pipeline Arroyo and Mill Site PMFs

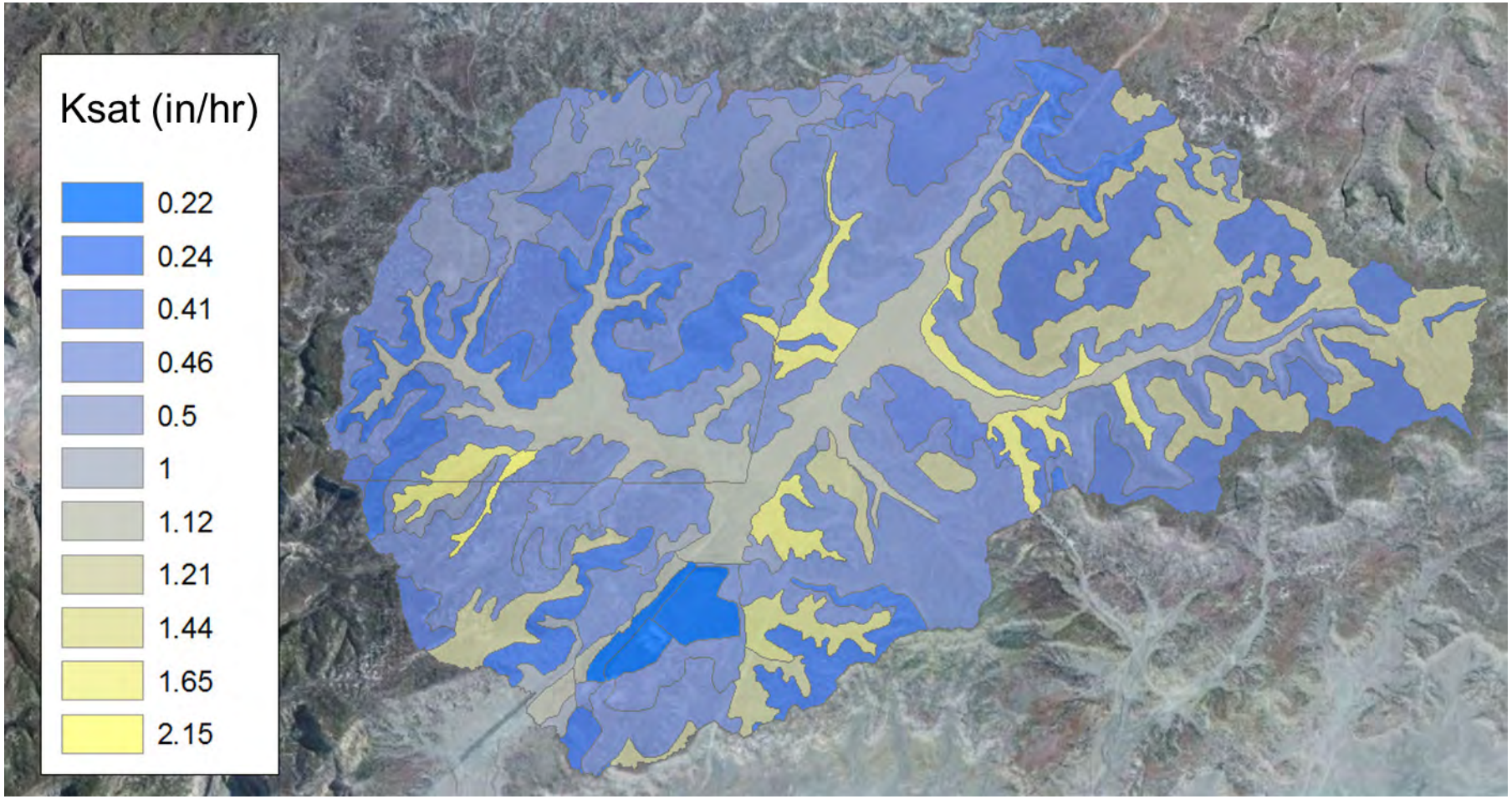

Figure 7: Bare Ground Saturated Hydraulic Conductivities

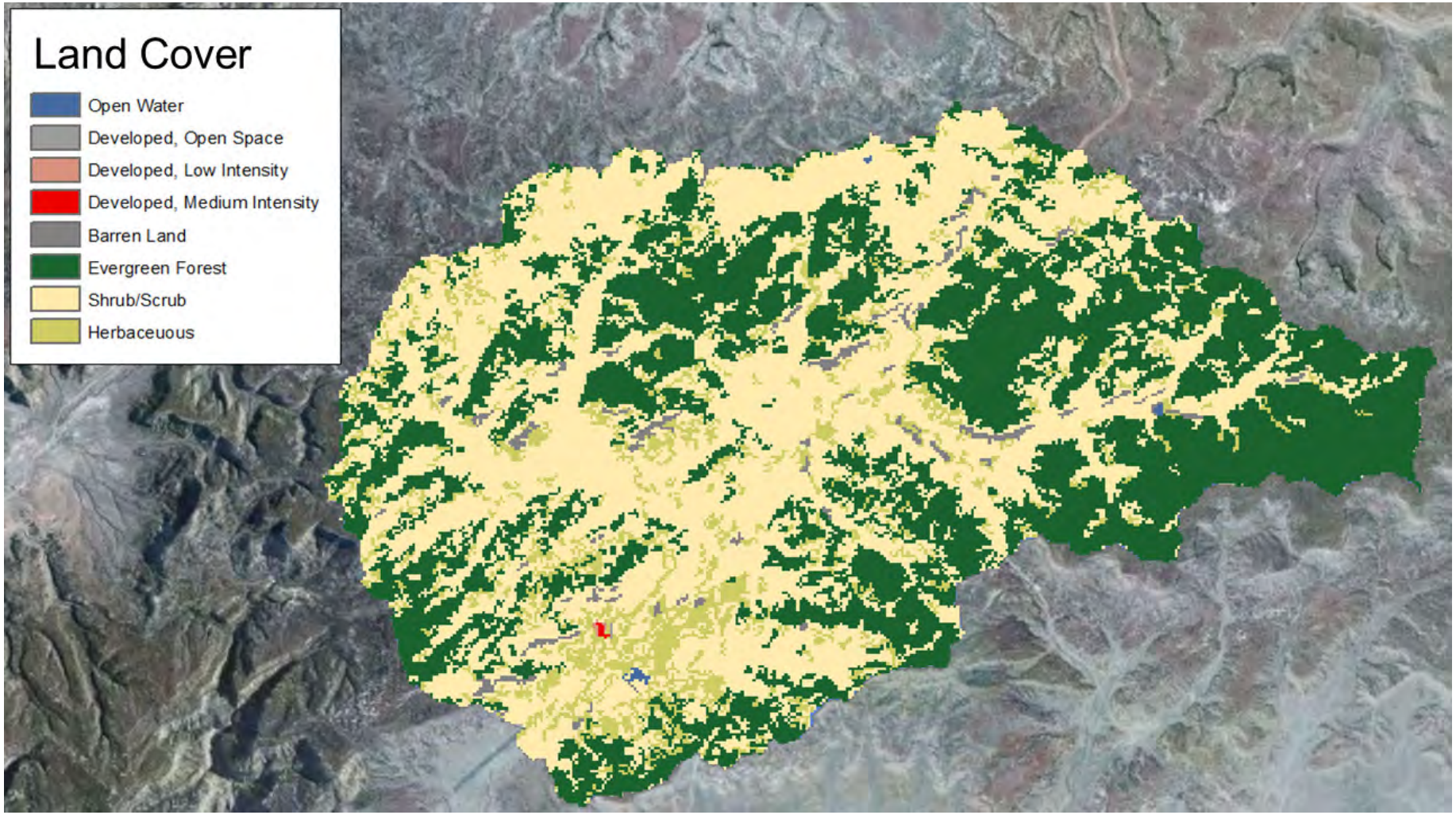

Figure 8: 2011 National Land Cover Database for the Pipeline Arroyo Watershed

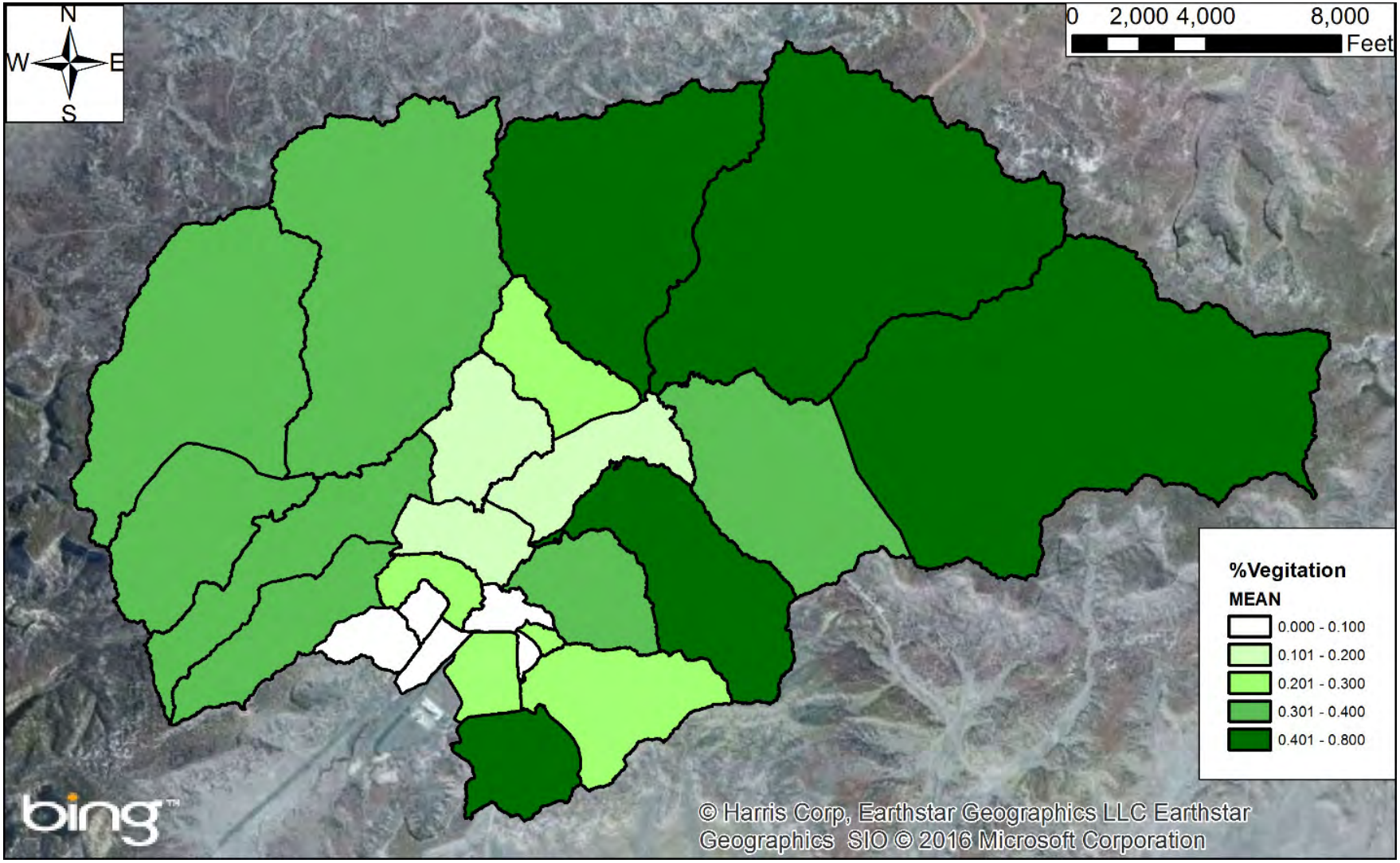

Figure 9: Percent Vegetation Coverage for the Existing Pipeline Arroyo Watersheds

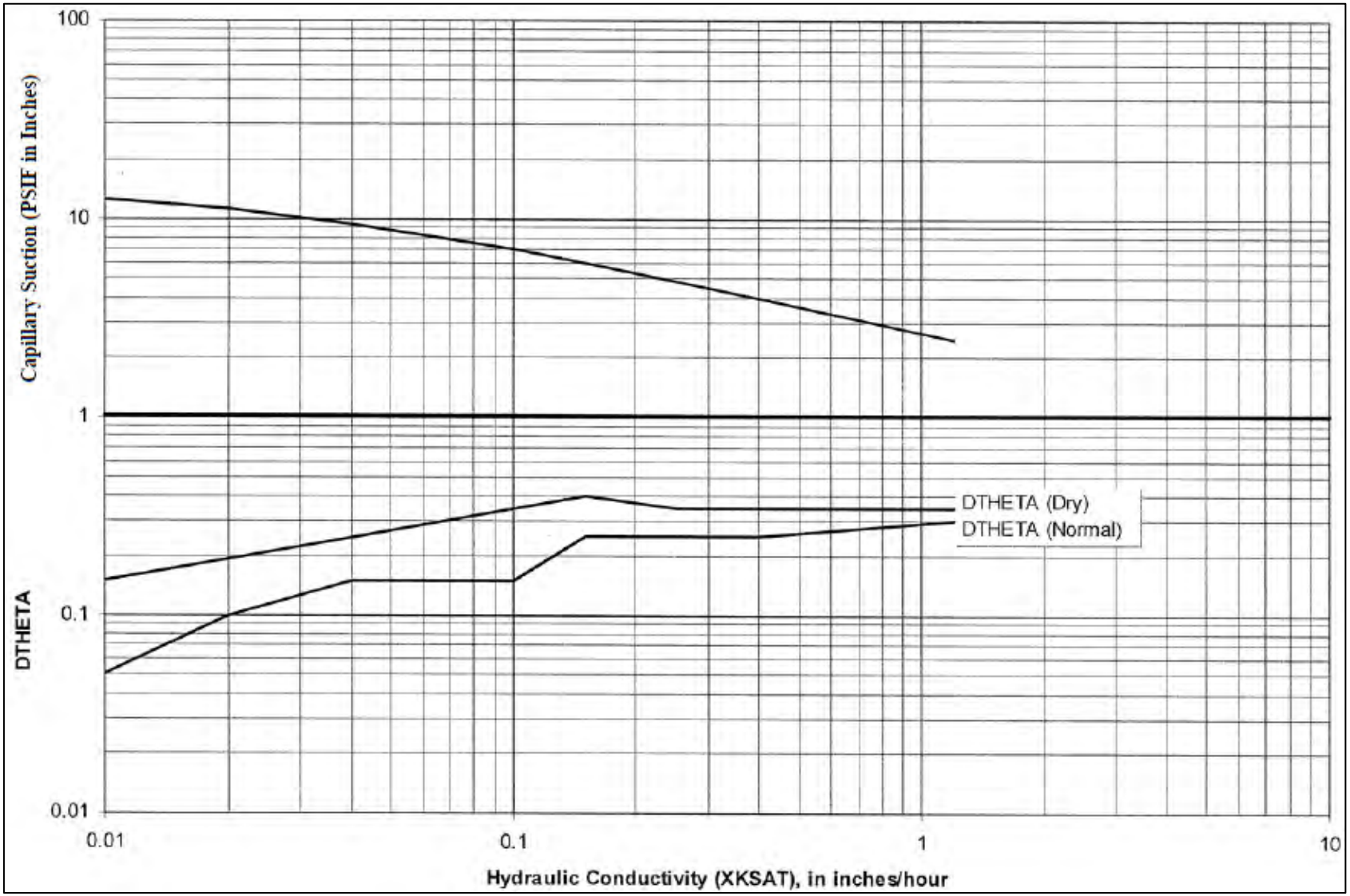

Figure 10: Relationship between Saturated Hydraulic Conductivity, Soil Moisture Deficit, and Soil Suction (from ADWR, 2007)

ATTACHMENT A

TABLES OF WATERSHED AREAS AND FIGURES OF WATERSHED DELINEATIONS AND MODEL ELEMENTS

Table 1a: Pipeline Arroyo, Existing Condition Watershed Areas

Watershed ID	Area (mi^2)
0	0.607268
1	0.138530
2	0.252849
3	0.037395
4	0.146419
5	0.073367
9	0.336413
10	0.544192
16	0.055649
17	0.397469
18	0.863512
19	0.393805
20	0.668204
21	0.390948
22	3.212219
23	1.541179
24	1.561185
25	2.747083
26	2.063947
27	0.162332
31	0.335478
32	0.078264
33	0.023686
34	0.008757
35	0.026925
36	0.010058
37	0.023734
38	0.025865
39	0.086768
42	0.359253
43	0.990445
44	0.020123

Table 1b: Pipeline Arroyo, Post-RA Condition Watershed Areas

Watershed ID	Area (mi^2)
0	0.607268
1	0.138530
2	0.252849
3	0.037395
4	0.146419
5	0.073367
9	0.336413
10	0.544192
16	0.055649
17	0.397469
18	0.863512
19	0.393805
20	0.668204
21	0.390948
22	3.212219
23	1.541179
24	1.561185
25	2.747083
26	2.063947
27	0.167067
31	0.481541
37	0.023734
38	0.025865
39	0.086768
42	0.359253
43	0.990445
44	0.029626

Table 1c: Mill Site, Post-RA Condition Watershed Areas

Watershed ID	Area (mi^2)
0	0.004857
1	0.002526
2	0.004111
3	0.007433
4	0.019797
5	0.046732
6	0.032685
7	0.013431
8	0.003734
12	0.013278
14	0.007294
16	0.006010
32	0.055148
33	0.288123
34	0.230045
35	0.256070
36	0.025987
37	0.023734
38	0.025865
39	0.086768
40	0.005180
41	0.025233
44	0.029626

Table 1d: Mine Site, RA-Phase 3 Construction Watershed Areas

Watershed ID	Area (mi^2)
2	0.001978
3	0.003633
19	0.081415
20	0.144731
22	0.010027
23	0.041932
24	0.008757
25	0.034857
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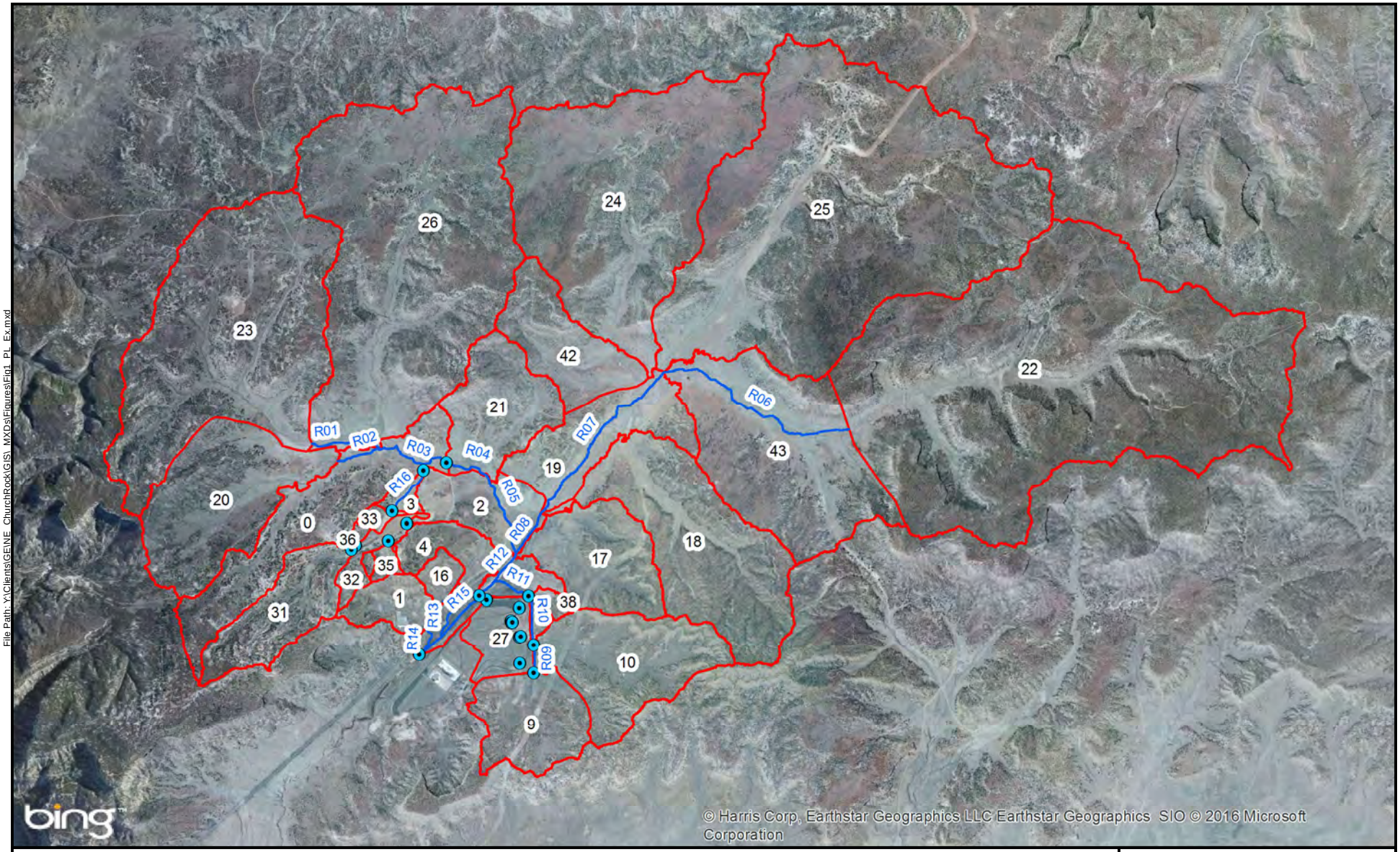
27	0.037482
28	0.010058
29	0.054403
30	0.026967



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Legend

- Peak Flow Point of Interest
- Reaches
- Watershed Boundaries

N
W E
S

0 2,500 5,000 10,000 Feet

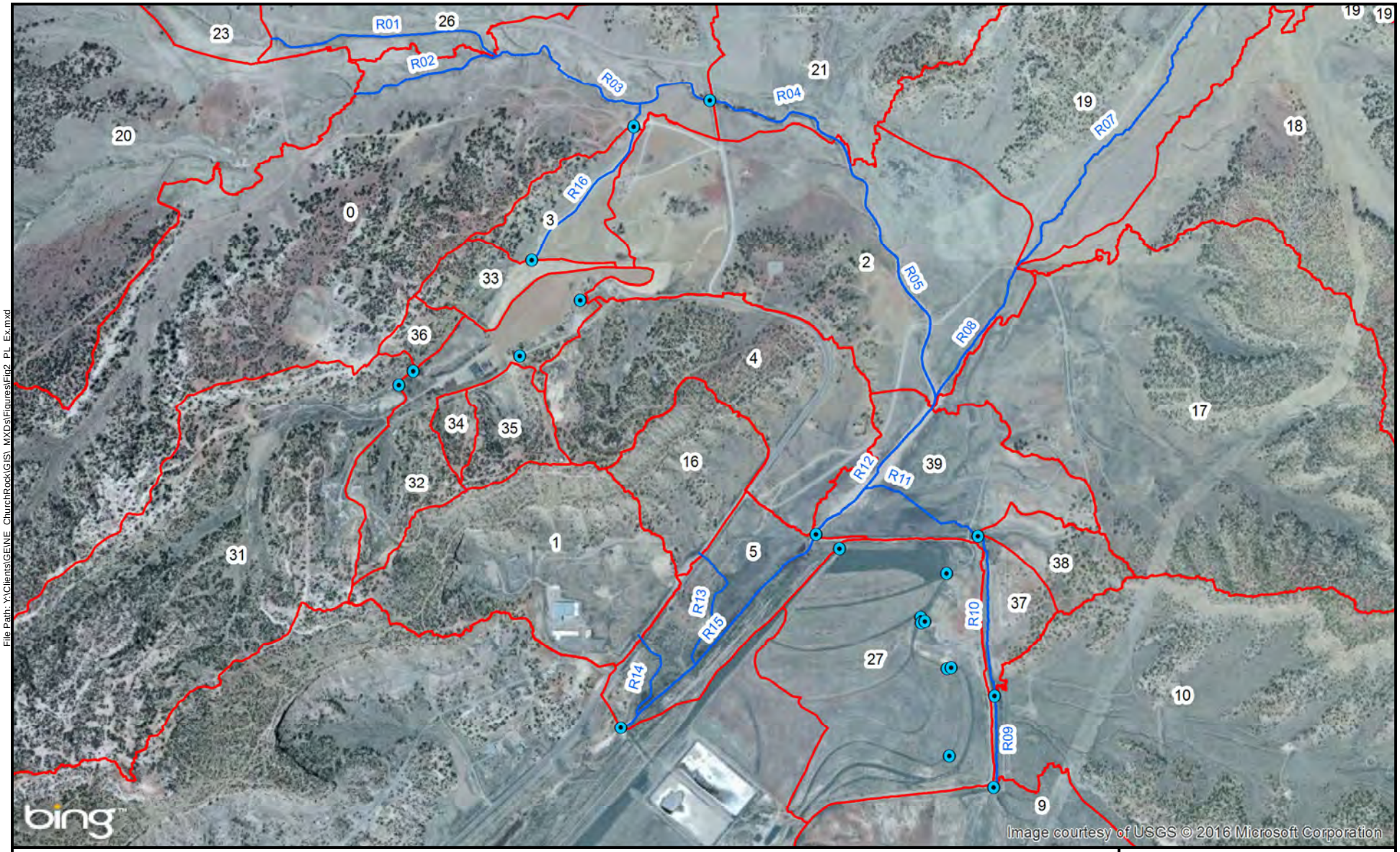
Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE I-1.1a:
Pipeline Arroyo
Existing Condition Catchments

Northeast Church Rock

Date Revised: 4/13/2016

MWH



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Legend

- Peak Flow Point of Interest
- Reaches
- Watershed Boundaries

N
W E
S

0 500 1,000 2,000 Feet

Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE I-1.1b:
Pipeline Arroyo
Existing Condition Catchments

Northeast Church Rock

Date Revised: 4/13/2016

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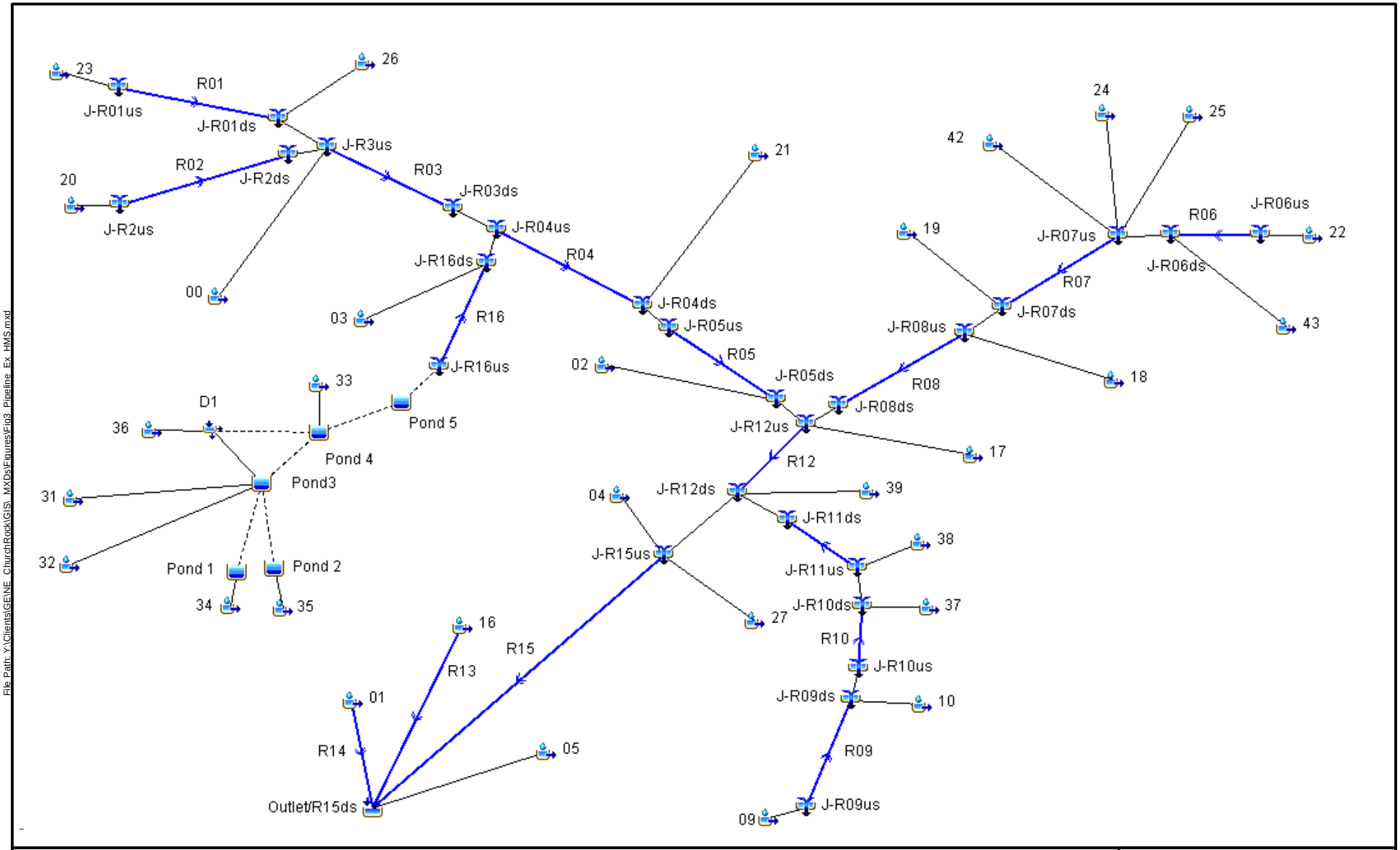

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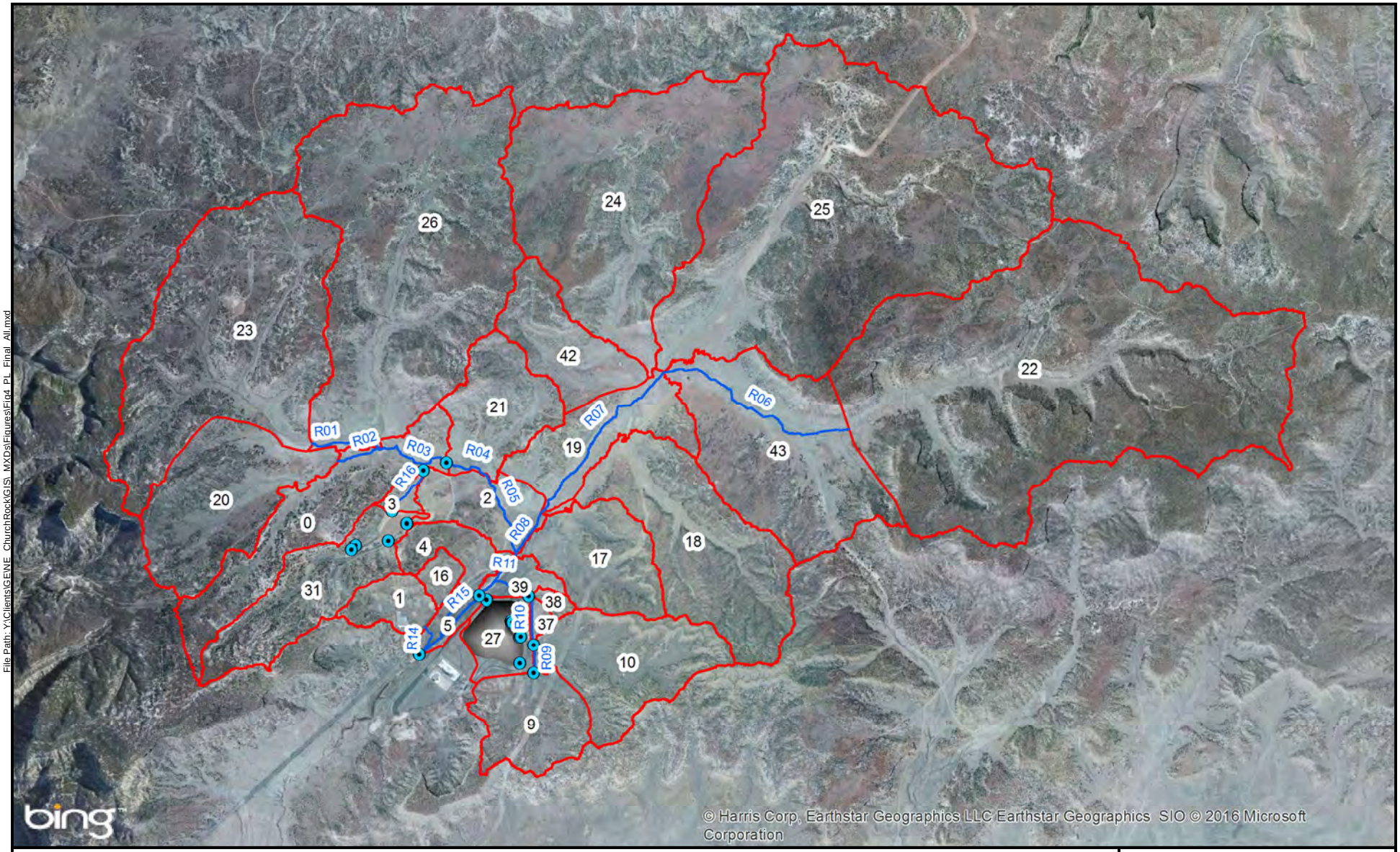
Legend

FIGURE I-1.1c:
Pipeline Arroyo Existing Condition HEC-HMS Model

Northeast Church Rock

Date Revised: 4/19/2016

MWH



Legend

- Peak Flow Point of Interest
- Reaches
- Watershed Boundaries

N
W E
S

0 2,500 5,000 10,000 Feet

Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE I-1.1d:
Pipeline Arroyo
Final Condition Catchments

Northeast Church Rock

Date Revised: 4/13/2016

MWH

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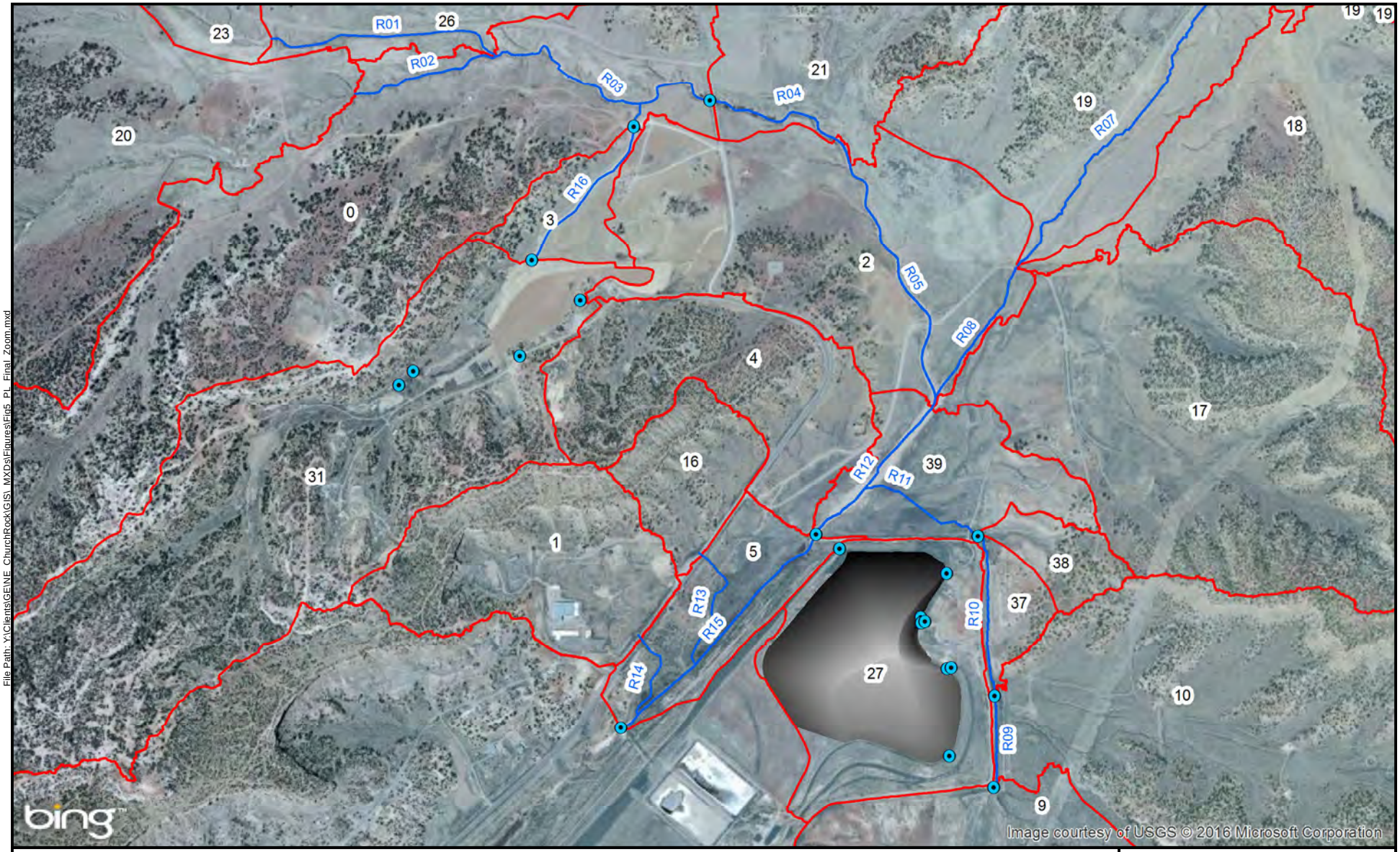

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Legend

- Peak Flow Point of Interest
- Reaches
- Watershed Boundaries

N
W E
S

0 500 1,000 2,000 Feet

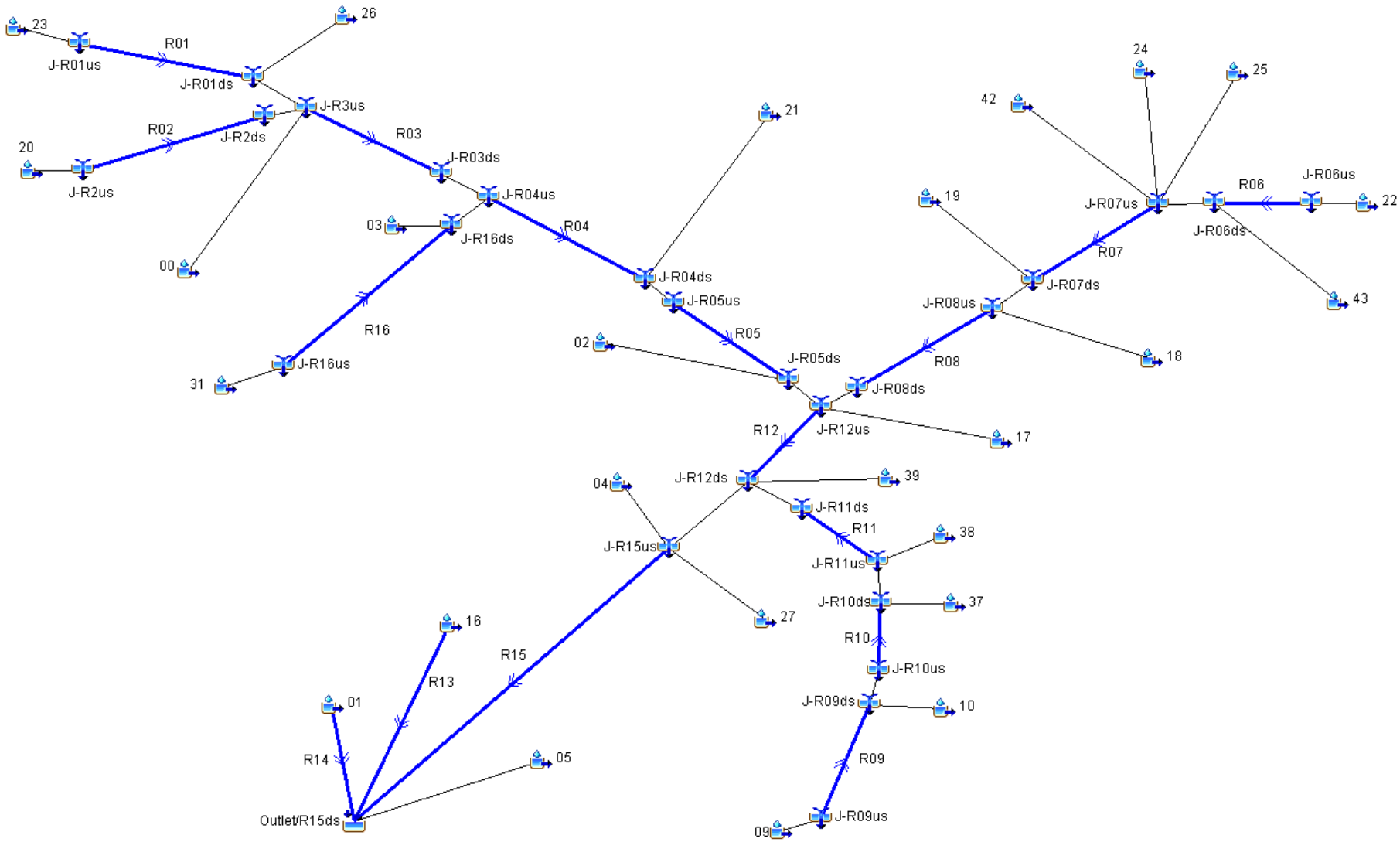
Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE I-1.1e:
Pipeline Arroyo
Final Condition Catchments

Northeast Church Rock

Date Revised: 4/13/2016

MWH



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Legend

FIGURE I-1.1f:
Pipeline Arroyo
Final Condition HEC-HMS Model

Northeast Church Rock

Date Revised: 4/13/2016

MWH

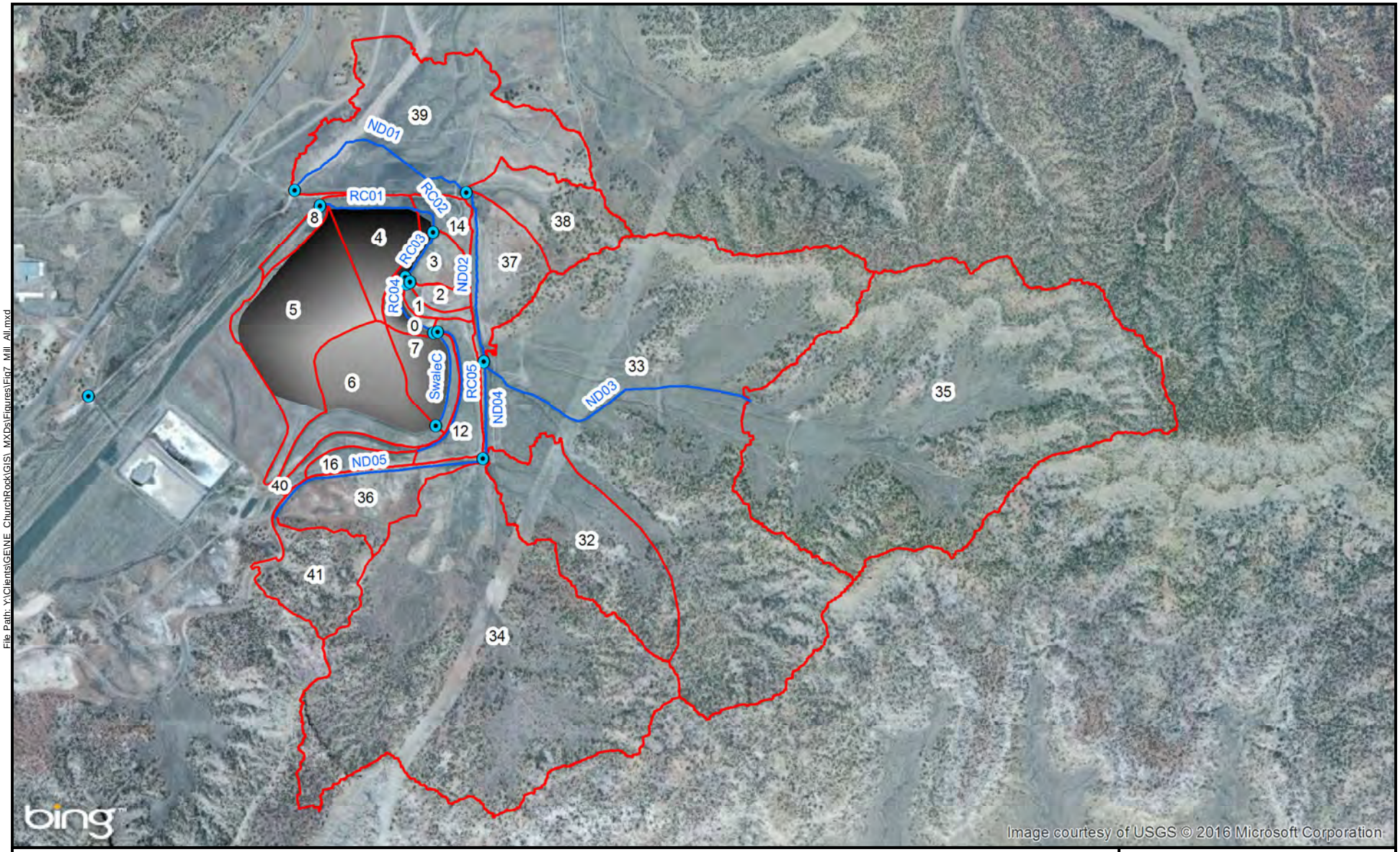

Image courtesy of USGS © 2016 Microsoft Corporation

Legend

- Peak Flow Point of Interest
- Reaches
- Watershed Boundaries

N
W E
S

0 500 1,000 2,000 Feet

Coordinate System:

FIGURE I-1.1g:
Mill Site
Final Condition Catchments

Northeast Church Rock

Date Revised: 4/14/2016

MWH

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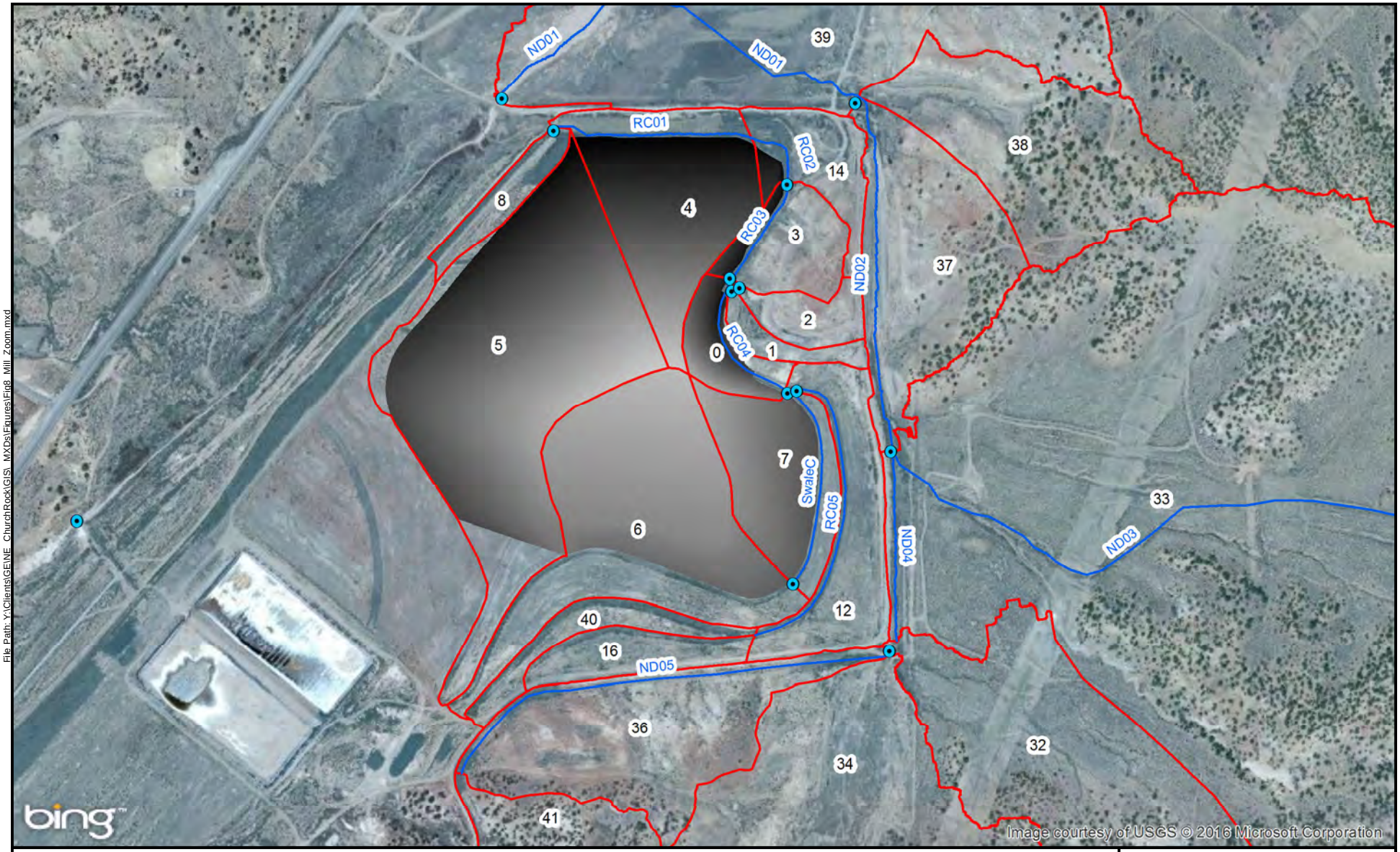

Legend

- Peak Flow Point of Interest
- Reaches
- Watershed Boundaries

N
W E
S

0 250 500 1,000 Feet

Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE I-1.1h:
Mill Site
Final Condition Catchments

Northeast Church Rock

Date Revised: 4/13/2016

MWH

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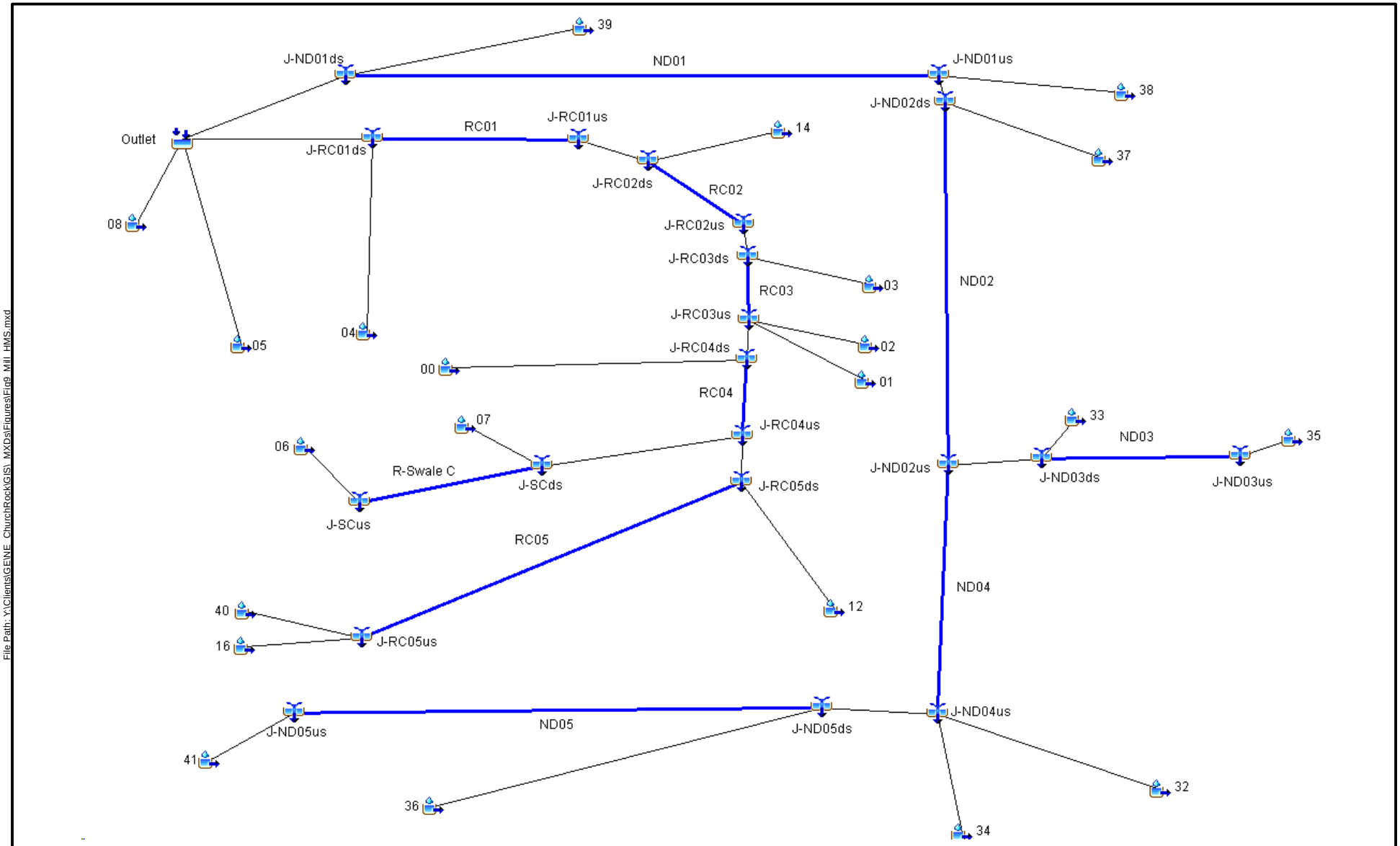

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Legend

FIGURE I-1.1i:

Mill Site Final Condition HEC-HMS Model

Northeast Church Rock

Date Revised: 4/14/2016

MWH

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Legend

- Peak Flow Point of Interest
- Reaches
- Watershed Boundaries

N
W E
S

0 500 1,000 2,000 Feet

Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE I-1.1j:
Mine Site Catchments
During Phase 3 Remediation

Northeast Church Rock

Date Revised: 4/13/2016

MWH

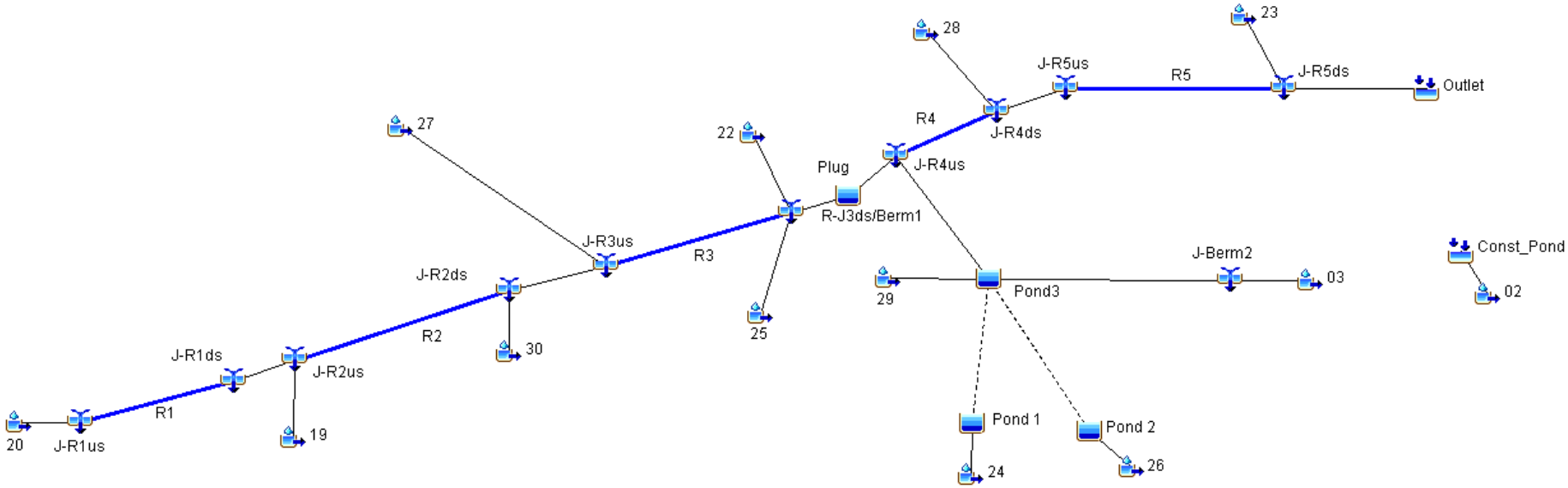

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FIGURE I-1.1k:

Mine Site HEC-HMS Model For Phase 3 Remediation

Northeast Church Rock

Date Revised: 4/14/2016

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ATTACHMENT B

STORM HYETOGRAPH TABLES

Table 2a: 1-hour PMP Hyetographs for Pipeline Arroyo and Mill Site

Storm Duration (Ending Timestep)	Incremental Depth (in)	Total Depth (in)	Incremental Depth (in)	Total Depth (in)
10	0.78	0.78	0.78	0.78
20	0.98	1.76	0.99	1.77
30	1.53	3.29	1.54	3.31
40	1.22	4.51	1.23	4.54
50	0.85	5.36	0.85	5.39
60	0.78	6.14	0.78	6.18

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0008	0.0017	0.0019	0.0008	0.0017	0.0019
10	0.0008	0.0017	0.0020	0.0016	0.0034	0.0039
15	0.0008	0.0017	0.0020	0.0024	0.0051	0.0059
20	0.0008	0.0017	0.0020	0.0032	0.0069	0.0079
25	0.0008	0.0017	0.0020	0.0040	0.0086	0.0099
30	0.0008	0.0018	0.0020	0.0049	0.0104	0.0119
35	0.0008	0.0018	0.0020	0.0057	0.0121	0.0139
40	0.0008	0.0018	0.0020	0.0065	0.0139	0.0159
45	0.0008	0.0018	0.0021	0.0074	0.0157	0.0180
50	0.0008	0.0018	0.0021	0.0082	0.0175	0.0201
55	0.0009	0.0018	0.0021	0.0091	0.0193	0.0221
60	0.0009	0.0018	0.0021	0.0099	0.0212	0.0242
65	0.0009	0.0018	0.0021	0.0108	0.0230	0.0264
70	0.0009	0.0019	0.0021	0.0117	0.0249	0.0285
75	0.0009	0.0019	0.0021	0.0125	0.0267	0.0306
80	0.0009	0.0019	0.0022	0.0134	0.0286	0.0328
85	0.0009	0.0019	0.0022	0.0143	0.0305	0.0349
90	0.0009	0.0019	0.0022	0.0152	0.0324	0.0371
95	0.0009	0.0019	0.0022	0.0161	0.0343	0.0393
100	0.0009	0.0019	0.0022	0.0170	0.0363	0.0416
105	0.0009	0.0020	0.0022	0.0179	0.0382	0.0438
110	0.0009	0.0020	0.0023	0.0188	0.0402	0.0460
115	0.0009	0.0020	0.0023	0.0197	0.0422	0.0483
120	0.0009	0.0020	0.0023	0.0207	0.0442	0.0506
125	0.0009	0.0020	0.0023	0.0216	0.0462	0.0529
130	0.0009	0.0020	0.0023	0.0226	0.0482	0.0552
135	0.0010	0.0020	0.0023	0.0235	0.0503	0.0576

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
140	0.0010	0.0021	0.0024	0.0245	0.0523	0.0599
145	0.0010	0.0021	0.0024	0.0254	0.0544	0.0623
150	0.0010	0.0021	0.0024	0.0264	0.0565	0.0647
155	0.0010	0.0021	0.0024	0.0274	0.0586	0.0671
160	0.0010	0.0021	0.0024	0.0284	0.0607	0.0696
165	0.0010	0.0021	0.0025	0.0294	0.0629	0.0720
170	0.0010	0.0022	0.0025	0.0304	0.0650	0.0745
175	0.0010	0.0022	0.0025	0.0314	0.0672	0.0770
180	0.0010	0.0022	0.0025	0.0324	0.0694	0.0795
185	0.0010	0.0022	0.0025	0.0334	0.0716	0.0821
190	0.0010	0.0022	0.0026	0.0345	0.0739	0.0846
195	0.0010	0.0023	0.0026	0.0355	0.0761	0.0872
200	0.0011	0.0023	0.0026	0.0366	0.0784	0.0898
205	0.0011	0.0023	0.0026	0.0376	0.0807	0.0925
210	0.0011	0.0023	0.0027	0.0387	0.0830	0.0951
215	0.0011	0.0023	0.0027	0.0398	0.0854	0.0978
220	0.0011	0.0024	0.0027	0.0409	0.0878	0.1005
225	0.0011	0.0024	0.0027	0.0420	0.0901	0.1032
230	0.0011	0.0024	0.0028	0.0431	0.0925	0.1060
235	0.0011	0.0024	0.0028	0.0442	0.0950	0.1088
240	0.0011	0.0025	0.0028	0.0453	0.0974	0.1116
245	0.0011	0.0025	0.0028	0.0465	0.0999	0.1144
250	0.0012	0.0025	0.0029	0.0476	0.1024	0.1173
255	0.0012	0.0025	0.0029	0.0488	0.1049	0.1202
260	0.0012	0.0026	0.0029	0.0499	0.1075	0.1231
265	0.0012	0.0026	0.0030	0.0511	0.1101	0.1261
270	0.0012	0.0026	0.0030	0.0523	0.1127	0.1291
275	0.0012	0.0026	0.0030	0.0535	0.1153	0.1321
280	0.0012	0.0027	0.0030	0.0548	0.1180	0.1351
285	0.0012	0.0027	0.0031	0.0560	0.1207	0.1382
290	0.0012	0.0027	0.0031	0.0572	0.1234	0.1413
295	0.0013	0.0027	0.0031	0.0585	0.1261	0.1445
300	0.0013	0.0028	0.0032	0.0598	0.1289	0.1476
305	0.0013	0.0028	0.0032	0.0610	0.1317	0.1509
310	0.0013	0.0028	0.0033	0.0623	0.1346	0.1541
315	0.0013	0.0029	0.0033	0.0636	0.1375	0.1574
320	0.0013	0.0029	0.0033	0.0650	0.1404	0.1607
325	0.0013	0.0029	0.0034	0.0663	0.1433	0.1641

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
330	0.0014	0.0030	0.0034	0.0677	0.1463	0.1675
335	0.0014	0.0030	0.0035	0.0690	0.1493	0.1710
340	0.0014	0.0031	0.0035	0.0704	0.1524	0.1745
345	0.0014	0.0031	0.0035	0.0718	0.1555	0.1780
350	0.0014	0.0031	0.0036	0.0732	0.1586	0.1816
355	0.0014	0.0032	0.0036	0.0747	0.1618	0.1852
360	0.0015	0.0032	0.0037	0.0761	0.1650	0.1889
365	0.0015	0.0033	0.0037	0.0776	0.1682	0.1926
370	0.0015	0.0033	0.0038	0.0791	0.1715	0.1964
375	0.0015	0.0033	0.0038	0.0806	0.1749	0.2002
380	0.0015	0.0034	0.0039	0.0821	0.1783	0.2041
385	0.0015	0.0034	0.0039	0.0837	0.1817	0.2081
390	0.0016	0.0035	0.0040	0.0853	0.1852	0.2121
395	0.0016	0.0035	0.0041	0.0868	0.1887	0.2161
400	0.0016	0.0036	0.0041	0.0885	0.1923	0.2202
405	0.0016	0.0036	0.0042	0.0901	0.1960	0.2244
410	0.0017	0.0037	0.0042	0.0918	0.1997	0.2286
415	0.0017	0.0038	0.0043	0.0934	0.2034	0.2329
420	0.0017	0.0038	0.0044	0.0952	0.2073	0.2373
425	0.0017	0.0039	0.0044	0.0969	0.2111	0.2417
430	0.0018	0.0039	0.0045	0.0986	0.2151	0.2463
435	0.0018	0.0040	0.0046	0.1004	0.2191	0.2509
440	0.0018	0.0041	0.0047	0.1023	0.2232	0.2555
445	0.0018	0.0042	0.0047	0.1041	0.2273	0.2603
450	0.0019	0.0042	0.0048	0.1060	0.2315	0.2651
455	0.0019	0.0043	0.0049	0.1079	0.2358	0.2700
460	0.0019	0.0044	0.0050	0.1098	0.2402	0.2750
465	0.0020	0.0045	0.0051	0.1118	0.2447	0.2801
470	0.0020	0.0045	0.0052	0.1138	0.2492	0.2853
475	0.0020	0.0046	0.0053	0.1159	0.2539	0.2906
480	0.0021	0.0047	0.0054	0.1179	0.2586	0.2961
485	0.0021	0.0048	0.0055	0.1201	0.2634	0.3016
490	0.0022	0.0049	0.0056	0.1222	0.2683	0.3072
495	0.0022	0.0050	0.0058	0.1244	0.2734	0.3130
500	0.0023	0.0051	0.0059	0.1267	0.2785	0.3189
505	0.0023	0.0053	0.0060	0.1290	0.2838	0.3249
510	0.0023	0.0054	0.0062	0.1313	0.2892	0.3310
515	0.0024	0.0055	0.0063	0.1337	0.2947	0.3373

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
520	0.0025	0.0056	0.0065	0.1362	0.3003	0.3438
525	0.0025	0.0058	0.0066	0.1387	0.3061	0.3504
530	0.0026	0.0059	0.0068	0.1413	0.3120	0.3572
535	0.0026	0.0061	0.0070	0.1439	0.3181	0.3642
540	0.0027	0.0063	0.0072	0.1466	0.3244	0.3713
545	0.0028	0.0064	0.0074	0.1494	0.3308	0.3787
550	0.0028	0.0066	0.0076	0.1522	0.3374	0.3862
555	0.0029	0.0068	0.0078	0.1552	0.3442	0.3940
560	0.0030	0.0070	0.0080	0.1582	0.3513	0.4021
565	0.0031	0.0072	0.0083	0.1613	0.3585	0.4103
570	0.0032	0.0075	0.0086	0.1644	0.3660	0.4189
575	0.0033	0.0077	0.0088	0.1677	0.3737	0.4277
580	0.0034	0.0080	0.0092	0.1711	0.3818	0.4369
585	0.0035	0.0083	0.0095	0.1746	0.3901	0.4464
590	0.0036	0.0086	0.0099	0.1783	0.3987	0.4563
595	0.0038	0.0090	0.0103	0.1820	0.4077	0.4665
600	0.0039	0.0093	0.0107	0.1859	0.4170	0.4772
605	0.0041	0.0098	0.0111	0.1900	0.4268	0.4884
610	0.0042	0.0102	0.0117	0.1942	0.4370	0.5000
615	0.0044	0.0107	0.0122	0.1987	0.4477	0.5122
620	0.0046	0.0112	0.0128	0.2033	0.4589	0.5250
625	0.0048	0.0118	0.0135	0.2081	0.4707	0.5386
630	0.0051	0.0125	0.0143	0.2132	0.4832	0.5528
635	0.0054	0.0132	0.0151	0.2186	0.4964	0.5679
640	0.0057	0.0141	0.0161	0.2243	0.5105	0.5840
645	0.0060	0.0150	0.0172	0.2303	0.5255	0.6012
650	0.0064	0.0161	0.0184	0.2367	0.5416	0.6195
655	0.0069	0.0174	0.0198	0.2436	0.5590	0.6394
660	0.0074	0.0188	0.0215	0.2511	0.5778	0.6609
665	0.0080	0.0206	0.0235	0.2591	0.5984	0.6844
670	0.0088	0.0227	0.0259	0.2679	0.6211	0.7103
675	0.0097	0.0252	0.0288	0.2776	0.6464	0.7391
680	0.0108	0.0284	0.0324	0.2884	0.6748	0.7715
685	0.0122	0.0325	0.0370	0.3005	0.7072	0.8085
690	0.0140	0.0378	0.0431	0.3145	0.7451	0.8516
695	0.0165	0.0451	0.0514	0.3310	0.7902	0.9030
700	0.0199	0.0556	0.0633	0.3509	0.8458	0.9663
705	0.0253	0.0718	0.0818	0.3762	0.9176	1.0481

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
710	0.0343	0.0997	0.1133	0.4104	1.0173	1.1614
715	0.0525	0.1564	0.1776	0.4629	1.1738	1.3390
720	0.1061	0.3205	0.3632	0.5690	1.4943	1.7022
725	0.2092	0.6080	0.6875	0.7782	2.1023	2.3897
730	0.0706	0.2127	0.2413	0.8488	2.3151	2.6310
735	0.0415	0.1223	0.1390	0.8904	2.4374	2.7700
740	0.0291	0.0837	0.0952	0.9195	2.5211	2.8652
745	0.0223	0.0628	0.0714	0.9417	2.5839	2.9367
750	0.0180	0.0498	0.0568	0.9598	2.6337	2.9935
755	0.0151	0.0412	0.0469	0.9749	2.6749	3.0403
760	0.0130	0.0349	0.0398	0.9879	2.7098	3.0802
765	0.0114	0.0303	0.0346	0.9994	2.7401	3.1148
770	0.0102	0.0267	0.0305	1.0096	2.7669	3.1453
775	0.0092	0.0239	0.0273	1.0188	2.7908	3.1725
780	0.0084	0.0216	0.0246	1.0272	2.8123	3.1972
785	0.0077	0.0197	0.0225	1.0349	2.8320	3.2196
790	0.0071	0.0181	0.0206	1.0421	2.8501	3.2403
795	0.0067	0.0167	0.0191	1.0487	2.8668	3.2593
800	0.0062	0.0155	0.0178	1.0549	2.8824	3.2771
805	0.0059	0.0145	0.0166	1.0608	2.8969	3.2937
810	0.0055	0.0136	0.0156	1.0663	2.9105	3.3093
815	0.0052	0.0128	0.0147	1.0715	2.9234	3.3239
820	0.0050	0.0121	0.0139	1.0765	2.9355	3.3378
825	0.0047	0.0115	0.0132	1.0812	2.9470	3.3400
830	0.0045	0.0109	0.0125	1.0858	2.9580	3.3400
835	0.0043	0.0104	0.0119	1.0901	2.9684	3.3400
840	0.0041	0.0100	0.0114	1.0942	2.9784	3.3400
845	0.0040	0.0095	0.0109	1.0982	2.9879	3.3400
850	0.0038	0.0092	0.0105	1.1021	2.9900	3.3400
855	0.0037	0.0088	0.0101	1.1058	2.9900	3.3400
860	0.0036	0.0085	0.0097	1.1093	2.9900	3.3400
865	0.0035	0.0082	0.0093	1.1128	2.9900	3.3400
870	0.0033	0.0079	0.0090	1.1161	2.9900	3.3400
875	0.0032	0.0076	0.0087	1.1194	2.9900	3.3400
880	0.0031	0.0074	0.0084	1.1225	2.9900	3.3400
885	0.0030	0.0071	0.0082	1.1255	2.9900	3.3400
890	0.0030	0.0069	0.0079	1.1285	2.9900	3.3400
895	0.0029	0.0067	0.0077	1.1314	2.9900	3.3400

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
900	0.0028	0.0065	0.0075	1.1342	2.9900	3.3400
905	0.0027	0.0063	0.0073	1.1369	2.9900	3.3400
910	0.0027	0.0062	0.0071	1.1396	2.9900	3.3400
915	0.0026	0.0060	0.0069	1.1422	2.9900	3.3400
920	0.0025	0.0059	0.0067	1.1447	2.9900	3.3400
925	0.0025	0.0057	0.0065	1.1472	2.9900	3.3400
930	0.0024	0.0056	0.0064	1.1497	2.9900	3.3400
935	0.0024	0.0054	0.0062	1.1520	2.9900	3.3400
940	0.0023	0.0053	0.0061	1.1544	2.9900	3.3400
945	0.0023	0.0052	0.0060	1.1566	2.9900	3.3400
950	0.0022	0.0051	0.0058	1.1589	2.9900	3.3400
955	0.0022	0.0050	0.0057	1.1610	2.9900	3.3400
960	0.0021	0.0049	0.0056	1.1632	2.9900	3.3400
965	0.0021	0.0048	0.0055	1.1653	2.9900	3.3400
970	0.0021	0.0047	0.0054	1.1674	2.9900	3.3400
975	0.0020	0.0046	0.0053	1.1694	2.9900	3.3400
980	0.0020	0.0045	0.0052	1.1700	2.9900	3.3400
985	0.0020	0.0044	0.0051	1.1700	2.9900	3.3400
990	0.0019	0.0043	0.0050	1.1700	2.9900	3.3400
995	0.0019	0.0043	0.0049	1.1700	2.9900	3.3400
1000	0.0019	0.0042	0.0048	1.1700	2.9900	3.3400
1005	0.0018	0.0041	0.0047	1.1700	2.9900	3.3400
1010	0.0018	0.0040	0.0046	1.1700	2.9900	3.3400
1015	0.0018	0.0040	0.0046	1.1700	2.9900	3.3400
1020	0.0017	0.0039	0.0045	1.1700	2.9900	3.3400
1025	0.0017	0.0038	0.0044	1.1700	2.9900	3.3400
1030	0.0017	0.0038	0.0043	1.1700	2.9900	3.3400
1035	0.0017	0.0037	0.0043	1.1700	2.9900	3.3400
1040	0.0016	0.0037	0.0042	1.1700	2.9900	3.3400
1045	0.0016	0.0036	0.0041	1.1700	2.9900	3.3400
1050	0.0016	0.0036	0.0041	1.1700	2.9900	3.3400
1055	0.0016	0.0035	0.0040	1.1700	2.9900	3.3400
1060	0.0016	0.0035	0.0040	1.1700	2.9900	3.3400
1065	0.0015	0.0034	0.0039	1.1700	2.9900	3.3400
1070	0.0015	0.0034	0.0039	1.1700	2.9900	3.3400
1075	0.0015	0.0033	0.0038	1.1700	2.9900	3.3400
1080	0.0015	0.0033	0.0038	1.1700	2.9900	3.3400
1085	0.0015	0.0032	0.0037	1.1700	2.9900	3.3400

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
1090	0.0014	0.0032	0.0037	1.1700	2.9900	3.3400
1095	0.0014	0.0032	0.0036	1.1700	2.9900	3.3400
1100	0.0014	0.0031	0.0036	1.1700	2.9900	3.3400
1105	0.0014	0.0031	0.0035	1.1700	2.9900	3.3400
1110	0.0014	0.0030	0.0035	1.1700	2.9900	3.3400
1115	0.0014	0.0030	0.0034	1.1700	2.9900	3.3400
1120	0.0013	0.0030	0.0034	1.1700	2.9900	3.3400
1125	0.0013	0.0029	0.0034	1.1700	2.9900	3.3400
1130	0.0013	0.0029	0.0033	1.1700	2.9900	3.3400
1135	0.0013	0.0029	0.0033	1.1700	2.9900	3.3400
1140	0.0013	0.0028	0.0032	1.1700	2.9900	3.3400
1145	0.0013	0.0028	0.0032	1.1700	2.9900	3.3400
1150	0.0013	0.0028	0.0032	1.1700	2.9900	3.3400
1155	0.0013	0.0027	0.0031	1.1700	2.9900	3.3400
1160	0.0012	0.0027	0.0031	1.1700	2.9900	3.3400
1165	0.0012	0.0027	0.0031	1.1700	2.9900	3.3400
1170	0.0012	0.0026	0.0030	1.1700	2.9900	3.3400
1175	0.0012	0.0026	0.0030	1.1700	2.9900	3.3400
1180	0.0012	0.0026	0.0030	1.1700	2.9900	3.3400
1185	0.0012	0.0026	0.0029	1.1700	2.9900	3.3400
1190	0.0012	0.0025	0.0029	1.1700	2.9900	3.3400
1195	0.0012	0.0025	0.0029	1.1700	2.9900	3.3400
1200	0.0011	0.0025	0.0029	1.1700	2.9900	3.3400
1205	0.0011	0.0025	0.0028	1.1700	2.9900	3.3400
1210	0.0011	0.0024	0.0028	1.1700	2.9900	3.3400
1215	0.0011	0.0024	0.0028	1.1700	2.9900	3.3400
1220	0.0011	0.0024	0.0027	1.1700	2.9900	3.3400
1225	0.0011	0.0024	0.0027	1.1700	2.9900	3.3400
1230	0.0011	0.0024	0.0027	1.1700	2.9900	3.3400
1235	0.0011	0.0023	0.0027	1.1700	2.9900	3.3400
1240	0.0011	0.0023	0.0026	1.1700	2.9900	3.3400
1245	0.0011	0.0023	0.0026	1.1700	2.9900	3.3400
1250	0.0010	0.0023	0.0026	1.1700	2.9900	3.3400
1255	0.0010	0.0022	0.0026	1.1700	2.9900	3.3400
1260	0.0010	0.0022	0.0026	1.1700	2.9900	3.3400
1265	0.0010	0.0022	0.0025	1.1700	2.9900	3.3400
1270	0.0010	0.0022	0.0025	1.1700	2.9900	3.3400
1275	0.0010	0.0022	0.0025	1.1700	2.9900	3.3400

Table 2b: Incremental and Cumulative Hyetographs for 2-year, 100-year, and 200-year Storms

Time (Minutes)	Incremental Storm Depths (inches)			Cumulative Storm Depths (inches)		
	2-Year	100-Year	200-Year	2-Year	100-Year	200-Year
1280	0.0010	0.0022	0.0025	1.1700	2.9900	3.3400
1285	0.0010	0.0021	0.0024	1.1700	2.9900	3.3400
1290	0.0010	0.0021	0.0024	1.1700	2.9900	3.3400
1295	0.0010	0.0021	0.0024	1.1700	2.9900	3.3400
1300	0.0010	0.0021	0.0024	1.1700	2.9900	3.3400
1305	0.0010	0.0021	0.0024	1.1700	2.9900	3.3400
1310	0.0010	0.0021	0.0024	1.1700	2.9900	3.3400
1315	0.0009	0.0020	0.0023	1.1700	2.9900	3.3400
1320	0.0009	0.0020	0.0023	1.1700	2.9900	3.3400
1325	0.0009	0.0020	0.0023	1.1700	2.9900	3.3400
1330	0.0009	0.0020	0.0023	1.1700	2.9900	3.3400
1335	0.0009	0.0020	0.0023	1.1700	2.9900	3.3400
1340	0.0009	0.0020	0.0022	1.1700	2.9900	3.3400
1345	0.0009	0.0019	0.0022	1.1700	2.9900	3.3400
1350	0.0009	0.0019	0.0022	1.1700	2.9900	3.3400
1355	0.0009	0.0019	0.0022	1.1700	2.9900	3.3400
1360	0.0009	0.0019	0.0022	1.1700	2.9900	3.3400
1365	0.0009	0.0019	0.0022	1.1700	2.9900	3.3400
1370	0.0009	0.0019	0.0021	1.1700	2.9900	3.3400
1375	0.0009	0.0019	0.0021	1.1700	2.9900	3.3400
1380	0.0009	0.0018	0.0021	1.1700	2.9900	3.3400
1385	0.0009	0.0018	0.0021	1.1700	2.9900	3.3400
1390	0.0009	0.0018	0.0021	1.1700	2.9900	3.3400
1395	0.0008	0.0018	0.0021	1.1700	2.9900	3.3400
1400	0.0008	0.0018	0.0021	1.1700	2.9900	3.3400
1405	0.0008	0.0018	0.0020	1.1700	2.9900	3.3400
1410	0.0008	0.0018	0.0020	1.1700	2.9900	3.3400
1415	0.0008	0.0018	0.0020	1.1700	2.9900	3.3400
1420	0.0008	0.0018	0.0020	1.1700	2.9900	3.3400
1425	0.0008	0.0017	0.0020	1.1700	2.9900	3.3400
1430	0.0008	0.0017	0.0020	1.1700	2.9900	3.3400
1435	0.0008	0.0017	0.0020	1.1700	2.9900	3.3400
1440	0.0008	0.0017	0.0020	1.1700	2.9900	3.3400

ATTACHMENT C

GREEN-AMPT RAINFALL LOSS INPUT PARAMETERS

Table 3a: Pipeline Arroyo, Existing Condition Rainfall Loss Parameters

Watershed ID	Depression Storage		Green And Ampt Losses				
	Initial Storage (%)	Max Storage (in)	Initial Content	Saturated Content	Suction (in)	Conductivity (in/hr)	Impervious (%)
00	0	0.15	0.241	0.5	3.184	0.779	0.0
01	0	0.15	0.250	0.5	3.845	0.411	0.0
02	0	0.15	0.222	0.5	2.852	0.832	0.0
03	0	0.15	0.222	0.5	2.855	0.832	0.0
04	0	0.15	0.243	0.5	3.319	0.666	0.0
05	0	0.15	0.242	0.5	3.295	0.551	0.0
09	0	0.15	0.240	0.5	3.198	0.849	0.0
10	0	0.15	0.250	0.5	3.456	0.574	0.0
16	0	0.15	0.250	0.5	3.756	0.429	0.0
17	0	0.15	0.232	0.5	2.950	0.947	0.0
18	0	0.15	0.241	0.5	3.195	0.851	0.0
19	0	0.15	0.234	0.5	3.022	0.726	0.0
20	0	0.15	0.243	0.5	3.338	0.668	0.0
21	0	0.15	0.250	0.5	3.798	0.457	0.0
22	0	0.15	0.235	0.5	3.047	1.179	0.0
23	0	0.15	0.250	0.5	3.692	0.549	0.0
24	0	0.15	0.250	0.5	3.435	0.666	0.0
25	0	0.15	0.241	0.5	3.211	0.797	0.0
26	0	0.15	0.250	0.5	3.643	0.592	0.0
27	0	0.05	0.250	0.5	4.626	0.289	0.0
31	0	0.15	0.244	0.5	3.457	0.678	0.0
32	0	0.15	0.250	0.5	3.475	0.589	0.0
33	0	0.15	0.250	0.5	3.600	0.460	0.0
34	0	0.15	0.241	0.5	3.141	0.917	0.0
35	0	0.15	0.238	0.5	3.078	0.948	0.0
36	0	0.15	0.250	0.5	3.600	0.460	0.0
37	0	0.15	0.250	0.5	3.550	0.470	0.0
38	0	0.15	0.250	0.5	3.430	0.603	0.0
39	0	0.15	0.217	0.5	2.591	0.954	0.0
42	0	0.15	0.241	0.5	3.169	0.660	0.0
43	0	0.15	0.236	0.5	2.958	0.885	0.0
44	0	0.05	0.25	0.5	4.956	0.257	0.0

Table 3b: Pipeline Arroyo, Post-RA Condition Rainfall Loss Parameters

Watershed ID	Depression Storage		Green And Ampt Losses				
	Initial Storage (%)	Max Storage (in)	Initial Content	Saturated Content	Suction (in)	Conductivity (in/hr)	Impervious (%)
00	0	0.15	0.241	0.500	3.180	0.779	0.0
01	0	0.15	0.250	0.500	3.845	0.411	0.0
02	0	0.15	0.222	0.500	2.859	0.832	0.0
03	0	0.15	0.222	0.500	2.859	0.608	0.0
04	0	0.15	0.243	0.500	3.319	0.666	0.0
05	0	0.15	0.242	0.500	3.295	0.551	0.0
09	0	0.15	0.240	0.500	3.198	0.849	0.0
10	0	0.15	0.250	0.500	3.456	0.574	0.0
16	0	0.15	0.250	0.500	3.756	0.429	0.0
17	0	0.15	0.232	0.500	2.950	0.947	0.0
18	0	0.15	0.241	0.500	3.195	0.851	0.0
19	0	0.15	0.234	0.500	3.022	0.726	0.0
20	0	0.15	0.243	0.500	3.338	0.668	0.0
21	0	0.15	0.250	0.500	3.798	0.457	0.0
22	0	0.15	0.235	0.500	3.047	1.179	0.0
23	0	0.15	0.250	0.500	3.692	0.549	0.0
24	0	0.15	0.250	0.500	3.435	0.666	0.0
25	0	0.15	0.241	0.500	3.211	0.797	0.0
26	0	0.15	0.250	0.500	3.643	0.592	0.0
27	0	0.05	0.250	0.500	4.626	0.288	0.0
31	0	0.15	0.244	0.500	3.457	0.661	0.0
37	0	0.15	0.250	0.500	3.550	0.470	0.0
38	0	0.15	0.250	0.500	3.430	0.603	0.0
39	0	0.15	0.217	0.500	2.591	0.954	0.0
42	0	0.15	0.241	0.500	3.169	0.660	0.0
43	0	0.15	0.236	0.500	2.958	0.885	0.0
44	0	0.05	0.25	0.5	4.956	0.257	0.0

Table 3c: Mill Site, Post-RA Condition Rainfall Loss Parameters

Watershed ID	Depression Storage		Green And Ampt Losses				
	Initial Storage (%)	Max Storage (in)	Initial Content	Saturated Content	Suction (in)	Conductivity (in/hr)	Impervious (%)
00	0	0.05	0.250	0.5	4.659	0.286	0.0
01	0	0.05	0.250	0.5	3.645	0.526	0.0
02	0	0.05	0.250	0.5	3.607	0.535	0.0
03	0	0.05	0.250	0.5	3.763	0.443	0.0
04	0	0.05	0.250	0.5	4.672	0.285	0.0
05	0	0.05	0.250	0.5	4.956	0.257	0.0
06	0	0.05	0.250	0.5	4.951	0.258	0.0
07	4	0.05	0.250	0.5	4.960	0.257	0.0
08	0	0.05	0.250	0.5	4.960	0.257	0.0
12	0	0.05	0.250	0.5	4.764	0.297	0.0
14	0	0.05	0.250	0.5	3.846	0.479	0.0
16	0	0.05	0.250	0.5	4.745	0.300	0.0
32	0	0.15	0.217	0.5	2.783	1.226	0.0
33	0	0.15	0.243	0.5	3.316	0.520	0.0
34	0	0.15	0.241	0.5	3.171	0.858	0.0
35	0	0.15	0.250	0.5	3.742	0.514	0.0
36	0	0.15	0.250	0.5	3.600	0.460	0.0
37	0	0.15	0.250	0.5	3.550	0.470	0.0
38	0	0.15	0.250	0.5	3.430	0.602	0.0
39	0	0.15	0.217	0.5	2.591	0.954	0.0
40	0	0.05	0.250	0.5	4.814	0.271	0.0
41	0	0.15	0.250	0.5	3.600	0.675	0.0
44	0	0.05	0.25	0.5	4.956	0.257	0.0

Table 3d: Mine Site, RA-Phase 3 Construction Rainfall Loss Parameters

Watershed ID	Depression Storage		Green And Ampt Losses				
	Initial Storage (%)	Max Storage (in)	Initial Content	Saturated Content	Suction (in)	Conductivity (in/hr)	Impervious (%)
02	0	0.1	0.250	0.5	3.600	0.460	0.0
03	0	0.1	0.250	0.5	3.600	0.460	0.0
19	0	0.15	0.242	0.5	3.296	0.724	0.0
20	0	0.15	0.244	0.5	3.381	0.792	0.0
22	0	0.1	0.250	0.5	3.600	0.460	0.0
23	0	0.1	0.250	0.5	3.600	0.460	0.0
24	0	0.1	0.241	0.5	3.141	0.590	0.0
25	0	0.1	0.250	0.5	3.600	0.460	0.0
26	0	0.1	0.238	0.5	3.078	0.641	0.0
27	0	0.15	0.250	0.5	3.600	0.476	0.0
28	0	0.1	0.250	0.5	3.600	0.460	0.0
29	0	0.1	0.250	0.5	3.418	0.583	0.0
30	0	0.1	0.250	0.5	3.600	0.460	0.0

ATTACHMENT D

CLARK UNIT HYDROGRAPH PARAMETERS CALCULATION TABLES

Table 4a: Pipeline Arroyo, Existing Condition Clark Unit Hydrograph Parameters

Storm	PMP		200-yr and 100-yr, 24hr		2yr, 24hr	
Watershed ID	Tc (hours)	R (hours)	Tc (hours)	R (hours)	Tc (hours)	R (hours)
00	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066
01	0.19617	0.14010	0.21983	0.15898	0.88374	0.74480
02	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152
03	0.20136	0.20203	0.21343	0.21551	0.99905	1.19550
04	0.36387	0.41842	0.44529	0.52354	1.59136	2.15240
05	0.38238	0.34741	0.46326	0.42987	1.51737	1.60430
09	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191
10	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827
16	0.22965	0.19170	0.27922	0.23815	1.14302	1.13835
17	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071
18	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130
19	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100
20	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624
21	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254
22	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134
23	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285
24	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051
25	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462
26	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956
27	0.84478	0.91807	1.05949	1.18046	2.16887	2.61463
31	0.69014	0.59450	0.69014	0.59450	0.69014	0.59450
32	0.20219	0.15177	0.25464	0.19606	1.33072	1.22898
33	0.09305	0.06467	0.10180	0.07145	0.26960	0.21062
34	0.06529	0.05737	0.07467	0.06658	0.18123	0.17816
35	0.06654	0.03464	0.07292	0.03834	0.18023	0.10469
36	0.10349	0.10939	0.11440	0.12226	0.19878	0.22576
37	0.25911	0.32624	0.30594	0.39231	0.66111	0.92272
38	0.23437	0.25095	0.23437	0.25095	0.23437	0.25095
39	0.43968	0.40768	0.54908	0.52172	1.47332	1.56046
42	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318
43	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524
44	0.32165	0.24868	0.35795	0.28002	0.51421	0.41861

Table 4b: Pipeline Arroyo, Post-RA Condition Clark Unit Hydrograph Parameters

Storm	PMP		200-yr and 100-yr, 24hr		2-yr, 24hr	
Watershed ID	Tc (hours)	R (hours)	Tc (hours)	R (hours)	Tc (hours)	R (hours)
00	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066
01	0.19626	0.14017	0.21983	0.15898	0.88412	0.74516
02	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152
03	0.20127	0.20193	0.25984	0.26812	0.99942	1.19597
04	0.36465	0.41942	0.44529	0.52354	1.59024	2.15073
05	0.38303	0.34807	0.46326	0.42987	1.51706	1.60393
09	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191
10	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827
16	0.23022	0.19222	0.27922	0.23815	1.14351	1.13889
17	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071
18	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130
19	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100
20	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624
21	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254
22	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134
23	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285
24	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051
25	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462
26	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956
27	0.84292	0.90095	1.05090	1.15082	2.12887	2.51954
31	0.81504	0.69580	0.81504	0.69580	0.81504	0.69580
37	0.25936	0.32659	0.30594	0.39231	0.66113	0.92274
38	0.23437	0.25095	0.23437	0.25095	0.23437	0.25095
39	0.44047	0.40850	0.54908	0.52172	1.47315	1.56025
42	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318
43	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524
44	0.30212	0.18608	0.32974	0.2050	0.44085	0.28305

Table 4c: Mill Site, Post-RA Condition Clark Unit Hydrograph Parameters

Storm	PMP		200-yr and 100-yr, 24hr		2-yr, 24hr	
Watershed ID	Tc (hours)	R (hours)	Tc (hours)	R (hours)	Tc (hours)	R (hours)
00	0.11580	0.14210	0.14252	0.17893	0.33427	0.46094
01	0.14949	0.32630	0.21043	0.47691	0.86218	2.28198
02	0.16181	0.29308	0.20448	0.38003	0.56863	1.18266
03	0.12637	0.12448	0.14717	0.14742	0.27881	0.29960
04	0.33112	0.38434	0.36446	0.42752	0.52367	0.63927
05	0.23305	0.26540	0.31125	0.36592	0.86580	1.13912
06	0.33670	0.47863	0.50306	0.74740	1.70246	2.89234
07	0.17353	0.11154	0.19358	0.12593	0.28992	0.19717
08	0.22578	0.28952	0.29626	0.39142	0.64714	0.93176
12	0.30665	0.47645	0.43379	0.70022	1.40237	2.57552
14	0.17183	0.28441	0.19754	0.33201	0.34607	0.61866
16	0.17705	0.28640	0.23662	0.39518	0.69759	1.31219
32	0.32368	0.32666	0.32368	0.32666	0.32368	0.32666
33	0.49875	0.28830	0.49875	0.28830	0.49875	0.28830
34	0.49783	0.33100	0.49783	0.33100	0.49783	0.33100
35	0.44462	0.27039	0.44462	0.27039	0.44462	0.27039
36	0.31159	0.42326	0.42176	0.59232	1.19005	1.87331
37	0.26309	0.34385	0.33083	0.44342	0.82964	1.23032
38	0.23427	0.25036	0.23427	0.25036	0.23427	0.25036
39	0.48753	0.47121	0.68022	0.68198	2.28225	2.61406
40	0.29878	0.72999	0.46881	1.20357	1.66527	4.91492
41	0.22193	0.19497	0.26133	0.23376	0.62617	0.61660
44	0.31812	0.19705	0.35266	0.22093	0.49939	0.32506

Table 4d: Mine Site, RA-Phase 3 Construction Clark Unit Hydrograph Parameters

Storm	PMP		200-yr and 100-yr, 24hr		2-yr, 24hr	
Watershed ID	Tc (hours)	R (hours)	Tc (hours)	R (hours)	Tc (hours)	R (hours)
02	-	-	-	-	0.77937	3.99150
03	-	-	-	-	0.77937	2.82241
19	-	-	-	-	0.33914	0.32630
20	-	-	-	-	0.46383	0.40772
22	-	-	-	-	0.26744	0.33541
23	-	-	-	-	0.26972	0.15213
24	-	-	-	-	0.13019	0.12341
25	-	-	-	-	0.51679	0.65696
26	-	-	-	-	0.14261	0.08073
27	-	-	-	-	0.30976	0.37691
28	-	-	-	-	0.26494	0.31064
29	-	-	-	-	0.61461	0.64149
30	-	-	-	-	0.55175	0.65924

ATTACHMENT E

CHANNEL ROUTING PARAMETERS TABLES

Table 5a: Channel Routing Parameters for Pipeline Arroyo, Existing Condition Model

Reach	Time Step Method	Length (ft)	Slope (ft/ft)	Manning's n	Shape	Width (ft)	Side Slope (xH:1V)
R01	Automatic Adaption	2293	0.0313	0.04	Triangle		2.5
R02	Automatic Adaption	1518	0.0105	0.04	Triangle		2.5
R03	Automatic Adaption	2736	0.0113	0.04	Trapezoid	15	2.5
R04	Automatic Adaption	1771	0.0079	0.04	Trapezoid	20	2.5
R05	Automatic Adaption	2915	0.0163	0.04	Trapezoid	20	2.5
R06	Automatic Adaption	6919	0.0114	0.04	Triangle		2.5
R07	Automatic Adaption	6441	0.0138	0.04	Triangle		2.5
R08	Automatic Adaption	1696	0.0083	0.04	Trapezoid	10	2.5
R09	Automatic Adaption	876	0.0034	0.04	Trapezoid	10	2.5
R10	Automatic Adaption	1669	0.0216	0.04	Trapezoid	5.0	2
R11	Automatic Adaption	2002	0.0055	0.04	Trapezoid	25	2.5
R12	Automatic Adaption	1763	0.0040	0.04	Trapezoid	25	2.5
R13	Automatic Adaption	1337	0.0322	0.04	Triangle		2
R14	Automatic Adaption	1184	0.0312	0.04	Triangle		2.5
R15	Automatic Adaption	3021	0.0056	0.04	Trapezoid	12.5	2
R16	Automatic Adaption	1919	0.0323	0.04	Trapezoid	20	2.5

Table 5b: Channel Routing Parameters for Pipeline Arroyo, Post-RA Condition Model

Reach	Time Step Method	Length (ft)	Slope (ft/ft)	Manning's n	Shape	Width (ft)	Side Slope (xH:1V)
R01	Automatic Adaption	2293	0.0313	0.04	Triangle	-	2.5
R02	Automatic Adaption	1518	0.0105	0.04	Triangle	-	2.5
R03	Automatic Adaption	2736	0.0113	0.04	Trapezoid	15	2.5
R04	Automatic Adaption	1771	0.0079	0.04	Trapezoid	20	2.5
R05	Automatic Adaption	2915	0.0163	0.04	Trapezoid	20	2.5
R06	Automatic Adaption	6919	0.0114	0.04	Triangle	-	2.5
R07	Automatic Adaption	6441	0.0138	0.04	Triangle	-	2.5
R08	Automatic Adaption	1696	0.0083	0.04	Trapezoid	10	2.5
R09	Automatic Adaption	876	0.0034	0.04	Trapezoid	10	2.5
R10	Automatic Adaption	1669	0.0216	0.04	Trapezoid	5.0	2
R11	Automatic Adaption	2002	0.0055	0.04	Trapezoid	25	2.5
R12	Automatic Adaption	1763	0.0040	0.04	Trapezoid	25	2.5
R13	Automatic Adaption	1337	0.0322	0.04	Triangle	-	2
R14	Automatic Adaption	1184	0.0312	0.04	Triangle	-	2.5
R15	Automatic Adaption	3021	0.0056	0.04	Trapezoid	12.5	2
R16	Automatic Adaption	1919	0.0323	0.04	Trapezoid	20	2.5

Table 5c: Channel Routing Parameters for Mill Site, Post-RA Condition Model

Reach	Time Step Method	Length (ft)	Slope (ft/ft)	Manning's n	Shape	Width (ft)	Side Slope (xH:1V)
ND01	Automatic Adaption	2001	0.0055	0.04	Trapezoid	8	2.5
ND02	Automatic Adaption	1665	0.0216	0.03	Trapezoid	4	2.5
ND03	Automatic Adaption	2701	0.0344	0.04	Triangle	-	2
ND04	Automatic Adaption	872	0.0023	0.04	Trapezoid	8	2.5
ND05	Automatic Adaption	2050	0.0054	0.035	Trapezoid	8	2.5
RC01	Automatic Adaption	20	0.01	0.04	Trapezoid	60	2.5
RC02	Automatic Adaption	326	0.0095	0.04	Trapezoid	2	2.5
RC03	Automatic Adaption	515	0.0117	0.04	Trapezoid	4	2.5
RC04	Automatic Adaption	643	0.0210	0.04	Trapezoid	25	2.5
RC05	Automatic Adaption	1431	0.01	0.04	Trapezoid	5	2.5
R-Swale C	Automatic Adaption	945	0.0042	0.04	Trapezoid	10	3

Table 5d: Channel Routing Parameters for Mine Site, RA-Phase 3 Construction Model

Reach	Time Step Method	Length (ft)	Slope (ft/ft)	Manning's n	Shape	Width (ft)	Side Slope (xH:1V)
R1	Automatic Adaption	734	0.0231	0.04	Trapezoid	1	3
R2	Automatic Adaption	1328	0.0293	0.04	Trapezoid	1	2.5
R3	Automatic Adaption	841	0.0273	0.04	Trapezoid	2	2.5
R4	Automatic Adaption	700	0.016	0.04	Triangle	-	2
R5	Automatic Adaption	896	0.04	0.04	Triangle		5

ATTACHMENT F

RESERVOIR STAGE-AREA-STORAGE TABLES

Table 6a: Stage-Area-Storage for Pond 1

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7098	823	0.01889	0	0
7099	2,748	0.06310	1,786	0.04099
7100	4,743	0.10889	5,531	0.12699
7101	6,159	0.14140	10,983	0.25213
7102	7,345	0.16862	17,735	0.40714
7103	8,257	0.18956	25,536	0.58623
7104	9,171	0.21053	34,250	0.78627
7105	10,070	0.23117	43,870	1.00712
7106	10,941	0.25118	54,376	1.24829
7107	11,766	0.27011	65,729	1.50894
7108	12,563	0.28841	77,894	1.7882
7109	13,317	0.30571	90,834	2.08526
7110	14,094	0.32356	104,539	2.39989
7111	14,878	0.34155	119,025	2.73245
7112	15,643	0.35910	134,286	3.08278
7113	16,423	0.37702	150,319	3.45084
7114	17,239	0.39575	167,150	3.83723
7115	18,148	0.41661	184,843	4.24341
7116	19,255	0.44203	203,544	4.67274
7117	20,634	0.47369	223,489	5.1306
7118	21,798	0.50042	244,705	5.61765
7119	22,968	0.52727	267,088	6.1315
7120	24,168	0.55482	290,656	6.67254
7121	25,396	0.58301	315,438	7.24146
7122	26,713	0.61324	341,492	7.83959
7123	28,246	0.64845	368,972	8.47043
7124	32,678	0.75018	399,434	9.16974

Table 6b: Stage-Area-Storage for Pond 2

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7102	192	0.00441	0	0
7103	7,207	0.16544	3,699	0.08493
7104	14,861	0.34116	14,733	0.33823
7105	26,134	0.59995	35,230	0.80878
7106	33,582	0.77095	65,089	1.49423
7107	36,258	0.83237	100,009	2.29588
7108	40,772	0.93599	138,523	3.18006
7109	46,246	1.06167	182,032	4.17889
7110	51,335	1.17849	230,823	5.29897
7111	56,271	1.29181	284,626	6.53412
7112	61,136	1.40350	343,330	7.88177
7113	65,668	1.50753	406,732	9.33728
7114	70,122	1.60979	474,627	10.89594
7115	75,116	1.72443	547,247	12.56305
7116	79,732	1.83039	624,671	14.34047
7117	84,269	1.93456	706,671	16.22294
7118	88,546	2.03273	793,079	18.20658
7119	92,601	2.12582	883,652	20.28586
7120	96,764	2.22140	978,334	22.45947
7121	101,870	2.33860	1,077,651	24.73947
7122	108,382	2.48812	1,182,777	27.15283
7123	114,961	2.63915	1,294,449	29.71646
7124	124,390	2.85559	1,414,125	32.46383

Table 6c: Stage-Area-Storage for Pond 3

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7056	7	0.00017	0	0
7057	10,088	0.23159	5,048	0.11588
7058	20,253	0.46494	20,218	0.46414
7059	29,582	0.67912	45,136	1.03617
7060	37,178	0.85350	78,516	1.80248
7061	48,477	1.11289	121,344	2.78567
7062	57,695	1.32449	174,430	4.00436
7063	65,686	1.50795	236,121	5.42058
7064	73,013	1.67615	305,470	7.01263
7065	80,537	1.84888	382,245	8.77515
7066	87,525	2.00930	466,277	10.70424
7067	94,360	2.16620	557,219	12.79199
7068	101,184	2.32286	654,991	15.03652
7069	107,912	2.47733	759,539	17.43661
7070	114,583	2.63046	870,786	19.9905
7071	120,999	2.77775	988,577	22.69461
7072	127,389	2.92445	1,112,771	25.54571
7073	133,919	3.07435	1,243,425	28.54511
7074	140,512	3.22572	1,380,640	31.69514
7075	146,562	3.36460	1,524,178	34.9903
7076	152,407	3.49878	1,673,662	38.42199
7077	157,954	3.62612	1,828,842	41.98444
7078	163,281	3.74841	1,989,459	45.6717
7079	169,178	3.88379	2,155,689	49.48781
7080	174,998	4.01740	2,327,777	53.4384
7081	200,643	4.60612	2,515,597	57.75017
7082	209,664	4.81322	2,720,751	62.45984
7083	218,764	5.02212	2,934,964	67.37751
7084	227,166	5.21502	3,157,929	72.49608

Table 6d: Stage-Area-Storage for Pond 4

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7044	514	0.01180	0	0
7046	4,446	0.10207	4,960	0.11387
7048	8,665	0.19892	18,071	0.41486
7050	13,010	0.29867	39,746	0.91245
7052	16,305	0.37432	69,062	1.58544
7054	21,850	0.50160	107,216	2.46135
7056	27,810	0.63844	156,877	3.60139

Table 6e: Stage-Area-Storage for Pond 5

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7044	992	0.02276	0	0
7046	2,873	0.06596	3,865	0.08873
7048	4,404	0.10111	11,143	0.2558
7050	7,320	0.16805	22,868	0.52497
7052	11,684	0.26822	41,872	0.96124

Table 6f: Stage-Area-Storage for Temporary Plug at Pond 3

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7080	5	0.00012	0	0
7081	62	0.00143	34	0.00077
7082	324	0.00744	227	0.0052
7083	675	0.01549	726	0.01667
7084	1,016	0.02333	1,571	0.03608
7085	1,301	0.02986	2,730	0.06267
7086	1,613	0.03703	4,187	0.09612
7087	1,958	0.04495	5,972	0.13711
7088	2,375	0.05453	8,139	0.18685
7089	2,999	0.06885	10,826	0.24854

ATTACHMENT G

HEC-HMS MODEL RESULTS

Table 7a: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
D1	0.0100583	45.708	4.759
J-R01ds	3.6051259	6816.937	4.565
J-R01us	1.5411787	3376.713	4.6
J-R03ds	4.880598	9031.182	4.519
J-R04ds	5.3089407	9852.784	4.727
J-R04us	4.9179928	9132.77	4.723
J-R05ds	5.5617898	10255.726	4.707
J-R05us	5.3089407	9852.784	4.727
J-R06ds	4.2026638	6281.166	3.882
J-R06us	3.2122186	4746.091	3.777
J-R07ds	9.2639891	13354.643	4.147
J-R07us	8.8701844	12827.028	4.129
J-R08ds	10.1275011	14566.954	4.153
J-R08us	10.1275011	14590.09	4.152
J-R09ds	0.8806052	2483.099	4.443
J-R09us	0.3364131	1041.247	4.203
J-R10ds	0.9043397	2544.613	4.455
J-R10us	0.8806052	2483.099	4.443
J-R11ds	0.9302049	2584.588	4.464
J-R11us	0.9302049	2616.093	4.457
J-R12ds	17.1037326	26318.569	4.349
J-R12us	16.0867596	24978.946	4.343
J-R15us	17.4124837	26764.862	4.357
J-R16ds	0.0373948	352.047	31.276
J-R16us	0.0373948	353.598	31.23
J-R2ds	0.6682043	1696.601	4.451
J-R2us	0.6682043	1711.43	4.45
J-R3us	4.880598	9040.867	4.517
Outlet/R15ds	17.6800299	26764.409	4.364
Pond 1	0.0087573	0	0
Pond 2	0.0269247	0	0
Pond 4	0.0236861	0	0
Pond 5	0	0	n/a
Pond3	0.4237999	0	0
R01	1.5411787	3361.802	4.602
R02	0.6682043	1696.601	4.451
R03	4.880598	9031.182	4.519
R04	4.9179928	9105.01	4.725
R05	5.3089407	9808.937	4.729
R06	3.2122186	4718.715	3.788
R07	8.8701844	12791.953	4.136
R08	10.1275011	14566.954	4.153
R09	0.3364131	1031.394	4.204
R10	0.8806052	2475.982	4.447
R11	0.9302049	2584.588	4.464
R12	16.0867596	24930.004	4.344
R13	0.0556491	219.851	4.798
R14	0.1385302	590.575	4.824
R15	17.4124837	26688.28	4.358
R16	0.0373948	352.047	31.276
0	0.6072678	849.204	4.307
1	0.1385302	598.211	4.816
2	0.2528491	569.342	4.252
3	0.0373948	134.168	4.251
4	0.1464189	411.973	4.456

Table 7a: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
5	0.0733669	229.378	4.635
9	0.3364131	1041.247	4.203
10	0.5441921	1488.025	4.591
16	0.0556491	220.89	4.794
17	0.3974687	821.729	4.095
18	0.863512	1304.738	4.202
19	0.3938047	882.082	4.396
20	0.6682043	1711.43	4.45
21	0.3909479	1037.782	4.74
22	3.2122186	4746.091	3.777
23	1.5411787	3376.713	4.6
24	1.561185	2323.015	4.452
25	2.7470829	3857.887	4.276
26	2.0639472	3586.077	4.538
27	0.1623322	322.567	5.074
31	0.3354781	765.844	4.419
32	0.0782635	320.172	4.565
33	0.0236861	115.991	4.759
34	0.0087573	40.766	4.12
35	0.0269247	130.252	4.083
36	0.0100583	45.708	4.759
37	0.0237345	78.623	4.748
38	0.0258652	91.372	4.55
39	0.0867681	229.595	4.126
42	0.3592527	812.726	4.484
43	0.9904452	1987.495	4.186

Table 7b: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
D1	0.0100583	20.961	0.974
J-R01ds	3.6051259	1421.94	0.863
J-R01us	1.5411787	731.393	0.884
J-R03ds	4.880598	1842.107	0.84
J-R04ds	5.3089407	1985.721	0.85
J-R04us	4.9179928	1846.094	0.84
J-R05ds	5.5617898	2042.688	0.845
J-R05us	5.3089407	1985.721	0.85
J-R06ds	4.2026638	937.911	0.566
J-R06us	3.2122186	705.536	0.526
J-R07ds	9.2639891	2206.394	0.673
J-R07us	8.8701844	2129.091	0.665
J-R08ds	10.1275011	2408.953	0.674
J-R08us	10.1275011	2414.585	0.674
J-R09ds	0.8806052	597.004	0.804
J-R09us	0.3364131	256.802	0.689
J-R10ds	0.9043397	609.927	0.809
J-R10us	0.8806052	597.004	0.804
J-R11ds	0.9302049	612.193	0.815
J-R11us	0.9302049	621.595	0.81
J-R12ds	17.1037326	4676.868	0.737
J-R12us	16.0867596	4450.52	0.732
J-R15us	17.4124837	4771.405	0.742
J-R16ds	0.0373948	42.334	0.748
J-R16us	0.0373948	42.858	0.709
J-R2ds	0.6682043	378.374	0.801
J-R2us	0.6682043	384.732	0.799
J-R3us	4.880598	1843.153	0.838
Outlet/R15ds	17.6800299	4766.154	0.747
Pond 1	0.0087573	0	0
Pond 2	0.0269247	0	0
Pond 4	0.0236861	0	0
Pond 5	0	0	n/a
Pond3	0.4237999	0	0
R01	1.5411787	728.116	0.885
R02	0.6682043	378.374	0.801
R03	4.880598	1842.107	0.84
R04	4.9179928	1838.223	0.841
R05	5.3089407	1979.203	0.852
R06	3.2122186	702.83	0.531
R07	8.8701844	2124.711	0.668
R08	10.1275011	2408.953	0.674
R09	0.3364131	251.877	0.689
R10	0.8806052	594.842	0.805
R11	0.9302049	612.193	0.815
R12	16.0867596	4422.933	0.733
R13	0.0556491	72.395	1.002
R14	0.1385302	226.373	1.019
R15	17.4124837	4747.512	0.744
R16	0.0373948	42.334	0.748
0	0.6072678	159.823	0.735
1	0.1385302	240.015	1.015
2	0.2528491	118.542	0.709
3	0.0373948	42.858	0.709
4	0.1464189	91.322	0.802

Table 7b: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
5	0.0733669	56.708	0.9
9	0.3364131	256.802	0.689
10	0.5441921	365.896	0.875
16	0.0556491	73.307	0.999
17	0.3974687	154.364	0.638
18	0.863512	235.227	0.688
19	0.3938047	185.002	0.773
20	0.6682043	384.732	0.799
21	0.3909479	266.643	0.966
22	3.2122186	705.536	0.526
23	1.5411787	731.393	0.884
24	1.561185	444.659	0.8
25	2.7470829	686.117	0.722
26	2.0639472	722.715	0.847
27	0.1623322	71.698	1.24
31	0.3354781	169.672	0.787
32	0.0782635	105.694	0.86
33	0.0236861	60.271	0.974
34	0.0087573	18.546	0.651
35	0.0269247	59.673	0.633
36	0.0100583	20.961	0.974
37	0.0237345	22.852	0.967
38	0.0258652	30.545	0.85
39	0.0867681	42.345	0.65
42	0.3592527	181.863	0.812
43	0.9904452	368.973	0.679

Table 7c: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
D1	0.0100583	0	0
J-R01ds	3.6051259	0	0
J-R01us	1.5411787	0	0
J-R03ds	4.880598	0	0
J-R04ds	5.3089407	0	0
J-R04us	4.9179928	0	0
J-R05ds	5.5617898	0	0
J-R05us	5.3089407	0	0
J-R06ds	4.2026638	0	0
J-R06us	3.2122186	0	0
J-R07ds	9.2639891	0	0
J-R07us	8.8701844	0	0
J-R08ds	10.1275011	0	0
J-R08us	10.1275011	0	0
J-R09ds	0.8806052	0	0
J-R09us	0.3364131	0	0
J-R10ds	0.9043397	0	0
J-R10us	0.8806052	0	0
J-R11ds	0.9302049	0	0
J-R11us	0.9302049	0	0
J-R12ds	17.1037326	0	0
J-R12us	16.0867596	0	0
J-R15us	17.4124837	3.23	0.001
J-R16ds	0.0373948	0	0
J-R16us	0.0373948	0	0
J-R2ds	0.6682043	0	0
J-R2us	0.6682043	0	0
J-R3us	4.880598	0	0
Outlet/R15ds	17.6800299	3.222	0.001
Pond 1	0.0087573	0	0
Pond 2	0.0269247	0	0
Pond 4	0.0236861	0	0
Pond 5	0	0	n/a
Pond3	0.4237999	0	0
R01	1.5411787	0	0
R02	0.6682043	0	0
R03	4.880598	0	0
R04	4.9179928	0	0
R05	5.3089407	0	0
R06	3.2122186	0	0
R07	8.8701844	0	0
R08	10.1275011	0	0
R09	0.3364131	0	0
R10	0.8806052	0	0
R11	0.9302049	0	0
R12	16.0867596	0	0
R13	0.0556491	0	0
R14	0.1385302	0	0
R15	17.4124837	3.222	0.001
R16	0.0373948	0	0
0	0.6072678	0	0
1	0.1385302	0	0
2	0.2528491	0	0
3	0.0373948	0	0
4	0.1464189	0	0

Table 7c: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
5	0.0733669	0	0
9	0.3364131	0	0
10	0.5441921	0	0
16	0.0556491	0	0
17	0.3974687	0	0
18	0.863512	0	0
19	0.3938047	0	0
20	0.6682043	0	0
21	0.3909479	0	0
22	3.2122186	0	0
23	1.5411787	0	0
24	1.561185	0	0
25	2.7470829	0	0
26	2.0639472	0	0
27	0.1623322	3.23	0.117
31	0.3354781	0	0
32	0.0782635	0	0
33	0.0236861	0	0
34	0.0087573	0	0
35	0.0269247	0	0
36	0.0100583	0	0
37	0.0237345	0	0
38	0.0258652	0	0
39	0.0867681	0	0
42	0.3592527	0	0
43	0.9904452	0	0

Table 7d: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
J-R01ds	3.6051259	6816.93	4.565
J-R01us	1.5411787	3376.713	4.6
J-R03ds	4.880598	9031.332	4.519
J-R04ds	5.7921082	10724.572	4.53
J-R04us	5.4011603	9973.853	4.514
J-R05ds	6.0449573	11155.819	4.52
J-R05us	5.7921082	10724.572	4.53
J-R06ds	4.2026638	6281.334	3.882
J-R06us	3.2122186	4746.091	3.777
J-R07ds	9.2639891	13354.8	4.147
J-R07us	8.8701844	12827.015	4.129
J-R08ds	10.1275011	14566.218	4.153
J-R08us	10.1275011	14590.247	4.152
J-R09ds	0.8806052	2483.157	4.443
J-R09us	0.3364131	1041.247	4.203
J-R10ds	0.9043397	2544.57	4.455
J-R10us	0.8806052	2483.157	4.443
J-R11ds	0.9302049	2584.466	4.465
J-R11us	0.9302049	2616.049	4.457
J-R12ds	17.5869001	27163.855	4.295
J-R12us	16.5699271	25714.378	4.286
J-R15us	17.9003855	27621.292	4.304
J-R16ds	0.5205623	1038.173	4.46
J-R16us	0.4831675	996.954	4.445
J-R2ds	0.6682043	1696.601	4.451
J-R2us	0.6682043	1711.43	4.45
J-R3us	4.880598	9040.981	4.517
Outlet/R15ds	18.1679317	27572.976	4.312
R01	1.5411787	3361.808	4.602
R02	0.6682043	1696.601	4.451
R03	4.880598	9031.332	4.519
R04	5.4011603	9951.322	4.515
R05	5.7921082	10705.195	4.532
R06	3.2122186	4718.702	3.788
R07	8.8701844	12792	4.136
R08	10.1275011	14566.218	4.153
R09	0.3364131	1031.077	4.204
R10	0.8806052	2475.936	4.447
R11	0.9302049	2584.466	4.465
R12	16.5699271	25660.541	4.287
R13	0.0556491	219.692	4.798
R14	0.1385302	590.486	4.824
R15	17.9003855	27484.389	4.305
R16	0.4831675	993.808	4.451
0	0.6072678	849.325	4.307
1	0.1385302	598.148	4.816
2	0.2528491	569.194	4.251
3	0.0373948	141.488	4.578
4	0.1464189	411.511	4.456
5	0.0733669	229.216	4.635
9	0.3364131	1041.247	4.203

Table 7d: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
10	0.5441921	1488.025	4.591
16	0.0556491	220.776	4.794
17	0.3974687	821.729	4.095
18	0.863512	1304.738	4.202
19	0.3938047	882.082	4.396
20	0.6682043	1711.43	4.45
21	0.3909479	1037.782	4.74
22	3.2122186	4746.091	3.777
23	1.5411787	3376.713	4.6
24	1.561185	2323.015	4.452
25	2.7470829	3857.887	4.276
26	2.0639472	3586.077	4.538
27	0.1670665	335.786	5.076
31	0.4831675	996.954	4.445
37	0.0237345	78.593	4.748
38	0.0258652	91.372	4.55
39	0.0867681	229.413	4.126
42	0.3592527	812.726	4.484
43	0.9904452	1987.495	4.186

Table 7e: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
J-R01ds	3.6051259	1421.933	0.863
J-R01us	1.5411787	731.393	0.884
J-R03ds	4.880598	1842.16	0.84
J-R04ds	5.7921082	2178.677	0.847
J-R04us	5.4011603	2030.223	0.837
J-R05ds	6.0449573	2243.213	0.842
J-R05us	5.7921082	2178.677	0.847
J-R06ds	4.2026638	937.969	0.566
J-R06us	3.2122186	705.536	0.526
J-R07ds	9.2639891	2206.427	0.673
J-R07us	8.8701844	2129.105	0.665
J-R08ds	10.1275011	2408.971	0.674
J-R08us	10.1275011	2414.651	0.674
J-R09ds	0.8806052	597.013	0.804
J-R09us	0.3364131	256.802	0.689
J-R10ds	0.9043397	609.879	0.809
J-R10us	0.8806052	597.013	0.804
J-R11ds	0.9302049	612.168	0.815
J-R11us	0.9302049	621.547	0.81
J-R12ds	17.5869001	4853.981	0.739
J-R12us	16.5699271	4616.843	0.735
J-R15us	17.9003855	4951.337	0.744
J-R16ds	0.5205623	217.922	0.807
J-R16us	0.4831675	212.558	0.798
J-R2ds	0.6682043	378.374	0.801
J-R2us	0.6682043	384.732	0.799
J-R3us	4.880598	1843.208	0.839
Outlet/R15ds	18.1679317	4957.031	0.749
R01	1.5411787	728.115	0.885
R02	0.6682043	378.374	0.801
R03	4.880598	1842.16	0.84
R04	5.4011603	2024.133	0.838
R05	5.7921082	2169.794	0.848
R06	3.2122186	702.824	0.531
R07	8.8701844	2124.744	0.668
R08	10.1275011	2408.971	0.674
R09	0.3364131	251.748	0.689
R10	0.8806052	594.795	0.805
R11	0.9302049	612.168	0.815
R12	16.5699271	4600.033	0.735
R13	0.0556491	72.396	1.002
R14	0.1385302	226.367	1.019
R15	17.9003855	4938.382	0.745
R16	0.4831675	210.598	0.803
0	0.6072678	159.876	0.735
1	0.1385302	240.015	1.015
2	0.2528491	118.464	0.709
3	0.0373948	41.546	0.863
4	0.1464189	91.322	0.802
5	0.0733669	56.708	0.9
9	0.3364131	256.802	0.689
10	0.5441921	365.896	0.875
16	0.0556491	73.307	0.999
17	0.3974687	154.364	0.638

Table 7e: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
18	0.863512	235.227	0.688
19	0.3938047	185.002	0.773
20	0.6682043	384.732	0.799
21	0.3909479	266.643	0.966
22	3.2122186	705.536	0.526
23	1.5411787	731.393	0.884
24	1.561185	444.659	0.8
25	2.7470829	686.117	0.722
26	2.0639472	722.715	0.847
27	0.1670665	75.274	1.242
31	0.4831675	212.558	0.798
37	0.0237345	22.852	0.967
38	0.0258652	30.545	0.85
39	0.0867681	42.345	0.65
42	0.3592527	181.863	0.812
43	0.9904452	368.973	0.679

Table 7f: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 200-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
J-R01ds	3.6051259	1806.8	1.10
J-R01us	1.5411787	925.5	1.12
J-R03ds	4.880598	2346.6	1.07
J-R04ds	5.7921082	2786.4	1.08
J-R04us	5.4011603	2597.1	1.07
J-R05ds	6.0449573	2872.4	1.08
J-R05us	5.7921082	2786.4	1.08
J-R06ds	4.2026638	1261.7	0.76
J-R06us	3.2122186	949.8	0.71
J-R07ds	9.2639891	2895.6	0.88
J-R07us	8.8701844	2793.9	0.87
J-R08ds	10.1275011	3163.9	0.88
J-R08us	10.1275011	3172.9	0.88
J-R09ds	0.8806052	758.7	1.03
J-R09us	0.3364131	332.2	0.90
J-R10ds	0.9043397	770.5	1.04
J-R10us	0.8806052	758.7	1.03
J-R11ds	0.9302049	772.7	1.04
J-R11us	0.9302049	785.6	1.04
J-R12ds	17.5869001	6306.5	0.96
J-R12us	16.5699271	5998.9	0.95
J-R15us	17.9003855	6360.0	0.96
J-R16ds	0.5205623	284.1	1.04
J-R16us	0.4831675	272.6	1.03
J-R2ds	0.6682043	483.6	1.03
J-R2us	0.6682043	492.6	1.03
J-R3us	4.880598	2348.0	1.07
Outlet/R15ds	18.1679317	6458.8	0.97
R01	1.5411787	920.9	1.12
R02	0.6682043	483.6	1.03
R03	4.880598	2346.6	1.07
R04	5.4011603	2590.5	1.07
R05	5.7921082	2777.4	1.09
R06	3.2122186	946.5	0.71
R07	8.8701844	2790.6	0.87
R08	10.1275011	3163.9	0.88
R09	0.3364131	325.0	0.90
R10	0.8806052	757.1	1.03
R11	0.9302049	772.7	1.04
R12	16.5699271	5984.2	0.95
R13	0.0556491	24.8	1.26
R14	0.1385302	88.3	1.27
R15	17.9003855	6344.9	0.96
R16	0.4831675	269.7	1.03
0	0.6072678	205.2	0.94
1	0.1385302	89.0	1.27
2	0.2528491	152.6	0.92
3	0.0373948	14.9	1.10
4	0.1464189	32.2	1.03
5	0.0733669	22.0	1.14
9	0.3364131	332.2	0.90
10	0.5441921	462.0	1.11
16	0.0556491	25.0	1.25
17	0.3974687	204.2	0.85

Table 7f: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 200-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
18	0.863512	306.4	0.90
19	0.3938047	236.9	0.99
20	0.6682043	492.6	1.03
21	0.3909479	332.9	1.22
22	3.2122186	949.8	0.71
23	1.5411787	925.5	1.12
24	1.561185	571.9	1.03
25	2.7470829	884.7	0.93
26	2.0639472	924.1	1.08
27	0.1670665	37.5	1.52
31	0.4831675	272.6	1.03
37	0.0237345	13.9	1.22
38	0.0258652	38.1	1.09
39	0.0867681	20.2	0.86
42	0.3592527	232.7	1.05
43	0.9904452	482.0	0.89

Table 7f: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
J-R01ds	3.6051259	0	0
J-R01us	1.5411787	0	0
J-R03ds	4.880598	0	0
J-R04ds	5.7921082	0	0
J-R04us	5.4011603	0	0
J-R05ds	6.0449573	0	0
J-R05us	5.7921082	0	0
J-R06ds	4.2026638	0	0
J-R06us	3.2122186	0	0
J-R07ds	9.2639891	0	0
J-R07us	8.8701844	0	0
J-R08ds	10.1275011	0	0
J-R08us	10.1275011	0	0
J-R09ds	0.8806052	0	0
J-R09us	0.3364131	0	0
J-R10ds	0.9043397	0	0
J-R10us	0.8806052	0	0
J-R11ds	0.9302049	0	0
J-R11us	0.9302049	0	0
J-R12ds	17.5869001	0	0
J-R12us	16.5699271	0	0
J-R15us	17.9003855	3.451	0.001
J-R16ds	0.5205623	0	0
J-R16us	0.4831675	0	0
J-R2ds	0.6682043	0	0
J-R2us	0.6682043	0	0
J-R3us	4.880598	0	0
Outlet/R15ds	18.1679317	3.444	0.001
R01	1.5411787	0	0
R02	0.6682043	0	0
R03	4.880598	0	0
R04	5.4011603	0	0
R05	5.7921082	0	0
R06	3.2122186	0	0
R07	8.8701844	0	0
R08	10.1275011	0	0
R09	0.3364131	0	0
R10	0.8806052	0	0
R11	0.9302049	0	0
R12	16.5699271	0	0
R13	0.0556491	0	0
R14	0.1385302	0	0
R15	17.9003855	3.444	0.001
R16	0.4831675	0	0
0	0.6072678	0	0
1	0.1385302	0	0
2	0.2528491	0	0
3	0.0373948	0	0
4	0.1464189	0	0
5	0.0733669	0	0
9	0.3364131	0	0
10	0.5441921	0	0
16	0.0556491	0	0
17	0.3974687	0	0

Table 7f: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
18	0.863512	0	0
19	0.3938047	0	0
20	0.6682043	0	0
21	0.3909479	0	0
22	3.2122186	0	0
23	1.5411787	0	0
24	1.561185	0	0
25	2.7470829	0	0
26	2.0639472	0	0
27	0.1670665	3.451	0.118
31	0.4831675	0	0
37	0.0237345	0	0
38	0.0258652	0	0
39	0.0867681	0	0
42	0.3592527	0	0
43	0.9904452	0	0

Table 7g: HEC-HMS Model Results for Mill Site, Post-RA Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
J-ND01ds	1.0169735	3116.798	4.486
J-ND01us	0.9302053	2929.52	4.52
J-ND02ds	0.9043401	2850.424	4.518
J-ND02us	0.8806056	2777.883	4.509
J-ND03ds	0.5441922	1826.242	4.698
J-ND03us	0.2560696	874.324	4.681
J-ND04us	0.3364134	972.517	4.21
J-ND05ds	0.05122	167.561	4.62
J-ND05us	0.0252333	94.895	4.445
J-RC01ds	0.1166014	362.171	5.072
J-RC01us	0.0968041	298.15	5.064
J-RC02ds	0.0968041	298.15	5.064
J-RC02us	0.0895105	274.029	5.082
J-RC03ds	0.0895105	274.029	5.082
J-RC03us	0.0820777	249.65	5.096
J-RC04ds	0.0754404	227.543	5.125
J-RC04us	0.0705838	211.835	5.124
J-RC05ds	0.0244678	72.651	5.087
J-RC05us	0.0111899	33.343	5.097
J-SCds	0.046116	140.195	5.143
J-SCus	0.0326852	97.708	5.145
ND01	0.9302053	2900.952	4.517
ND02	0.8806056	2777.318	4.511
ND03	0.2560696	867.155	4.68
ND04	0.3364134	960.511	4.203
ND05	0.0252333	94.889	4.445
Outlet	1.1840409	3636.072	4.572
RC01	0.0968041	298.067	5.065
RC02	0.0895105	273.084	5.083
RC03	0.0820777	248.73	5.098
RC04	0.0705838	211.82	5.126
RC05	0.0111899	33.262	5.102
R-Swale C	0.0326852	97.456	5.141
0	0.0048566	21.665	5.108
1	0.0025263	8.468	4.773
2	0.004111	14.32	4.764
3	0.0074328	33.108	4.899
4	0.0197973	64.44	5.109
5	0.0467322	177.232	5.147
6	0.0326852	97.708	5.145
7	0.0134308	62.598	5.148
8	0.0037338	13.748	5.146
12	0.0132779	39.39	5.076
14	0.0072936	25.922	4.827
16	0.0060103	22.126	5.071
32	0.0551482	150.835	3.762
33	0.2881226	959.087	4.714
34	0.2300452	669.369	4.227
35	0.2560696	874.324	4.681
36	0.0259867	77.76	4.789
37	0.0237345	77.685	4.778
38	0.0258652	92.268	4.581
39	0.0867682	215.846	4.156
40	0.0051796	12.644	5.127

Table 7g: HEC-HMS Model Results for Mill Site, Post-RA Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
41	0.0252333	94.895	4.445

Table 7h: HEC-HMS Model Results for Mill Site, Post-RA Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
J-ND01ds	1.0169735	792.077	0.817
J-ND01us	0.9302053	778.092	0.834
J-ND02ds	0.9043401	761.809	0.834
J-ND02us	0.8806056	752.702	0.83
J-ND03ds	0.5441922	536.018	0.921
J-ND03us	0.2560696	265.953	0.914
J-ND04us	0.3364134	225.533	0.687
J-ND05ds	0.05122	43.294	0.882
J-ND05us	0.0252333	28.216	0.786
J-RC01ds	0.1166014	94.241	1.218
J-RC01us	0.0968041	73.571	1.212
J-RC02ds	0.0968041	73.571	1.212
J-RC02us	0.0895105	65.955	1.225
J-RC03ds	0.0895105	65.955	1.225
J-RC03us	0.0820777	57.913	1.238
J-RC04ds	0.0754404	52.158	1.258
J-RC04us	0.0705838	48.112	1.259
J-RC05ds	0.0244678	18.678	1.228
J-RC05us	0.0111899	8.959	1.237
J-SCds	0.046116	32.878	1.276
J-SCus	0.0326852	23.685	1.275
ND01	0.9302053	759.307	0.833
ND02	0.8806056	743.855	0.83
ND03	0.2560696	259.391	0.912
ND04	0.3364134	216.684	0.684
ND05	0.0252333	28.175	0.786
Outlet	1.1840409	910.468	0.876
RC01	0.0968041	73.487	1.212
RC02	0.0895105	65.525	1.226
RC03	0.0820777	57.712	1.238
RC04	0.0705838	47.835	1.259
RC05	0.0111899	8.757	1.235
R-Swale C	0.0326852	23.262	1.275
0	0.0048566	9.248	1.243
1	0.0025263	2.285	1.009
2	0.004111	4.389	1.002
3	0.0074328	14.484	1.083
4	0.0197973	21.158	1.244
5	0.0467322	57.568	1.277
6	0.0326852	23.685	1.275
7	0.0134308	28.437	1.277
8	0.0037338	4.449	1.277
12	0.0132779	9.921	1.221
14	0.0072936	8.817	1.042
16	0.0060103	6.95	1.217
32	0.0551482	33.88	0.512
33	0.2881226	276.627	0.928
34	0.2300452	157.717	0.686
35	0.2560696	265.953	0.914
36	0.0259867	18.077	0.974
37	0.0237345	20.635	0.967
38	0.0258652	30.616	0.851

Table 7h: HEC-HMS Model Results for Mill Site, Post-RA Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
39	0.0867682	33.785	0.65
40	0.0051796	2.628	1.26
41	0.0252333	28.216	0.786

Table 7i: HEC-HMS Model Results for Mill Site, Post-RA Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
J-ND01ds	1.0169735	0	0
J-ND01us	0.9302053	0	0
J-ND02ds	0.9043401	0	0
J-ND02us	0.8806056	0	0
J-ND03ds	0.5441922	0	0
J-ND03us	0.2560696	0	0
J-ND04us	0.3364134	0	0
J-ND05ds	0.05122	0	0
J-ND05us	0.0252333	0	0
J-RC01ds	0.1166014	5.606	0.114
J-RC01us	0.0968041	4.013	0.113
J-RC02ds	0.0968041	4.013	0.113
J-RC02us	0.0895105	3.92	0.117
J-RC03ds	0.0895105	3.92	0.117
J-RC03us	0.0820777	3.426	0.12
J-RC04ds	0.0754404	3.364	0.127
J-RC04us	0.0705838	2.84	0.126
J-RC05ds	0.0244678	0.537	0.114
J-RC05us	0.0111899	0.271	0.114
J-SCds	0.046116	2.794	0.132
J-SCus	0.0326852	0.72	0.13
ND01	0.9302053	0	0
ND02	0.8806056	0	0
ND03	0.2560696	0	0
ND04	0.3364134	0	0
ND05	0.0252333	0	0
Outlet	1.1840409	7.396	0.017
RC01	0.0968041	4.007	0.113
RC02	0.0895105	3.735	0.117
RC03	0.0820777	3.401	0.121
RC04	0.0705838	2.818	0.127
RC05	0.0111899	0.265	0.121
R-Swale C	0.0326852	0.717	0.133
0	0.0048566	0.546	0.118
1	0.0025263	0.03	0.051
2	0.004111	0.088	0.05
3	0.0074328	0.657	0.068
4	0.0197973	1.599	0.118
5	0.0467322	2.428	0.13
6	0.0326852	0.72	0.13
7	0.0134308	2.793	0.131
8	0.0037338	0.241	0.13
12	0.0132779	0.277	0.108
14	0.0072936	0.316	0.057
16	0.0060103	0.24	0.106
32	0.0551482	0	0
33	0.2881226	0	0
34	0.2300452	0	0
35	0.2560696	0	0
36	0.0259867	0	0
37	0.0237345	0	0
38	0.0258652	0	0
39	0.0867682	0	0
40	0.0051796	0.072	0.124

Table 7i: HEC-HMS Model Results for Mill Site, Post-RA Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
41	0.0252333	0	0

Table 7j: HEC-HMS Model Results for Mine Site, RA-Phase 3 Construction 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Volume (inches)
Const_Pond	0.001978	0	0
J-Berm2	0.0036332	0	0
J-R1ds	0.1447309	0	0
J-R1us	0.1447309	0	0
J-R2ds	0.0269669	0	0
J-R2us	0.2261458	0	0
J-R3us	0.0644484	0	0
J-R4ds	0.1774266	0	0
J-R4us	0.1673683	0	0
J-R5ds	0.2193583	0	0
J-R5us	0.1774266	0	0
Outlet	0.2193583	0	0
Plug	0.1093323	0	0
Pond 1	0.0087573	0	0
Pond 2	0.0269247	0	0
Pond3	0.058036	0	0
R-J3ds/Berm1	0.1093323	0	0
R1	0.1447309	0	0
R2	0	0	0
R3	0.0644484	0	0
R4	0.1673683	0	0
R5	0.1774266	0	0
2	0.001978	0	0
3	0.0036332	0	0
19	0.0814149	0	0
20	0.1447309	0	0
22	0.010027	0	0
23	0.0419317	0	0
24	0.0087573	0	0
25	0.0348569	0	0
26	0.0269247	0	0
27	0.0374815	0	0
28	0.0100583	0	0
29	0.0544028	0	0
30	0.0269669	0	0

ATTACHMENT I.2

Hydraulic Analysis of the North Diversion Channel

ATTACHMENT I.2: HYDRAULIC ANALYSIS OF THE NORTH DIVERSION CHANNEL

Revisioning					
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**
0		*Preliminary (30%) Design*	*J. Erickson*	*C. Michalos*	

Revisions	
Issue Date	**Description**
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Location and Format

Electronic copies of these calculations are located on the project team site.

http://projects.mwhglobal.com/sites/genecrpreliminarydesign/Pages/Technical/Design/Stormwater_Hydrology_Hydraulics/

Calculations were generated using the following software:

- HEC-RAS – River Analysis System. Version 4.1.0 Jan 2010. U.S. Army Corps of Engineers Hydraulic Engineering Center
- HEC-GeoRAS – GIS Tools for Support of HEC-RAS using Arc-GIS ArcMap Version 10.2.2
- ESRI ArcMap 10.2.2
- Microsoft Excel 2013

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Objective

Evaluate the capacity of the existing Northeast Church Rock (NECR) North Diversion Channel (NDC) to convey the Probable Maximum Flood (PMF).

Background

The NDC intercepts runoff from areas upgradient of the North Cell of the tailings disposal area (TDA) and routes runoff to the alluvial floodplain to the north of the TDA. MWH evaluated the hydraulic conditions of the existing NDC using the one-dimensional River Analysis System developed by the US Army Corps of Engineers-Hydrologic Engineering Center (HEC-RAS) version 4.1.0.

Applicable Codes and Standards

The calculation methods used in this analysis are consistent with the following codes and standards:

- Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site (AOC; USEPA, 2015)
- Design of Erosion Protection for Long-Term Stabilization (Johnson, 2002)

Methods

MWH modeled the NDC as a single branch with three reaches. The three reaches are described in **Table 1**. **Figure 1** shows the channel alignment, stationing, and cross-section locations. Cross sections 3978 through 3449 include proposed improvements to channel bottom and left embankment as shown in Drawing 9-06.

MWH extracted channel geometry data from an aerial survey completed by Cooper Aerial Surveys Company in 2013. This survey has an expected accuracy of 1-foot horizontal and 0.5 feet vertical (MWH, 2014). MWH used ArcMap and HEC-GeoRAS to extract the channel alignment and cross sections from the survey. **Figures 2 to 26** display each of the model channel cross sections. To improve the model's computational stability, the model has interpolated cross-sections between the measured cross sections with a maximum spacing between interpolated cross sections equal to 25 feet.

Channel Roughness

The model uses Manning's roughness values to simulate resistance to flow in the channel and floodplain. MWH assigned values for the roughness coefficient based on typical values given in Chow (1959). **Table 2** lists the assigned roughness values for the current condition of the left bank, channel, and right bank and provides justification for selection of these values. The roughness values are also displayed in the cross section figures (**Figures 2 to 26**).

To determine the simulated water surface elevation to the assigned roughness values, MWH estimated the maximum likely channel roughness values along the four reaches of the NDC (**Table 3**). These values represent maximum vegetation overgrowth that might occur in the NDC.

Expansion and Contraction Losses

The transitions in geometry between all cross-sections along the NDC is gradual, and cross-sectional geometry contraction and expansion loss coefficients were assumed to be 0.1 and 0.3, respectively.

Flow Conditions

MWH ran the model simulation in steady-state mode with the estimated PMF flow values assigned to each reach (**Table 4**). The estimation of PMF values is described in Attachment I-1: Estimates of Flood Flows for Design of Surface Water Controls for the Remedial Actions at the Church Rock Mine Site and Mill Site.

The model was evaluated using a mixed flow regime considering both sub-critical and super-critical flows. To facilitate the mixed flow computations, MWH entered initial boundary conditions at the upstream (Station 6121) and downstream (Station 229) cross sections. The upstream boundary condition is the calculated normal depth established with a slope of 0.5 percent. The downstream boundary condition was set by solving for the water surface elevation in the Pipeline Arroyo at the NDC confluence using a normal depth calculation for the PMF peak discharge. This is a conservative assumption as it assumes the peak PMF stage in the Pipeline Arroyo occurs simultaneously with the peak PMF stage in the NDC; however, the simulated flow velocities and depths in the reaches of interest (upper and middle) are not impacted by this downstream boundary condition because flows in the lower reach are supercritical.

Assumptions

Assumptions are described in the explanation of calculation methods.

Results

The NDC water surface profile at the PMF discharge along with the critical depth are presented in **Figure 27**. **Figure 27** also shows the “left levee”, which represents the elevation of the top of the left bank (facing downstream), or the elevation along the profile at which flow would overtop the left channel bank (see the channel cross-section plots in **Figures 26**). The average channel velocity along the profile is shown in **Figure 28**, and summarized in **Table 5**.

Figure 27 also shows the sensitivity plot of the NDC water surface profile at the PMF discharge using the maximum likely roughness values from **Table 3**.

Conclusions

Figure 27 shows that PMF flows are contained throughout all reaches of the NDC under the current channel conditions.

Figure 27 also shows mixed flow (both super-critical and sub-critical flow) through the upper reach, sub-critical flow through the middle reach, and primarily super-critical flow through the lower reach.

The water surface profile shown in **Figure 27** also indicates that the NDC left embankment would not overtop even with the maximum likely vegetative overgrowth.

References

Chow, V.T., 1959. Open-Channel Hydraulics. McGraw-Hill Civil Engineering Series.

Johnson, T.L., 2002. Design of Erosion Protection for Long-term Stabilization. US Nuclear Regulatory Agency NUREG-1623. September.

MWH, 2014. Pre-Design Studies-Northeast Church Rock Mine Site Removal Action. Church Rock Mill Site. October 31, 2014.

US Environmental Protection Agency (USEPA), 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site, McKinley County, New Mexico. April 27.

TABLES

Table 1: North Diversion Channel Reaches

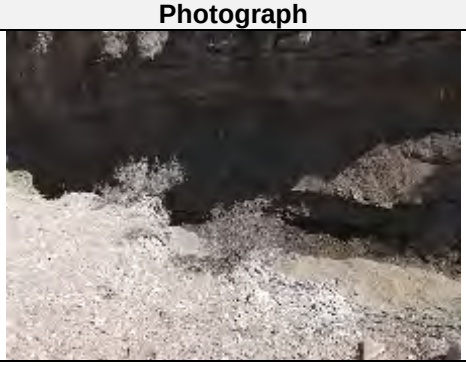
Reach	Station Range	Description	Photograph
Lower	1144 through 2387	The Lower reach of the NDC is blasted through the Dilco Hill and has a rock foundation. The channel slope through this section is steep (approximately 3.0% average). Channel cross-sections through this reach are deep with steep sidewall, and are comprised of weathered bedrock with very little vegetation.	
Middle	2387 through 3638	The Middle reach of the NDC is formed by a large berm constructed with approximately 1.5 horizontal to 1 vertical side slopes forming the left (west) (left) channel bank. There is no defined right channel bank through the majority of this section and the cross- section extends into the relatively flat alluvial area located to the west. The channel slope through this section is approximately 0.5% with moderately dense growth of grass and brush.	
Upper	3638 through 6121	The Upper reach of the NDC is formed with a large berm on the left (north and east) bank and excavation of the adjacent hillside to form the right bank. The channel bed slope along this reach is an average of 0.5% with sparse grasses and brush.	

Table 2: Manning's Roughness Values Assigned to North Diversion Channel Reaches for Current Average Roughness Conditions Analysis

Reach	Left Bank	Channel	Right Bank	*Description
Lower	0.03	0.03	0.03	Excavated channel - Earth bottom and rubble sides
Middle	0.05	0.035	0.05	Flood plains – Scatter brush with heavy weeds (minimum coverage in the channel)
Upper	0.035	0.035	0.035	Flood plains – Scatter brush with heavy weeds (minimum)

*The reach description corresponds to Table 5-6 Values of the Roughness Coefficient from Chow (1959)

Table 3: Roughness Values Assigned for to the North Diversion Channel Reaches for Sensitivity Analysis of Maximum Expected Roughness Conditions

Reach	Left Bank	Channel	Right Bank	*Description
Lower	0.04	0.04	0.04	Excavated channel – Stone bottom and weedy banks (Maximum)
Middle	0.07	0.07	0.07	Flood plains – Scatter brush with heavy weeds (maximum)
Upper	0.05	0.05	0.05	Flood plains – Scatter brush with heavy weeds

*The reach description corresponds to Table 5-6 Values of the Roughness Coefficient from Chow (1959)

Table 4: PMF Discharge for Each Reach

Reach	Discharge (cfs)
Lower	2850
Middle	2780
Upper	993

cfs = cubic feet per second

Table 5: Maximum Velocity by Reach in the North Diversion Channel

Reach	Velocity (fps)
Lower	29.2
Middle	10.6
Upper	11.4

fps = feet per second

FIGURES

Figure 1: Channel Alignment, Stationing and Cross-Section Locations for the North Diversion Channel Hydraulic Model

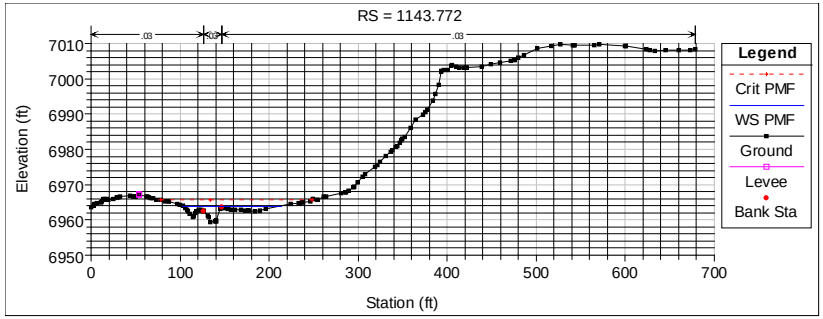


Figure 2: Cross Section 5 (River Station 1144)

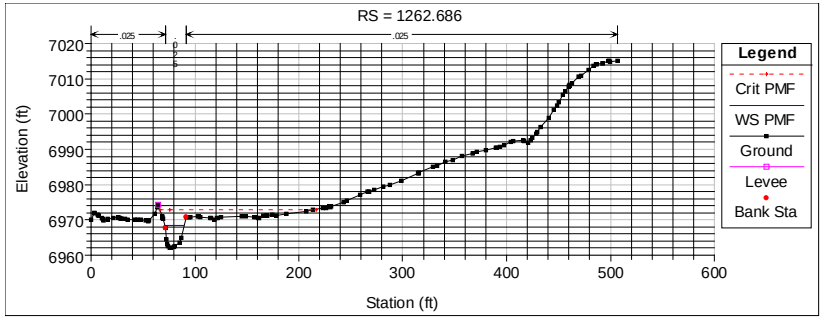


Figure 3: Cross Section 6 (River Station 1263)

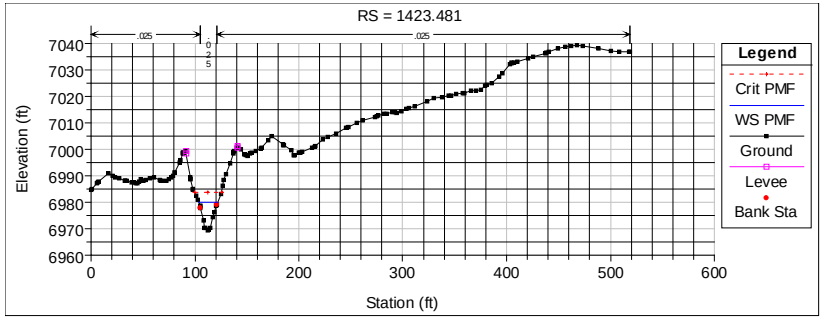


Figure 4: Cross Section 7 (River Station 1423)

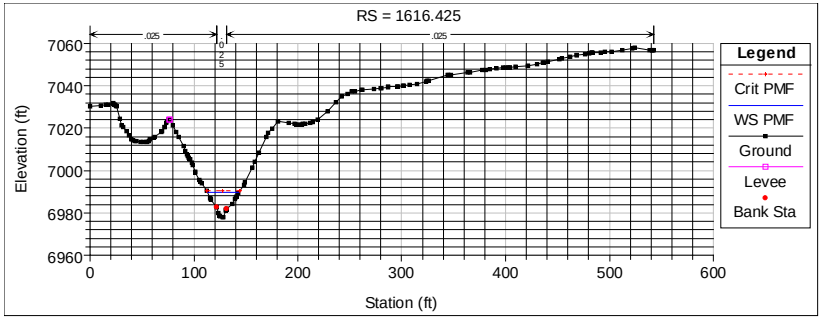


Figure 5: Cross Section 8 (River Station 1616)

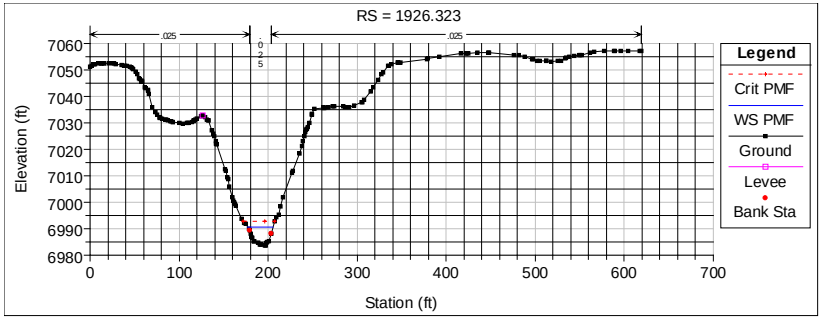


Figure 6: Cross Section 9 (River Station 1926)

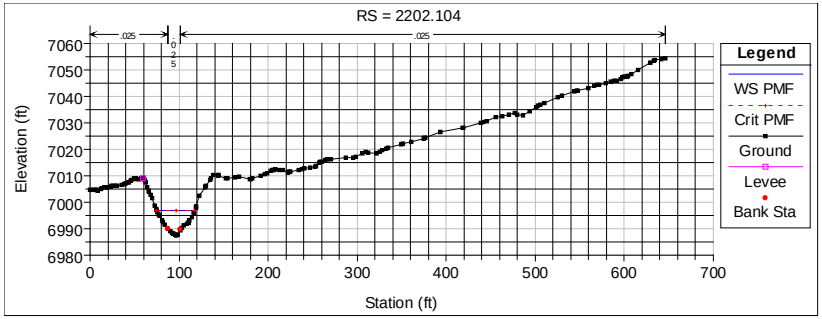


Figure .7: Cross Section 10 (River Station 2202)

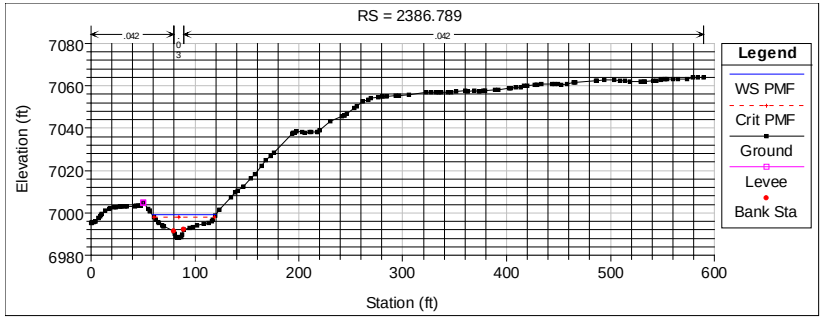


Figure 8: Cross Section 11 (River Station 2387)

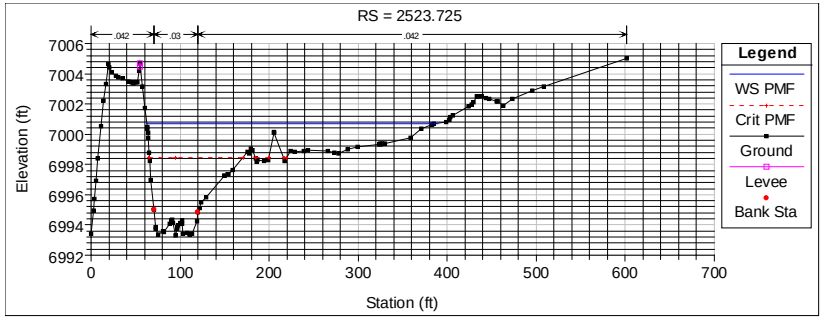


Figure 9: Cross Section 12 (River Station 2524)

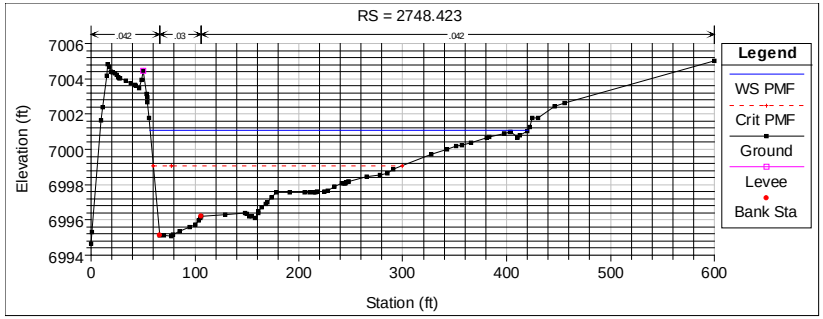


Figure 10: Cross Section 13 (River Station 2748)

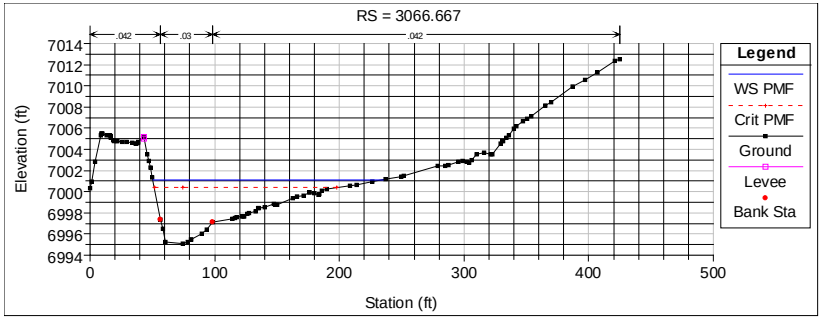


Figure 11: Cross Section 14 (River Station 3067)

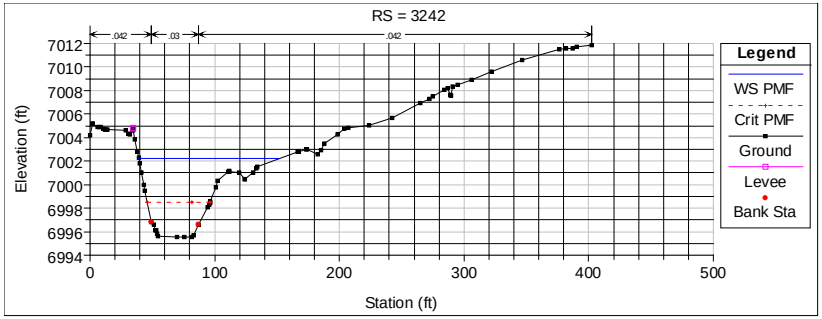


Figure 12: Cross Section 15 (River Station 3242)

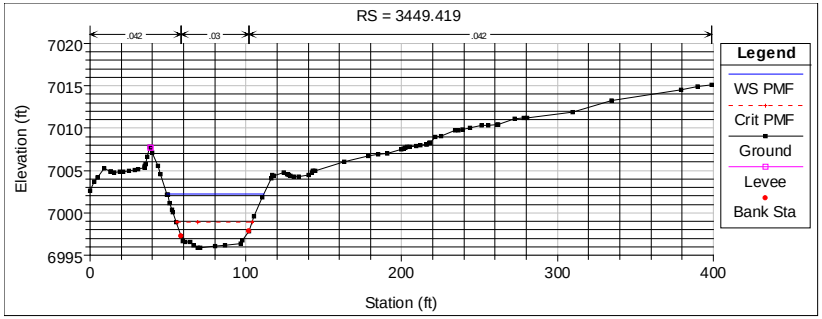


Figure 13: Cross Section 16 (River Station 3449)

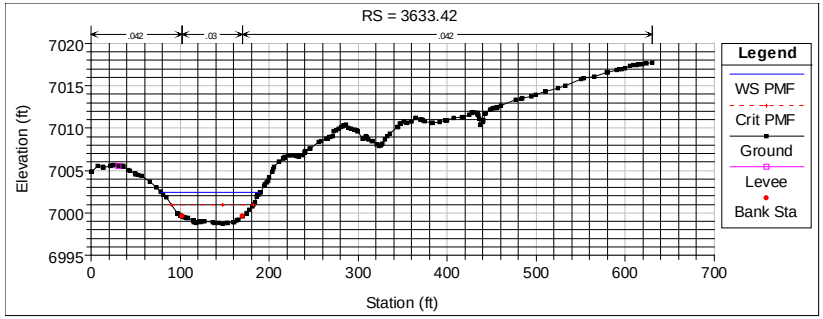


Figure 14: Cross Section 17 (River Station 3633)

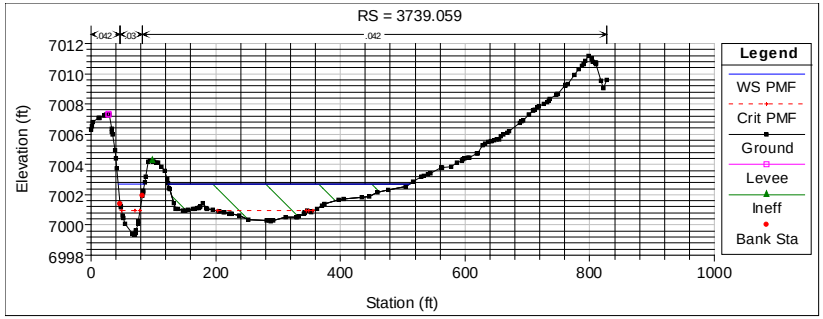


Figure 15: Cross Section 18 (River Station 3739)

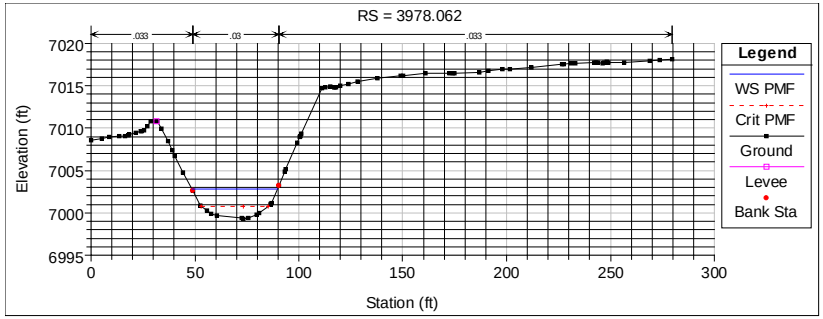


Figure 16: Cross Section 19 (River Station 3978)

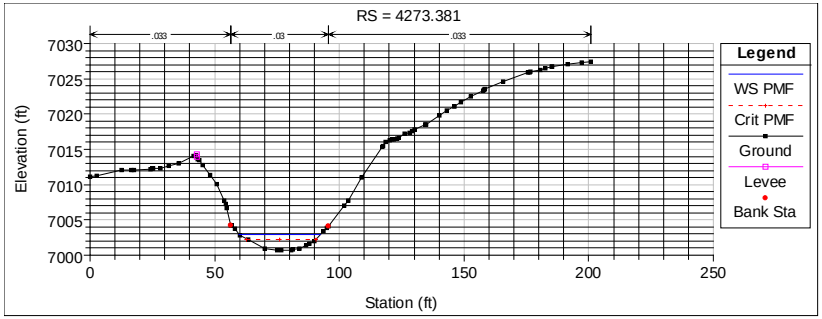


Figure 17: Cross Section 20 (River Station 4273)

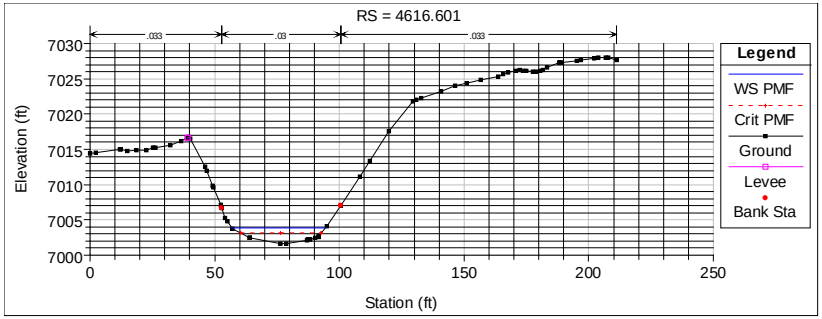


Figure 18: Cross Section 21 (River Station 4617)

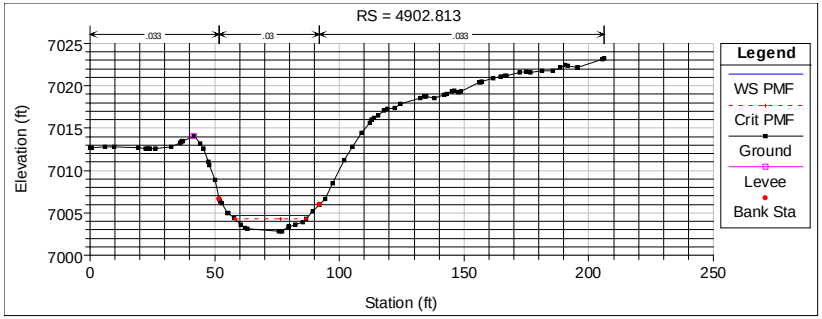


Figure 19: Cross Section 22 (River Station 4903)

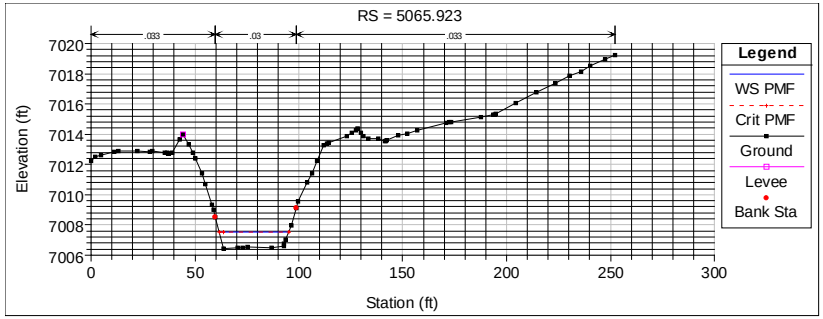


Figure 20: Cross Section 23 (River Station 5066)

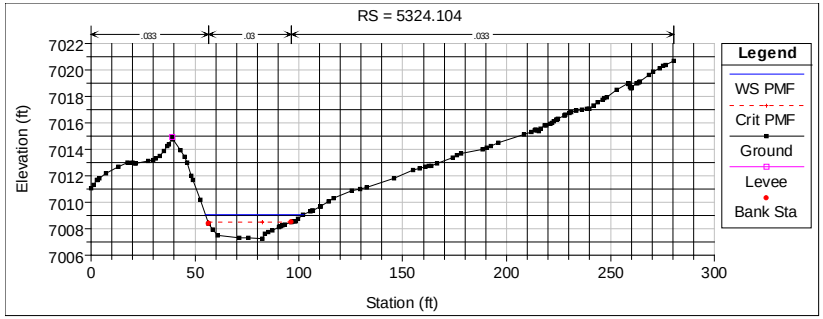


Figure 21: Cross Section 24 (River Station 5324)

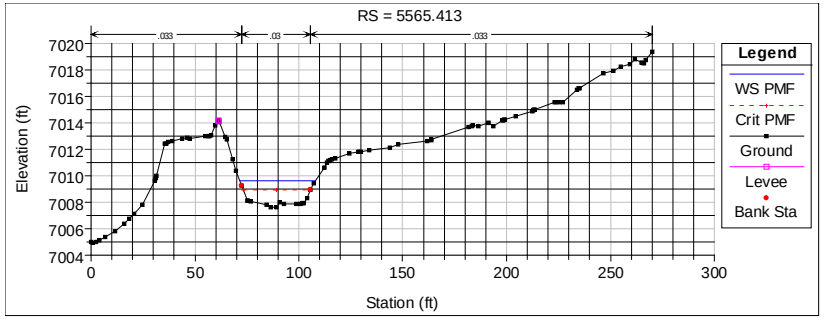


Figure 22: Cross Section 25 (River Station 5565)

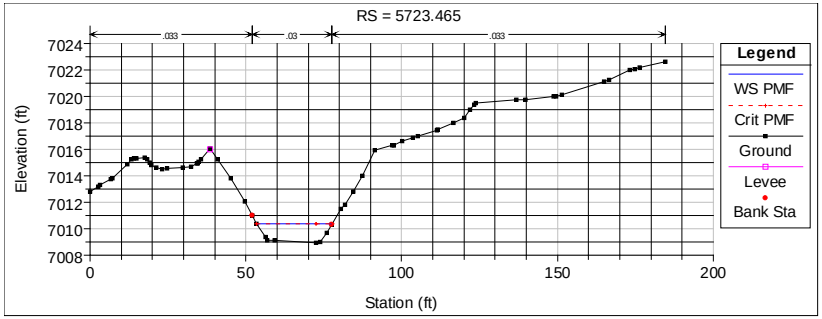


Figure 23: Cross Section 26 (River Station 5723)

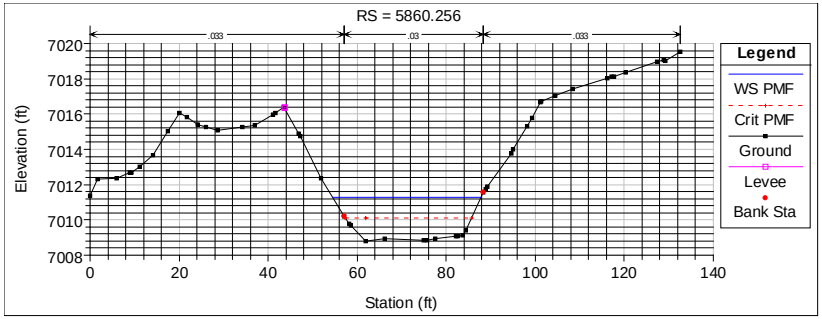


Figure 24: Cross Section 27 (River Station 5860)

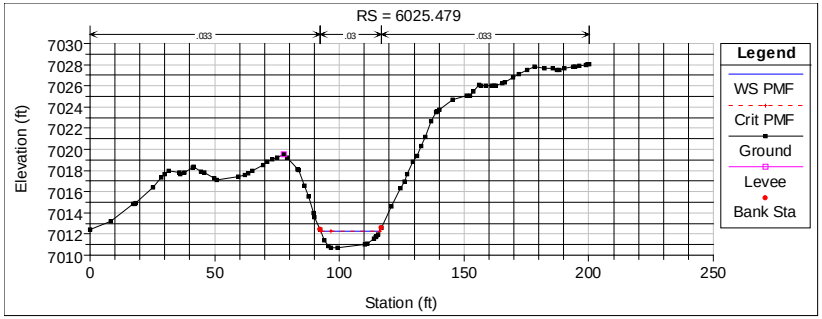


Figure 25: Cross Section 28 (River Station 6025)

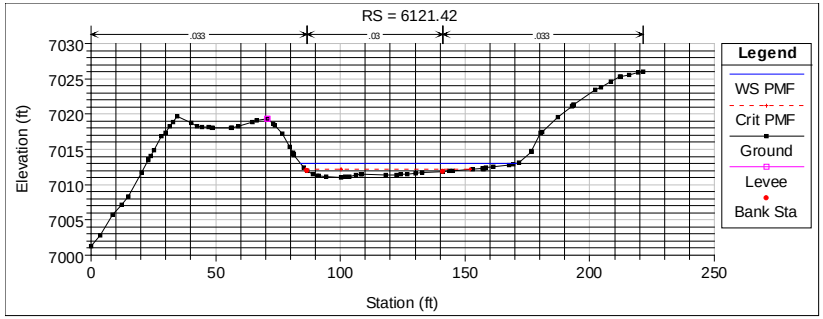


Figure 26: Cross Section 29 (River Station 6121)

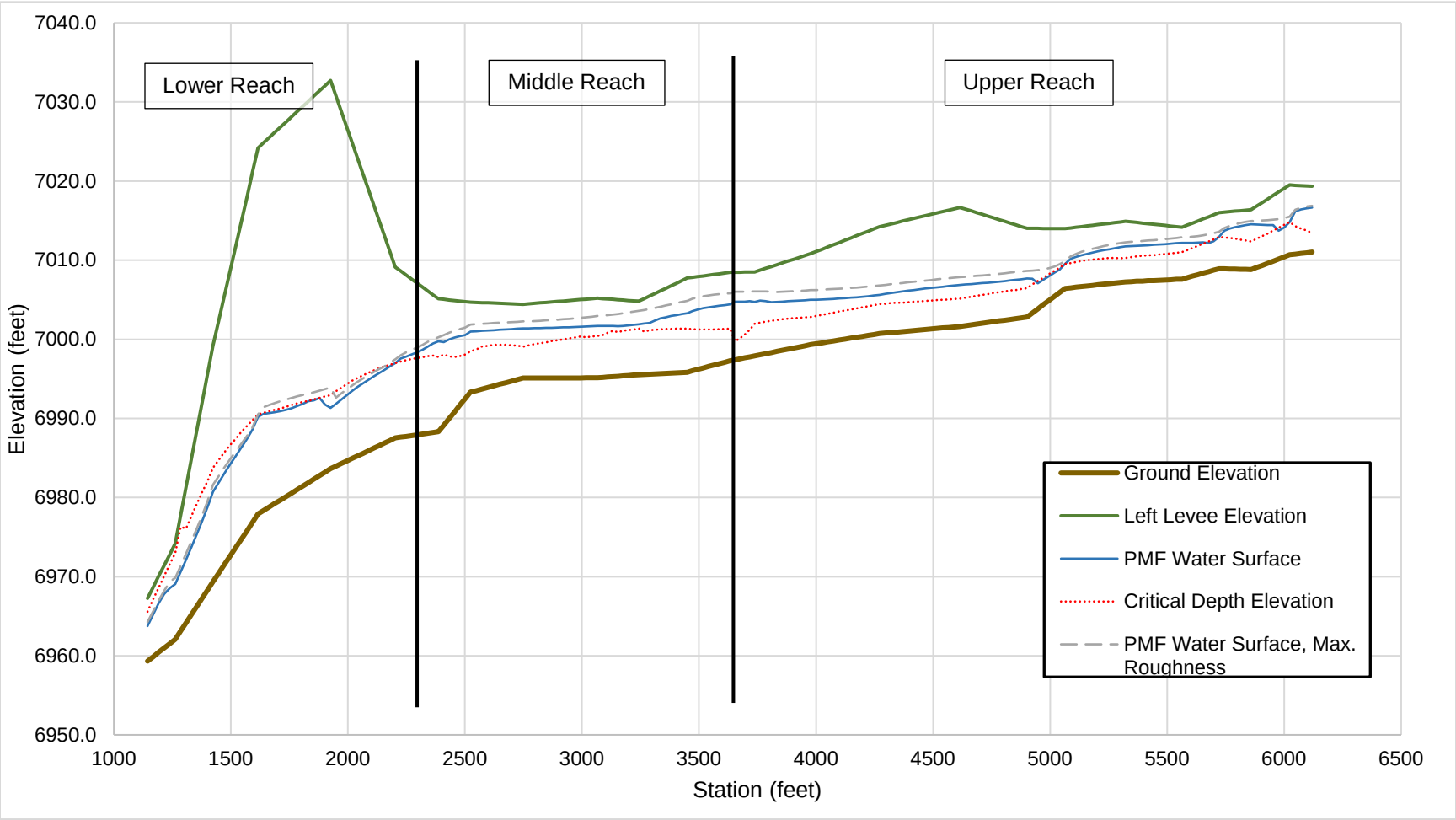


Figure 27: North Diversion Channel Water Surface, Critical Depth, and Left Levee Profile Plot

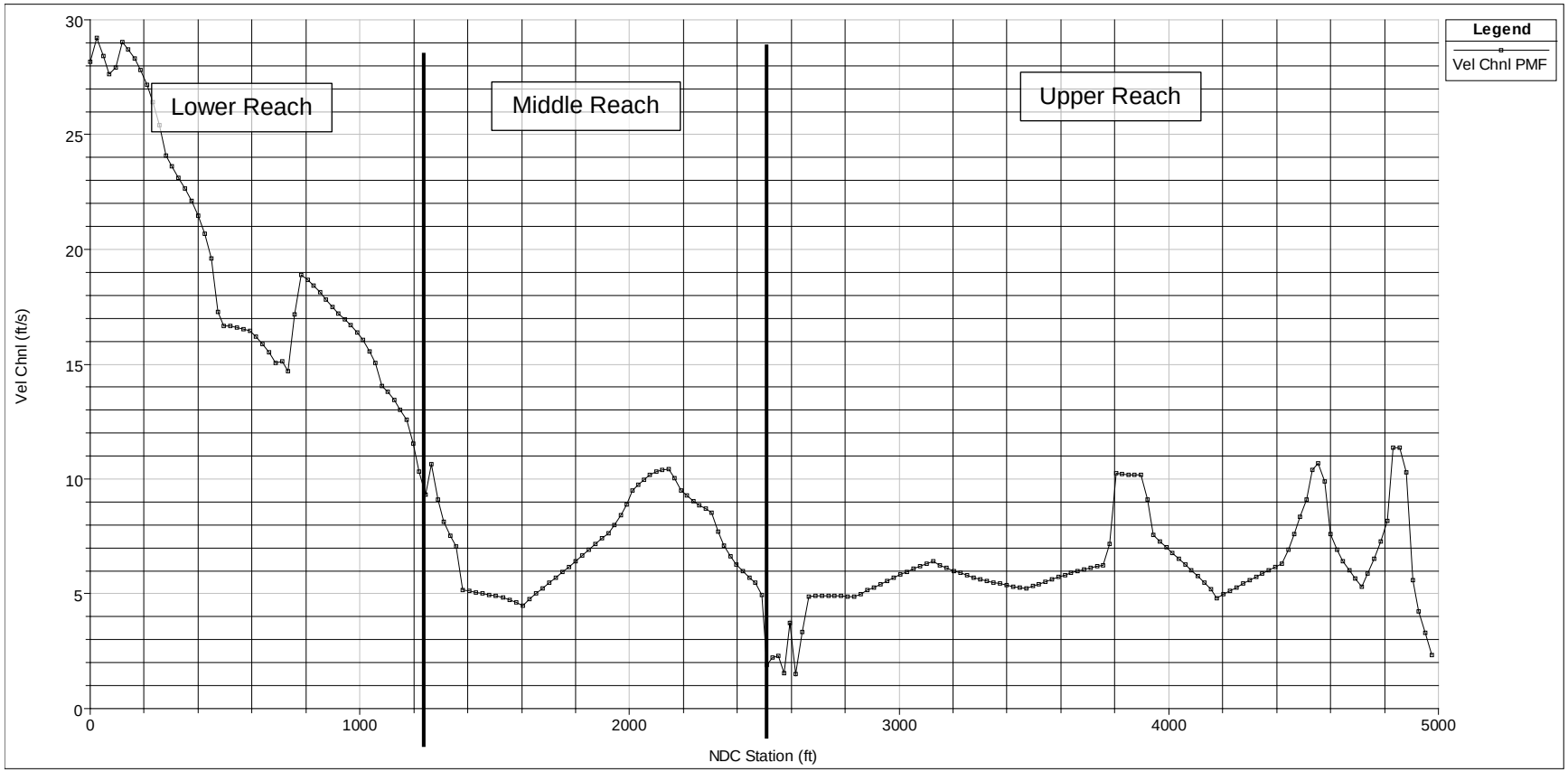


Figure 28: North Diversion Channel Velocity Profile

ATTACHMENT I.3
Evaluation of Mill Site Repository Channels Capacity and Erosional Stability

ATTACHMENT I.3: EVALUATION OF MILL SITE REPOSITORY CHANNELS CAPACITY AND EROSIONAL STABILITY

Revisioning

Rev.	Date	Description	By	Checked	Date
0	*4/15/2016*	*Preliminary (30%) Design*	*J. Erickson*	*C. Michalos*	*5/11/2016*

Revisions

Issue Date	Description
--	--

Location and Format

Electronic copies of these calculations are located on the project team site.

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Objectives

The objectives of this calculation brief are to evaluate the capacity and erosion stability (i.e., riprap size) of the proposed stormwater channels for the Mill Site Repository after remedial actions (RA) are completed Sediment transport and control measures calculations are described in calculation brief Attachment I-4: Analysis of Lower Repository Channel Sediment Transport Competency.

Background

These calculations evaluate design parameters for the stormwater and sediment control channels for the Mill Site Repository. These channels are shown on the Section 9 Drawings and include the East Repository Channel, (existing) runoff control ditch on the west side of the Repository, (existing) Drainage Swale H on the south side of the Repository, and Dilco Hill sediment control channels A and B. Some reaches of the East Repository Channel follow the alignment of the existing Drainage Swale C, and the calculations also the design parameters for these existing reaches assess the suitability of the existing channel condition for when the repository is in place. The channels and reaches included in the calculations are listed in **Table 1**.

Applicable Codes and Standards

Design criteria for the East Repository Channel stability and capacity are summarized below:

- The design storm is the probable maximum flood (PMF).
- Channels must be designed with 0.5 feet of freeboard (MWH, 2015).
- Riprap and filters must be sized to provide scour protection against the PMF using methods given by the United States Nuclear Regulatory Commission (NRC) (Johnson, 2002 and Nelson et al., 1986). Filters must be designed to meet compatibility criteria given by the NRC (Nelson et al., 1986)

Methods

Design Flow Rates

The design event for the Mill Site stormwater controls is the PMF. Estimates and methods for determination of PMF flow rates are presented in calculation brief Attachment I-1 (Estimation of Flood Flows for Design of Interim and Post-Removal Surface Water Controls for the Removal Action at the Northeast Church Rock Mine Site and Church Rock Mill Site). **Table 1** lists the PMF flow rates for channels and reaches. The stationing and reaches of the proposed East Repository Channel are shown on the Section 9 Drawings.

Channel Depth

MWH assumed normal flow and computed the maximum flow depth (Y_{max}) using Manning's Equation:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2} \qquad \text{Equation 1}$$

Where:

Q = Peak design discharge (cubic feet per second [cfs])
A = Channel cross-sectional area (square feet [ft^2]
R = Channel hydraulic radius = A/P, where P is the wetted perimeter (ft)
n = Manning roughness, dimensionless

The maximum flow depths can then be solved using the geometric relationships for the area and wetted perimeter of the channel. MWH estimated Manning's roughness values using the Strickler method from USACE (1991) as recommended in Johnson (2002).

$$n = C(k_s * 12)^{\frac{1}{6}} \qquad \text{Equation 2}$$

Where:

C = 0.034 for riprap stability computations; 0.038 for discharge capacity computations

k_s = D_{90} (diameter which is larger than 90% of the channel riprap) (inches), assumed to be 1.6 times D_{90} for proposed channel reaches, based on standard riprap gradation specifications recommended by the United States Department of Transportation (1989).

Superelevation

MWH accounted for superelevated depths along the inboard side of channel bends using the centrifugal force method presented in USACE (1991):

$$\Delta y = K\frac{V^2T}{gR} \qquad \text{Equation 3}$$

Where:

- Δy = superelevated depth (ft)
- K = flow type parameter (1.0 for supercritical flow and 0.5 for subcritical flow)
- T = flow top width (ft)
- g = gravitational acceleration (32.2 ft/s^2)
- R = channel bend radius at center-line of channel (ft)

Freeboard

The channel freeboard is the difference in the channel depth and the flow depth (including superelevation).

Riprap Size

The hydraulic calculations assume normal depth in the channel reaches.

The minimum required median channel riprap diameter was calculated using the shear stress method given by Johnson (2002), assuming a stone unit weight of 165 pounds per cubic foot.

$$D_{50min} = \frac{t}{4.51} * 12 \qquad \text{Equation 4}$$

Where:

- D_{50} = Median riprap diameter (inches)
- t = channel shear stress,
  - $t = \gamma_w * S_{max} * Y$ (pounds per square foot [psf])
- γ_w = unit weight of water (62.4 pounds per cubic foot [pcf])
- Y = channel normal depth (feet)
- S_{max} = friction slope (equivalent to channel bed slope at normal depth) (feet per foot [ft/ft])

Filter Criteria

The evaluation of filter requirements uses the Terzaghi filter criteria as presented in Nelson et al. (1986):

$$\frac{D_{15}(\text{filter})}{D_{85}(\text{base})} < 5 \qquad \text{Equation 5}$$

Where:

- D_{15} = Diameter at which 15 percent of the particles (by weight) are smaller
- D_{85} = Diameter at which 85 percent of the particles (by weight) are smaller

The “filter” and “base” designations refer to the coarser and finer granular layers, respectively. The calculations evaluate filter compatibility for between the granular filter layer (filter) and underlying subgrade (base) and between the riprap (filter)

and granular filter layer (base). MWH used 0.15 inches as the D_{85} particle size for the subgrade material, which is approximately the average D_{85} soil stockpile materials used to cover the borrow pit in the north cell over which Drainage Swale C was constructed (Figure 3.2 of Canonie, 1991). MWH specified riprap gradations using the Federal Highway Administration gradation windows (USDOT, 1989) (**Table 2**). MWH evaluated the subgrade and riprap against a slight modification of the Type 2 granular bedding layer gradation given in Drainage Design Manual for Maricopa County (Maricopa, 2013) (**Table 3**), with a minimum D_{85} of approximately 1 inch and a maximum D_{15} of approximately 0.75 inches.

Assumptions

Assumptions that should be verified prior to final design include the following:

- The riprap sizing assumes NRC quality specifications for riprap (Johnson, 2002) are met including a minimum stone unit weight of 165 pounds per cubic foot. If riprap quality specifications are not met, the riprap size should be increased as described in Johnson (2002).
- The filter evaluation assumes the gradation of the subgrade below the East Repository Channel is similar to the soil stockpile material shown in Figure 3.2 of Canonie (1991)

Results

Tables 4 summarizes the recommended channel dimensions and resulting flow properties; **Table 5** identifies the minimum required riprap size (before quality considerations). **Table 6** shows the filter compatibility ratios for the subgrade and for the various riprap sizes. **Attachment A** to this calculation brief includes the calculation worksheets for the channel capacity and riprap sizing calculations.

Conclusions

The calculations show that the existing channel geometry and riprap size in the East Repository Channel from Station 0+00 to Station 18+50 (existing upper reach of Swale C) is suitable for post-RA conditions. Reaches of the East Repository Channel downstream of Station 18+50 require increases in the channel base width and/or riprap size for post-RA conditions. The existing drainage control ditch will have sufficient capacity post-RA but the riprap in the channel will need to be upsized for stability during the PMF event. The required channel dimensions and riprap sizes for other proposed channels are as shown in in **Table 4** and **Table 5**. **Table 6** indicates that a single bedding layer will be sufficient, with the gradation of the bedding layer as shown in **Table 3**.

Attachments

Attachment A – Calculation Worksheets

References

Canonie Environmental (Canonie), 1991. Tailings Reclamation Plan As Approved by NRC March 1, 1991. License No. SUA – 1475.

Johnson, T.L., 2002. Design of Erosion Protection for Long-Term Stabilization. U.S. Nuclear Regulatory Commission, September.

Maricopa, 2013. Drainage Design Manual for Maricopa County – Hydraulics. Flood Control District of Maricopa County

MWH, 2015. Design Criteria and Methods Report. Northeast Church Rock Mine Site Removal Action. November 23, 2015

Nelson, J.D.S., R. Abt, R.K. Volpe, D. van Zyl, N.E. Hinkle, W.P. Staub, 1986. Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments. NUREG/CR-4620.

United States Army Corps of Engineers (USACE), 1991. Hydraulic Design of Flood Control Channels. EM 1110-2-1601. U.S. Army Corps of Engineers.

U.S. Department of Transportation (USDOT), Federal Highway Administration, 1989. Design of Riprap Revetment, Hydraulic Engineering Circular No. 11, Publication No. FHWA-IP-89-016.

TABLES

Table 1: Channels Reaches and PMF Flow Rates

Channel Reach	PMF Flow Rate (cfs)
East Repository Channel STA 00+00 to 18+50	97.5
East Repository Channel STA 18+50 to 28+30	140.2
East Repository Channel STA 28+30 to 34+60	227.5
East Repository Channel STA 34+60 to 41+39	274
Dilco Hill Channel A	14.3
Dilco Hill Channel B	8.5
Branch Swale H	120.8

Table 2: Riprap Gradations

Percent Smaller Than	USDOT Riprap Gradation Limits	
	Minimum Size (x D_{50})	Maximum Size (x D_{50})
100	1.5	1.7
85	1.2	1.4
50	1.0	1.15
15	0.4	0.6

Table 3: Bedding Layer Grading Envelope

Type 2 Bedding Material			
Sieve Size	Opening Size (inches)	Percent Passing	
		Max	Min
3-in	3.00	90	100
3/4-in	0.75	20	80
#4	0.19	0	20
#200	0.003	0	3

Note:
Gradation envelope adapted from Simons, Li, and Associates (1989)

Table 4: Evaluation of Channel Capacity at PMF Flow

Channel Reach	East Repository Channel STA 00+00 to 18+50*	East Repository Channel STA 18+50 to 28+30	East Repository Channel STA 28+30 to 34+60	East Repository Channel STA 34+60 to 41+39	Dilco Hill Channel A	Dilco Hill Channel B	Branch Swale H*	Runoff Control Ditch
Min. Slope (ft/ft)	0.005	0.005	0.011	0.010	0.10	0.08	0.009	0.008
Base Width (ft)	7.7	10	12	12	8	3	19	10
Channel Side Slope (z:1)	4	3	3	3	3	3	4	5
Channel Depth (ft)	2.2	2.75	3.05	4.0	1.0	1.0	2.0	2.0
Flow Depth at PMF (ft)	1.7	2.1	2.5	3.5	0.3	0.4	1.1	1.3
Freeboard at PMF (ft)	0.5	0.7	0.6	0.6	0.7	0.6	0.9	0.7

Note:
* Existing channel

Table 5: Evaluation of Channel Erosion Stability (Riprap Size) at PMF Flow

Channel Reach	East Repository Channel STA 00+00 to 18+50	East Repository Channel STA 18+50 to 28+30	East Repository Channel STA 28+30 to 34+60	East Repository Channel STA 34+60 to 41+39	Dilco Hill Channel A	Dilco Hill Channel B	Branch Swale H	Runoff Control Ditch
Max. Slope (ft/ft)	0.005	0.005	0.03	0.016	0.10	0.08	0.015	0.008
Existing Median Riprap Size (inches)	1.5	1.5	3.0	9.0	NA	NA	3.0	1.5
Required Median (D_{50}) Riprap Size (inches)	1.48	1.81	9.53	8.90	5.2	5.5	2.7	1.9
Design Median Riprap Size (inches)	Use Existing	3.0	12	12	6.0	6.0	Use Existing	3.0

Table 6: Filter Compatibility Requirements

Filter Condition:	D_{15} Filter (inches)	D_{85} Base (inches)	Ratio D_{15}/D_{85}
Type 2 bedding to subgrade	0.75	0.15	5
3-in Riprap to Type 2 bedding	2	1	2
6-in Riprap to Type 2 bedding	4	1	4
9-in Riprap to Type 2 bedding	5	1	5

ATTACHMENT A

CALCULATION WORKSHEETS

Repository Area Channel Capacity Evaluation

Computed by: JNE
Date: 4/8/2016

Parameter	Unit	East Repository STA 00+00 to 18+50 (Swale C - Existing)	East Repository STA 18+50 to 28+30 (Swale C- Existing)	East Repository STA 18+50 to 28+30 (Swale C- Improved)	East Repository Channel STA 28+30 to 34+60	East Repository Channel STA 34+60 to 41+39	Dilco Hill Channel A	Dilco Hill Channel B	Branch Swale H	Runoff Control Ditch		Notes:
Inputs												
Design Discharge, Q (cfs) :	cfs	97.5	140.2	140.2	227.5	274	14.3	8.5	120.8	92		From MWH Hydrologic Evaluation
Bottom Width, B (ft) :	ft	7.7	7.7	10	12	12	8	3	19	10		Measure from survey surface. (Cooper, 2013)
Side Slope Anlge, Z:1 :	z:1	4	4	3	3	3	3	3	4	5		Measure from survey surface. (Cooper, 2013)
Low-Flow Side Slope Angle, Z:1 :	z:1	-	-	-	-	6	-	-				
Low-Flow Channel Depth, DLF (ft) :	ft	-	-	-	-	1	-	-				
Minimum Channel Slope, Smin (ft/ft) :	ft/ft	0.005	0.005	0.005	0.011	0.01	0.1	0.08	0.009	0.008		Measured from survey surface. (Cooper, 2013)
Riprap Diameter, D50 (in) :	inch	1.5	1.5	3	12	12	6	6	3	1.5		From Canonie (1991) Design Documents (table 5.6)
Riprap Diameter, D90 (in) :	inch	2.4	2.4	4.8	19.2	19.2	10.5	10.5	4.8	2.4		From Canonie (1991) Design Documents
Channel Roughness (Capacity), nc :	-	0.029	0.029	0.033	0.041	0.041	0.037	0.037	0.030	0.029		Strickler Method (USACE, 1991)
Design/Existing Channel Depth, D (ft) :	ft	2.2	2.2	2.75	3.05	4.00	1.00	1.00	2.00	2.00		MWH (2014) or this design
Critical bend radius	ft	295	NA	NA	240	NA	300	225	1100	NA		
Slope around critical bend	ft/ft	0.0065	NA	NA	0.0301	NA	0.1	0.08	0.02	NA		
Straight Channel Flow Depth, Y (ft) :	ft	1.7	2.0	2.1	2.3	3.3	0.3	0.4	1.1	1.3		
Iteration to Zero -->		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
Flow Area -Min Slope, A (ft2) :	ft2	24.7	32.2	33.8	43.2	49.9	2.7	1.7	26.7	21.3		A = B*Y+Z*Y^2
Wetted Perimeter -Min Slope, P (ft) :	ft	21.7	24.5	23.1	26.5	26.8	9.9	5.5	28.4	23.2		P = B+2*Y*(Z^2+1)^0.5
Straight Channel Freeboard, FB (ft) :	ft	0.5	0.2	0.7	0.8	0.7	0.7	0.6	0.9	0.7		
Critical Bend												
Bench Channel Flow Depth, Y (ft) :	ft	1.6	NA	NA	1.8	NA	0.3	0.4	1.0	NA		
Iteration to Zero -->		-0.67	NA	NA	0.00	NA	0.00	0.22	0.00	NA		72.03
Flow Area -Bend Slope, A (ft2) :	ft2	22.6	NA	NA	30.2	NA	2.7	1.6	22.5	NA		A = B*Y+Z*Y^2
Wetted Perimeter -Bend Slope, P (ft) :	ft	20.9	NA	NA	23.1	NA	9.9	5.5	27.1	NA		P = B+2*Y*(Z^2+1)^0.5
Top Width around bend	ft	20.5	NA	NA	22.5	NA	9.8	5.4	26.8	NA		
Velocity around bend	ft	4.3	NA	NA	7.5	NA	5.3	5.2	5.4	NA		
Froude Number	ft	0.7	NA	NA	1.1	NA	1.8	1.7	1.0	NA		
C value	-	0.5	NA	NA	1.0	NA	1.0	1.0	1.0	NA		
Super-elevation	ft	0.02	NA	NA	0.16	NA	0.03	0.02	0.02	NA		USACE (1991)
Bend Channel Freeboard, FB (ft) :	ft	0.6	NA	NA	1.1	NA	0.7	0.6	1.0	NA		

References

Canonie Environmental (Canonie). 1991. Tailings Reclamation Plan As Approved by NRC March 1, 1991. License No. SUA – 1475.
Cooper, 2013. Survey of Churchrock Mill Site Completed by Cooper Aerial Surveys in 2013.
USACE, 1991. Hydraulic Design of Flood Control Channels. EM 1110-2-1601. U.S. Army Corps of Engineers.

NECR East Repository Channel Riprap Evaluation

Computed by: JNE
Date: 4/8/2016

Channel Section	East Repository STA 00+00 to 18+50 (Swale C - Existing)	East Repository STA 18+50 to 28+30 (Swale C- Existing)	East Repository STA 18+50 to 28+30 (Swale C- Improved)	East Repository Channel STA 28+30 to 34+60	East Repository Channel STA 34+60 to 41+39		Notes:
Design Discharge, Q (cfs) :	97.5	140.2	140.2	227.5	274		From MWH Hydrologic Evaluation
Bottom Width, B (ft) :	7.7	7.7	10	12	12		Measure from survey surface. (Cooper, 2013)
Side Slope Angle, Z:1 :	4	4	3	3.7	3.2		Measure from survey surface. (Cooper, 2013)
Low-Flow Side Slope Angle, Z:1 :	-	-	-	-	6		
Low-Flow Channel Depth, DLF (ft) :	-	-	-	-	1		
Maximum Channel Slope, Smax (ft/ft) :	0.005	0.005	0.005	0.03	0.016		Maximum channel slope. Measured from survey surface. (Cooper, 2013)
In-place or Design Median Riprap Diameter, D50 (in) :	1.5	1.5	3	12	12		From Canonie (1991) Design Documents (table 5.6)
place or Design 90th Percentile Riprap Diameter, D90 (in) :	2.4	2.4	4.8	19.2	19.2		From Canonie (1991) Design Documents or D90=1.75*D50
Channel Roughness (Stability), ns :	0.026	0.026	0.029	0.037	0.037		Strickler Method (USACE, 1991)
Flow Depth, Y (ft) :	1.61	1.93	1.96	1.61	2.85		Computed
Iteration to Zero -->	0.00	0.00	0.00	0.00	0.00		Convergence parameter
Flow Area, A (ft2) :	22.8	29.7	31.2	28.8	39.2		A = B*Y+Z*Y^2
Wetted Perimeter, P (ft) :	21.0	23.6	22.4	24.2	24.6		P = B+2*Y*(Z^2+1)^0.5
Top Width, W (ft) :	20.6	23.1	21.8	23.8	30.2		W = B+2*Z*Y
Average Velocity, V (fps) :	4.28	4.72	4.50	7.89	6.99		V = Qd/A
Froude Number, Fr :	0.72	0.73	0.66	1.26	1.08		Fr = V/(32.2*A/W)^0.5
Max Shear Stress, Tmax (lbs/ft2) :	0.50	0.60	0.61	3.02	2.85		Tm = 62.4*S*Ys
Computed Minimum Riprap Diameter, D50 min (in)	1.47	1.76	1.79	8.83	8.33		D50min = Tm/4.1*12 (Johnson, 2002) (Assumes stone weight of 165 pcf)
OK?	Yes	No	Yes	Yes	Yes		

References

Canonie Environmental (Canonie). 1991. Tailings Reclamation Plan As Approved by NRC March 1, 1991. License No. SUA – 1475.

Cooper, 2013. Survey of Churchrock Mill Site Completed by Cooper Aerial Surveys in 2013.

NRC, 2002. Design of Erosion Protection for Long-Term Stabilization. Appendix D - Procedures for Designing Riprap Erosion Protection. U.S. Nuclear Regulatory Commission.

USACE, 1991. Hydraulic Design of Flood Control Channels. EM 1110-2-1601. U.S. Army Corps of Engineers.

Proposed Channel Riprap Evaluation

Computed by: JNE
Date: 4/8/2016

Channel Section	Delco Hill Channel A	Delco Hill Channel B	Branch Swale H	Runoff Control Ditch		Notes
Discharge, Q (cfs) :	14.3	8.5	120.8	92		From MWH Hydrologic Evaluation
Bottom Width, B (ft) :	8	3	19	10		Design variable
Side Slope Anlge, Z:1 :	3	3	4	5		Design variable
Channel Slope, S (ft/ft) :	0.1	0.08	0.015	0.008		Measure from survey surface. (Cooper, 2013)
Design Riprap Diameter, D50d (in) :	6	6	3	3		Design variable
Riprap Diameter, D90d (in) :	10.5	10.5	5.5	4.5		Design variable
Channel Roughness, n :	0.033	0.033	0.030	0.029		Strickler Method (USACE, 1991)
Flow Depth, Y (ft) :	0.3	0.4	1.0	1.3		Computed
Iteration to Zero -->	0.00	0.00	0.00	0.00		0.00
Flow Area, A (ft2) :	2.5	1.5	22.4	21.2		Computed
Wetted Perimeter, P (ft) :	9.8	5.4	27.1	23.1		Computed
Top Width, W (ft) :	9.7	5.2	26.8	22.9		Computed
Average Velocity, V (fps) :	5.71	5.52	5.39	4.35		Computed
Froude Number, Fr :	1.98	1.79	1.04	0.80		Computed
Avg. Shear Stress, Ta (lbs/ft2) :	1.60	1.43	0.78	0.46		Ta = 62.4*S*(A/P)
Max Shear Stress, Tmax (lbs/ft2) :	1.77	1.87	0.92	0.64		Tm = 62.4*S*Y
Computed Minimum Riprap Diameter, D50min (in) :	5.2	5.5	2.7	1.9		Computed using NRC (2002)

References

Canonie Environmental (Canonie). 1991. Tailings Reclamation Plan As Approved by NRC March 1, 1991. License No. SUA – 1475.

Cooper, 2013. Survey of Churchrock Mill Site Completed by Cooper Aerial Surveys in 2013.

NRC, 2002. Design of Erosion Protection for Long-Term Stabilization. Appendix D - Procedures for Designing Riprap Erosion Protection. U.S. Nuclear Regulatory Commission.

USACE, 1991. Hydraulic Design of Flood Control Channels. EM 1110-2-1601. U.S. Army Corps of Engineers.

ATTACHMENT I.4
Analysis of Lower East Repository Channel Sediment Transport Competency

ATTACHMENT I.4: ANALYSIS OF LOWER EAST REPOSITORY CHANNEL SEDIMENT TRANSPORT COMPETENCY

Revisioning

Rev.	Date	Description	By	Checked	Date
0	*05/01/2016*	*Preliminary (30%) Design*	*J. Erickson*	*C. Michalos*	*05/11/2016*

Revisions

Issue Date	Description
--	--

Location and Format

Electronic copies of these calculations are located on the project team site.

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Objective

The objective of these calculations is to evaluate the effectiveness of sediment controls designed for the East Repository Channel.

Background

The proposed East Repository Channel (Drawing 9.02) will convey stormwater from the repository area that will be constructed as part of the Remedial Action (RA). The proposed East Repository Channel will primarily follow the alignment of the existing Drainage Swale C and North Cell Drainage Channel (See Drawing 9.01).

Currently, sediment accumulation along the reach in the existing Drainage Swale C that runs along the base of the south side of Dilco Hill has created localized high points in the swale that severely limit the swale capacity and are promoting further sediment deposition. Sediment has also accumulated in the upper reach of the North Cell Drainage

Channel where an erosional feature from Dilco Hill empties into the channel. The apparent source of the sediment is from bare areas on the south side of Dilco Hill and from an erosional feature on the east side of Dilco Hill. The reaches of concern and the apparent sediment source areas are shown in **Figure 1**.

The RA design for the East Repository channel proposes several controls to reduce sediment delivery to the East Repository Channel and to increase the sediment transport competency of the channel:

- Two interceptor channels would be constructed on Dilco Hill. The interceptor channels would reduce sediment delivery from Dilco Hill by cutting the overland flow length. The interceptor channels would also divert stormwater runoff and sediment from Dilco Hill into the lower reach of the East Repository Channel, which is designed for improve sediment transport competency.

- A rock check dam would be constructed at the base of the erosional feature where it empties into the East Repository Channel. The check dam would decrease sediment loading to the lower reach of the East Repository Channel.

- The lower reach of the East Repository Channel would be constructed to modify the base of the existing channel from flat to triangular. The purpose of the triangular section is to improve the sediment transport competency of the channel compared to the existing channel reach.

MWH performed a relative evaluation of the existing and modified cross section of the upper reach of the North Cell Channel (East Repository Channel Stations 34+60 to 41+39) and of the proposed Dilco Hill channels, using a critical particle diameter (Shields) analysis. The Shield Analysis estimates the largest (critical) particle diameter than can be mobilized from the channel bed under a given flow condition. A larger critical particle diameter is indicative of greater sediment transport competency.

Table 1 lists the proposed channel geometries for the existing and modified North Cell channel and the two Dilco Hill Channels.

Applicable Codes and Standards

The design of sediment controls addresses the performance standard outlined in the Record of Decision (ROD). The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required. (10 CFR §61.44).

Methods

The Shields analysis computes the largest particle (critical particle diameter) that can be mobilized from the channel bed at a given discharge. Although this does not explicitly evaluate the sediment transport capacity in the channel, it does provide a quantitative measure that can be used for relative comparison of channel sediment transport. MWH used the 2-year flood event as the design discharge for this analyses to represent a large flow event in which significant portions of sediment would be mobilized, and one that occurs frequently enough to move significant volumes of sediment over time. The 2-year peak flow estimates are provided in a separate calculation brief (Attachment I.1 - Estimate of Flood Flows for Design of Interim and Post-Removal Surface Water Controls for the Removal Action at the Northeast Church Rock Mine Site and Church Rock Mill Site) and are listed **Table 1**.

MWH assumed normal flow and estimated the critical particle diameter using the Shields Diagram shown in **Figure 2**. The Shields Diagram represents, using dimensional parameters, the empirical relationship between the shear stress in a channel and the initiation of motion for particles in the channel bed. In this relationship, bed particles of a critical particle diameter are mobilized at a critical bed shear stress. Using this relationship with the computed bed shear stress

under the design discharge provides an estimate of the largest (critical) particle diameter that can be mobilized. This analysis, by itself, is not sufficiently precise to determine the exact particle size that will mobilize and then be transported through the channel, but it is sufficient for the relative comparison.

MWH approximated the bed shear stress for use with the Shields curve using Equation 1.

$$\tau_{max} = \gamma * S * Y_{max} \qquad \text{Equation 1}$$

Where:

τ_{max} = maximum Shear Stress in the channel (pounds per square foot [lbs/ft^2])
γ = unit weight of water (62.4 pounds per cubic foot [lbs/ft^3])
S = channel energy slope (feet per foot [ft/ft]), approximated as the channel bed slope for normal flow
Y_{max} = maximum flow depth in the channel (feet [ft])

MWH computed the maximum flow depth (Y_{max}) using Manning's Equation:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2} \qquad \text{Equation 2}$$

Where:

Q = Peak design discharge (cubic feet per second [cfs])
A = Channel cross-sectional area (square feet [ft^2]
R = Channel hydraulic radius = A/P, where P is the wetted perimeter
n = Manning roughness

The maximum flow depths can then be solved using the geometric relationships for the area and wetted perimeter of the channel. The calculations used Manning's Roughness (n) values determined for the existing or proposed channel riprap as explained in Attachment I-3 – Evaluation of Mill Site Repository Channels Capacity and Erosional Stability.

Assumptions

These calculations make the following assumptions:

- Normal flow existing in the channels (constant bed slope and uniform, steady flow conditions)
- The particle density is 2.65
- The unit weight of water is 62.4 lbs/ft^3

Results

A comparison of computed critical particle diameters (**Table 1**) indicates that the sediment transport competency of the proposed East Repository Channel (Stations 34+60 to 41+39) would be approximately 3 times as great as the existing upper reach of the North Cell Drainage Channel. The comparison also indicates that this reach of the East Repository Channel would have greater sediment transport competency than the proposed Dilco Hill channels that would discharge into this reach.

Discussion

The Dilco Hill channels would reduce sediment delivery to the East Repository Channel between Stations 28+30 and 34+60 by breaking the flow lengths on the Dilco Hill slope and by intercepting mobilized sediment on the slope. The

Dilco Hill Channels would convey this mobilized sediment to the lower reach of the East Repository Channel (Stations 34+60 to 41+39). The calculation results indicate the lower reach of the East Repository Channel would have greater sediment transport competency than the two Dilco Hill Channels and could therefore convey sediment delivered from the Dilco Hill Channels.

Attachments

Calculation worksheets are provided in **Attachment A**.

TABLE

Table 1: Channel Flows, Geometries, and Critical Particle Diameters

Channel	Upper North Cell Drainage Channel (existing)[1]	East Repository Channel STA 34+60 to 41+39 (proposed)[2]	Dilco Hill Channel A (proposed)	Dilco Hill Channel B (proposed)
2-year Peak Flow (cfs)	3.81	3.81	0.087	0.031
Base Width (ft)	10	0	7	3
Side Slope (z:1)	3.2	5	3	3
Depth (ft)	3.5	1	2	3
Critical Particle Diameter (mm)	9	28	4.8	5.1

Notes:
1. Channel geometry values for the Upper North Cell Channel are as-built values
2. Channel geometry values for the East Repository Channel reach are for the low-flow channel that is in-set into the larger channel (see Section 9 drawings)

cfs = cubic feet per second
ft = feet
z = slope horizontal dimension

FIGURES

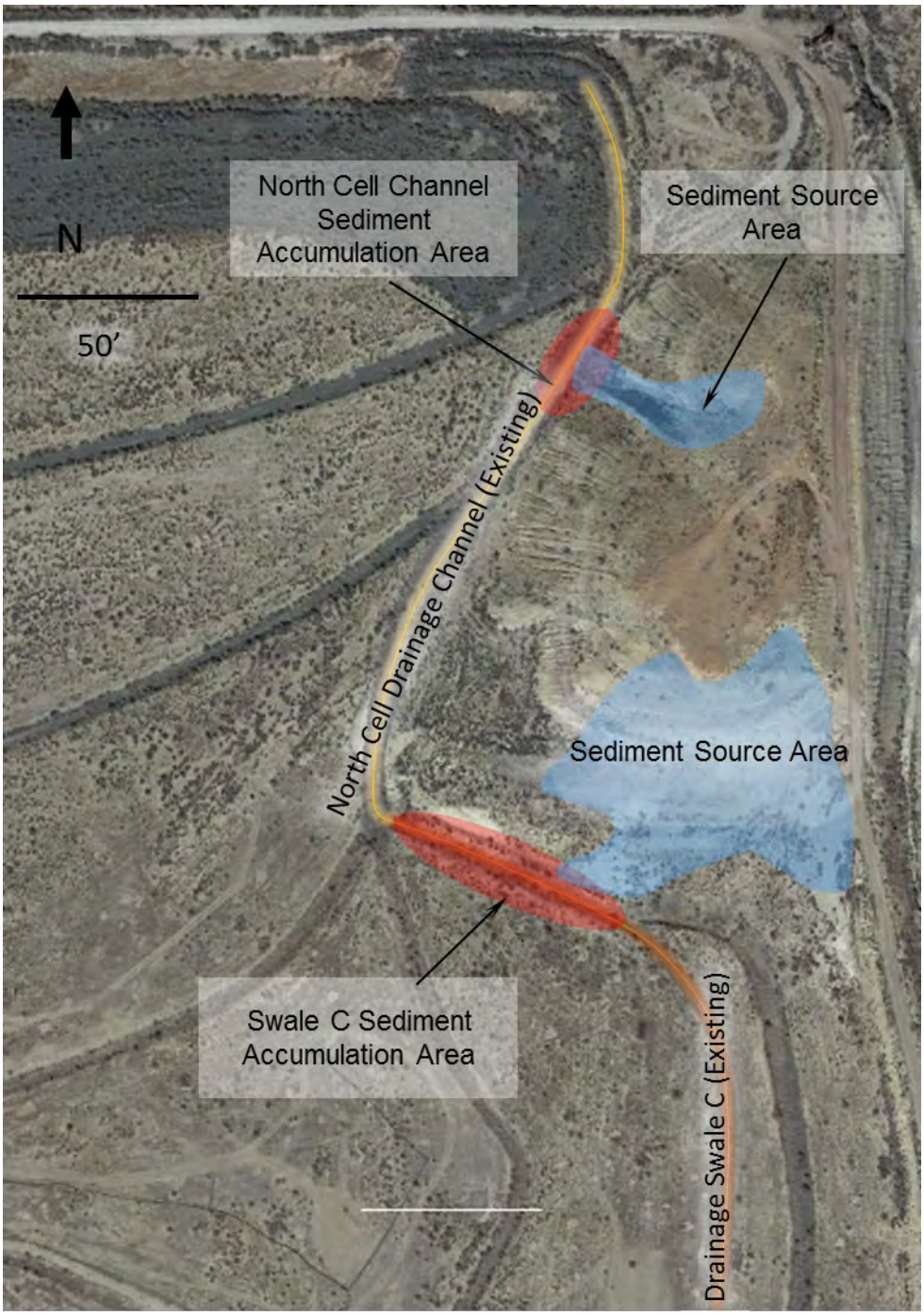

Figure 1: Existing Sediment Accumulation Areas

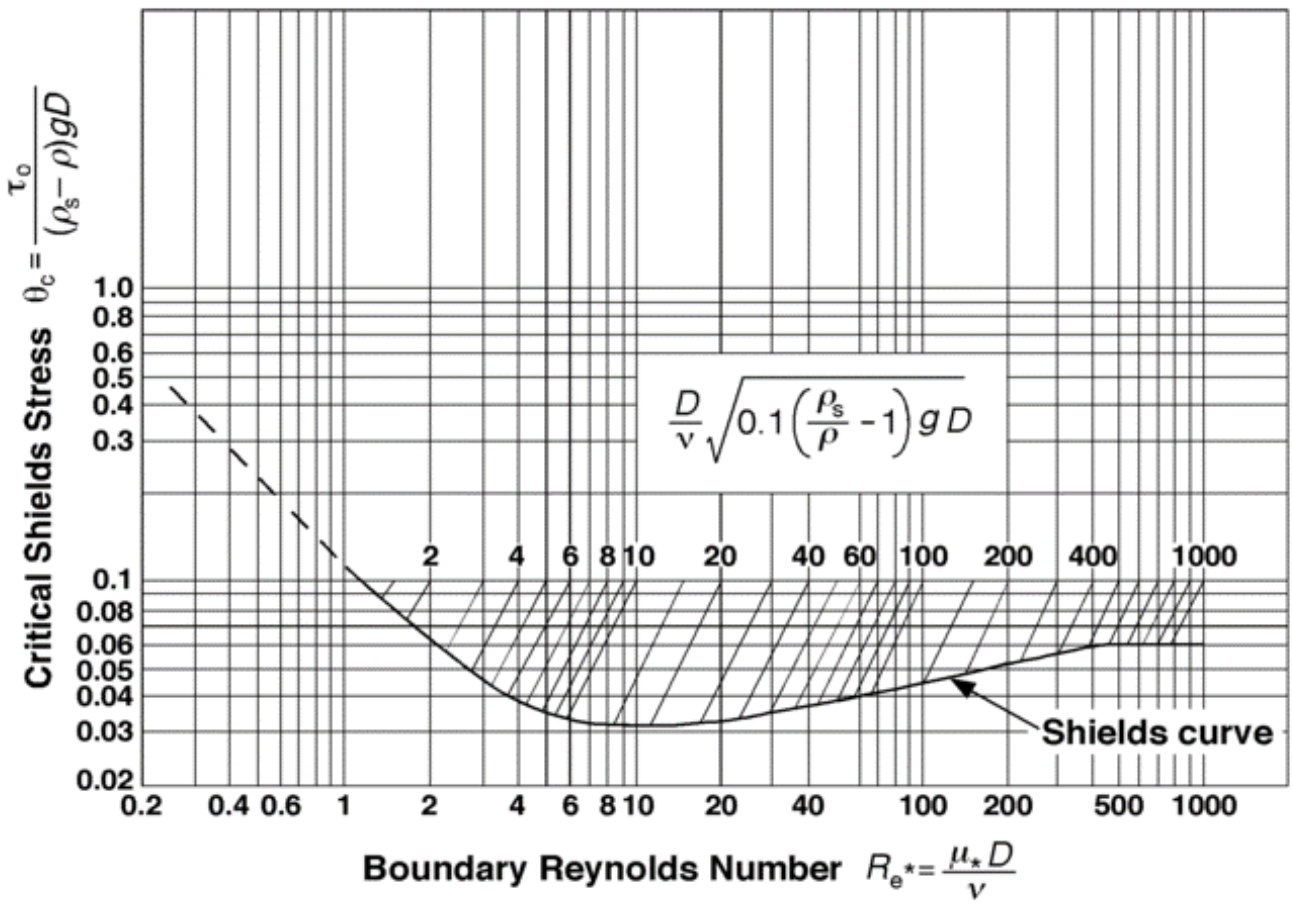

Figure 2: Shields Diagram

ATTACHMENT A

CALCULATION WORKSHEET

Shields Analysis for Critical Particle Diameter						
Parameter	**Unit**	**Upper Reach North Cell Drainage (existing)**	**East Repository STA 34+60 to 41+39 (proposed)**	**Dilco Hill Channel A (proposed)**	**Dilco Hill Channel B (proposed)**	
		Value	**Value**	**Value**	**Value**	**Comment**
Base Width	feet	10.00	0.00	7.00	3.00	
Side Slope	z:1	3.20	5.00	3.00	3.00	
Channel Depth	feet	3.50	1.00	2.00	3.00	
Channel Slope	feet/feet	0.014	0.014	0.080	0.100	
Discharge	cfs	3.90	3.90	0.088	0.03	2-year discharge
Manning's Roughness (n)	-	0.034	0.042	0.037	0.037	
Particle specific gravity	-	2.65	2.65	2.65	2.65	
Unit weight of water	lb/ft^3	62.40	62.40	62.40	62.40	
Manning and Shear Computations						
Flow Depth	feet	0.21	0.66	0.02	0.02	Solved iteratively
Cross-section area	ft2	2.26	2.18	0.13	0.05	Computed from flow depth
Wetted Perimeter	ft2	11.78	7.92	7.15	3.13	Computed from flow depth
Hyd. Radius	ft2	0.19	0.28	0.02	0.02	Computed from flow depth
Q-calc	cfs	3.90	3.87	0.107	0.04	Manning's Calculated Q
SSE	-	0.00	0.00	0.00	0.00	Iteration minimization
Shear Stress	lb/ft^2	0.18	0.58	0.09	0.10	
Shields Analysis						
Particle diameter of Interest	mm	9.00	28.00	4.80	5.10	
Particle diameter of Interest	in	0.35	1.10	0.19	0.20	Unit conversion
Reynolds Number (Re)	-	966.55	5303.95	376.46	412.30	
Shields Parameter, Θc :	-	0.06	0.06	0.058	0.058	
Critical shear	lb/ft^2	0.18	0.57	0.09	0.10	
Mobile ?		YES	YES	YES	YES	

ATTACHMENT I.5
Evaluation of Pipeline Arroyo Stabilization Alternatives

ATTACHMENT I.5: EVALUATION OF PIPELINE ARROYO STABILIZATION ALTERNATIVES

Revisioning

Rev.	Date	Description	By	Checked	Date
0	*5/31/2016*	*Preliminary (30%) Design*	*J. Erickson*	*C. Michalos*	*6/7/2016*

Revisions

Issue Date	Description
--	--

Location and Format

Electronic copies of these calculations are located on the project team site.

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Objectives

The objective of this calculation brief is to summarize the technical evaluation of alternatives for stabilization of the nickpoint area within Pipeline Arroyo.

Background

The Pipeline Arroyo is an existing ephemeral arroyo that runs along the east side of the tailings disposal area (TDA). Lateral stability of the Pipeline Arroyo is important for long-term protection of the repository because lateral eastward migration of the arroyo within the repository limits could threaten an erosional or geotechnical failure of the repository and potentially result in release of mine waste or tailings. A particular concern with the Pipeline Arroyo is the buried rock “jetty” that was constructed as part of the prior tailings reclamation (Canonie, 1991). Progressive scour and undermining in front of the jetty has led to ongoing concerns that loss of the jetty will result in uncontrolled lateral scour in the arroyo. In 2003

the Nuclear Regulatory Commission (NRC) noted damage to the jetty and headcutting toward the jetty that could pose a risk of uncontrolled migration (NRC, 2003). The United States Environmental Protection Agency (USEPA) also expressed concern with potential flood levels in the Pipeline Arroyo north of the TDA North Cell and has requested this be assessed during the preliminary RA design (USEPA, 2016).

MWH evaluated several stabilization alternatives to replace or upgrade the existing rock jetty. These alternatives, summarized in Appendix I of the Design Report, include the following:

- Alternative 1: Monitor and Repair
- Alternative 2: Re-constructed Jetty
- Alternative 3: Re-constructed Channel
- Alternative 4: Stepped Energy Dissipation Structure
- Alternative 5: Rock-Cut Chute

MWH evaluated these alternatives for both the Probable Maximum Flood (PMF) and the 200-year flood. This calculation brief reviews the design equations and calculation results used as the basis for the conceptual design of alternatives presented in Appendix I. The calculation input parameters for each alternative are summarized in Table 1.

Applicable Codes and Standards

40 CFR §192.32(b). Designs shall be effective for one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years.

Methods

Design Flow Rates

MWH evaluated the alternatives for two design flood events: the PMF (27,700 cubic feet per second [cfs]) and the 200-year flood (6,460) cfs) (see Attachment I-1 of Appendix I).

Channel Hydraulics

<u>Mild Slope (less than 5 percent)</u>

MWH estimated the flow depth (Y) on mild slopes using Manning's Equation (Equation 1).

$$Q = \frac{1.49}{n_m} A R^{2/3} S^{1/2} \qquad \text{Equation 1}$$

Where:
Q = peak design discharge, cubic feet per second
A = channel cross-sectional area, square feet
R = channel hydraulic radius = A/P, where P is the wetted perimeter, ft
n_m = manning's roughness for mild slopes, dimensionless
*n_m = 0.03 for the mild sloping channel (Alternative 3), a typical values for natural alluvial channels (Chow, 1959)

<u>Steep Slopes (greater than 5 percent)</u>

MWH calculated the channel hydraulics for steep slopes through balance of the energy equation with consideration for friction losses along the length of the chute using Equations 2 through 9.

$$H_i = H_o + \frac{q^2 * n_s{}^2}{1.49^2 * Y^{3.33}} * L$$ Equation 2

Where:

H_i = total head at the inlet of the chute, feet
H_o = residual head or total head at the outlet of the chute, feet
q = unit discharge, cubic feet per second per foot
n_s = manning's roughness for steep riprap slopes, dimensionless (Rice et al., 1998)
* n_s = 0.04 was used for the rock chute (Alternative 5) (Chow, 1959)
L = length of the channel chute, feet

$$L = \frac{\Delta z}{S}$$ Equation 3

$$n_s = 0.029 * (D_{50} * 25.4 * S)^{0.159}$$ Equation 4

$$H_i = Y_{ci} + \frac{V_{ci}{}^2}{2 * g} + \Delta z$$ Equation 5

$$H_o = Y_o + \frac{q^2}{2 * g * Y_o{}^2}$$ Equation 6

$$q = V * Y$$ Equation 7

Y_{ci} = critical depth of flow at the inlet of the chute, feet
Δz = change in elevation top and bottom of the chute, feet
Y_o = flow depth at the outlet of the chute, feet

$$\frac{Q^2 * TW_c}{g * A_c^3} = 1$$ Equation 8

TW_c = flow top width at critical depth, feet
A_c = flow area at critical depth, feet squared
g = gravitational acceleration constant, 32.2 feet per second squared
V_{ci} = critical velocity of flow at the inlet of the chute, feet per second

$$V_{ci} = \frac{Q}{A_C}$$ Equation 9

<u>Stepped Slopes</u>

MWH calculated the channel hydraulics for the stepped chute (Alternative 4) using the method Hunt et al. (2014) developed for moderately sloped stepped chutes (Equation 10).

$$Y_o = 0.34 * \left(\frac{h}{Y_{ci}}\right)^{0.063} * (\cos\theta)^{0.063} * (\sin\theta)^{-0.18} * Y_{ci}$$ Equation 10

Where:

h = chute step height, feet (3)
Θ = chute slope, degrees (9.5)

MWH computed the energy dissipation efficiency (E) as the percent of head remaining at the chute outlet (Equation 11).

$$E = \frac{H_i - H_o}{H_i} * 100 \qquad \text{Equation 11}$$

Channel Stability

Riprap Sizing on Mild Slope (less or equal to 2 percent)

For mild slopes, MWH used the shear stress method of Johnson (2002) (Equation 12) to determine the minimum median stone diameter.

$$D_{50min} = \frac{t}{4.51} * 12 \qquad \text{Equation 12}$$

Where:

t = channel shear stress, pounds per square foot

$$t = \gamma_w * S_{max} * Y \qquad \text{Equation 13}$$

γ_w = unit weight of water, pounds per cubic foot (62.4)
Y = channel depth, feet
S_{max} = friction slope (equivalent to channel bed slope at normal depth), feet per foot

Riprap Sizing on Steep Slopes (greater than 2 percent)

For steep slopes, MWH used the method of Robinson et al. (1998) (Equation 14) to determine the minimum median stone diameter required for riprap revetment.

$$D_{50min} = 1.413 * q^{0.529} * S^{0.794} * 12 * FS \qquad \text{Equation 14}$$

Where:

D_{50min} = minimum median riprap diameter, inches
q = unit discharge, cubic feet per second per foot
S = chute slope, feet per feet
FS = riprap factor of safety (1.5)

Results

The design slope, design median riprap diameter (where applicable), residual energy head the structure outlet, and the energy dissipation efficiency for each alternative are provided in **Table 2**.

Attachments

Attachment A – Calculation Worksheets

References

Canonie Environmental (Canonie), 1991. Tailings Reclamation Plan As Approved by NRC March 1, 1991. License No. SUA – 1475.

Chow, V.T., 1959. Open-Channel Hydraulics. McGraw-Hill Civil Engineering Series.

Hunt, S.L., K.C. Kadavy, and G.J. Hanson, 2014. Simplistic Design Methods for Moderate-Sloped Stepped Chutes. Journal of Hydraulic Engineering.

Johnson, T.L., 2002. Design of Erosion Protection for Long-Term Stabilization. U.S. Nuclear Regulatory Commission, September.

US Nuclear Regulatory Commission (NRC), 2003. Erosion Protection Design Concerns Identified at Recent Site Visit (TAC NO. L52459). Letter from the U.S. Nuclear Regulatory Commission sent on January 7, 2003

Rice, C.E., K.C. Kadavy, and K.M. Robinson, 1998. Roughness of Loose Rock Riprap on Steep Slopes. Journal of Hydraulic Engineering. February.

Robinson, K.M., K.C. Rice, and K.C. Kadavy, 1998. Design of Rock Chutes. American Society of Agricultural Engineers, 1998. Volume 41(3):621-626.

United States Environmental Protection Agency (USEPA), 2016. Comments on Design Work Plan. Northeast Church Rock Mine Site Removal Action. Excel Spreadsheet.

TABLES

Table 1: Rock Jetty Stabilization Alternatives Calculation Input Parameters

Alternative	Alternative 2 Reconstructed Jetty	Alternative 3 Reconstructed Channel	Alternative 4 Stepped Energy Dissipation Structure	Alternative 5 Rock-Cut Chute
Unit Discharge – PMF* (cfs/ft)	114	209	96.4	227
Unit Discharge - 200-yr Flood*(cfs/ft)	27.8	56.5	32.6	69.9
Inlet Bottom Width, Bi (ft)	350	100	120	20
Outlet Bottom Width, Bo (ft)	225	100	120	20
Right Bank Side Slope Angle, ZRt (Z:1)	6	5	43	3
Left Bank Side Slope Angle, ZLt (Z:1)	0.5	2	0.5	5
Cross Slope Angle (ft/ft)	N/A	N/A	N/A	0.02
Cross Slope Depth (ft)	N/A	N/A	N/A	2
Chute Elevation Change, Δz (ft)	36	N/A	36	36
Chute/Channel Slope, S (ft/ft)	0.08	0.014	0.17	0.1
Chute Step Height, h (ft)	N/A	N/A	3	N/A

Notes:
* Unit discharge computed as the product of the velocity at the outlet and the maximum depth at the outlet.

Table 2: Calculation Results for Stabilization Alternatives

Alternative		Alternative 2: Re-constructed Jetty	Alternative 3: Re-constructed Channel	Alternative 4: Stepped Energy Dissipation Structure	Alternative 5: Rock-Cut Chute
Median Riprap Size (inches)	PMF	48	24	NA	60
	200-year	24	12	NA	24
Residual Head (ft)	PMF	12.2	NA	15.8	25.4
	200-year	4.7	NA	7.6	11.3
Energy Dissipation Efficiency	PMF	73%	NA	66%	51%
	200-year	88%	NA	81%	74%

ATTACHMENT A

CALCULATION WORKSHEETS

Alternative 2 - Reconstructed Jetty Alternative (200 Year Discharge)

Design Discharge, Q (cfs) :	6460	
Rock Chute Bottom Width-1, B1 (ft) :	350	Width at Chute Inlet
Rock Chute Bottom Width-2, B2 (ft) :	225	Width at Chute Outlet
Rock Chute Slope, S (ft) :	0.08	
Rt Bk Side Slope Angle, ZRt:1 :	6	
Lt Bk Side Slope Angle, ZLt:1 :	0.5	
Chute Elevation Change - Top to Bottom, Δz (ft) :	36	
Chute Length, L (ft) :	450	Equation 8
Manning's Roughness, n :	0.054	Equation 7 (Rice, 1998)

Inlet Hydraulics

Critical Depth, Yc (ft) :	2.2	Equation 4
Iteration Parameter--->	0	
Critical Top Width, TWc (ft) :	364.2	TWc = B1+ZRt*Yc+ZLt*Yc
Critical Area, Ac (ft2) :	778.6	Ac = B1*Yc+0.5*ZRt*Yc^2+0.5*ZLt*Y
Critical Velocity, Vc (ft) :	8.30	Equation 5
Total Inlet Head, Hi (ft) :	39.25	Equation 3

Outlet Hydraulics

Outlet Depth, Y (ft) :	2.17	Equation 2
Iteration Parameter--->	0.00	
Outlet Flow Area, Ao (ft2) :	503.29	Ao = B2*Y+0.5*ZRt*Y^2+0.5*ZLt*Yc^
Outlet Velocity, Vo (fps) :	12.84	Vo=Q/Ao
Outlet Unit Discharge, qo (cfs/ft) :	27.8	Equation 9
Total Outlet Head, Ho (ft) :	4.7	Equation 6
Rock Chute Energy Dissipation Efficiency :	88%	Equation 11

Stone Sizing

Riprap Factor of Safety, FS :	1.5	
Minimum Required Stone Diameter, D50min (in) :	19.9	Equation 14, (Robinson, 1998)
Design Median Stone Diameter, D50 (in) :	24	

Rice, C.E., Kadavy, K.C., Robinsoin, K.M., 1998. Roughness of Loose Rock Riprap on Steep Slopes. Journal of Hydraulic Engineering. February 1998

Robinson, K.M., Rice, C.E., Kadavy, K.C., 1998. Design of Rock Chutes. American Society of Agricultural Engineers. Vol. 41(3):621-626

Alternative 2 - Reconstructed Jetty Alternative (PMF Discharge)

Design Discharge, Q (cfs) :	27700	
Rock Chute Bottom Width-1, B1 (ft) :	350	Width at Chute Inlet
Rock Chute Bottom Width-2, B2 (ft) :	225	Width at Chute Outlet
Rock Chute Slope, S (ft) :	0.08	
Rt Bk Side Slope Angle, ZRt:1 :	6	
Lt Bk Side Slope Angle, ZLt:1 :	0.5	
Chute Elevation Change - Top to Bottom, Δz (ft) :	36	
Chute Length, L (ft) :	450	Equation 8
Manning's Roughness, n :	0.060	Equation 7 (Rice, 1998)

Inlet Hydraulics

Critical Depth, Yc (ft) :	5.7	Equation 4
Iteration Parameter--->	0	
Critical Top Width, TWc (ft) :	387.0	TWc = B1+ZRt*Yc+ZLt*Yc
Critical Area, Ac (ft2) :	2097.0	Ac = B1*Yc+0.5*ZRt*Yc^2+0.5*ZLt*Y
Critical Velocity, Vc (ft) :	13.21	Equation 5
Total Inlet Head, Hi (ft) :	44.40	Equation 3

Outlet Hydraulics

Outlet Depth, Y (ft) :	5.52	Equation 2
Iteration Parameter--->	0.00	
Outlet Flow Area, Ao (ft2) :	1340.05	Ao = B2*Y+0.5*ZRt*Y^2+0.5*ZLt*Yc^
Outlet Velocity, Vo (fps) :	20.67	Vo=Q/Ao
Outlet Unit Discharge, qo (cfs/ft) :	114.0	Equation 9
Total Outlet Head, Ho (ft) :	12.2	Equation 6
Rock Chute Energy Dissipation Efficiency :	73%	Equation 11

Stone Sizing

Riprap Factor of Safety, FS :	1.5	
Minimum Required Stone Diameter, D50min (in) :	41.9	Equation 14, (Robinson, 1998)
Design Median Stone Diameter, D50 (in) :	48	

Rice, C.E., Kadavy, K.C., Robinson, K.M., 1998. Roughness of Loose Rock Riprap on Steep Slopes. Journal of Hydraulic Engineering. February 1998

Robinson, K.M., Rice, C.E., Kadavy, K.C., 1998. Design of Rock Chutes. American Society of Agricultural Engineers. Vol. 41(3):621-626

Alternative 3 - Reconstructed Channel Alternative (200 Year Discharge)

Design Discharge, Q (cfs) :	6460	
Channel Bottom Width, B (ft) :	100	
Left Side Slope Angle, Z1 (Z:1) :	5	
Right Side Slope Angle, Z2 (Z:1) :	2	
Channel Slope, S (ft/ft) :	0.014	
Channel Roughness, n :	0.03	Clean, Straight Natural Channel (Chow, 1959)
Channel Flow Depth, Y (ft) :	4.09	Equation 1
Iteration Parameter--->	0.00	
Flow Area, A (ft2) :	468.0	
Wetted Perimeter, P (ft) :	130.0	
Top Width, TW (ft) :	128.7	
Average Velocity, V (fps) :	13.8	
Shear Stress, T (lbs/ft2) :	3.58	
Min Median Stone Diameter, D50m (in) :	10.47	Equation 12
Design Median Stone Diameter, D50 (in) :	12	

Alternative 3 - Reconstructed Channel Alternative (PMF Discharge)

Design Discharge, Q (cfs) :	27700	
Channel Bottom Width, B (ft) :	100	
Left Side Slope Angle, Z1 (Z:1) :	5	
Right Side Slope Angle, Z2 (Z:1) :	2	
Channel Slope, S (ft/ft) :	0.014	
Channel Roughness, n :	0.03	Clean, Straight Natural Channel (Chow, 1959)
Channel Flow Depth, Y (ft) :	9.37	Equation 1
Iteration Parameter--->	0.00	
Flow Area, A (ft2) :	1244.2	
Wetted Perimeter, P (ft) :	168.7	
Top Width, TW (ft) :	165.6	
Average Velocity, V (fps) :	22.3	
Shear Stress, T (lbs/ft2) :	8.19	
Min Median Stone Diameter, D50m (in) :	23.96	Equation 12
Design Median Stone Diameter, D50 (in) :	24	

Alternative 4 - Stepped Energy Dissipation Structure (200 Year Discharge)

Design Flow, Q (cfs) :	6460	
Flat Bottom Width, B (ft) :	120	
Lt Bk Side Slope Angle, ZLt :1 :	43	
Rt Bk Side Slope Angle, ZRt:1 :	0.5	
Critical Flow Depth, Yci (ft) :	3.59	Equation 4
Iteration Parameter--->	0	
Critical Top Width, Twci (ft) :	276.0	
Critical Area, Aci (ft2) :	709.8	
Critical Velocity, Vci (fps) :	9.1	Equation 5
Unit Discharge, q (cfs/ft) :	32.6	Equation 7
Change in Elevation, Δz (ft) :	36	
Chute Slope, S:	0.17	
Chute Slope, Θ (degrees) :	9.5	
Structure Length, L (ft) :	216	Equation 9
Step Height, h (ft) :	3	
Step Length, Ls (ft) :	18	
Channel Flow Depth, Y (ft) :	1.67	Equation 10
Total Inlet Head, HI (ft) :	40.9	Equation 3
Total Outlet Head, Ho (ft) :	7.6	Equation 6
Energy Dissipation Efficiency, E :	81%	Equation 11

Alternative 4 - Stepped Energy Dissipation Structure (PMF Discharge)

Design Flow, Q (cfs) :	27700	
Flat Bottom Width, B (ft) :	120	
Lt Bk Side Slope Angle, ZLt :1 :	43	
Rt Bk Side Slope Angle, ZRt:1 :	0.5	
Critical Flow Depth, Yci (ft) :	7.70	Equation 4
Iteration Parameter--->	0	
Critical Top Width, Twci (ft) :	454.9	
Critical Area, Aci (ft2) :	2213.1	
Critical Velocity, Vci (fps) :	12.5	Equation 5
Unit Discharge, q (cfs/ft) :	96.4	Equation 7
Change in Elevation, Δz (ft) :	36	
Chute Slope, S:	0.17	
Chute Slope, Θ (degrees) :	9.5	
Structure Length, L (ft) :	216	Equation 9
Step Height, h (ft) :	3	
Step Length, Ls (ft) :	18	
Channel Flow Depth, Y (ft) :	3.41	Equation 10
Total Inlet Head, HI (ft) :	46.1	Equation 3
Total Outlet Head, Ho (ft) :	15.8	Equation 6
Energy Dissipation Efficiency, E :	66%	Equation 11

Alternative 5 - Rock-Cut Chute (200 Year Discharge)

Design Discharge, Q (cfs) :	6460	
Flat Bottom Width, B (ft) :	20	
Cross Slope (ft/ft) :	0.02	
Cross Slope Length (ft) :	100	
Cross Slope Depth (ft) :	2	
Lt Bk Side Slope Angle, ZLt (Z:1) :	5	
Rt Bk Side Slope Angle, ZRt (Z:1) :	3	
Manning's Roughness, n :	0.04	
Channel Slope, S (ft/ft) :	0.1	
Change in Elevation, Δz (ft) :	36	
Slope Length, L (ft) :	360	Equation 8
Critical Depth, Yci (ft) :	5.14	Equation 4
Iteration Parameter--->	0.00	
Critical Area, Aci (ft2) :	580.7	
Critical Top Width, Twci (ft) :	151.1	
Critical Velocity, Vci (fps) :	11.1	Equation 5
Total Inlet Head, Hi (ft) :	43.1	Equation 3
Flow Depth, Y (ft) :	3.03	Equation 2
Iteration Parameter--->	0.00	
Flow Area, A (ft2) :	279.6	
Channel Velocity, V (fps) :	23.10	
Outlet Head, Ho (ft) :	11.3	Equation 6
Dissipation Efficiency, E :	74%	Equation 11
Main Stream Power, P (kW/m2) :	6.76	Equation 15
Erodability Index at Onset of Scour :	12.7	Equation 16
Min Lt Bk Riprap, D50m (in) :	21.8	Equation 14
Design Lt Bk Riprap, D50 (in) :	24	

Alternative 5 - Rock-Cut Chute (PMF Discharge)

Design Discharge, Q (cfs) :	27700	
Flat Bottom Width, B (ft) :	20	
Cross Slope (ft/ft) :	0.02	
Cross Slope Length (ft) :	100	
Cross Slope Depth (ft) :	2	
Lt Bk Side Slope Angle, ZLt (Z:1) :	5	
Rt Bk Side Slope Angle, ZRt (Z:1) :	3	
Manning's Roughness, n :	0.04	
Channel Slope, S (ft/ft) :	0.1	
Change in Elevation, Δz (ft) :	36	
Slope Length, L (ft) :	360	Equation 8
Critical Depth, Yci (ft) :	11.41	Equation 4
Iteration Parameter--->	0.00	
Critical Area, Aci (ft2) :	1686.5	
Critical Top Width, Twci (ft) :	201.3	
Critical Velocity, Vci (fps) :	16.4	Equation 5
Total Inlet Head, Hi (ft) :	51.6	Equation 3
Flow Depth, Y (ft) :	6.50	Equation 2
Iteration Parameter--->	0.00	
Flow Area, A (ft2) :	793.9	
Channel Velocity, V (fps) :	34.89	
Outlet Head, Ho (ft) :	25.4	Equation 6
Dissipation Efficiency, E :	51%	Equation 11
Main Stream Power, P (kW/m2) :	21.28	Equation 15
Erodability Index at Onset of Scour :	59.1	Equation 16
Min Lt Bk Riprap, D50m (in) :	59.3	Equation 14
Design Lt Bk Riprap, D50 (in) :	60	

ATTACHMENT I.6
Upper Pipeline Arroyo Hydraulic Model

ATTACHMENT I.6: UPPER PIPELINE ARROYO HYDRAULIC MODEL

Revisioning

Rev.	Date	Description	By	Checked	Date
0	*5/25/16*	*Preliminary (30%) Design*	*J. Erickson*	*C. Michalos*	*5/27/16*

Revisions

Issue Date	Description
--	--

Location and Format

Electronic copies of these calculations are located on the project team site.

http://projects.mwhglobal.com/sites/genecrpreliminarydesign/Pages/Technical/Design/Stormwater_Hydrology_Hydraulics/

Calculations were generated using the following software:

- HEC-RAS – River Analysis System. Version 4.1.0 Jan 2010. U.S. Army Corps of Engineers Hydraulic Engineering Center
- HEC-GeoRAS – GIS Tools for Support of HEC-RAS using Arc-GIS ArcMap Version 10.2.2
- ESRI ArcMap 10.2.2
- Microsoft Excel 2013

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Objective

The objective of these calculations is to estimate the water surface elevations along Pipeline Arroyo in the arroyo reach adjacent to the Tailing Disposal Area (TDA), upstream of the Pipeline Arroyo "nickpoint" (Upper Reach), for the Probable Maximum Flood (PMF), 100-year flood, and 5-year flood.

Background

The upper reach of the Pipeline Arroyo runs parallel with, and adjacent to, the north-west edge of the TDA at the Northeast Church Rock Mill Site (Drawing 9.01). Near the current south end of the North Cell of the TDA, the Pipeline Arroyo crosses an outcrop of bedrock which extends into the Pipeline Arroyo and forms a natural "nickpoint" in the arroyo. Currently an engineered buried "rock jetty" ties into the "nickpoint" and extends perpendicular across the arroyo and floodplain. The design intent of the jetty was to provide grade control and stabilize the arroyo from lateral migration. At the location of the nick point, the Pipeline Arroyo has a watershed area of approximately 18 square miles.

MWH estimated the water surface elevation and floodplain limits in the upper reach of the Pipeline Arroyo using the one-dimensional River Analysis System developed by the US Army Corps of Engineers-Hydrologic Engineering Center (HEC-RAS) version 4.1.0.

Applicable Codes and Standards

The calculation methods used in this analysis are consistent with the following documents :

- Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site (AOC; USEPA, 2015)
- Design of Erosion Protection for Long-Term Stabilization (Johnson, 2002)

Methods

MWH developed the cross-section geometry for the arroyo and floodplain for input into HEC-RAS from an aerial survey completed by Cooper Aerial Surveys Company in 2013. This survey has an expected accuracy of 1-foot horizontal and 0.5 feet vertical (MWH, 2014). MWH estimated the cross-sections from the survey using ArcMap and HEC-GeoRAS. **Figure 1** shows the cross-section locations and each of the model channel cross-sections are shown in Attachment A of Attachment I-5. To improve the computational stability of the model, MWH added interpolated cross-sections between the surveyed cross-sections with a maximum spacing of 25 feet.

Channel Roughness

The HEC-RAS model used Manning's roughness values to simulate resistance to flow in the channel and floodplain. Values of the roughness coefficient were taken from Chow (1959). MWH selected "average" roughness conditions for the base-case simulation, but also evaluated "high" roughness values as a sensitivity analysis. **Table 1** lists the estimated roughness values for the average and high roughness conditions. The roughness values for the average conditions are also displayed in the cross sections shown in Attachment A of Attachment I-5.

Expansion and Contraction Losses

The transitions in geometry between all cross-sections along the upper reach are gradual, and MWH used the default contraction and expansion loss coefficients within HEC-RAS of 0.1 and 0.3, respectively.

MWH ran the HEC-RAS model for steady-state flow conditions for the PMF, 100-year flood, and 5-year flood. These discharge values are listed in **Table 2**, and estimation methods are provided in Attachment I-1: Estimation of Flood Flows for Design of Interim and Post-Remediation Surface Water Controls for the Remedial Action at the Northeast Church Rock Mine Site and Church Rock Mill Site.

MWH ran the HEC-RAS model using a mixed flow regime, which considers sub-critical and super-critical flows. MWH estimated initial boundary conditions at the upstream (Station 4385) and downstream (Station 0) cross sections for the mixed flow computations. MWH assumed the upstream boundary condition is normal depth, estimated using the local channel bed slope (0.4 percent). MWH assumed the downstream boundary condition is critical depth at the location of the nick point.

Assumptions

These calculations assume that vegetation, soil, and other channel conditions in the NDC remain constant in the future. Other assumptions are described in the explanation of calculation methods.

Results

The water surface elevations were mapped along the Upper Pipeline Arroyo reach area surveyed to show the estimated flooding extents during the PMF, 100-year flood, and 5-year flood. These estimated flooding extents are shown in **Figure I.8-1** of Appendix I**. Figure I.8-1** shows that flooding may inundate multiple areas of interest during the PMF and the 100-year flood. The flooding extents shown in **Figure I-8.1** are preliminary estimates due to the limitations of the 1-dimensional HEC-RAS model. Flow in the flood plain is expected to be 2-dimensional and more accurate estimates of flood plain inundation could be achieved using a model capable of simulating 2-dimensional flow. Despite the challenges of modeling 2-dimensional flood plain hydraulics using a 1-dimensional model, it is expected that the results presented in this analysis are sufficient to for the intended purpose of the model.

Figure 2 of this attachment shows that flow is estimated to be sub-critical through a majority of the Upper Reach with transitions between sub- and super-critical flow occurring along the lower 1000 feet during the PMF. **Figure 2** also shows flow is near critical for the majority of the Upper Reach during the 100-year and 5-year events.

References

Chow, V.T., 1959. Open Channel Hydraulics. McGraw-Hill Civil Engineering Series.

Johnson, T.L., 2002. Design of Erosion Protection for Long-Term Stabilization. U.S. Nuclear Regulatory Commission NUREG 1623. September.

MWH, 2014. Pre-Design Studies-Northeast Church Rock Mine Site Removal Action. Church Rock Mill Site October 31, 2014.

US Environmental Protection Agency (USEPA), 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site, McKinley County, New Mexico. April 27.

TABLES

Table 1: Manning's Roughness Values Selected for Pipeline Arroyo Upper Reach

Reach	Left Bank	Channel	Right Bank	Description
Average Condition	0.035	0.025	0.035	**Channel**: Stream on plain – Clean, straight, full stage, no rifts or deep pools (minimum). **Banks**: Flood plains – Scattered brush, heavy weed (minimum)
High Roughness Condition	0.050	0.030	0.050	**Channel**: Stream on plain – Clean, straight, full stage, no rifts or deep pool. **Banks:** Flood plains – Scattered brush, heavy weeds (maximum)

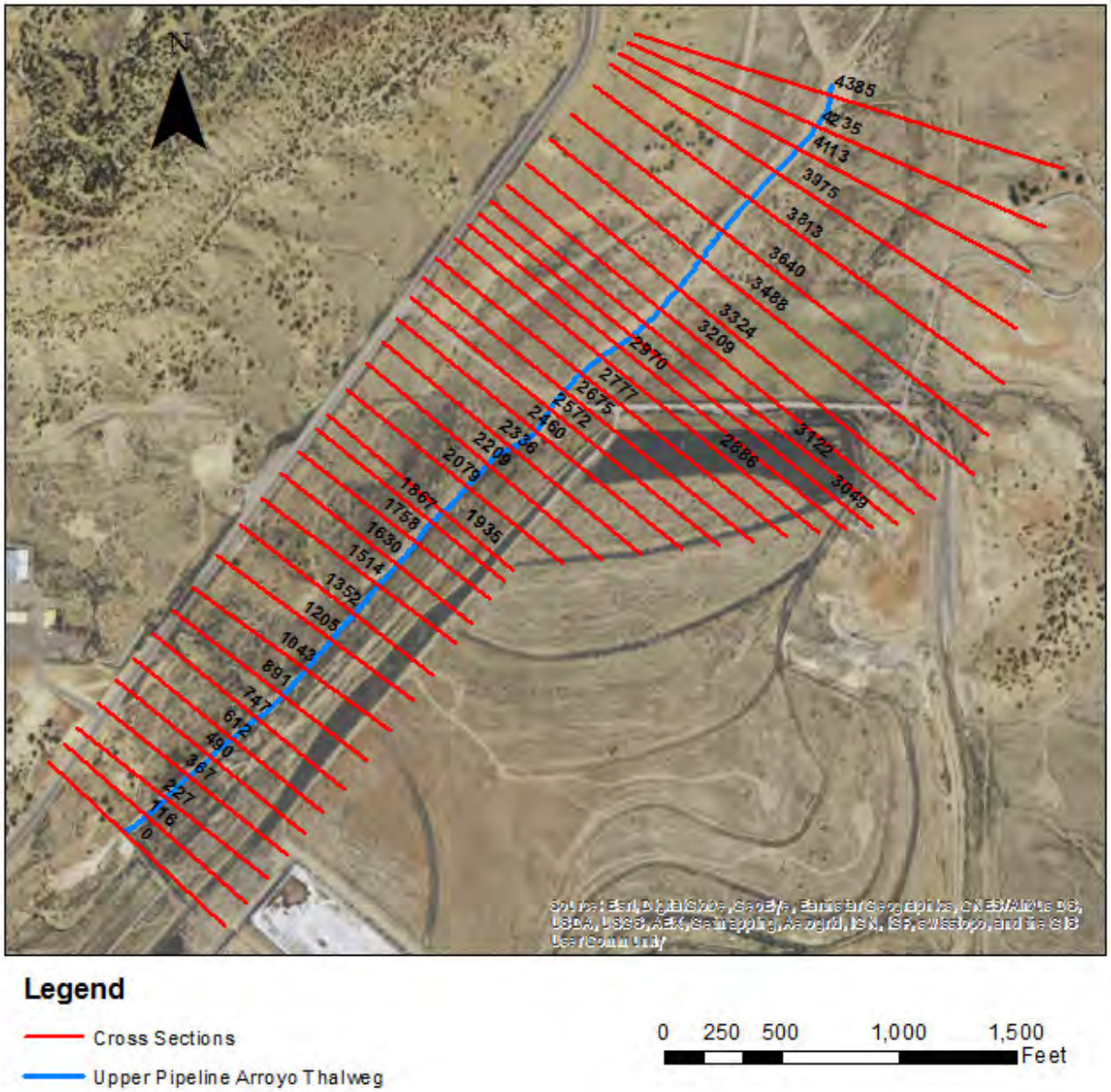
Note: Values of the Roughness Coefficient from Chow (1959).

Table 2: Design Peak Discharges for Pipeline Arroyo Upper Reach

Storm	Discharge (cfs)
PMF	27,600
100-Year Flood	4,957
5-Year Flood	289

cfs = cubic feet per second

FIGURES



Legend

Cross Sections

Upper Pipeline Arroyo Thalweg

0 250 500 1,000 1,500 Feet

Figure 1: Cross-Section Locations for the Upper Pipeline Arroyo HEC-RAS Model

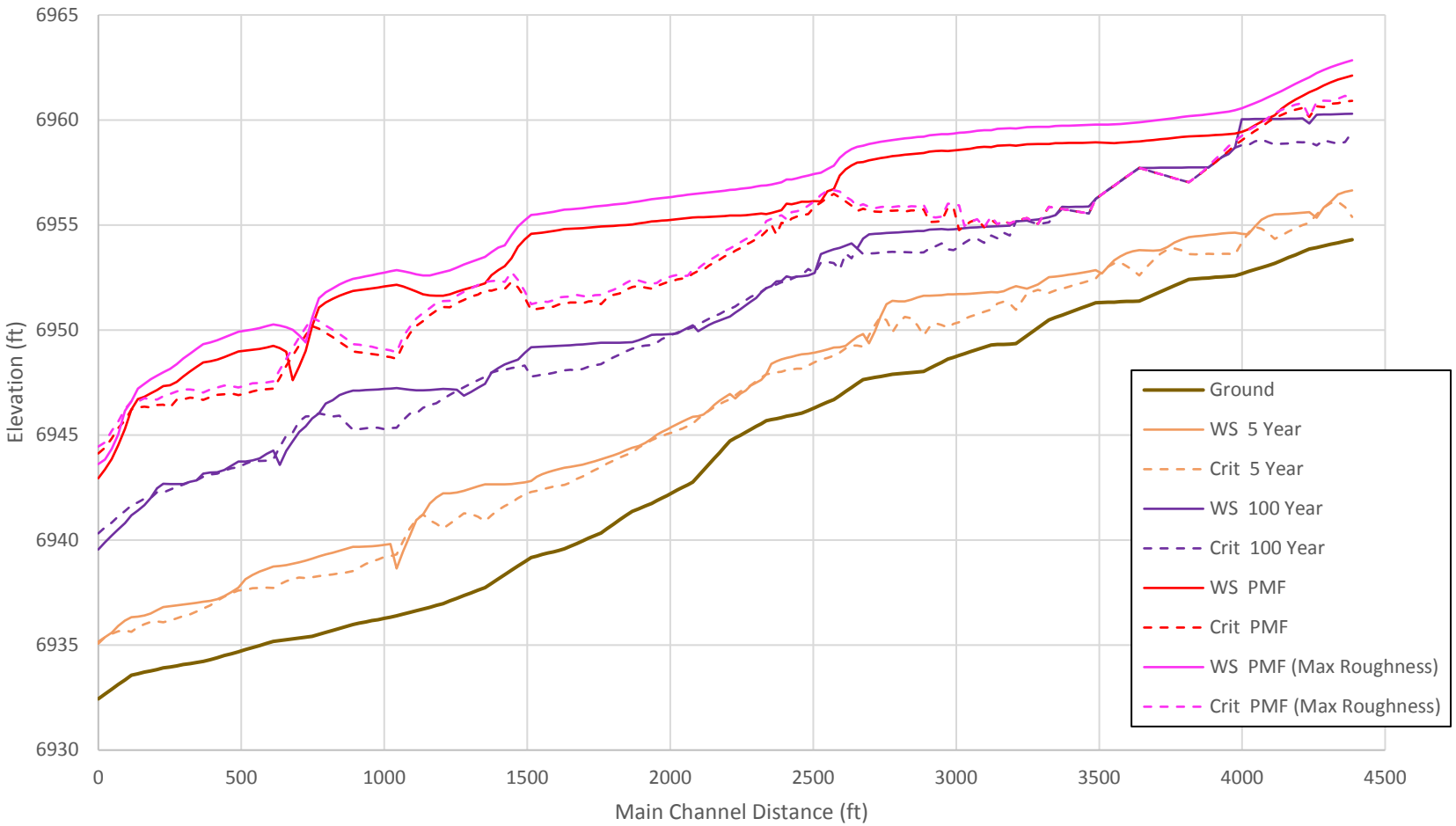


Figure 2: Water Surface Profile and Critical Depth Profile for the PMF, 100 Year, and 5 Year Events

Northeast Church Rock 30% Design Report

Appendix J:
Technical Specifications

MWH® now part of Stantec

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LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
PTW	principal threat waste
RAO	Removal Action Objective
ROD	Record of Decision
SOW	Statement of Work
TBD	to be determined
USEPA	US Environmental Protection Agency

J.1 INTRODUCTION

This appendix to the Northeast Church Rock 30% Design Report summarizes the technical specifications that will be developed for the construction activities required for execution of the Removal Action at the Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site). Specifically, this appendix lists the technical specifications and outlines select specifications as noted in other design appendices. The organization of the technical specifications follows a format used successfully for remediation and reclamation of other uranium mine and mill sites in the western US.

J.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (ROD; USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work (SOW) attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table J.2-1 presents Performance Standards related to technical specifications and explains how the design accomplishes these standards.

Table J.2-1: Task Specific Performance Standards

Location of Performance Standard Requirement	Performance Standard	Comments
2015 AOC SOW, Paragraph 17 – Soil Transportation and Management	In the Design, Respondents shall provide detailed plans and specifications explaining how mine waste from the NECR Site and other materials (including borrow, backfill, and cover materials) will be managed and transported. Respondents shall include details for ensuring that Principal Threat Waste from the NECR Site, as described in the 2011 Action Memo, is not transported to the UNC Site or disposed at the Tailings Disposal Area.	Mine waste will be excavated and transported to the repository as discussed in Appendix C. Materials characterized as principal threat waste (PTW) (Appendices C and T) will be stockpiled for removal from the Mine Site as discussed in Appendix C. Technical specifications will be developed for all construction activities, including mine waste excavation and disposal. A list of proposed technical specifications is included in this appendix.
2015 AOC SOW, Paragraph 19 – Site Controls and Security	In the Design, Respondents shall include plans and specifications for security for the SA Site to prevent access by unauthorized humans and livestock during the construction of the remedy. Respondents shall include plans and specifications for a fence, cattle guards and other security features, as needed.	Site security and access controls are provided through fencing, gates, and institutional controls. See Appendix M. Technical specifications will be developed for construction activities, including construction of access controls. A list of proposed technical specifications is included in this appendix.
2015 AOC SOW, Paragraph 20 – Site Preparation Activities	In the Design, Respondents shall include detailed plans and specifications for the following site preparation activities: a. An underground utility survey for the identification and verification of the location of subsurface utilities in SA Site areas that will be used for consolidation or disposal; b. A land survey that will delineate the parts of the Tailings Disposal Area that will be used for NECR Site contaminated soil and mine waste disposal; c. A description of construction activities to be undertaken on the portion of the SA Site that is at the UNC Site in order to prepare for placement of the NECR Site contaminated soil and mine waste in the Tailings Disposal Area; d. A description of the methods that will be used to decontaminate existing structures such as culverts, catch	a. See Appendix B –Construction Support Facilities b. See Appendix G – Mine Waste Repository Design c. See Appendix G – Mine Waste Repository Design d. See Appendix C – Mine Site Removal Excavations and Demolition Technical specifications will be developed for construction activities. A list of proposed technical specifications is included in this appendix.

Location of Performance Standard Requirement	Performance Standard	Comments
	basins, foundations, and vaults; and, where decontamination is not practicable, a description of methods that shall be used to disassemble these structures, demolish and remove these structures, or include these structures within the Tailings Disposal Area.	
2015 AOC SOW, Paragraph 24 – Air Monitoring	In the Design, Respondents shall include detailed plans and specifications for air monitoring stations to be installed around the perimeter of the SA Site during the response action. Respondents' detailed plans and specifications shall ensure that perimeter air monitoring stations will be positioned and operated to monitor emissions during dust-or emission-generating activities, including site preparation, construction activities, excavation and backfill, stockpiling (staging), loading of bulk-carriers, stockpile management, consolidation, cap construction and regrading. Respondents shall ensure that their detailed plans and specifications also include dust prevention and dust suppression controls that will be implemented to maintain a safe working environment and to protect human health and the environment.	Technical specifications will be developed for construction activities, including dust control performance standards and/or reference to appropriate plans incorporation of appropriate refer. A list of proposed technical specifications is included in this appendix. Additionally, air monitoring and dust control are addressed in such as the Air Monitoring and Dust Control Plan (Appendix Q).
2015 AOC SOW, Paragraph 26 – Acceptance Criteria	For the part of the Tailings Disposal Area that is to contain the mine waste from the NECR Site and for the part of the current tailings cell that may be disturbed during implementation of the remedy, Respondents shall include, in their Design, detailed plans and specifications to meet and demonstrate compliance with Acceptance Criteria consistent with Section 5.1 of NU REG 1620.	See Appendix G – Mine Waste Repository Design Technical specifications will be developed for construction activities. A list of proposed technical specifications is included in this appendix.
2015 AOC SOW, Paragraph 27 – Site Restoration	In the Design, Respondents shall include detailed plans and specifications for restoration of the Tailings Disposal Area and borrow areas on the UNC Site and for restoration of the NECR Site. Respondents shall also include plans and specifications for contouring to promote drainage, and for re-vegetation of the Tailings Disposal Area, borrow pits and NECR Site with native species. Respondents shall include plans and specifications for backfilling and regrading of disturbed (e.g., excavated) areas in the NECR Site and the UNC Site for erosion and storm water control, including re-vegetation of those areas with native species	See Appendix U – Revegetation Plans Technical specifications will be developed for construction activities, including revegetation. A list of proposed technical specifications is included with the 30% design.
2013 ROD, Table 1	10 CFR 61.52(a)(4), 52(a)(5), 52(a)(7), 52(a)(8) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard will be developed for construction activities. A list of proposed technical specifications is included with the 30% design.
2013 ROD, Table 1	10 CFR 61.52(a)(9) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard will be developed for construction activities. A list of proposed technical specifications is included with the 30% design.

Location of Performance Standard Requirement	Performance Standard	Comments
2013 ROD, Table 1	10 CFR 61.52(a)(10) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard will be developed for construction activities. A list of proposed technical specifications is included with the 30% design.
2013 ROD, Table 1	10 CFR 61.52(a)(11) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard will be developed for construction activities. A list of proposed technical specifications is included with the 30% design.
2013 ROD, Table 1	10 CFR 61.56(b) through 56(b)(3) Waste Characteristics. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard will be developed for construction activities. A list of proposed technical specifications is included with the 30% design.
2013 ROD, Table 1	10 CFR 40, Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content - Criterion 4. Refer to www.ecfr.gov.	Technical specifications consistent with the listed performance standard will be developed for construction activities. A list of proposed technical specifications is included with the 30% design.

J.3 TECHNICAL SPECIFICATIONS

J.3.1 Organization

The technical specifications will be organized into divisions as follows:

DIVISION 01 - GENERAL REQUIREMENTS

DIVISION 02 - SITEWORK

DIVISION 03 - CONCRETE

DIVISION 04 – MASONRY (NOT USED)

DIVISION 05 – METALS (USE TO BE DETERMINED [TBD])

DIVISION 06 – WOOD AND PLASTIC (NOT USED)

DIVISION 07 – THERMAL AND MOISTURE PROTECTION (NOT USED)

DIVISION 08 – DOORS AND WINDOWS (NOT USED)

DIVISION 09 – FINISHES (NOT USED)

DIVISION 10 – SPECIALTIES (NOT USED)

DIVISION 11 – EQUIPMENT (TBD)

DIVISION 12 – FURNISHINGS (NOT USED)

DIVISION 13 – SPECIAL CONSTRUCTION (NOT USED)

DIVISION 14 – CONVEYING SYSTEMS (NOT USED)

DIVISION 15 – MECHANICAL (TBD)

DIVISION 16 – ELECTRICAL (TBD)

DIVISION 17 – INSTRUMENTATION AND CONTROLS (TBD)

Technical specifications will be provided in their entirety for each major construction task so that the specifications are clear for completion of the work. Individual specifications sections will typically be organized as follows:

Section 1: General

- Summary of requirements
- Reference standards
- Related specification sections
- Related compliance plans
- Submittals (work plans, surveys, product information, samples)
- Quality assurance/quality control general provisions

Section 2: Products

- Material and product requirements

Section 3: Execution

- Performance requirements for execution of the work

- Quality control inspection and testing specifics
- Quality assurance inspection and testing specifics

J.3.2 Specification List

DIVISION 01 - GENERAL REQUIREMENTS

01010	Summary of Work
01015	Removal Action Work Plans
01018	Construction Surveying and Staking
01060	Permits
01070	Abbreviations of Institutions
01090	Reference Standards
01300	Contractor Submittals
01301	Schedule of Values
01310	Construction Schedule
01400	Quality Control
01505	Mobilization
01510	Temporary Utilities
01525	Construction Support Facilities
01530	Protection of Existing Facilities
01532	Site Conditions Surveys
01551	Construction Access and Haul Roads
01552	Staging and Stockpile Areas
01560	Temporary Environmental Controls
01570	Stormwater Pollution Prevention Plan
01575	Spill Prevention Control and Countermeasure Plan
01585	Green and Sustainable Practices
01600	Products, Materials, Equipment and Substitutions
01700	Project Closeout

DIVISION 02 - SITEWORK

02000	Control of Dust
02050	Demolition
02100	Site Preparation
02105	Borrow Areas
02120	Road, Staging, and Parking Area Maintenance
02140	Dewatering and Control of Water
02160	Sediment and Erosion Control
02200	Earthwork
	Note: Section 02200 is intended to include earthwork items located outside of the repository, or constructed with clean imported or borrow materials. Alternatively, this section could be replaced at the 95% design with several individual sections such as:
02XXX	Haul and Access Road Construction
02XXX	Outlet Channel Construction
02XXX	Evapotranspiration (ET) Cover Construction
02XXX	Jetty Construction
02205	Mine Waste Excavation and Disposal
	Note: Section 02205 is intended to include excavation and placement of mine waste, as well as earthwork items within contaminated areas or using potentially contaminated materials. Alternatively, this section could be replaced at the 95% design with several individual sections such as:

02XXX – Mine Waste Excavation and Placement
02XXX – Principal Threat Waste Excavation, Handling, and Disposal
02XXX – Repository Base Layer Preparation

02210	Blasting (if required)
02272	Geomembranes (if required)
02273	Riprap
02274	Geotextiles
02460	Asphalt Concrete (A.C.) Pavement and Base
02567	Corrugated Pipe
02780	Geosynthetic Clay Liner (if required)
02831	Chain Link Fencing and Gates
02970	Revegetation

DIVISION 03 - CONCRETE

03300	Cast-in-Place Concrete
03495	Pre-Cast Concrete

The specification list included in this 30% Design Report has been developed based on the current level of project design and understanding. Revisions to this list will be necessary between the 30 and 95 percent design to reflect the evolution of the overall design concepts.

J.3.3 Select Draft Specifications

Drafts of the following select specifications are attached:

- 01525 – Construction Support Facilities (Attachment J.1) is included as an example of a performance specification for facilities that will be designed by the Construction Contractor.

- 01585 – Green and Sustainable Practices (Attachment J.2) is included as an example of how green and sustainable principles would be incorporated into the specifications.

J.4 REFERENCES

US Environmental Protection Agency (USEPA), 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Mine Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. Prepared for U.S. EPA Regions 6 and 9. September 29.

US Environmental Protection Agency (USEPA) Region 6, 2013. Record of Decision for Operable Unit OU02, Surface Soil Operable Unit, United Nuclear Corporation Site, McKinley County, New Mexico. March 29.

US Environmental Protection Agency (USEPA), 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site, McKinley County, New Mexico. April 27

ATTACHMENT J.1

Outline, Specification Section 01525 – Construction Support Facilities

SECTION 01525 – CONSTRUCTION SUPPORT FACILITIES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide labor, equipment, and materials to construct the temporary Construction Support Facilities (CSFs) as shown on the Drawings.

B. The CONTRACTOR shall furnish, install and service the ENGINEER'S field office at the Site, including connection to the CONTRACTOR's temporary power system as indicated in Section 01510 – Temporary Utilities. The ENGINEERS's office shall be located in a location designated by the ENGINEER.

1.2 REFERENCE REMOVAL ACTION WORK PLANS

A. The work under this section shall be conducted in substantial compliance with the following work plans included as part of the Contract Documents in accordance with Section 01015 – Removal Action Work Plans:

1. *TBD*

a. Special consideration shall be given to the Performance Standards listed in the above referenced work plan. CONTRACTOR provided facilities shall comply with these standards.

1.3 CSF REQUIREMENTS

A. A general layout and grading plan for the CSFs is shown on the Drawings.

B. ZONE DESIGNATIONS: *This section will provide a performance definition of each zone.*

a. Exclusion Zone

b. Decontamination Zone

c. Support Zone

C. Yard areas available for CONTRACTOR use are designated on the Drawings and include:

1. Former Mill Site Yard

2. Repository Yard

3. Mill Site Yard

D. The CONTRACTOR may elect to configure the facilities differently to suit its operations. Any reconfiguration or deviation from that shown on the plans shall meet the requirements of this specification, and shall be submitted to the ENGINEER for review and approval. Expansion of the CSFs beyond the limits shown on the Drawings requires AGENCY approval in addition to ENGINEER approval.

E. A list of support facilities and uses are provided in the table below for the CONTRACTOR'S reference.

Area Designation	Function/Use

1.4 SUBMITTALS

A. CONTRACTOR shall submit the following for ENGINEER review and approval in accordance with Section 01300 - Contractor Submittals:

1. Plan layout and grading of yards and CSFs.

2. Description of facilities and list of all equipment to be provided for each area listed in the table in Part 1.3 of this Section.

3. List of proposed deviations or modifications from the Drawings and Specifications.

4. Any other information required to demonstrate compliance with applicable performance standards (see Part 1.2 of this Section).

B. To the extent practical, the submittal listed above shall be compiled in a single comprehensive submittal.

1.5 ENGINEER'S FIELD OFFICE SCHEDULE

A. The ENGINEER's field office shall be for exclusive use by the ENGINEER and the COMPANY's representative and staff and shall be furnished and setup by the CONTRACTOR within 14 Days after the commencement date stated in the Notice-to-Proceed or other time as mutually agreed with the ENGINEER.

B. The CONTRACTOR will recognize that no payment for that portion of the Contract Price designated for mobilization, or any part thereof, will be approved for payment until the field office facilities indicated herein have been set up. Separate payment will be made for set up and servicing of the ENGINEER's field office.

C. Unless released earlier by the ENGINEER in writing, the field office shall be maintained in full operation at the Site with all utilities connected and operable until the Notice of Completion has been executed or recorded. Upon execution or recordation of the Notice of Completion, or upon early release of the field office by the ENGINEER, the CONTRACTOR shall disconnect and remove the office, and the CONTRACTOR shall restore the Site occupied by the field office according to the requirements of the Contract Documents.

PART 2 -- PRODUCTS

2.1 OFFICE FACILITIES

A. **General:** The CONTRACTOR shall provide necessary electrical wiring, plumbing, toilet and lavatory fixtures, air conditioning and heating equipment, and shelving, and shall furnish light, heat, water, and daily janitorial services in connection with the field office.

B. **Primary Field Office:** The office shall be one separate, well lighted, air conditioned, electrically-heated field office with a toilet room containing a water closet and lavatory partitioned off from the working area. The water closet may be of the chemical type provided that it is a flush type with an approved holding tank. The toilet room door shall be provided with a latch set. Water efficient fixtures shall be provided. The office shall have an outside door lock. The area of the field office shall not be less than 896 square feet, excluding toilet room area. The office shall be of the portable trailer type unless otherwise specifically authorized by the ENGINEER in writing and shall be a separate unit, not attached or connected to any other structures. The office shall have as minimum three private offices, one conference room, and one common area that can accommodate at least two desks, four filing cabinets, one plan table, and two bookcases.

2.2 FIELD OFFICE FURNISHINGS

A. The CONTRACTOR shall furnish the following items in good condition in the primary field office:

2.3 FIELD OFFICE SERVICES

A. Each field office shall be provided with sufficient lighting to produce not less than 50 foot-candles at desktop height at each desk location. Exterior lighting shall be provided over the entrance door. Lighting fixtures and bulbs shall be energy-efficient fluorescent or LED.

B. A minimum of four 110 VAC duplex grounded electric convenience outlets shall be provided in each office and in the conference room and common area. At least one such outlet shall be located on each wall. The electric distribution panel shall service not less than two 110 VAC circuits.

C. Where inside toilet facilities are not connected to outside plumbing, a flush-type chemical toilet with a holding tank shall be provided. Sanitary waste material shall be regularly pumped out and the chemicals recharged. Toilet paper and paper towels shall be furnished for each toilet facility.

D. Regular daily janitorial services shall be furnished during working hours each day. Offices shall be swept, dusted, and waste receptacles and recycling receptacles emptied. Toilet facilities shall be sanitized and cleaned daily, and paper supplies shall be replenished.

2.4 COMMUNICATIONS

A. Communications shall be provided in accordance with Specification Section 01510 - Temporary Utilities.

2.5 DECONTAMINATION FACILITIES

A. The Decontamination Facilities shall contain (1) a vehicle decontamination area, and (2) a personnel decontamination area. As shown on the Drawings, these decontamination areas will be adjacent to one another, but separate to isolate personnel traffic from vehicular traffic and to minimize the potential for accidents.

B. **Vehicle Decontamination Pad:** *This section will include requirements for the vehicle decontamination pad that are consistent with the approved design. Typical requirements would include the configuration, dimensions, performance expectations for the decontamination pad, equipment storage, and collection and containment requirements.*

C. **Personnel Decontamination Area:** *This section will include requirements for personnel decontamination consistent with the approved design. Typical requirements would include scanning equipment, showers, lockers (for changing from civilian clothes into work clothes and vice versa), restroom, and laundry facilities.*

2.6 CONSTRUCTION WATER MANAGEMENT FACILITIES

A. *This section will include requirements for well upgrades and water storage facilities consistent with the approved design.*

2.7 STORMWATER MANAGEMENT FACILITIES

A. *This section will include requirements for stormwater controls with the approved design*

2.8 FIRE SUPPRESSION

A. *This section would include supplemental fire suppression requirements, if any.*

PART 3 -- EXECUTION

3.1 GENERAL

A. Clearing, grubbing, or grading performed by the CONTRACTOR for setting up and maintaining CSF areas shall be approved by the ENGINEER, and shall be performed in accordance with and Section 02100 – Site Preparation.

B. Fill placement, gravel surfacing, drainage work shall be performed in accordance with Section 02200 – Earthwork.

C. Asphalt paving shall be performed in accordance with Section 02460 – Asphalt Concrete Pavement and Base.

D. Geomembranes shall be installed in accordance with Section 02272 – Geomembranes.

E. *Additional reference sections to be added as needed to be consistent with the approved design.*

- END OF SECTION –

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ATTACHMENT J.2

Outline, Specification Section 01585 – Green and Sustainable Practices

SECTION 01585 – GREEN AND SUSTAINABLE PRACTICES

PART 1 -- GENERAL

1.1 GENERAL DESCRIPTION

A. Furnish all labor, materials, equipment and supplies required to implement the green and sustainable practices outlined in this specification.

B. Required green and sustainable practices include elements of Materials Management, Water Management, and Emissions Reduction are tabulated below. These efforts shall be conducted throughout RA activities at the site.

Materials Management	Paper reduction Recycling Equipment Reuse
Water Management	Efficient use of available site water
Air Emissions Reduction	Ultra-low sulfur diesel fuel for vehicles and equipment Vehicle and equipment “no-idling” policy Vehicle speed limit Worker Transportation (carpool/rideshare) Emissions reduction measures for temporary generators Non-road diesel equipment fleet requirements

1.2 REFERENCES AND STANDARDS

A. Comply with all Federal and State laws or ordinances, as well as applicable codes, standards, regulations and/or regulatory agency requirements including the partial list below:

1. Occupational Safety and Health Administration (OSHA) 29 CFR Part 1926 Safety and Health Regulations for construction.

2. National Primary Drinking Water Standards 40 CFR Part 141.61 through 141.63

3. Green Remediation Best Management Practices for Excavation and Surface Restoration, EPA 542-F-08-012, December 2008.

1.3 SUBMITTALS

A. The following plans are required to be prepared and submitted by the CONTRACTOR for ENGINEER review and approval.

1. Comply with Section 01300 – Contractor Submittals.

2. **Materials Management Plan**: Include plans to maximize use of electronic format for communications and submittals, and to minimize paper uses (i.e., provide double-sided prints). Include recycling plans for collection of plastics, paper, cardboard, and aluminum.

3. **Emissions Reduction Plan:** Verify the existence of and contract with a local low-sulfur diesel supplier for all vehicles and equipment used; provide worker transportation plan, include carpool or rideshare parking area(s) in centralized

location(s); and no-idle and speed limit policies. Outline an emissions reduction education plan for workers, include benefits of not idling (e.g., reduction in emissions). Include a section titled "Emission Reduction Plan for Temporary Generators" outlining policies to minimize power uses from temporary fuel-powered generators that will be needed before power drops are available at the construction support facilities. The plan shall include provisions to comply with EPA emission requirements for non-emergency stationary engines (excluding those already in use at the Site) as well as procedures and guidelines for optimizing the use of temporary generator sets for heating, lighting, tools, and equipment (include guidelines for reducing idling time, following manufacturer's recommended maintenance and engine warm-up and cool-down times, and optimize generator size given anticipated needs).

4. **Water Management Plan:** To the extent possible, optimize water use through construction practices. Plans for the use of effluent water (uses, schedule for use, estimated volume, location of water truck filling stations, effluent/pipeline diversion details, treatment details for off-site water use as appropriate, deviation criteria [e.g., criteria when treatment plant effluent will not be used], etc.) shall be submitted in accordance with Section 01300 – Contractor Submittals. Include coordination efforts with COMPANY operators.

5. **Signs**: Submit plans for speed limit and no-idling policy signs.

6. **Non-road Diesel Equipment List**: A list of all non-road diesel engine powered construction equipment to be used on the project shall be submitted at the beginning of construction. All the project-specific Non-road Construction Equipment shall be reviewed by the Construction Contractor every 12 months to ensure compliance with the fleet requirements tabulated in Section 3.2F of this specification.

1.5 LABOR TRANSPORTATION COORDINATION

A. Coordinate with officials of centralized carpooling and bus pickup locations (e.g., Gallup) concerning selection and approval of carpool and rideshare parking areas in their respective municipalities.

PART 2 -- PRODUCTS

NOT USED

PART 3 -- EXECUTION

3.1 MATERIALS MANAGEMENT

A. Reduce paper use:

1. Minimize hardcopy submittals. Utilize electronic communications and submit required submittals in electronic format.

2. Develop electronic file sharing system for submittals and communication.

3. Set printers to default double-sided print. When hardcopy printouts are necessary, utilize double-sided printing.

3.2 EMISSIONS REDUCTION

A. Fuel for Vehicles and Equipment. Ultra-low sulfur diesel fuel shall be used for all on and off-road operation of vehicles and construction equipment.

B. On-Site Vehicle Speed Limits. On-Site vehicle speeds will be restricted to accommodate safe roadway conditions based on roadway grade, roadway soil conditions, roadway congestion, and the need to limit air emissions caused by roadway fugitive dust. These dust emission shall be controlled on-site through use of chemical dust suppressant and/or water applications to roadways.

C. No-idling Policy

1. No work vehicles or work equipment is allowed to idle longer than 5 minutes unless:

a) The vehicle/equipment is undergoing testing, servicing, repair, or diagnostic

b) The vehicle/equipment is accomplishing work for which it was designed

c) There is a safety issue

2. Follow manufacturer-recommended warm-up and cool-down periods.

D. Worker Transportation. Identify carpooling and/or rideshare parking areas in centralized area(s) for workers to use to get to the site. Encourage worker participation.

E. Conduct Worker Training. Cover specific idle-reduction operating practices, environmental benefits, and safety.

F. Minimize Emissions from Temporary Generators. Diesel generators used on site for more than 10 days must be either compliant with EPA Tier 4 non-road emission standards or be equipped with emission control technology verified by EPA or CARB to reduce PM emissions by a minimum of 85%. Follow protocol outlined in the approved 'Emissions Reduction Plan for Temporary Generators' section of the approved Emissions Reduction Plan. Implement measures to minimize use of temporary generators for lighting, heat, tools, and equipment (to include, but not necessarily be limited to: minimizing generator idling time, following manufacturer's recommended maintenance and motor warm-up/cool-down, and optimizing generator sizing and selection based on anticipated loads).

G. Non-road Diesel Powered Construction Equipment Fleet Requirements.

This section will include requirements to comply with 40 CFR 1039.

3.3 CLEAN WATER MANAGEMENT

A. Follow ENGINEER-approved Water Management Plan, and coordinate with COMPANY personnel.

- END OF SECTION -

Northeast Church Rock
30% Design Report

Appendix K:
Removal Action Schedule

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FIGURE

Figure K.1-1: Removal Action Schedule

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
CY	cubic yards
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
RAO	Remedial Action Objective
ROD	Record of Decision
SOW	Statement of Work
USEPA	US Environmental Protection Agency

K.1 INTRODUCTION

This appendix to the Northeast Church Rock 30% Design Report provides a schedule in support of the design for the Removal Action at the Northeast Church Rock Mine Site (Mine Site) and repository construction at the Church Rock Mill Site (Mill Site). This schedule is intended to be used as a high-level planning tool and generally illustrates the work activity layout (organized in a manner consistent with the Design Drawings), work activity interrelationships, and reasonable durations which the Removal Action could be conducted, based on the 30% design. The schedule will be revised as the design is advanced, based on more detailed construction information such as: riprap sources and production rates, Construction Contractor equipment and production rates, and dust control measures. This schedule is not intended to be a construction schedule and does not show sufficient detail to execute the work. The schedule is presented in Figure K.1-1.

K.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (ROD; USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table K.2-1 presents Performance Standards related to the removal action schedule and explains how the design accomplishes these standards.

Table K.2-1: Performance Standards Applicable to the Removal Action Schedule

Location of Performance Standard Requirement	Performance Standard	Comments
2015 AOC SOW, Paragraph 37 – Preliminary Design	Respondents shall include the following elements in their Preliminary Design: k. A preliminary construction schedule, including a schedule for applicable permit requirements;	The preliminary construction schedule is included in this appendix as Figure K.1-1.

K.3 SCHEDULE

K.3.1 Schedule Format

This schedule was developed using Microsoft Project 2010 and is presented in Gantt chart format, with task durations and task dependencies indicated. The organization of tasks is generally consistent with the Sections in the 30% Design Drawings to aid in identifying the location of tasks within the design documents.

This schedule is intended as high-level planning tool and does not show sufficient detail to execute the work. Therefore, this schedule does not indicate the critical path, float, specific construction related constraints, or general procurement items, and many tasks have been consolidated.

K.3.2 Schedule Inputs and Assumptions

The primary inputs for schedule development were the design drawings and associated quantity calculations. The following major assumptions were used in the development of this construction schedule:

- A generic yearly schedule was assumed, with procurement beginning in January of Year 1.
- USEPA design approval and US Nuclear Regulatory Commission License Amendment approval prior to procurement start.
- Permitting for the transport of principle threat waste to the disposal facility was assumed to require 6 months. Detailed permitting requirements will be determined during the pre-final design phase.
- Permitting for local traffic control was assumed to require 1 month.
- Construction sequence and duration assumptions:
    - The first 4 months of construction is limited to activities that do not expose or transport contaminated materials. This includes early works, haul and access roads, repository preparation activities, and several drainage improvement activities in the vicinity of the repository. This allows for the establishment of drainage controls around the repository and development and adjustment of dust control measures prior to transporting mine waste.
    - Construction hours are based on five 8-hour shifts per week based on dust control water limitations discussed in Appendix Q.
    - Mine waste removal is based on an average production of 3,150 cubic yards (CY) per day assuming the use of a fleet of between five and ten 30 CY articulated trucks operating 7 hours per day. The Mine Site excavation areas are not well suited to high volume excavation fleets such as scrapers or large haul trucks.
    - Radon barrier conditioning, principal threat waste removal, and borrow area development are shown as continuous operations on the schedule, but are likely to be conducted in several discrete events within the duration shown.
    - Cover construction consists of hauling and placement of the cover soils and the erosion protection layer. This activity is expected to be conducted in phases, concurrently with mine waste placement. For scheduling purposes, it is shown as a continuous activity concurrent with mine waste placement.
    - Other durations are based on engineering and construction experience.

K.3.3 Schedule Delays

There is not expected to be a formal winter shutdown of construction operations; however, an approximate two-week weather delay has been included within each winter season (indicated by split tasks on the Gantt chart). Other potential items that could delay the schedule include:

- Delays in regulatory approvals

- Changed site conditions
- Inclement weather
- Procurement or supply disruptions for imported materials
- Excessive dust (i.e. water supply disruption)
- Labor issues

K.4 REFERENCES

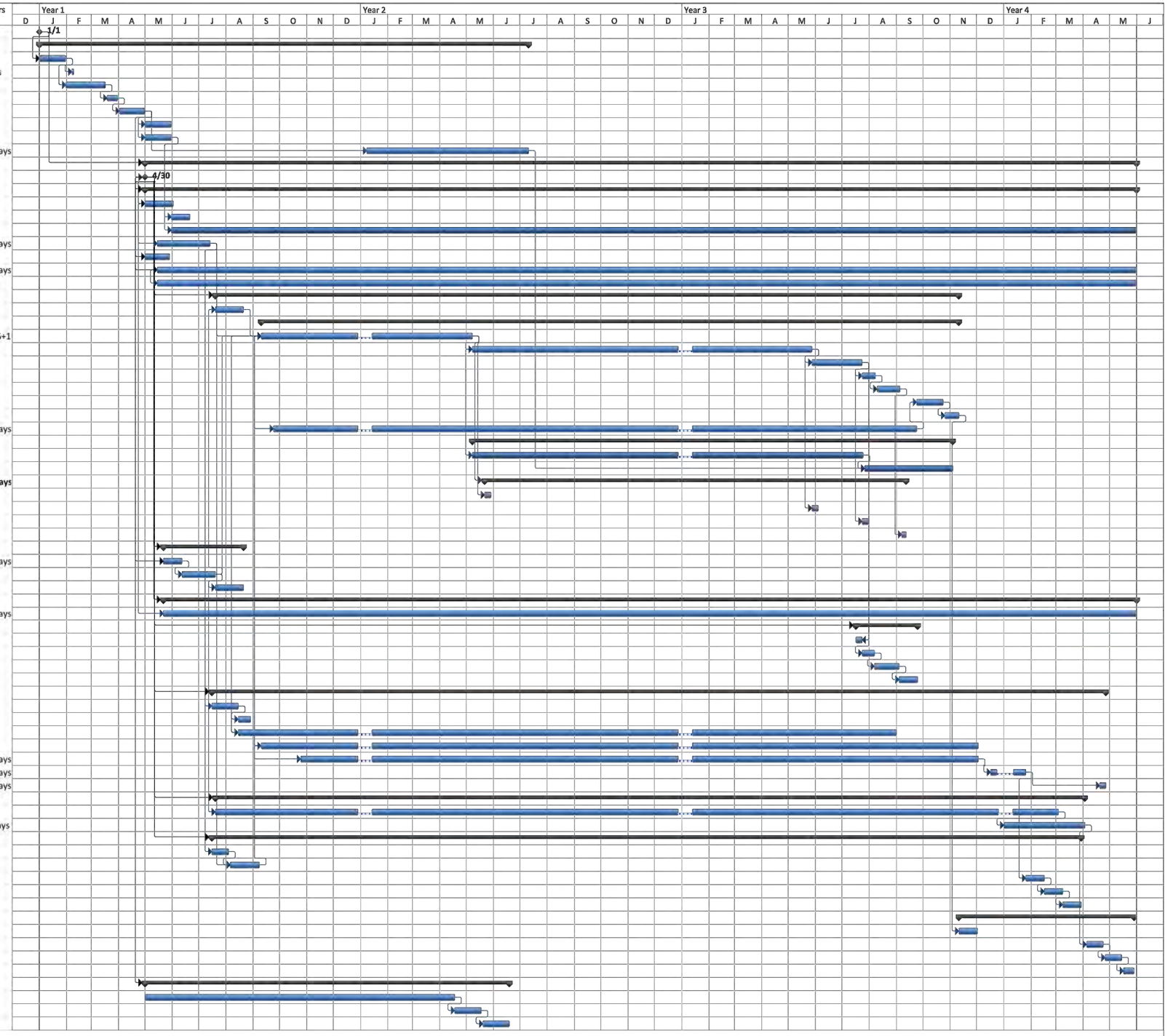
US Environmental Protection Agency (USEPA), 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Mine Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. Prepared for U.S. EPA Regions 6 and 9. September 29.

US Environmental Protection Agency (USEPA) Region 6, 2013. Record of Decision for Operable Unit OU02, Surface Soil Operable Unit, United Nuclear Corporation Site, McKinley County, New Mexico. March 29.

US Environmental Protection Agency (USEPA), 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site, McKinley County, New Mexico. April 27.

FIGURE

ID	Task Name	Duration	Predecessors
1	NRC License Amendment Approval	0 days	
2	**PROCUREMENT**	**398 days**	
3	Prepare Bid Documents	22 days	1
4	Site Walk	2 days	3FS+5 days
5	Contractors Prepare Bids	33 days	3
6	Bid Review and Award	10 days	5
7	Contract Negotiation and Execution	21 days	6
8	Pre-construction Submittals (including SWPPP)	22 days	7
9	Traffic Control Permits (NMDOT, NDOT, County)	22 days	7
10	PTW Transport and Disposal Permits	132 days	7FS+180 days
11	**REMOVAL ACTION**	**805 days**	**1**
12	Construction Notice-To-Proceed	0 days	7
13	**Early Works and Construction Support Facilities (Section 2)**	**805 days**	**12**
14	Mobilization	24 days	12
15	Establish Access Controls	15 days	9
16	Implement Traffic Controls	783 days	9
17	Construct Support Facilities	44 days	14SS+10 days
18	Establish Construction Water	20 days	12SS
19	Air Monitoring	795 days	12SS+10 days
20	Dust Control	795 days	19SS
21	**Mine Site Excavation (Section 3)**	**603 days**	**12**
22	Site Preparation and Construction Access Development	22 days	42
23	**Mine Waste Excavation**	**567 days**	
24	Phase 1 (342K CY; Excavate and Haul)	162 days	42,17,54SS+1
25	Phase 2 (548K CY; Excavate and Haul)	266 days	24
26	Phase 3 (87K CY; Excavate and Haul)	41 days	25
27	Phase 4 (22K CY; Excavate and Haul)	11 days	26
28	Phase 5 (42K CY; Excavate and Haul)	20 days	27
29	Haul Road Verification Surveys and Clean Up	22 days	31
30	Former Mill Site Yard Verification Surveys and Clean Up	12 days	29
31	Verification Surveys	503 days	24SS+10 days
32	**Principal Threat Waste Removal**	**390 days**	
33	Stockpiling	308 days	25SS
34	Loadout and Haul to Disposal Facility	72 days	10,33
35	**Final Grading and Seeding**	**343 days**	**24FS+10 days**
36	Phase 1	5 days	24
37	Phase 2	5 days	25
38	Phase 3	5 days	26
39	Phase 4 and 5	5 days	28
40	**Haul Roads (Section 4)**	**65 days**	**12**
41	Construct Access Roads	15 days	12SS+15 days
42	Construct Mine Waste Haul Road	28 days	41
43	Construct Borrow Haul Roads	22 days	42
44	**Construction Stormwater Management (Section 5)**	**790 days**	**12**
45	Implement Construction Stormwater Controls	790 days	14SS+15 days
46	**Mine Site Permanent Stormwater Controls (Section 6)**	**50 days**	**12**
47	Cutoff Wall	5 days	26FF
48	Outlet Channel	10 days	47
49	Box Culvert and Outlet Apron	20 days	48
50	Outlet Channel Downdrain	15 days	49
51	**Repository (Section 7)**	**726 days**	**12**
52	Cover Stripping. Screening, Stockpiling	22 days	17
53	Stormwater Containment Berm Construction	10 days	52
54	Radon Barrier Conditioning	514 days	52
55	Mine Waste Placement	563 days	24SS
56	Cover Construction (Haul and Place Cover Layers)	530 days	55SS+33 days
57	West Apron and Southwest Regrade	15 days	56FS+10 days
58	Seeding	5 days	57FS+60 days
59	**Borrow Areas (Section 8)**	**706 days**	**12**
60	Borrow Area Development	654 days	42
61	Borrow Area Reclamation and Seeding	66 days	60FS-44 days
62	**Mill Site Stormwater Controls (Section 9)**	**706 days**	**12**
63	Dilco Hill Channels	15 days	17
64	East Repository Channel	25 days	17,63
65	Alluvial Flood Plain Improvements	15 days	57
66	North Cell Drainage Channel	15 days	65
67	North Diversion Channel Improvements	15 days	66
68	**Demobilization/Revegetation (Section 10)**	**143 days**	
69	Reclaim Haul Roads	15 days	30
70	Reclaim Repository Yard and Access Roads	15 days	61
71	Reclaim Former Millsite Yard	15 days	70
72	Seeding of Remaining Areas	10 days	71
73	**ROCK JETTY REPLACEMENT (Section 9)**	**296 days**	**12**
74	Riprap Development (Off-site Pit) & Stockpile	252 days	
75	Excavation	22 days	74
76	Riprap Placement	22 days	75



Page 1

DESIGNED J.COLEMAN
CHECKED J.CUMBERS
APPROVED C.STRACHAN

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UNITED NUCLEAR CORPORATION AND NORTHEAST CHURCH ROCK MINE
McKINLEY COUNTY, NEW MEXICO

NECR REMOVAL ACTION SCHEDULE

FIGURE
K 1-1
10508639
JULY, 2016

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APPENDIX L
Removal Action Health and Safety Plan and
Emergency Response Plan
(to be provided with 95% Design Report)

Northeast Church Rock 30% Design Report

Appendix M:
Traffic Safety and Security

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Table M.2-1: Performance Standards Applicable to the Traffic Safety and Security Plan 2-1

FIGURE

Figure M.3-1 General Layout of Mine and Mill Site Traffic and Security Controls

LIST OF ACRONYMS / ABBREVIATIONS

AADT	annual average daily traffic
ALARA	As Low as Reasonably Achievable
AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
HASP	Health and Safety Plan
ISEA	International Safety Equipment Association
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
MUTCD	Manual on Uniform Traffic Control Devices for Streets and Highways
NDOT	Navajo Nation Department of Transportation
NMDOT	New Mexico Department of Transportation
RA	Removal Action
RAO	Remedial Action Objective
TCP	Traffic Control Plan
USDOT	US Department of Transportation

M.1 INTRODUCTION

This appendix to the Northeast Church Rock 30% Design Report outlines the Traffic Safety and Security Plan that will be implemented during the Removal Action (RA) at the Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site). Specifically, this appendix discusses construction traffic control and safety, public traffic control and safety, vehicle and personnel decontamination requirements, and site access controls. The Remedial Action Health and Safety Plan (HASP) is not part of this appendix. The HASP will be included as a separate appendix in the pre-final design.

For the purposes of traffic control, contamination control, and security, areas of the Mine and Mill sites that will be active during the RA are organized in zones using the following terms and definitions referred to throughout this appendix:

- Support Zone: Area(s) free of contamination.
- Exclusion Zone: Area(s) with actual or potential contamination.
- Decontamination Zone: The transition area between the exclusion and support zones. This area is where personnel enter and exit the Exclusion Zone and where decontamination activities occur.

This Traffic Safety and Security Plan is completed to a 30 percent level of detail. This plan will evolve as the design progresses and additional detail will be added at the pre-final design stage. The Construction Contractor will be required to prepare and submit a Traffic Control Plan (TCP) consistent with its planned operations. The TPC will be required to be in substantial compliance with the final approved Traffic Safety and Security Plan as well as with any supplemental requirements included in the Technical Specifications.

Coordination with New Mexico Department of Transportation (NMDOT), the Navajo Division of Transportation (NDOT), McKinley County, and other appropriate stakeholder agencies will be conducted during the 95% design phase to develop the additional detail required.

M.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table M.2-1 presents Performance Standards related to traffic safety and security and explains how the design accomplishes these standards.

Table M.2-1: Performance Standards Applicable to the Traffic Safety and Security Plan

Location of Performance Standard Requirement	Performance Standard	Comments
2015 AOC SOW, Paragraph 17 – Soil Transportation and Management	In the Design, Respondents shall provide detailed plans and specifications explaining how mine waste from the NECR Site and other materials (including borrow, backfill, and cover materials) will be managed and transported. Respondents shall include details for ensuring that Principal Threat Waste from the NECR Site, as described in the 2011 Action Memo, is not transported to the UNC Site or disposed at the Tailings Disposal Area.	This appendix presents the safety and security aspects of construction traffic, including mine waste transportation. Mine waste material handling is addressed in Appendix C. Mine waste and borrow haul roads are addressed in Appendix D. Principal threat waste handling facilities are addressed in Appendix B.
2015 AOC SOW, Paragraph 19 – Site Controls and Security	In the Design, Respondents shall include plans and specifications for security for the SA Site to prevent access by unauthorized humans and livestock during the construction of the remedy. Respondents shall include plans and specifications for a fence, cattle guards and other security features, as needed.	Site access controls include livestock fencing, temporary chain link fencing, gates, and manned security posts as described in this appendix. Appendix J – Technical Specifications will include technical specifications for fencing, gates, and other constructed security measures.
2013 ROD, Section 2.9.5, Transportation	Transportation of all mine waste will be transported in such a manner to mitigate the production of dust, including the use of covers and/or dust suppression actions. A transportation plan will be used to identify the routes of travel, times of operation, and traffic rules. Emergency spill containment and cleanup contingencies would also be included in the transportation plan to address mine waste spills.	This appendix presents the safety and security aspects of construction traffic (including routes of travel and traffic rules). Dust suppression is addressed in Appendix Q. Emergency spill containment and cleanup contingencies will be addressed in the final approved Spill Prevention, Containment, Clean-up and Countermeasures Plan.
2013 ROD, Section 2.9.5, Site Controls and Security	During response activities access will be restricted by construction of a temporary fence. Domestic livestock or unauthorized persons would not be allowed to enter.	Site access controls include livestock fencing, temporary chain link fencing, gates, and manned security posts as described in this appendix. Appendix J – Technical Specifications will include technical specifications for fencing, gates, and other constructed security measures.

M.3 TRAFFIC SAFETY AND CONTROL

An outline of traffic safety and control measures is presented in the following subsections. Traffic control signage and devices will comply with the following U.S. Department of Transportation (USDOT) manuals:

- Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), 2009 Edition Including Revisions 1 and 2 (USDOT, 2012b)
- Standard Highway Signs, 2004 Edition (USDOT, 2004)
- Standard Highway Signs, 2012 Supplement (USDOT, 2012a)

A general layout of the Mine and Mill sites with regard to traffic control and security is shown on Figure M.3-1. Additional details such as fencing, gates, parking areas, and construction entrances and exits can be found on the 30% design Drawings (Section 2).

M.3.1 Construction Traffic Control

Traffic patterns have been designed to segregate site worker daily commuting traffic and visitor traffic from heavy equipment and construction traffic. The following controls will be utilized for construction traffic safety:

- Designated construction entrance(s) and exit(s) for workers and visitors
- Designated construction entrance(s) for heavy equipment
- Designated parking areas for workers and visitors
- Segregated haul roads for mine waste and borrow materials
- Speed limits on haul, access and borrow roads
- Warning signs and/or lights at the intersections of access and haul roads, and at the intersection of haul roads and public roads
- Contract requirement that all construction traffic utilizing public roads are compliant with weight restrictions

Construction haul and access roads have been designed to segregate clean and contaminated construction traffic. The following controls will be utilized to maintain contamination control:

- Designated access points to the Exclusion Zone
- Designated egress points from the Exclusion Zone via the Decontamination Zone for equipment and personnel
- Fencing and gates

M.3.2 Public Traffic Control

New Mexico State Highway 566 (NM 566) provides access to the Mine and Mill sites and will be utilized for construction equipment mobilization, material deliveries, and site worker and visitor traffic. Mine waste haul traffic has been kept away from NM 566 with the exception of a single haul road crossing (Figure M.3-1) further discussed in Section M.3.2.1.

The following traffic controls will be utilized for public traffic safety:

- MUTCD compliant advance warning signs and lights

- Reduced speed limits
- Channelization and flaggers
- Temporary gates to restrict traffic from entering work areas

Flaggers or other personnel working in the vicinity of NM 566 or other public roads will be equipped with high-visibility safety apparel that meets the requirements of the ISEA "American National Standard for High-Visibility Apparel" (ANSI, 2015).

M.3.2.1 Mine Waste Haul Road Crossing at NM 566

Mine waste excavated at the Mine Site west of NM 566 will be transported to the Mill Site repository for disposal, which is located east of NM 566. The mine waste haul road crosses NM 566 north of the existing United Nuclear Corporation offices as shown on Figure M.3-1. The New Mexico Department of Transportation 2040 Plan (NMDOT, 2015) indicates that NM 566 is a relatively low-volume highway with an annual average daily traffic volume of 0 – 5,000.

A traffic and contamination control system is necessary for the intersection of the mine waste haul road and NM 566. A temporary traffic light system will be employed during working hours for traffic safety at the crossing. The intersection will also be monitored by personnel stationed at a safe location off the travelled way who will control the signals. The default control will be for public traffic on NM 566 to be stopped by the temporary traffic light when haul trucks are operating. During haul operations, public traffic on NM 566 will be stopped by the temporary traffic light when haul trucks are operating. Once clear of haul trucks, the light will change allowing public traffic to proceed. Associated warnings lights will be placed on the mine waste haul road so haul truck drivers know the status of the intersection at all times. The crossing will be inspected and swept at the end of each haul shift. Additional details are provided in Appendix D.

Prior to work beginning, the Construction Contractor will have the ability to submit for approval alternate methods of contamination control for this location. Temporary gates will be used to restrict haul road access when the mine waste haul road is not in use.

Coordination with NMDOT and other appropriate stakeholder agencies for approval and operation of this haul road crossing will be conducted during the 95% design phase. Agency coordination will include protocols for accommodating emergency vehicles. Upon construction completion, impacted areas of NM 566 will be inspected for structural damage. Any damage to the pavement or underlying road prism resulting from haul operations will be corrected to the satisfaction of NMDOT.

M.4 SITE SECURITY AND ACCESS CONTROLS

The following controls will be utilized for security and access control:

- Security shack and personnel at each designated construction entrance and exit
- Continuous livestock fencing on the perimeter of the Mine and Mill site Exclusion Zone
- Temporary gates and warning signage on haul and access roads

The following controls will be utilized to maintain contamination control:

- Designated access points to the Exclusion Zone
- Designated egress points from the Exclusion Zone via the Decontamination Zone for equipment and personnel
- Temporary chain-link fencing and gates within the Former Mill Site Yard to delineate the exclusion and decontamination zones and control access
- Sign-in and sign out procedures for workers and visitors

M.5 DECONTAMINATION PROCEDURES

Specific decontamination procedures and layout of the decontamination facilities and area will be the responsibility of the selected Construction Contractor. This 30% design appendix provides an outline of decontamination procedures for equipment and personnel. Decontamination facilities are discussed in Appendix B – Construction Support Facilities. The ultimate selection of decontamination methods is dependent upon As Low as is Reasonably Achievable (ALARA) principles, economic and functional considerations, and waste minimization.

M.5.1 General Methods and Precautions

Decontamination activities will be performed in compliance with the Remedial Action HASP and include the following general methods and precautions:

- All instruments shall be properly calibrated.
- Decontamination methods that generate excessive amounts of waste materials shall be used only after other methods, such as vacuuming, tape presses, sweeping, etc., have been attempted or considered.
- Decontamination should normally proceed from the area of lowest to highest concentration.
- To the extent practical, decontamination solutions should be limited to washing with water, soap and/or a mild detergent. Decontamination solvents may be required for oily surfaces.
- Vacuum cleaning is effective on dry, porous and non-porous surfaces for the removal of loose surface dust or particles.
- No decontamination approach shall be used on people that can potentially abrade the skin resulting in potential for internalization of the contamination.

The following equipment and materials will be required:

- Survey instrumentation
- Anti-contamination clothing, including respiratory protection equipment as required
- Container(s) for waste materials generated due to decontamination activities as required

M.5.2 Personnel Decontamination

The following are general considerations to be observed during personnel decontamination activities:

- Decontamination of wounds (other than minor cuts or abrasions) shall be performed by medical personnel.
- The mildest methods of decontamination should be attempted first, progressing to harsher methods when necessary. Cleansing methods, from the least to the most harsh are listed below:
    - Flushing with water
    - Soap and warm water
    - Mild abrasive soap, soft brush, and water
    - Detergent
- Use protective clothing (i.e. gloves) as necessary when decontaminating personnel.
- Minor wounds (cuts, abrasions, etc.) can be flushed with lukewarm water or a saline solution.
- After decontamination, individuals should wash hair, hands, and fingernails thoroughly.
- Work clothing (e.g. coveralls) will remain on site and be laundered for subsequent re-issue.

- Personal clothing or items may be released when surveys indicate that radioactive material is indistinguishable from background.

M.5.3 Decontamination of Small Equipment

The following are general considerations to be observed during small equipment decontamination activities:

- Physically remove any gross contamination by scraping or wiping it off, if practical. Always proceed from the area with the least contamination to the area with the highest contamination.
- Cleaning materials shall be surveyed for contamination using the appropriate survey meter (e.g., alpha survey meter or alpha/beta/gamma Geiger Mueller pancake probe or equivalent) and released or, if necessary, decontaminated.
- For equipment that will not be damaged by moisture, remove any remaining contamination with a brush and distilled or de-ionized water solution containing Alconox detergent, or equivalent.
- Equipment that may be damaged by water should be wiped clean using clean towels and detergent water (Alconox or equivalent) or using a spray bottle with a towel moistened with distilled or de-ionized water.
- Place the equipment in a clean location or use appropriate controls to ensure it will not be contaminated while drying.
- Allow equipment to air dry, if practical, or dry with a clean, lint-free towel.

M.5.4 Decontamination of Heavy Equipment and Vehicles

The following are general considerations to be observed during heavy equipment decontamination activities:

- Water used for decontamination must be contained within the decontamination pad.
- Personnel performing decontamination shall wear appropriate safety equipment and clothing including hand, eye, foot, hearing, and body protection, as applicable to the job, particularly when using high pressure water sprays.
- Equipment with gross contamination should be scraped off with a flat bladed scraper at the sampling or construction site.
- Equipment such as drill rigs, auger, drill bits, and shovels should be sprayed with water (high pressure when required) then rinsed with clean water. Care should be taken to adequately clean hard-to-reach places on complicated pieces of machinery.
- After cleaning and sufficient drying of equipment has been completed, perform surveys to verify that the equipment meets the criteria for additional use or release from the controlled area, as applicable.

M.6 REFERENCES

American National Standards Institute (ANSI), 2015. American National Standard for High-Visibility Safety Apparel and Accessories, (ANSI/ISEA 107-2015), 2015 Edition.

New Mexico Department of Transportation (NMDOT), 2015. New Mexico Department of Transportation 2040 Plan. September.

US Department of Transportation (USDOT), Federal Highway Administration, 2004. Standard Highway Signs. 2004 Edition.

US Department of Transportation (USDOT), Federal Highway Administration, 2012a. 2012 Supplement to 2004 Edition of Standard Highway Signs. March.

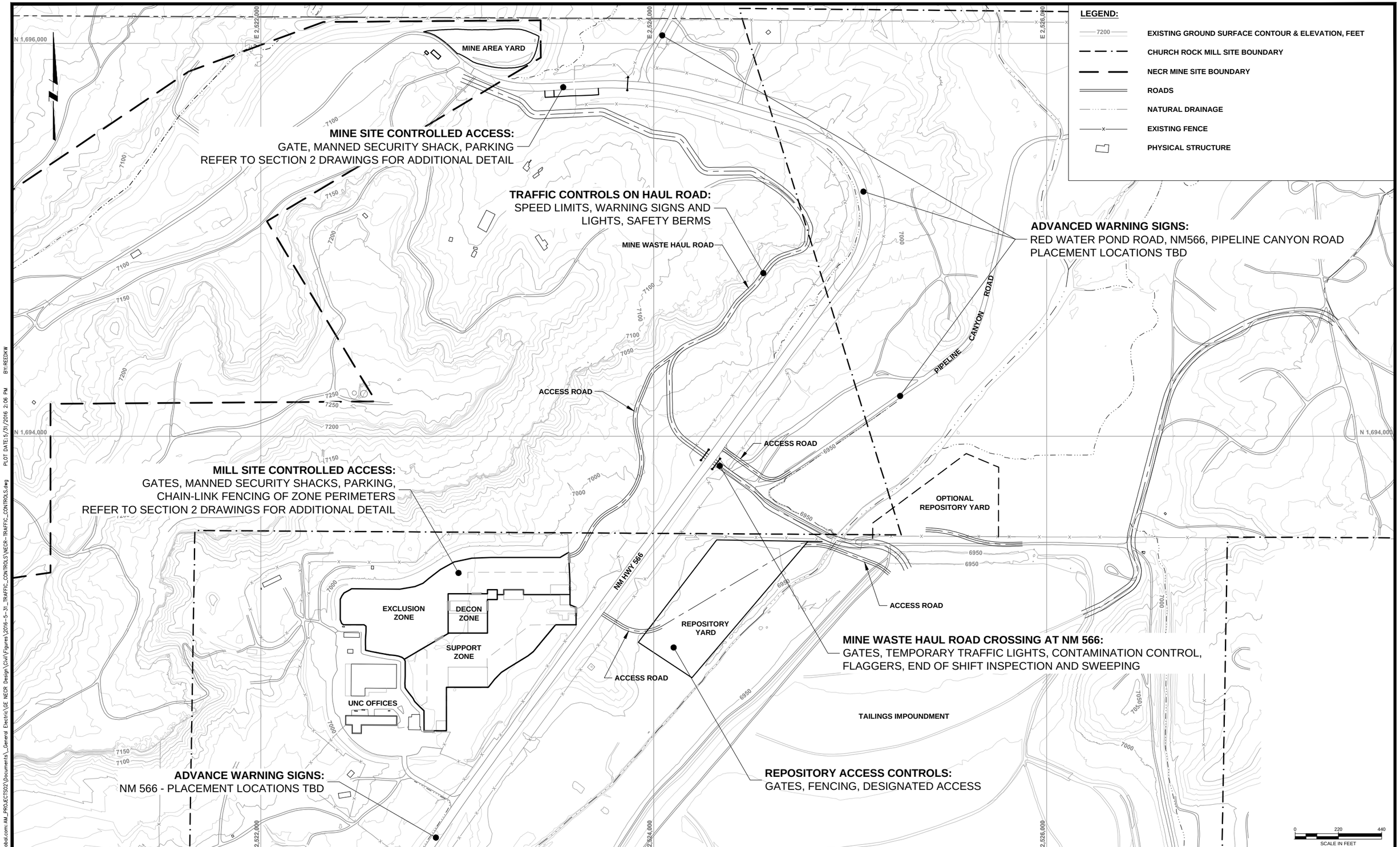
US Department of Transportation (USDOT), Federal Highway Administration, 2012b. Manual on Uniform Traffic Control Devices for Streets and Highways. 2009 Edition, Including Revision1 and Revision 2. May.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. September 29.

US Environmental Protection Agency (USEPA) Region 6, 2013. Record of Decision, United Nuclear Corporation Site, McKinley County, New Mexico. Operable Unit OU2: Surface Soil Operable Unit. March 29.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, Appendix D: Statement of Work. April 27.

FIGURE



DESIGNED J COLEMAN
CHECKED J CUMBERS
APPROVED C STRACHAN

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UNITED NUCLEAR CORPORATION AND NORTHEAST CHURCH ROCK MINE
McKINLEY COUNTY, NEW MEXICO

GENERAL LAYOUT OF MINE AND MILL SITE TRAFFIC
AND SECURITY CONTROLS

FIGURE
M.3-1
10508639
MAY, 2016

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Northeast Church Rock 30% Design Report

Appendix N:

Permitting Requirements and Compliance Plan

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LIST OF ACRONYMS / ABBREVIATIONS

AOC	Agreement and Order of Consent
ARAR	Applicable or Relevant and Appropriate Requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
CAA	Clean Air Act
ESA	Endangered Species Act
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NECR	Northeast Church Rock
NMAC	New Mexico Administrative Code
NMDOT	New Mexico Department of Transportation
NMED	New Mexico Environmental Department
NMSA	New Mexico Statutes Annotated
NPDES	National Pollutant Discharge Elimination System
NRC	US Nuclear Regulatory Commission
PTW	principal threat waste
RA	Removal Action
RCRA	Resource Conservation and Recovery Act
SOW	Statement of Work
TDA	Tailings Disposal Area
UMTRCA	Uranium Mill Tailings Radiation Control Act
US	United States
USC	United States Code
USEPA	United States Environmental Protection Agency

N.1 INTRODUCTION

N.1.1 Project Background

This appendix identifies and provides a brief description of the federal, Navajo Nation, and state of New Mexico Applicable or Relevant and Appropriate Requirements (ARARs) to which this design will conform. The Northeast Church Rock (NECR) Mine Site (Mine Site) Removal Action (RA) consists of removal of mine waste materials. These materials will be excavated and removed from the Mine Site and disposed of either at the repository to be constructed on the Church Rock Mill Site (Mill Site) Tailings Disposal Area (TDA) or at an off-site location (in the case of principal threat waste).

This appendix to the 30% Design Report is one of many work elements being conducted pursuant to the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC), United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site (USEPA, 2015) including the Statement of Work (SOW) attached as Appendix D to the AOC. The required design elements for the RA described in the AOC and SOW (USEPA, 2015) include activities at both the Mine Site and Mill Site. The Selected Remedy will be designed to be protective of human health and the environment and to conform to the ARARs defined in the following:

- Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Mine Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation (USEPA, 2011)
- Record of Decision: United Nuclear Corporation Site, McKinley County, New Mexico (USEPA, 2013)
- Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (USEPA, 2015)

The Mine Site is a non-operating uranium mine located within Sections 34 and 35 of Township 17 North, Range 16 West and Section 3 of Township 16 North, Range 16 West at the terminus of NM State Highway 566, approximately 17 miles northeast of Gallup, New Mexico, in McKinley County. The NECR Site is located within an area of approximately 125 acres, part of which is located on lands held by the United States in trust for the Navajo Nation. The Mill Site is owned by United Nuclear Corporation (UNC) (now an indirect subsidiary of GE). The selected remedy is to remove waste material from the Mine Site and dispose of the material at the nearby Mill Site (site consisting of former mill site and TDA).

The USEPA determined that these areas are considered to be on-site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and therefore are exempt from permit requirements with the exception of the off-site disposal of principal threat waste (PTW) excavated from the Mine Site. Section 121(e) of CERCLA, 42 USC § 9621(e) and 40 CFR § 300.400(e) of the National Contingency Plan states:

> *(1) No federal, state, or local permits are required for on-site response actions conducted pursuant to CERCLA Sections 104, 106, 120, 121, or 122. The term on-site means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action.*

As a result, the design will substantially conform to the ARARs defined in the above-listed documents and described in this appendix. For design elements that do not fall under the CERCLA exemption described above (transportation and off-site disposal of the PTW, and state highway traffic control requirements), permits will be obtained where required. Agencies with jurisdictions or regulatory authority over these two design elements are:

- US Environmental Protection Agency (USEPA)
- US Nuclear Regulatory Commission (NRC)
- US Department of Transportation
- New Mexico Environment Department
- New Mexico Department of Transportation

The means for conforming the design to the ARARs are described for each activity in the corresponding appendix in this 30% Design Report. Table N.1-1 lists each federal, tribal, and state regulation, statue, or act that has been identified as an ARAR with respect to the 30% Design and identifies the appendix (design element) in which the ARAR is addressed.

Table N.1-1. ARARs

Source of ARAR/Performance Standard	Appendix A - General Design Information	Appendix B - Construction Support Facilities	Appendix C - Mine Site Removal Excavations and Demolition	Appendix D - Haul Routes	Appendix E – Stormwater Management Plan	Appendix F - Mine Site Storm Water Controls	Appendix G – Mine Waste Repository Design	Appendix H - Borrow Areas	Appendix I - Mill Site Storm Water Controls	Appendix J - Technical Specifications	Appendix K - Remedial Action Schedule	Appendix L - Remedial Action Health and Safety Plan	Appendix M - Traffic Safety and Security Plan	Appendix O - Cultural Resources Reports	Appendix P - Natural Resources Reports	Appendix Q – Dust Control and Air Monitoring Plan	Appendix R - Release Prevention and Contingency Plan	Appendix S - Labor Plan	Appendix T - Cleanup Verification Plan	Appendix U - Revegetation Plans	Appendix V - Construction Quality Assurance Plan	Appendix W - Operation, Monitoring and Maintenance Plan	Appendix X - Institutional Control Implementation and Assurance Plan
Atomic Energy Act																							
10 CFR 61		✓	✓		✓		✓		✓	✓		✓			✓	✓					✓	✓	✓
Surface Mining Control and Reclamation Act																							
30 CFR 780																✓							
30 CFR 816		✓	✓	✓	✓	✓	✓	✓	✓	✓					✓		✓			✓		✓	✓
Uranium Mill Tailings Radiation Control Act																							
40 CFR 192	✓		✓				✓		✓			✓							✓			✓	
Clean Air Act																							
40 CFR 50																✓							
40 CFR 61							✓									✓						✓	
Resource Conservation and Recovery Act																							
40 CFR 262													✓										
40 CFR 264							✓		✓	✓												✓	
42 USC, Chapter 82										✓													
42 USC 6901, et seq.			✓				✓			✓													
Clean Water Act																							
33 CFR 320 through 330					✓	✓			✓	✓													
40 CFR 122					✓																	✓	
40 CFR 125					✓																		
40 CFR 230					✓	✓			✓	✓													
Title 49, Transportation																							
49 CFR 171										✓			✓										
49 CFR 172										✓			✓										
49 CFR 173										✓			✓										
Comprehensive Environmental Response, Compensation, and Liability Act																							
40 CFR 300			✓							✓			✓										
OSWER Directive 9200.4-18			✓			✓	✓		✓										✓			✓	
Energy Reorganization Act of 1974																							
10 CFR 20												✓											

Source of ARAR/Performance Standard	Appendix A - General Design Information	Appendix B - Construction Support Facilities	Appendix C - Mine Site Removal Excavations and Demolition	Appendix D - Haul Routes	Appendix E – Stormwater Management Plan	Appendix F - Mine Site Storm Water Controls	Appendix G – Mine Waste Repository Design	Appendix H - Borrow Areas	Appendix I - Mill Site Storm Water Controls	Appendix J - Technical Specifications	Appendix K - Remedial Action Schedule	Appendix L - Remedial Action Health and Safety Plan	Appendix M - Traffic Safety and Security Plan	Appendix O - Cultural Resources Reports	Appendix P - Natural Resources Reports	Appendix Q – Dust Control and Air Monitoring Plan	Appendix R - Release Prevention and Contingency Plan	Appendix S - Labor Plan	Appendix T - Cleanup Verification Plan	Appendix U - Revegetation Plans	Appendix V - Construction Quality Assurance Plan	Appendix W - Operation, Monitoring and Maintenance Plan	Appendix X - Institutional Control Implementation and Assurance Plan
10 CFR 40			✓				✓		✓	✓	✓				✓					✓		✓	✓
Native American Graves Protection and Repatriation Act																							
25 USC, Chapter 32														✓									
43 CFR 10										✓				✓									
American Indian Religious Freedom Act																							
42 USC, Chapter 21																		✓					
Archaeological Resources Protection Act of 1979																							
16 USC, Chapter 1B														✓									
43 CFR 7										✓				✓									
Endangered Species Act																							
16 USC, Chapter 35															✓								
50 CFR 17															✓								
50 CFR 402															✓								
7 USC, Chapter 6															✓								
National Historic Preservation Act																							
36 CFR 800														✓									
Navajo Nation Air Pollution Prevention and Control Act																							
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Navajo Nation Clean Water Act																							
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Navajo Nation Solid Waste Act																							
			✓							✓													
Navajo Nation Endangered Species List																							
															✓								
New Mexico Water Quality Act																							
NMAC 20.6					✓																	✓	
New Mexico Solid Waste Act																							
NMAC 20.9	✓	✓	✓				✓			✓	✓									✓	✓	✓	✓
New Mexico Mining Act																							
NMAC 19.10	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓						✓			
New Mexico Cultural Properties Protection Act																							
NMSA 1978, Chapter 18														✓									

Source of ARAR/Performance Standard	Appendix A - General Design Information	Appendix B - Construction Support Facilities	Appendix C - Mine Site Removal Excavations and Demolition	Appendix D - Haul Routes	Appendix E – Stormwater Management Plan	Appendix F - Mine Site Storm Water Controls	Appendix G – Mine Waste Repository Design	Appendix H - Borrow Areas	Appendix I - Mill Site Storm Water Controls	Appendix J - Technical Specifications	Appendix K - Remedial Action Schedule	Appendix L - Remedial Action Health and Safety Plan	Appendix M - Traffic Safety and Security Plan	Appendix O - Cultural Resources Reports	Appendix P - Natural Resources Reports	Appendix Q – Dust Control and Air Monitoring Plan	Appendix R - Release Prevention and Contingency Plan	Appendix S - Labor Plan	Appendix T - Cleanup Verification Plan	Appendix U - Revegetation Plans	Appendix V - Construction Quality Assurance Plan	Appendix W - Operation, Monitoring and Maintenance Plan	Appendix X - Institutional Control Implementation and Assurance Plan
New Mexico Air Quality Control Act																							
NMAC 20.2																✓							
New Mexico Wildlife Conservation Act																							
NMAC 19.21															✓								
NMSA 1978, Chapter 17															✓								
New Mexico Natural Lands Protection Act																							
NMAC 19.8.20			✓		✓		✓	✓	✓	✓						✓				✓		✓	
New Mexico Radiation Control Act																							
NMAC 20.3												✓											
New Mexico Hazardous Waste Act																							
NMAC 20.4			✓							✓													
New Mexico Prehistoric and Historic Sites Preservation Act																							
NMAC 4.10.12														✓									
New Mexico Natural Resources Trustees Act																							
NMSA 1978, Chapter 75					✓								✓		✓								
New Mexico Department of Transportation																							
Traffic Control/Roadway Work Permit				✓									✓										

N.2 FEDERAL ARARS

N.2.1 Atomic Energy Act (10 CFR 61)

The Atomic Energy Act is the fundamental United States (US) law on both civilian and military uses of nuclear materials. On the civilian side, it provides for both the development and regulation of the uses of nuclear materials and facilities in the United States, declaring the policy that "the development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise." The Act requires that civilian uses of nuclear materials and facilities be licensed, and it empowers the NRC to establish by rule or order, and to enforce, such standards to govern these uses as "the Commission may deem necessary or desirable in order to protect health and safety and minimize danger to life or property." NRC action under the Act must conform to the Act's procedural requirements, which provide an opportunity for hearings and Federal judicial review in many instances.

10 Code of Federal Regulation (CFR) 61 is the specific regulation applicable to the design. This regulation establishes the procedures, criteria, and terms and conditions upon which the NRC issues licenses for land disposal of radioactive wastes containing byproduct, source and special nuclear material received from other persons. Additionally, 10 CFR 61 may apply to the transportation, and off-site disposal of the PTW. The regulations set forth in 10 CFR 61 will be considered for specific activities and the means of conformance are detailed in appendices B, C, E, G, I, J, L, P, Q, V, W, and X of this 30% Design Report.

N.2.2 Surface Mining Control and Reclamation Act of 1977 (30 CFR 816, 30 CFR 780)

The Surface Mining Control and Reclamation Act is defined as, “An Act to provide for the cooperation between the Secretary of the Interior and the States with respect to the regulation of surface coal mining operations, and the acquisition and reclamation of abandoned mines, and for other purposes." It is the primary federal law regulating the environmental effects of coal mining in the US.

Specific regulations relevant or appropriate to the design report are 30 CFR 780 and 30 CFR 816. 30 CFR 780 provides minimum requirements of regulatory program provisions for the mining operations and reclamation plan portions of applications for permits for surface mining activities, except to the extent that different requirements for those plans are established under 30 CFR 785. 30 CFR 816 sets forth minimum environmental protection performance standards to be adopted and implemented under regulatory programs for surface mining activities. The regulations set forth in 30 CFR 780 will be considered for specific activities and the means of conformance are detailed in Appendix Q of this 30% Design Report. The regulations set forth in 30 CFR 816 will be considered for specific activities and the means of conformance are detailed in appendices B, C, D, E, F, G, H, I, J, P, R, U, W, and X of this 30% Design Report.

N.2.3 Uranium Mill Tailings Radiation Control Act of 1978 (40 CFR 192)

The Uranium Mill Tailings Radiation Control Act (UMTRCA) is a federal law that provides for the safe and environmentally sound disposal, long-term stabilization, and control of uranium mill tailings in a manner that minimizes or eliminates radiation health hazards to the public.

The specific regulation relevant to the design is 40 CFR 192. This regulation establishes standards for protection of public health, safety, and environment from radiological and non-radiological hazards associated with uranium and thorium ore processing, and their associated wastes. The regulations set forth in 40 CFR 192 will be considered for specific activities and the means of conformance are detailed in appendices A, C, G, I, L, T, and W of this 30% Design Report.

N.2.4 The Clean Air Act (40 CFR 61, 40 CFR 50)

The Clean Air Act (CAA) is the comprehensive federal law that regulates air emissions from stationary and mobile sources. Among other things, this law authorizes USEPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants.

The specific regulations applicable to the design are 40 CFR 50 and 40 CFR 61. 40 CFR 50 sets forth national primary and secondary ambient air quality standards under section 109 of the CAA. 40 CFR 61 sets forth national emission standards for hazardous air pollutants. The regulations set forth in 40 CFR 50 will be applied to specific activities and the means of conformance are detailed in Appendix Q of this 30% Design Report. The regulations set forth in 40 CFR 61 will be considered for specific activities and the means of conformance are detailed in appendices G, Q, and W of this 30% Design Report.

N.2.5 Resource Conservation and Recovery Act of 1976 (40 CFR 262, 40 CFR 264, and 42 US Code, Chapter 82)

The Resource Conservation and Recovery Act (RCRA) gives USEPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also sets forth a framework for the management of non-hazardous solid wastes including the identification, transportation, treatment, and disposal of such wastes.

The specific regulations relevant to the design are:

- 40 CFR 262 - 40 CFR 262 establishes standards for generators of hazardous waste. The regulation covers generation, recovery, transport and disposal (on-site and off-site) of hazardous waste. The regulations set forth in 40 CFR 262 will be considered for specific activities and the means of conformance are detailed in Appendix M of this 30% Design Report.
- 40 CFR 264 - 40 CFR 264 establishes minimum national standards which define the acceptable management of hazardous waste. The regulations set forth in 40 CFR 264 will be considered for specific activities and the means of conformance are detailed in appendices G, I, J, and W of this 30% Design Report.
- 42 US Code Chapter 82 (6901 et seq.) – 42 US Code Chapter 82 establishes a cooperative effort among the Federal, State, and local governments and private enterprise to recover valuable materials and energy from solid waste and provides technical and financial assistance to State and local governments and interstate agencies for the development of solid waste management plans. The regulations set forth in 42 US Code Chapter 82 will be considered for specific activities and the means of conformance are detailed in appendices C, G, and J of this 30% Design Report.

Additionally, 40 CFR 262 and 40 CFR 264 apply to transportation, and off-site disposal of the PTW. As these two design elements do not fall under the CERCLA exemption described in Section N.1.1, applicable permits will be obtained.

N.2.6 The Clean Water Act (33 CFR 320 – 330, 40 CFR 122, 40 CFR 125, 40 CFR 230)

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.

The specific regulations that will be substantively conformed to in the 30% Design are as follows:

- 33 CFR 320 through 330 – 33 CFR 320 through 330 establish the US Army Corps of Engineers as the regulatory agency managing impacts to navigable waters as defined by Section 404 of the CWA. The regulations set forth in 32 CFR 320 through 330 will be considered for specific activities and the means of conformance are detailed in appendices E, F I and J of this 30% Design Report.

- 40 CFR 122 – 40 CFR 122 sets forth the regulatory provisions to implement the National Pollutant Discharge Elimination System (NPDES). The regulations set forth in 40 CFR 122 will be considered for specific activities and the means of conformance are detailed in appendices E and W of this 30% Design Report.

- 40 CFR 125 – 40 CFR 125 establishes criteria and standards for the imposition of technology-based treatment requirements in NPDES permits under Section 301(b) of the CWA, including the application of USEPA promulgated effluent limitations and case-by-case determinations of effluent limitations. The regulations set forth in 40 CFR 125 will be considered for specific activities and the means of conformance are detailed in Appendix E of this 30% Design Report.

- 40 CFR 230 – 40 CFR 230 establishes guidelines to restore and maintain the chemical, physical, and biological integrity of waters of the US through the control of discharges of dredged or fill material. The regulations set forth in 40 CFR 230 will be considered for specific activities and the means of conformance are detailed in appendices E, F, I and J of this 30% Design Report.

N.2.7 Title 49, United States Code, Transportation (49 CFR 170-173)

Title 49 establishes the US Department of Transportation and sets forth the various administrations and regulations for pipelines, railroads, and motor vehicles.

Specific regulations relevant to the design are 49 CFR 170 through 173. 49 CFR 170 establishes regulations for the safe and secure transportation of hazardous materials in commerce. 49 CFR 171 sets forth the applicability, general requirements, and provides definitions for hazardous waste. 49 CFR 172 lists and classifies materials which the Department of Transportation designated as hazardous materials for purposes of transportation and prescribes the requirements for shipping papers, package marking, labeling, and transport vehicle placarding applicable to the shipment and transportation of those hazardous materials. 49 CFR 173 defines hazardous materials for transportation purposes, establishes requirements for preparing hazardous materials for shipment by air, highway, rail, or water, or any combination thereof, and defines inspection, testing, and retesting responsibilities for persons who retest, recondition, maintain, repair and rebuild containers used or intended for use in the transportation of hazardous materials. The regulations set forth in 49 CFR 170 through 173 will be considered for specific activities and the means of conformance are detailed in appendices J and M of this 30% Design Report.

Additionally, 49 CFR 170 through 173 apply to transportation and off-site disposal of the principal threat waste. As these two design elements do not fall under the CERCLA exemption described in Section N.1.1, applicable permits will be obtained.

N.2.8 Comprehensive Environmental Response, Compensations, and Liability Act (40 CFR 300)

The CERCLA, commonly known as Superfund, created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA establishes prohibitions and requirements concerning closed and abandoned hazardous waste sites, provides for liability of persons responsible for releases of hazardous waste at these sites, and establishes a trust fund to provide for cleanup when no responsible party can be identified.

The specific regulation applicable to the design is 40 CFR 300. 40 CFR 300 establishes the organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants. The regulations set forth in 40 CFR 300 will be considered for specific activities and the means of conformance are detailed in appendices C, J, and M of this 30% Design Report. Office of Solid waste and Emergency Response (OSWER) Directives are documents used to identify and communicate policy and procedures to USEPA regional offices. They are memos and guidance manuals that clarify existing policy and offer program guidance. These are not regulations or statutes to which the design must conform but they are used in the 30% design where applicable.

N.2.9 Energy Reorganization Act of 1974 (10 CFR 20, 10 CFR 40)

The Energy Reorganization Act established the Nuclear Regulatory Commission. The NRC is an independent agency of the US government tasked with protecting public health and safety related to nuclear energy.

Specific regulations that apply to the removal design are 10 CFR 20 and 10 CFR 40. 10 CFR 20 sets forth standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in such a manner that the total dose to an individual does not exceed the standards for protection against radiation prescribed in this part. 10 CFR 40 establishes procedures and criteria for the issuance of licenses to receive title to, receive, possess, use, transfer, or deliver source and byproduct materials, as defined in this part, and establish and provide for the terms and conditions upon which the NRC will issue such licenses. The regulations set forth in 10 CFR 20 will be considered for specific activities and the means of conformance are detailed in Appendix L of this 30% Design Report. The regulations set forth in 10 CFR 40 will be considered for specific activities and the means of conformance are detailed in appendices C, G, I, J, K, P, U, W, and X of this 30% Design Report.

10 CFR 20 and 10 CFR 40 do not fall under the CERCLA exemption described in Section N.1.1. Applicable permits and licenses will be obtained.

N.2.10 Native American Graves Protection and Repatriation Act (25 US Code Chapter 32, 43 CFR 10)

The Native American Graves Protection and Repatriation addresses the rights of lineal descendants, Indian tribes, and Native Hawaiian organizations (parties with standing) to Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony (cultural items). The statute requires Federal agencies and museums to provide information about Native American cultural items to parties with standing and, upon presentation of a valid claim, ensure the item(s) undergo disposition or repatriation.

Regulations applicable to the design are 25 USC Chapter 32 and 43 CFR 10. 25 USC Chapter 32 establishes regulations for the definition, means of identification, and means of repatriation of Native American cultural items. 43 CFR 10 define provisions of the Native American Graves Protection to develop a systematic process for determining the rights of lineal descendants and Indian tribes and Native Hawaiian organizations to certain Native American human remains, funerary objects, sacred objects, or objects of cultural patrimony with which they are affiliated. The regulations set forth in 25 USC Chapter 32 will be considered for specific activities and the means of conformance are detailed in Appendix O of this 30% Design Report. The regulations set forth in 43 CFR 10 will be considered for specific activities and the means of conformance are detailed in appendices J and O of this 30% Design Report.

N.2.11 American Indian Religious Freedom Act (42 US Code Chapter 21)

The American Indian Religious Freedom Act was enacted to protect and preserve the traditional religious rights and cultural practices of American Indians, Eskimos, Aleuts, and Native Hawaiians. These rights include access to sacred sites, freedom to worship through ceremonial and traditional rights, and use and possession of objects considered sacred as defined by the Archeological Resources Protection Act of 1979.

The specific regulation that applies to the design is 42 USC Chapter 21. 42 USC Chapter 21 establishes laws governing civil rights, stating “All persons within the jurisdiction of the United States shall have the same right in every State and Territory to make and enforce contracts, to sue, be parties, give evidence, and to the full and equal benefit of all laws and proceedings for the security of persons and property as is enjoyed by white citizens, and shall be subject to like punishment, pains, penalties, taxes, licenses, and exactions of every kind, and to no other.” The regulations set forth in 42 USC Chapter 21 will be considered for specific activities and the means of conformance are detailed in Appendix S of this 30% Design Report.

N.2.12 Archeological Resources Protection Act of 1979(16 USC Chapter 1B, 43 CFR 7)

The Archeological Resources Protection Act was enacted to "secure, for the present and future benefit of the American people, the protection of archaeological resources and sites which are on public lands and Indian lands, and to foster increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals having collections of archaeological resources and data which were obtained before October 31, 1979."

The applicable regulations for the design are 16 USC Chapter 1B and 43 CFR 7. 16 USC Chapter 1B sets forth guidelines and regulations for (1) excavation and removal and establishing custody of archaeological resources, and (2) defining prohibited acts and criminal and civil penalties. The regulations set forth in 16 USC Chapter 1B will be considered for specific activities and the means of conformance are detailed in Appendix O of this 30% Design Report. 43 CFR 7 establishes provisions of the Archaeological Resources Protection Act of 1979 to form definitions, standards, and procedures to be followed by Federal land managers in providing protection for archaeological resources located on public lands and Indian lands of the United States. The regulations set forth in 43 CFR 7 will be considered for specific activities and the means of conformance are detailed in appendices J and O of this 30% Design Report.

N.2.13 Endangered Species Act (16 USC Chapter 35, 50 CFR 17, 50 CFR 402, 7 US Chapter 6)

The Endangered Species Act (ESA) provides a program for conservation of threatened and endangered plants and animals and the habitats in which they are found. The lead federal agencies for implementing ESA are the US Fish and Wildlife Service and the US National Oceanic and Atmospheric Administration Fisheries Service. Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees.

The law requires federal agencies ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law also prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife.

The specific regulations that will be substantively conformed to in the 30% Design are as follows:

- 7 USC Chapter 6 – 7 USC Chapter 6 sets forth the regulations for the registration, storage, transportation, use, and disposal of insecticides and pesticides.

- 16 USC Chapter 35 – 16 USC Chapter 35 provides a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in this chapter.

- 50 CFR 17 – 50 CFR 17 identifies species of wildlife and plants determined to be endangered or threatened with extinction under Section 4(a) of the ESA and also carry over the species and subspecies of wildlife designated as endangered under the Endangered Species Conservation Act of 1969 which are deemed endangered species under section 4(c)(3) of the ESA.

- 50 CFR 402 – 50 CFR 402 interprets and implements Sections 7(a) through 7(d) of the ESA which includes carrying out conservation programs for listed species, sets requirements for Federal agencies to ensure that any action authorized, funded, or carried out in the US or high seas are not likely to jeopardize the continued existence of listed species or critical habitat, and establishes the permitting and licensing guidance for proposed actions.

The regulations set forth in list above will be considered for specific activities and the means of conformance are detailed in Appendix P of this 30% Design Report.

N.2.14 National Historic Preservation Act (36 CFR 800)

The National Historic Preservation Act provides regulations and guidance for the preservation of the historical and cultural foundations of the US, including the criteria for defining historic properties significant to the heritage of the US.

The specific regulation related to the design is 36 CFR 800, which requires Federal agencies to account for the effects of their undertakings on historic properties. The procedures in this regulation define how Federal agencies meet these statutory responsibilities.The regulations set forth in 36 CFR 800 will be considered for specific activities and the means of conformance are detailed in Appendix O of this 30% Design Report.

N.3 NAVAJO NATION ARARS

Subject to Paragraph 81.b of the Administrative Settlement Agreement and Order on Consent for Design (USEPA, 2015), the design will conform to the following Navajo Nation ARARs.

N.3.1 Navajo Nation Air Pollution Prevention and Control Act

The Navajo Nation Air Pollution Prevention and Control Act is a coordinated program to control present and future sources of air pollution on the Navajo Nation. The act provides for the regulation of air pollution activities in a manner that ensures the health, safety and general welfare of Navajo Nation residents, protects property, and values and protects plant and animal life. The Navajo Nation Council further is placing primary responsibility for air pollution control and abatement in the Navajo Nation Air Quality Control Program, a program of the Navajo Nation Environmental Protection Agency. The regulations set forth in the Navajo Nation Air Pollution Prevention and Control Act will be considered for specific activities and the means of conformance are detailed in appendices J and Q of this 30% Design Report.

N.3.2 Navajo Nation Clean Water Act

The Navajo Nation Clean Water Act establishes (1) the policy for protecting the health, safety, and welfare of Navajo Nation residents, (2) the policy to prevent, reduce, and eliminate pollution of the waters of the Navajo Nation, and (3) the policy for the development and use of land and water resources within the Navajo Nation. The Navajo Nation Clean Water, similar to the US Clean Water Act, establishes water quality standards and establishes the program for permit issuance and implementation under the act. The regulations set forth in the Navajo Nation Clean Water Act will be considered for specific activities and the means of conformance are detailed in Appendix E of this 30% Design Report.

N.3.3 Navajo Nation Solid Waste Act

The Navajo Nation Solid Waste Act is intended to protect the health, safety, welfare and environment of the Navajo Nation by establishing solid waste management practices guidance, including solid waste collection, transportation, separation, recovery, and disposal. The regulations set forth in the Navajo Nation Solid Waste Act will be considered for specific activities and the means of conformance are detailed in appendices C and J of this 30% Design Report.

N.3.4 Navajo Nation Endangered Species List (No. RCS-41-08)

The Navajo Nation Endangered Species List details the species or subspecies that no longer occur on the Navajo Nation, species or subspecies whose prospects of survival or recruitment are in jeopardy or likely to be jeopardized on the Navajo Nation, and species or subspecies lacking sufficient information to support their being listed otherwise by the Navajo Nation Department of Fish and Wildlife. The regulations set forth in the Navajo Nation Endangered Species List will be considered for specific activities and the means of conformance are detailed in Appendix P of this 30% Design Report.

N.4 NEW MEXICO ARARS

N.4.1 New Mexico Water Quality Act (NMAC Title 20 Chapter 6)

The New Mexico Water Quality Act establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters and groundwater within the state of New Mexico.

The specific regulation applicable to in this design are New Mexico Administrative Code (NMAC) Title 20 Chapter 6 which establishes the Water Quality Control Commission as the issuing agency and establishes procedures and guidance for surface water discharges to waters of the US, defines a voluntary remediation program, defines groundwater and surface water quality standards, and provides permitting and compliance guidance for groundwater discharges. The regulations set forth in NMAC Title 20 Chapter 6 will be considered for specific activities and the means of conformance are detailed in appendices E and W of this 30% Design Report.

N.4.2 New Mexico Solid Waste Act (NMAC Title 20 Chapter 9)

The New Mexico Solid Waste Act establishes a comprehensive solid waste management program for the state of New Mexico that provides technical and financial assistance to counties and municipalities for solid waste management, regulations for the reduction, storage, collection, transportation, separation, processing, recycling, and disposal of solid waste, and provide permitting guidance for solid waste facilities.

The applicable regulation for the design is NMAC Title 20 Chapter 9, which sets forth the general requirements for solid waste management including permitting and registration, design criteria, transportation regulations, “special waste” requirements, and groundwater monitoring and correction action guidance. The regulations set forth in NMAC Title 20 Chapter 9 will be considered for specific activities and the means of conformance are detailed in appendices A, B, C, G, J, K, U, V, W, and X of this 30% Design Report.

Additionally, NMAC Title 20 Chapter 9 applies to the transportation and off-site disposal of the PTW design elements. As these two design elements do not fall under the CERCLA exemption described in Section N.1.1, applicable permits will be obtained.

N.4.3 New Mexico Mining Act (NMAC Title 19 Chapter 10)

The New Mexico Natural Resources and Wildlife Non-Coal Mining General Provisions Title 19 Chapter 10 establishes regulations to ensure proper reclamation through permitting for operations subject to the New Mexico Mining Act. The design will substantively conform to these regulations. The regulations set forth in NMAC Title 19 Chapter 10 will be considered for specific activities and the means of conformance are detailed in appendices A, B, C, D, E, F, G, H, I, O, and U of this 30% Design Report.

N.4.4 New Mexico Cultural Properties Protection Act (NMSA 1978 Chapter 18)

The New Mexico Cultural Properties Protection Act establishes the Historic Preservation Division and the Cultural Properties Review Committee to provide for the protection of New Mexico’s archaeological sites by creating a permitting process for the survey and excavation of archaeological sites and unmarked human burials. The design will substantively conform to the Act. The regulations set forth in New Mexico Statutes Annotated (NMSA) 1978 Chapter 18 will be considered for specific activities and the means of conformance are detailed in Appendix O of this 30% Design Report.

N.4.5 New Mexico Air Quality Control Act (NMAC Title 20 Chapter 2)

The New Mexico Air Quality Control Act sets forth general air quality and air pollution control laws aimed at maintaining national ambient air quality standards and preventing and abating air pollution. The act establishes the New Mexico Air Quality Bureau within the New Mexico Environmental Department to enforce air quality regulations.

The specific regulation applicable to the design is NMAC Title 20 Chapter 2, which provides permitting and compliance guidance for activities that may impact air quality and sets forth air quality standards. The regulations set forth in NMAC Title 20 Chapter 2 will be considered for specific activities and the means of conformance are detailed in Appendix Q of this 30% Design Report.

N.4.6 New Mexico Wildlife Conservation Act (NMAC Title 19 Chapter 21, NMSA 1978 Chapter 17)

The New Mexico Wildlife Conservation Act sets forth guidance and a process for the state's commitment to maintaining and managing wildlife indigenous species to New Mexico that may be found to be threatened or endangered. The act commits the state of New Mexico to assisting in the management of species including funding.

Applicable regulations for the design are NMAC Title 19 Chapter 21 and NMSA 1978 Chapter 17. NMAC Title 19 Chapter 21 lists the New Mexico endangered plant species and sets forth permitting requirements for taking endangered plants during scientific investigation or propagation and transplantation. NMSA 1978 Chapter 17 establishes a system and regulations for the protection of game and fish of New Mexico and for their use and development for public recreation and food supply. The regulations set forth in NMAC Title 19 Chapter 21 and NMSA 1978 Chapter 17 will be considered for specific activities and the means of conformance are detailed in Appendix P of this 30% Design Report.

N.4.7 New Mexico Natural Lands Protection Act (NMAC Title 19 Chapter 8, Subchapter 20)

The New Mexico Natural Lands Protection Act was established to acquire and protect unique and ecologically significant lands in the state of New Mexico by the state and by New Mexico corporations for the purposes of education, research, and preservation.

The specific regulation that applies to the design is NMAC Title 19 Chapter 21, Subchapter 20. This regulation defines performance standards for surface coal mining operations specifically related to the permitting and reclamation of surface coal mining operations. The regulations set forth in NMAC Title 19 Chapter 8, Subchapter 20 will be considered for specific activities and the means of conformance are detailed in appendices C, E, G, H, I, J, Q, U, and W of this 30% Design Report.

N.4.8 New Mexico Radiation Control Act (NMAC Title 20 Chapter 3, Subchapter 4, Subchapter 14)

The New Mexico Radiation Control Act, also referred to as the "Radiation Protection Act" established regulations and guidance for management of radioactive materials and created the New Mexico Radiation Technical Advisory Council and defined the council's duties and authority.

Specific applicable regulations for the design are NMAC Title 20 Chapter 3, Subchapter 4 and Subchapter 14. NMAC Title 20 Chapter 3, Subchapter 4 sets forth standards for the protection against ionizing radiation resulting from activates conducted pursuant to licenses and registrations issued by the New Mexico Environmental Department (NMED). The facility has no licenses or registrations issued by the NMED, and so these regulations do not apply, but may be considered for the control, possession, use, transfer, and disposal of radioactive materials. NMAC Title 20 Chapter 3, Subchapter 14 sets forth standards and requirements apply to the extraction, control, possession, use, transfer, and disposal of naturally-occurring radioactive materials within the oil and gas industry. The regulations set forth in NMAC Title 20 Chapter 3, Subchapter 4 and 14 will be considered for specific activities and the means of conformance are detailed in Appendix L of this 30% Design Report.

NMAC Title 20 Chapter 3, Subchapter 4, Subchapter 14 apply to transportation and off-site disposal of the PTW and, as these two design elements do not fall under the CERCLA exemption described in Section N.1.1, applicable permits will be obtained.

N.4.9 New Mexico Hazardous Waste Act (NMAC Title 20 Chapter 4)

The New Mexico Hazardous Waste Act sets forth the regulations and guidance for the management of hazardous waste for the purpose of maintaining the quality of the state's environment and to confer optimum health, safety, comfort, economic, and social well-being of New Mexico's residents and to protect the proper utilization of the state's lands.

The applicable regulation to the design is NMAC Title 20 Chapter 4. This act establishes regulations for management of hazardous waste, including standards for the identification and listing of hazardous waste, the transportation of hazardous waste, the storage of hazardous waste, and the disposal of hazardous waste. The regulations set forth in NMAC Title 20 Chapter 4 will be considered for specific activities and the means of conformance are detailed in Appendix C and J of this 30% Design Report.

NMAC Title 20 Chapter 4 applies to the design elements related to transportation and off-site disposal of the PTW. As these two design elements do not fall under the CERCLA exemption described in Section N.1.1, applicable permits will be obtained.

N.4.10 New Mexico Prehistoric and Historic Sites Preservation Act (NMAC Title 4 Chapter 10, Subchapter 12)

The New Mexico Prehistoric and Historic Sites Preservation Act sets forth the regulations and guidance for the acquisition, stabilization, restoration, or protection of significant prehistoric and historic sites by the state of New Mexico and New Mexico corporations.

NMAC Title 4 Chapter 10, Subchapter 12 is the regulation that applies to the design. This regulation establishes procedures for the acquisition, stabilization, restoration, or protection of significant prehistoric and historic sites by the state of New Mexico and New Mexico corporations. It also establishes procedures and guidelines for determinations of the prudence and feasibility of alternatives to programs and projects requiring the use of land from significant prehistoric and historic sites, and establishes procedures and guidelines to determine whether all possible planning to preserve and protect and to minimize harm to significant prehistoric and historic sites affected by use of lands from such sites has been carried out. The regulations set forth in NMAC Title 4 Chapter 10, Subchapter 12 will be considered for specific activities and the means of conformance are detailed in Appendix O of this 30% Design Report.

N.4.11 New Mexico Natural Resources Trustees Act (NMSA 1978 Chapter 75)

The New Mexico Natural Resources Trustees Act, NMSA 1978 Chapter 75, establishes the office of Natural Resources Trustees and sets forth guidelines for appointing "natural resources trustees" and declares the duties and responsibilities of natural resource trustee. The act also defines methods for identifying, assessing, and awarding damages to natural resources and establishes the "natural resources trustee fund. The design will substantively conformed to this act where applicable. The regulations set forth in NMSA 1978 Chapter 75 will be considered for specific activities and the means of conformance are detailed in Appendix E, M and P of this 30% Design Report.

N.4.12 New Mexico Department of Transportation (NMDOT Traffic Control/Roadway Work Permit Form No. A-66)

The New Mexico Department of Transportation (NMDOT) requires a traffic control/roadway work permit be obtained for operations that require the control of traffic on NMDOT controlled roadways. The permit requires the preparation, submittal, and approval of a temporary traffic control plan that meets the NMDOT standard specifications for highway and bridge construction (latest edition) and the manual on uniform traffic control devices (latest edition). The regulations set forth by NMDOT as it relates to obtaining a traffic control/roadway work permit will be considered for specific activities and the means of conformance are detailed in appendices D and M of this 30% Design Report.

N.5 REFERENCES

Atomic Energy Act of 1954, 42 U.S.C §§ 2011-2021, 2022-2286i, 2296a-2297h-13

Surface Mining Control and Reclamation Act of 1977, Pub.L. 95-87, 91 Stat. 445, as amended 87, codified at 30 U.S.C. 1201-1328

Uranium Mill Tailings Radiation Control Act of 1987, Pub.L. 95-604, 92 Stat. 3021, as amended 96, codified at 42 U.S.C. 88 §7901 et seq.

Clean Air Act of 1963, Pub. L. 88-206, 77 Stat. 392, as amended 90, codified at 42 U.S.C. 85 §7401 et seq.

Resource Conservation and Recovery Act of 1976, Pub. L. 94-580, 90 Stat. 2795, enacted 76, codified at 42 U.S.C. 82 §6901 et seq.

Clean Water Act of 1972, Pub. L. 92-500, 86 Stat. 816, enacted 72, codified at 33 U.S.C. §1251-1387, 23 §1151

Title 49 of the U.S.C., Pub. L. 95-473, 92 Stat. 1337, as amended 94, codified at 49 U.S.C.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Pub. L. 96-510, 94 Stat. 2767, enacted 80, codified 42 U.S.C. §9601 et seq.

Energy Reorganization Act of 1974, Pub. L. 93-438, 88 Stat. 1233, enacted 74, codified at 42 U.S.C.A §5801Native American Graves Protection and Repatriation Act of 1990, Pub. L. 101-601, 104 Stat. 3048, enacted 90, codified at 25 U.S.C. 32 §3001 et seq.

American Indian Religious Freedom Act of 1978, Pub. L. 95-341, 92 Stat. 469, enacted 78, codified at 42 U.S.C. 21, sub I §1996 & 1996a

Archeological Resources Protection Act of 1979, Pub. L. 96-95 as amended, 93 Stat. 721, codified at 16 U.S.C. §§470aa-470mm

Endangered Species Act of 1973, Pub. L. 93-205, 87 Stat. 884, enacted 73, codified at 16 U.S.C. 34 §1531 et seq.

National Historic Preservation Act of 1966, Pub. L. 89-665, 80 Stat. 915, enacted 66, codified at 54 U.S.C. 1A, sub II, §470 et seq.

Navajo Nation Air Pollution Prevention and Control Act of 1995, enacted 95, codified at 2 N.N.C 11, §1100 et seq.

Navajo Nation Clean Water of 1995, enacted 95, codified at 2 N.N.C 13, §1300 et seq.

Navajo Nation Solid Waste Act of 1980, enacted 80, codified at 2 N.N.C 1, §100 et seq.

Navajo Nation Endangered Species List, as amended 08, set forth by the Navajo Nation Division of Natural Resources Department of Fish and Wildlife, codified at No. RCS-41-08

New Mexico Water Quality Act of 1995, codified at 20 N.M.A.C. 6 §20.6.2 et seq.

New Mexico Solid Waste Act of 2007, codified at 20 N.M.A.C 9, §20.9.2 et seq.

New Mexico Natural Resources and Wildlife Non-coal Mining General Provisions of 1996, codified at 19 N.M.A.C. 10, §19.10.1 et seq.

New Mexico Cultural Properties Protection Act of 1978, codified at N.M.S.A. 1978, 18-6A-1 – 6

New Mexico Air Quality Control Act of 1995, codified at 20 N.M.A.C. 2, §20.2.1 et seq.

New Mexico Wildlife Conservation Act of 1995, codified at 19 N.M.A.C. 21, §19.21.2 et seq. and 1978 N.M.S.A 17

New Mexico Natural Lands Protection Act of 1997, codified at 19 N.M.A.C. 8, §19.8.29 et seq.

New Mexico Radiation Control Act of 2009, codified at 20 N.M.A.C. 3, §20.3.1 et seq.

New Mexico Hazardous Waste Act of 2000, codified at 1978 N.M.S.A. §74-4 et seq.

New Mexico Prehistoric and Historic Sites Preservation Act of 1989, codified at 4 N.M.A.C. 10, §4.10.12 et seq.

New Mexico Natural Resources Trustees Act of 1993, codified at 1978 N.M.S.A. §75-7 et seq.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. September 29.

US Environmental Protection Agency (USEPA) Region 6, 2013. Record of Decision, United Nuclear Corporation Site, McKinley County, New Mexico. Operable Unit OU2: Surface Soil Operable Unit. March 29.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, Appendix D: Statement of Work. April 27.

Northeast Church Rock 30% Design Report

Appendix O:
Cultural Resources Reports

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Figure O-1: Limits of Disturbance and Previous Cultural Resource Surveys

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
CFR	Code of Federal Regulations
et seq.	and what follows
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NRC	US Nuclear Regulatory Commission
RAO	Remedial Action Objective
ROD	Record of Decision
SOW	Statement of Work
TCP	Traditional Cultural Property
USC	United States Code
USEPA	US Environmental Protection Agency

O.1 INTRODUCTION

This appendix to the Northeast Church Rock 30% Design Report provides the existing cultural resource surveys conducted at the Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site). Previously identified cultural resource sites have been accounted for in the 30% Design. However, the 30% Design includes new areas of proposed ground disturbance that have not been previously surveyed for cultural resources. These new areas of disturbance would be inventoried for cultural resources as part of a forthcoming Environmental Review required by the US Nuclear Regulatory Commission (NRC) to amend source material license SUA-1475, with the appropriate level of surveying, reporting, consultation, and notification. Figure O.1-1 identifies previously surveyed areas of disturbance and areas of disturbance that would be surveyed as part of the Environmental Review.

If Native American burials or eligible resources (cultural items or sacred sites) are discovered within the surveyed areas to be disturbed, then operations in the immediate vicinity of the discovery would cease, and the required protection, notification, consultation, and reporting processes would be followed in compliance with the Native American Graves Protection and Repatriation Act (25 USC Section 3001 et seq. and its regulations under Title 43 CFR Part 10), the National Historic Preservation Act (16 USC 470 et seq.; 36 CFR Part 800), the Archeological Resources Protection Act of 1979 (16 USC Sections 47000-47011; 43 CFR Part 7), and the American Religious Freedom Act (42 USC Section 1996 et seq.).

O.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (ROD; USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table O.2-1 presents Performance Standards related to cultural resources and explains how the design accomplishes these standards.

Table O.2-1: Performance Standards Applicable to Cultural Resources Protection

Location of Performance Standard Requirement	Performance Standard	Comments
2013 ROD, Section 2.9.5, Natural and Cultural Resources	Natural and cultural resources will be surveyed by a Navajo Nation archeologist and the State and Tribal Historic Preservation Officer will be consulted in accordance with the National Historic Preservation Act. Local residents will be consulted as part of this process.	Cultural resources have been surveyed by a qualified archeologist and the State and Tribal Historic Preservation Officer was consulted in accordance with the national Historic Preservation Act. Local residents were consulted as part of this process. Additional cultural surveys, if required, will be conducted under the Environmental Review and these same Performance Standards will be followed.
2015 AOC SOW, Paragraph 23 – Natural and Cultural Resources	In the Design, Respondents shall include results of any supplemental cultural surveys as required by EPA and conducted by a qualified archaeologist in coordination with the Tribal Historic Preservation Officer, the State Historic Preservation Officer, and other affected parties in accordance with the National Historic Preservation Act, as necessary to supplement existing surveys. Similarly, in the Design, Respondents shall include results of any supplemental biological surveys as required by EPA and conducted by a qualified biologist in coordination with the US Fish and Wildlife Service, Navajo Department of Fish and Wildlife and New Mexico Department of Fish and Game in accordance with the Endangered Species Act, as necessary to supplement existing surveys. Respondents shall ensure coordination with the Navajo Nation for work on the Nation and trust land and with the State of New Mexico for work on state and private lands. Respondents' plans and specifications for any supplemental cultural or biological surveys, as required by EPA, shall include detailed plans and specifications for meetings with the community to garner local knowledge from the community regarding cultural, historical, and biological aspects of the SA Site, as necessary to supplement prior meetings.	Results of previous cultural surveys are summarized in this appendix. If supplemental cultural surveys are required, these will be conducted under the Environmental Review and will include detailed plans and specifications for meetings with the community. Biological surveys (natural resources reports) are described in Appendix P.

Location of Performance Standard Requirement	Performance Standard	Comments
2011 Action Memo, Table A-2; 2013 ROD, Table 1 and Section 2.9.5 - Natural and Cultural Resources	16 USC, Chapter 1B – Archaeological Resources Protection. Sections 470aa through 470mm. Refer to www.gpo.gov.	Protection of archaeological resources is addressed by this appendix and shall be in accordance with applicable regulations.

O.3 CULTURAL RESOURCE STUDIES TO DATE

The information is this section is excerpted from the Final Environmental Data Gap Report (INTERA, 2015). Cultural resources surveys and reports have been completed for both the Mine Site (Boggess and Begay, 2005) and the Mill Site (Appendix E in UNC, 1975). In addition, surveys on behalf of General Electric/United Nuclear Corporation (GE/UNC) were conducted for 68.87 acres of land proposed for reclamation north of the Mine Site (Martin and Begay, 2009), 27.5 acres of land proposed for reclamation to the north and east of the Mine Site (Begay and Wero, 2011), and 73.94 acres of land proposed as borrow areas within and surrounding the Mill Site (Begay, 2013). Each survey report describes the physical extent of the survey, survey techniques, qualifications of the surveyors, and the survey findings in sufficient detail to permit a subsequent, independent assessment of the impacts of the Selected Remedy. Information provided in each report is sufficient for describing historical, archaeological, and cultural resources, including statements of the significance of cultural property potentially affected. To protect potentially sensitive information, these reports are not attached to this appendix.

The following list summarizes each report and its findings:

- In 1974 an archaeological survey of Section 2, T16N R16W, was completed on behalf of UNC. Three archaeological sites were identified during the survey. One site was recommended for protection by avoidance since the site was not located in an area of proposed disturbance. Excavation of the two other sites was recommended (Appendix E of UNC, 1975).
- In 2005 an archaeological survey of the 125-acre Mine Site and an ethnographic study of the area were completed on behalf of UNC. No new sites were recorded and no previously recorded sites were identified during the pre-field investigation (Boggess and Begay, 2005).
- In 2009 an archaeological survey of 68.87 acres north of the Mine Site, which were proposed for reclamation, was completed. One Traditional Cultural Property (TCP), two in-use sites, and one site evaluated as not eligible for nomination to the National Register of Historic Places were identified during the survey (Martin and Begay, 2009).
- In 2011 a cultural resources inventory of 27.5 acres was completed for the proposed reclamation of two parcels of land north and east of the Mine Site. Ethnographic interviews were also conducted as part of the study. The survey identified areas of archaeological significance, and the Navajo Nation Historic Preservation Department defined conditions of compliance, which included protecting and avoiding one site during ground-disturbing activities (Begay and Wero, 2011).
- In 2013 an archaeological survey was completed for 73.94 acres proposed as areas for five soil borrow pits for the Selected Remedy. Four archaeological sites were identified during the survey, and archaeological clearance was recommended for each site. During the survey, the project archaeologists interviewed nearby residents concerning sacred places, burials, or TCPs that might be affected by the proposed undertaking. No TCPs were identified in the area of effect. This survey report offers the most recent analysis of sacred places within a 1-mile radius of the project area (Begay, 2013).

O.4 REFERENCES

Begay, R., 2013. A Cultural Resources Inventory of Five Proposed Borrow Pits for MWH Global in the NECR Mine Area, McKinley County, New Mexico. Consultant's Report Prepared by Dinétahdóó Cultural Resources Management for MWH, November 18.

Begay, J., and S.V. Wero, 2011. *A Cultural Resource Inventory of 27.5 Acres of Land for Reclamation for MWH Global in Churchrock Mine in McKinley County, New Mexico.* Consultant's Report prepared by Dinétahdóó Cultural Resources Management for MWH Global, April.

Boggess, D., and R. Begay, 2005. A Cultural Resources Survey of 125 Acres for the Proposed Closeout of the Northeast Church Rock Mine, McKinley County, New Mexico. Consultant's Report prepared by Lone Mountain for MWH, July 11.

INTERA Incorporated (INTERA), 2015. Final Environmental Data Gap Report for the Northeast Church Rock Site Removal Action and the United Nuclear Corporation Site Remedial Action. November 23.

Martin, R., and R. Begay, 2009. A Cultural Resources Inventory of 68.87 Acres of Proposed Reclamation North of the Church Rock Mine, McKinley County, New Mexico. Consultant's Report prepared by Dinétahdóó Cultural Resources Management for MHW, May 15.

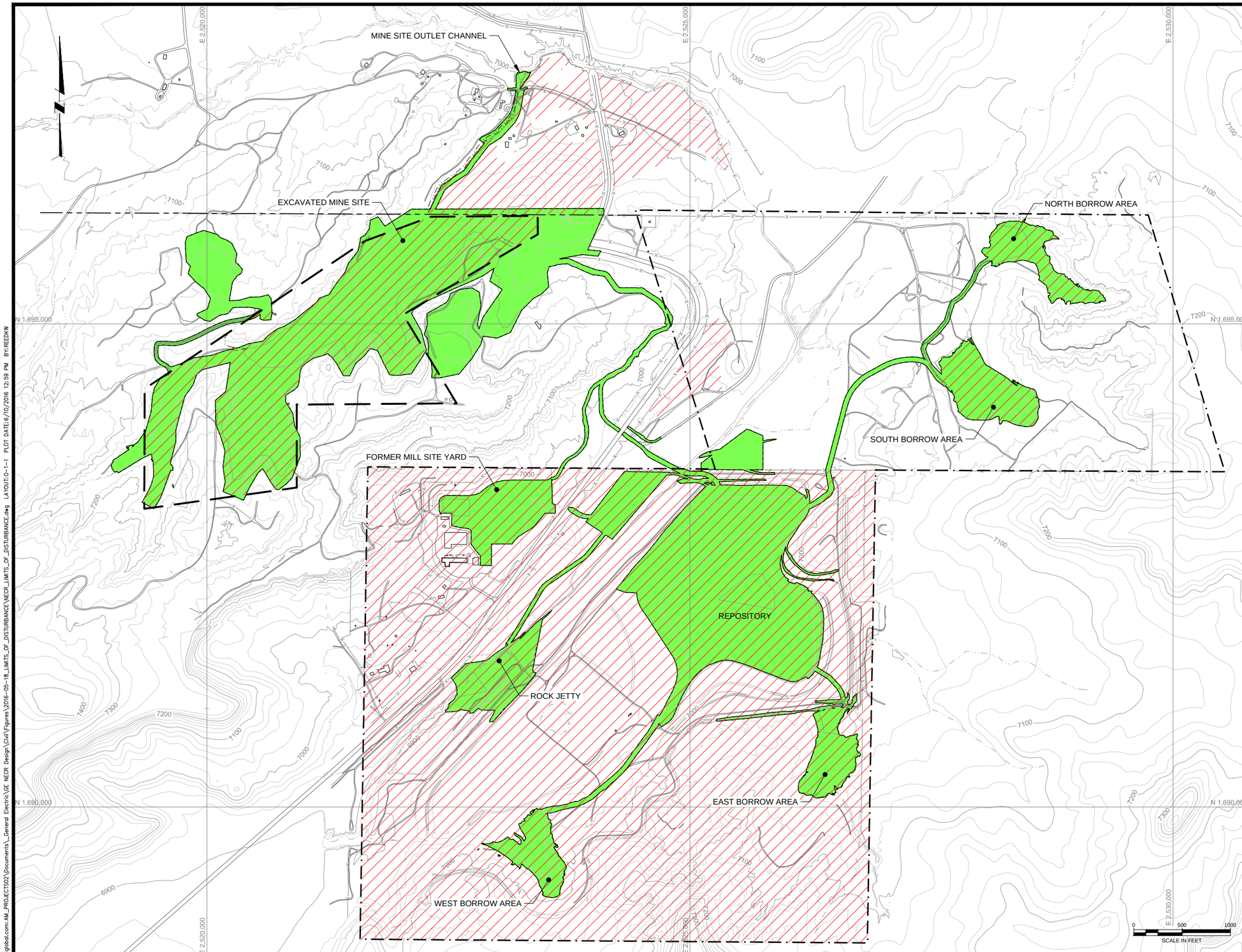
United Nuclear Corporation (UNC), 1975. Environmental Report on the Church Rock, New Mexico Uranium Mill and Mine, Volumes I and II.

US Environmental Protection Agency (USEPA), 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Mine Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. Prepared for U.S. EPA Regions 6 and 9. September 29.

US Environmental Protection Agency (USEPA) Region 6, 2013. Record of Decision for Operable Unit OU02, Surface Soil Operable Unit, United Nuclear Corporation Site, McKinley County, New Mexico. March 29.

US Environmental Protection Agency (USEPA), 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site, McKinley County, New Mexico. April 27.

FIGURE



LEGEND:

- EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET (7200)
- NECR MINE PERMIT BOUNDARY
- UNC PROPERTY BOUNDARY
- APPROXIMATE NAVAJO NATION BOUNDARY
- ROADS
- NATURAL DRAINAGE
- EXISTING FENCE
- AREA OF DISTURBANCE
- PREVIOUSLY SURVEYED FOR CULTURAL RESOURCES

NOTE(S):

1. AREAS OF DISTURBANCE NOT PREVIOUSLY SURVEYED ARE SUBJECT TO SURVEY UNDER THE ENVIRONMENTAL REVIEW.

DESIGNED J.COLEMAN
CHECKED J.CUMBERS
APPROVED C.STRACHAN

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UNITED NUCLEAR CORPORATION AND NORTHEAST CHURCH ROCK MINE
McKINLEY COUNTY, NEW MEXICO

LIMITS OF DISTURBANCE
AND PREVIOUS CULTURAL RESOURCE SURVEYS

FIGURE
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Northeast Church Rock 30% Design Report

Appendix P:
Natural Resources Reports

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LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
EDRA	East Drainage Removal Area
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
RAO	Remedial Action Objective
ROD	Record of Decision
USEPA	US Environmental Protection Agency
UNC	United Nuclear Corporation

P.1 INTRODUCTION

This appendix to the Northeast Church Rock 30% Design Report summarizes previous natural resource (vegetation and wildlife) surveys conducted at the Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site). The 30% Design includes new areas of proposed ground disturbance not been previously surveyed for natural resources. These new areas of disturbance would be inventoried for natural resources as part of the forthcoming Environmental Review required by the US Nuclear Regulatory Commission to amend source material license no. SUA-1475. Figure P.1-1 identifies the proposed limits of disturbance for the 30% Design, areas of disturbance previously surveyed, and areas of disturbance that would be surveyed as part of the Environmental Review.

P.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (ROD; USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table P.2-1 presents Performance Standards related to natural resources and explains how the design accomplishes these standards.

Table P.2-1: Performance Standards Applicable to Natural Resources Protection

Location of Performance Standard Requirement	Performance Standard	Comments
2013 ROD, Section 2.9.5, Natural and Cultural Resources	Natural and cultural resources will be surveyed by a Navajo Nation archeologist and the State and Tribal Historic Preservation Officer will be consulted in accordance with the National Historic Preservation Act. Local residents will be consulted as part of this process.	Refer to Appendix O for cultural resource surveys. Natural (ecological) resource surveys would not require participation of a qualified archeologist or the State and Tribal Historic Preservation Officer.
2015 AOC SOW, Paragraph 23 – Natural and Cultural Resources	In the Design, Respondents shall include results of any supplemental cultural surveys as required by EPA and conducted by a qualified archaeologist in coordination with the Tribal Historic Preservation Officer, the State Historic Preservation Officer, and other affected parties in accordance with the National Historic Preservation Act, as necessary to supplement existing surveys. Similarly, in the Design, Respondents shall include results of any supplemental biological surveys as required by EPA and conducted by a qualified biologist in coordination with the US Fish and Wildlife Service, Navajo Department of Fish and Wildlife and New Mexico Department of Fish and Game in accordance with the Endangered Species Act, as necessary to supplement existing surveys. Respondents shall ensure coordination with the Navajo Nation for work on the Nation and trust land and with the State of New Mexico for work on state and private lands. Respondents' plans and specifications for any supplemental cultural or biological surveys, as required by EPA, shall include detailed plans and specifications for meetings with the community to garner local knowledge from the community regarding cultural, historical,	Results of previous natural resources (biological) surveys are summarized in this appendix. If additional supplemental natural resources surveys are required, these will be conducted under the Environmental Review and include detailed plans and specifications for meetings with the community. Refer to Appendix O for the cultural resources surveys.
2013 ROD, Table 1	10 CFR 40, Appendix A - Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content. Criterion 7. Refer to www.ecfr.gov.	The potential impacts of the design on the site groundwater are being evaluated. The natural resources surveys will be used along with the groundwater evaluation to evaluate potential impacts or damage to wildlife, crops and vegetation. The Dwyer Engineering, LLC Consolidation and Groundwater Evaluation Report will be provided as a separate submittal by July 29, 2016.

P.3 NATURAL RESOURCE SURVEYS TO DATE

The information is this section is taken from the Final Environmental Data Gap Report (INTERA, 2015).

In 1974, prior to the construction and operation of the Mill Site, a vegetation and wildlife survey of Section 2, T16N R16W, McKinley County, New Mexico was performed (Appendix C of UNC, 1975). This survey established baseline ecological conditions for evaluation of potential environmental stresses on the region's ecology caused by construction and operation of the proposed Mill Site. The survey included vegetative sampling and wildlife trapping along with a grazing capacity estimate of the four vegetation types identified on the United Nuclear Corporation (UNC) property.

From 1975 through 1980, a vegetation monitoring program was conducted at five sites surrounding the mill to evaluate trends in radiological impacts on vegetation. UNC expanded the evaluation in 1979 by sampling vegetation at 10 locations along the Pipeline Canyon arroyo and the Rio Puerco up to 45 miles from the Tailings Disposal Area. These studies are summarized in D'Appolonia (1981).

In 2009 a baseline vegetation and wildlife survey of the undisturbed vegetation communities within the Mine Site and step-out area 1 (SO-1) was conducted as part of interim removal actions conducted north of the Mine Site in SO-1. Surveys were conducted twice in 2009, first from May 1 to 2 and then from August 16 to 20, to determine (1) flora and fauna conditions in the vicinity of the survey areas, (2) quality of habitat for indigenous wildlife, and (3) revegetation potential. None of the plant or wildlife species identified during the survey were determined to be rare, threatened, endangered or otherwise protected by statute. In addition, none of the 19 wildlife taxa identified as threatened, endangered, or rare that had a remote chance of existing within or near the project area were observed during the wildlife survey (Cedar Creek, 2009).

In 2012 a baseline vegetation survey of the East Drainage Removal Area (EDRA), northeast of the Mine Site, was completed to establish baseline conditions in the EDRA, within the area referred to as step-out area 2 (SO-2). The survey was conducted August 15 to 16 and verified that no rare, threatened, or endangered plant species occur in or near the survey area. A reference area representing the post-mining land use was selected from undisturbed areas near the EDRA and was used to characterize the final revegetation success comparison (Cedar Creek, 2012).

A vegetation and wildlife survey was conducted from October 19 to 23, 2013 to assess existing vegetation on and near the proposed borrow areas. Information from the survey was used to develop a revegetation plan that establishes long-term, self-sustaining species at the borrow areas and for the Mill Site repository cover surface. Results from the vegetation and wildlife surveys showed that: (1) no Navajo Nation or federally-listed rare, threatened, or endangered species occur on or near the survey areas; (2) noxious weeds (musk thistle and tamarix) were observed in the east borrow area (mitigation measures were recommended to control the potential spread of noxious weeds, if the east borrow area is used for construction); and (3) analog sites are representative of communities potentially disturbed during construction and can be used as logical targets for revegetation success criteria. Survey results also indicate which species may prove successful during revegetation (Cedar Creek, 2014).

P.4 REFERENCES

Cedar Creek Associates (Cedar Creek), 2009. Vegetation & Wildlife Evaluations / Revegetation Recommendations, 2009 Evaluations and Planning, Northeast Church Rock Mine. Consultant's Report prepared for United Nuclear Corporation. February.

Cedar Creek Associates (Cedar Creek), 2012. 2012 Eastern Drainage Baseline Vegetation Evaluation, Northeast Church Rock Mine. Consultant's Report prepared for United Nuclear Corporation. November.

Cedar Creek Associates (Cedar Creek), 2014. United Nuclear Corporation Baseline Vegetation and Wildlife Surveys, Church Rock Mill Site. Consultant's Report prepared for United Nuclear Corporation, July.

D'Appolonia, 1981. State of New Mexico Environmental Improvement Division Uranium Mill License Renewal Application Environmental Report License No. NM-UNC-ML. Consultant's Report prepared for UNC Mining and Milling Church Rock Operations Division of United Nuclear Corporation, Project No. NM81-433, December.

INTERA Incorporated (INTERA), 2015. Final Environmental Data Gap Report for the Northeast Church Rock Site Removal Action and the United Nuclear Corporation Site Remedial Action. November 23.

United Nuclear Corporation (UNC), 1975. Environmental Report on the Church Rock, New Mexico Uranium Mill and Mine, Volumes I and II.

US Environmental Protection Agency (USEPA), 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Mine Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. Prepared for U.S. EPA Regions 6 and 9. September 29.

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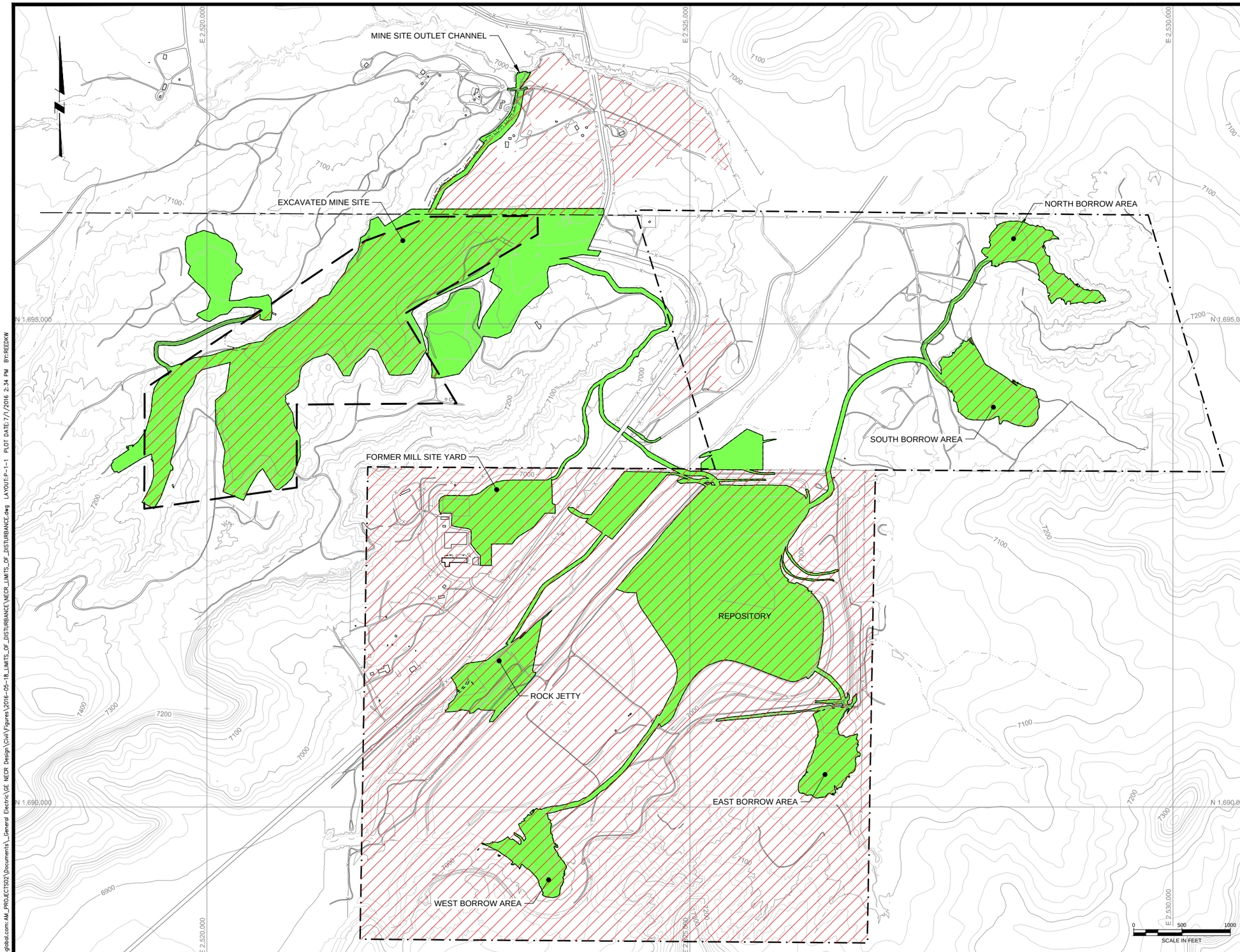

LEGEND:

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UNITED NUCLEAR CORPORATION AND NORTHEAST CHURCH ROCK MINE
McKINLEY COUNTY, NEW MEXICO

LIMITS OF DISTURBANCE
AND PREVIOUS NATURAL RESOURCE SURVEYS

FIGURE
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Northeast Church Rock 30% Design Report

Appendix Q:
Dust Control and Air Monitoring Plan

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LIST OF ACRONYMS / ABBREVIATIONS

AMP	Air Monitoring Plan
AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
CFR	Code of Federal Regulations
GPM	gallons per minute
HASP	Health and Safety Plan
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
mrem	millirem
NMAC	New Mexico Administrative Code
PTW	principal threat waste
RA	Removal Action
RAO	Remedial Action Objective
ROD	Record of Decision
RSO	Radiation Safety Officer
SOP	standard operating procedure
TLD	thermoluminescent dosimeter
TWA	time weighted average
USEPA	US Environmental Protection Agency
µCi/ml	microcuries per milliliter
µR	microroentgen

Q.1 INTRODUCTION

This appendix to the Northeast Church Rock 30% Design Report presents requirements and protocols for dust control and air monitoring at the Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site).

This appendix:

- Demonstrates that the design will attain the applicable standards identified in the Record of Decision (ROD; USEPA, 2013)
- Explains performance requirements for dust control during construction
- Presents methods and protocols for air monitoring during construction, including radiation and dust monitoring

Q.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table Q.2-1 presents Performance Standards related to the Dust Control and Air Monitoring Plan and explains how the design accomplishes these standards.

Table Q.2-1: Performance Standards Applicable to the Dust Control Air Monitoring Plan

Location of Performance Standard Requirement	Performance Standard	Comments
2013 ROD, Section 2.9.5, Transportation	Transportation of all mine waste will be transported in such a manner to mitigate the production of dust, including the use of covers and/or dust suppression actions. A transportation plan will be used to identify the routes of travel, times of operation, and traffic rules. Emergency spill containment and cleanup contingencies will also be included in the transportation plan to address mine waste spills.	Dust suppression controls are addressed in this appendix. The transportation plan is included as Appendix M.
2013 ROD, Section 2.9.5, Perimeter Air Monitoring	Perimeter air monitoring stations will be positioned and operated to monitor emissions during site preparation construction, stockpiling, loading of bulk-carriers, stockpile management, consolidation, cover construction and restoration. Dust suppression controls will be implemented to maintain a safe working environment and to protect human health and the environment.	Air monitoring and dust suppression controls are addressed in this appendix. The transportation plan is included as Appendix M.
2013 ROD, Table 1	New Mexico Surface Mining Act Coal Mining Regulations. 19.8.20.2050 NMAC. Refer to http://164.64.110.239/nmac/cgi-bin/hse/homepagesearchengine.exe.	Air monitoring and dust suppression controls are addressed in this appendix.
2015 AOC SOW, Paragraph 24 – Air Monitoring	In the Design, Respondents shall include detailed plans and specifications for air monitoring stations to be installed around the perimeter of the SA Site during the response action. Respondents' detailed plans and specifications shall ensure that perimeter air monitoring stations will be positioned and operated to monitor emissions during dust-or emission-generating activities, including site preparation, construction activities, excavation and backfill, stockpiling (staging), loading of bulk-carriers, stockpile management, consolidation, cap construction and regrading. Respondents shall ensure that their detailed plans and specifications also include dust prevention and dust suppression controls that will be implemented to maintain a safe working environment and to protect human health and the environment.	Air monitoring and dust suppression controls are addressed in this appendix.
2013 ROD Table 1	10 CFR 61.53(c), Environmental Monitoring. Refer to www.ecfr.gov.	Air monitoring to detect the release of radionuclides during construction is addressed in this appendix.

Q.3 DUST CONTROL PLAN

Dust will be controlled during the Removal Action (RA) using water, dust suppressants, gravel surfacing, and operational controls. The Construction Contractor will be required to prepare and implement a dust control plan tailored to its specific operations prior to any earthwork activities at the Mine and Mill Sites (including borrow areas).

The Construction Contractor's dust control measures must comply with the maximum nuisance dust levels discussed in Section Q.4. Perimeter air monitoring will be conducted to evaluate dust levels during construction and the Construction Contractor will be notified if dust levels exceed acceptable limits. The Construction Contractor will be required to stop work if dust levels are not kept below the levels outlined in Section Q.4. The Construction Contractor shall use daily field reports to document dust control measures implemented and their effectiveness as well as the details of water usage, storage, and water withdrawal.

Q.3.1 Specific Dust Control Measures

The following sections describe dust suppression measures that will be employed for specific construction activities, including:

- Excavation, placement, and grading
- Hauling
- Speed limits
- Screening (separating soil and rock)
- Stockpiles

Q.3.1.1 Excavation, Placement and Grading

Methods and equipment to minimize/control dust generation during earthwork operations will include some or all of the following measures:

- Application of water or other approved dust suppressants to minimize visible dust during execution of work
- Avoidance of excavation or placement of overly dry or fine soils during high wind conditions to the extent practical
- Application of water or other approved dust suppressants to areas where wind can generate dust, including disturbed areas that are not being actively worked
- Use of windrows or other wind break methods
- Maintenance and protection of native vegetation where possible, through minimization of site disturbance
- Stabilization of inactive, disturbed work areas by longer term methods such as matting, tack and mulch, or crusting agents
- Implementation of permanent stabilization on a regular basis when sufficient area exists for application

Q.3.1.2 Hauling

The methods and equipment to minimize/control dust generation during earthwork operations will include some or all of the following measures:

- Application of water or other approved dust suppressants to haul roads to minimize visible dust during hauling
- Application of water during loading
- Wetting or covering loads during hauling

- Street sweeping and/or cleaning as necessary
- Implementing haul road speed limits (see below)
- Limiting access and haul road development to the minimum necessary to execute work

In addition, wet washing or dry brushing of equipment will be conducted as needed to control tracking of impacted material or mud onto roadways. Vehicles carrying materials to or from the Mine and Mill sites will be secured and covered.

Q.3.1.2.1 Speed Limits

In general, a speed limit of 20 to 30 miles per hour will be implemented on haul and access roads. Speed limit and no-idle zone signs will be posted on on-site roads and haul roads. Lower speed limits may be necessary to control dust depending on actual day-to-day site conditions. Site supervisory personnel will enforce speed limits. Appropriate corrective actions will be implemented if equipment operators are observed to be operating equipment at excessive speeds.

Q.3.1.3 Screening

Material screening operations can be major sources of airborne dust due to the inherent nature of the size reduction and segregation processes. Dust from screening operations will be controlled using water trucks, water sprays, and/or manned water hoses.

Q.3.1.4 Stockpiles

Temporary stockpiles may be required for borrow and imported materials. During active stockpile construction, water will be applied directly to the stockpiles by spraying with hoses and water truck sprays.

Principal threat waste (PTW) stockpiles will require more robust dust control than water or chemical agents. Active stockpile areas can be effectively managed for dust control during placement using water and small tracked equipment for moderate compaction. Water is also effective for dust control during excavation and loading. Inactive PTW stockpiles will require a membrane cover. There are many effective alternatives for this application and the Construction Contractor will be required to submit for approval the cover materials and system it will use to manage the PTW stockpiles. The Construction Contractor will be required to demonstrate that its proposed cover system will be stable during reasonably anticipated high wind events.

Q.3.2 Water Management

The Construction Contractor will have a minimum of two water trucks on-site to spray haul roads, excavation areas, placement areas, and borrow areas for dust control. A dedicated water truck will be required for work conducted in contaminated areas and a dedicated water truck will be required for work in non-contaminated areas. Due to the potential for dry and windy conditions, work areas will likely need to be wetted regularly for dust control. Allowing a contractor to move a water truck between the Exclusion Zone and Support Zone for daily dust control operations will require decontamination and could result in insufficient dust control in either or both zones. Additional water trucks may be necessary to suit the Construction Contractor's operations.

The Mill Site well will supply water for dust control as well as for decontamination and sanitary uses. A typical haul road can be expected to require 25 to 50 gallons per 1,000 square feet per hour for dust control under typical summertime conditions, such as can be expected at the Mine and Mill Sites (Tannant and Regensburg, 2001). Additional dust suppression water will be required for excavation, placement and stockpiling activities. Table Q.3-1 provides estimates of daily dust control water demand during construction and the required storage capacity to meet this demand without the use of supplemental dust control measures. Table Q.3-2 provides estimates of daily dust control water demand during construction and the required storage capacity to meet this demand with the use of supplemental dust control measures to reduce water consumption. The calculation brief for dust control water demand is presented in Attachment Q.1.

Table Q.3-1: 30% Design Estimate of Dust Control Water Demand and Required Storage without Supplemental Dust Control Measures

Dust Control Area	Estimated Hourly Demand (gal/hr)	Required Storage and Well Production	
		40-Hour Week*	48-Hour Week**
All Areas	14,475	147,000 gallon storage 50 GPM well yield	189,000 gallon storage 61 GPM well yield
Mine Waste Haul Roads	10,800	*40-hour week is (5) 8-hour shifts **48-hour week is (4) 10-hour + (1) 8-hour shifts Note: 30% estimate assumes decontamination and sanitary water are incidental to dust control water.	
Borrow Haul Roads	2,050		
Yards	1,375		
Excavation/Placement	250		

GPM – gallons per minute

Table Q.3-2: 30% Design Estimate of Dust Control Water Demand and Required Storage with Supplemental Dust Control Measures

Dust Control Area	Estimated Hourly Demand (gal/hr)	Required Storage and Well Production	
		40-Hour Week*	48-Hour Week**
All Areas	9,800	105,000 gallon storage 34 GPM well yield	126,000 gallon storage 43 GPM well yield
Mine Waste Haul Roads	7,150	*40-hour week is (5) 8-hour shifts **48-hour week is (4) 10-hour + (1) 8-hour shifts Note: 30% estimate assumes decontamination and sanitary water are incidental to dust control water.	
Borrow Haul Roads	1,025		
Yards	1,375		
Excavation/Placement	250		

GPM – gallons per minute

The on-site well is estimated currently to have a yield of between 25 and 50 gallons per minute (GPM). Construction operations are likely to be constrained by water production and storage capacity as indicated in Tables Q.3-1 and Q.3-2. Alternative methods of dust suppression (such as the use of road salts, resin modified emulsions, and/or biodegradable oils) on haul roads may be proposed by the Construction Contractor to reduce water use or to increase working hours. The RA schedule in Appendix K is based on a 40-hour work week to account for the water production constraints indicated in Tables Q.3-1 and Table Q.3-2.

This 30% design assumes that 21,000-gallon closed-top portable water tanks, or similar, will be placed in the Former Mill Site Yard and connected to the well with temporary piping. Sufficient space is indicated on the Drawings to accommodate each of the storage scenarios indicated above. Piping and layout configurations will be determined by the Construction Contractor. Closed top tanks are preferable to a water management pond because they offer scalability and eliminate water losses from evaporation. Well testing to confirm production capacity and determine necessary mechanical upgrades prior to commencement of the RA will be required. Water storage capacity and the RA schedule will be revised accordingly based on the outcome of this evaluation.

Q.4 AIR MONITORING PLAN

The Air Monitoring Plan (AMP) establishes air monitoring, sampling and analysis protocol during construction activities to demonstrate protection of individual members of the public that meets the dose limits defined in 10 CFR 20, Appendix B, Table 2. To achieve this, air monitoring will be conducted at upwind and downwind locations for internal and external radiation. The proposed locations are shown on Figure Q.4-1. Occupational air monitoring for site workers will be addressed in the RA Health and Safety Plans (HASP); the MWH HASP will be developed for the 95% design phase.

The methods that will be used to monitor internal and external radiation exposure are described in the Standard Operating Procedure for Perimeter Airborne Particulate Monitoring, which is included as Attachment Q.2 and are discussed below.

The AMP will also include monitoring for respirable dust according to US Environmental Protection Agency's (USEPA's) Primary National Ambient Air Quality Standard. Respirable dust will be monitored during construction to determine the effectiveness of dust control measures. Records of air monitoring implemented during the RA at the Mine and Mill Sites will be provided with the RA Final Construction Report.

Q.4.1 Radiation Monitoring

Perimeter air monitoring for internal and external radiation exposure to individual members of the public will be conducted using the methods described here, and as summarized on Table Q.4-1. Background monitoring at downwind perimeter locations will begin at the start of earth moving activities, and continue through the end of construction.

To evaluate the potential internal radiation exposure to the public, air particulates will be collected on a 47-mm Type A/E glass fiber air filters using air samplers (e.g., RAS-2), as specified in Attachment Q.2. The loaded filter will be counted on-site for gross alpha activity after allowing at least 72 hours for decaying of the alpha emitting radon progeny collected on filters from ambient air. Individual airborne concentrations will be determined for U-234, U-238, Ra-226, and Th-230 from their activity fraction of the gross alpha activity of dust material, which has the potential for becoming airborne. Since these radionuclides are in secular equilibrium in uranium ore dust, their airborne concentrations will be determined by multiplying the airborne gross alpha activity by 0.25. The net airborne concentrations (downwind concentrations minus the background concentrations) will be compared to the air concentration values specified in Table 2 of Appendix B to 10 CFR Part 20. These calculations can be conducted following counting of the air sample filter, as needed for assessing effectiveness of control measures. For the purpose of demonstrating compliance with the limits, net concentrations will be averaged quarterly.

To evaluate potential internal airborne radon and radon progeny concentrations, track etch radon monitors will be continuously exposed at the perimeter stations and submitted for laboratory analysis on a quarterly basis. The track etch monitors will be analyzed by the manufacturer quarterly or at the end of project.

To evaluate potential external radiation exposure, environmental thermoluminescent dosimeters (TLDs) will be exposed continuously at the perimeter stations and will be submitted for laboratory analysis on a quarterly basis. Until the TLD results have been received from the laboratory, external exposure to gamma radiation will be estimated based on area exposure rate field measurements using a calibrated micro-R-meter. This will be done weekly, or less frequently, based on changes in the gamma radiation source as determined by the Radiation Safety Officer (RSO).

The results and measurements will be compared against the limits presented in Section Q.4.1.2. If exceedances of the limits are observed, construction will stop, USEPA will be notified, and construction will not resume until the cause(s) for the exceedances were identified and rectified. The results of these monitoring activities will be transmitted to the USEPA with the monthly status reports.

Table Q.4-1: Summary of Perimeter Air Monitoring Plan

Type	Instrumentation	Location[1]	Frequency	Action Level	Analysis
Radiation Monitoring					
Internal Radiation	RAS-2 Sampling pump with 47-mm Type A/E glass fiber filter	1 upwind and 2 downwind	5 days/week the week prior to construction, 5 days/week the first week of mobilization, and 3 days/week the second week of mobilization. Weekly thereafter (based on results).	U-234, U-238, Ra-226, and Th-230, air concentration values as specified in 10 CFR 20, Appendix B, Table 2 (annual total effective dose equivalent of 0.05 rem)	Analyzed by RSO using an Alpha Radiation Counting Instrument
Internal Radiation	Landauer Radtrak Alpha-track detector	1 upwind and 2 downwind	As above, then continuously during construction.	Rn-222 dose limits as specified in 10 CFR 20, Appendix B, Table 2	Analyzed by manufacturer quarterly or at end of project
External Radiation	Landauer InLight Dosimeter	1 upwind and 2 downwind	Continuously for duration of project.	Dose limits as specified in 10 CFR 20.1302(b)	Analyzed by manufacturer on a quarterly basis
External Radiation	Ludlum Model 19 Micro R Meter	1 upwind and 2 downwind	Estimate exposure rate weekly	Dose limits as specified in 10 CFR 20.1302(b)	Estimated by RSO
Airborne Dust Monitoring					
Airborne Dust	Model 8520 Dustrack Aerosol Monitor	1 upwind and 3 downwind	Starting 2 days prior to construction, 24 hrs/day for the first 3 days of significant earthmoving activities, then continuously during working hours thereafter.	24-hr TWAs for PM10 = 150 $\mu g/m^3$ & PM 2.5 = 35 $\mu g/m^3$ (40 CFR 50)	Direct read

Notes:
1. The downwind perimeter air monitoring location may be adjusted based on wind conditions and daily activities. The radtrak and dosimeter will be placed at fixed locations for the duration of construction.
2. TWA = time weighted average

Q.4.1.1 Background Monitoring

Mobilization for construction is expected to take approximately two to four weeks, with minimal earth moving activities occurring the first week. Mobilization activities will include fence removal, installation of erosion and sediment control measures, and vegetation removal. Baseline perimeter monitoring will be conducted the week prior to the start of earthwork, including the following:

- Airborne dust monitoring will be conducted for a minimum of two days prior to beginning earthwork.
- Dust monitoring will be conducted 24 hrs/day for the first 3 days of significant earthmoving activities (e.g., excavation/hauling) and then during working hours for the remainder of construction.
- Background for internal radiation monitoring will simultaneously be conducted with downwind monitoring, 5 days/week during the first week of construction activities. The monitoring frequency will be revised as work progresses, to 3 days/week (or less), based on the monitoring results, construction activities, and the effectiveness of control measures for the remainder of construction.

Results of initial monitoring will be reviewed to evaluate whether adjustments need made to construction methods to ensure public and worker safety.

Q.4.1.2 Radiation Criteria

The individual airborne concentrations obtained from the gross alpha activity counts and estimates from the track etch monitors will be reviewed to assess compliance with the following airborne concentrations. These counts, if inhaled or ingested continuously over the course of a year, will produce a total effective dose equivalent of 0.05 rem. This total dose equivalent coincides with the internal radiation dose limits for individual members of the public as specified in 10 CFR § 20.1302(b) and New Mexico Administration Code (NMAC) 20.3.4.414:

- U-234: 3.0E-12 µCi/ml
- U-238: 3.0E-12 µCi/ml
- Ra-226: 9.0E-13 µCi/ml
- Th-230: 2.0E-14 µCi/ml
- Rn-222: 1.0E-08 µCi/ml

The Rn-222 limit for the class “with daughters removed” is used because the track etch radon monitor is equipped with a filter that removes the daughters prior to the measurement.

Q.4.1.3 External Radiation Criteria

Quarterly TLD laboratory results and weekly field gamma results will be reviewed by the RSO to assess compliance with the following external radiation dose limits for individual members of the public as specified in 10 CFR 20.1301 and NMAC 20.3.4.413 (see Table Q.4-1):

- Total effective dose equivalent of 0.1 rem (100 mrem) per year to individual members of the public
- Maximum dose rate of 0.002 rem/hour and 0.05 rem per/year in the unrestricted area from external radiation sources

If a member of the public enters a controlled area outside the restricted area, the above dose limits will apply.

Q.4.1.4 Monitoring Methods

Q.4.1.4.1 Internal Radiation

In order to demonstrate compliance with the dose limits, monitoring will be conducted for:

- Airborne gross alpha activity from particulates
- Airborne radon and radon progeny concentrations

Airborne gross alpha activity will be monitored by collecting approximately 8-hour air particulate samples (the potential maximum time of exposure based on the construction activities) for field analysis at locations both downwind and upwind of the construction activities using air sampler, such as an Eberline RAS-2 (see Table Q.4-1). Consistent with the prior Interim Removal Actions, air samples will be collected on day one, three and five from the start of excavation activities. After the first five days, samples will be collected weekly or if excessive wind prevents adequate dust control. If sampling data indicate that gross alpha activity is greater than 0.25 times the airborne concentration limits, air sampling will be increased to three days per week until the airborne concentrations decline back to less than 0.25 of the limits. Gross alpha activity measurements will be measured at one location upwind of the construction activities to establish background and generally two downwind locations: one downwind of the tailings disposal area to monitor soil placement activities, and one downwind of excavation activities. The location of the monitoring station downwind of the excavation activities will be adjusted based on the where excavation is taking place.

To evaluate potential internal radiation exposure, the RAS-2 air filters will be counted on-site for gross alpha activity from uranium, Ra-226 and Th-230 after radon progeny from the particulate sample has decayed, generally 72 hours, using an Alpha Radiation Counting Instrument such as Eberline SAC R-5.

Airborne radon and radon progeny concentrations will be monitored continuously for the duration of excavation and soil placement activities with track etch radon monitors at one upwind and two downwind locations: one at the edge of the NECR-1 and a second downwind of the Tailings Disposal Area; these locations will be fixed for the duration of construction activities. Track etch monitors will be replaced quarterly or at the end of the RA, and analyzed by the manufacturer (Landauer, Inc.).

Q.4.1.4.2 External Radiation

To evaluate external radiation exposure, both TLDs and direct gamma radiation exposure rate field measurements will be used. Exposure rate measurements will be made using a microroentgen (µR) gamma survey meter. Exposure rate measurements will be performed weekly at the location of the environmental TLDs and at additional perimeter locations based on construction activities and environmental conditions.

TLDs will be used continuously for the duration of excavation and soil placement activities at upwind and downwind locations (to be determined), and in the vicinity of PTW handling operations. Locations will be fixed for the duration of construction activities. The TLDs will be analyzed by the manufacturer on a quarterly basis.

Q.4.2 Nuisance Dust Monitoring

The perimeter AMP will include monitoring for respirable dust (PM10 and PM2.5), as per USEPA's Primary National Ambient Air Quality Standard (40 CFR 50) during this project, especially during the beginning stages of construction to determine any long-term measures that may be needed to protect employee health. Monitoring will be conducted at an upwind location and at downwind locations to be determined in the next design phase. The location of the monitoring stations downwind of excavation activities will move based on the location of the excavation activities. Dust monitoring will be conducted using a Model 8520 Dustrack Aerosol Monitor and will be conducted continuously during working hours (see Table Q.4-1).

The results of the dust monitoring will be reviewed by the RSO and assessed to determine potential health hazards or risks. Respirable dust standards shall be USEPA's Primary National Ambient Air Quality Standards at 24 hour Time Weighted Average (TWA) of:

- PM10: 50 micrograms/cubic meter ($\mu g/m^3$)
- PM2.5: 35 $\mu g/m^3$

Personal air space monitoring necessary for General Electric/United Nuclear Corporation employees and the Construction Contractor's employees will be performed in accordance with their respective HASPs.

Q.5 REFERENCES

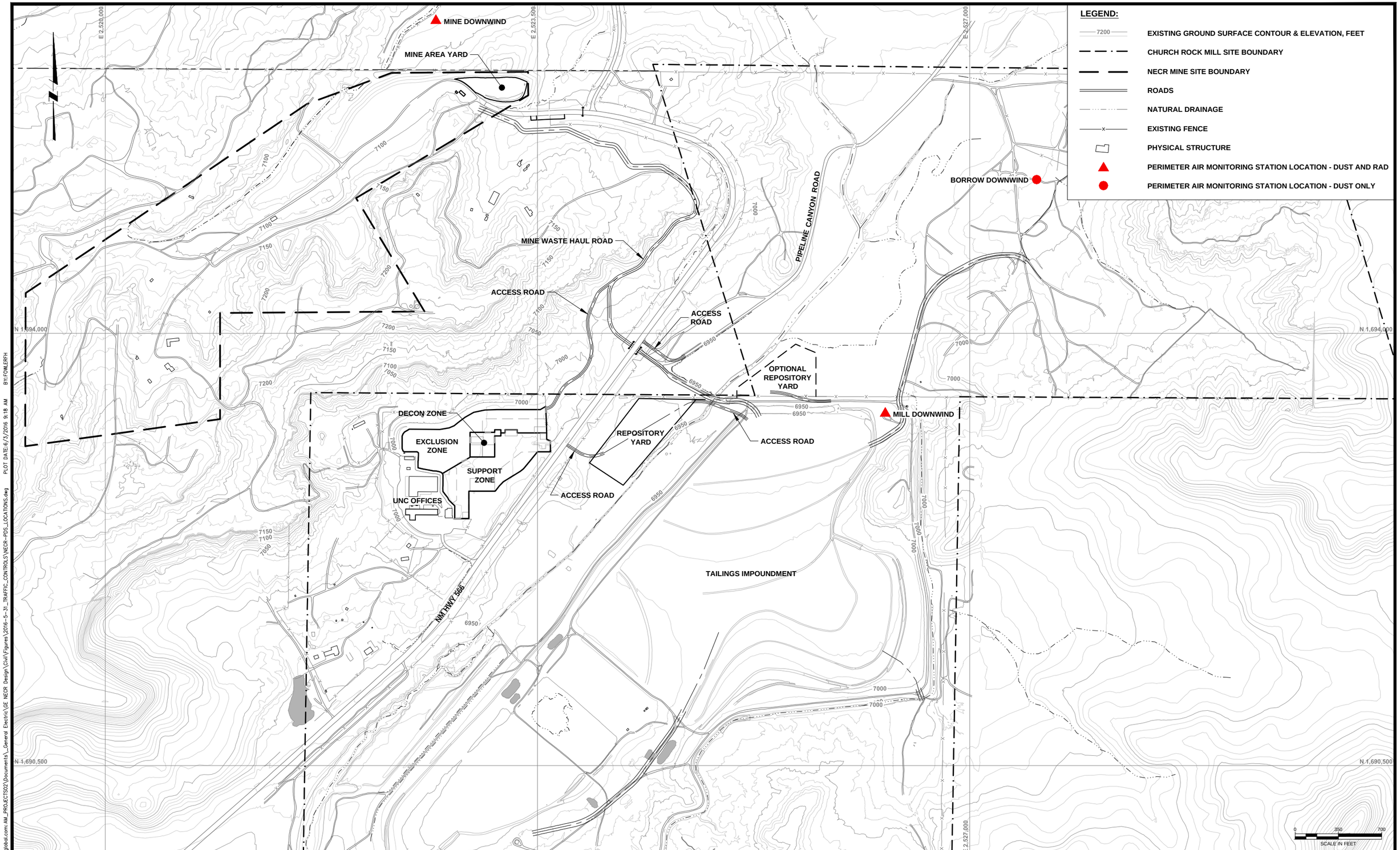
Tannant, D.D. and B. Regensburg, 2001. Guidelines for Mine Haul Road Design.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. September 29.

US Environmental Protection Agency (USEPA) Region 6, 2013. Record of Decision, United Nuclear Corporation Site, McKinley County, New Mexico. Operable Unit OU2: Surface Soil Operable Unit. March 29.

US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, Appendix D: Statement of Work. April 27.

FIGURE



DESIGNED J.COLEMAN
CHECKED J.CUMBERS
APPROVED C.STRACHAN

MWH. now part of Stantec

UNITED NUCLEAR CORPORATION AND NORTHEAST CHURCH ROCK MINE
McKINLEY COUNTY, NEW MEXICO

PROPOSED AIR MONITORING STATION LOCATIONS

FIGURE
Q.4-1
10508639
MAY, 2016

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ATTACHMENT Q.1

Calculation Brief - Dust Control Water Balance

ATTACHMENT Q.1: DUST CONTROL WATER BALANCE

Revisioning					
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**
0	*06/06/16*	*Preliminary (30%) Design*	*J. Coleman*	*J. Cumbers*	*06/08/16*
1	*07/01/16*	*Preliminary (30%) Design*	*J. Coleman*	*J. Cumbers*	*07/08/16*

Revisions	
Issue Date	**Description**
7/1/16	Recalculated using revised water use scenarios – including use of supplemental dust suppressants.

Location and Format

Electronic copies of these calculations are located in the project files system at:

http://projects.mwhglobal.com/sites/genecrpreliminarydesign/Shared%20Documents/Design/Civil/Quantity%20Estimates/UNC-NECR_Calc_Summary-Dust%20Control%20Water%20Balance_DRAFT.docx?Web=1

The following calculations were generated using the following software:

Microsoft Excel 2013

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Objective

The objective of these calculations are to estimate daily water needs for dust control and verify the well yield and storage capacity required to provide adequate dust control water.

Background

Site personnel have reported the on-site well produces between about 25 and 50 GPM. This has not been verified for these calculations. The well will require testing and verification in the subsequent design phase.

Applicable Codes and Standards

The estimated dust control requirements for haul roads is taken from “Guideline for Mine Haul Road Construction” (Tannant and Regensburg, 2001). Excerpts are included in Attachment D.

Methods

Simple spreadsheet daily water balance.

Assumptions

The following assumptions were used:

Hourly Haul Road Dust Control Water Application: 25 Gal/KSF (LOW); 50 Gal/KSF (HIGH). Tannant and Regensburg, 2001.

Assume high application rate needed for Mine Waste Haul Road as this will be a high visibility road that crosses a public highway. Low application rate used in mine area assuming lower speeds, distributed traffic, opportunity for other dust control measures. Assumes low water use for borrow roads for control of nuisance dust only. Additional assumptions listed in calculation tables.

Water balance calculations assume pumping 7 days per week to maintain storage.

Calculations

See Attachments A and B.

Results

Well productions between 34 and 61 GPM are required depending on supplemental dust control and work shifts. Storage capacity between 105,000 gallons and 189,000 gallons is required – there is sufficient space in the Mill yard for this range of required water storage. Because the well is estimated to yield between 25 and 50 GPM, 40-hr/week construction operations may be more feasible than 48-hr/week operations.

Conclusions

The 30% design construction schedule is be based on a 40hr/week operation due to the limitations in well capacity. The Construction Contractor may be able to extend operations with the use of alternate dust suppression techniques.

Attachments

Attachment A – Water Balance for 34 and 44 GPM Well
Attachment B – Water Balance for 50 and 61 GPM Well
Attachment C – Typical water storage tank
Attachment D – Excerpt from Guidelines for Mine Haul Road Design (2001).

References

Tannant, D.D. and B. Regensburg, 2001. Guidelines for Mine Haul Road Design.

ATTACHMENT A

WATER BALANCE FOR 34 AND 44 GPM WELL

NECR 30% Design Dust Control Water Balance

	Begin STA	End STA	Segment Length (FT)	Running Width (FT)	Surface	Surface Area (KSF)	Application Rate (GAL/KSF) Low	Application Rate (GAL/KSF) High	Water Use (GAL/HR) Low	Water Use (GAL/HR) High	Assumptions
Mine Area Haul Roads	N/A	N/A	4000	35	U	140	25	50	3500	7000	Impacted area, low demand assumed.
Mine Waste Haul Road	0	2125	2125	35	U	74	25	50	1859	3719	Mine waste haul road is in primarily unimpacted areas,
	2125	4000	1875	22.5	G	42	25	50	1055	2109	low demand assumed if supplemental dust control
	4000	4846	846	35	U	30	25	50	740	1481	methods are used such as road salts, lignin, resin
								Total	3654	7309	modified emulsions, or other technology.
North Borrow Haul Road	0	2500	2500	35	U	88	25	50	2188	4375	
East Borrow Haul Road	0	100	100	35	U	4	25	50	88	175	Only one haul road assumed to be in use at any given
	100	538	438	35	V	15	6	13	383	767	time. Assumes vegetated surface demand is 25% of
								Total	471	942	unpaved surface.
West Borrow Haul Road	0	1400	1400	35	U	49	25	50	1225	2450	Nuisance dust issue, assumes average of 50% of low
	1400	2218	818	35	V	29	6	13	716	1432	demands for north and west haul roads with
								Total	1941	3882	supplemental dust control
							Average of North and West Borrow Haul Roads:		2064	1032	
Repository Yard	N/A	N/A			U	25	3	5	625	1250	Assume 10% effort of low haul road watering demand,
Former Mill Site Yard	N/A	N/A			G	25	3	5	625	1250	25,000 SF of active area requiring dust control at any
Mine Site Yard	N/A	N/A			U	5	3	5	125	250	given time
Point of Excavation	N/A	N/A			Spray				50	200	Intermittent spraying. Expert judgement hourly
Point of Placement	N/A	N/A			Spray				50	200	demand (i.e. no reference)
								Average for each operation:		125	x2 (Excavation and Placement)

U	Unpaved
V	Vegetated
G	Gravel

Daily Water Consumption @	9811	GAL/HR
8-Hr Shift (7 hours operation)	68,679	Gallons
10-Hr Shift (9 hours operation)	88,302	Gallons

28-day Water Balance

	(5) 8Hr Shifts Input	Output	Storage	Day	(4) 10hr + (1)8hr Input	Output	Storage
Day 1	49,100	-	49,100	1	63,073	-	63,073
Day 2	49,100	-	98,200	2	63,073	-	126,146
Day 3	49,100	68,679	78,621	3	63,073	88,302	100,917
Day 4	49,100	68,679	59,042	4	63,073	88,302	75,688
Day 5	49,100	68,679	39,462	5	63,073	88,302	50,460
Day 6	49,100	68,679	19,883	6	63,073	88,302	25,231
Day 7	49,100	68,679	304	7	63,073	88,302	2
Day 8	49,100	-	49,404	8	63,073	-	63,075
Day 9	49,100	-	98,504	9	63,073	-	126,148
Day 10	49,100	68,679	78,925	10	63,073	88,302	100,919
Day 11	49,100	68,679	59,346	11	63,073	88,302	75,690
Day 12	49,100	68,679	39,767	12	63,073	88,302	50,462
Day 13	49,100	68,679	20,187	13	63,073	88,302	25,233
Day 14	49,100	68,679	608	14	63,073	88,302	4
Day 15	49,100	-	49,708	15	63,073	-	63,077
Day 16	49,100	-	98,808	16	63,073	-	126,150
Day 17	49,100	68,679	79,229	17	63,073	88,302	100,921
Day 18	49,100	68,679	59,650	18	63,073	88,302	75,692
Day 19	49,100	68,679	40,071	19	63,073	88,302	50,463
Day 20	49,100	68,679	20,491	20	63,073	88,302	25,235
Day 21	49,100	68,679	912	21	63,073	88,302	6
Day 22	49,100	-	50,012	22	63,073	-	63,079
Day 23	49,100	-	99,112	23	63,073	-	126,152
Day 24	49,100	68,679	79,533	24	63,073	88,302	100,923
Day 25	49,100	68,679	59,954	25	63,073	88,302	75,694
Day 26	49,100	68,679	40,375	26	63,073	88,302	50,465
Day 27	49,100	68,679	20,795	27	63,073	88,302	25,237
Day 28	49,100	68,679	1,216	28	63,073	88,302	8

34 GPM required well production
105,000 GAL storage requirement (5 tanks @ 21,000 Gal/Tank)

44 GPM required well production
126,000 GAL Storage Capacity (6 Tanks)

ATTACHMENT B

WATER BALANCE FOR 50 AND 61 GPM WELL

NECR 30% Design Dust Control Water Balance

	Begin STA	End STA	Segment Length (FT)	Running Width (FT)	Surface	Surface Area (KSF)	Application Rate (GAL/KSF) Low	Application Rate (GAL/KSF) High	Water Use (GAL/HR) Low	Water Use (GAL/HR) High	Assumptions
Mine Area Haul Roads	N/A	N/A	4000	35	U	140	25	50	3500	7000	Impacted area, low demand assumed.
Mine Waste Haul Road	0	2125	2125	35	U	74	25	50	1859	3719	Mine waste haul road is in primarily unimpacted areas,
	2125	4000	1875	22.5	G	42	25	50	1055	2109	high demand assumed if no supplemental dust control
	4000	4846	846	35	U	30	25	50	740	1481	methods are used such as road salts, lignin, resin
								Total	3654	7309	modified emulsions, or other technology.
North Borrow Haul Road	0	2500	2500	35	U	88	25	50	2188	4375	
East Borrow Haul Road	0	100	100	35	U	4	25	50	88	175	Only one haul road assumed to be in use at any given
	100	538	438	35	V	15	6	13	383	767	time. Assumes vegetated surface demand is 25% of
								Total	471	942	unpaved surface.
West Borrow Haul Road	0	1400	1400	35	U	49	25	50	1225	2450	Nuisance dust issue, assumes average of low demands
	1400	2218	818	35	V	29	6	13	716	1432	for north and west haul roads with no supplemental
								Total	1941	3882	dust control
								Average of North and West Borrow Haul Roads:	2064		
Repository Yard	N/A	N/A			U	25	3	5	625	1250	Assume 10% effort of low haul road watering demand,
Former Mill Site Yard	N/A	N/A			G	25	3	5	625	1250	25,000 SF of active area requiring dust control at any
Mine Site Yard	N/A	N/A			U	5	3	5	125	250	given time
Point of Excavation	N/A	N/A			Spray				50	200	Intermittent spraying. Expert judgement hourly
Point of Placement	N/A	N/A			Spray				50	200	demand (i.e. no reference)
								Average for each operation:		125	x2 (Excavation and Placement)

U	Unpaved
V	Vegetated
G	Gravel

Daily Water Consumption @	14498	GAL/HR
8-Hr Shift (7 hours operation)	101,483	Gallons
10-Hr Shift (9 hours operation)	130,479	Gallons

28-day Water Balance

	(5) 8Hr Shifts Input	Output	Storage		Day	(4) 10hr + (1)8hr Input	Output	Storage
Day 1	72,489	-	72,489		1	88,182	-	88,182
Day 2	72,489	-	144,978		2	88,182	-	176,364
Day 3	72,489	101,483	115,984		3	88,182	130,479	134,067
Day 4	72,489	101,483	86,989		4	88,182	130,479	91,771
Day 5	72,489	101,483	57,995		5	88,182	130,479	49,474
Day 6	72,489	101,483	29,001		6	88,182	130,479	7,178
Day 7	72,489	101,483	6		7	88,182	95,358	2
Day 8	72,489	-	72,495		8	88,182	-	88,184
Day 9	72,489	-	144,984		9	88,182	-	176,366
Day 10	72,489	101,483	115,990		10	88,182	130,479	134,069
Day 11	72,489	101,483	86,995		11	88,182	130,479	91,772
Day 12	72,489	101,483	58,001		12	88,182	130,479	49,476
Day 13	72,489	101,483	29,007		13	88,182	130,479	7,179
Day 14	72,489	101,483	12		14	88,182	95,358	3
Day 15	72,489	-	72,501		15	88,182	-	88,185
Day 16	72,489	-	144,990		16	88,182	-	176,367
Day 17	72,489	101,483	115,996		17	88,182	130,479	134,070
Day 18	72,489	101,483	87,002		18	88,182	130,479	91,774
Day 19	72,489	101,483	58,007		19	88,182	130,479	49,477
Day 20	72,489	101,483	29,013		20	88,182	130,479	7,181
Day 21	72,489	101,483	18		21	88,182	95,358	5
Day 22	72,489	-	72,507		22	88,182	-	88,187
Day 23	72,489	-	144,996		23	88,182	-	176,369
Day 24	72,489	101,483	116,002		24	88,182	130,479	134,072
Day 25	72,489	101,483	87,008		25	88,182	130,479	91,775
Day 26	72,489	101,483	58,013		26	88,182	130,479	49,479
Day 27	72,489	101,483	29,019		27	88,182	130,479	7,182
Day 28	72,489	101,483	25		28	88,182	95,358	6

50 GPM required well production
147,000 GAL storage requirement (7 tanks @ 21,000 Gal/Tank)

61 GPM required well production
189,000 GAL Storage Capacity (8 Tanks)

ATTACHMENT C

TYPICAL WATER STORAGE TANK

Steel Tank

Flat Top Smooth Wall

Overview:

Store liquids with confidence with Rain for Rent's Flat Top Smooth Wall tank. Permanently attached axles, for maximum maneuverability, allows this tank to be moved with ease on the jobsite. The staircase ensures proper protection for workers on site. The tank also offers optional epoxy coating, which offers chemical resistance and additional cleanliness for sensitive environmental applications.

Features:

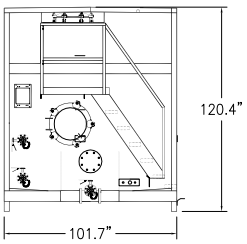
- Vapor Tight Tanks: rated to 16oz/in^2 of pressure and 0.4oz/in^2 of vacuum
- V-drain floor with front and rear 4" 150-lb flanges with valves
- OSHA Compliant Stairway
- 1.5" SCH80 level gauge port
- 8" External manifold or internal manifold
- Rear 3" or 6" SCH40 fill line
- Optional: Epoxy Coating - chemical resistance for a wide variety of chemical compatibility and keeps stored product within the tank cleaner
- Optional: Steam Coils

Accessories:

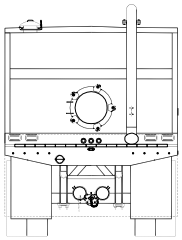
- E-CONTAIN® Spillguards
- SolidGround® Traction Mats
- Radar Level Gauge
- Mechanical Level Gauge
- PipeStax®
- HoseTrax®
- Suction and Discharge Hose

Specs:

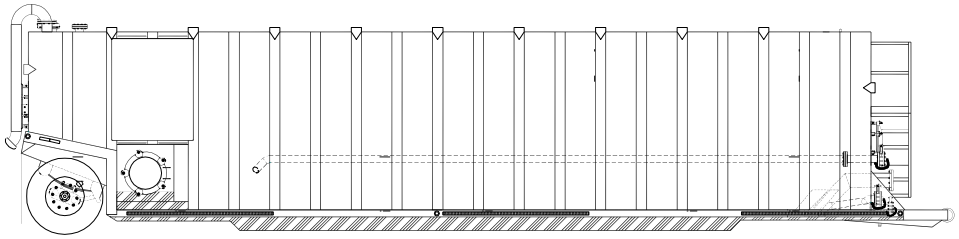
Material	Steel, Epoxy Coated (Option)
Capacity	21,000 gallons
Manways	Four 22" hatches
Dry weight	29,500 lbs.
Footprint (LxWxH):	560" x 102" x 120"



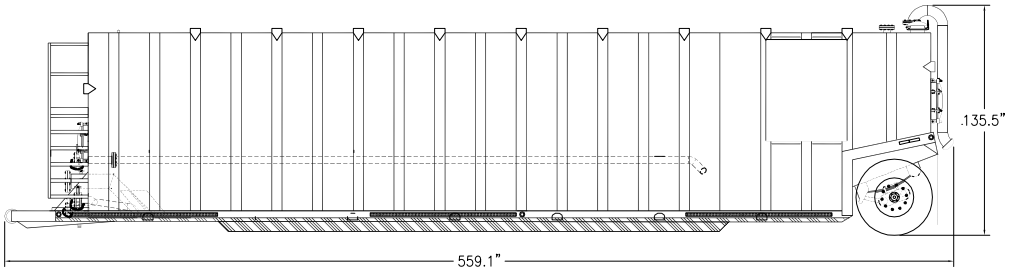
FRONT VIEW



REAR VIEW



PASSENGER SIDE VIEW



DRIVER SIDE VIEW

PUMPS • TANKS • FILTRATION • PIPE • SPILLGUARDS

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Liquid Ingenuity®
800-742-7246
rainforrent.com

ATTACHMENT D

EXCERPT FROM GUIDELINES FOR MINE HAUL ROAD DESIGN (2001)

GUIDELINES FOR MINE HAUL ROAD DESIGN

Dwayne D. Tannant
&
Bruce Regensburg

2001

maintained. A rock lining is needed in steep ditches (>8%) to prevent erosion. Ditches must lead to diversions and the water from the diversions led safely to settling ponds. Temporary silt traps in the ditches and diversions can be made from bails of hay, staked into the path of the ditch. Haul roads should have a crown that causes water to run to the side and then to the ditch. Permanent silt traps usually consist of an excavated pit and these require maintenance. Hillside roads have the ditches placed on the up-hill side of the road to ensure that they will not be washed out.

Culverts are typically used where roads cross streams or natural drainage paths. The culverts should be buried deep enough to prevent being crushed by vehicles passing over them. Unless the culverts lead to additional diversionary ditching, they need special water run-outs to reduce the velocity to the point where the water is non-erosive. On shallow slopes (less than 10%) with limited water flows (<0.5m/s), this may be done with vegetated outflow areas. Energy dissipaters (riprap or dumped-rock) may be required where flow rates are high.

Where permitted by local regulatory authorities, rock-fill causeways are sometimes used at watercourse crossings in lieu of culverts. In such cases, coarse rock up to 1m in diameter is end-dumped from the advancing causeway, allowing the coarser fraction to accumulate at the base of the fill by segregation.

Haul roads constructed along mountain slopes may interrupt surface run-off channels or block natural springs emerging from the mountainside. To prevent high groundwater levels within the road embankment, free draining rockfill, clean sand and gravel or a culvert should be installed at the base of the fill. High water levels occurring in existing road fills can often be lowered by installing, at appropriate spacing along the downstream slope, perforated horizontal drain pipe or backhoe-excavated finger drains that are backfilled with gravel.

Trafficability on temporary in pit roads with high ground water levels can be improved by placing a gravel or rockfill pad over the offending area or by installing pumping wells to lower the water table. The latter procedure may be cost effective if it also reduces the water level in, and improves the stability of, the shovel working face.

4.8 Dust Suppressants

Dust generated by moving vehicles can reduce visibility to dangerous levels and harm engines. Dust is typically reduced by application of water to the road surface. In the dry season, watering helps maintain compaction and strength of the surface layer. It also maintains the surface shape and reduces the loss of gravel. Watering also helps reduce wash boarding or corrugation of the haul road surface. The generation of a corrugated running surface is a dry weather phenomenon.

The quantity of water needed to control dust depends on the nature of the road surface, traffic intensity, humidity and precipitation. During the summer months, a typical road may require 1 to 2 litres per square metre per hour.

L x .264 = GAL
M² x 10.7639 = FT²
1-2 L/M² =
.025-.05
GAL/SF/HR

Liquid stabilizers and polymers can also be used. In addition to dust suppression, these can help strengthen the surface layer as well as provide a degree of water proofing.

Field trials to evaluate the effectiveness of various dust suppressants were conducted over a two-month period in the summer of 1986 on a segment of haul road of Highvale Mine (Monenco 1986). The site consisted of seven 300m long by 25m wide contiguous sections which included two untreated control sections, one water test section and a single section for each of the

ATTACHMENT Q.2

SOP – Airborne Particulate Monitoring

STANDARD OPERATING PROCEDURE
AIRBORNE PARTICULATE MONITORING
AVM Environmental Services, Inc.

1.0 SCOPE

1.1 Purpose

This procedure describes the method for determining the concentration of airborne radioactive particulate at the upwind and downwind boundary areas during the Removal Action at the North East Church Rock site activities. The procedure is intended to:

1.1.1 Demonstrate compliance with the intake limits for the general public specified in the Radiation Protection Program.

1.1.2 Determine whether exposures to radioactive materials are being maintained As Low As Reasonably Achievable (ALARA) as stated in the Radiation Protection Program.

1.2 Applicability

This procedure applies to all personnel under Radiation Safety Officer (RSO) supervision performing airborne particulate monitoring during the RA at NECR.

2.0 REFERENCES

2.1 10 CFR 20, "Standards for Radiation Protection"

2.2 NRC Regulatory Guide 8.30, Health Physics Surveys in Uranium Mills

2.3 NRC Regulatory Guide 8.25, Calibration and Error Limits of Air Sampling Instruments for Total Volume of Air Sampled

3.0 EQUIPMENT AND MATERIALS

3.1 Air Sampler: Eberline RAS-II Low Volume Air Sampler (40 – 60 liters per minute).

3.2 0.45 micron particulate GF filter media. Envelopes for Filter Storage or Petri dishes.

3.4 Alpha radiation Counting Instrument (Ludlum 2929 with 43-10-1 detector or similar)

3.5 Air Particulate Sampling Survey Report/Form (Appendix A or equivalent).

4.0 AIR SAMPLE COLLECTION INSTRUCTIONS

4.1 Select a suitable upwind or downwind location for sampling. The filter head should be situated at approximately three to five feet from the ground surface.

4.2 Select a calibrated regulated air sampler (RAS-II). Install a 0.45 micron glass fiber filter in the filter head.

4.3 Determine the time and flow rate necessary to sample a volume sufficient to ensure that a required lower limit of detection (LLD) will be met.

4.4 Turn on the air sampling unit, adjust the flow rate to a the desired calibrated flow rate, and record the starting time, flow rate, vacuum, totalizer flow meter reading, and initials of the technician on a field data sheet. Record any other pertinent comments.

4.6 Periodically check air sampler unit for proper operation.

4.7 After the minimum collection time to meet the LLD requirement in Step 4.3, record ending flow rate, vacuum and time, and turn off the air sampling unit. Remove the air filter and place in a sample envelope or Petri dish and label it. Record sampling data in the attached Air Particulate Sampling Survey Report/Form

5.0 FILTER COUNTING INSTRUCTIONS

5.1 An initial 24-hour decayed count may be performed for informational purposes only. Allow a minimum of 72 hours from the end of sample collection before counting sample for decaying off the alpha emitting radon progeny collected on filters from ambient air. The LLD should be at least 10% of MPC (i.e. 8 x 10^{-13} μCi/ml for gross alpha based on Th-230 limit) for the final counting of the sample.

5.2 Count the air sample filter and background for at least 60 minutes for alpha activity counts using the Ludlum 2929 scaler.

5.3 Record the background and air sample filter counts and the counting data in attached Air Particulate Sampling Survey Report/Form. Calculate the airborne gross alpha activity, uncertainty and Lower Limit of Detection as shown in the Air Particulate Sampling Survey Report/Form.

Calculate the individual radionuclide (U-234, U-238, Th-230 and Ra-226) concentrations from gross alpha activity based on the site specific activity fraction ratio, if available. For airborne gross alpha activity from uranium ore dust, use 0.25 fractions for U-234, U-238, Th-230 and Ra-226 individual radionuclide airborne concentration calculation.

6.0 RECORDS

All forms generated as a result of this procedure shall be maintained throughout the duration of the project and then retained in the permanent project file.

AIR PARTICULATE SAMPLING FIELD DATA SHEETS

Sample #/Dish #_____ Date:_____

SOP:_____ Field Tech:_____

Area/Location/Assigned to:_____

_____

Sampler Used:_____ Filter Used:_____
Sampler Serial #:_____ Vac./Roto. Rdg(start)_____

Sampling Rate(SR):_____LPM Vac./Roto. Rdg(stop)_____

Time Start:_____Stop:_____Break Time:_____Elapsed(E):_____(min)
Volume of Air Sampled_____(ml)
(SR x E x 1000)

Initial Count

Alpha Counter_____ Efficiency_____Bkg._____

Count Date and Time_____
Alpha Counts_____ Count Time_____
Bkg. Counts_____ Count Time_____
Gross Alpha_____ µCi/mL
LLD_____µCi/mL
% MPC_____

Final Count

Alpha Counter_____ Efficiency_____Background_____

Count Date and Time_____
Alpha Counts_____ Count Time_____
Bkg. Counts_____ Count Time_____
Gross Alpha_____ µCi/mL
LLD_____µCi/mL
% MPC_____

Gross Alpha Activity, µCi/ml = $\frac{\text{(Gross cpm–Background cpm)(FA*)}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$

Estimated Error (uncertainty 95%), µCi/ml = $\frac{\text{1.96 x (FA*) x \{(Gross cpm/t min,Gorss)+(Bkg cpm/t, min Bkg)\}^0.5}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$

LLD, µCi/ml = $\frac{\text{4.66 x (FA) x [(Bkg counts)^0.5]/t min, Bkg count time}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$

*Filter Absorption (FA) = 1.25 for glass fiber filters; 1.0 for Cellulose nitrate filters

APPENDIX R

Release Prevention and Contingency Plan

(to be provided with 95% Design Report)