Northeast Church Rock 95% 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
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
BMP	best management practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
D_{50}	median stone diameter
fps	feet per second
FS	factor of safety
ft/ft	feet per foot
GE	General Electric
GSR	Green and Sustainable Remediation
HMR	Hydrometeorological Report
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NDC	North Diversion Channel
NECR	Northeast Church Rock
NOAA	National Oceanic and Atmospheric Administration
NRC	US Nuclear Regulatory Agency
PMF	probable maximum flood
PMP	probable maximum precipitation
RAO	Remedial Action Objective or Removal Action Objective
RCC	roller compacted concrete
ROD	Record of Decision
TDA	Tailings Disposal Area
UNC	United Nuclear Corporation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WRCC	Western Regional Climate Center

I.1 BACKGROUND

The intent of the stormwater controls at the Church Rock Mill Site (Mill Site) is to prevent storm water runoff from impacting the Tailings Disposal Area (TDA). As a result of remedial actions, including the construction of the Repository, modifications to the existing stormwater controls will be required. This appendix presents the design basis for these proposed modifications and others that will reduce sediment accumulation in channels (see Section I.4). This appendix also includes the evaluations and designs for items requested by the US Nuclear Regulatory Commission (NRC, 2003) and the United States Environmental Protection Agency (USEPA, 2016):

- Improvements to the North Diversion Channel, which is located along the south and east side of the TDA (see Section I.5).
- 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 I.6)
- Evaluation and mitigation designs for the Pipeline Arroyo stabilization upgradient of, and adjacent to, the Repository area, and specifically the existing buried rock “jetty” (see Section I.7).

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

Table I.1-1: 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	Dilco Hill Channel Confluence
9-07	North Cell Earthen Berm
9-08	Runoff Control Ditch Plan and Profile
9-09	Riprap Chute
9-10	Riprap Chute Sections
9-11	Riprap Chute Details

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

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
105	10 CFR 61.23(g)	Licensing	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.
79	2011 Action Memo, Table A-1; 2013 ROD Table 1 and Sections 2.9.2 and 2.9.5	Repository Design	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.
58	2013 ROD, Table 1	Repository Design	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 presents the proposed 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.
62	2013 ROD, Table 1	Repository Design	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	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.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
			Processed Primarily for Their Source Material Content - Criterion 4. Refer to www.ecfr.gov.	The siting of the Repository was predetermined by the location of the existing tailings impoundment. The remaining parts of Criterion 4 are addressed in Appendix G.
59	2013 ROD, Table 1	Repository Design	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.
55	2013 ROD, Table 1	Performance Objectives	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 to minimize maintenance requirements.
60	2013 ROD, Table 1	Repository Design	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.
74	2013 ROD, Table 1 and Section 2.9.5, Cap Design Criteria, Bullets 3 and 4	Storm Water and Erosion Control	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.
75	2013 ROD, Table 1 and Sections 2.9.2 and 2.9.5	Repository Design	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.
13	2015 AOC SOW, Paragraph 28 – Long-term Stormwater Management	Long-Term Storm Water 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 to minimize maintenance requirements. Permanent stormwater controls for the Northeast Church Rock Mine Site (Mine Site) are described in Appendix F.
14	2015 AOC SOW, Paragraph 29 – Green Remediation	Green Remediation Best	Respondents shall incorporate applicable Best Management Practices for Green Remediation listed in ASTM-E2893-13	Green and Sustainable Remediation (GSR) considerations are outlined in Section I.10.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
	Best Management Practices	Management Practices	consistent with EPA's policy Superfund Green Remediation Strategy (2010), found at http://www.epa.gov/superfund/greenremediation/sf-gr-strategy.pdf.	

*Refers to identifying numbers listed in Summary of ARARs, Performance Standards and Applicable NRC Design Requirements Table (provided in Attachment 1 to main text of the 95% Design Report)

I.3 STORMWATER HYDROLOGY

I.3.1 Site Hydrologic Setting

The Northeast Church Rock (NECR) Mine Site (Mine Site) is located approximately 17 miles northeast of Gallup, New Mexico. The mine was operated from 1967 to 1982 by the United Nuclear Corporation. The elevation of the 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 11.1 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 an average annual evaporation approaching 62.5 inches, approximately six times greater than the current annual average precipitation (WRCC, 2016). The site receives an average of 30.6 inches of snowfall annually.

Both the Mine Site and the Mill Site are contained within the Pipeline Arroyo Watershed, which is approximately 18 square miles. The landscape of the Pipeline Arroyo Watershed 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 outcrops 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 greatest stormwater runoff rate at both the Mill Site and Mine Site results from thunderstorms 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.3.2 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 design for the Pipeline Arroyo Stabilization evaluated a range of flood events and provides protection that can statistically be expected 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). Stantec 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 calculated design flows incorporate new methods that were not available when the previous TDA reclamation plan was developed (Canonie, 1991). In particular, the PMP depth and distribution presented in this document were calculated using the recently-developed PMP Tool prepared for the Arizona Department of Water Resources (ADWR, 2013) while the previous TDA reclamation plan utilized Hydrometeorological Report (HMR) 49 (Hansen et al., 1984). The ADWR PMP study, which incorporates the Pipeline Arroyo watershed, accesses a larger precipitation database and newer analytical techniques that were not available in the development of HMR 49. The ADWR PMP tool produces gridded PMP values using a grid spacing of approximately 2.5 square miles to allow site-specific estimation of precipitation depths. Similarly, other frequency-based storm hyetographs were developed with site-specific precipitation intensity-duration information as recommended in the recent National Engineering Handbook (NRCS, 2015). Finally, the updated design discharge estimates compute rainfall losses using the Green-Ampt method (Green & Ampt, 1911) which provide physically-based estimates of losses during different storm intensities and storm durations. The methods and assumptions used to develop these different model inputs are discussed in Attachment I.1.

Stantec estimated the PMF at various Mill Site stormwater control locations using a numerical rainfall-runoff model (HEC-HMS 4.2.1). The model development methods and simulation results for the Mill Site stormwater hydrology are presented in Attachment I.1. Stantec developed five hydrologic models to facilitate estimation of flood flows for different locations, conditions, and storm events. These models are summarized in Table I.3-1 and the development methods and simulation results for the models are provided in Attachment I.1.

Table I.3-1: Summary of Developed Hydrologic Models

Hydrologic Model	Peak Flows Simulated	Related Design Analyses/Model Uses
Pipeline Arroyo Watershed Model for Existing Conditions	PMF and 2-, 5-, 100-, 200-, 1,000-, 10,000-year events	Used to evaluate the existing hydraulic conditions within the Pipeline Arroyo
Pipeline Arroyo Watershed Model for Post-RA Conditions	PMF and 2-, 5-, 100-, 200-, 1,000-, 10,000-year events	Evaluation of Pipeline Arroyo Stabilization Alternatives (riprap sizing, erosional protection, energy dissipation efficiency), Evaluation of upper pipeline arroyo hydraulics (flood extents for design events in reach adjacent to TDA), Computational Fluid Dynamics modeling of rock jetty
Mill Site Sub-Catchments Model for Post-RA Conditions	PMF and 2-, 5-, 100-, 200-, 1,000-, 10,000-year events	Hydraulic Analysis of North Diversion Channel, Repository Channel Capacity and Erosional Stability, Lower East Repository Channel Sediment Transport Competency, and Hydraulic Analysis of Mine Site Outlet Channel
Mine Site Sub-Catchments Model for Construction Phases	2-year and 100-year	Hydraulic Analysis of Mine Site drainage channels during construction and post-RA phases
Haul Road Catchment Model for Construction Phases	10-year event	Hydraulic analysis of temporary retention ponds, roadside ditches, and culverts as described in Appendix D.

I.4 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, shown on Drawings 9-01 and 9-02, include the East Repository Channel and related sediment controls and drainage improvements for the south and west side of the Repository. Calculations for the design of the Repository stormwater controls are provided in Attachment I.2, and filter compatibility calculations for the granular filters below the channels are included in Attachment I.3.

I.4.1 East Repository Channel and Related Sediment Controls

The proposed East Repository Channel will run 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 Branch Swale C and Stations 34+60 to 41+39 are aligned with the existing upper reach of the North Cell Drainage Channel (see Drawings 9-02 through 9-04). 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.4.1.1 East Repository Channel Capacity and Scour Protection

The hydraulic calculations (see Attachment I.2) 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 Branch 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 Branch 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 Branch Swale C between approximately Stations 0+00 and 18+30 is constructed over tailings and a 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 two-layer granular filter is required to meet filter criteria for the subgrade and the various riprap sizes (Attachment I.3).

I.4.1.2 East Repository Channel Sediment Control Features

Sediment accumulation along the reach in the existing Branch Swale C that runs along the base of the south side of Dilco Hill has created localized high points in the swale that reduce the swale capacity and are promoting further sediment deposition. Sediment has also accumulated in the upper reach of the North Cell Drainage Channel (future East Repository 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 northwest side of Dilco Hill. The reaches of concern and the apparent sediment source areas are shown in Figure I.4-1.

The RA design for the East Repository Channel proposes several controls to reduce sediment delivery to and 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 details on Drawing 9-04). The triangular section will improve the sediment transport capacity of the channel by nearly three times and will have sufficient capacity to pass sediment delivered from the two Dilco Hill drainage channels.

Calculations demonstrating the sediment transport capabilities of the channels on Dilco Hill are provided in Attachment I.4.

I.4.2 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. Hydraulic 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 3 inches (see Attachment I.2) to maintain erosional stability during the PMF. Appendix G describes the Repository cover design.

The design 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 Drawing 9-02). 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 future tie-in reach of Branch Swale H is through the existing evaporation ponds and will be completed following removal of the ponds. The hydraulic calculations show that the existing Branch Swale H has capacity for the post-RA PMF (see Attachment I.2). Design and construction of the full length of Branch Swale H and the downstream South Diversion Channel were not within the scope of the RA, but these will be completed per the NRC-approved tailings reclamation plan, prior to license transfer.

I.5 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.5); 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 Drawing 9-05). With the proposed improvements, the hydraulic analysis shows that the NDC has 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 Drawings 9-02 and 05). 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 PIPELINE ARROYO FLOOD EXTENTS AND THE NORTH CELL DRAINAGE CHANNEL

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 (cfs) (see Attachment I.1). Figure I.6-1 shows the floodplain extents for the PMF and the 100-year and 5-year floods, estimated with a two-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.6-1). Note that PMF flood extents predicted by Canonie do not account for the Repository; whereas the flood extents estimated in this study do.

The results of the two-dimensional hydraulic model also show that the North Cell Drainage Channel will be inundated during the PMF. Under existing conditions, the downstream portion of the North Cell Drainage Channel could experience velocities on the order of 5 ft/s. To reduce velocities in the North Cell Drainage Channel in large flood events, and thus decrease potential for scour at the base of the Repository, the road that runs along the north bank of the North Cell Drainage Channel will be raised as a protective berm to hydraulically isolate the North Cell Drainage from the alluvial area to the north (see modeling results in Attachment I.6).

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 buried rock “jetty” that was constructed during the TDA reclamation (Canonie, 1991). Progressive scour and undermining of the jetty has 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 design description for the Pipeline Arroyo stabilization.

I.7.1 Assessment of the Existing Rock Jetty

The assessment of the existing rock jetty is based on Stantec’s review of the historical images of the Pipeline Arroyo, observations made on a 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 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 and 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 (now Stantec) toured the Pipeline Arroyo near the rock jetty on February 18, 2016. During the tour, MWH observed that flows across the rock jetty had 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. Collapse of the overhang 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 previous drilling; tailings reclamation (Canonie 1991), cone penetration testing (MWH, 2014), and geotechnical borings for this Interim Design (Stantec, 2017; Attachment I.8) 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 (Attachment I.8).

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). Rock core obtained from the geotechnical boring performed for this Interim Design indicate that the underlying rock consists of zones of sandstone, shale, and coal of similar quality as the exposed outcrop. The rock would be subject to substantial scour if exposed, unprotected, to a series of annual peak floods.

I.7.1.4 Preliminary Hydraulic Calculations

Hydraulic simulations show flood flows up to the 10-year return interval flood would not overtop the existing jetty. Under extreme flood events (100-year flood and greater), flow will overtop a significant length of the jetty, implying an event between the 10-year and 100-year floods will overtop 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 about 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.7-11). 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 of the pre-mine Pipeline Arroyo. The headcut has scoured to the bedrock 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 may not put the TDA embankment at immediate risk of failure but 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 indicate that the jetty was not designed to protect against flows overtopping the structure. The median design rock size is 6 inches (Canonie, 1991). The hydraulic simulations suggest that floods with an annual return interval of between 10 years and 100 years would exceed the capacity of the upstream arroyo channel. In such a flood event, flood waters would 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.

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. That the pathway would shift far enough to the east to threaten the TDA embankment is unlikely; 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

Stantec identified the following alternatives for stabilization of the Pipeline Arroyo:

- Alternative 1: Monitor and Repair. This alternative consists of leaving the existing rock jetty in place and providing long-term maintenance funding as needed.
- Alternative 2: Riprap Chute (Selected). This alternative consists of constructing a riprap chute capable of handling overtopping flows.
- Alternative 3: Re-constructed 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 east bank.
- Alternative 4: Roller Compacted Concrete (RCC) Stepped Spillway. This alternative would replace the rock jetty with a stepped spillway structure.
- Alternative 5: Rock-Cut Chute. This alternative would replace the rock jetty with a chute cut into the existing sandstone bedrock.

Stantec 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 (GE/UNC), Stantec selected the riprap chute (Alternative 2) as the stabilization method. 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). Alternative 2 also depends less on the depth to rock in the area than the rock cut chute (Alternative 5). Other factors influencing the selection of the riprap chute or dismissal of other alternatives are summarized below.

- Although the probability is low 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, the alternative to monitor and repair (Alternative 1) does not provide a long-term solution to stabilize the arroyo and mitigate the risks of impacts to the TDA. Under Alternative 1, future repairs would be likely and could be extensive.
- Although the reconstruction of the arroyo channel (Alternative 3) would provide stabilization of the arroyo along the entire length of the TDA, the very large disturbance area and the greater amount of excavation and riprap required relative to other alternatives made this alternative undesirable.
- Although the roller compacted concrete stepped spillway (Alternative 4) may provide the most robust and likely the most constructible alternative, NRC's aversion to the use of concrete as a long-term erosion control solution due to durability concerns and potential issues related to differential settlement made an RCC structure unsuitable for this application.
- A rock-cut chute (Alternative 5) would potentially stabilize the Pipeline Arroyo by providing grade control at the rock outcrop, the bedrock topography and the poor rock quality made this alternative tenuous as a long-term solution. There is also uncertainty regarding the impacts of shifting the arroyo alignment on the upstream flood levels and downstream scour and lateral migration.

I.7.3 Design Description for the Riprap Chute

Drawings 9-09 through 9-11 show the 95% design of the Riprap Chute, and the hydraulic evaluations and riprap sizing calculations for the chute are provided in Attachment I.7. The chute crest extends from just downstream of the rock outcrop on the right bank of the Pipeline Arroyo (looking downstream) to the embankment of the TDA. This extent is sufficient to capture flows from the PMF. The chute will slope longitudinally at 5.3 percent for a distance of about 56 feet vertically, where the flood flows will discharge into a sunken riprap basin. A 5.3 percent slope was selected over steeper slopes that would have less excavation volumes because the 5.3 percent slope grades the chute beyond the steep drop in the arroyo bed (see Figure I.7-12). This drop appears to be a headcut in the channel bottom, giving rise to the concern that if the drop were to migrate to the base of the chute, it could potentially undercut the chute stability. By grading the chute beyond the drop, the 5.3 percent slope chute eliminates this concern.

The median riprap diameter for the chute is 27 inches. The factor of safety (FS) of the median design riprap size (D_{50d}) to the median riprap size at the threshold of displacement (D_{50f}) can be computed as:

$$FS = \frac{D_{50d}}{D_{50f}}$$

The hydraulic analysis (Attachment I.7) demonstrates that these riprap sizes will provide a factor of safety for the PMF of slightly greater than 1.0. Flood events between the 10,000-year flood and 100-year flood are estimated to have greater factors of safety as shown in Table I.7-1 (see Attachment I.7). Granite and limestone riprap can be sourced from a quarry located near Gallup, New Mexico. Rock quality testing from quarry samples, provided in Appendix H, indicate that these local rock sources meet Johnson (2002) durability requirements. The granite could be used without upsizing, while the limestone would require a 5 percent increase in the median design diameter to account for long-term degradation potential (see Appendix H, Section H.1).

Table I.7-1: Estimated Factors of Safety against Riprap Failure for Various Flood Events

Flood Event		PMF	10,000-Yr	1,000-Yr	200-Yr	100-Yr
Exceedance Probability (%)	in 1,000-years	0.05	9.5	63	99.3	~100
	in 200-years	0.001	2.0	18	63	87
D_{50f} (inches)	Maximum inside of critical zone	25.5	20.4	18.1	16.0	14.2
	Maximum outside of critical zone	20.8	16.7	13.4	12.3	10.2
Factor of Safety	Inside of critical zone	1.06	1.32	1.49	1.69	1.90
	Outside of critical zone	1.30	1.62	2.01	2.20	2.65

Notes:

1. Exceedance probability is the probability that the designated flood event will be exceeded in a given time period (1,000 years and 200 years)
2. Exceedance probability of PMF is estimated using an assumed recurrence interval of 2×10^6 years based on regression of simulated flood events
3. Factor of safety values computed using a median riprap diameter of 27 inches assuming the specific gravity of the rock is 2.6
4. D_{50f} = median riprap size at the threshold of displacement

The sunken riprap basin is designed at the toe of the chute. The basin has a depth of 2 feet and a length of about 100 feet. The hydraulic modeling shows that the hydraulic jump on the chute will be a submerged jump and controlled by the downstream constriction (see Attachment I.7). Therefore, the jump length will not be influenced by the outlet basin length. To account for potential changes in downstream conditions, the length of the outlet basin was designed by assuming that a free jump would form at the toe of the chute and have a length of six times the sequent flow depth (Chow, 1959) for the PMF, approximately 15 feet.

The side slopes adjacent to the TDA embankment will slope toward the weir at 5 horizontal to 1 vertical (5:1), and the side slopes on the right side of the weir will be cut back into rock at a slope of 2.5:1. The side slopes will be armored with rock with a median diameter (D_{50}) of 3 inches to provide erosion protection from incidental rainfall and runoff.

Samples from the 2016 geotechnical characterization (Stantec, 2017) indicate that the existing subgrade below the proposed chute is composed of fine-grained soils. To prevent washout of the subgrade soil, a granular filter is included between the riprap and the underlying soil. Two filter layers are required to prevent loss of subgrade below the chute (see Attachment I.3).

The design provides no flood controls in the arroyo downstream of the chute outlet basin. The historical imagery of the area (Section I.7.1.1) shows no evidence of lateral migration of the downstream arroyo; however, post-closure monitoring downstream is recommended to identify possible instabilities with the potential to migrate back toward the riprap basin.

I.8 GREEN AND SUSTAINABLE REMEDIATION CONSIDERATIONS

USEPA's Superfund Green Remediation Strategy Policy (USEPA, 2010) requires incorporation of best management practices (BMPs) for green remediation as listed in ASTM-E2893-16 (ASTM, 2016). Specific proposed practices for the borrow areas relate to relate to: (1) construction materials (characteristics, manufacturing and transportation considerations), (2) construction methods, and (3) low impact/sustainability measures during construction. The 'BMP Process', as outlined in the 'Standard for Greener Cleanups' (ASTM, 2016), has been followed to select and prioritize BMPs for implementation during remedial action. The BMPs relating to Mill Site Stormwater Controls are listed below, for a complete description of the BMP Process and list of all GSR BMPs see Section 4 of the Main RD document and Appendix A (Section A.5).

I.8.1 Construction Materials

Green and Sustainable Remediation (GSR) considerations involving construction materials include requiring use of green concrete for channels and culverts (via technical specifications) and use of on-site, non-contaminated materials (soils and rock) for riprap and construction of berm-sub grades in order to limit fuel consumption and associated emissions.

I.8.2 Construction Methods

The design implements GSR practices by limiting the length of new channels to be constructed and makes use of the existing channels already in place at the site. 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 BMPs will be used to protect disturbed slopes during construction and minimize dust emissions.

I.8.3 Low Impact/Sustainability Measures

Low impact/sustainability measures include minimizing disturbance of undisturbed areas by aligning new channels with former channels and roads and minimizing overall length of channels required. Disturbed areas will be revegetated as quickly as possible following completion of work to avoid unneeded erosion repairs.

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FIGURES

Figure I.4-1: Sediment Source Areas for the East Repository Channel

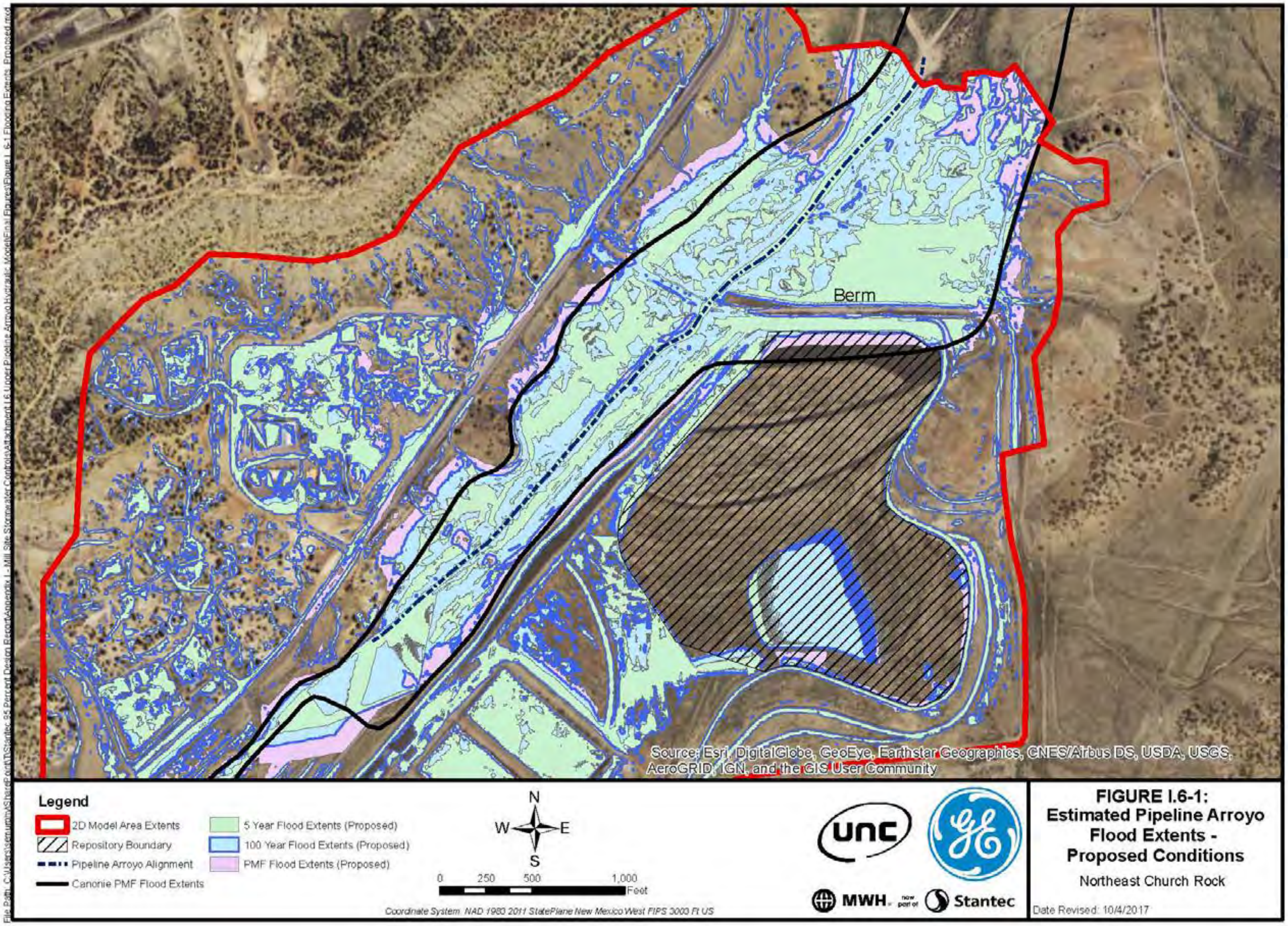

Figure I.6-1: Pipeline Arroyo Flooding Extents

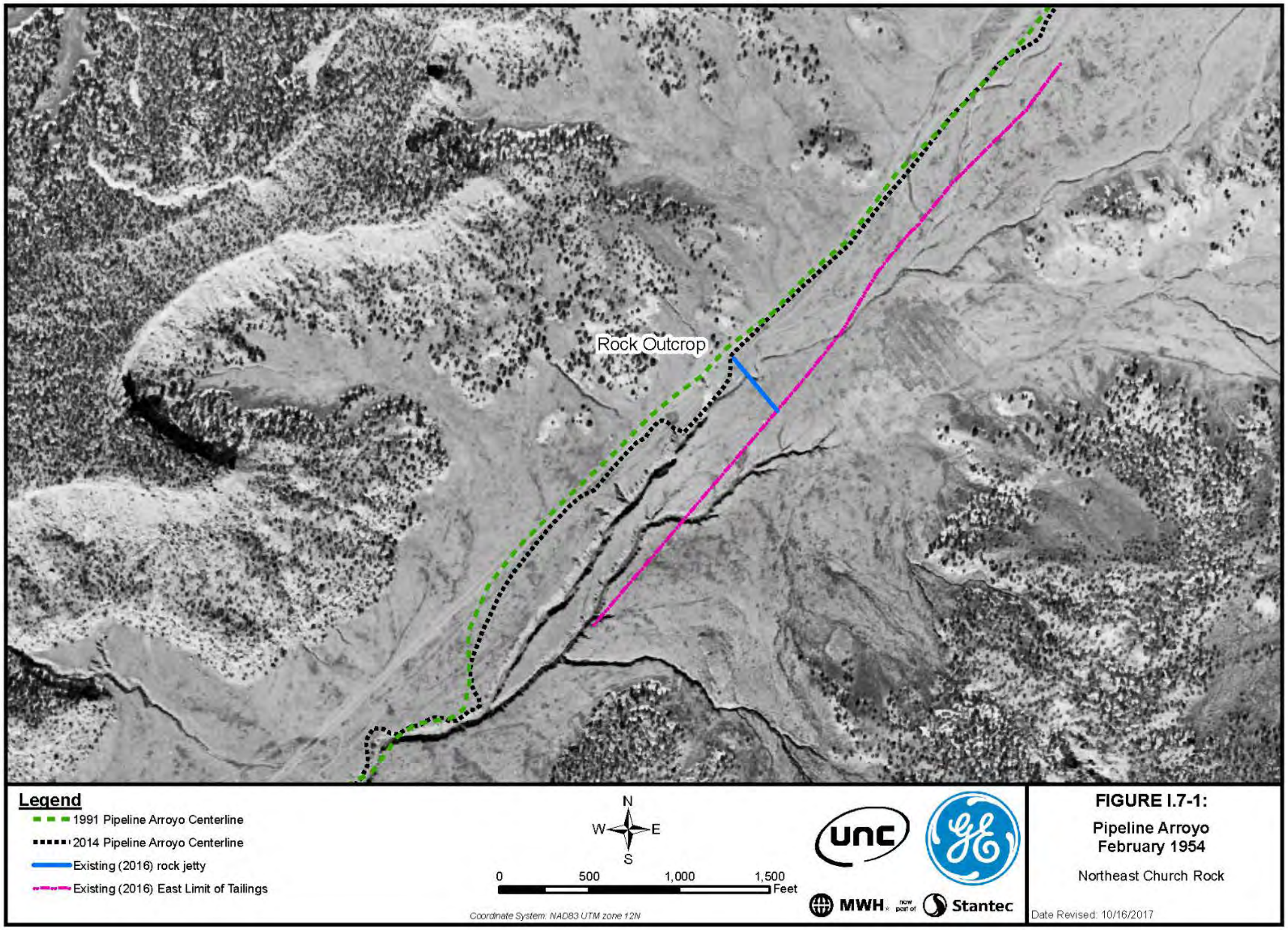

Figure I.7-1: Pipeline Arroyo February 1954

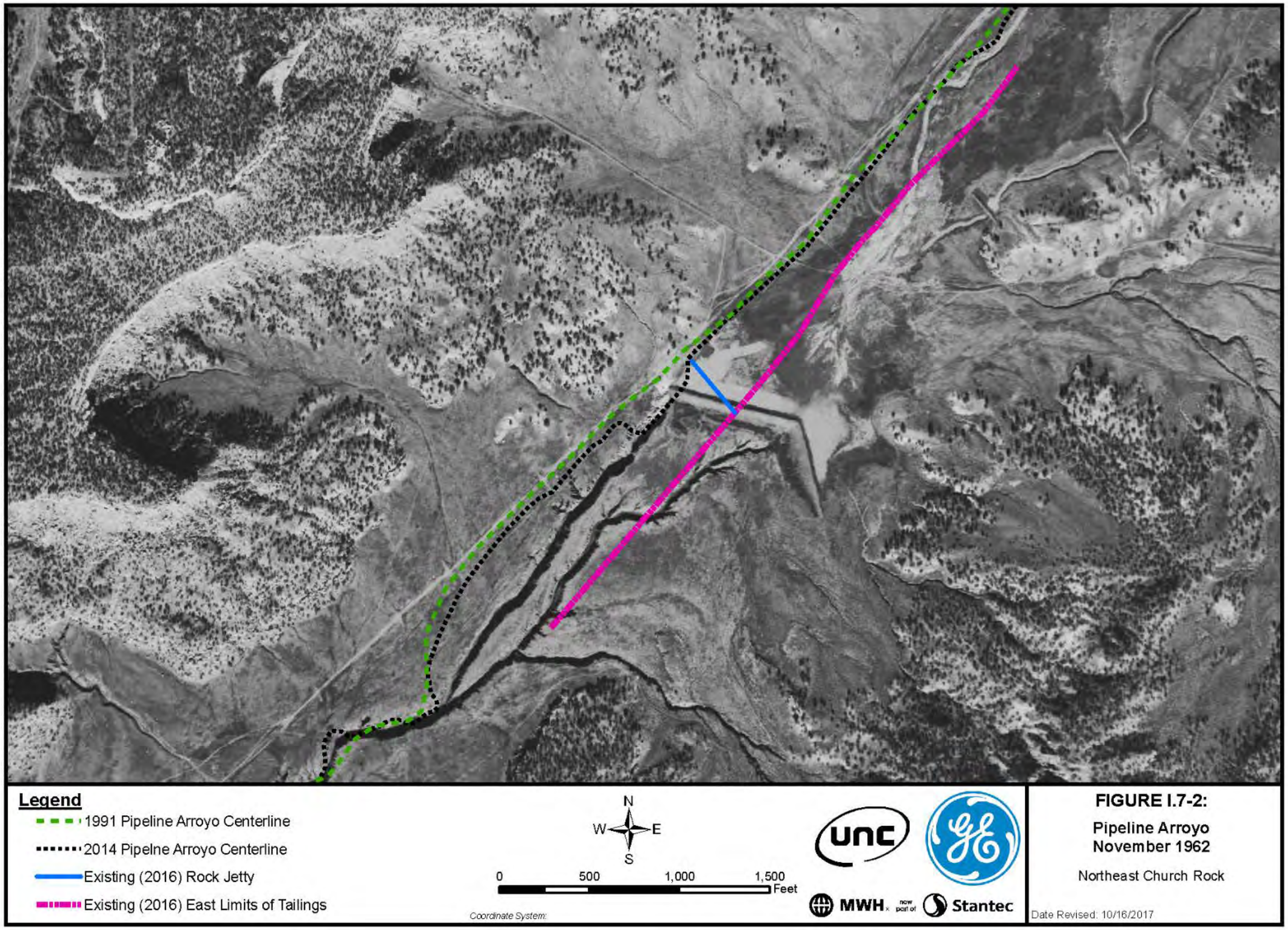

Figure I.7-2: Pipeline Arroyo November 1962

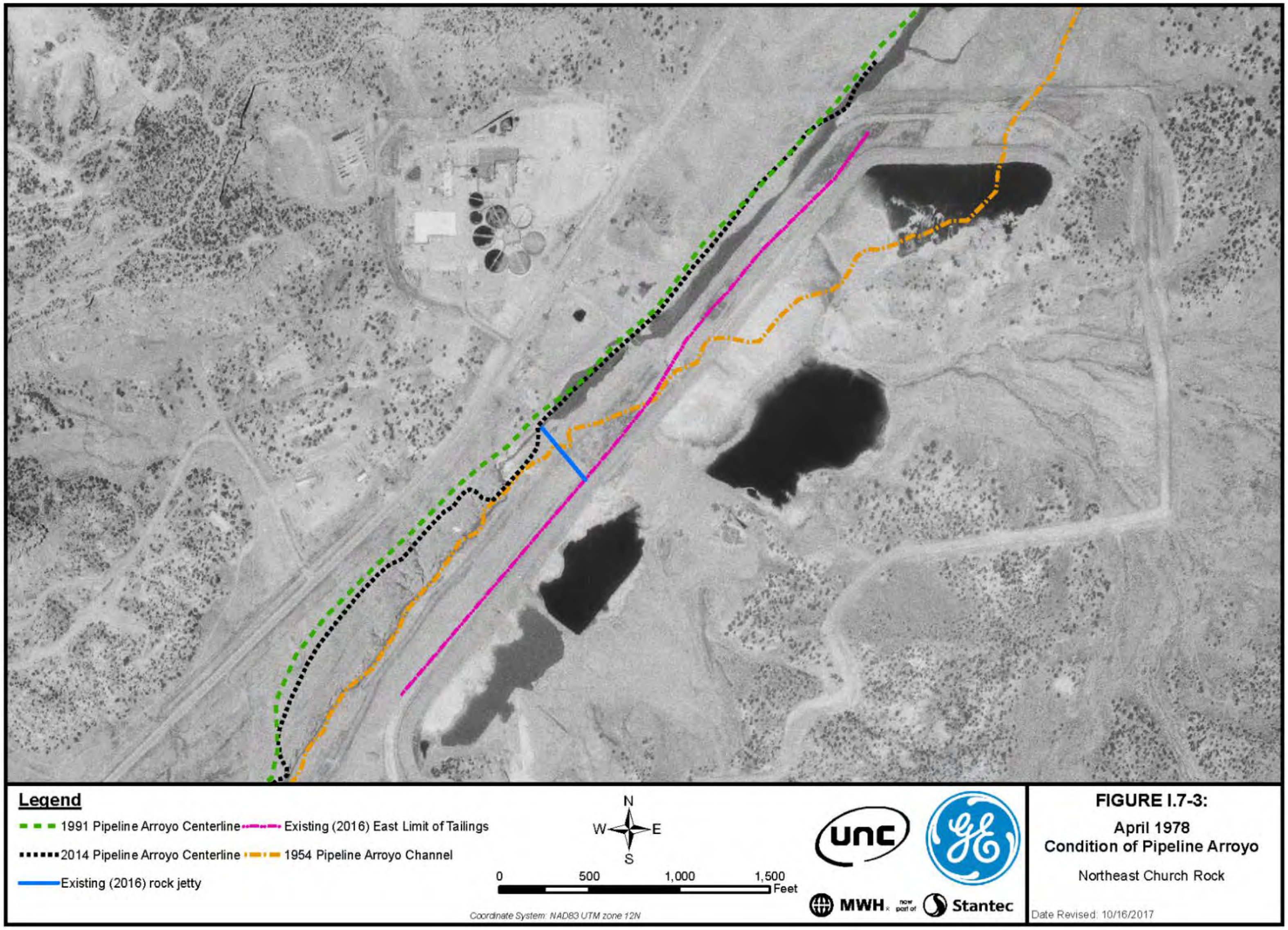

Figure I.7-3: Pipeline Arroyo April 1978

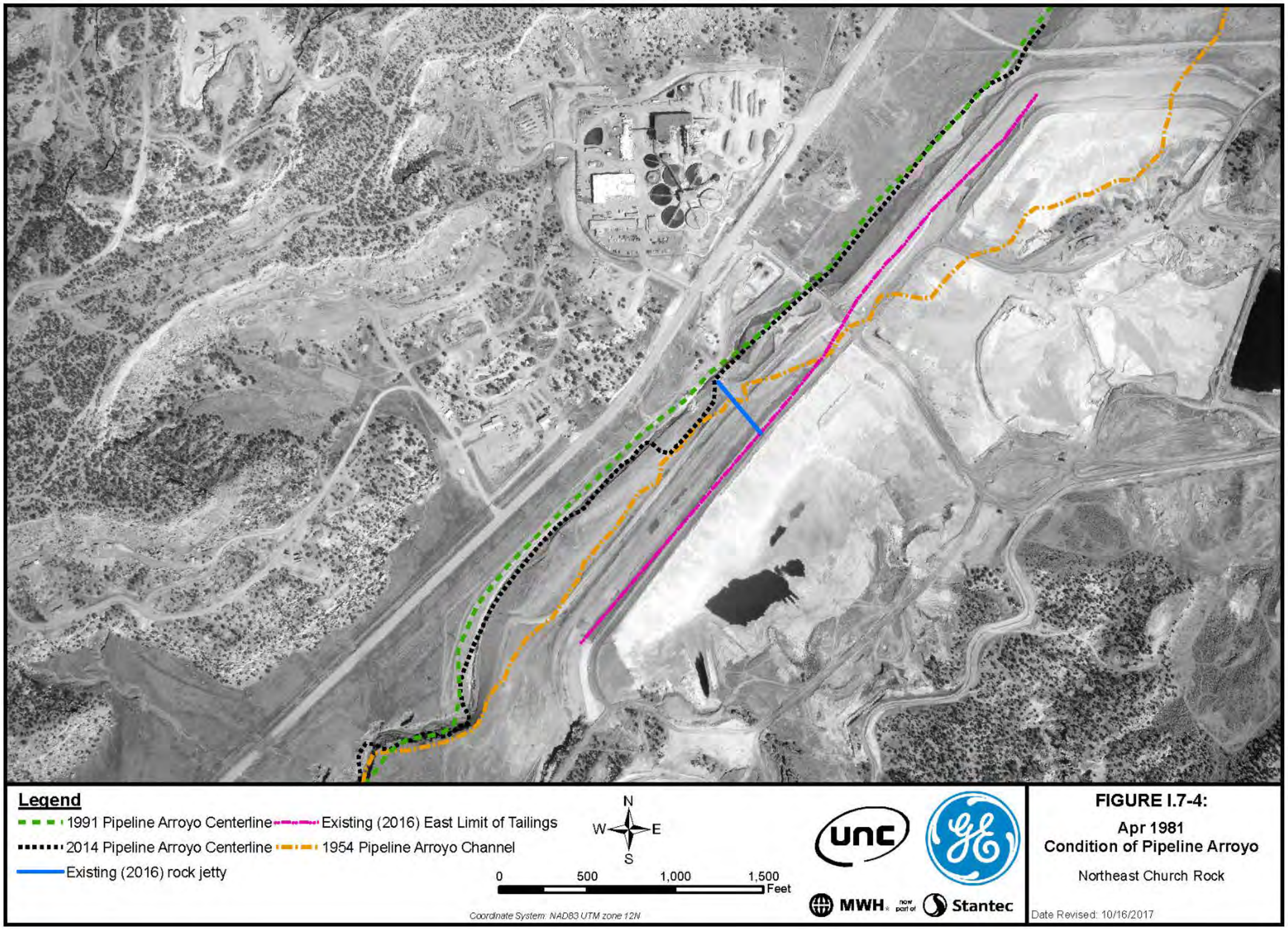

Figure I.7-4: Pipeline Arroyo April 1981

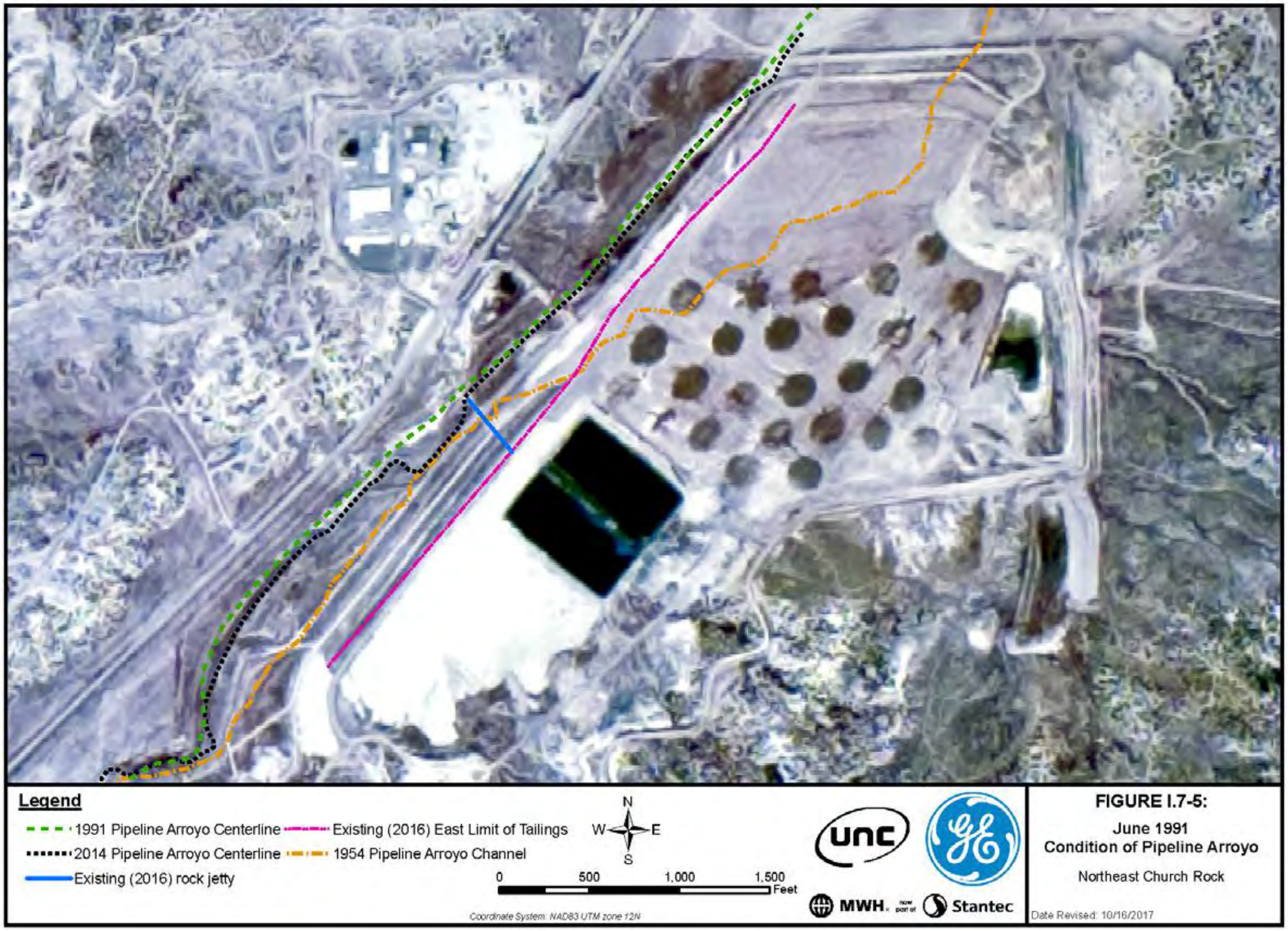

Figure I.7-5: Pipeline Arroyo June 1991

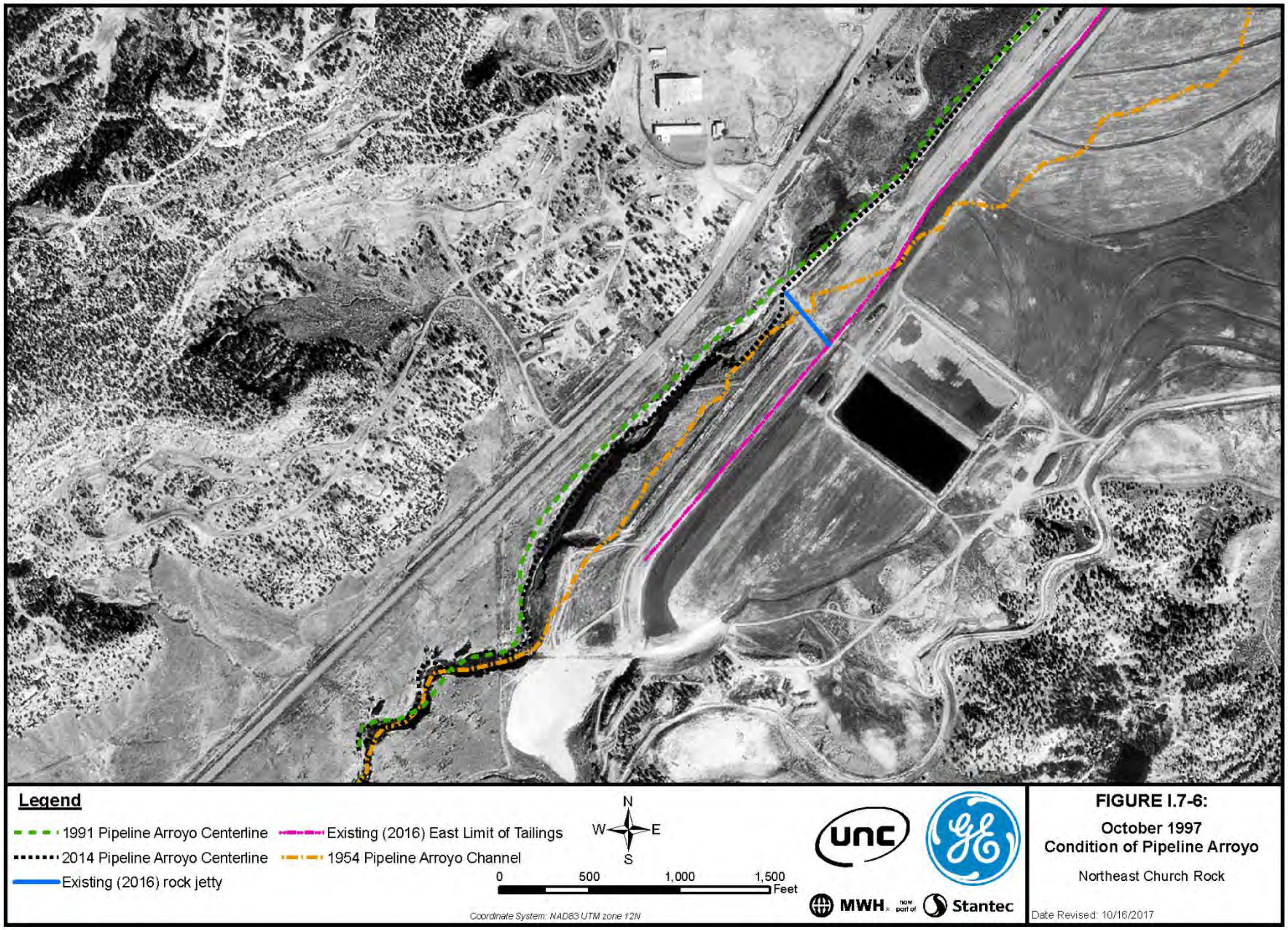

Figure I.7-6: Pipeline Arroyo October 1997

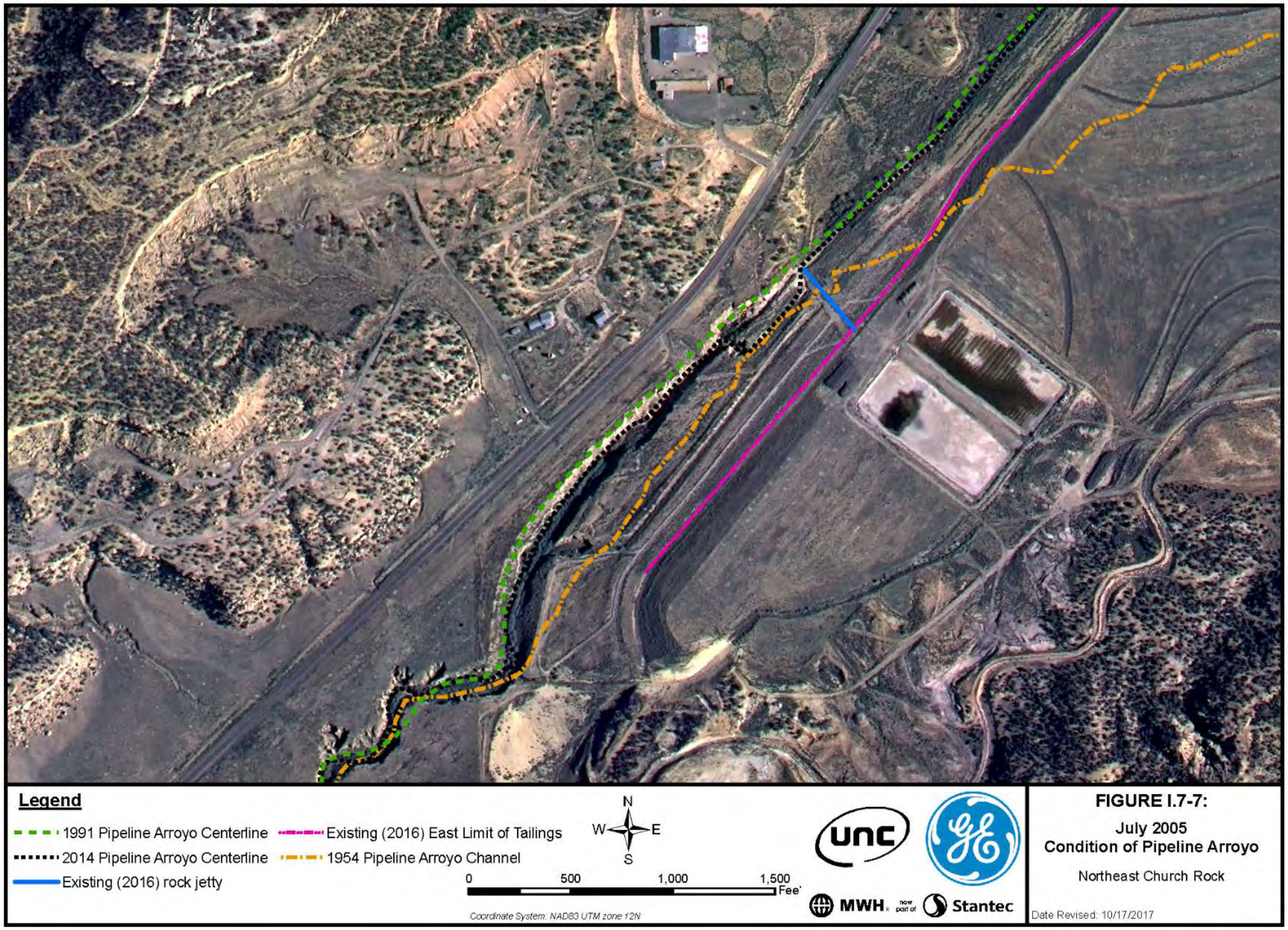

Figure I.7-7: Pipeline Arroyo July 2005

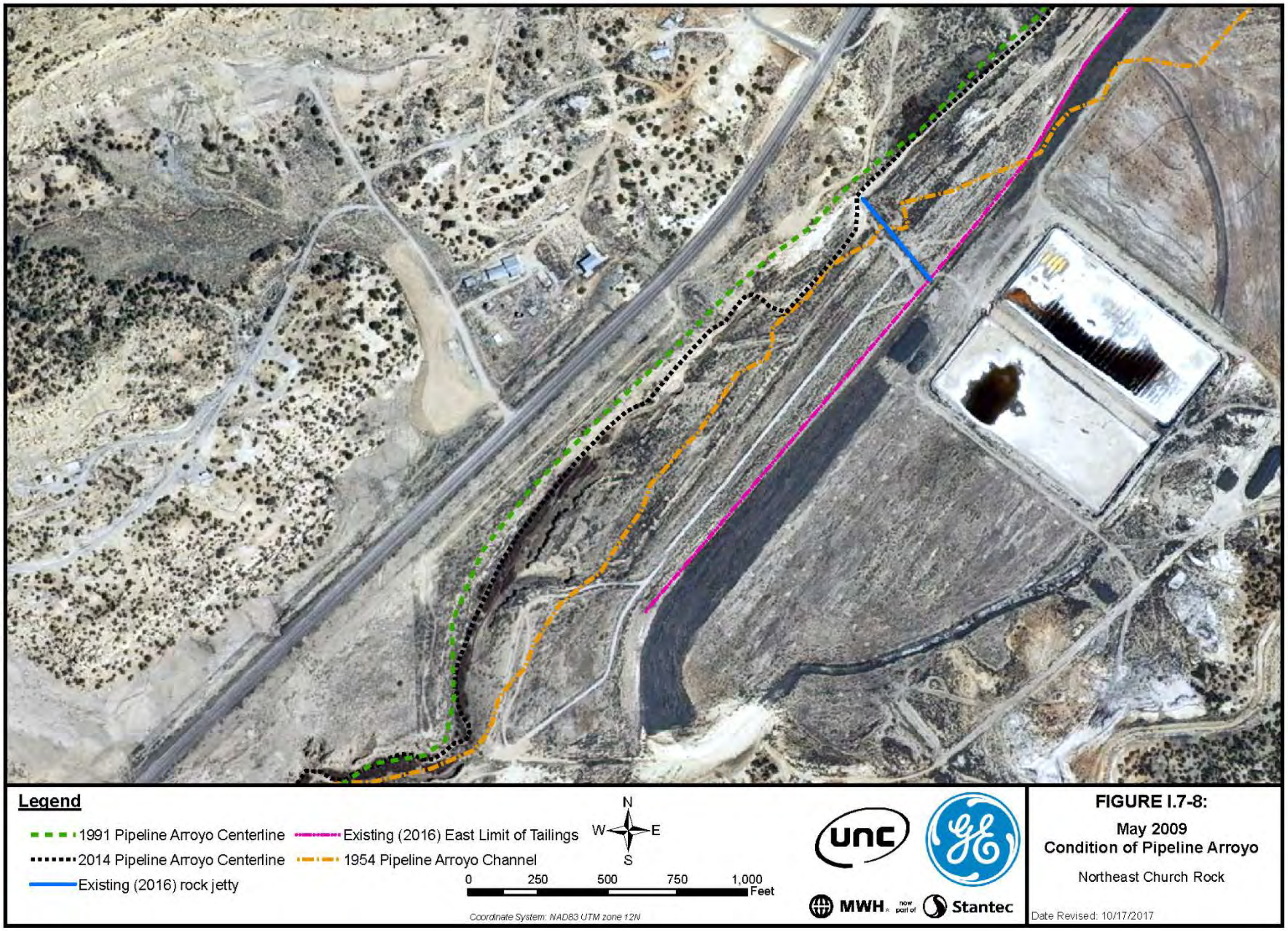

Figure I.7-8: Pipeline Arroyo May 2009

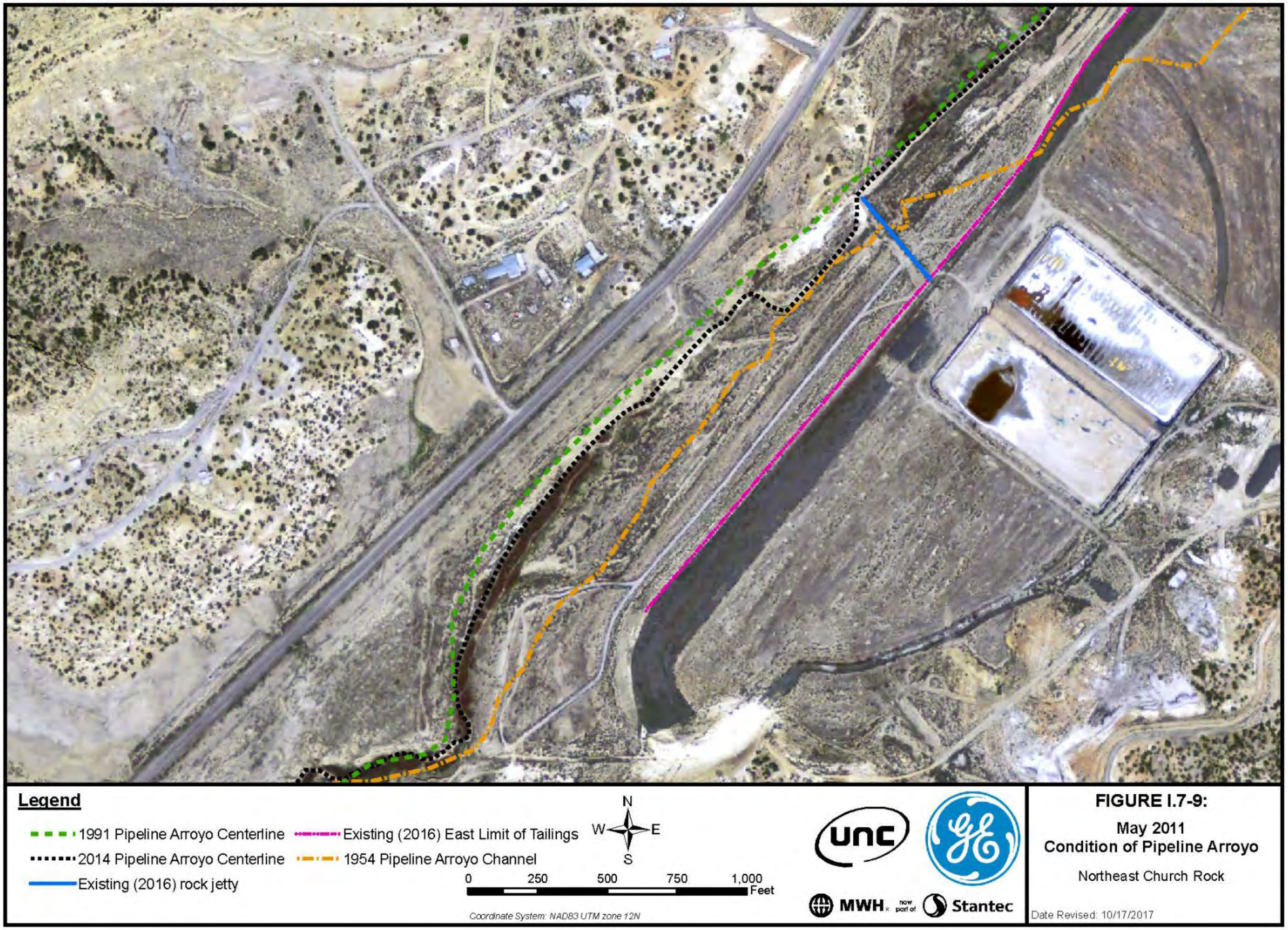

Figure I.7-9: Pipeline Arroyo May 2011

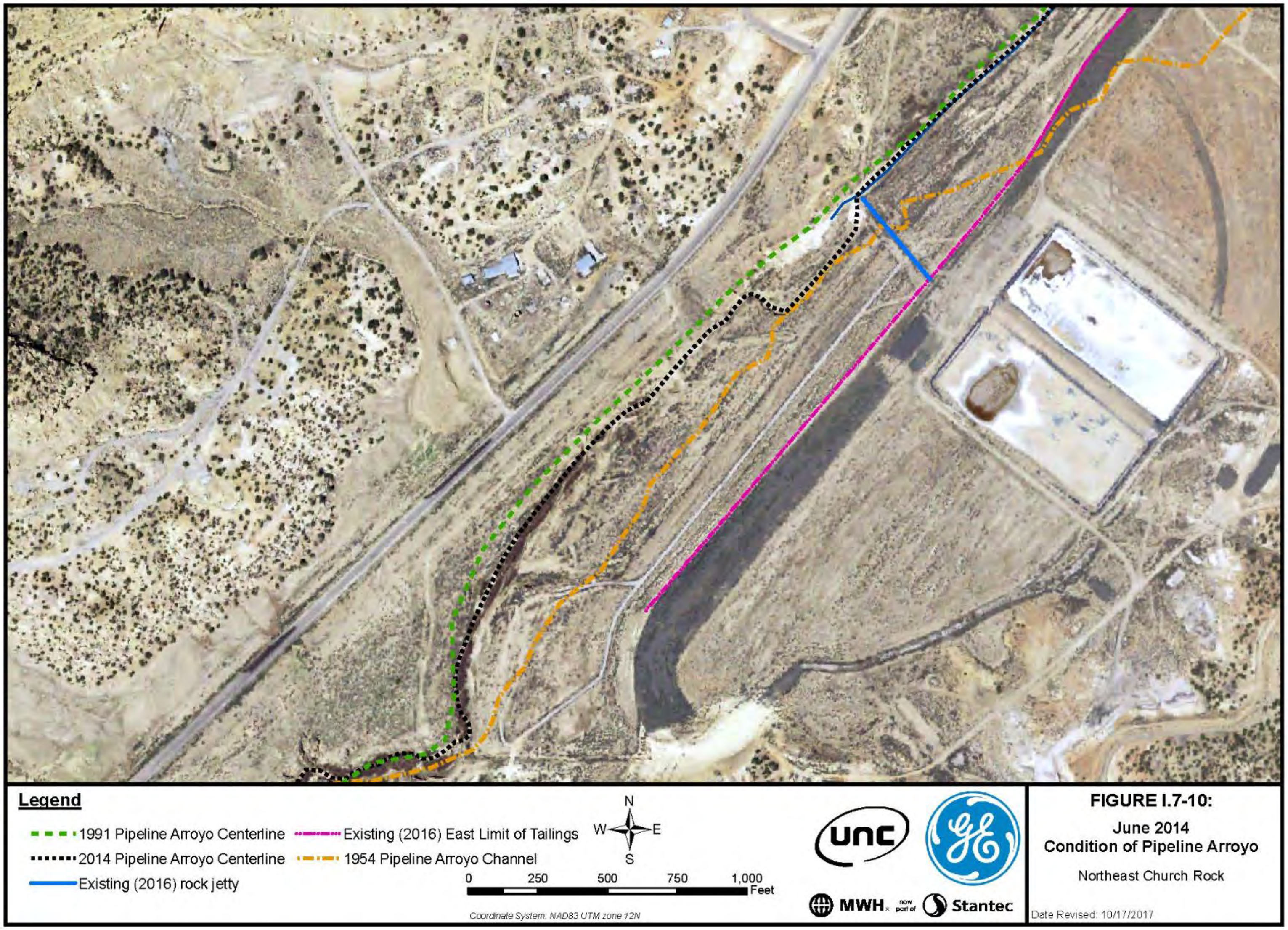

Figure I.7-10: Pipeline Arroyo June 2014

Figure I.7-11: Pipeline Arroyo in the Vicinity of the Rock Jetty

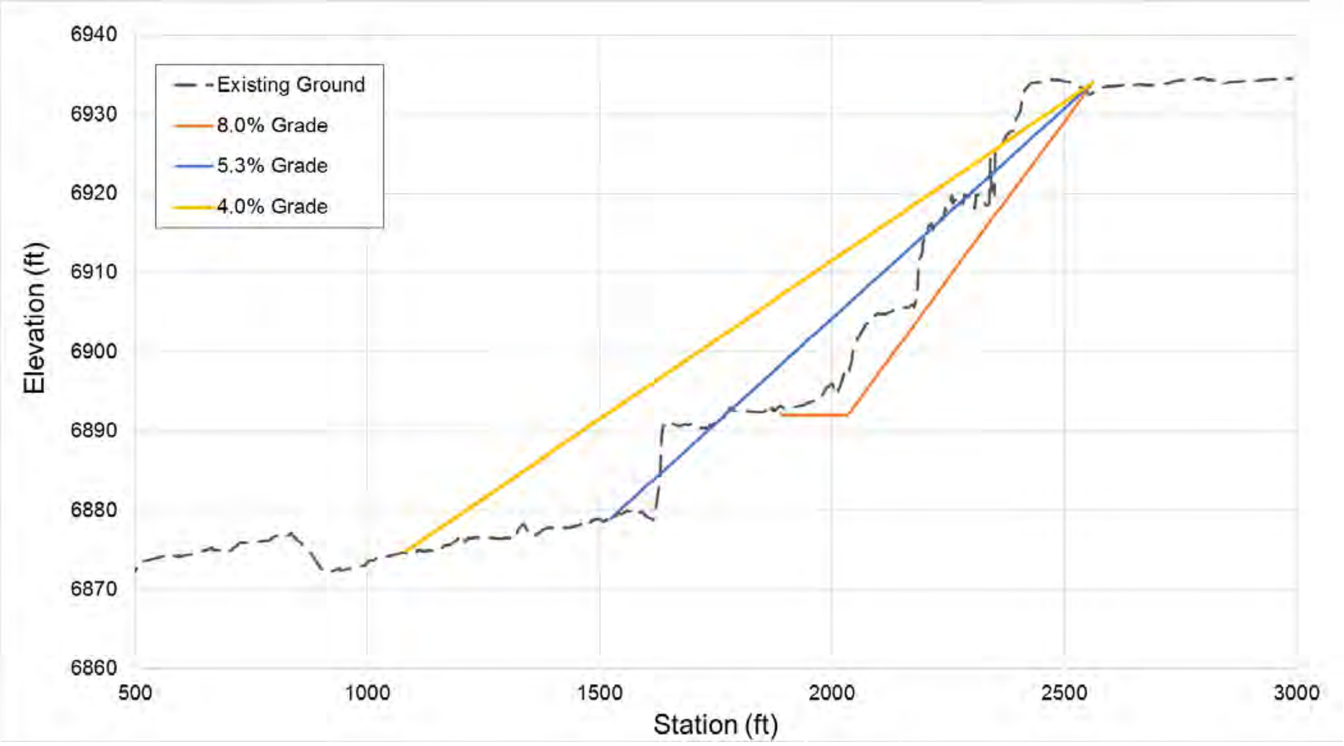

Figure I.7-12: Rock Jetty with Riprap Weir Alternatives (Profile Views)

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

Client:	*General Electric/United Nuclear Corporation*	**Sheet:** *1*	**of** *11*
Project:	*NECR 95% Design*	**Date:**	*09/16/2017*
Description:	*Estimation of Flood Flows For Design of Interim and Final Surface Water Controls for the Removal Action at the Northeast Church Rock Mine and Church Rock Mill Site*	**Job No:**	*10508639*

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*
1	*9/16/2017*	*95% Design*	*A. Edstrom*	*N. Haws*	*9/27/2017*

Revisions

Issue Date	Description
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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 4.2.1, build 28
- AutoCAD Civil 3D 2017
- ESRI ArcMAP 10.3.1
- Microsoft Excel 2013

Table of Contents

Objective

The objective of these calculations is to estimate flood flows used to produce hydraulic evaluations of design elements located within Appendix C, D, F, and I. These design elements include:

- The North Diversion Channel (see Appendix I.2)
- Various Mill Site Stormwater Controls (see Appendices I.3 and I.4)
- Stabilization alternatives for the Pipeline Arroyo in the vicinity of the Jetty and “nickpoint” (see Appendices I.5, and I.7)
- The Alluvial Fan area located north of the Mill Site (see Appendix I.6)
- Temporary stormwater management of the Mine Site during construction activity (see Appendix C)
- Temporary stormwater management around temporary haul roads (see Appendix D)
- Designs to evaluate and improve the Mine Site Outlet Channel (MSOC) and water entering Unnamed Arroyo No. 1 and the Pipeline Arroyo West Fork (see Appendix F)

A summary of these flow locations, their design purpose, and the corresponding calculation brief are also given in Table 1. The locations are shown on multiple figures including Figure 1 (Mill Site, Post-RA), Figure 2 (Pipeline Arroyo and Mine Site, Post-RA), and Figure 3 (Temporary Stormwater Control Points). In addition to the appendices referenced above, relevant engineering drawings are located in drawing sections 3, 6, and 9.

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 flows for lesser floods (2-year, 5-year, 10-year, 100-year, 200-year, 1,000-year, and 10,000-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 3 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.

Finally, stormwater controls for temporary support facilities, including temporary haul roads, were designed for the 10-year flood. These design elements include roadside ditches, culverts, and stormwater ponds shown in Attachment D.

Stantec developed five 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)
5. Haul Road Sub-Catchment Model for Construction Phases (Haul Road 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 4.2.1, build 28.

Watershed Delineations and Model Element Construction

Watershed delineations and the model element construction within HEC-HMS for the five hydrologic models are shown in Attachment A of this calculation brief. Subbasin delineations capture the major hydrologic features in each watershed while maintaining consistent subbasin sizes where possible.

Hyetograph Development

Frequency-Based Storms

Stantec developed the precipitation hyetographs for frequency-based storms using the center-peaking alternative block technique with the depth-duration frequency curves 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 2 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). 10,000-year rainfall depths are not given by NOAA and were extrapolated from the available data using Gumbel distributions for storm durations between 5-minutes and 1-day. 10,000-year storm depths are also presented in Table 2.

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

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

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 3 gives the fitting parameters for the IDF curve, and Figure 4 shows the analytical IDF curves with the PDFS depth-duration points.

Finally, Stantec constructed the alternating block hyetograph from the analytical IDF curves. Figure 5 shows cumulative hyetographs for different frequency-based storms. Fitting and rounding errors typically produced cumulative 24-hour rainfall depths greater than reported in the NOAA PDFS. As a result, the cumulative hyetographs were truncated at the 24-hour depth reported by NOAA.

Probable Maximum Precipitation Storm

Stantec 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 6).

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. Stantec 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, Stantec 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 7 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 8).

The PMP and frequency-based storm hyetographs are presented in Attachment B of this calculation brief.

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 of this calculation brief.

Depression Storage

Stantec 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). Stantec 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. For the Haul Road model, no depression storage was assumed.

Infiltration Losses

The hydrologic models use the Green and Ampt (1911) method to simulate losses due to infiltration. Stantec 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). Stantec 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 5 and the bare ground Ksat distribution for the Pipeline Arroyo Watershed is shown in Figure 9. Stantec compared these assigned values to measured values for similar New Mexico soils (Sabol et al., 1982a, 1982b) and found them consistent. Stantec assigned Ksat values for “Uranium Mined Lands” based on visual observations and previous site characterization reports (Canonie, 1991; MWH, 2014a and 2014b).

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

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

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

Stantec 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 (%)

Stantec approximated vegetation coverage using the 2011 National Land Cover Database (NLCD; see Homer et al., 2015) from the USDA-NRCS Geospatial Data Gateway website. Vegetation across the Pipeline Arroyo Watershed is shown on Figure 10.

Stantec 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 on Figure 11.

Stantec 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, Stantec set the vegetation percentage to zero for areas selected for soil removal during the RA. Stantec specified a 25 percent vegetation cover for the watersheds located on the TDA and just outside of the TDA.

Stantec used the relationship shown on Figure 12 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.

<u>Time of Concentration</u>

Tc values were estimated using two different methods: (1) the empirically based Sabol (1993) Tc equation, and (2) the velocity-based method (McCuen et al., 2002). These approaches are described in following sections, and worksheets for the calculation of the Tc and R values are provided in Attachment D of this calculation brief. Stantec used two different Tc methods because each method is more appropriate for different types of catchments. The Sabol (1993) time of concentration method is more appropriate for native catchments. The velocity-based time of concentration method (McCuen et al., 2002) is more appropriate for catchments with drainage dominated by engineered channels or where engineered practices have modified runoff slopes (i.e., the catchments containing the lower Mine Site and the tailings repository).

As presented below, the Sabol Tc method produces a Tc value that is constant for all storms; whereas, the velocity-based method produces a Tc that varies with the peak storm intensity. Also note that, that Tc is an input to calculating R. Therefore, for the velocity-based method, Tc and R both vary with the design storm intensity.

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

Stantec 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 6.

The sheet flow calculation uses iterative computations to solve for storm intensity and the sheet flow travel time. Stantec related storm intensities to travel time using the analytical IDF relationships developed for frequency-based storms. Stantec 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)

Stantec estimated values for L_{sc} and S from the available site topography and then computed the shallow concentrated flow coefficient, k, using McCuen (2002, Table 2.2). The values selected for hydrologic analysis are shown in Table 7.

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 8.

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).

Clark Unit Hydrograph Storage Coefficient (R Parameter)

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 described in Attachment I.2. Routing parameters for the Pipeline Arroyo watershed model, Mill Site model, and Mine Site model are listed in Attachment E of this calculation brief.

Reservoir Routing

The models route stormwater through the Mine Site ponds (for the Mine Site model) using the Modified Puls (level-pool) routing method. Stantec 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 of this calculation brief. 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 9 shows how overflows were simulated in HEC-HMS. Stantec 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 9.

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 locations shown on Figures 1, 2, and 3 are listed in Table 10. Tables in Attachment G list runoff drainage areas, peak flows, and total runoff volumes for all model elements shown in Attachment A.

Conclusions

Results shown in Table 10 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

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TABLES

Table 1: Flow Calculation Points and Design Purposes

Flow Calculation Locations	Design/Evaluation Element Purpose	Corresponding Calculation Brief
Pipeline Arroyo at the location of the “nickpoint” rock outcrop and upstream of the tailings disposal area (TDA) after removal action (RA) is complete (post-RA conditions).	Design of riprap chute for Pipeline Arroyo Stabilization	Attachments I.7, I.8
Pipeline Arroyo above the TDA	Hydraulic simulations for the Upper Pipeline Arroyo	Attachment I.6
North Diversion Channel at locations in the south and east reaches	North Diversion Channel	Attachment I.5
Several locations within the existing and proposed repository channels and tributary channels (Swale B and proposed Dilco Hill channels), and the Runoff Control Ditch under post-RA conditions.	Repository drainage channels	Attachments I.2, I.3, I.4
In the engineered channel protecting the unnamed arroyo at the outfall of the Mine Site under post-RA conditions.	Mine Site Outlet Channel	Attachment F.1
Various locations within the NECR Mine Site relevant to stormwater controls during implementation of the RA (during construction).	Stormwater controls for Mine Site removal construction phasing.	Appendix C
Various locations along the temporary haul road route and construction support facilities	Stormwater controls for haul roads and construction support facilities	Attachment D.1

Table 2: NOAA PDFS Depth-Duration Values for 2-; 5-; 10-; 100-; 200-; 1,000-; and 10,000-year Return Interval Storms

Duration (Minute)	Depth (inches)						
	2-year storm	5-year storm	10-year storm	100-year storm	200-year storm	1,000-year storm	10,000-year storm[1]
5	0.21	0.3	0.37	0.61	0.69	0.89	1.21
10	0.31	0.46	0.56	0.92	1.04	1.36	1.86
15	0.39	0.57	0.69	1.14	1.29	1.69	2.31
30	0.52	0.76	0.93	1.54	1.75	2.27	3.09
60	0.65	0.94	1.15	1.91	2.16	2.81	3.84
120	0.77	1.11	1.36	2.28	2.60	3.44	4.82
180	0.83	1.17	1.42	2.35	2.67	3.52	4.93
300	0.95	1.31	1.57	2.50	2.81	3.63	4.92
720	1.10	1.5	1.77	2.69	3.00	3.82	5.05
1440	1.17	1.6	1.91	2.99	3.34	4.21	5.54

1. 10,000-year values were extrapolated from Gumbel distributions of 2- to 1000-year storms for each storm duration.

Table 3: Fitting Parameters for the 2-, 5-, 100-, 200-, 1000-, and 10000-year Return Interval Storms

Storm	c	e	f
2-year, 24-hour	22.77	0.831	5.26
5-year, 24-hour	42.23	0.884	7.59
10-year, 24-hour	47.37	0.867	6.65
100-year, 24-hour	78.29	0.867	6.70
200-year, 24-hour	88.53	0.867	6.70
1,000-year, 24-hour	124.15	0.880	7.53
10,000-year, 24-hour	171.00	0.880	7.69

Table 4: 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 5: Assigned Bare Ground Saturated Hydraulic Conductivity Values

Name	MUKEY[1]	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>

1. MUKEY (map unit key): ID number used to define unique soils in the NRCS SSURGO Database.

Table 6: 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 7: 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 8: 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 9: 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 10: Simulated Peak Flows at Locations of Interest for the Remedial Design

Report Appendix	Design Element	Watershed Model	HEC-HMS Element	Design Event	Peak Flow (cfs)
I.2	East Repository Channel STA 00+00 to 18+50	Mill Site (Post-RA)	06	PMF; 1hr PMP	98
I.2	East Repository Channel STA 18+50 to 28+30	Mill Site (Post-RA)	J-SCds	PMF; 1hr PMP	140
I.2	East Repository Channel STA 28+30 to 34+60	Mill Site (Post-RA)	J-RC04ds	PMF; 1hr PMP	228
I.2	East Repository Channel STA 34+60 to 41+39	Mill Site (Post-RA)	J-RC03ds	PMF; 1hr PMP	274
I.2	Dilco Hill Channel A	Mill Site (Post-RA)	02	PMF; 1hr PMP	14
I.2	Dilco Hill Channel B	Mill Site (Post-RA)	01	PMF; 1hr PMP	8.5
I.2	Branch Swale H	Pipeline Arroyo (Post-RA)	44	PMF; 1hr PMP	120
I.2	Runoff Control Ditch	Mill Site (Post-RA)	05	PMF; 1hr PMP	143
I.2	North Cell Drainage Channel	Mill Site (Post-RA)	J-RC01ds	PMF; 1hr PMP	361
I.4	East Repository Channel STA 34+60 to 41+39	Mill Site (Post-RA)	J-RC03ds	10yr	22.11
I.4	East Repository Channel STA 34+60 to 41+39	Mill Site (Post-RA)	J-RC03ds	2yr	3.92
I.4	Dilco Hill Channel A	Mill Site (Post-RA)	02	10yr	1.297
I.4	Dilco Hill Channel A	Mill Site (Post-RA)	02	2yr	0.088
I.4	Dilco Hill Channel B	Mill Site (Post-RA)	01	10yr	0.591
I.4	Dilco Hill Channel B	Mill Site (Post-RA)	01	2yr	0.030
I.5	North Diversion Channel - Lower	Mill Site (Post-RA)	J-ND02ds	PMF; 1hr PMP	2,861
I.5	North Diversion Channel - Middle	Mill Site (Post-RA)	J-ND02us	PMF; 1hr PMP	2,788
I.5	North Diversion Channel - Upper	Mill Site (Post-RA)	J-ND04us	PMF; 1hr PMP	982
I.6	Northern Flow into Alluvial Fan Area	Pipeline Arroyo (Post-RA)	J-R12us	PMF; 1hr PMP	25,704
I.6	Northern Flow into Alluvial Fan Area	Pipeline Arroyo (Post-RA)	J-R12us	100yr	4612

Report Appendix	Design Element	Watershed Model	HEC-HMS Element	Design Event	Peak Flow (cfs)
I.6	Northern Flow into Alluvial Fan Area	Pipeline Arroyo (Post-RA)	J-R12us	5yr	261
I.6	Eastern Flow into Alluvial Fan Area	Pipeline Arroyo (Post-RA)	J-R11us	PMF; 1hr PMP	2,616
I.6	Eastern Flow into Alluvial Fan Area	Pipeline Arroyo (Post-RA)	J-R11us	100yr	622
I.6	Eastern Flow into Alluvial Fan Area	Pipeline Arroyo (Post-RA)	J-R11us	5yr	46
I.7	Pipeline Arroyo	Pipeline Arroyo (Post-RA)	Outlet/R15ds	PMF; 1hr PMP	27,502
I.7	Pipeline Arroyo	Pipeline Arroyo (Post-RA)	Outlet/R15ds	10000yr	17,401
I.7	Pipeline Arroyo	Pipeline Arroyo (Post-RA)	Outlet/R15ds	1000yr	10,425
I.7	Pipeline Arroyo	Pipeline Arroyo (Post-RA)	Outlet/R15ds	200yr	6,397
I.7	Pipeline Arroyo	Pipeline Arroyo (Post-RA)	Outlet/R15ds	100yr	4,932
I.7	Pipeline Arroyo	Pipeline Arroyo (Post-RA)	Outlet/R15ds	5yr	298
I.7	Pipeline Arroyo	Pipeline (Existing)	Outlet/R15ds	PMF; 1hr PMP	26,764
I.7	Pipeline Arroyo	Pipeline (Existing)	Outlet/R15ds	100yr	4,766
I.7	Pipeline Arroyo	Pipeline (Existing)	Outlet/R15ds	2yr	3.22
C	Diversion Berm Upstream of Pond 3, RA-Phase 3	Mine Site (Construction Phase 3)	R-J3ds/Berm1	2yr	0
C	Diversion Berm Near Haul Road, RA-Phase 3	Mine Site (Construction Phase 3)	J-Berm2	2yr	0
C	Diversion Berm/Attenuation Pond Near Haul Road, RA-Phase 3	Mine Site (Construction Phase 3)	Const_Pond	2yr	0
C	Pond 3 Diversion Plug	Mine Site (Construction Phase 3)	R-J3ds/Berm1	2yr	0
D	Temporary Culvert 1	Haul Road	C01	10yr	13.2
D	Temporary Culvert 2	Haul Road	C02	10yr	52.4
D	Temporary Culvert 3	Haul Road	C03	10yr	2.9
D	Temporary Culvert 4	Haul Road	C04	10yr	5.3

Report Appendix	Design Element	Watershed Model	HEC-HMS Element	Design Event	Peak Flow (cfs)
D	Temporary Culvert 5	Haul Road	C05	10yr	8.2
D	Temporary Culvert 6	Haul Road	C06	10yr	8.0
D	Temporary Culvert 7	Haul Road	C07	10yr	9.0
D	Temporary Culvert 8	Haul Road	C08	10yr	19.5
D	Temporary Culvert 9	Haul Road	C09	10yr	72.8
D	Temporary Culvert 10	Haul Road	C10	10yr	16.3
D	Temporary Culvert 11	Pipeline Arroyo (Post-RA)	J-R12ds	5yr	298
D	Temporary Culvert 12	Mill Site (Post-RA)	J-RC01ds	10yr	37.8
D	Temporary Culvert 13	Mill Site (Post-RA)	J-SCds	10yr	14.3
D	Temporary Culvert 14	Mill Site (Post-RA)	J-RC05ds	10yr	8.1
D	Temporary Culvert 15	Mill Site (Post-RA)	J-ND04us	10yr	45.5
D	Temporary Culvert 16	Mill Site (Post-RA)	J-RC03ds	10yr	26.2
D	Temporary Stormwater Pond 1	Haul Road	S01	10yr	9.7
D	Temporary Stormwater Pond 2	Haul Road	S02	10yr	5.6
D	Temporary Stormwater Pond 3	Haul Road	S03	10yr	3.1
D	Temporary Stormwater Pond 4	Haul Road	S04	10yr	2.4
D	Temporary Stormwater Pond 5	Haul Road	S05	10yr	2.7
D	Temporary Stormwater Pond 6	Haul Road	S06	10yr	3.0
D	Temporary Stormwater Pond 7	Haul Road	S07	10yr	7.7
D	Temporary Stormwater Pond 8	Haul Road	S08	10yr	3.5
D	Temporary Stormwater Pond 9	Haul Road	S09	10yr	4.5
D	Temporary Stormwater Pond 10	Haul Road	S10	10yr	2.1
D	Temporary Stormwater Pond 11	Haul Road	S11	10yr	3.6
F	Mine Outlet Channel	Pipeline Arroyo (Post-RA)	31	100yr	206

Report Appendix	Design Element	Watershed Model	HEC-HMS Element	Design Event	Peak Flow (cfs)
F	Flow into Pipeline Arroyo West Fork	Pipeline Arroyo (Post-RA)	J-R16ds	100yr	211

FIGURES

Legend

● Peak Flow Point of Interest

▭ Watershed Boundary

N
W E
S

0 250 500 1,000 Feet

Coordinate System:

FIGURE 1:
Permanent Stormwater Control Peak Flow Locations Mill Site - Post RA

Northeast Church Rock

Date Revised: 9/20/2017

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Legend

● Peak Flow Point of Interest

▭ Watershed Boundary

N
W E
S

0 1,250 2,500 5,000
Feet

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

unc

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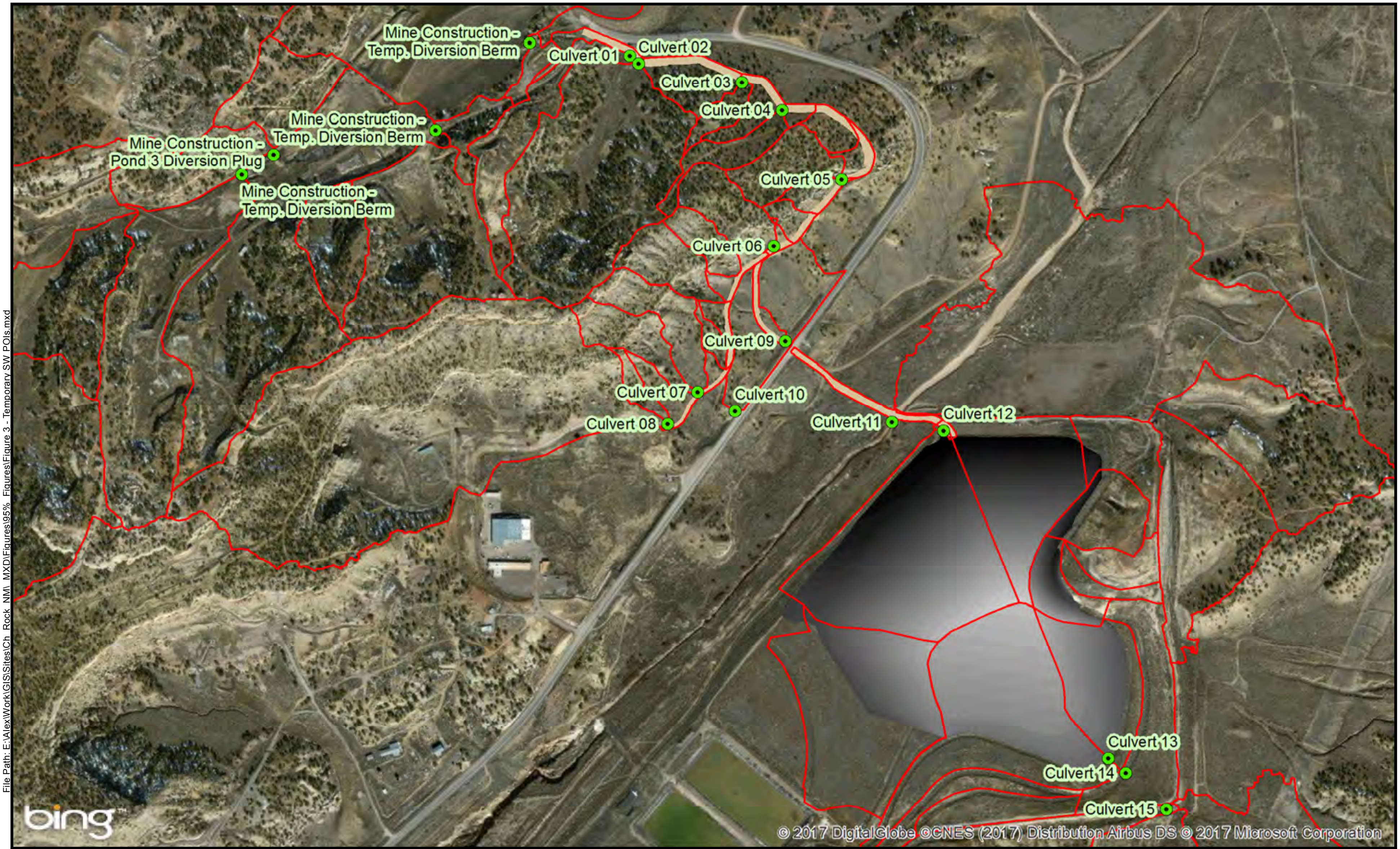
FIGURE 2:
Permanent Stormwater Controls Peak Flow Locations Mine Site and Pipeline Arroyo

Northeast Church Rock

Date Revised: 9/20/2017

File Path: E:\AlexWork\GIS\Sites\Ch Rock NM MXD\Figures\95% Figures\Figure 3 - Temporary SW POIs.mxd



Legend

●	Temporary Structure Flow Point
☐	Watershed Boundary
▨	Temporary Haul Road

N
W E
S

0 250 500 1,000
Feet

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

FIGURE 3:
Temporary Stormwater Controls Peak Flow Locations Mine Site and Haul Roads

Northeast Church Rock

Date Revised: 9/20/2017

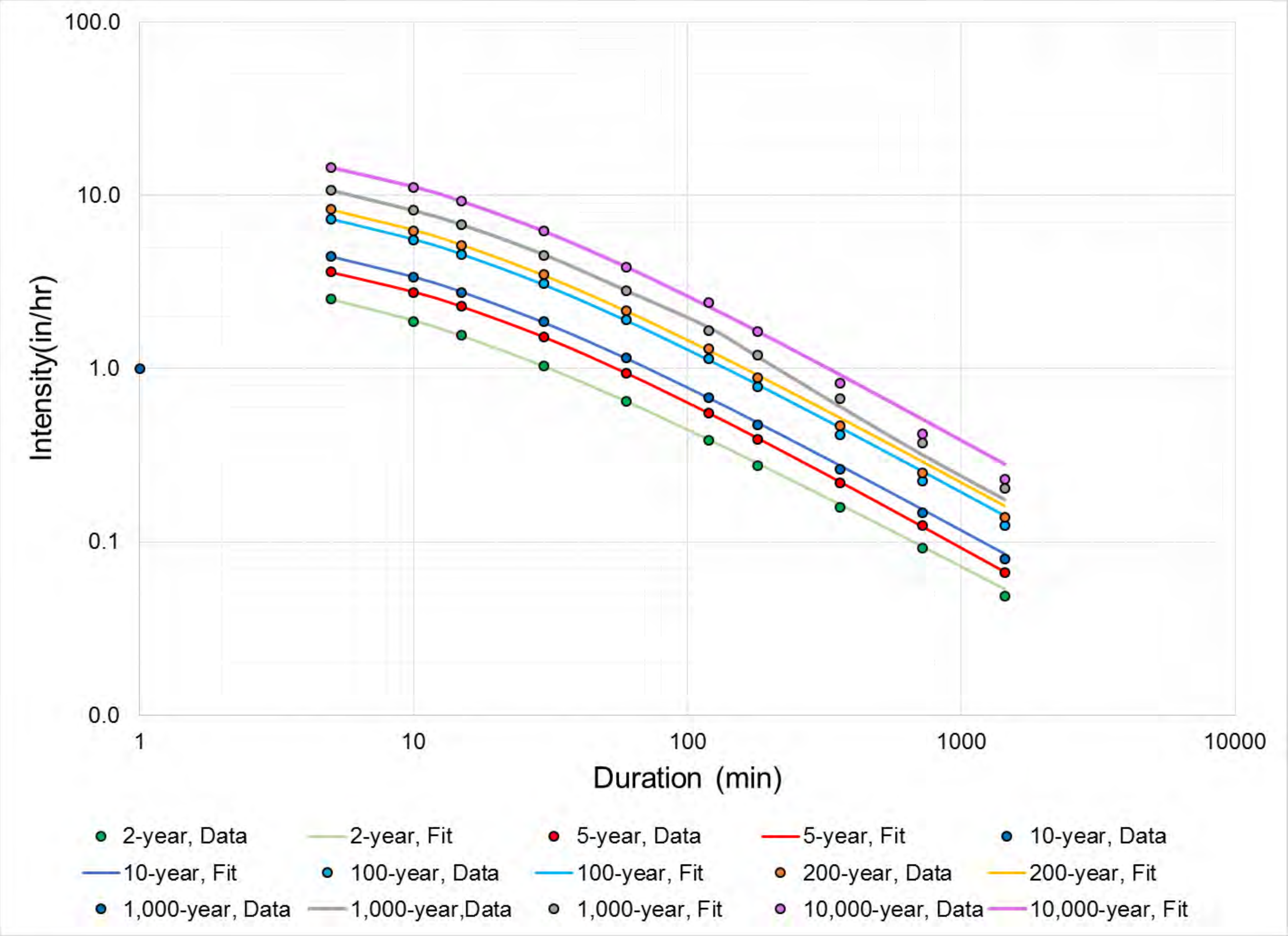


Figure 4: Analytical (fit) Depth-Duration-Frequency Curves Compared to NOAA PDFS Values for 10000-, 1000-, 200-, 100-, 5- and 2-Year Return Intervals

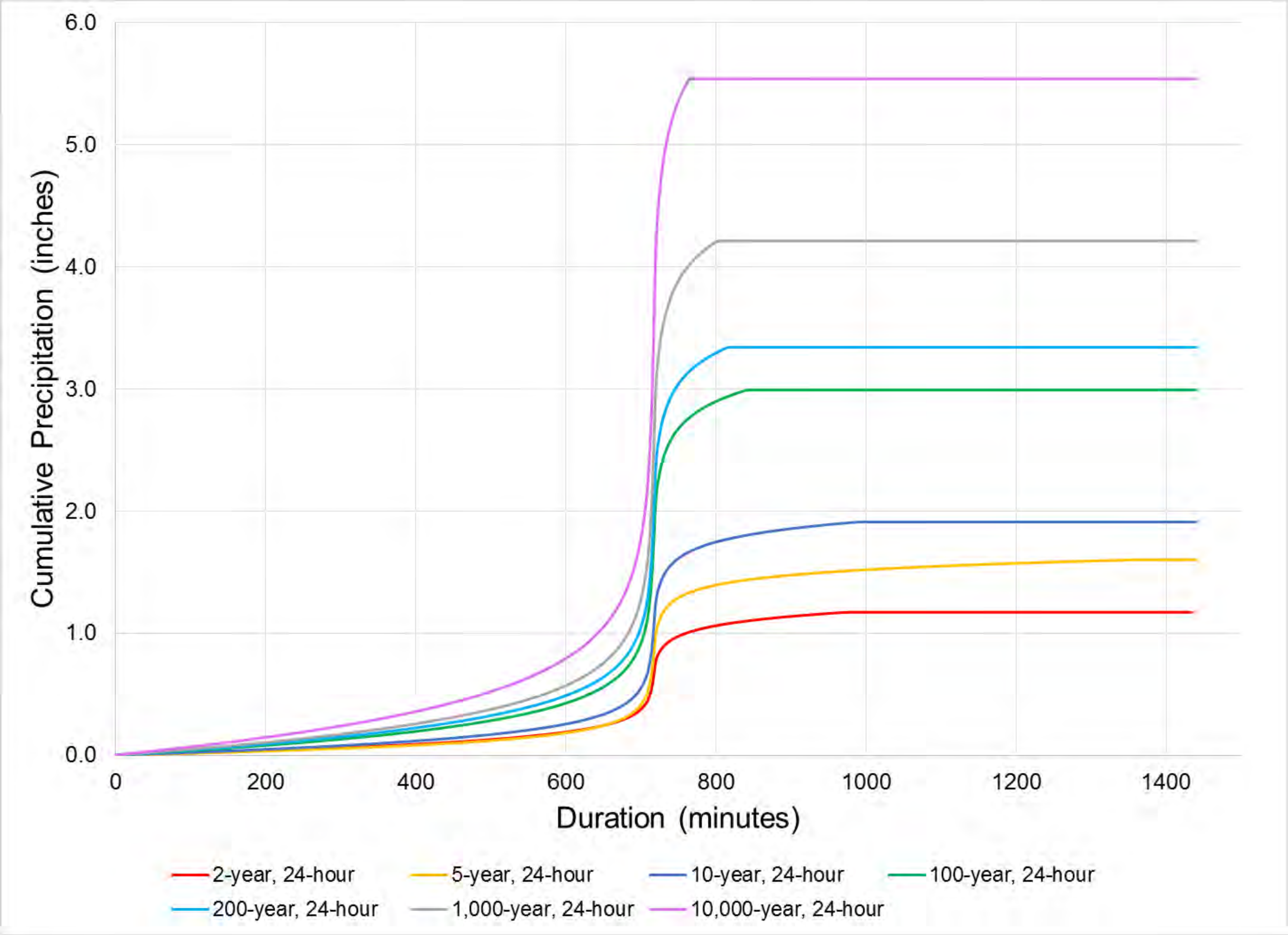


Figure 5: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 5- and 2-Year Storm Events

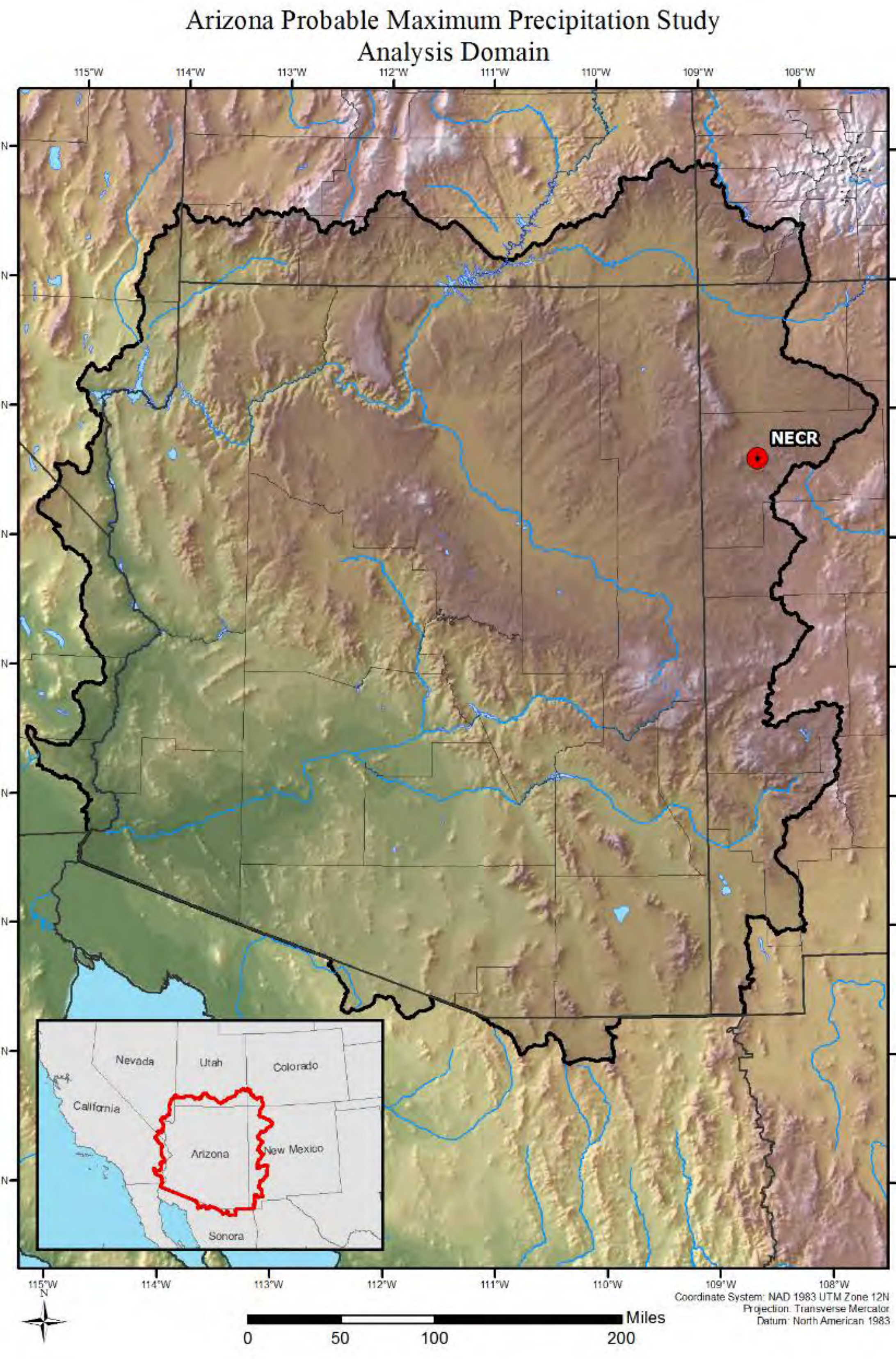


Figure 6: Location of Northeast Church Rock mine in Relation to the Arizona PMP Study Domain

(Source: Applied Weather Associates)

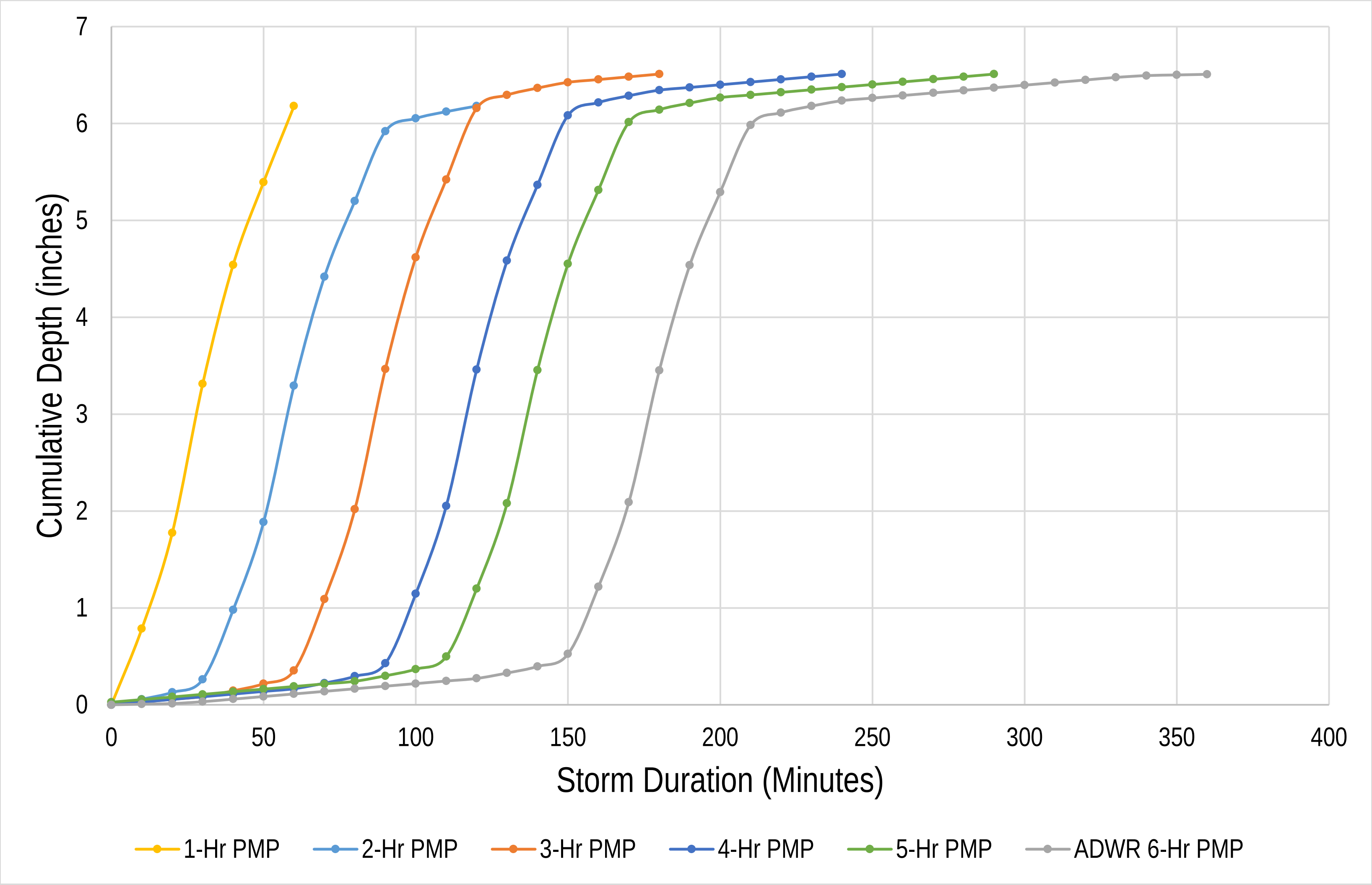


Figure 7: PMP storms for Durations of 1-Hour to 6-Hour PMP for the Pipeline Arroyo Watershed

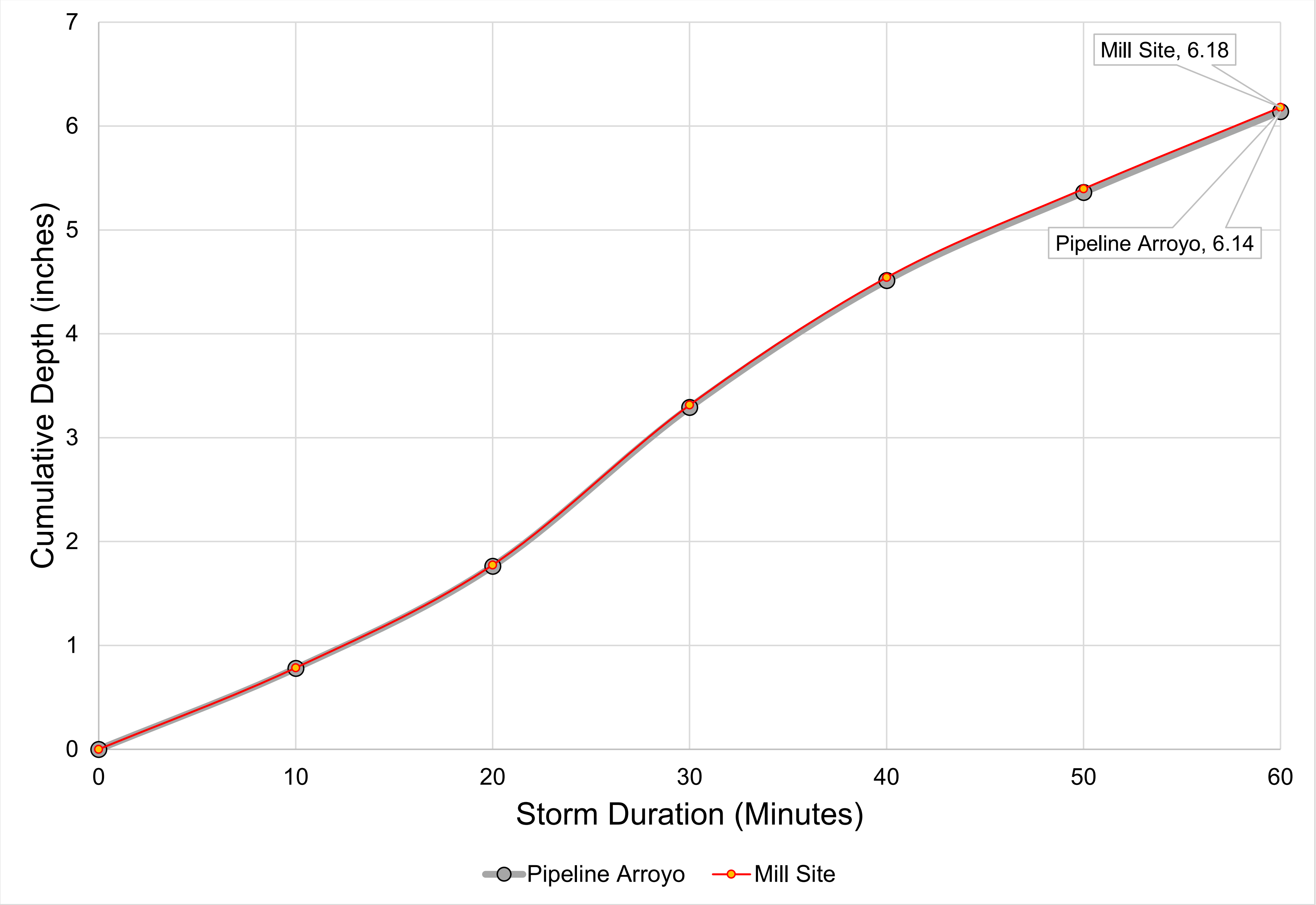


Figure 8: 1-Hour PMP Distributions for the Pipeline Arroyo and Mill Site PMFs

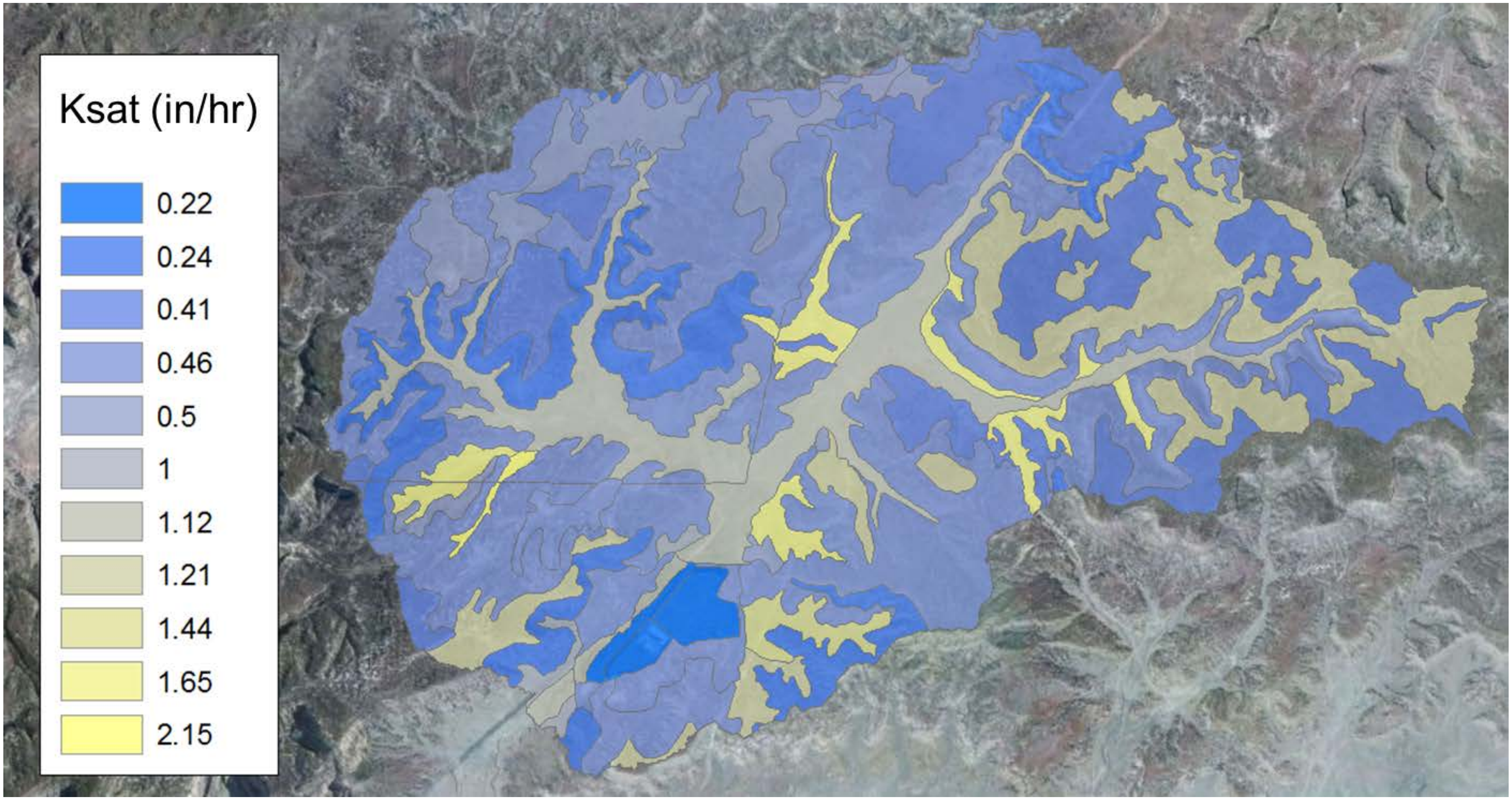


Figure 9: Bare Ground Saturated Hydraulic Conductivities

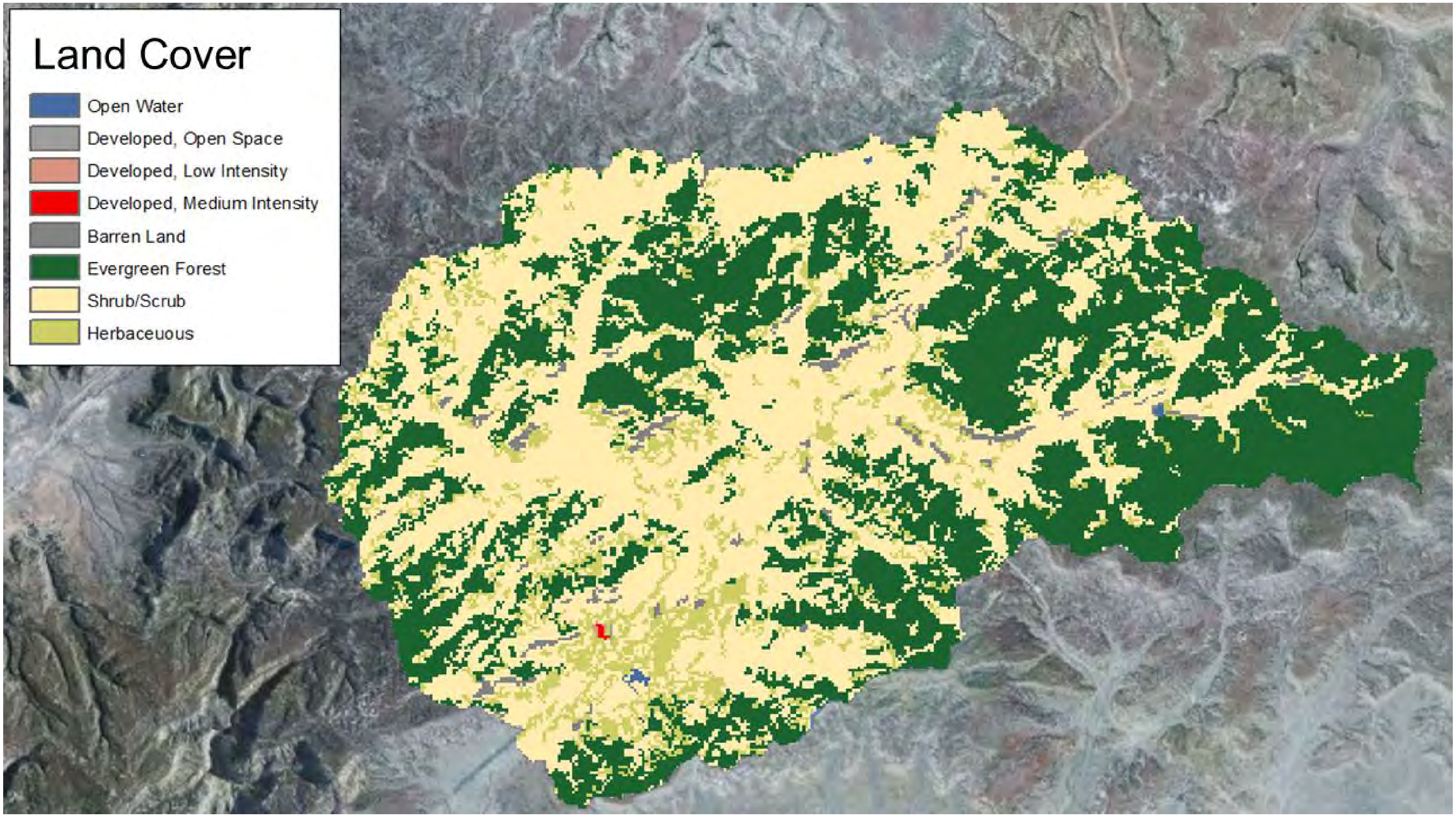


Figure 10: 2011 National Land Cover Database for the Pipeline Arroyo Watershed

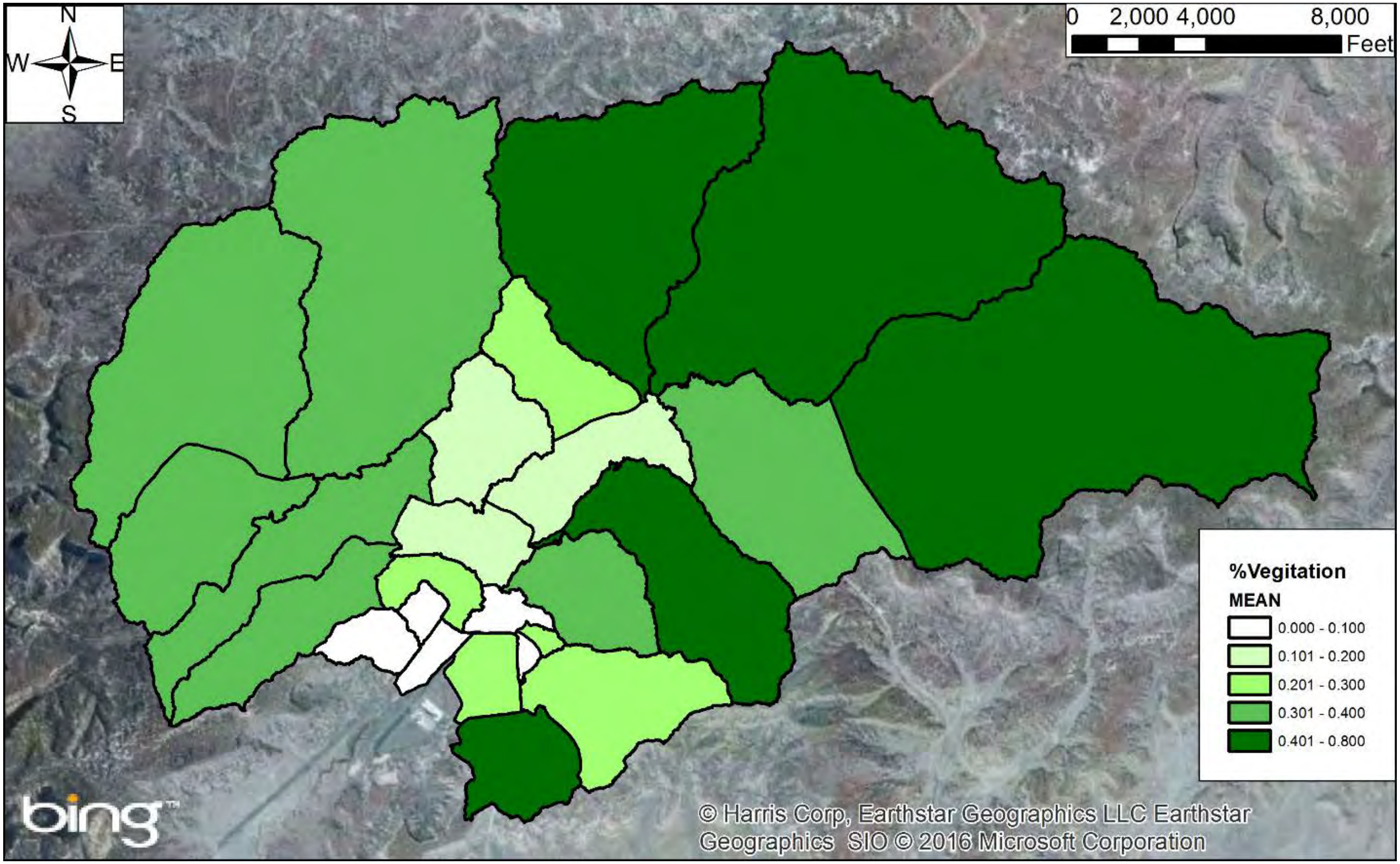


Figure 11: Percent Vegetation Coverage for the Existing Pipeline Arroyo Watersheds

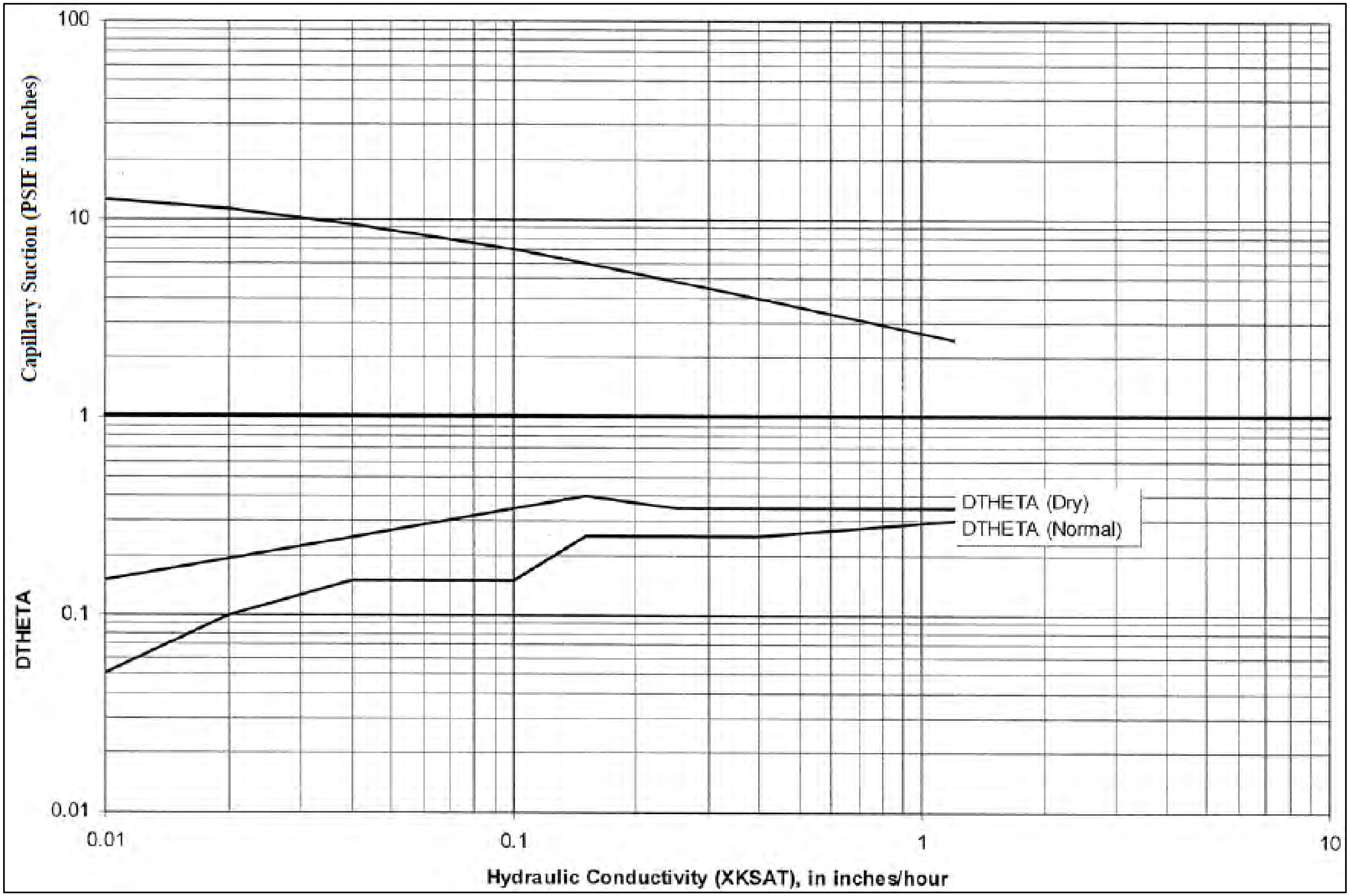


Figure 12: Relationship between Saturated Hydraulic Conductivity, Soil Moisture Deficit, and Soil Suction (from ADWR, 2007)

ATTACHMENT A

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

Table A1: 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 A2: 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	0.153653
31	0.481541
37	0.023734
38	0.025865
39	0.086768
42	0.359253
43	0.990445
44	0.030964

Table A3: 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	0.037054
6	0.032685
7	0.013431
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	0.030964

Table A4: 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
26	0.026925
27	0.037482
28	0.010058
29	0.054403
30	0.026967

Table A5: Watersheds to size Temporary Haul Road stormwater controls

Watershed ID	Area (mi^2)
00	0.001635
01a	0.010471
01b	0.041663
02	0.005170
03	0.002341
04	0.002793
05	0.004242
06	0731
07	0.002221
08	0.001523
09	0.006546
10	0.001925
11	0.001569
12	0461
13	0.006399
14	0.003524
15	0.001565
16	0.006073
17	0.001287
18	0.001197
19	0761
20	0.007287
21	0.005932
22	0.001686
23	0.002501
24	0.005872
25	0.001156
26	0.006506
27	0.001926
28	0.096676

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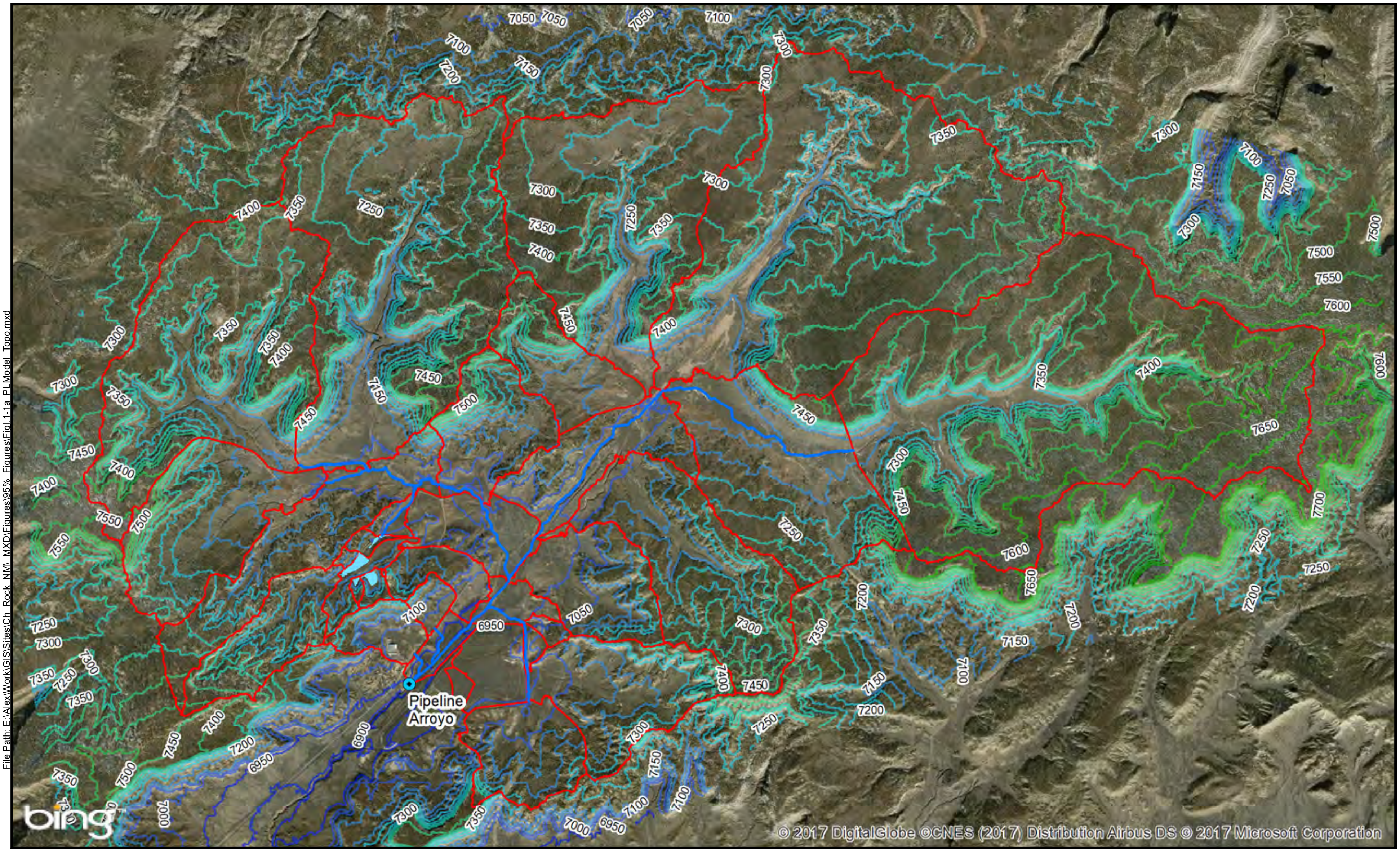

Legend

● Peak Flow Point of Interest	**Contours**		7100 - 7150	7400 - 7450
Flow Path	6850 - 6950		7200 - 7250	7500 - 7550
🟥 Watershed Boundary	7000 - 7050		7300 - 7350	7600 - 7750
Mine Pond				

N
W E
S

0 1,250 2,500 5,000
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: 9/20/2017

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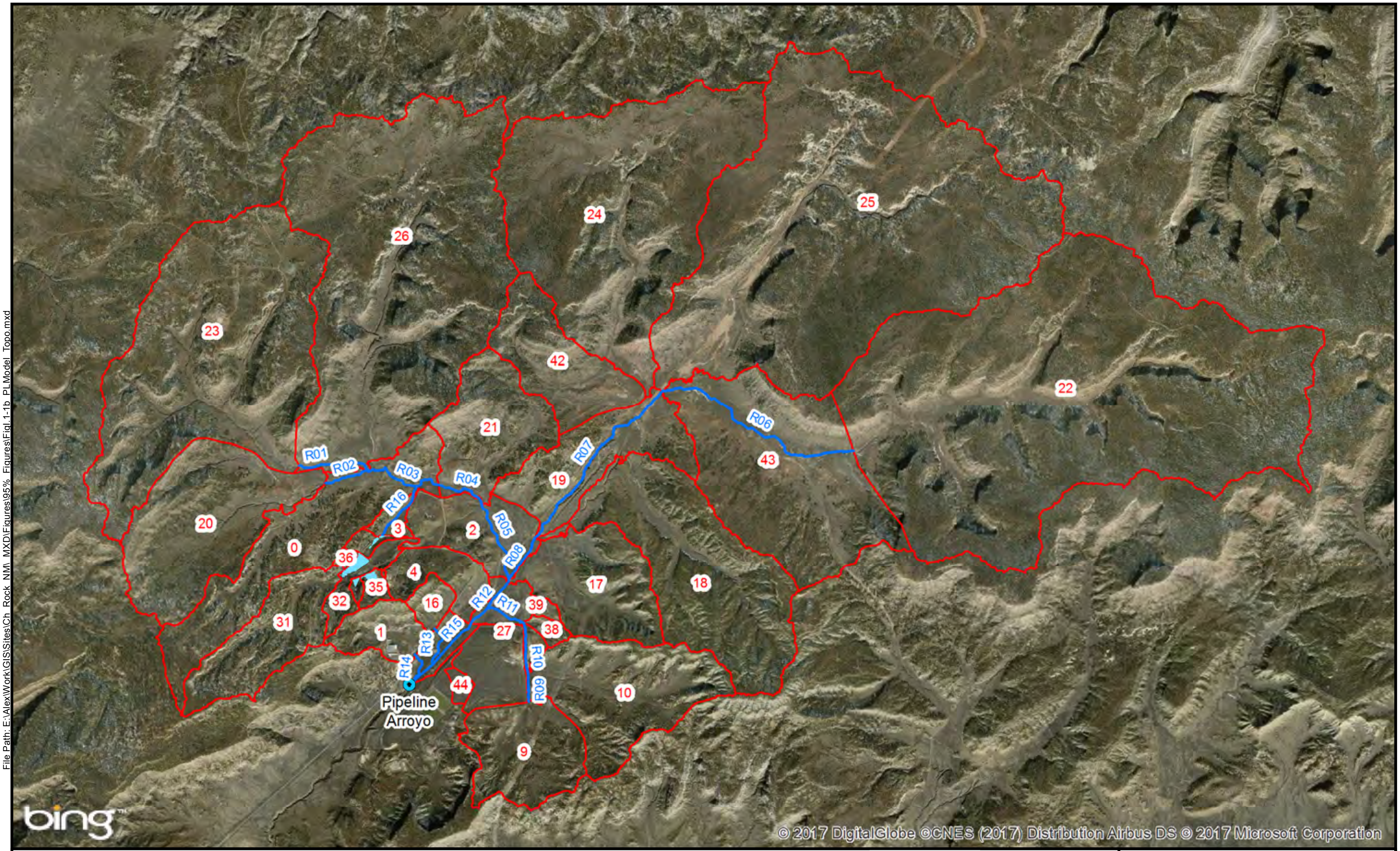

Legend

● Peak Flow Point of Interest

— Flow Path

☐ Watershed Boundary

🟦 Mine Pond

N
W E
S

0 1,250 2,500 5,000 Feet

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

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FIGURE I.1-1B:

Pipeline Arroyo Existing Condition Catchments

Northeast Church Rock

Date Revised: 9/20/2017

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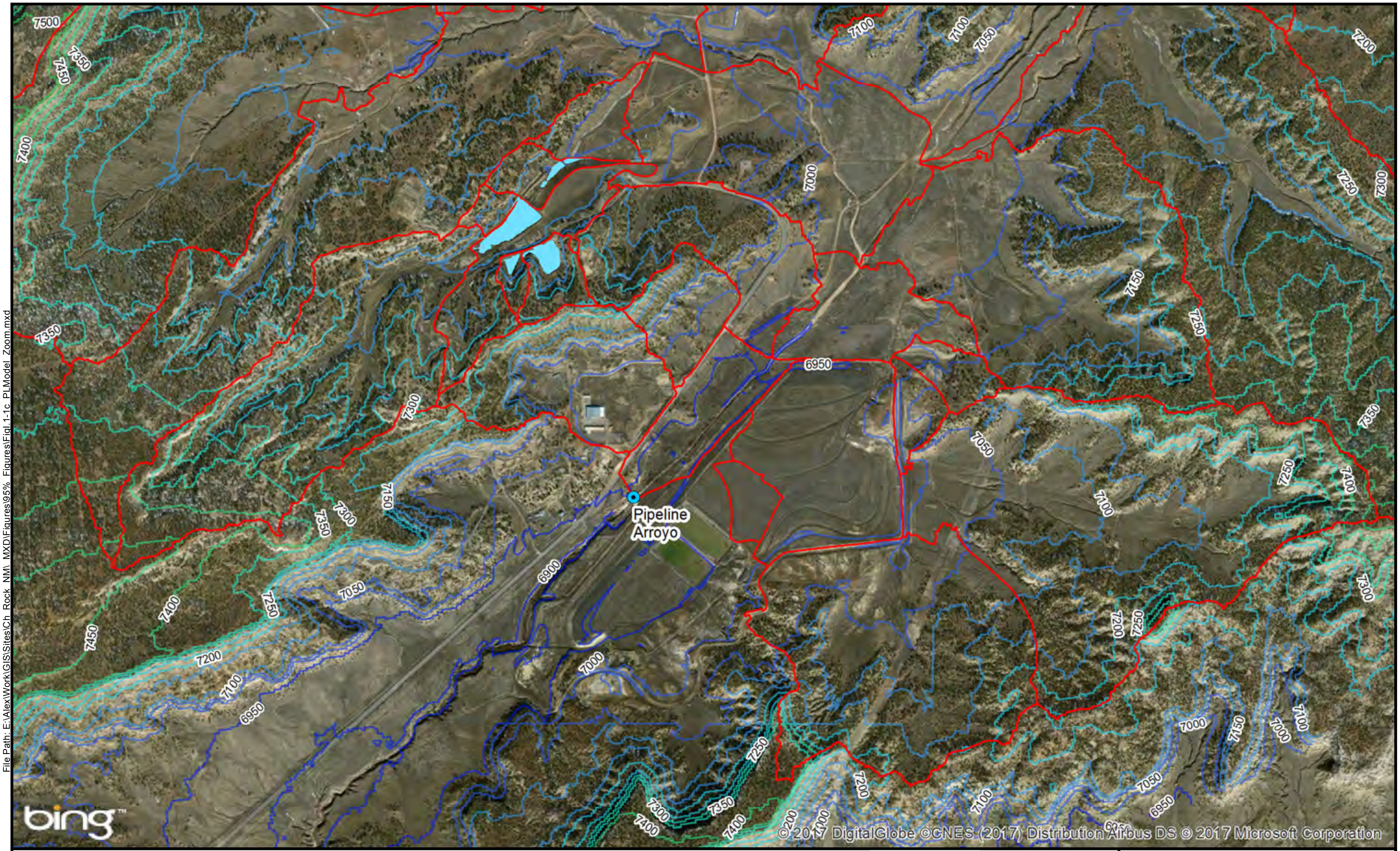

Legend

● Peak Flow Point of Interest

🟥 Watershed Boundary

🟦 Mine Pond

Contours

— 6850 - 6950	— 7100 - 7150	— 7400 - 7450
— 7000 - 7050	— 7200 - 7250	— 7500 - 7550
	— 7300 - 7350	— 7600 - 7750

N W E S

0 500 1,000 2,000 Feet

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

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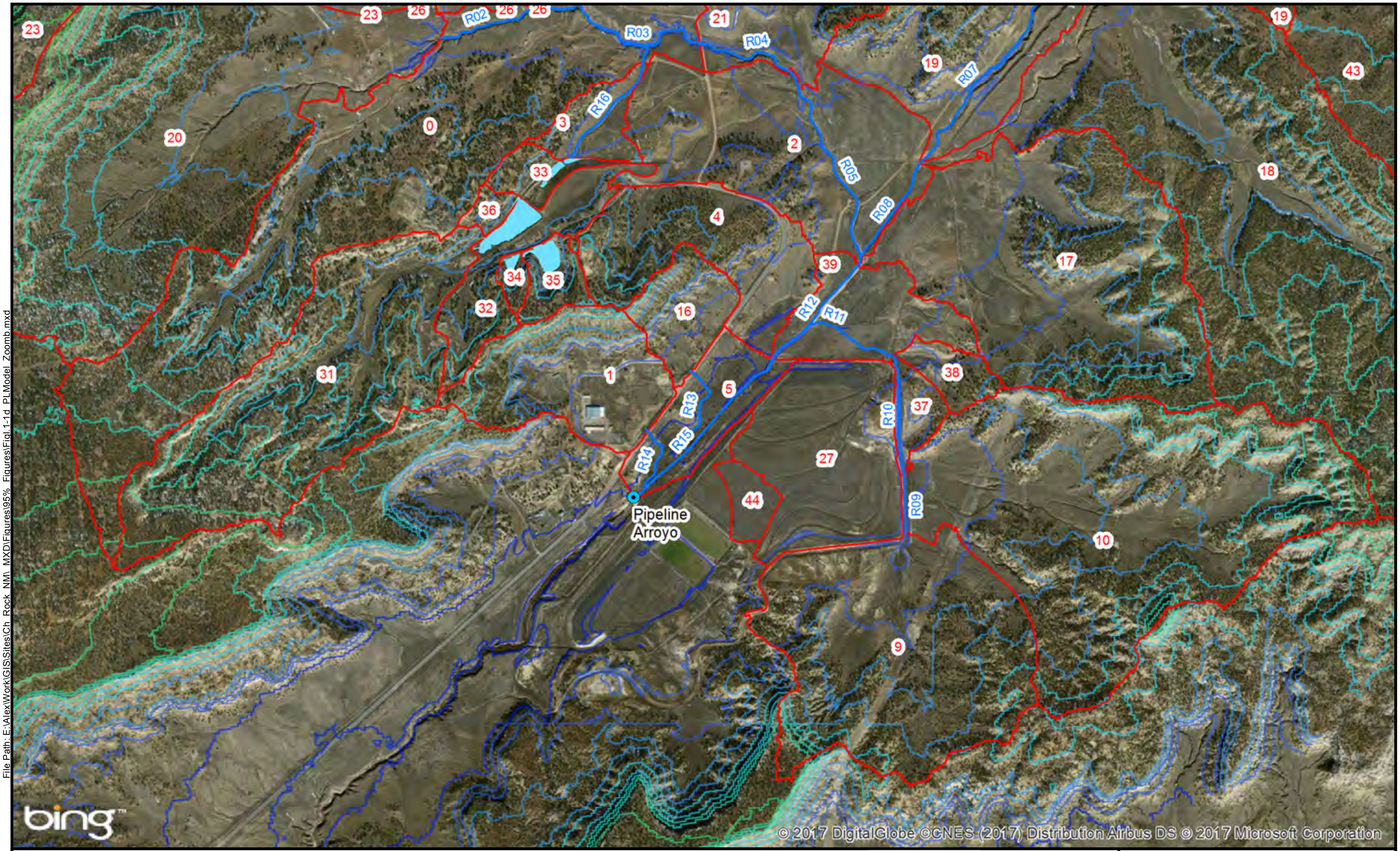
FIGURE I.1-1C:

Pipeline Arroyo Existing Condition Catchments

Northeast Church Rock

Date Revised: 9/20/2017



Legend

◉ Peak Flow Point of Interest

Flow Path

☐ Watershed Boundary

▇ Mine Ponds

Contours

6850 - 6950	7400 - 7450
7000 - 7050	7500 - 7550
7100 - 7150	7600 - 7750
7200 - 7250	
7300 - 7350	

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.1-1D:

Pipeline Arroyo Existing Condition Catchments

Northeast Church Rock

Date Revised: 9/20/2017

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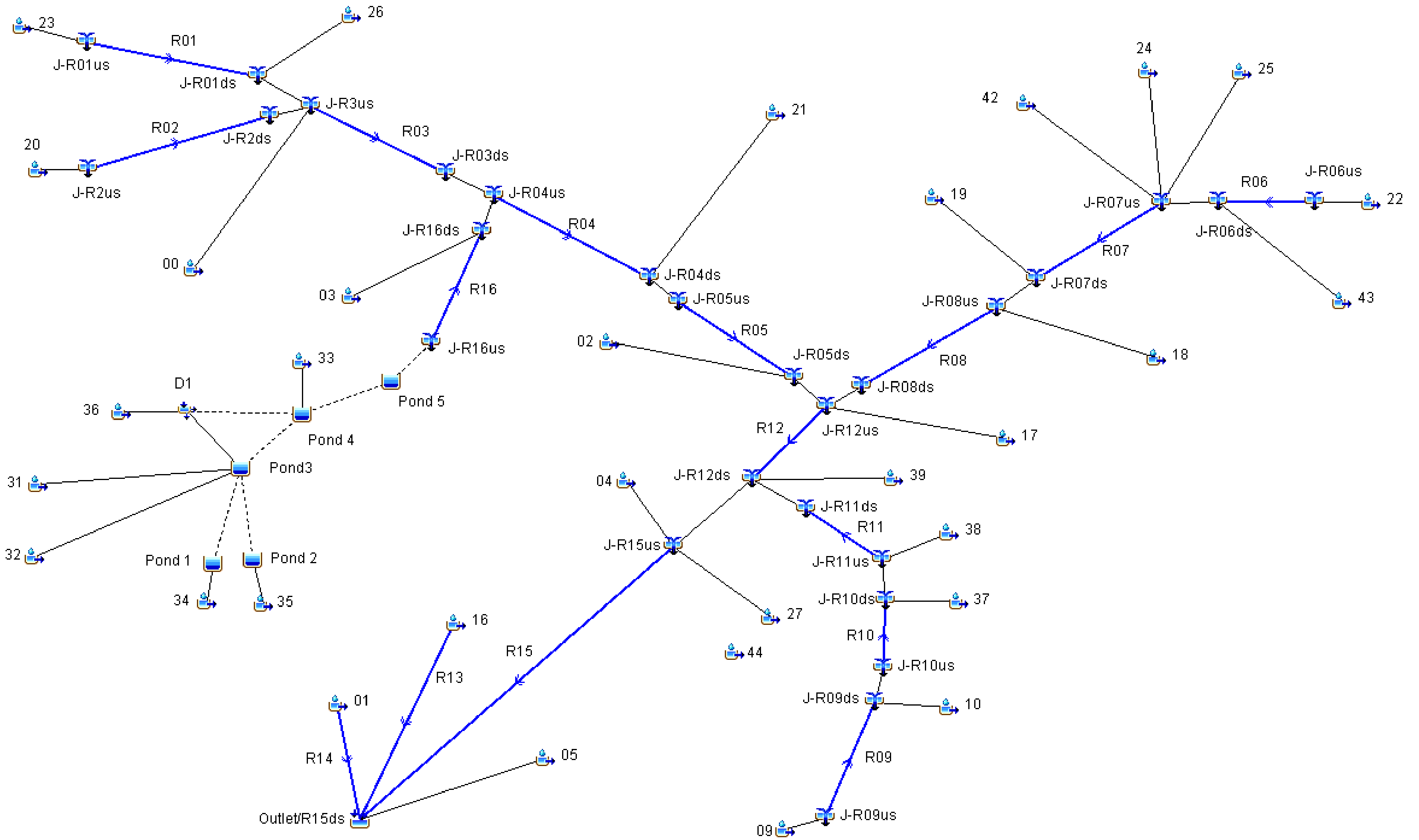

FIGURE I.1-1E:

Pipeline Arroyo Existing Condition HEC-HMS Model

Northeast Church Rock

Date Revised: 9/20/2017

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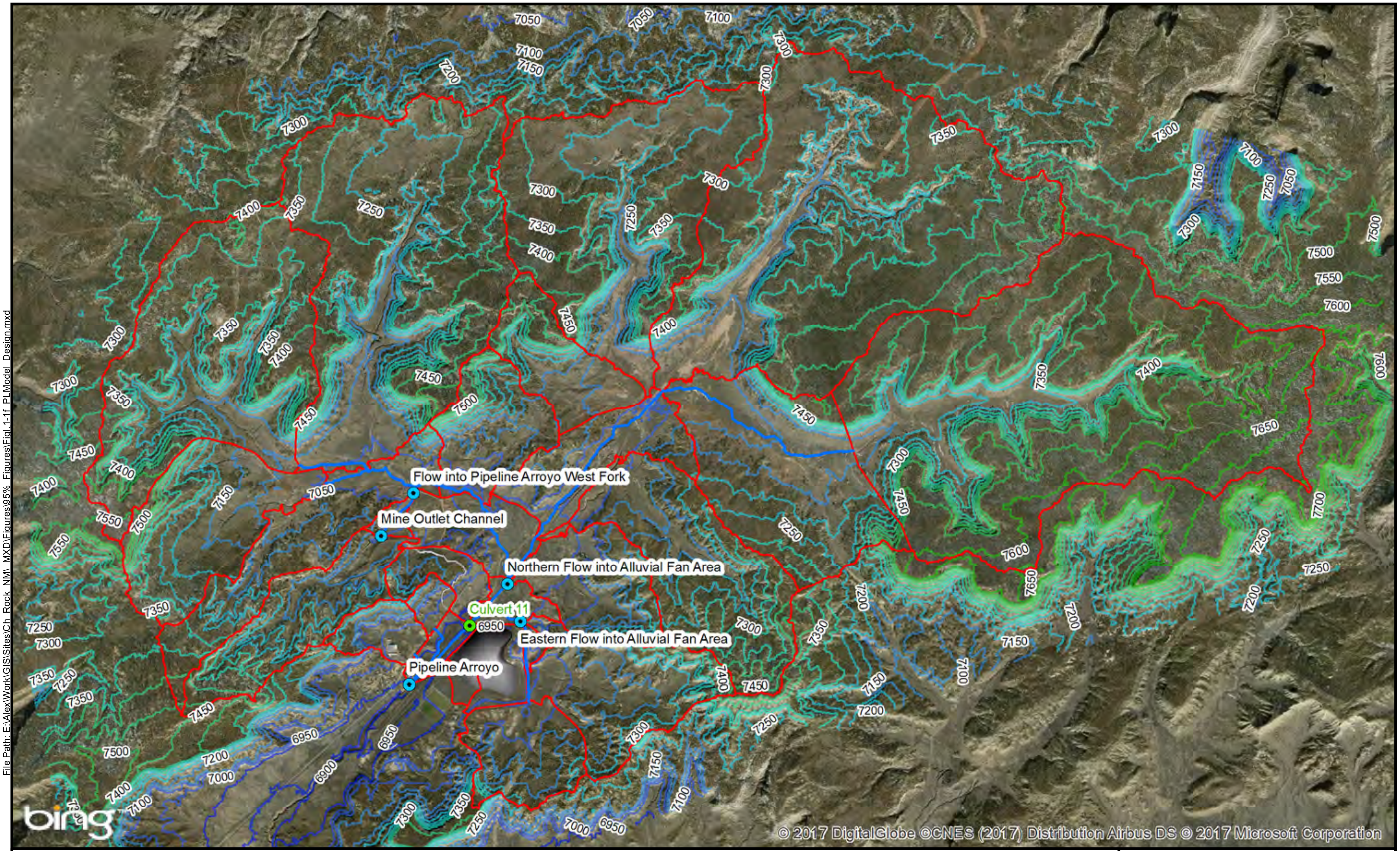

Legend

● Peak Flow Point of Interest

● Temporary Structure Flow Point

Flow Path

🟥 Watershed Boundary

Contours

6850 - 6950

7000 - 7050

7100 - 7150

7200 - 7250

7300 - 7350

7400 - 7450

7500 - 7550

7600 - 7750

N
W E
S

0 1,250 2,500 5,000
Feet

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

FIGURE I.1-1F:

Pipeline Arroyo Post-RA Catchments

Northeast Church Rock

Date Revised: 9/20/2017

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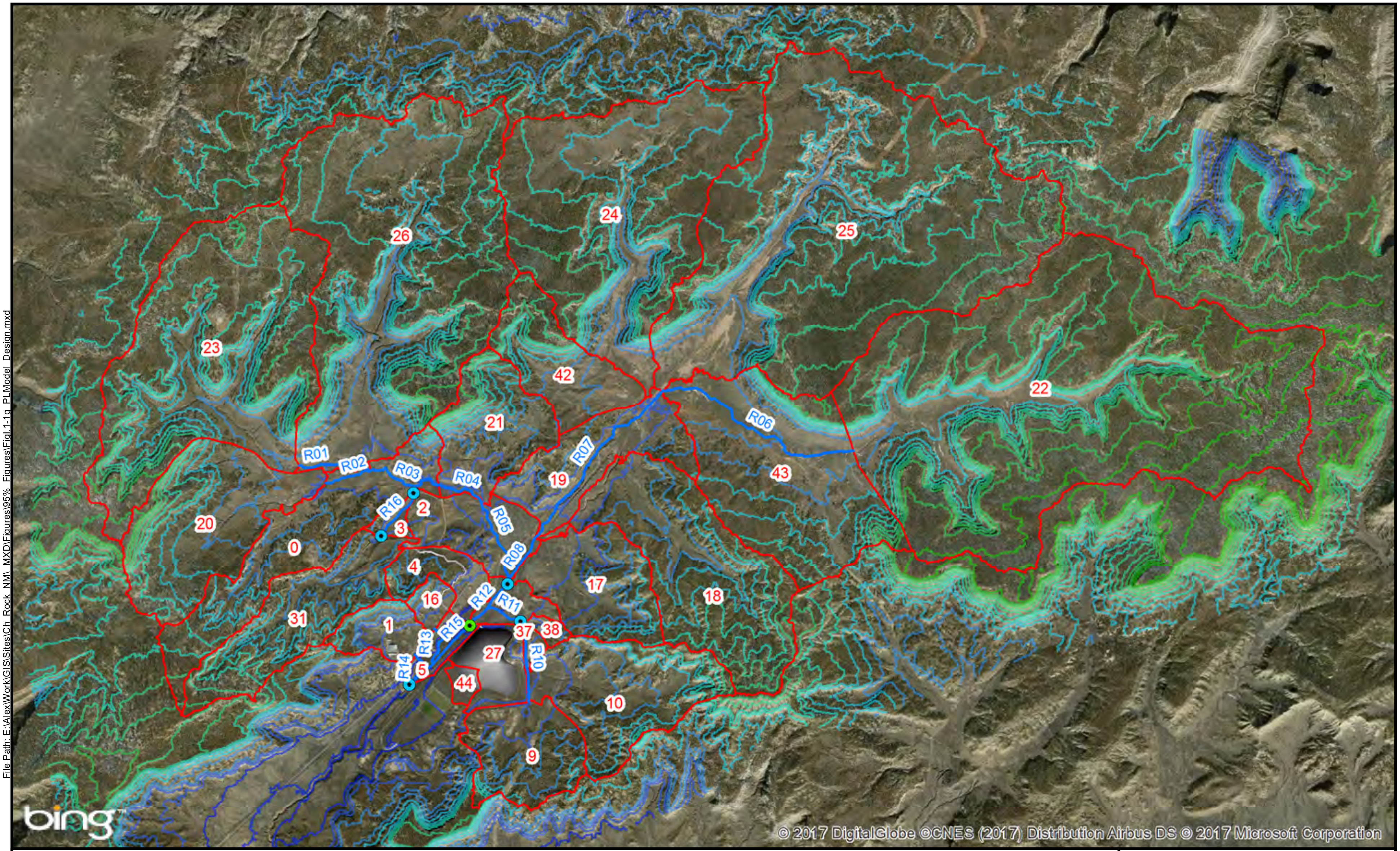

Legend

- ● Peak Flow Point of Interest
- ● Temporary Structure Flow Point
- Flow Path
- 🟥 Watershed Boundary

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

N
W E
S

0 1,250 2,500 5,000
Feet

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

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FIGURE I.1-1G:

Pipeline Arroyo Post-RA Catchments

Northeast Church Rock

Date Revised: 9/20/2017

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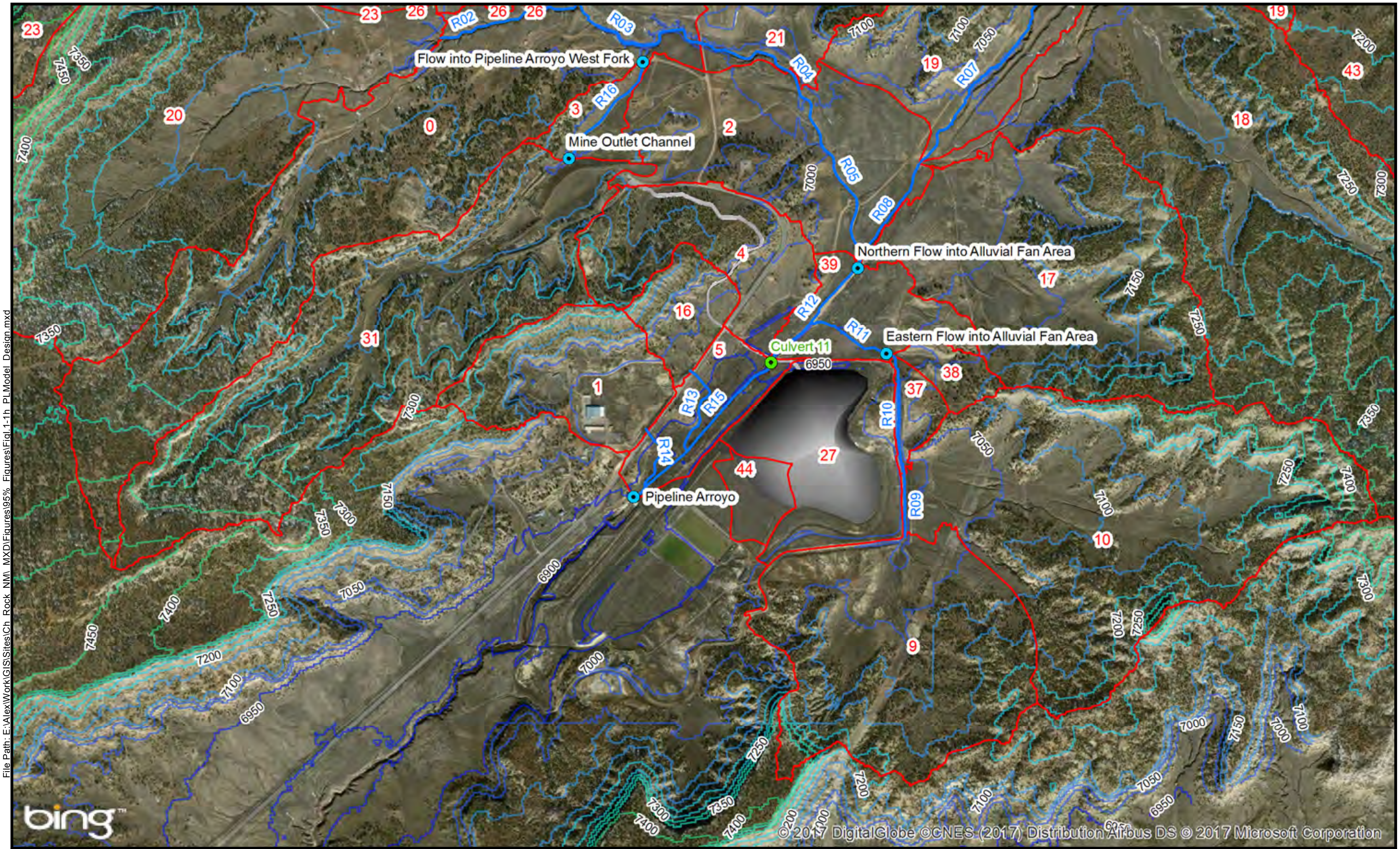

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Legend

- ● Peak Flow Point of Interest
- ● Temporary Structure Flow Point
- Flow Path
- ☐ Watershed Boundary

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

N
W E
S

0 500 1,000 2,000
Feet

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

unc

MWH. now part of Stantec

FIGURE I.1-1H:

Pipeline Arroyo Post-RA Catchments

Northeast Church Rock

Date Revised: 9/21/2017

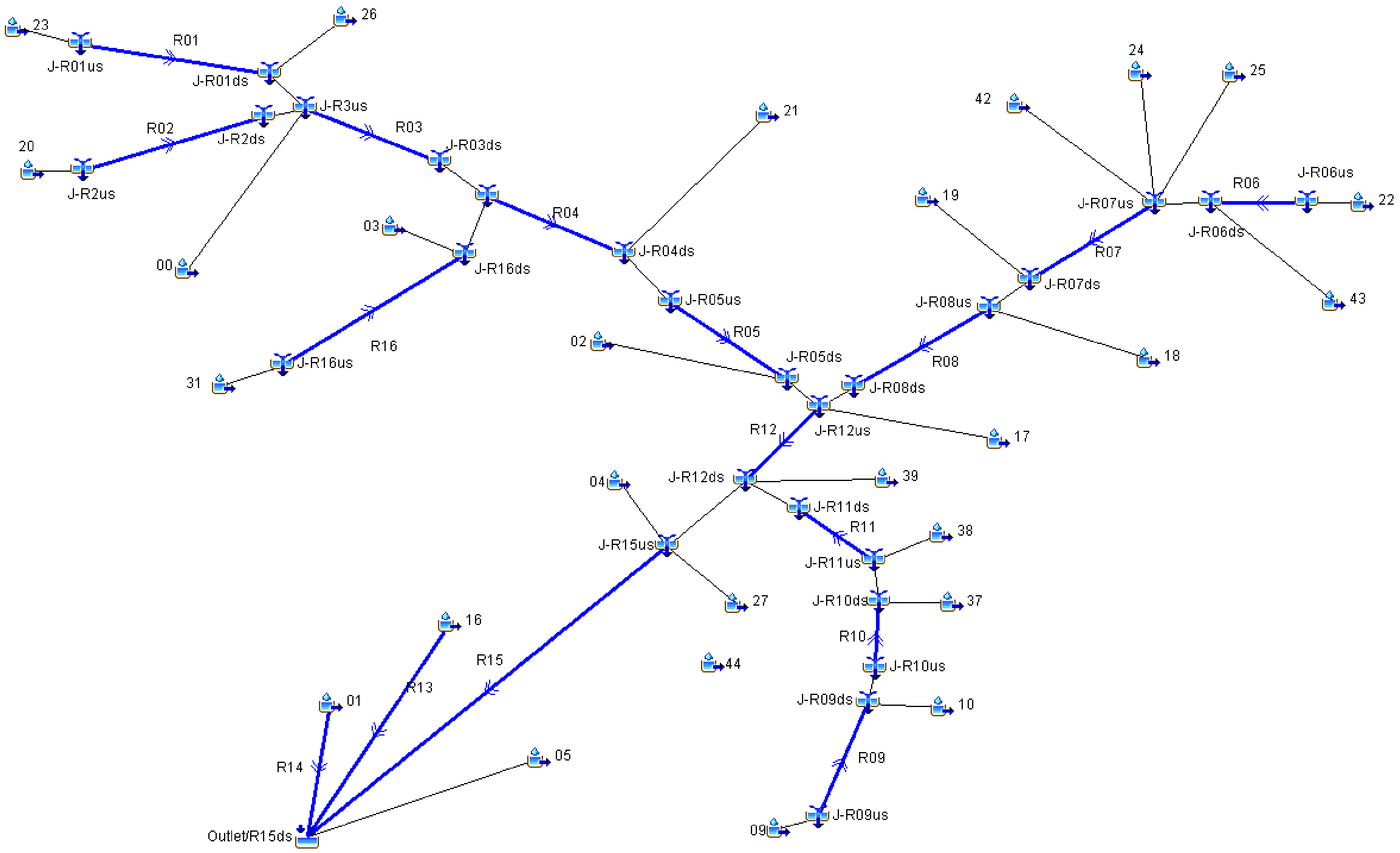

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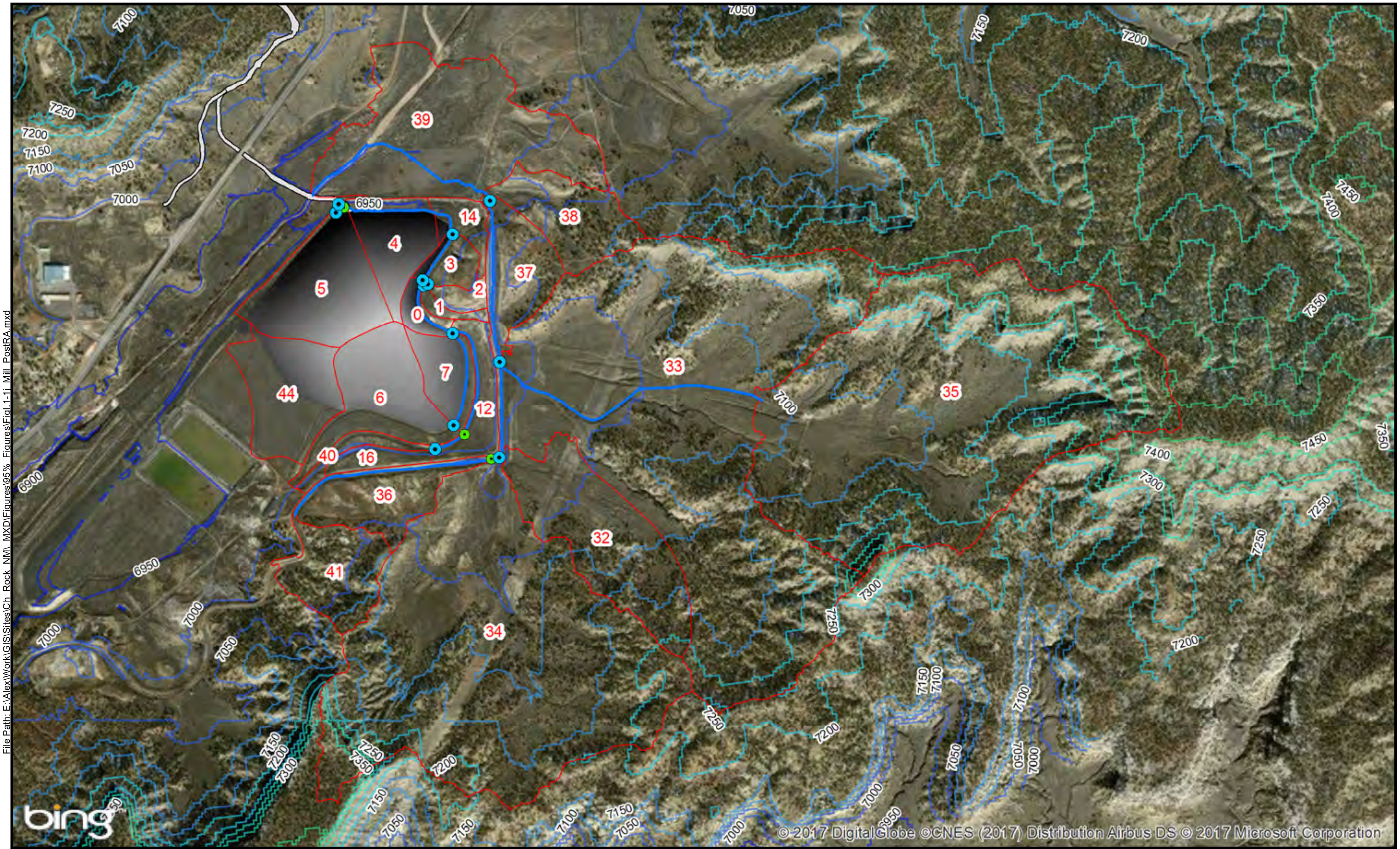
FIGURE I.1-1i:

Pipeline Arroyo Post-RA HEC-HMS Model

Northeast Church Rock

Date Revised: 9/20/2017



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Legend

- ◉ Peak Flow Point of Interest
- ◉ Temporary Structure Flow Point
- — Flow Path
- ☐ Watershed Boundary
- ▨ Temporary Haul Road

Contours

- — 6850 - 6950
- — 7000 - 7050
- — 7100 - 7150
- — 7200 - 7250
- — 7300 - 7350
- — 7400 - 7450
- — 7500 - 7550
- — 7600 - 7750

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:

Mill Site Post-RA Catchments

Northeast Church Rock

Date Revised: 9/20/2017

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Legend

- ● Peak Flow Point of Interest
- ● Temporary Structure Flow Point
- — Flow Path
- 🟥 Watershed Boundary
- ▨ Temporary Haul Road

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

N W E S

0 200 400 800 Feet

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

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FIGURE I.1-1K:

Mill Site
Post-RA Catchments

Northeast Church Rock

Date Revised: 9/20/2017

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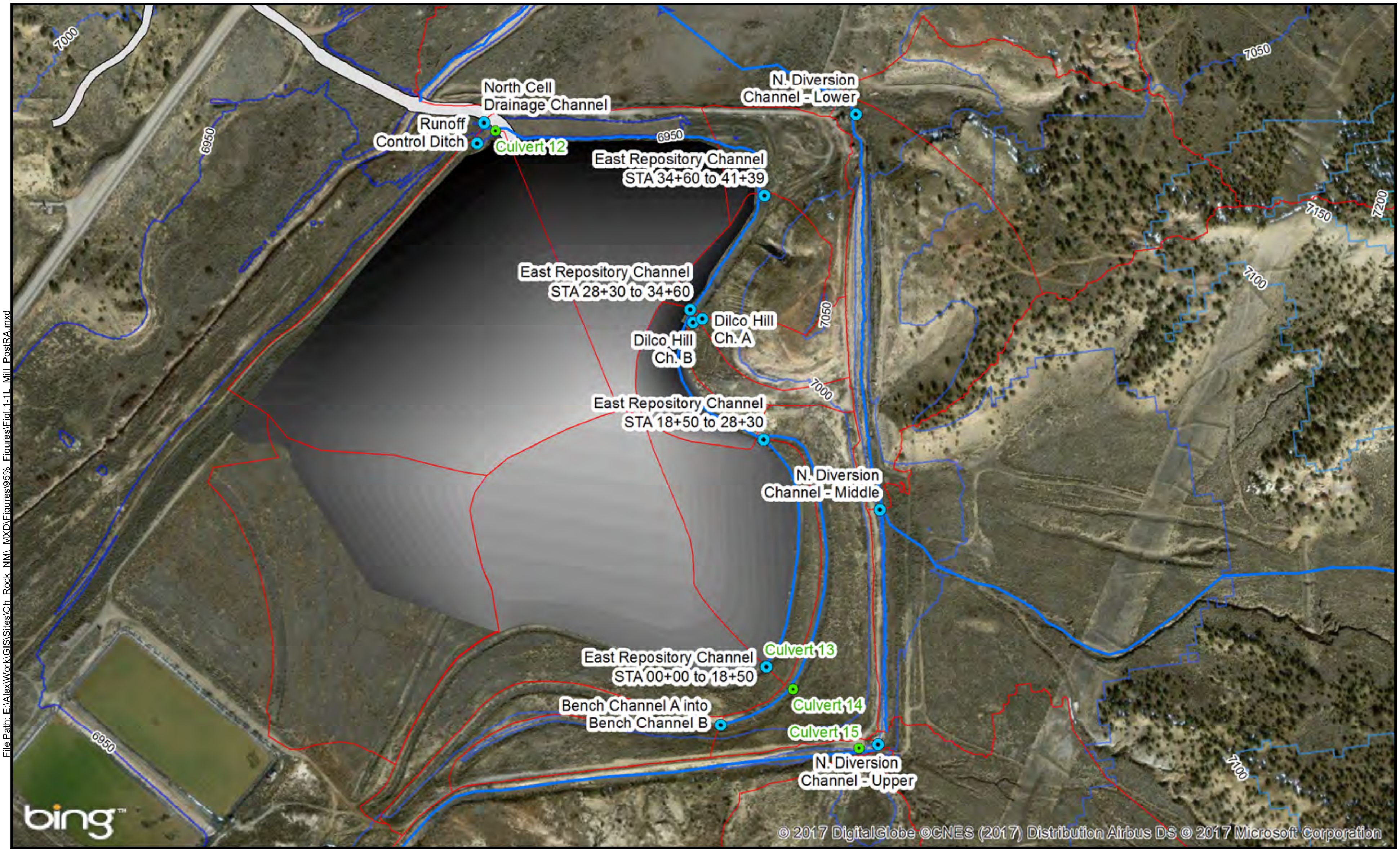


Legend

- ● Peak Flow Point of Interest
- ● Temporary Structure Flow Point
- — Flow Path
- ☐ Watershed Boundary
- ▨ Temporary Haul Road

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

N
W E
S

0 200 400 800 Feet

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

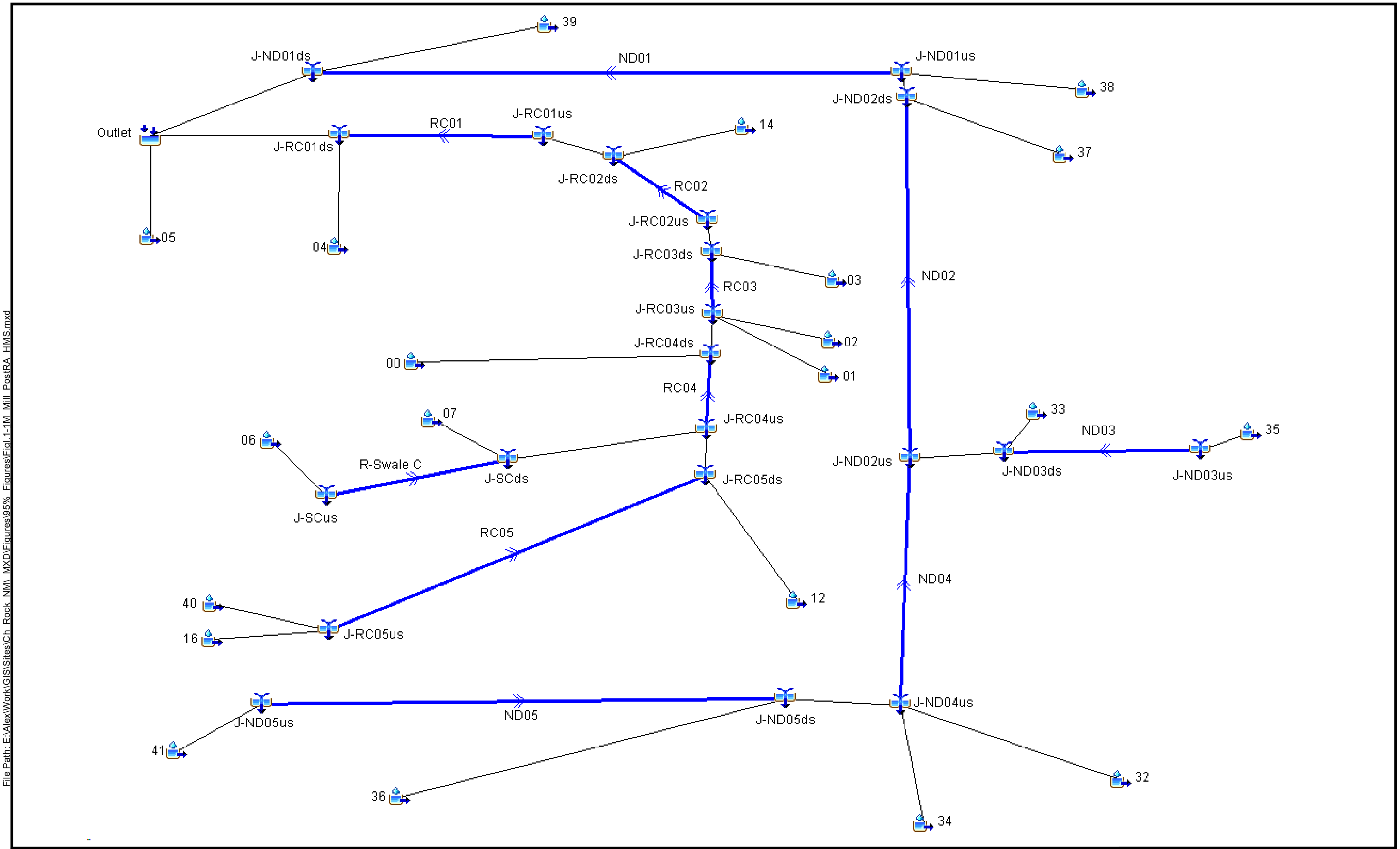
now part of

FIGURE I.1-1L:

Mill Site Post-RA Catchments

Northeast Church Rock

Date Revised: 9/20/2017



File Path: E:\AlexWork\GIS\Sites\Ch_Rock_NM_MXD\Figures\95%_Figures\FigI.1-1M_Mill_PostRA_HMS.mxd

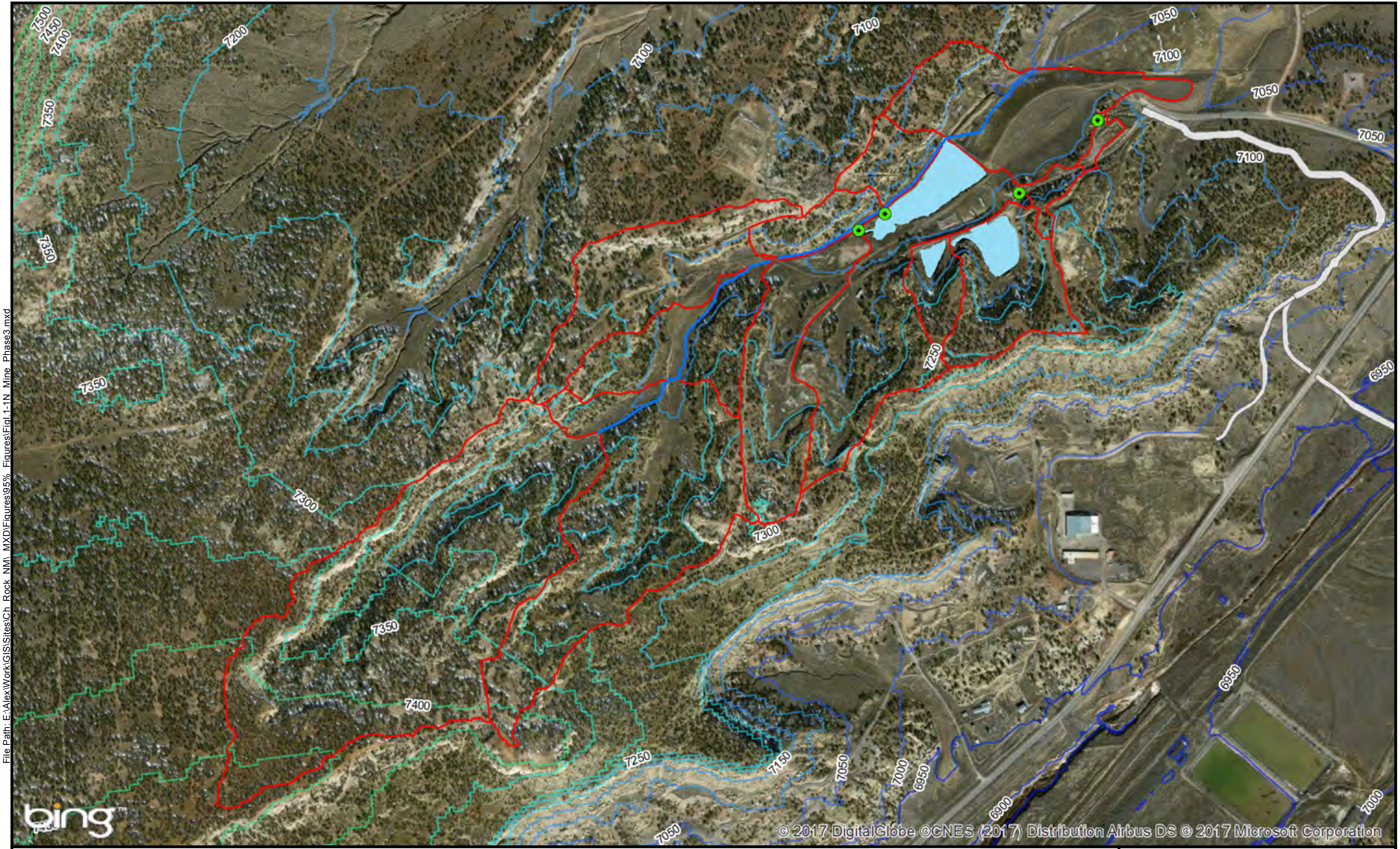
FIGURE I.1-1M:

Mill Site Post-RA HEC-HMS Model

Northeast Church Rock

Date Revised: 9/20/2017

Note - Presented contours show pre-construction elevations



File Path: E:\AlexWork\GIS\Sites\Ch Rock NM MXD\Figures\95% Figures\FigI.1-1N Mine Phase3.mxd

Legend

- ● Temporary Structure Flow Point
- Flow Path
- ☐ Watershed Boundary
- Mine Pond
- ☐ Temporary Haul Road

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

N W E S

0 400 800 1,600 Feet

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

MWH. now part of Stantec

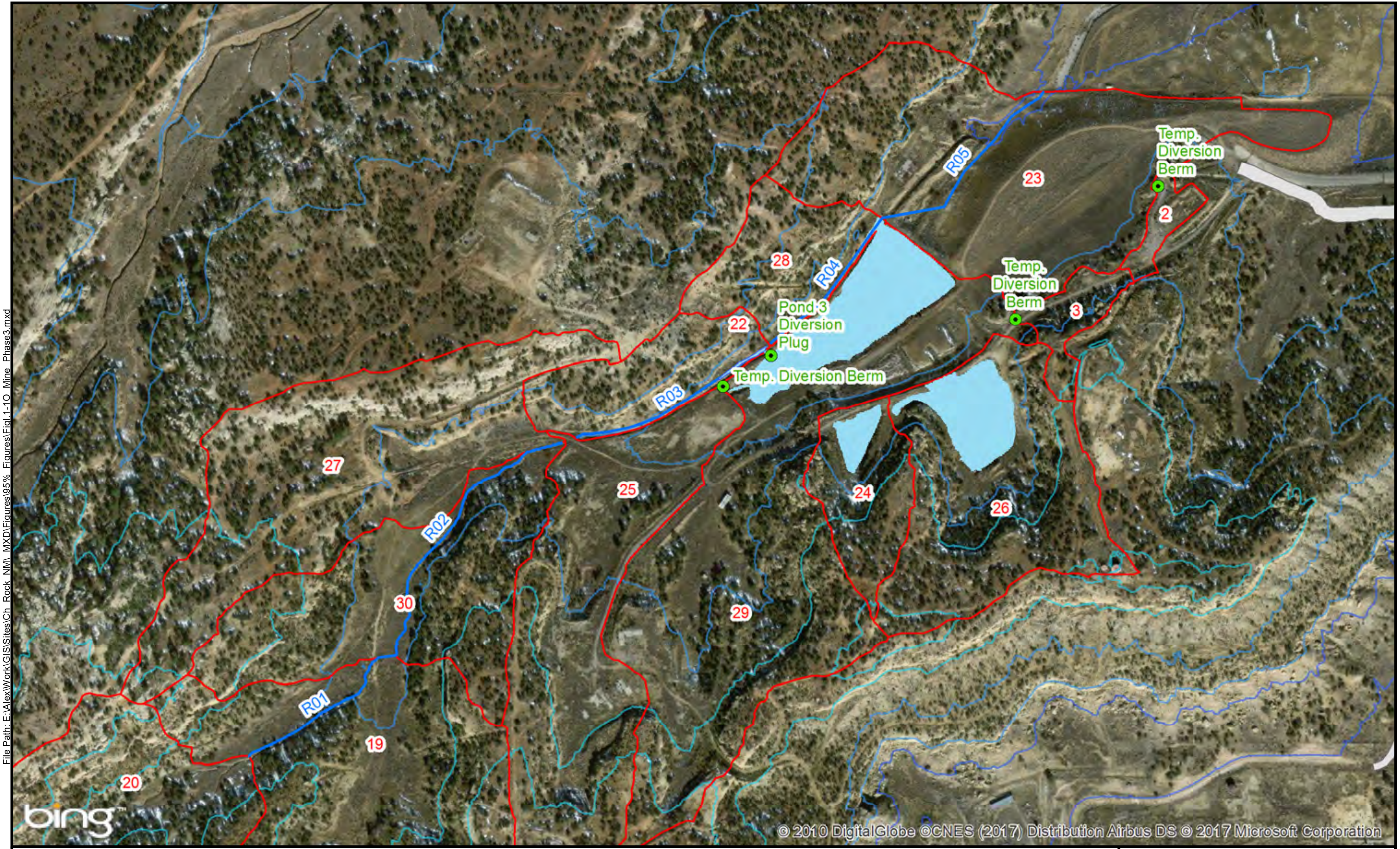
FIGURE I.1-1N:

Mine Site - Phase 3 Construction Catchments

Northeast Church Rock

Date Revised: 9/20/2017

Note - Presented contours show pre-construction elevations



Legend

- ● Temporary Structure Flow Point
- Flow Path
- Watershed Boundary
- Mine Pond
- Temporary Haul Road

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

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

UNC

GE

MWH. now part of Stantec

FIGURE I.1-1O:

Mine Site - Phase 3 Construction Catchments

Northeast Church Rock

Date Revised: 9/20/2017

File Path: E:\AlexWork\GIS\Sites\Ch_Rock_NM_MXD\Figures\95%_Figures\FigI.1-1O_Mine_Phase3.mxd

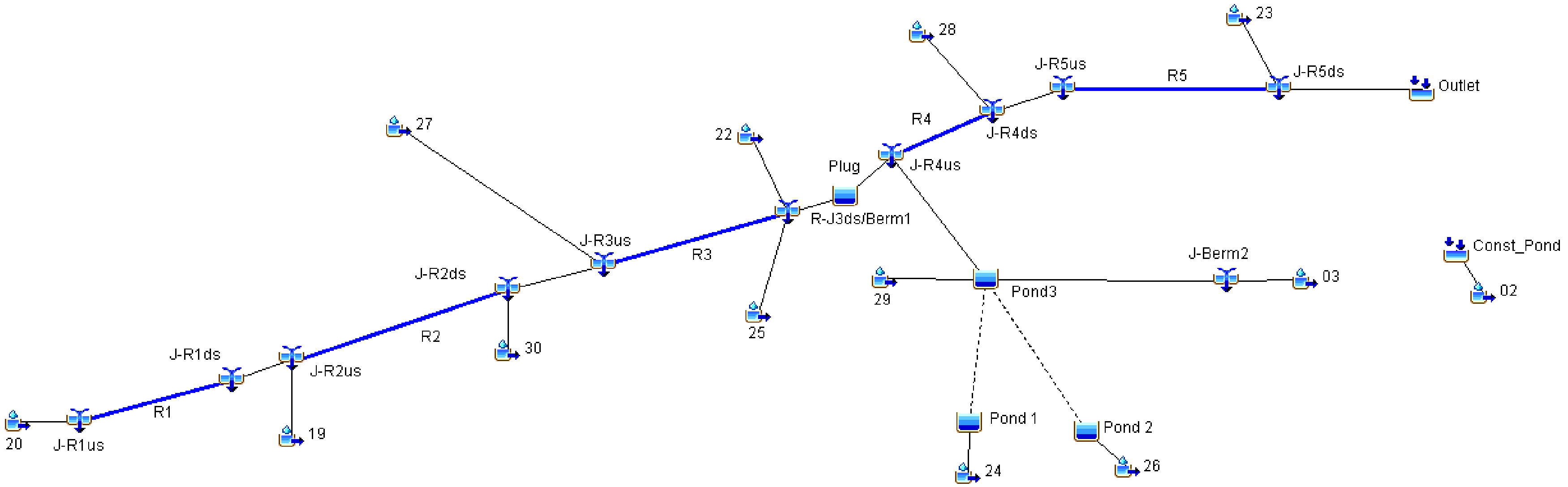


FIGURE I.1-1P:

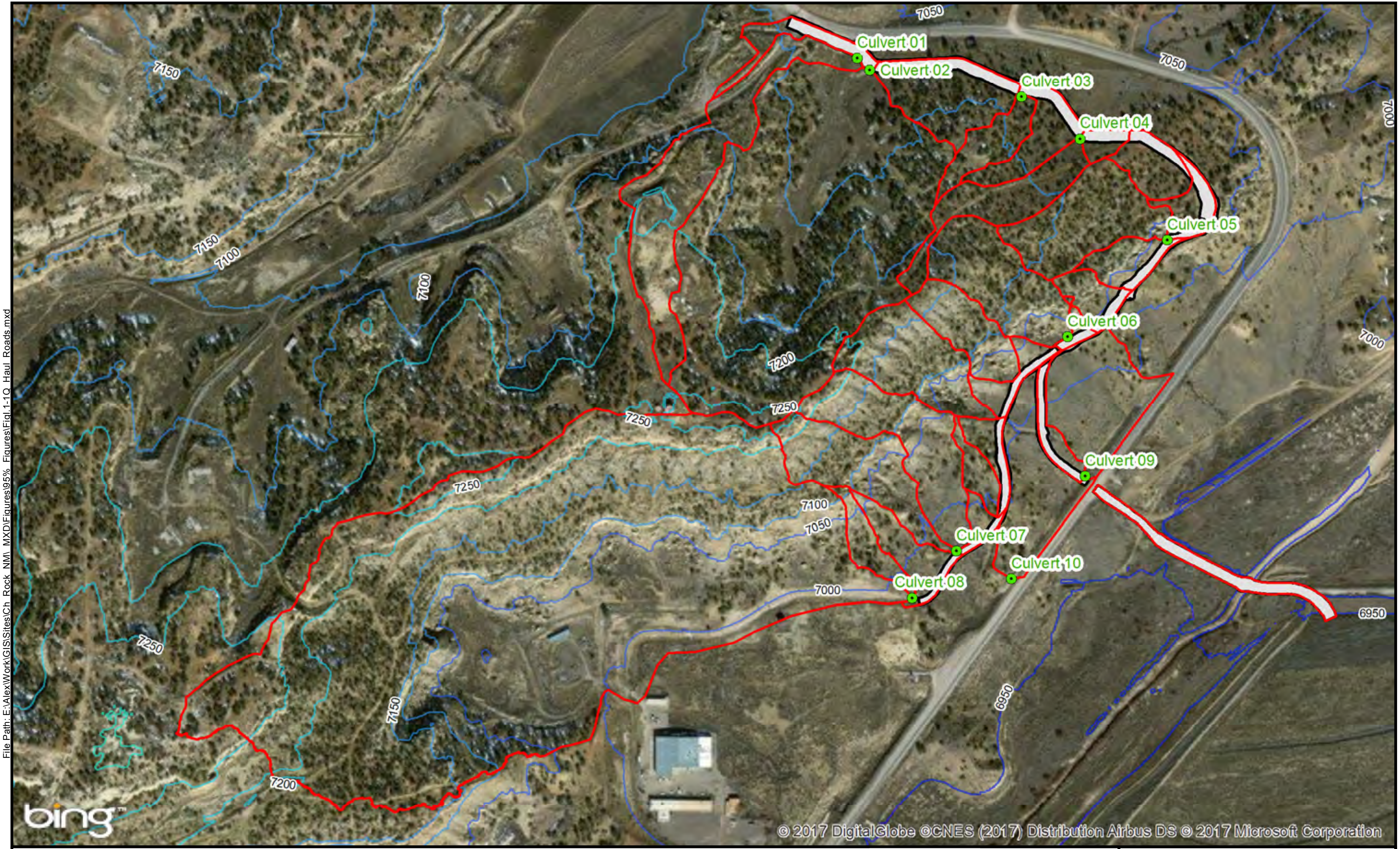
Mine Site, Construction Phase 3, HEC-HMS Model

Northeast Church Rock

Date Revised: 9/20/2017

File Path: E:\Alex\Work\GIS\Sites\Ch_Rock_NM_MXD\Figures\95%_Figures\Fig I.1-1P_MinePh3_HMS.mxd

Note - Presented contours show pre-construction elevations



File Path: E:\AlexWork\GIS\Sites\Ch Rock NM\ MXD\Figures\95% Figures\FigI.1-1Q Haul Roads.mxd

Legend

- ● Temporary Structure Flow Point
- 🟥 Watershed Boundary
- ▭ Temporary Haul Road

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

N
W E
S

0 200 400 800 Feet

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

unc

MWH. now part of Stantec

FIGURE I.1-1Q:

Haul Road Temporary Stormwater Control Catchments

Northeast Church Rock

Date Revised: 9/20/2017

Note - Presented contours show pre-construction elevations

File Path: E:\AlexWork\GIS\Sites\Ch Rock NM\ MXD\Figures\95% Figures\FigI.1-1R Haul Roads.mxd

Legend

- ● Temporary Structure Flow Point
- ▭ Watershed Boundary
- ▭ Temporary Haul Road

Contours

- 6850 - 6950
- 7000 - 7050
- 7100 - 7150
- 7200 - 7250
- 7300 - 7350
- 7400 - 7450
- 7500 - 7550
- 7600 - 7750

N
W E
S

0 200 400 800
Feet

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

UNC GE MWH now part of Stantec

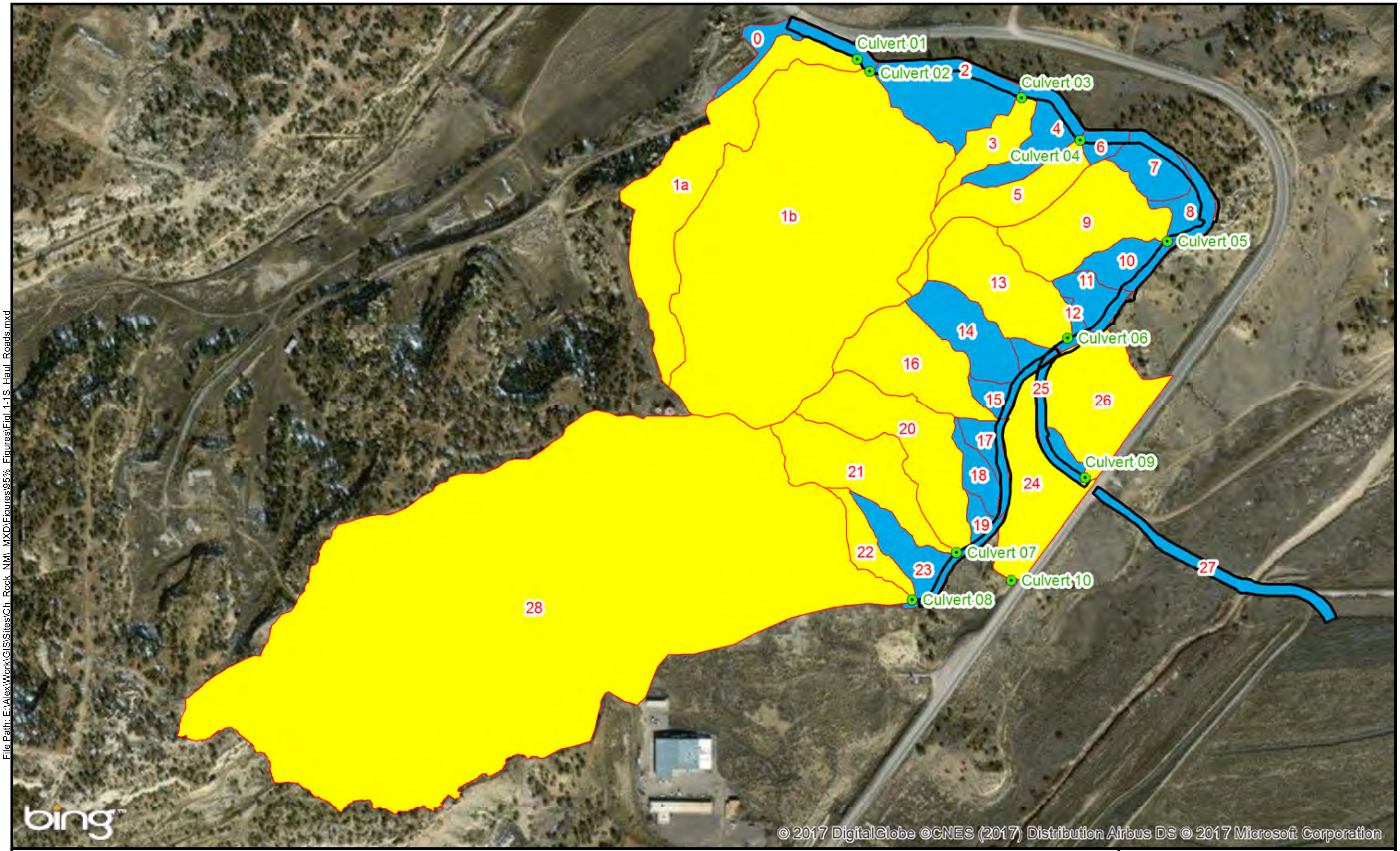
FIGURE I.1-1R:

Haul Road Temporary Stormwater Control Catchments

Northeast Church Rock

Date Revised: 9/20/2017

File Path: E:\Alex\Work\GIS\Sites\Ch Rock NM\ MXD\Figures\95% Figures\FigI.1-1S Haul Roads.mxd



Legend

● Temporary Structure Flow Point

▭ Temporary Haul Road

Watershed Boundary

Drains to

🟨 Culvert

🟦 Sump

N
W E
S

0 200 400 800
Feet

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

unc

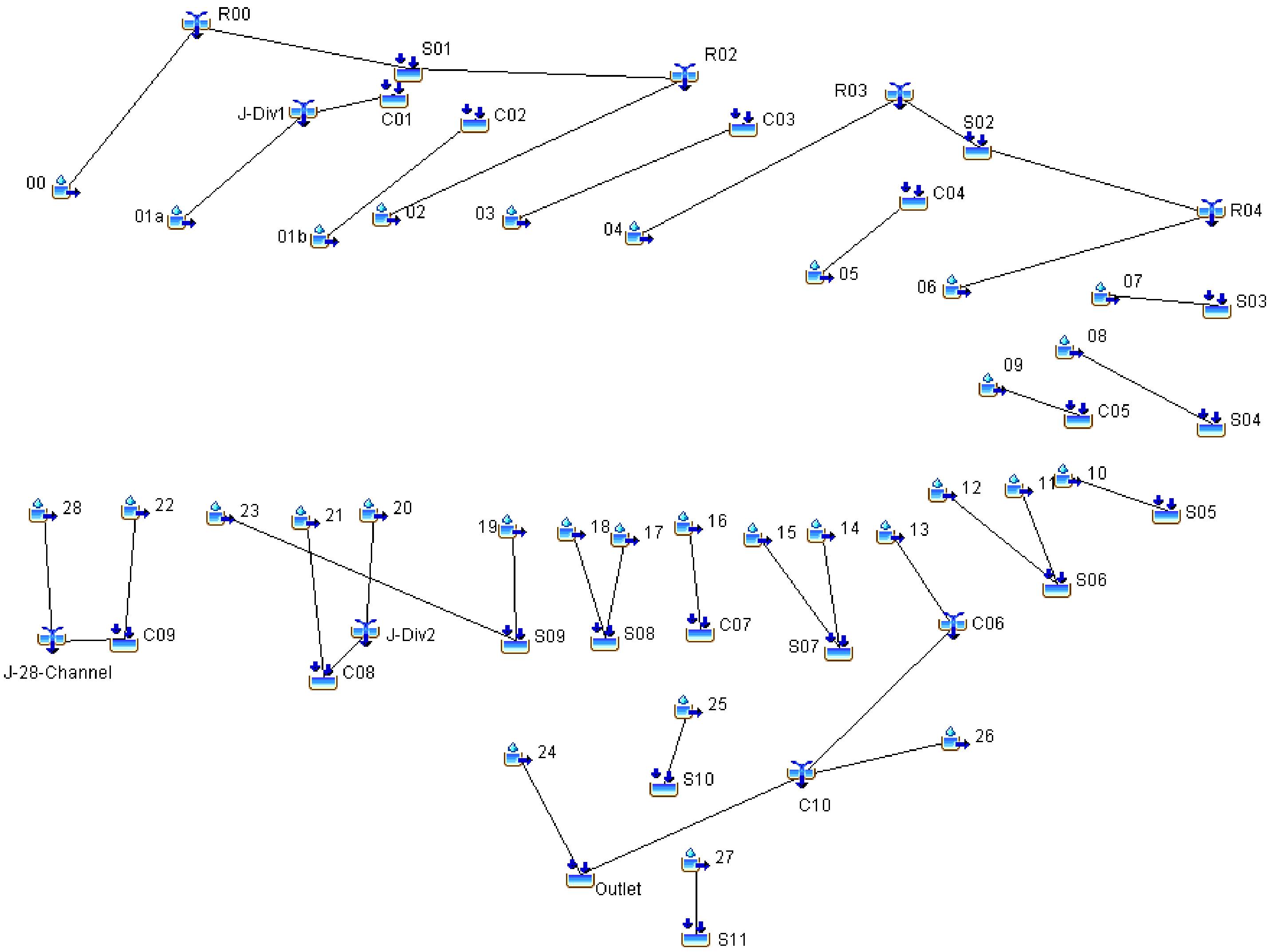
MWH. now part of Stantec

FIGURE I.1-1S:

Haul Road Temporary Stormwater Control Catchments

Northeast Church Rock

Date Revised: 9/20/2017



File Path: E:\Alex\Work\GIS\Sites\Ch Rock NM\ MXD\Figures\95% Figures\FigI.1-1T Haul Road HMS.mxd

MWH. now part of Stantec

FIGURE I.1-1T:

Haul Road Temporary Controls HEC-HMS Model

Northeast Church Rock

Date Revised: 9/20/2017

ATTACHMENT B

STORM HYETOGRAPH TABLES

Table B1: 1-hour PMP Hyetographs for Pipeline Arroyo and Mill Site

Storm Duration (Ending Timestep)	Pipeline Arroyo		Mill Site	
	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 B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
0	00	00	00	00	00	00	00
5	08	07	0.0010	0.0017	0.0019	0.0022	0.0031
10	08	07	0.0010	0.0017	0.0020	0.0022	0.0031
15	08	07	0.0010	0.0017	0.0020	0.0022	0.0031
20	08	07	0.0010	0.0017	0.0020	0.0023	0.0031
25	08	07	0.0010	0.0017	0.0020	0.0023	0.0032
30	08	07	0.0011	0.0018	0.0020	0.0023	0.0032
35	08	07	0.0011	0.0018	0.0020	0.0023	0.0032
40	08	07	0.0011	0.0018	0.0020	0.0023	0.0032
45	08	07	0.0011	0.0018	0.0021	0.0023	0.0032
50	08	08	0.0011	0.0018	0.0021	0.0024	0.0033
55	09	08	0.0011	0.0018	0.0021	0.0024	0.0033
60	09	08	0.0011	0.0018	0.0021	0.0024	0.0033
65	09	08	0.0011	0.0018	0.0021	0.0024	0.0033
70	09	08	0.0011	0.0019	0.0021	0.0024	0.0034
75	09	08	0.0011	0.0019	0.0021	0.0024	0.0034
80	09	08	0.0011	0.0019	0.0022	0.0025	0.0034
85	09	08	0.0011	0.0019	0.0022	0.0025	0.0034
90	09	08	0.0011	0.0019	0.0022	0.0025	0.0035
95	09	08	0.0012	0.0019	0.0022	0.0025	0.0035
100	09	08	0.0012	0.0019	0.0022	0.0025	0.0035
105	09	08	0.0012	0.0020	0.0022	0.0026	0.0035
110	09	08	0.0012	0.0020	0.0023	0.0026	0.0036
115	09	08	0.0012	0.0020	0.0023	0.0026	0.0036
120	09	08	0.0012	0.0020	0.0023	0.0026	0.0036
125	09	08	0.0012	0.0020	0.0023	0.0026	0.0037
130	09	08	0.0012	0.0020	0.0023	0.0027	0.0037
135	0.0010	09	0.0012	0.0020	0.0023	0.0027	0.0037
140	0.0010	09	0.0012	0.0021	0.0024	0.0027	0.0037
145	0.0010	09	0.0012	0.0021	0.0024	0.0027	0.0038

Table B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
150	0.0010	09	0.0013	0.0021	0.0024	0.0027	0.0038
155	0.0010	09	0.0013	0.0021	0.0024	0.0028	0.0038
160	0.0010	09	0.0013	0.0021	0.0024	0.0028	0.0039
165	0.0010	09	0.0013	0.0021	0.0025	0.0028	0.0039
170	0.0010	09	0.0013	0.0022	0.0025	0.0028	0.0039
175	0.0010	09	0.0013	0.0022	0.0025	0.0029	0.0040
180	0.0010	09	0.0013	0.0022	0.0025	0.0029	0.0040
185	0.0010	09	0.0013	0.0022	0.0025	0.0029	0.0040
190	0.0010	09	0.0013	0.0022	0.0026	0.0029	0.0041
195	0.0010	09	0.0014	0.0023	0.0026	0.0030	0.0041
200	0.0011	0.0010	0.0014	0.0023	0.0026	0.0030	0.0042
205	0.0011	0.0010	0.0014	0.0023	0.0026	0.0030	0.0042
210	0.0011	0.0010	0.0014	0.0023	0.0027	0.0030	0.0042
215	0.0011	0.0010	0.0014	0.0023	0.0027	0.0031	0.0043
220	0.0011	0.0010	0.0014	0.0024	0.0027	0.0031	0.0043
225	0.0011	0.0010	0.0014	0.0024	0.0027	0.0031	0.0044
230	0.0011	0.0010	0.0014	0.0024	0.0028	0.0032	0.0044
235	0.0011	0.0010	0.0015	0.0024	0.0028	0.0032	0.0044
240	0.0011	0.0010	0.0015	0.0025	0.0028	0.0032	0.0045
245	0.0011	0.0010	0.0015	0.0025	0.0028	0.0033	0.0045
250	0.0012	0.0011	0.0015	0.0025	0.0029	0.0033	0.0046
255	0.0012	0.0011	0.0015	0.0025	0.0029	0.0033	0.0046
260	0.0012	0.0011	0.0015	0.0026	0.0029	0.0034	0.0047
265	0.0012	0.0011	0.0015	0.0026	0.0030	0.0034	0.0047
270	0.0012	0.0011	0.0016	0.0026	0.0030	0.0034	0.0048
275	0.0012	0.0011	0.0016	0.0026	0.0030	0.0035	0.0048
280	0.0012	0.0011	0.0016	0.0027	0.0030	0.0035	0.0049
285	0.0012	0.0011	0.0016	0.0027	0.0031	0.0035	0.0049
290	0.0012	0.0011	0.0016	0.0027	0.0031	0.0036	0.0050
295	0.0013	0.0012	0.0016	0.0027	0.0031	0.0036	0.0050
300	0.0013	0.0012	0.0017	0.0028	0.0032	0.0037	0.0051
305	0.0013	0.0012	0.0017	0.0028	0.0032	0.0037	0.0052
310	0.0013	0.0012	0.0017	0.0028	0.0033	0.0038	0.0052
315	0.0013	0.0012	0.0017	0.0029	0.0033	0.0038	0.0053
320	0.0013	0.0012	0.0017	0.0029	0.0033	0.0038	0.0053
325	0.0013	0.0012	0.0018	0.0029	0.0034	0.0039	0.0054
330	0.0014	0.0013	0.0018	0.0030	0.0034	0.0039	0.0055
335	0.0014	0.0013	0.0018	0.0030	0.0035	0.0040	0.0055
340	0.0014	0.0013	0.0018	0.0031	0.0035	0.0040	0.0056

Table B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
345	0.0014	0.0013	0.0019	0.0031	0.0035	0.0041	0.0057
350	0.0014	0.0013	0.0019	0.0031	0.0036	0.0041	0.0058
355	0.0014	0.0013	0.0019	0.0032	0.0036	0.0042	0.0058
360	0.0015	0.0014	0.0019	0.0032	0.0037	0.0043	0.0059
365	0.0015	0.0014	0.0020	0.0033	0.0037	0.0043	0.0060
370	0.0015	0.0014	0.0020	0.0033	0.0038	0.0044	0.0061
375	0.0015	0.0014	0.0020	0.0033	0.0038	0.0044	0.0062
380	0.0015	0.0014	0.0020	0.0034	0.0039	0.0045	0.0063
385	0.0015	0.0015	0.0021	0.0034	0.0039	0.0046	0.0063
390	0.0016	0.0015	0.0021	0.0035	0.0040	0.0046	0.0064
395	0.0016	0.0015	0.0021	0.0035	0.0041	0.0047	0.0065
400	0.0016	0.0015	0.0022	0.0036	0.0041	0.0048	0.0066
405	0.0016	0.0016	0.0022	0.0036	0.0042	0.0049	0.0067
410	0.0017	0.0016	0.0022	0.0037	0.0042	0.0049	0.0068
415	0.0017	0.0016	0.0023	0.0038	0.0043	0.0050	0.0070
420	0.0017	0.0016	0.0023	0.0038	0.0044	0.0051	0.0071
425	0.0017	0.0017	0.0023	0.0039	0.0044	0.0052	0.0072
430	0.0018	0.0017	0.0024	0.0039	0.0045	0.0053	0.0073
435	0.0018	0.0017	0.0024	0.0040	0.0046	0.0054	0.0074
440	0.0018	0.0018	0.0024	0.0041	0.0047	0.0054	0.0076
445	0.0018	0.0018	0.0025	0.0042	0.0047	0.0055	0.0077
450	0.0019	0.0018	0.0025	0.0042	0.0048	0.0056	0.0078
455	0.0019	0.0019	0.0026	0.0043	0.0049	0.0058	0.0080
460	0.0019	0.0019	0.0026	0.0044	0.0050	0.0059	0.0081
465	0.0020	0.0019	0.0027	0.0045	0.0051	0.0060	0.0083
470	0.0020	0.0020	0.0027	0.0045	0.0052	0.0061	0.0085
475	0.0020	0.0020	0.0028	0.0046	0.0053	0.0062	0.0086
480	0.0021	0.0020	0.0028	0.0047	0.0054	0.0063	0.0088
485	0.0021	0.0021	0.0029	0.0048	0.0055	0.0065	0.0090
490	0.0022	0.0021	0.0030	0.0049	0.0056	0.0066	0.0092
495	0.0022	0.0022	0.0030	0.0050	0.0058	0.0068	0.0094
500	0.0023	0.0022	0.0031	0.0051	0.0059	0.0069	0.0096
505	0.0023	0.0023	0.0032	0.0053	0.0060	0.0071	0.0099
510	0.0023	0.0023	0.0032	0.0054	0.0062	0.0073	0.0101
515	0.0024	0.0024	0.0033	0.0055	0.0063	0.0074	0.0103
520	0.0025	0.0025	0.0034	0.0056	0.0065	0.0076	0.0106
525	0.0025	0.0025	0.0035	0.0058	0.0066	0.0078	0.0109
530	0.0026	0.0026	0.0036	0.0059	0.0068	0.0080	0.0112
535	0.0026	0.0027	0.0036	0.0061	0.0070	0.0082	0.0115

Table B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
540	0.0027	0.0027	0.0037	0.0063	0.0072	0.0085	0.0118
545	0.0028	0.0028	0.0039	0.0064	0.0074	0.0087	0.0121
550	0.0028	0.0029	0.0040	0.0066	0.0076	0.0090	0.0125
555	0.0029	0.0030	0.0041	0.0068	0.0078	0.0093	0.0129
560	0.0030	0.0031	0.0042	0.0070	0.0080	0.0096	0.0133
565	0.0031	0.0032	0.0043	0.0072	0.0083	0.0099	0.0137
570	0.0032	0.0033	0.0045	0.0075	0.0086	0.0102	0.0142
575	0.0033	0.0034	0.0046	0.0077	0.0088	0.0106	0.0147
580	0.0034	0.0035	0.0048	0.0080	0.0092	0.0110	0.0153
585	0.0035	0.0037	0.0050	0.0083	0.0095	0.0114	0.0158
590	0.0036	0.0038	0.0052	0.0086	0.0099	0.0118	0.0165
595	0.0038	0.0040	0.0054	0.0090	0.0103	0.0123	0.0172
600	0.0039	0.0042	0.0056	0.0093	0.0107	0.0129	0.0179
605	0.0041	0.0044	0.0058	0.0098	0.0111	0.0135	0.0187
610	0.0042	0.0046	0.0061	0.0102	0.0117	0.0141	0.0196
615	0.0044	0.0048	0.0064	0.0107	0.0122	0.0148	0.0206
620	0.0046	0.0051	0.0067	0.0112	0.0128	0.0156	0.0217
625	0.0048	0.0053	0.0071	0.0118	0.0135	0.0164	0.0229
630	0.0051	0.0056	0.0075	0.0125	0.0143	0.0174	0.0242
635	0.0054	0.0060	0.0079	0.0132	0.0151	0.0185	0.0257
640	0.0057	0.0064	0.0084	0.0141	0.0161	0.0197	0.0274
645	0.0060	0.0069	0.0090	0.0150	0.0172	0.0211	0.0293
650	0.0064	0.0074	0.0097	0.0161	0.0184	0.0227	0.0316
655	0.0069	0.0080	0.0104	0.0174	0.0198	0.0245	0.0341
660	0.0074	0.0087	0.0113	0.0188	0.0215	0.0267	0.0372
665	0.0080	0.0096	0.0124	0.0206	0.0235	0.0293	0.0408
670	0.0088	0.0106	0.0136	0.0227	0.0259	0.0324	0.0451
675	0.0097	0.0118	0.0151	0.0252	0.0288	0.0362	0.0504
680	0.0108	0.0134	0.0171	0.0284	0.0324	0.0409	0.0570
685	0.0122	0.0154	0.0195	0.0325	0.0370	0.0470	0.0654
690	0.0140	0.0181	0.0227	0.0378	0.0431	0.0550	0.0766
695	0.0165	0.0218	0.0271	0.0451	0.0514	0.0661	0.0919
700	0.0199	0.0271	0.0334	0.0556	0.0633	0.0820	0.1140
705	0.0253	0.0354	0.0432	0.0718	0.0818	0.1067	0.1482
710	0.0343	0.0496	0.0600	0.0997	0.1133	0.1492	0.2069
715	0.0525	0.0787	0.0943	0.1564	0.1776	0.2356	0.3256
720	0.1061	0.1617	0.1939	0.3205	0.3632	0.4807	0.6594
725	0.2092	0.2998	0.3692	0.6080	0.6875	0.8880	1.2065
730	0.0706	0.1074	0.1284	0.2127	0.2413	0.3205	0.4417

Table B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
735	0.0415	0.0612	0.0737	0.1223	0.1390	0.1837	0.2544
740	0.0291	0.0414	0.0503	0.0837	0.0952	0.1248	0.1732
745	0.0223	0.0307	0.0377	0.0628	0.0714	0.0929	0.1291
750	0.0180	0.0242	0.0299	0.0498	0.0568	0.0733	0.1019
755	0.0151	0.0198	0.0247	0.0412	0.0469	0.0601	0.0836
760	0.0130	0.0167	0.0210	0.0349	0.0398	0.0507	0.0706
765	0.0114	0.0144	0.0182	0.0303	0.0346	0.0438	0.0609
770	0.0102	0.0126	0.0160	0.0267	0.0305	0.0384	0.0472
775	0.0092	0.0112	0.0143	0.0239	0.0273	0.0342	00
780	0.0084	0.0101	0.0130	0.0216	0.0246	0.0308	00
785	0.0077	0.0091	0.0118	0.0197	0.0225	0.0279	00
790	0.0071	0.0083	0.0108	0.0181	0.0206	0.0256	00
795	0.0067	0.0077	0.0100	0.0167	0.0191	0.0236	00
800	0.0062	0.0071	0.0093	0.0155	0.0178	0.0219	00
805	0.0059	0.0066	0.0087	0.0145	0.0166	0.0204	00
810	0.0055	0.0062	0.0082	0.0136	0.0156	0.0064	00
815	0.0052	0.0058	0.0077	0.0128	0.0147	00	00
820	0.0050	0.0055	0.0073	0.0121	0.0139	00	00
825	0.0047	0.0052	0.0069	0.0115	0.0022	00	00
830	0.0045	0.0049	0.0066	0.0109	00	00	00
835	0.0043	0.0047	0.0063	0.0104	00	00	00
840	0.0041	0.0045	0.0060	0.0100	00	00	00
845	0.0040	0.0043	0.0057	0.0095	00	00	00
850	0.0038	0.0041	0.0055	0.0021	00	00	00
855	0.0037	0.0039	0.0053	00	00	00	00
860	0.0036	0.0038	0.0051	00	00	00	00
865	0.0035	0.0036	0.0049	00	00	00	00
870	0.0033	0.0035	0.0047	00	00	00	00
875	0.0032	0.0034	0.0046	00	00	00	00
880	0.0031	0.0032	0.0044	00	00	00	00
885	0.0030	0.0031	0.0043	00	00	00	00
890	0.0030	0.0030	0.0041	00	00	00	00
895	0.0029	0.0029	0.0040	00	00	00	00
900	0.0028	0.0029	0.0039	00	00	00	00
905	0.0027	0.0028	0.0038	00	00	00	00
910	0.0027	0.0027	0.0037	00	00	00	00
915	0.0026	0.0026	0.0036	00	00	00	00
920	0.0025	0.0026	0.0035	00	00	00	00
925	0.0025	0.0025	0.0034	00	00	00	00

Table B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
930	0.0024	0.0024	0.0033	00	00	00	00
935	0.0024	0.0024	0.0033	00	00	00	00
940	0.0023	0.0023	0.0032	00	00	00	00
945	0.0023	0.0023	0.0031	00	00	00	00
950	0.0022	0.0022	0.0030	00	00	00	00
955	0.0022	0.0022	0.0030	00	00	00	00
960	0.0021	0.0021	0.0029	00	00	00	00
965	0.0021	0.0021	0.0029	00	00	00	00
970	0.0021	0.0020	0.0028	00	00	00	00
975	0.0020	0.0020	0.0028	00	00	00	00
980	06	0.0019	0.0027	00	00	00	00
985	00	0.0019	0.0026	00	00	00	00
990	00	0.0019	0.0026	00	00	00	00
995	00	0.0018	0.0025	00	00	00	00
1000	00	0.0018	00	00	00	00	00
1005	00	0.0018	00	00	00	00	00
1010	00	0.0017	00	00	00	00	00
1015	00	0.0017	00	00	00	00	00
1020	00	0.0017	00	00	00	00	00
1025	00	0.0016	00	00	00	00	00
1030	00	0.0016	00	00	00	00	00
1035	00	0.0016	00	00	00	00	00
1040	00	0.0016	00	00	00	00	00
1045	00	0.0015	00	00	00	00	00
1050	00	0.0015	00	00	00	00	00
1055	00	0.0015	00	00	00	00	00
1060	00	0.0015	00	00	00	00	00
1065	00	0.0015	00	00	00	00	00
1070	00	0.0014	00	00	00	00	00
1075	00	0.0014	00	00	00	00	00
1080	00	0.0014	00	00	00	00	00
1085	00	0.0014	00	00	00	00	00
1090	00	0.0014	00	00	00	00	00
1095	00	0.0013	00	00	00	00	00
1100	00	0.0013	00	00	00	00	00
1105	00	0.0013	00	00	00	00	00
1110	00	0.0013	00	00	00	00	00
1115	00	0.0013	00	00	00	00	00
1120	00	0.0013	00	00	00	00	00

Table B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
1125	00	0.0012	00	00	00	00	00
1130	00	0.0012	00	00	00	00	00
1135	00	0.0012	00	00	00	00	00
1140	00	0.0012	00	00	00	00	00
1145	00	0.0012	00	00	00	00	00
1150	00	0.0012	00	00	00	00	00
1155	00	0.0012	00	00	00	00	00
1160	00	0.0011	00	00	00	00	00
1165	00	0.0011	00	00	00	00	00
1170	00	0.0011	00	00	00	00	00
1175	00	0.0011	00	00	00	00	00
1180	00	0.0011	00	00	00	00	00
1185	00	0.0011	00	00	00	00	00
1190	00	0.0011	00	00	00	00	00
1195	00	0.0011	00	00	00	00	00
1200	00	0.0010	00	00	00	00	00
1205	00	0.0010	00	00	00	00	00
1210	00	0.0010	00	00	00	00	00
1215	00	0.0010	00	00	00	00	00
1220	00	0.0010	00	00	00	00	00
1225	00	0.0010	00	00	00	00	00
1230	00	0.0010	00	00	00	00	00
1235	00	0.0010	00	00	00	00	00
1240	00	0.0010	00	00	00	00	00
1245	00	0.0010	00	00	00	00	00
1250	00	0.0010	00	00	00	00	00
1255	00	09	00	00	00	00	00
1260	00	09	00	00	00	00	00
1265	00	09	00	00	00	00	00
1270	00	09	00	00	00	00	00
1275	00	09	00	00	00	00	00
1280	00	09	00	00	00	00	00
1285	00	09	00	00	00	00	00
1290	00	09	00	00	00	00	00
1295	00	09	00	00	00	00	00
1300	00	09	00	00	00	00	00
1305	00	09	00	00	00	00	00
1310	00	09	00	00	00	00	00
1315	00	09	00	00	00	00	00

Table B2: Incremental Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000-year
1320	00	08	00	00	00	00	00
1325	00	08	00	00	00	00	00
1330	00	08	00	00	00	00	00
1335	00	08	00	00	00	00	00
1340	00	08	00	00	00	00	00
1345	00	08	00	00	00	00	00
1350	00	08	00	00	00	00	00
1355	00	08	00	00	00	00	00
1360	00	08	00	00	00	00	00
1365	00	06	00	00	00	00	00
1370	00	00	00	00	00	00	00
1375	00	00	00	00	00	00	00
1380	00	00	00	00	00	00	00
1385	00	00	00	00	00	00	00
1390	00	00	00	00	00	00	00
1395	00	00	00	00	00	00	00
1400	00	00	00	00	00	00	00
1405	00	00	00	00	00	00	00
1410	00	00	00	00	00	00	00
1415	00	00	00	00	00	00	00
1420	00	00	00	00	00	00	00
1425	00	00	00	00	00	00	00
1430	00	00	00	00	00	00	00
1435	00	00	00	00	00	00	00
1440	00	00	00	00	00	00	00

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
0	0.001	0.001	0.001	0.002	0.002	0.002	0.003
5	0.002	0.001	0.002	0.003	0.004	0.004	0.006
10	0.002	0.002	0.003	0.005	0.006	0.007	0.009
15	0.003	0.003	0.004	0.007	0.008	0.009	0.012
20	0.004	0.004	0.005	0.009	0.010	0.011	0.016
25	0.005	0.004	0.006	0.010	0.012	0.014	0.019
30	0.006	0.005	0.007	0.012	0.014	0.016	0.022
35	0.007	0.006	0.008	0.014	0.016	0.018	0.025
40	0.007	0.007	0.009	0.016	0.018	0.020	0.028
45	0.008	0.007	0.010	0.018	0.020	0.023	0.032
50	0.009	0.008	0.012	0.019	0.022	0.025	0.035
55	0.010	0.009	0.013	0.021	0.024	0.028	0.038
60	0.011	0.010	0.014	0.023	0.026	0.030	0.042
65	0.012	0.010	0.015	0.025	0.028	0.032	0.045
70	0.013	0.011	0.016	0.027	0.031	0.035	0.048
75	0.013	0.012	0.017	0.029	0.033	0.037	0.052
80	0.014	0.013	0.018	0.031	0.035	0.040	0.055
85	0.015	0.014	0.019	0.032	0.037	0.042	0.059
90	0.016	0.014	0.021	0.034	0.039	0.045	0.062
95	0.017	0.015	0.022	0.036	0.042	0.047	0.066
100	0.018	0.016	0.023	0.038	0.044	0.050	0.069
105	0.019	0.017	0.024	0.040	0.046	0.052	0.073
110	0.020	0.018	0.025	0.042	0.048	0.055	0.076
115	0.021	0.018	0.026	0.044	0.051	0.058	0.080
120	0.022	0.019	0.028	0.046	0.053	0.060	0.084
125	0.023	0.020	0.029	0.048	0.055	0.063	0.087
130	0.024	0.021	0.030	0.050	0.058	0.066	0.091
135	0.024	0.022	0.031	0.052	0.060	0.068	0.095
140	0.025	0.023	0.033	0.054	0.062	0.071	0.099
145	0.026	0.024	0.034	0.056	0.065	0.074	0.102
150	0.027	0.024	0.035	0.059	0.067	0.077	0.106
155	0.028	0.025	0.036	0.061	0.070	0.079	0.110
160	0.029	0.026	0.038	0.063	0.072	0.082	0.114
165	0.030	0.027	0.039	0.065	0.075	0.085	0.118
170	0.031	0.028	0.040	0.067	0.077	0.088	0.122
175	0.032	0.029	0.042	0.069	0.080	0.091	0.126
180	0.033	0.030	0.043	0.072	0.082	0.094	0.130
185	0.034	0.031	0.044	0.074	0.085	0.097	0.134
190	0.036	0.032	0.046	0.076	0.087	0.100	0.138
195	0.037	0.033	0.047	0.078	0.090	0.103	0.142

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
200	0.038	0.034	0.048	0.081	0.092	0.106	0.147
205	0.039	0.035	0.050	0.083	0.095	0.109	0.151
210	0.040	0.036	0.051	0.085	0.098	0.112	0.155
215	0.041	0.037	0.053	0.088	0.101	0.115	0.159
220	0.042	0.038	0.054	0.090	0.103	0.118	0.164
225	0.043	0.039	0.055	0.093	0.106	0.121	0.168
230	0.044	0.040	0.057	0.095	0.109	0.124	0.173
235	0.045	0.041	0.058	0.097	0.112	0.128	0.177
240	0.046	0.042	0.060	0.100	0.114	0.131	0.182
245	0.048	0.043	0.061	0.102	0.117	0.134	0.186
250	0.049	0.044	0.063	0.105	0.120	0.137	0.191
255	0.050	0.045	0.064	0.107	0.123	0.141	0.195
260	0.051	0.046	0.066	0.110	0.126	0.144	0.200
265	0.052	0.047	0.067	0.113	0.129	0.148	0.205
270	0.054	0.048	0.069	0.115	0.132	0.151	0.210
275	0.055	0.049	0.071	0.118	0.135	0.155	0.215
280	0.056	0.051	0.072	0.121	0.138	0.158	0.220
285	0.057	0.052	0.074	0.123	0.141	0.162	0.225
290	0.058	0.053	0.076	0.126	0.144	0.165	0.230
295	0.060	0.054	0.077	0.129	0.148	0.169	0.235
300	0.061	0.055	0.079	0.132	0.151	0.173	0.240
305	0.062	0.056	0.081	0.135	0.154	0.176	0.245
310	0.064	0.058	0.082	0.137	0.157	0.180	0.250
315	0.065	0.059	0.084	0.140	0.161	0.184	0.256
320	0.066	0.060	0.086	0.143	0.164	0.188	0.261
325	0.068	0.061	0.088	0.146	0.168	0.192	0.267
330	0.069	0.063	0.089	0.149	0.171	0.196	0.272
335	0.070	0.064	0.091	0.152	0.174	0.200	0.278
340	0.072	0.065	0.093	0.155	0.178	0.204	0.283
345	0.073	0.067	0.095	0.159	0.182	0.208	0.289
350	0.075	0.068	0.097	0.162	0.185	0.212	0.295
355	0.076	0.069	0.099	0.165	0.189	0.217	0.301
360	0.078	0.071	0.101	0.168	0.193	0.221	0.307
365	0.079	0.072	0.103	0.172	0.196	0.225	0.313
370	0.081	0.074	0.105	0.175	0.200	0.230	0.319
375	0.082	0.075	0.107	0.178	0.204	0.234	0.325
380	0.084	0.076	0.109	0.182	0.208	0.239	0.332
385	0.085	0.078	0.111	0.185	0.212	0.244	0.338
390	0.087	0.079	0.113	0.189	0.216	0.248	0.345
395	0.088	0.081	0.115	0.192	0.220	0.253	0.351

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
400	0.090	0.083	0.117	0.196	0.224	0.258	0.358
405	0.092	0.084	0.120	0.200	0.229	0.263	0.365
410	0.093	0.086	0.122	0.203	0.233	0.268	0.372
415	0.095	0.087	0.124	0.207	0.237	0.273	0.379
420	0.097	0.089	0.126	0.211	0.242	0.278	0.386
425	0.099	0.091	0.129	0.215	0.246	0.283	0.394
430	0.100	0.092	0.131	0.219	0.251	0.289	0.401
435	0.102	0.094	0.134	0.223	0.256	0.294	0.409
440	0.104	0.096	0.136	0.227	0.260	0.300	0.416
445	0.106	0.098	0.139	0.232	0.265	0.305	0.424
450	0.108	0.100	0.141	0.236	0.270	0.311	0.432
455	0.110	0.102	0.144	0.240	0.275	0.317	0.440
460	0.112	0.103	0.147	0.245	0.280	0.323	0.449
465	0.114	0.105	0.149	0.249	0.285	0.329	0.457
470	0.116	0.107	0.152	0.254	0.291	0.335	0.466
475	0.118	0.110	0.155	0.259	0.296	0.342	0.475
480	0.120	0.112	0.158	0.263	0.302	0.348	0.484
485	0.122	0.114	0.161	0.268	0.307	0.355	0.493
490	0.124	0.116	0.164	0.273	0.313	0.362	0.502
495	0.127	0.118	0.167	0.279	0.319	0.368	0.512
500	0.129	0.120	0.170	0.284	0.325	0.376	0.522
505	0.131	0.123	0.173	0.289	0.331	0.383	0.532
510	0.134	0.125	0.177	0.295	0.337	0.390	0.542
515	0.136	0.128	0.180	0.300	0.344	0.398	0.553
520	0.139	0.130	0.183	0.306	0.350	0.406	0.564
525	0.141	0.133	0.187	0.312	0.357	0.414	0.575
530	0.144	0.135	0.191	0.318	0.364	0.422	0.586
535	0.147	0.138	0.194	0.324	0.371	0.430	0.598
540	0.149	0.141	0.198	0.331	0.379	0.439	0.610
545	0.152	0.144	0.202	0.337	0.386	0.448	0.623
550	0.155	0.147	0.206	0.344	0.394	0.457	0.635
555	0.158	0.150	0.210	0.351	0.402	0.467	0.649
560	0.161	0.153	0.215	0.359	0.410	0.477	0.663
565	0.164	0.156	0.219	0.366	0.419	0.487	0.677
570	0.168	0.160	0.224	0.374	0.428	0.498	0.691
575	0.171	0.163	0.229	0.382	0.437	0.509	0.707
580	0.175	0.167	0.234	0.390	0.446	0.520	0.723
585	0.178	0.171	0.239	0.399	0.456	0.532	0.739
590	0.182	0.175	0.244	0.408	0.467	0.544	0.756
595	0.186	0.179	0.250	0.417	0.477	0.557	0.774

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
600	0.190	0.183	0.256	0.427	0.488	0.571	0.793
605	0.194	0.188	0.262	0.437	0.500	0.585	0.812
610	0.199	0.193	0.268	0.448	0.512	0.599	0.833
615	0.203	0.198	0.275	0.459	0.525	0.615	0.855
620	0.208	0.203	0.282	0.471	0.539	0.631	0.878
625	0.213	0.209	0.290	0.483	0.553	0.649	0.902
630	0.219	0.215	0.297	0.496	0.568	0.667	0.927
635	0.224	0.221	0.306	0.510	0.584	0.687	0.955
640	0.230	0.228	0.315	0.526	0.601	0.708	0.984
645	0.237	0.235	0.325	0.542	0.620	0.731	1.016
650	0.244	0.243	0.335	0.559	0.639	0.755	1.050
655	0.251	0.252	0.346	0.578	0.661	0.782	1.087
660	0.259	0.262	0.359	0.598	0.684	0.811	1.128
665	0.268	0.272	0.372	0.621	0.710	0.844	1.173
670	0.278	0.284	0.387	0.646	0.739	0.880	1.223
675	0.288	0.298	0.404	0.675	0.771	0.921	1.280
680	0.301	0.313	0.424	0.707	0.809	0.968	1.346
685	0.315	0.331	0.447	0.745	0.852	1.023	1.422
690	0.331	0.353	0.474	0.790	0.903	1.089	1.514
695	0.351	0.380	0.507	0.846	0.966	1.171	1.628
700	0.376	0.415	0.550	0.918	1.048	1.278	1.776
705	0.410	0.465	0.610	1.017	1.161	1.427	1.983
710	0.463	0.544	0.705	1.174	1.339	1.662	2.309
715	0.569	0.705	0.899	1.494	1.702	2.143	2.968
720	0.778	1.005	1.268	2.102	2.390	3.031	4.175
725	0.849	1.113	1.396	2.315	2.631	3.352	4.616
730	0.890	1.174	1.470	2.437	2.770	3.535	4.871
735	0.919	1.215	1.520	2.521	2.865	3.660	5.044
740	0.942	1.246	1.558	2.584	2.937	3.753	5.173
745	0.960	1.270	1.588	2.634	2.993	3.826	5.275
750	0.975	1.290	1.613	2.675	3.040	3.886	5.358
755	0.988	1.307	1.634	2.710	3.080	3.937	5.429
760	0.999	1.321	1.652	2.740	3.115	3.981	5.490
765	1.010	1.334	1.668	2.767	3.145	4.019	5.537
770	1.019	1.345	1.682	2.791	3.173	4.054	5.537
775	1.027	1.355	1.695	2.812	3.197	4.084	5.537
780	1.035	1.364	1.707	2.832	3.220	4.112	5.537
785	1.042	1.372	1.718	2.850	3.240	4.138	5.537
790	1.049	1.380	1.728	2.867	3.259	4.161	5.537
795	1.055	1.387	1.737	2.882	3.277	4.183	5.537

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
800	1.061	1.394	1.746	2.897	3.294	4.204	5.537
805	1.066	1.400	1.754	2.911	3.309	4.210	5.537
810	1.072	1.406	1.762	2.923	3.324	4.210	5.537
815	1.077	1.411	1.769	2.936	3.338	4.210	5.537
820	1.081	1.416	1.776	2.947	3.340	4.210	5.537
825	1.086	1.421	1.783	2.958	3.340	4.210	5.537
830	1.090	1.426	1.789	2.968	3.340	4.210	5.537
835	1.094	1.431	1.795	2.978	3.340	4.210	5.537
840	1.098	1.435	1.800	2.988	3.340	4.210	5.537
845	1.102	1.439	1.806	2.990	3.340	4.210	5.537
850	1.106	1.443	1.811	2.990	3.340	4.210	5.537
855	1.109	1.447	1.816	2.990	3.340	4.210	5.537
860	1.113	1.450	1.821	2.990	3.340	4.210	5.537
865	1.116	1.454	1.826	2.990	3.340	4.210	5.537
870	1.119	1.457	1.830	2.990	3.340	4.210	5.537
875	1.122	1.460	1.835	2.990	3.340	4.210	5.537
880	1.126	1.463	1.839	2.990	3.340	4.210	5.537
885	1.129	1.466	1.843	2.990	3.340	4.210	5.537
890	1.131	1.469	1.847	2.990	3.340	4.210	5.537
895	1.134	1.472	1.851	2.990	3.340	4.210	5.537
900	1.137	1.475	1.855	2.990	3.340	4.210	5.537
905	1.140	1.478	1.859	2.990	3.340	4.210	5.537
910	1.142	1.480	1.862	2.990	3.340	4.210	5.537
915	1.145	1.483	1.866	2.990	3.340	4.210	5.537
920	1.147	1.485	1.869	2.990	3.340	4.210	5.537
925	1.150	1.488	1.873	2.990	3.340	4.210	5.537
930	1.152	1.490	1.876	2.990	3.340	4.210	5.537
935	1.154	1.492	1.879	2.990	3.340	4.210	5.537
940	1.157	1.495	1.882	2.990	3.340	4.210	5.537
945	1.159	1.497	1.885	2.990	3.340	4.210	5.537
950	1.161	1.499	1.888	2.990	3.340	4.210	5.537
955	1.163	1.501	1.891	2.990	3.340	4.210	5.537
960	1.165	1.503	1.894	2.990	3.340	4.210	5.537
965	1.167	1.505	1.897	2.990	3.340	4.210	5.537
970	1.169	1.507	1.900	2.990	3.340	4.210	5.537
975	1.170	1.509	1.902	2.990	3.340	4.210	5.537
980	1.170	1.511	1.905	2.990	3.340	4.210	5.537
985	1.170	1.513	1.908	2.990	3.340	4.210	5.537
990	1.170	1.515	1.910	2.990	3.340	4.210	5.537
995	1.170	1.517	1.910	2.990	3.340	4.210	5.537

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
1000	1.170	1.518	1.910	2.990	3.340	4.210	5.537
1005	1.170	1.520	1.910	2.990	3.340	4.210	5.537
1010	1.170	1.522	1.910	2.990	3.340	4.210	5.537
1015	1.170	1.523	1.910	2.990	3.340	4.210	5.537
1020	1.170	1.525	1.910	2.990	3.340	4.210	5.537
1025	1.170	1.527	1.910	2.990	3.340	4.210	5.537
1030	1.170	1.528	1.910	2.990	3.340	4.210	5.537
1035	1.170	1.530	1.910	2.990	3.340	4.210	5.537
1040	1.170	1.531	1.910	2.990	3.340	4.210	5.537
1045	1.170	1.533	1.910	2.990	3.340	4.210	5.537
1050	1.170	1.534	1.910	2.990	3.340	4.210	5.537
1055	1.170	1.536	1.910	2.990	3.340	4.210	5.537
1060	1.170	1.537	1.910	2.990	3.340	4.210	5.537
1065	1.170	1.539	1.910	2.990	3.340	4.210	5.537
1070	1.170	1.540	1.910	2.990	3.340	4.210	5.537
1075	1.170	1.542	1.910	2.990	3.340	4.210	5.537
1080	1.170	1.543	1.910	2.990	3.340	4.210	5.537
1085	1.170	1.544	1.910	2.990	3.340	4.210	5.537
1090	1.170	1.546	1.910	2.990	3.340	4.210	5.537
1095	1.170	1.547	1.910	2.990	3.340	4.210	5.537
1100	1.170	1.548	1.910	2.990	3.340	4.210	5.537
1105	1.170	1.550	1.910	2.990	3.340	4.210	5.537
1110	1.170	1.551	1.910	2.990	3.340	4.210	5.537
1115	1.170	1.552	1.910	2.990	3.340	4.210	5.537
1120	1.170	1.553	1.910	2.990	3.340	4.210	5.537
1125	1.170	1.555	1.910	2.990	3.340	4.210	5.537
1130	1.170	1.556	1.910	2.990	3.340	4.210	5.537
1135	1.170	1.557	1.910	2.990	3.340	4.210	5.537
1140	1.170	1.558	1.910	2.990	3.340	4.210	5.537
1145	1.170	1.559	1.910	2.990	3.340	4.210	5.537
1150	1.170	1.561	1.910	2.990	3.340	4.210	5.537
1155	1.170	1.562	1.910	2.990	3.340	4.210	5.537
1160	1.170	1.563	1.910	2.990	3.340	4.210	5.537
1165	1.170	1.564	1.910	2.990	3.340	4.210	5.537
1170	1.170	1.565	1.910	2.990	3.340	4.210	5.537
1175	1.170	1.566	1.910	2.990	3.340	4.210	5.537
1180	1.170	1.567	1.910	2.990	3.340	4.210	5.537
1185	1.170	1.568	1.910	2.990	3.340	4.210	5.537
1190	1.170	1.569	1.910	2.990	3.340	4.210	5.537
1195	1.170	1.570	1.910	2.990	3.340	4.210	5.537

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
1200	1.170	1.571	1.910	2.990	3.340	4.210	5.537
1205	1.170	1.573	1.910	2.990	3.340	4.210	5.537
1210	1.170	1.574	1.910	2.990	3.340	4.210	5.537
1215	1.170	1.575	1.910	2.990	3.340	4.210	5.537
1220	1.170	1.576	1.910	2.990	3.340	4.210	5.537
1225	1.170	1.577	1.910	2.990	3.340	4.210	5.537
1230	1.170	1.577	1.910	2.990	3.340	4.210	5.537
1235	1.170	1.578	1.910	2.990	3.340	4.210	5.537
1240	1.170	1.579	1.910	2.990	3.340	4.210	5.537
1245	1.170	1.580	1.910	2.990	3.340	4.210	5.537
1250	1.170	1.581	1.910	2.990	3.340	4.210	5.537
1255	1.170	1.582	1.910	2.990	3.340	4.210	5.537
1260	1.170	1.583	1.910	2.990	3.340	4.210	5.537
1265	1.170	1.584	1.910	2.990	3.340	4.210	5.537
1270	1.170	1.585	1.910	2.990	3.340	4.210	5.537
1275	1.170	1.586	1.910	2.990	3.340	4.210	5.537
1280	1.170	1.587	1.910	2.990	3.340	4.210	5.537
1285	1.170	1.588	1.910	2.990	3.340	4.210	5.537
1290	1.170	1.589	1.910	2.990	3.340	4.210	5.537
1295	1.170	1.589	1.910	2.990	3.340	4.210	5.537
1300	1.170	1.590	1.910	2.990	3.340	4.210	5.537
1305	1.170	1.591	1.910	2.990	3.340	4.210	5.537
1310	1.170	1.592	1.910	2.990	3.340	4.210	5.537
1315	1.170	1.593	1.910	2.990	3.340	4.210	5.537
1320	1.170	1.594	1.910	2.990	3.340	4.210	5.537
1325	1.170	1.595	1.910	2.990	3.340	4.210	5.537
1330	1.170	1.595	1.910	2.990	3.340	4.210	5.537
1335	1.170	1.596	1.910	2.990	3.340	4.210	5.537
1340	1.170	1.597	1.910	2.990	3.340	4.210	5.537
1345	1.170	1.598	1.910	2.990	3.340	4.210	5.537
1350	1.170	1.599	1.910	2.990	3.340	4.210	5.537
1355	1.170	1.599	1.910	2.990	3.340	4.210	5.537
1360	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1365	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1370	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1375	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1380	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1385	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1390	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1395	1.170	1.600	1.910	2.990	3.340	4.210	5.537

Table B3: Cumulative Hyetographs for 10000-, 1000-, 200-, 100-, 10-, 5-, and 2-year Storms

Time (min)	2-Year	5-year	10-year	100-Year	200-Year	1,000-year	10,000yr
1400	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1405	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1410	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1415	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1420	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1425	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1430	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1435	1.170	1.600	1.910	2.990	3.340	4.210	5.537
1440	1.170	1.600	1.910	2.990	3.340	4.210	5.537

ATTACHMENT C

GREEN-AMPT RAINFALL LOSS INPUT PARAMETERS

Table C1: 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	0.250	0.5	4.956	0.257	0.0

Table C2: 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	0.250	0.500	4.956	0.257	0.0

Table C3: 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	0	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

Table C4: 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

Table C5: Temporary Haul Road, 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	0.250	0.5	3.600	0.460	43.56
01a	0	0	0.250	0.5	3.600	0.460	0.02
01b	0	0	0.250	0.5	3.600	0.460	0.00
02	0	0	0.250	0.5	3.600	0.460	21.96
03	0	0	0.250	0.5	3.600	0.460	0.02
04	0	0	0.250	0.5	4.720	0.240	21.82
05	0	0	0.250	0.5	3.600	0.460	0.00
06	0	0	0.250	0.5	5.200	0.200	49.57
07	0	0	0.250	0.5	3.600	0.460	21.33
08	0	0	0.250	0.5	3.600	0.460	47.17
09	0	0	0.250	0.5	3.600	0.460	0.06
10	0	0	0.250	0.5	3.600	0.460	20.98
11	0	0	0.250	0.5	3.600	0.460	20.55
12	0	0	0.350	0.5	7.000	0.100	47.31
13	0	0	0.250	0.5	3.600	0.460	0.00
14	0	0	0.250	0.5	4.720	0.240	0.06
15	0	0	0.250	0.5	5.200	0.200	31.04
16	0	0	0.250	0.5	4.720	0.240	0.00
17	0	0	0.250	0.5	4.400	0.300	36.92
18	0	0	0.250	0.5	3.600	0.460	0.00
19	0	0	0.250	0.5	4.400	0.300	32.01
20	0	0	0.250	0.5	4.720	0.240	0.00
21	0	0	0.250	0.5	4.720	0.240	0.00
22	0	0	0.250	0.5	3.600	0.460	0.00
23	0	0	0.250	0.5	3.600	0.460	10.47
24	0	0	0.250	0.5	4.720	0.240	3.57
25	0	0	0.386	0.5	6.03	0.075	60.90
26	0	0	0.250	0.5	3.600	0.460	1.09
27	0	0	0.45	0.5	11	0.01	99.55
28	0	0.1	0.250	0.5	4.720	0.240	0.00

ATTACHMENT D

CLARK UNIT HYDROGRAPH PARAMETERS CALCULATION TABLES

Table D1: Pipeline Arroyo, Existing Condition Clark Unit Hydrograph Parameters

Subbasin	Tc Calculation Procedure	Tc Varies?	1hr PMP		100yr		2yr	
			Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)
0	Sabol Equation	No	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066
1	Velocity Method	Yes	0.19626	0.14017	0.21983	0.15898	0.88287	0.74399
2	Sabol Equation	No	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152
3	Velocity Method	Yes	0.20322	0.20410	0.27126	0.28123	0.99802	1.19413
4	Velocity Method	Yes	0.36465	0.41942	0.44529	0.52354	1.58909	2.14900
5	Velocity Method	Yes	0.38303	0.34807	0.46326	0.42987	1.51603	1.60272
9	Sabol Equation	No	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191
10	Sabol Equation	No	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827
16	Velocity Method	Yes	0.23022	0.19222	0.27922	0.23815	1.14287	1.13818
17	Sabol Equation	No	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071
18	Sabol Equation	No	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130
19	Sabol Equation	No	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100
20	Sabol Equation	No	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624
21	Sabol Equation	No	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254
22	Sabol Equation	No	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134
23	Sabol Equation	No	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285
24	Sabol Equation	No	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051
25	Sabol Equation	No	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462
26	Sabol Equation	No	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956
27	Velocity Method	Yes	0.84749	0.92134	1.05950	1.18047	2.16905	2.61488
31	Sabol Equation	No	0.69014	0.59450	0.69014	0.59450	0.69014	0.59450
32	Velocity Method	Yes	0.20245	0.15199	0.25464	0.19606	1.32967	1.22791
33	Velocity Method	Yes	0.09311	0.06471	0.10180	0.07145	0.26970	0.21070
34	Velocity Method	Yes	0.06522	0.05730	0.07467	0.06658	0.18121	0.17815
35	Velocity Method	Yes	0.06656	0.03465	0.07292	0.03834	0.18021	0.10468
36	Velocity Method	Yes	0.10350	0.10941	0.11440	0.12226	0.19880	0.22579
37	Velocity Method	Yes	0.25936	0.32659	0.30595	0.39231	0.66104	0.92260
38	Sabol Equation	No	0.23437	0.25095	0.23437	0.25095	0.23437	0.25095
39	Velocity Method	Yes	0.44047	0.40850	0.54909	0.52173	1.47216	1.55909
42	Sabol Equation	No	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318
43	Sabol Equation	No	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524
44	Velocity Method	Yes	0.32165	0.24868	0.35796	0.28003	0.51421	0.41861

Note: Green Cells indicate Sabol Equation for Tc

Table D2: Pipeline Arroyo, Post-RA Condition Clark Unit Hydrograph Parameters

Sub-basin	Tc Calc. Method	Tc Varies?	1hr PMP		10,000yr		1,000yr		200yr		100yr		10yr		5yr		2yr	
			Tc	R	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)
0	Sabol	No	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066	1.08053	1.19066
1	Velocity	Yes	0.19626	0.14017	0.19626	0.14017	0.19980	0.14299	0.21239	0.15302	0.15898	0.15898	0.26770	0.19784	0.30633	0.22977	0.88412	0.74516
2	Sabol	No	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152	0.68535	0.57152
3	Velocity	Yes	0.20127	0.20193	0.20127	0.20193	0.21466	0.21689	0.24159	0.24730	0.26812	0.26812	0.39568	0.42762	0.60080	0.67982	0.99942	1.19597
4	Velocity	Yes	0.36465	0.41942	0.36465	0.41942	0.39241	0.45501	0.42437	0.49631	0.52354	0.52354	0.59708	0.72503	0.89425	1.13522	1.59024	2.15073
5	Velocity	Yes	0.38303	0.34807	0.38303	0.34807	0.41392	0.37936	0.44373	0.40980	0.42987	0.42987	0.60772	0.58101	0.79743	0.78551	1.51706	1.60393
9	Sabol	No	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191	0.49030	0.27191
10	Sabol	No	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827	0.67344	0.42827
16	Velocity	Yes	0.23022	0.19222	0.23022	0.19222	0.24189	0.20307	0.26506	0.22477	0.23815	0.23815	0.37942	0.33470	0.48256	0.43709	1.14351	1.13889
17	Sabol	No	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071	0.77272	0.61071
18	Sabol	No	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130	1.14837	0.98130
19	Sabol	No	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100	0.84318	0.57100
20	Sabol	No	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624	0.74284	0.45624
21	Sabol	No	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254	0.67698	0.49254
22	Sabol	No	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134	1.40214	0.74134
23	Sabol	No	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285	1.09292	0.56285
24	Sabol	No	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051	1.46097	0.98051
25	Sabol	No	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462	1.61244	0.94462
26	Sabol	No	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956	1.35871	0.77956
27	Velocity	Yes	0.86958	1.02210	0.86958	1.02210	0.97670	1.16277	1.05426	1.26570	1.15082	1.32770	1.38202	1.70935	1.59502	2.00415	2.12887	2.51954
31	Sabol	No	0.81504	0.69580	0.81504	0.69580	0.81504	0.69580	0.81504	0.69580	0.81504	0.69580	0.81504	0.69580	0.81504	0.69580	0.81504	0.69580
37	Velocity	Yes	0.25936	0.32659	0.25936	0.32659	0.26905	0.34016	0.29243	0.37312	0.39231	0.39231	0.38963	0.51309	0.45871	0.61499	0.66113	0.92274
38	Sabol	No	0.23437	0.25095														
39	Velocity	Yes	0.44047	0.40850	0.44047	0.40850	0.47673	0.44599	0.52054	0.49171	0.52172	0.52173	0.80332	0.79592	1.19280	1.23434	1.47315	1.56025
42	Sabol	No	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318	0.71338	0.61318
43	Sabol	No	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524	0.98427	0.60524
44	Velocity Method	Yes	0.26619	0.20826	0.26619	0.20826	0.26749	0.20939	0.28317	0.22305	0.20500	0.20506	0.33275	0.26681	0.35499	0.28667	0.44085	0.28305

Note: Green Cells indicate Sabol Equation for Tc

Table D3: Mill Site, Post-RA Condition Clark Unit Hydrograph Parameters

Subbasin	Tc Calculation Procedure	Tc Varies?	1hr PMP		10yr		2yr	
			Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)	Tc (hrs)	R (hrs)
0	Velocity Method	Yes	0.11580	0.14210	0.19115	0.24786	0.33437	0.46109
1	Velocity Method	Yes	0.14949	0.32630	0.32276	0.76676	0.85353	2.25660
2	Velocity Method	Yes	0.16181	0.29308	0.27980	0.53827	0.56714	1.17922
3	Velocity Method	Yes	0.12637	0.12448	0.18602	0.19119	0.27877	0.29955
4	Velocity Method	Yes	0.33112	0.38433	0.41530	0.49420	0.52369	0.63929
5	Velocity Method	Yes	0.29129	0.24058	0.38432	0.32725	0.56059	0.61347
6	Velocity Method	Yes	0.33670	0.47863	0.75819	1.17844	1.70244	2.89230
7	Velocity Method	Yes	0.17353	0.11154	0.22825	0.15120	0.28992	0.19717
12	Velocity Method	Yes	0.30666	0.47647	0.63311	1.06534	1.40169	2.57415
14	Velocity Method	Yes	0.17183	0.28441	0.23978	0.41168	0.34608	0.61869
16	Velocity Method	Yes	0.17705	0.28640	0.33441	0.58016	0.69785	1.31273
32	Sabol Equation	No	0.32368	0.32666	0.32368	0.32666	0.32368	0.32666
33	Sabol Equation	No	0.49875	0.28830	0.49875	0.28830	0.49875	0.28830
34	Sabol Equation	No	0.49783	0.33100	0.49783	0.33100	0.49783	0.33100
35	Sabol Equation	No	0.44462	0.27039	0.44462	0.27039	0.44462	0.27039
36	Velocity Method	Yes	0.31159	0.42326	0.62541	0.91722	1.18960	1.87252
37	Velocity Method	Yes	0.26309	0.34384	0.45250	0.62775	0.82935	1.22985
38	Sabol Equation	No	0.23427	0.25036	0.23427	0.25036	0.23427	0.25036
39	Velocity Method	Yes	0.48753	0.47121	1.24255	1.33113	2.28036	2.61166
40	Velocity Method	Yes	0.29879	0.73000	0.72554	1.95434	1.67067	4.93260
41	Velocity Method	Yes	0.22193	0.19497	0.35001	0.32331	0.62617	0.61660

Note: Green Cells indicate Sabol Equation for Tc

Table D4: Mine Site, RA-Phase 3 Construction Clark Unit Hydrograph Parameters

Subbasin	Tc Calc. Method	Tc Varies?	2yr	
			Tc (hrs)	R (hrs)
2	Velocity	Yes	0.77945	3.99196
3	Velocity	Yes	0.77945	2.82274
19	Sabol	No	0.33914	0.32630
20	Sabol	No	0.46383	0.40772
22	Velocity	Yes	0.26753	0.33553
23	Velocity	Yes	0.26979	0.15218
24	Velocity	Yes	0.13021	0.12343
25	Velocity	Yes	0.51695	0.65720
26	Velocity	Yes	0.14264	0.08075
27	Velocity	Yes	0.30976	0.37691
28	Sabol	No	0.26500	0.31072
29	Velocity	Yes	0.61481	0.64172
30	Velocity	Yes	0.55194	0.65948

Note: Green Cells indicate Sabol Equation for Tc

Table D5: Temporary Haul Road Stormwater Management; Clark Unit Hydrograph Parameters

Subbasin	Tc Calc. Method	Tc Varies?	10yr	
			Tc (hrs)	R (hrs)
00	Assigned*		0.08333	0.08333
01a	Assigned*		0.08333	0.08333
01b	Assigned*		0.08333	0.08333
02	Assigned*		0.08333	0.08333
03	Assigned*		0.08333	0.08333
04	Assigned*		0.08333	0.08333
05	Assigned*		0.08333	0.08333
06	Assigned*		0.08333	0.08333
07	Assigned*		0.08333	0.08333
08	Assigned*		0.08333	0.08333
09	Assigned*		0.08333	0.08333
10	Assigned*		0.08333	0.08333
11	Assigned*		0.08333	0.08333
12	Assigned*		0.08333	0.08333
13	Assigned*		0.08333	0.08333
14	Assigned*		0.08333	0.08333
15	Assigned*		0.08333	0.08333
16	Assigned*		0.08333	0.08333
17	Assigned*		0.08333	0.08333
18	Assigned*		0.08333	0.08333
19	Assigned*		0.08333	0.08333
20	Assigned*		0.08333	0.08333
21	Assigned*		0.08333	0.08333
22	Assigned*		0.08333	0.08333
23	Assigned*		0.08333	0.08333
24	Assigned*		0.08333	0.08333
25	Assigned*		0.08333	0.08333
26	Assigned*		0.08333	0.08333
27	Assigned*		0.08333	0.08333
28	Velocity	Yes	0.28317	0.26563

***Assigned Tc/R values of 5 minutes**

ATTACHMENT E

CHANNEL ROUTING PARAMETERS TABLES

Table E1: 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 E2: 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 E3: 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 E4: 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 F1: 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 F2: 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 F3: Stage-Area-Storage for Pond 3

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7056	7	017	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 F4: 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 F5: 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 F6: Stage-Area-Storage for Temporary Plug at Pond 3

Elevation (ft)	Area (ft^2)	Area (acres)	Storage (cf)	Storage (ac-ft)
7080	5	012	0	0
7081	62	0.00143	34	077
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 G1: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 1-Hour PMP

Element	Drainage Area (mi^2)	**Peak Discharge (cfs)**	**Runoff Volume (inches)**
D1	0.0101	45.7	4.759
J-R01ds	3.6051	6816.9	4.565
J-R01us	1.5412	3376.7	4.600
J-R03ds	4.8806	9031.2	4.519
J-R04ds	5.3089	9844.5	4.726
J-R04us	4.9180	9125.5	4.723
J-R05ds	5.5618	10245.9	4.707
J-R05us	5.3089	9844.5	4.726
J-R06ds	4.2027	6455.5	3.996
J-R06us	3.2122	4895.3	3.927
J-R07ds	9.2640	13151.1	4.049
J-R07us	8.8702	12986.1	4.183
J-R08ds	10.1275	14350.0	4.063
J-R08us	10.1275	14386.6	4.062
J-R09ds	0.8806	2483.1	4.443
J-R09us	0.3364	1041.2	4.203
J-R10ds	0.9043	2544.6	4.455
J-R10us	0.8806	2483.1	4.443
J-R11ds	0.9302	2584.6	4.464
J-R11us	0.9302	2616.1	4.457
J-R12ds	17.1037	25981.3	4.296
J-R12us	16.0868	24718.8	4.286
J-R15us	17.4125	26400.2	4.305
J-R16ds	0.0374	351.8	31.302
J-R16us	00	352.9	n/a
J-R2ds	0.6682	1696.6	4.451
J-R2us	0.6682	1711.4	4.450
J-R3us	4.8806	9040.9	4.517
Outlet/R15ds	17.6800	26443.5	4.313
Pond 1	0.0088	0.0	0
Pond 2	0.0269	0.0	0
Pond 4	0.0237	0.0	0
Pond 5	00	0.0	n/a
Pond3	0.4238	0.0	0
R01	1.5412	3361.8	4.602
R02	0.6682	1696.6	4.451
R03	4.8806	9031.2	4.519
R04	4.9180	9100.9	4.725
R05	5.3089	9803.1	4.729
R06	3.2122	4874.0	3.938
R07	8.8702	12968.1	4.191
R08	10.1275	14350.0	4.063
R09	0.3364	1031.4	4.204
R10	0.8806	2476.0	4.447
R11	0.9302	2584.6	4.464
R12	16.0868	24638.1	4.287
R13	0.0556	219.7	4.798
R14	0.1385	590.5	4.824
R15	17.4125	26367.0	4.306
R16	00	351.1	n/a
0	0.6073	849.2	4.307
1	0.1385	598.1	4.816
2	0.2528	569.3	4.252
3	0.0374	133.9	4.251
4	0.1464	411.5	4.456
5	0.0734	229.2	4.635

Table G1: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 1-Hour PMP

Element	Drainage Area (mi^2)	**Peak Discharge (cfs)**	**Runoff Volume (inches)**
9	0.3364	1041.2	4.203
10	0.5442	1488.0	4.591
16	0.0556	220.8	4.794
17	0.3975	821.7	4.095
18	0.8635	1304.7	4.203
19	0.3938	203.2	0.854
20	0.6682	1711.4	4.450
21	0.3909	1037.8	4.740
22	3.2122	4895.3	3.927
23	1.5412	3376.7	4.600
24	1.5612	2323.0	4.452
25	2.7471	3857.9	4.276
26	2.0639	3586.1	4.538
27	0.1623	321.8	5.074
31	0.3355	765.8	4.419
32	0.0783	320.0	4.565
33	0.0237	116.0	4.759
34	0.0088	40.8	4.120
35	0.0269	130.3	4.083
36	0.0101	45.7	4.759
37	0.0237	78.6	4.748
38	0.0259	91.4	4.550
39	0.0868	229.4	4.127
42	0.3593	812.7	4.484
43	0.9904	1987.5	4.186
44	0.0201	76.2	5.117

Table G2: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
D1	0.0101	21.0	0.974
J-R01ds	3.6051	1421.9	0.863
J-R01us	1.5412	731.4	0.884
J-R03ds	4.8806	1842.1	0.840
J-R04ds	5.3089	1985.1	0.850
J-R04us	4.9180	1845.6	0.839
J-R05ds	5.5618	2042.2	0.845
J-R05us	5.3089	1985.1	0.850
J-R06ds	4.2027	1140.4	0.681
J-R06us	3.2122	906.2	0.676
J-R07ds	9.2640	2328.4	0.692
J-R07us	8.8702	2333.3	0.720
J-R08ds	10.1275	2524.2	0.692
J-R08us	10.1275	2526.7	0.692
J-R09ds	0.8806	597.0	0.804
J-R09us	0.3364	256.8	0.689
J-R10ds	0.9043	609.9	0.809
J-R10us	0.8806	597.0	0.804
J-R11ds	0.9302	612.2	0.815
J-R11us	0.9302	621.6	0.810
J-R12ds	17.1037	4733.2	0.748
J-R12us	16.0868	4525.1	0.744
J-R15us	17.4125	4827.7	0.753
J-R16ds	0.0374	34.3	0.709
J-R16us	00	0.0	n/a
J-R2ds	0.6682	378.4	0.801
J-R2us	0.6682	384.7	0.799
J-R3us	4.8806	1843.2	0.838
Outlet/R15ds	17.6800	4826.2	0.758
Pond 1	0.0088	0.0	0
Pond 2	0.0269	0.0	0
Pond 4	0.0237	0.0	0
Pond 5	00	0.0	n/a
Pond3	0.4238	0.0	0
R01	1.5412	728.1	0.885
R02	0.6682	378.4	0.801
R03	4.8806	1842.1	0.840
R04	4.9180	1837.8	0.840
R05	5.3089	1978.7	0.851
R06	3.2122	903.0	0.681
R07	8.8702	2328.4	0.723
R08	10.1275	2524.2	0.692
R09	0.3364	251.9	0.689
R10	0.8806	594.8	0.805
R11	0.9302	612.2	0.815
R12	16.0868	4507.2	0.744
R13	0.0556	72.4	1.002
R14	0.1385	226.4	1.019
R15	17.4125	4811.7	0.754
R16	00	0.0	n/a
0	0.6073	159.8	0.735
1	0.1385	240.0	1.015
2	0.2528	118.5	0.709
3	0.0374	34.3	0.709
4	0.1464	91.3	0.802
5	0.0734	56.7	0.900

Table G2: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
9	0.3364	256.8	0.689
10	0.5442	365.9	0.875
16	0.0556	73.3	0.999
17	0.3975	154.4	0.638
18	0.8635	235.2	0.688
19	0.3938	0.0	0
20	0.6682	384.7	0.799
21	0.3909	266.6	0.966
22	3.2122	906.2	0.676
23	1.5412	731.4	0.884
24	1.5612	444.7	0.801
25	2.7471	686.1	0.722
26	2.0639	722.7	0.847
27	0.1623	71.7	1.240
31	0.3355	169.7	0.787
32	0.0783	105.7	0.860
33	0.0237	60.3	0.974
34	0.0088	18.5	0.651
35	0.0269	59.7	0.633
36	0.0101	21.0	0.974
37	0.0237	22.9	0.967
38	0.0259	30.5	0.850
39	0.0868	42.3	0.650
42	0.3593	181.9	0.812
43	0.9904	369.0	0.679
44	0.0201	28.0	1.277

Table G3: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
D1	0.0101	0.0	0
J-R01ds	3.6051	0.0	0
J-R01us	1.5412	0.0	0
J-R03ds	4.8806	0.0	0
J-R04ds	5.3089	0.0	0
J-R04us	4.9180	0.0	0
J-R05ds	5.5618	0.0	0
J-R05us	5.3089	0.0	0
J-R06ds	4.2027	1.7	0.001
J-R06us	3.2122	1.7	0.001
J-R07ds	9.2640	1.7	0.001
J-R07us	8.8702	1.7	0
J-R08ds	10.1275	1.7	0
J-R08us	10.1275	1.7	0
J-R09ds	0.8806	0.0	0
J-R09us	0.3364	0.0	0
J-R10ds	0.9043	0.0	0
J-R10us	0.8806	0.0	0
J-R11ds	0.9302	0.0	0
J-R11us	0.9302	0.0	0
J-R12ds	17.1037	1.7	0
J-R12us	16.0868	1.7	0
J-R15us	17.4125	3.6	0.001
J-R16ds	0.0374	0.0	0
J-R16us	00	0.0	n/a
J-R2ds	0.6682	0.0	0
J-R2us	0.6682	0.0	0
J-R3us	4.8806	0.0	0
Outlet/R15ds	17.6800	3.6	0.001
Pond 1	0.0088	0.0	0
Pond 2	0.0269	0.0	0
Pond 4	0.0237	0.0	0
Pond 5	00	0.0	n/a
Pond3	0.4238	0.0	0
R01	1.5412	0.0	0
R02	0.6682	0.0	0
R03	4.8806	0.0	0
R04	4.9180	0.0	0
R05	5.3089	0.0	0
R06	3.2122	1.7	0.001
R07	8.8702	1.7	0.001
R08	10.1275	1.7	0
R09	0.3364	0.0	0
R10	0.8806	0.0	0
R11	0.9302	0.0	0
R12	16.0868	1.7	0
R13	0.0556	0.0	0
R14	0.1385	0.0	0
R15	17.4125	3.6	0.001
R16	00	0.0	n/a
0	0.6073	0.0	0
1	0.1385	0.0	0
2	0.2528	0.0	0
3	0.0374	0.0	0
4	0.1464	0.0	0
5	0.0734	0.0	0

Table G3: HEC-HMS Model Results for Pipeline Arroyo, Existing Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
9	0.3364	0.0	0
10	0.5442	0.0	0
16	0.0556	0.0	0
17	0.3975	0.0	0
18	0.8635	0.0	0
19	0.3938	0.0	0
20	0.6682	0.0	0
21	0.3909	0.0	0
22	3.2122	1.7	0.001
23	1.5412	0.0	0
24	1.5612	0.0	0
25	2.7471	0.0	0
26	2.0639	0.0	0
27	0.1623	3.2	0.117
31	0.3355	0.0	0
32	0.0783	0.0	0
33	0.0237	0.0	0
34	0.0088	0.0	0
35	0.0269	0.0	0
36	0.0101	0.0	0
37	0.0237	0.0	0
38	0.0259	0.0	0
39	0.0868	0.0	0
42	0.3593	0.0	0
43	0.9904	0.0	0
44	0.0201	2.4	0.130

Table G4: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	6816.9	4.565
J-R01us	1.5412	3376.7	4.600
J-R03ds	4.8806	9031.3	4.519
J-R04ds	5.7921	10713.4	4.525
J-R04us	5.4012	9962.8	4.508
J-R05ds	6.0450	11144.4	4.516
J-R05us	5.7921	10713.4	4.525
J-R06ds	4.2027	6281.3	3.882
J-R06us	3.2122	4746.1	3.777
J-R07ds	9.2640	13354.8	4.147
J-R07us	8.8702	12827.0	4.129
J-R08ds	10.1275	14566.2	4.153
J-R08us	10.1275	14590.2	4.152
J-R09ds	0.8806	2483.2	4.443
J-R09us	0.3364	1041.2	4.203
J-R10ds	0.9043	2544.6	4.455
J-R10us	0.8806	2483.2	4.443
J-R11ds	0.9302	2584.5	4.465
J-R11us	0.9302	2616.0	4.457
J-R12ds	17.5869	27152.4	4.294
J-R12us	16.5699	25703.6	4.284
J-R15us	17.8756	27553.0	4.301
J-R16ds	0.5206	1026.1	4.405
J-R16us	0.4832	984.9	4.386
J-R2ds	0.6682	1696.6	4.451
J-R2us	0.6682	1711.4	4.450
J-R3us	4.8806	9041.0	4.517
Outlet/R15ds	18.1431	27502.4	4.310
R01	1.5412	3361.8	4.602
R02	0.6682	1696.6	4.451
R03	4.8806	9031.3	4.519
R04	5.4012	9940.1	4.510
R05	5.7921	10693.8	4.527
R06	3.2122	4718.7	3.788
R07	8.8702	12792.0	4.136
R08	10.1275	14566.2	4.153
R09	0.3364	1031.1	4.204
R10	0.8806	2475.9	4.447
R11	0.9302	2584.5	4.465
R12	16.5699	25650.0	4.285
R13	0.0556	219.7	4.798
R14	0.1385	590.5	4.824
R15	17.8756	27421.3	4.303
R16	0.4832	981.9	4.392
0	0.6073	849.3	4.307
1	0.1385	598.1	4.816
2	0.2528	569.2	4.251
3	0.0374	141.5	4.578
4	0.1464	411.5	4.456
5	0.0734	229.2	4.635
9	0.3364	1041.2	4.203
10	0.5442	1488.0	4.591
16	0.0556	220.8	4.794

Table G4: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
17	0.3975	821.7	4.095
18	0.8635	1304.7	4.203
19	0.3938	882.1	4.396
20	0.6682	1711.4	4.450
21	0.3909	1037.8	4.740
22	3.2122	4746.1	3.777
23	1.5412	3376.7	4.600
24	1.5612	2323.0	4.452
25	2.7471	3857.9	4.276
26	2.0639	3586.1	4.538
27	0.1423	263.8	5.076
31	0.4832	984.9	4.386
37	0.0237	78.6	4.748
38	0.0259	91.4	4.550
39	0.0868	229.4	4.127
42	0.3593	812.7	4.484
43	0.9904	1987.5	4.186
44	0.0296	119.6	5.117

Table G5: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 10,000-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	4579.3	2.864
J-R01us	1.5412	2321.9	2.900
J-R03ds	4.8806	6003.0	2.816
J-R04ds	5.7921	7089.6	2.824
J-R04us	5.4012	6603.3	2.805
J-R05ds	6.0450	7354.3	2.815
J-R05us	5.7921	7089.6	2.824
J-R06ds	4.2027	3825.2	2.265
J-R06us	3.2122	2909.3	2.185
J-R07ds	9.2640	8249.4	2.482
J-R07us	8.8702	7937.4	2.465
J-R08ds	10.1275	9015.1	2.485
J-R08us	10.1275	9022.4	2.484
J-R09ds	0.8806	1901.8	2.740
J-R09us	0.3364	864.0	2.513
J-R10ds	0.9043	1933.2	2.752
J-R10us	0.8806	1901.8	2.740
J-R11ds	0.9302	1952.6	2.763
J-R11us	0.9302	1973.6	2.754
J-R12ds	17.5869	17175.7	2.612
J-R12us	16.5699	16332.5	2.603
J-R15us	17.8756	17432.7	2.620
J-R16ds	0.5206	698.8	2.700
J-R16us	0.4832	686.2	2.682
J-R2ds	0.6682	1231.1	2.739
J-R2us	0.6682	1245.6	2.737
J-R3us	4.8806	6008.8	2.814
Outlet/R15ds	18.1431	17401.1	2.627
R01	1.5412	2304.4	2.902
R02	0.6682	1231.1	2.739
R03	4.8806	6003.0	2.816
R04	5.4012	6597.6	2.807
R05	5.7921	7089.3	2.826
R06	3.2122	2898.7	2.196
R07	8.8702	7927.5	2.473
R08	10.1275	9015.1	2.485
R09	0.3364	843.4	2.516
R10	0.8806	1890.7	2.744
R11	0.9302	1952.6	2.763
R12	16.5699	16270.8	2.604
R13	0.0556	216.4	3.126
R14	0.1385	631.4	3.159
R15	17.8756	17350.3	2.620
R16	0.4832	677.6	2.688
0	0.6073	554.3	2.601
1	0.1385	636.7	3.150
2	0.2528	405.5	2.547
3	0.0374	145.8	2.850
4	0.1464	339.3	2.742
5	0.0734	192.5	2.922
9	0.3364	864.0	2.513
10	0.5442	1121.3	2.879
16	0.0556	226.7	3.120
17	0.3975	562.9	2.416
18	0.8635	842.1	2.512

Table G5: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 10,000-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
19	0.3938	615.1	2.675
20	0.6682	1245.6	2.737
21	0.3909	777.2	3.061
22	3.2122	2909.3	2.185
23	1.5412	2321.9	2.900
24	1.5612	1500.6	2.740
25	2.7471	2425.0	2.576
26	2.0639	2373.3	2.835
27	0.1423	184.3	3.480
31	0.4832	686.2	2.682
37	0.0237	72.6	3.056
38	0.0259	86.7	2.836
39	0.0868	184.3	2.428
42	0.3593	584.7	2.762
43	0.9904	1322.8	2.488
44	0.0296	121.5	3.541

Table G6: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 1,000-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	2833.1	1.742
J-R01us	1.5412	1445.9	1.769
J-R03ds	4.8806	3699.9	1.708
J-R04ds	5.7921	4367.0	1.713
J-R04us	5.4012	4067.9	1.700
J-R05ds	6.0450	4519.6	1.707
J-R05us	5.7921	4367.0	1.713
J-R06ds	4.2027	2192.1	1.302
J-R06us	3.2122	1661.8	1.242
J-R07ds	9.2640	4844.0	1.459
J-R07us	8.8702	4667.1	1.448
J-R08ds	10.1275	5295.7	1.462
J-R08us	10.1275	5304.4	1.461
J-R09ds	0.8806	1190.3	1.652
J-R09us	0.3364	535.9	1.484
J-R10ds	0.9043	1216.7	1.660
J-R10us	0.8806	1190.3	1.652
J-R11ds	0.9302	1214.3	1.668
J-R11us	0.9302	1241.1	1.662
J-R12ds	17.5869	10267.6	1.557
J-R12us	16.5699	9764.5	1.550
J-R15us	17.8756	10433.6	1.563
J-R16ds	0.5206	429.6	1.623
J-R16us	0.4832	421.7	1.609
J-R2ds	0.6682	764.7	1.653
J-R2us	0.6682	776.7	1.652
J-R3us	4.8806	3702.9	1.705
Outlet/R15ds	18.1431	10425.4	1.571
R01	1.5412	1436.5	1.771
R02	0.6682	764.7	1.653
R03	4.8806	3699.9	1.708
R04	5.4012	4062.7	1.700
R05	5.7921	4363.1	1.715
R06	3.2122	1657.7	1.250
R07	8.8702	4663.1	1.453
R08	10.1275	5295.7	1.462
R09	0.3364	523.5	1.484
R10	0.8806	1188.7	1.654
R11	0.9302	1214.3	1.668
R12	16.5699	9742.3	1.551
R13	0.0556	139.2	1.939
R14	0.1385	422.5	1.966
R15	17.8756	10396.9	1.566
R16	0.4832	416.6	1.615
0	0.6073	333.7	1.546
1	0.1385	428.5	1.957
2	0.2528	247.4	1.509
3	0.0374	90.9	1.736
4	0.1464	205.0	1.655
5	0.0734	120.3	1.789
9	0.3364	535.9	1.484
10	0.5442	712.6	1.756
16	0.0556	146.6	1.935
17	0.3975	337.2	1.417
18	0.8635	503.3	1.484

Table G6: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 1,000-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
19	0.3938	378.4	1.607
20	0.6682	776.7	1.652
21	0.3909	502.1	1.890
22	3.2122	1661.8	1.242
23	1.5412	1445.9	1.769
24	1.5612	913.4	1.653
25	2.7471	1446.8	1.527
26	2.0639	1457.9	1.720
27	0.1423	113.9	2.240
31	0.4832	421.7	1.609
37	0.0237	45.8	1.889
38	0.0259	57.0	1.723
39	0.0868	103.6	1.429
42	0.3593	365.3	1.671
43	0.9904	792.3	1.470
44	0.0296	81.2	2.291

Table G7: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 200-Year, 24-Hour Storm

Element	Drainage Area (mi²)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	1806.8	1.101
J-R01us	1.5412	925.5	1.121
J-R03ds	4.8806	2346.6	1.073
J-R04ds	5.7921	2768.4	1.078
J-R04us	5.4012	2578.4	1.067
J-R05ds	6.0450	2855.1	1.075
J-R05us	5.7921	2768.4	1.078
J-R06ds	4.2027	1261.7	0.755
J-R06us	3.2122	949.8	0.708
J-R07ds	9.2640	2895.6	0.879
J-R07us	8.8702	2793.9	0.870
J-R08ds	10.1275	3163.9	0.881
J-R08us	10.1275	3172.9	0.880
J-R09ds	0.8806	758.7	1.031
J-R09us	0.3364	332.2	0.899
J-R10ds	0.9043	775.9	1.037
J-R10us	0.8806	758.7	1.031
J-R11ds	0.9302	777.4	1.044
J-R11us	0.9302	791.0	1.038
J-R12ds	17.5869	6282.7	0.956
J-R12us	16.5699	5980.6	0.951
J-R15us	17.8756	6393.4	0.961
J-R16ds	0.5206	269.9	1.006
J-R16us	0.4832	263.8	0.994
J-R2ds	0.6682	483.6	1.031
J-R2us	0.6682	492.6	1.030
J-R3us	4.8806	2348.0	1.072
Outlet/R15ds	18.1431	6396.6	0.968
R01	1.5412	920.9	1.122
R02	0.6682	483.6	1.031
R03	4.8806	2346.6	1.073
R04	5.4012	2572.6	1.068
R05	5.7921	2760.1	1.082
R06	3.2122	946.5	0.714
R07	8.8702	2790.6	0.874
R08	10.1275	3163.9	0.881
R09	0.3364	325.0	0.900
R10	0.8806	757.1	1.032
R11	0.9302	777.4	1.044
R12	16.5699	5965.1	0.952
R13	0.0556	92.4	1.257
R14	0.1385	284.2	1.277
R15	17.8756	6375.6	0.964
R16	0.4832	261.1	0.998
0	0.6073	205.2	0.945
1	0.1385	295.7	1.272
2	0.2528	152.6	0.918
3	0.0374	55.7	1.098
4	0.1464	123.3	1.033
5	0.0734	74.6	1.137
9	0.3364	332.2	0.899
10	0.5442	462.0	1.112
16	0.0556	93.5	1.255
17	0.3975	204.2	0.849
18	0.8635	306.4	0.899
19	0.3938	236.9	0.994

Table G7: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 200-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
20	0.6682	492.6	1.030
21	0.3909	332.9	1.218
22	3.2122	949.8	0.708
23	1.5412	925.5	1.121
24	1.5612	571.9	1.031
25	2.7471	884.7	0.931
26	2.0639	924.1	1.084
27	0.1423	72.9	1.516
31	0.4832	263.8	0.994
37	0.0237	29.3	1.218
38	0.0259	38.1	1.087
39	0.0868	59.2	0.860
42	0.3593	232.7	1.046
43	0.9904	482.0	0.889
44	0.0296	55.6	1.555

Table G8: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	1421.9	0.863
J-R01us	1.5412	731.4	0.884
J-R03ds	4.8806	1842.2	0.840
J-R04ds	5.7921	2172.6	0.845
J-R04us	5.4012	2024.4	0.835
J-R05ds	6.0450	2236.9	0.840
J-R05us	5.7921	2172.6	0.845
J-R06ds	4.2027	938.0	0.566
J-R06us	3.2122	705.5	0.526
J-R07ds	9.2640	2206.4	0.673
J-R07us	8.8702	2129.1	0.665
J-R08ds	10.1275	2409.0	0.674
J-R08us	10.1275	2414.7	0.674
J-R09ds	0.8806	597.0	0.804
J-R09us	0.3364	256.8	0.689
J-R10ds	0.9043	609.9	0.809
J-R10us	0.8806	597.0	0.804
J-R11ds	0.9302	612.2	0.815
J-R11us	0.9302	621.5	0.810
J-R12ds	17.5869	4848.5	0.738
J-R12us	16.5699	4611.6	0.734
J-R15us	17.8756	4931.5	0.743
J-R16ds	0.5206	211.3	0.783
J-R16us	0.4832	205.8	0.773
J-R2ds	0.6682	378.4	0.801
J-R2us	0.6682	384.7	0.799
J-R3us	4.8806	1843.2	0.839
Outlet/R15ds	18.1431	4932.3	0.748
R01	1.5412	728.1	0.885
R02	0.6682	378.4	0.801
R03	4.8806	1842.2	0.840
R04	5.4012	2018.1	0.836
R05	5.7921	2163.5	0.846
R06	3.2122	702.8	0.531
R07	8.8702	2124.7	0.668
R08	10.1275	2409.0	0.674
R09	0.3364	251.7	0.689
R10	0.8806	594.8	0.805
R11	0.9302	612.2	0.815
R12	16.5699	4594.6	0.735
R13	0.0556	72.4	1.002
R14	0.1385	226.4	1.019
R15	17.8756	4913.6	0.745
R16	0.4832	204.0	0.777
0	0.6073	159.9	0.735
1	0.1385	240.0	1.015
2	0.2528	118.5	0.709
3	0.0374	41.5	0.863
4	0.1464	91.3	0.802
5	0.0734	56.7	0.900
9	0.3364	256.8	0.689
10	0.5442	365.9	0.875
16	0.0556	73.3	0.999
17	0.3975	154.4	0.638
18	0.8635	235.2	0.688
19	0.3938	185.0	0.774

Table G8: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 100-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
20	0.6682	384.7	0.799
21	0.3909	266.6	0.966
22	3.2122	705.5	0.526
23	1.5412	731.4	0.884
24	1.5612	444.7	0.801
25	2.7471	686.1	0.722
26	2.0639	722.7	0.847
27	0.1423	57.4	1.242
31	0.4832	205.8	0.773
37	0.0237	22.9	0.967
38	0.0259	30.5	0.850
39	0.0868	42.3	0.650
42	0.3593	181.9	0.812
43	0.9904	369.0	0.679
44	0.0296	46.3	1.277

Table G9: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 10-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	406.0	0.243
J-R01us	1.5412	211.4	0.254
J-R03ds	4.8806	509.9	0.230
J-R04ds	5.7921	597.0	0.232
J-R04us	5.4012	557.0	0.227
J-R05ds	6.0450	609.6	0.230
J-R05us	5.7921	597.0	0.232
J-R06ds	4.2027	98.2	0.063
J-R06us	3.2122	55.8	0.042
J-R07ds	9.2640	396.0	0.128
J-R07us	8.8702	378.3	0.124
J-R08ds	10.1275	434.1	0.128
J-R08us	10.1275	434.4	0.128
J-R09ds	0.8806	153.8	0.206
J-R09us	0.3364	51.0	0.133
J-R10ds	0.9043	155.3	0.209
J-R10us	0.8806	153.8	0.206
J-R11ds	0.9302	156.6	0.213
J-R11us	0.9302	158.6	0.210
J-R12ds	17.5869	1105.9	0.168
J-R12us	16.5699	1039.1	0.165
J-R15us	17.8756	1133.2	0.171
J-R16ds	0.5206	54.5	0.195
J-R16us	0.4832	50.8	0.189
J-R2ds	0.6682	100.8	0.209
J-R2us	0.6682	101.7	0.208
J-R3us	4.8806	511.0	0.229
Outlet/R15ds	18.1431	1137.2	0.173
R01	1.5412	211.0	0.254
R02	0.6682	100.8	0.209
R03	4.8806	509.9	0.230
R04	5.4012	555.4	0.227
R05	5.7921	596.5	0.233
R06	3.2122	55.5	0.043
R07	8.8702	377.8	0.125
R08	10.1275	434.1	0.128
R09	0.3364	49.6	0.133
R10	0.8806	150.5	0.207
R11	0.9302	156.6	0.213
R12	16.5699	1034.5	0.165
R13	0.0556	19.2	0.322
R14	0.1385	72.9	0.331
R15	17.8756	1128.7	0.171
R16	0.4832	50.7	0.191
0	0.6073	36.1	0.165
1	0.1385	73.2	0.331
2	0.2528	25.1	0.148
3	0.0374	8.8	0.246
4	0.1464	18.6	0.210
5	0.0734	13.4	0.264
9	0.3364	51.0	0.133
10	0.5442	106.7	0.251
16	0.0556	19.7	0.321
17	0.3975	26.5	0.109
18	0.8635	45.6	0.133
19	0.3938	46.4	0.192

Table G9: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 10-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
20	0.6682	101.7	0.208
21	0.3909	84.4	0.297
22	3.2122	55.8	0.042
23	1.5412	211.4	0.254
24	1.5612	116.6	0.209
25	2.7471	148.2	0.155
26	2.0639	201.4	0.235
27	0.1423	18.8	0.507
31	0.4832	50.8	0.189
37	0.0237	6.0	0.299
38	0.0259	9.2	0.238
39	0.0868	5.2	0.116
42	0.3593	49.6	0.219
43	0.9904	70.4	0.129
44	0.0296	19.8	0.526

Table G10: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 5-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	150.7	0.089
J-R01us	1.5412	83.7	0.100
J-R03ds	4.8806	174.8	0.077
J-R04ds	5.7921	203.0	0.080
J-R04us	5.4012	185.6	0.074
J-R05ds	6.0450	203.4	0.078
J-R05us	5.7921	203.0	0.080
J-R06ds	4.2027	1.6	0.001
J-R06us	3.2122	0.0	0
J-R07ds	9.2640	59.9	0.020
J-R07us	8.8702	56.2	0.019
J-R08ds	10.1275	61.1	0.019
J-R08us	10.1275	61.2	0.019
J-R09ds	0.8806	43.5	0.063
J-R09us	0.3364	1.8	0.005
J-R10ds	0.9043	45.5	0.065
J-R10us	0.8806	43.5	0.063
J-R11ds	0.9302	45.7	0.068
J-R11us	0.9302	46.3	0.066
J-R12ds	17.5869	282.7	0.041
J-R12us	16.5699	261.5	0.040
J-R15us	17.8756	294.7	0.044
J-R16ds	0.5206	12.6	0.046
J-R16us	0.4832	11.2	0.041
J-R2ds	0.6682	27.5	0.057
J-R2us	0.6682	27.7	0.057
J-R3us	4.8806	175.3	0.077
Outlet/R15ds	18.1431	297.8	0.046
R01	1.5412	83.6	0.101
R02	0.6682	27.5	0.057
R03	4.8806	174.8	0.077
R04	5.4012	185.1	0.075
R05	5.7921	202.3	0.080
R06	3.2122	0.0	0
R07	8.8702	56.1	0.019
R08	10.1275	61.1	0.019
R09	0.3364	1.7	0.005
R10	0.8806	43.4	0.063
R11	0.9302	45.7	0.068
R12	16.5699	260.5	0.040
R13	0.0556	7.8	0.163
R14	0.1385	32.1	0.169
R15	17.8756	293.7	0.044
R16	0.4832	11.1	0.043
0	0.6073	5.4	0.025
1	0.1385	34.4	0.168
2	0.2528	2.3	0.014
3	0.0374	2.2	0.095
4	0.1464	3.4	0.058
5	0.0734	4.3	0.112
9	0.3364	1.8	0.005
10	0.5442	41.9	0.098
16	0.0556	7.9	0.161
17	0.3975	0.0	0
18	0.8635	1.6	0.005
19	0.3938	11.0	0.045

Table G10: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 5-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
20	0.6682	27.7	0.057
21	0.3909	41.1	0.145
22	3.2122	0.0	0
23	1.5412	83.7	0.100
24	1.5612	31.9	0.057
25	2.7471	17.0	0.018
26	2.0639	69.0	0.080
27	0.1423	10.2	0.319
31	0.4832	11.2	0.041
37	0.0237	2.5	0.147
38	0.0259	3.4	0.085
39	0.0868	0.0	0
42	0.3593	14.8	0.065
43	0.9904	1.6	0.003
44	0.0296	12.2	0.338

Table G11: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-R01ds	3.6051	0.0	0
J-R01us	1.5412	0.0	0
J-R03ds	4.8806	0.0	0
J-R04ds	5.7921	0.0	0
J-R04us	5.4012	0.0	0
J-R05ds	6.0450	0.0	0
J-R05us	5.7921	0.0	0
J-R06ds	4.2027	0.0	0
J-R06us	3.2122	0.0	0
J-R07ds	9.2640	0.0	0
J-R07us	8.8702	0.0	0
J-R08ds	10.1275	0.0	0
J-R08us	10.1275	0.0	0
J-R09ds	0.8806	0.0	0
J-R09us	0.3364	0.0	0
J-R10ds	0.9043	0.0	0
J-R10us	0.8806	0.0	0
J-R11ds	0.9302	0.0	0
J-R11us	0.9302	0.0	0
J-R12ds	17.5869	0.0	0
J-R12us	16.5699	0.0	0
J-R15us	17.8756	2.9	0.001
J-R16ds	0.5206	0.0	0
J-R16us	0.4832	0.0	0
J-R2ds	0.6682	0.0	0
J-R2us	0.6682	0.0	0
J-R3us	4.8806	0.0	0
Outlet/R15ds	18.1431	2.9	0.001
R01	1.5412	0.0	0
R02	0.6682	0.0	0
R03	4.8806	0.0	0
R04	5.4012	0.0	0
R05	5.7921	0.0	0
R06	3.2122	0.0	0
R07	8.8702	0.0	0
R08	10.1275	0.0	0
R09	0.3364	0.0	0
R10	0.8806	0.0	0
R11	0.9302	0.0	0
R12	16.5699	0.0	0
R13	0.0556	0.0	0
R14	0.1385	0.0	0
R15	17.8756	2.9	0.001
R16	0.4832	0.0	0
0	0.6073	0.0	0
1	0.1385	0.0	0
2	0.2528	0.0	0
3	0.0374	0.0	0
4	0.1464	0.0	0
5	0.0734	0.0	0
9	0.3364	0.0	0
10	0.5442	0.0	0
16	0.0556	0.0	0
17	0.3975	0.0	0
18	0.8635	0.0	0
19	0.3938	0.0	0

Table G11: HEC-HMS Model Results for Pipeline Arroyo, Post-RA Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
20	0.6682	0.0	0
21	0.3909	0.0	0
22	3.2122	0.0	0
23	1.5412	0.0	0
24	1.5612	0.0	0
25	2.7471	0.0	0
26	2.0639	0.0	0
27	0.1423	2.9	0.118
31	0.4832	0.0	0
37	0.0237	0.0	0
38	0.0259	0.0	0
39	0.0868	0.0	0
42	0.3593	0.0	0
43	0.9904	0.0	0
44	0.0296	4.6	0.130

Table G12: HEC-HMS Model Results for Mill Site, Post-RA Condition 1-Hour PMP

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-ND01ds	1.0170	3130.4	4.498
J-ND01us	0.9302	2939.6	4.527
J-ND02ds	0.9043	2860.6	4.526
J-ND02us	0.8806	2788.5	4.514
J-ND03ds	0.5442	1826.1	4.701
J-ND03us	0.2561	874.3	4.681
J-ND04us	0.3364	981.9	4.213
J-ND05ds	0.0512	171.1	4.639
J-ND05us	0.0252	94.9	4.445
J-RC01ds	0.1166	361.1	5.095
J-RC01us	0.0968	298.3	5.085
J-RC02ds	0.0968	298.3	5.085
J-RC02us	0.0895	274.2	5.101
J-RC03ds	0.0895	274.2	5.101
J-RC03us	0.0821	249.8	5.114
J-RC04ds	0.0754	227.7	5.144
J-RC04us	0.0706	211.9	5.140
J-RC05ds	0.0245	72.7	5.113
J-RC05us	0.0112	33.3	5.097
J-SCds	0.0461	140.2	5.154
J-SCus	0.0327	97.7	5.145
ND01	0.9302	2914.6	4.530
ND02	0.8806	2787.4	4.519
ND03	0.2561	867.0	4.687
ND04	0.3364	971.1	4.210
ND05	0.0252	94.1	4.485
Outlet	1.1706	3611.3	4.578
RC01	0.0968	296.6	5.093
RC02	0.0895	273.3	5.106
RC03	0.0821	248.8	5.120
RC04	0.0706	211.8	5.147
RC05	0.0112	33.3	5.156
R-Swale C	0.0327	97.5	5.157
0	0.0049	21.7	5.108
1	0.0025	8.5	4.773
2	0.0041	14.3	4.764
3	0.0074	33.1	4.899
4	0.0198	64.4	5.109
5	0.0371	143.2	5.147
6	0.0327	97.7	5.145
7	0.0134	62.6	5.148
12	0.0133	39.4	5.076
14	0.0073	25.9	4.827
16	0.0060	22.1	5.071
32	0.0551	150.8	3.762
33	0.2881	959.1	4.714
34	0.2300	669.4	4.227
35	0.2561	874.3	4.681
36	0.0260	77.8	4.789
37	0.0237	77.7	4.778
38	0.0259	92.3	4.581
39	0.0868	215.8	4.157
40	0.0052	12.6	5.127
41	0.0252	94.9	4.445

Table G13: HEC-HMS Model Results for Mill Site, Post-RA Condition 10-Year, 24-Hour Storm

Element	Drainage Area **(mi²)**	Peak Discharge **(cfs)**	**Runoff Volume (inches)**
J-ND01ds	1.0170	201.9	0.218
J-ND01us	0.9302	204.9	0.226
J-ND02ds	0.9043	200.4	0.225
J-ND02us	0.8806	203.1	0.222
J-ND03ds	0.5442	168.6	0.276
J-ND03us	0.2561	82.4	0.269
J-ND04us	0.3364	38.7	0.135
J-ND05ds	0.0512	9.5	0.259
J-ND05us	0.0252	5.9	0.198
J-RC01ds	0.1166	32.4	0.501
J-RC01us	0.0968	24.5	0.496
J-RC02ds	0.0968	24.5	0.496
J-RC02us	0.0895	22.1	0.503
J-RC03ds	0.0895	22.1	0.503
J-RC03us	0.0821	18.3	0.511
J-RC04ds	0.0754	16.4	0.523
J-RC04us	0.0706	14.2	0.523
J-RC05ds	0.0245	5.5	0.509
J-RC05us	0.0112	2.7	0.503
J-SCds	0.0461	13.1	0.530
J-SCus	0.0327	6.8	0.525
ND01	0.9302	199.9	0.228
ND02	0.8806	195.4	0.223
ND03	0.2561	81.7	0.273
ND04	0.3364	37.3	0.135
ND05	0.0252	5.6	0.213
Outlet	1.1706	238.7	0.256
RC01	0.0968	24.1	0.500
RC02	0.0895	21.7	0.505
RC03	0.0821	18.2	0.512
RC04	0.0706	13.4	0.525
RC05	0.0112	2.6	0.529
R-Swale C	0.0327	6.7	0.531
0	0.0049	3.6	0.507
1	0.0025	0.6	0.366
2	0.0041	1.3	0.364
3	0.0074	5.4	0.409
4	0.0198	8.4	0.508
5	0.0371	20.8	0.526
6	0.0327	6.8	0.525
7	0.0134	13.0	0.526
12	0.0133	2.9	0.493
14	0.0073	2.9	0.383
16	0.0060	2.3	0.491
32	0.0551	2.4	0.036
33	0.2881	87.0	0.278
34	0.2300	30.8	0.131
35	0.2561	82.4	0.269
36	0.0260	4.0	0.304
37	0.0237	5.0	0.299
38	0.0259	9.3	0.239
39	0.0868	3.2	0.116
40	0.0052	0.7	0.516
41	0.0252	5.9	0.198

Table G14: HEC-HMS Model Results for Mill Site, Post-RA Condition 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
J-ND01ds	1.0170	0.0	0
J-ND01us	0.9302	0.0	0
J-ND02ds	0.9043	0.0	0
J-ND02us	0.8806	0.0	0
J-ND03ds	0.5442	0.0	0
J-ND03us	0.2561	0.0	0
J-ND04us	0.3364	0.0	0
J-ND05ds	0.0512	0.0	0
J-ND05us	0.0252	0.0	0
J-RC01ds	0.1166	5.5	0.115
J-RC01us	0.0968	4.0	0.113
J-RC02ds	0.0968	4.0	0.113
J-RC02us	0.0895	3.9	0.117
J-RC03ds	0.0895	3.9	0.117
J-RC03us	0.0821	3.4	0.120
J-RC04ds	0.0754	3.4	0.127
J-RC04us	0.0706	2.8	0.126
J-RC05ds	0.0245	0.5	0.114
J-RC05us	0.0112	0.3	0.114
J-SCds	0.0461	2.8	0.132
J-SCus	0.0327	0.7	0.130
ND01	0.9302	0.0	0
ND02	0.8806	0.0	0
ND03	0.2561	0.0	0
ND04	0.3364	0.0	0
ND05	0.0252	0.0	0
Outlet	1.1706	8.8	0.016
RC01	0.0968	3.9	0.115
RC02	0.0895	3.7	0.117
RC03	0.0821	3.4	0.121
RC04	0.0706	2.8	0.127
RC05	0.0112	0.3	0.121
R-Swale C	0.0327	0.7	0.133
0	0.0049	0.5	0.118
1	0.0025	0.0	0.051
2	0.0041	0.1	0.050
3	0.0074	0.7	0.068
4	0.0198	1.6	0.118
5	0.0371	3.3	0.130
6	0.0327	0.7	0.130
7	0.0134	2.8	0.131
12	0.0133	0.3	0.108
14	0.0073	0.3	0.057
16	0.0060	0.2	0.106
32	0.0551	0.0	0
33	0.2881	0.0	0
34	0.2300	0.0	0
35	0.2561	0.0	0
36	0.0260	0.0	0
37	0.0237	0.0	0
38	0.0259	0.0	0
39	0.0868	0.0	0
40	0.0052	0.1	0.124
41	0.0252	0.0	0

Table G15: HEC-HMS Model Results for Mine Site, RA-Phase 3 Construction 2-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
Const_Pond	0.0020	0	0
J-Berm2	0.0036	0	0
J-R1ds	0.1447	0	0
J-R1us	0.1447	0	0
J-R2ds	0.0270	0	0
J-R2us	0.2261	0	0
J-R3us	0.0644	0	0
J-R4ds	0.1774	0	0
J-R4us	0.1674	0	0
J-R5ds	0.2194	0	0
J-R5us	0.1774	0	0
Outlet	0.2194	0	0
Plug	0.1093	0	0
Pond 1	0.0088	0	0
Pond 2	0.0269	0	0
Pond3	0.0580	0	0
R-J3ds/Berm1	0.1093	0	0
R1	0.1447	0	0
R2	0.0000	0	0
R3	0.0644	0	0
R4	0.1674	0	0
R5	0.1774	0	0
2	0.0020	0	0
3	0.0036	0	0
19	0.0814	0	0
20	0.1447	0	0
22	0.0100	0	0
23	0.0419	0	0
24	0.0088	0	0
25	0.0349	0	0
26	0.0269	0	0
27	0.0375	0	0
28	0.0101	0	0
29	0.0544	0	0
30	0.0270	0	0

Table G16: HEC-HMS Model Results for the Temporary Haul Road Stormwater Controls 10-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
C01	0.0105	13.2	0.454
C02	0.0417	52.4	0.454
C03	0.0023	2.9	0.454
C04	0.0042	5.3	0.454
C05	0.0065	8.2	0.455
C06	0.0064	8.0	0.454
C07	0.0061	8.9	0.603
C08	0.0132	19.5	0.603
C09	0.0984	72.8	0.601
C10	0.0129	16.3	0.462
J-Div1	0.0105	13.2	0.454
J-Div2	0.0073	10.7	0.603
J-28-Channel	0.0967	72.5	0.603
Outlet	0.0188	25.0	0.521
R00	0.0016	2.5	1.088
R02	0.0052	7.2	0.773
R03	0.0028	4.4	0.888
R04	0.0007	1.2	1.269
S01	0.0068	9.7	0.849
S02	0.0035	5.6	0.967
S03	0.0022	3.1	0.764
S04	0.0015	2.4	1.140
S05	0.0019	2.7	0.759
S06	0.0020	3.0	0.891
S07	0.0051	7.7	0.736
S08	0.0025	3.5	0.765
S09	0.0033	4.5	0.695
S10	0.0012	2.1	1.556
S11	0.0019	3.6	1.907
0	0.0016	2.5	1.088
01a	0.0105	13.2	0.454
01b	0.0417	52.4	0.454
2	0.0052	7.2	0.773
3	0.0023	2.9	0.454
4	0.0028	4.4	0.888
5	0.0042	5.3	0.454
6	0.0007	1.2	1.269
7	0.0022	3.1	0.764
8	0.0015	2.4	1.140
9	0.0065	8.2	0.455
10	0.0019	2.7	0.759
11	0.0016	2.2	0.753
12	0.0005	0.8	1.360
13	0.0064	8.0	0.454
14	0.0035	5.2	0.604
15	0.0016	2.5	1.034
16	0.0061	8.9	0.603
17	0.0013	2.0	1.054
18	0.0012	1.5	0.454
19	0.0008	1.2	0.988
20	0.0073	10.7	0.603
21	0.0059	8.7	0.603
22	0.0017	2.1	0.454
23	0.0025	3.3	0.606
24	0.0059	8.7	0.650
25	0.0012	2.1	1.556

Table G16: HEC-HMS Model Results for the Temporary Haul Road Stormwater Controls 10-Year, 24-Hour Storm

Element	Drainage Area (mi^2)	Peak Discharge (cfs)	Runoff Volume (inches)
26	0.0065	8.2	0.470
27	0.0019	3.6	1.907
28	0.0967	72.5	0.603

ATTACHMENT I.2
Evaluation of Mill Site Repository Channels Capacity and Erosional Stability

ATTACHMENT I.2: 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*
1	*10/05/2017*	*95% Design*	*J. Erickson/Sean Murphy*	*N. Haws*	*10/20/2017*

Revisions

Issue Date	Description
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Location and Format

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

Table of Contents

Objectives

The objectives of this calculation brief are to evaluate the capacity and erosion stability of the proposed stormwater channels for the Mill Site Repository after removal action (RA) is completed. Sediment transport and control measures calculations are described in Attachment I-4: Analysis of Lower East 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 following channels:

- East Repository Channel
- North Cell Drainage Channel (existing)
- Runoff Control Ditch on the west side of the Repository
- Drainage Swale H (existing) on the south side of the Repository
- 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 and design parameters for these existing reaches assess the suitability of the existing channel condition for when the repository is in place. The East Repository Channel discharges into the North Cell Drainage Channel. The channels and reaches included in the calculations are listed in **Table 1.**

Currently, the alignment presented for Branch Swale H in the NRC-approved reclamation design completed by Canonie (1991) is disrupted by the evaporation ponds (see Sheet 9-01). Once the corrective groundwater action program is completed the ponds will no longer be needed. The outlet for Branch Swale H is outside the scope of this RA work and as a design basis Stantec assumed Branch Swale H will be completed as outlined in the Canonie (1991) design.

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. **Table 1** lists the simulated 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 Hydraulics

For all channels except the North Cell Drainage Channel, Stantec estimated the channel hydraulics using Manning's Equation with the assumption of normal depth at the design discharge:

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

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

Stantec 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_{50} for proposed channel reaches, based on standard riprap gradation specifications recommended by the United States Department of Transportation (1989).

Stantec accounted for super-elevated depths along the outboard 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 = super-elevated 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)

The super-elevated depth was included in the channel freeboard calculations.

The existing North Cell Drainage Channel is a relatively wide channel (base widths greater than 50 feet) lined with grasses and shrubs (**Figure 1**). Stantec simulated the hydraulics for this area using a two-dimensional hydraulic model (see **Attachment I.6**).

Riprap Size

For channels lined with riprap, the median channel riprap diameter (D_{50}) was calculated using the shear stress method given by Johnson (2002).

$$D_{50min} = \frac{t}{0.04*(SG_s*\gamma_w-\gamma_w)}*12 \qquad \text{Equation 4}$$

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])
SG_s = riprap specific gravity (assumed to be equal to 2.6)
Y = channel normal depth (feet)
S_{max} = friction slope (equivalent to channel bed slope at normal depth) (feet per foot [ft/ft])

The riprap diameter computed from Equation 4 is understood to be the median riprap diameter near instability under the PMF and is, therefore, the minimum D_{50} required for design.

Granular Filters for Repository Channels

Stantec developed a two-layer granular filter for the repository channels that can be found in **Attachment I.8, Table 2**.

Vegetation-Lined Channels

The riprap lined portion of the East Repository Channel outlets to the existing North Cell Drainage Channel, which is lined with a good stand of shrubs and grasses (**Figure 1**). Stantec evaluated the stability of the grasses in the North Cell Drainage Channel under the PMF using the Temple Method (Temple et al., 1987). The Temple Method compares the allowable stresses on the soil and grasses against the effective soil and grasses stresses under PMF flows from the 2D model (see Attachment I.6). The equations for determining allowable soil and vegetation stress are :

$$\tau_a = \tau_{ab} C_e^2 \qquad \text{Equation 5}$$

$$\tau_{va} = 0.75 C_i \qquad \text{Equation 6}$$

Where:

τ_a = Allowable Soil Stress (lbs/ft^2)
τ_{ab} = Basic Allowable Soil Stress (lbs/ft^2) from corresponding equation in **Table 2**
C_e = Void Ratio Correction Factor (from **Table 2**)
τ_{va} = Allowable Vegetation Stress (lbs/ft^2)
C_i = Retardance Potential

The Retardance Potential for vegetated areas, C_i, is defined as:

$$C_I = 2.5\left(h\sqrt{M}\right)^{\frac{1}{3}} \qquad \text{Equation 7}$$

Where:

C_i = Retardance Potential
h = Representative Stem Length (ft) = 1 foot (assumed)
M = Representative Stem Density (stems/ft^2)

Base values for representative stem densities for specific vegetative covers (**Table 3**) are multiplied by coefficients depending on the cover condition (**Table 4**) to determine the representative stem density (M) from the base stem density (m). Stantec assumed the representative stem height, h, is 1 foot and that the base vegetation is Blue Grama. Stantec selected Blue Grama because it is a native bunchgrass previously used in revegetation of the current site (Table 4.2 of Canonie 1991). Stantec used a cover condition coefficient of one (“good” cover).

Stantec compared the allowable soil and vegetal stresses to the effective soil stress and the effective vegetation stress:

$$\tau_e = \gamma DS(1 - C_F)\left(\frac{n_s}{n}\right)^2 \qquad \text{Equation 8}$$

$$\tau_v = \gamma DS - \tau_e \qquad \text{Equation 9}$$

$$n = \exp\{C_i(0.0122[\ln(q)]^2 + 0.297) - 4.16\} \qquad \text{Equation 10}$$

Where:

τ_v = Effective Stress on Soil (lbs/ft^2)
γ = Specific Weight of Water = 62.4 lbs/ft^3
D = Maximum Depth in Channel (ft)
C_F = Cover Factor (from **Table 3**)
n_s = Soil Grain Roughness (from equations in **Table 2**)
n = Channel Roughness
τ_e = Effective Stress on Vegetative Cover (lbs/ft^2)
C_i = Retardance Potential
q = Effective Unit Discharge (ft^2/s)

The effective unit discharge, q, varies:

$$
\begin{aligned}
q &= 36 && \text{if } VD > 36 \\
q &= VD && \text{if } 0.0025C_i < VD < 36 \\
q &= 0.0025C_i && \text{if } VD < 0.0025C_i
\end{aligned}
\qquad \text{Equation 11}
$$

Where:

q = Effective Unit Discharge (ft^2/s)
V = Channel Velocity (ft/s)
D = Channel Depth (ft)

The vegetative cover passes the design criteria if both $\tau_e < \tau_a$ and $\tau_v < \tau_{va}$.

Stantec evaluated three cases to determine the suitability of a vegetation-lined channel: (1) a worst case, where the native soil is a fine, silty material (Plasticity Index, I_w = 2, D_{75} = 0.01 inch), (2) a best-case scenario, where the native soil is highly cohesive (I_w = 33), and (3) a middle case scenario, where the soil a fairly non-cohesive clay (I_w = 10). The worst case scenario used a diameter approximately the average of the D_{75} particle size of the stockpile soil materials used to cover the borrow pit in the north cell (Figure 3.2 of Canonie 1991). The best case scenario used the plasticity index from a previous geotechnical investigation near the North Cell Drainage Channel from boring number SHB79-10 (Figure 1 and Table 1 Appendix A of MWH, 2014), and the middle case is a hypothetical scenario where the soil is cohesive with the lowest plasticity index, representing the lowest soil stability for a clayey soil, yet still more stable than a noncohesive soil.

Stantec used the maximum depth and velocity data from a HEC-RAS 2-D model of the upper Pipeline Arroyo (Attachment I.6) during a simulation of the 1-hour PMF to evaluate the suitability of a vegetation-lined North Cell Drainage Channel, using a maximum flow depth of 4.11 ft and a maximum channel velocity of 1.9 ft/s.

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 specific gravity of 2.6. 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 are similar to the soil stockpile material shown in Figure 3.2 of Canonie (1991)
- Vegetation-lined channel analysis assumes constant vegetation type, cover, and stem height.

Results

Table 5 summarizes the channel dimensions and hydraulic calculations for all channels except the North Cell Drainage Channel, which is discussed in Attachment I.6. **Table 6** identifies the design riprap size (before quality considerations). **Table 7** shows the allowable and effective stresses on the vegetation-lined channel and associated factors of safety. **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 Branch 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. Stationing along the East Repository Channel can be found in the Section 9 drawings (Sheet 9-02). The existing drainage control ditch will have sufficient capacity post-RA but the riprap in the channel would need to be upsized to 3 inches for stability during the PMF event. **Table 5** shows that the repository channels will have capacity for PMF flows and **Table 6** confirms riprap stability for the PMF**.** (See Attachment I.6 for capacity-related discussions for the North Cell Drainage Channel)**.** **Table 7** shows that a vegetation-lined channel is sufficient for North Cell Drainage Channel stability, showing a factor of safety of 1.75 for the worst case scenario.

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. NUREG-1623

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

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

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.

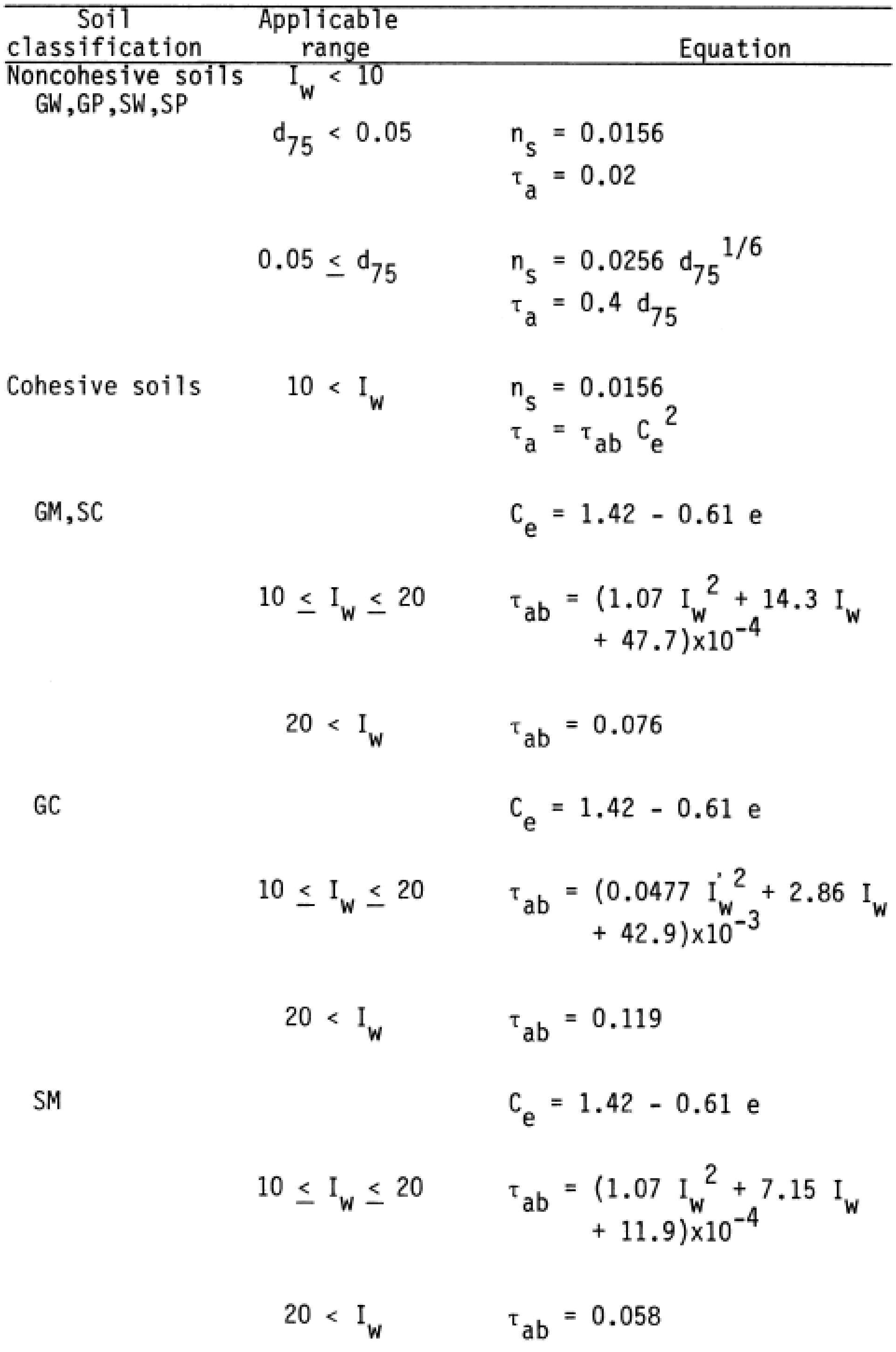
TABLES

Table 1: Channels Reaches and PMF Flow Rates

Channel Reach	PMF Flow Rate (cfs)
East Repository Channel STA 00+00 to 18+50	98
East Repository Channel STA 18+50 to 28+30	140
East Repository Channel STA 28+30 to 34+60	228
East Repository Channel STA 34+60 to 41+39	274
Dilco Hill Channel A	14
Dilco Hill Channel B	8.5
Branch Swale H	120
Runoff Control Ditch	143
North Cell Drainage Channel	361

Note: PMF flow rates calculated per Attachment I.1

Table 2: Equations for Allowable Stress Determination (from Temple et al., 1987)



Soil classification	Applicable range	Equation
Noncohesive soils GW,GP,SW,SP	$I_w < 10$	
	$d_{75} < 0.05$	$n_s = 0.0156$ $\tau_a = 0.02$
	$0.05 \leq d_{75}$	$n_s = 0.0256\ d_{75}^{1/6}$ $\tau_a = 0.4\ d_{75}$
Cohesive soils	$10 < I_w$	$n_s = 0.0156$ $\tau_a = \tau_{ab}\ C_e^2$
GM,SC		$C_e = 1.42 - 0.61\ e$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (1.07\ I_w^2 + 14.3\ I_w + 47.7) \times 10^{-4}$
	$20 < I_w$	$\tau_{ab} = 0.076$
GC		$C_e = 1.42 - 0.61\ e$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (0.0477\ I_w^2 + 2.86\ I_w + 42.9) \times 10^{-3}$
	$20 < I_w$	$\tau_{ab} = 0.119$
SM		$C_e = 1.42 - 0.61\ e$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (1.07\ I_w^2 + 7.15\ I_w + 11.9) \times 10^{-4}$
	$20 < I_w$	$\tau_{ab} = 0.058$

Soil classification	Applicable range	Equation
CH		$C_e = 1.38 - 0.373\ e$
		$\tau_{ab} = 0.0966$
CL		$C_e = 1.48 - 0.57\ e$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (1.07\ I_w^2 + 14.3\ I_w + 47.7) \times 10^{-4}$
	$20 < I_w$	$\tau_{ab} = 0.076$
MH		$C_e = 1.38 - 0.373\ e$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (0.0477\ I_w^2 + 1.43\ I_w + 10.7) \times 10^{-3}$
	$20 < I_w$	$\tau_{ab} = 0.058$
ML		$C_e = 1.48 - 0.57\ e$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (1.07\ I_w^2 + 7.15\ I_w + 11.9) \times 10^{-4}$
	$20 < I_w$	$\tau_{ab} = 0.058$

Soil classification	Applicable range	Equation
OH		$C_e = 1.0$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (0.0477\ I_w^2 + 1.43\ I_w + 10.7) \times 10^{-3}$
	$20 < I_w$	$\tau_{ab} = 0.058$
OL		$C_e = 1.0$
	$10 \leq I_w \leq 20$	$\tau_{ab} = (1.07\ I_w^2 + 7.15\ I_w + 11.9) \times 10^{-4}$
	$20 < I_w$	$\tau_{ab} = 0.058$

---

[1] English units = d_{75} in inches; τ_a and τ_{ab} in lb/ft^2

Table 3: Properties of Grass Channel Linings for Good and Uniform Stands (from Temple et al., 1987)

Grass Type	Cover Factor (Cf)	Base Stem Density, m (stems/ft^2)
Bermuda grass	0.9	500
Centipede Grass	0.9	500
Buffalo Grass	0.87	400
Kentucky Bluegrass	0.87	350
Blue Grama	0.87	350
Grass Mixture	0.7	200
Weeping Love Grass	0.5	350
Yellow Bluestem	0.5	250
Alfalfa	0.5	500
Lespedeza Sericea	0.5	300
Common Lespedeza	0.5	150
Sundan Grass	0.5	50

Table 4: Cover Condition Coefficients (from Temple et al., 1987)

Cover Condition	
Poor	0.333
Fair	0.667
Good	1.000
Very Good	1.333
Excellent	1.667

Table 5: Results of Channel Capacity Evaluations Calculations

Channel Reach	Min. Slope (ft/ft)	Base Width (ft/ft)	Side Slope (z:1)	Channel Depth (ft)	Flow Depth at PMF (ft)	Freeboard at PMF (ft)
East Repository Channel STA 00+00 to 18+50[1]	0.005	7.7	4	2.2	1.7	0.5
East Repository Channel STA 18+50 to 28+30	0.005	10	3	2.75	2.1	0.7
East Repository Channel STA 28+30 to 34+60	0.008	12	3	3	2.4	0.6
East Repository Channel STA 34+60 to 41+39	0.01	12	3	4	3.3	0.7
Dilco Hill Channel A	0.1	8	3	1	0.3	0.7
Dilco Hill Channel B	0.08	3	3	1	0.4	0.6
Branch Swale H[1]	0.009	19	4	2	1.2	0.8
Runoff Control Ditch	0.008	10	3	2	1.9	0.1

Notes:

1. Denotes existing channel

Table 6: Results of Riprap Sizing

Channel Reach	Max. Slope (S_{max}) (ft/ft)	Normal Depth at S_{max} (Y)	Existing D_{50} (inches)	Required D_{50} (inches)	Design D_{50} (inches)
East Repository Channel STA 00+00 to 18+50	0.005	1.6	1.5	1.5	1.5 (Use Existing)
East Repository Channel STA 18+50 to 28+30	0.005	2.0	1.5	1.8	3
East Repository Channel STA 28+30 to 34+60	0.030	1.6	3	9	9
East Repository Channel STA 34+60 to 41+39	0.016	2.8	9	8.5	9
Dilco Hill Channel A	0.10	0.28	NA	5.1	6
Dilco Hill Channel B	0.080	0.37	NA	5.4	6
Branch Swale H	0.015	1.0	3	2.6	3 (Use Existing)
Runoff Control Ditch	0.008	1.8	1.5	2.6	3

Table 7: Results of Vegetation Stability Evaluation for North Cell Drainage Channel

Soil Parameters	**Worst Case**	**Best Case**	**Middle Case**
Soil Classification (USCS):	SW	SC	SC
Plasticity Index, I_w:	2	33	10
Void Ratio, e:	0.45	0.45	0.45
D_{75} (inch):	0.010	-	-
Vegetation Parameters			
Vegetation Type:	blue grama	blue grama	blue grama
Minimum Stem Height (ft):	1.00	1.00	1.00
Cover Condition:	Good	Good	Good
Stem Density, m (Stems/ft^2) :	500	500	500
C_f:	0.87	0.87	0.87
Solve Soil Parameters			
n_s:	0.0156	0.0156	0.0156
C_e:	-	1.1455	1.1455
τ_{ab} (lb/ft^2):	-	0.076	0.030
τ_a (lb/ft^2):	0.020	0.100	0.039
Solve Vegetative Parameters			
Adjusted Density, m (Stems/ft^2):	500	500	500
C_i (Minimum):	7.04	7.04	7.04
τ_{va} (lb/ft^2):	5.28	5.28	5.28
Channel Hydraulics			
Bottom Width, B (ft) :	55	55	55
Minimum Channel Slope, S_{min} (ft/ft) :	0.003	0.003	0.003
Channel Roughness, n :	0.0467	0.0467	0.0467
Flow Depth, Y (ft) :	4.20	4.20	4.20
Channel Velocity (fps) :	1.93	1.93	1.93
Effective Unit Discharge, q (ft^2/s) :	8.11	8.11	8.11
Results			
Effective Soil Stress (lb/ ft^2) :	0.011	0.011	0.011
Effective Vegetal Stress (lb/ ft^2) :	0.775	0.775	0.775
Soil Factor of Safety :	1.75	8.74	3.42
Vegetal Factor of Safety :	6.82	6.82	6.82

FIGURE

Figure 1: North Cell Drainage Channel Looking East (February 2016)

ATTACHMENT A

CALCULATION WORKSHEETS

NECR East Repository Channel Riprap Evaluation

Computed by: JNE
Date: 9/7/2017

Channel Section	Unit	East Repository Channel STA 00+00 to 18+50 (Swale C - Existing)	East Repository Channel STA 18+50 to 28+30	Channel STA 28+30 to 34+60	Channel STA 34+60 to 41+39	Dilco Hill Channel A	Dilco Hill Channel B	Banrch Swale H	Runoff Control Ditch	Notes:
Input										
Design Discharge, Q	cfs	97.5	140.2	227.5	274	14.3	8.5	120.8	143.2	From MWH Hydrologic Evaluation
Bottom Width, B	ft	7.7	10	12	12	8	3	19	10	Measure from survey surface. (Cooper, 2013)
Side Slope Angle	Z:1	4	3	3.0	3	3	3	4	3	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	0.03	0.016	0.1	0.08	0.015	0.008	Maximum channel slope. Measured from survey surface. (Cooper, 2013)
In-place Median Riprap Diameter, D50	in	1.5	3	9	9	6	6	3	3	From Canonie (1991) Design Documents (table 5.6)
In-place 90th Percentile Riprap Diameter, D90	in	2.4	4.8	14.4	14.4	9.6	9.6	4.8	4.8	D90 = 1.6*D50
Channel Roughness (Stability), ns	-	0.026	0.029	0.035	0.035	0.033	0.033	0.029	0.029	Strickler Method (USACE, 1991)
Flow Depth, Y	ft	1.6	2.0	1.6	2.8	0.3	0.4	1.0	1.8	Computed
Iteration to Zero -->		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Flow Area, A	ft2	22.8	31.2	27.1	37.4	2.5	1.5	22.1	26.8	A = B*Y+Z*Y^2
Wetted Perimeter, P	ft	21.0	22.4	22.2	23.6	9.8	5.3	27.0	21.1	P = B+2*Y*(Z^2+1)^0.5
Top Width, W	ft	20.6	21.8	21.6	28.8	9.7	5.2	26.7	20.5	W = B+2*Z*Y
Average Velocity, V	fps	4.28	4.50	8.41	7.32	5.77	5.57	5.47	5.35	V = Qd/A
Froude Number, Fr		0.72	0.66	1.33	1.13	2.01	1.82	1.06	0.83	Fr = V/(32.2*A/W)^0.5
Max Shear Stress, Tmax	lbs/ft2	0.50	0.61	3.01	2.80	1.75	1.85	0.90	0.88	Tm = 62.4*S*Ys
Computed Minimum Riprap Diameter, D50 min	in	1.5	1.8	9.0	8.5	5.1	5.4	2.6	2.6	D50min = Tm/4.1*12 (Johnson, 2002) (Assumes stone weight of 165 pcf)
Minimum Riprap with 5% Upsize, D50 min	in	1.5	1.9	9.5	8.9	5.4	5.7	2.8	2.7	If riprap is souced from the Tampico Pit then a 5% upsize is required
OK?		Yes	Yes	No	Yes	Yes	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.

East Repository Channel Capacity Evaluation

Computed by: JNE
Date: 9/7/2017

Channel Section	Unit	East Repository Channel STA 00+00 to 18+50 (Swale C - Existing)	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	Banrch Swale H	Runoff Control Ditch	Notes:
Input										
Design Discharge, Q	cfs	97.5	140.2	227.5	274	14.3	8.5	120.8	143.2	From MWH Hydrologic Evaluation
Bottom Width, B	ft	7.7	10	12	12	8	3	19	10	Measure from survey surface. (Cooper, 2013)
Side Slope Anlge	Z:1	4	3	3	3	3	3	4	3	Measure from survey surface. (Cooper, 2013)
Low-Flow Side Slope Angle	Z:1	-	-	-	6	-	-	-	-	
Low-Flow Channel Depth, DLF	ft	-	-	-	1	-	-	-	-	
Minimum Channel Slope, Smin	ft/ft	0.005	0.005	0.008	0.01	0.1	0.08	0.009	0.008	Measured from survey surface. (Cooper, 2013)
Riprap Diameter, D50	in	**1.5**	3	9	9	6	6	3	3	**From Canonie (1991) Design Documents (table 5.6)**
Riprap Diameter, D90	in	2.4	4.8	14.4	14.4	9.6	9.6	4.8	4.8	D90 = 1.6*D50
Channel Roughness (Capacity), nc	-	0.029	0.033	0.039	0.039	0.037	0.037	0.033	0.033	Strickler Method (USACE, 1991)
Design/Existing Channel Depth, D	ft	2.20	2.75	3.00	4.00	1.00	1.00	2.00	2.00	MWH (2014) or this design
Critical Bend Radius	ft	295	NA	240	NA	300	225	1100	NA	
Slope around Critical Bend	ft/ft	0.007	NA	0.03	NA	0.10	0.08	0.02	NA	
Straight Channel Depth, Y	ft	1.70	2.08	2.43	3.25	0.30	0.39	1.19	1.86	MWH (2014)
Iteration to Zero -->		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Flow Area - Min Slope, A	ft2	24.7	33.8	46.8	48.2	2.7	1.6	28.2	29.0	A = B*Y+Z*Y^2
Wetted Perimeter - Min Slope, P	ft	21.7	23.1	27.3	26.4	9.9	5.5	28.8	21.8	P = B+2*Y*(Z^2+1)^0.5
Straight Channel Freeboard, FB	ft	0.5	0.7	0.6	0.7	0.7	0.6	0.8	0.1	
						Critical Bend				
Bench Channel Flow Depth, Y	ft	1.6	NA	1.7	NA	0.3	0.4	0.9	NA	
Iteration to Zero -->		0.00	NA	0.00	NA	0.00	0.00	0.00	NA	
Flow Area - Bend Slope, A	ft2	22.5	NA	29.2	NA	2.7	1.6	21.6	NA	
Wetted Perimeter - Bend Slope, P	ft	20.8	NA	22.8	NA	9.9	5.5	26.8	NA	
Top Width around Bend	ft	20.5	NA	22.2	NA	9.8	5.4	26.6	NA	
Velocity around Bend	fps	4.3	NA	7.8	NA	5.4	5.2	5.6	NA	
Froude Number	-	0.7	NA	1.2	NA	1.8	1.6	1.1	NA	
C Value	-	0.5	NA	1	NA	1	1	1	NA	
Super-elevation	ft	0.02	NA	0.17	NA	0.03	0.02	0.02	NA	USACE (1991)
Bend Channel Freeboard, FB	ft	0.6	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.

ATTACHMENT I.3
Filter Compatibility Calculations for Mill Site and Mine Site Stormwater Controls

Client: *General Electric/United Nuclear Corporation*
Project: *NECR 60% Design*
Description: *Design of Repository Channels*

Sheet: *1* **of** *4*
Date: *03/31/2017*
Job No: *10508639*

ATTACHMENT I.3: FILTER COMPATIBILITY CALCULATIONS FOR MILL SITE AND MINE SITE STORMWATER CONTROLS

Revisioning

Rev.	Date	Description	By	Checked	Date
0		*Preliminary (60%) Design*	*J. Erickson*	*N. Haws*	*4/12/2017*
1		*95% Design*	*J. Erickson / S. Murphy*	*N. Haws*	*10/20/2017*

Revisions

Issue Date	Description
--	--

Location and Format

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

Calculations were generated using the following software:

- Microsoft Excel 2013

Table of Contents

Objective

Compute required granular filter gradation for placement at both the Mill Site and the Mine Site.

Background

The Pipeline Arroyo stabilization design and Repository Channels design, shown in the Section 9 Drawings, include riprap armoring. Additionally, the Mine Site Outlet Channel (MSOC) design, shown in Section 6 Drawings, includes armoring with Reno mattresses and gabion baskets. The riprap, Reno mattresses and gabion baskets will be underlain by granular filters to seat the armoring and protect against washout of the underlying soils.

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

Stantec computed granular filter requirements using the Terzaghi method as given in Johnson (2002):

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

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 between three different interfaces:

- Interface between the granular filter (filter) and underlying subgrade (base)
- Interface between riprap (filter) and the granular filter (base)
- Interface between a coarse granular filter (filter) and a fine granular filter (base) – when necessary

Stantec evaluated the subgrade and riprap against a two-layer granular filter. The gradations for each of the filter layers was adapted, with slight modifications, from the Type 1 (fine) and Type 2 (coarse) granular bedding layer gradations given in Simons, Li, and Associates, Inc. (1989), (see **Table 2**).

The D_{15} size for the riprap was taken from the average D_{15} for the riprap gradation envelope shown in **Table 1**, and the D_{85} particle size for the subgrade was defined as follows:

- For the repository channels subgrade, the D_{85} particle size was defined as 0.15 millimeters (mm) (0.006 inches), which is approximately the average D_{85} of stockpile soil materials used to cover the borrow pit in the north cell of the TDA, over which Drainage Swale C was constructed (Figure 3.2 of Canonie, 1991).

- For the Dilco Hill channels, the D_{85} particle size was defined as 0.72 mm (0.028 inches) based on the average of the particle size gradations from samples collected at TP-3 and TP-4 which are located near where these channels will be constructed (see **Figure 1**).

- For the riprap chute, the D_{85} particle size was defined as 0.056 mm (0.002 inches) based on the average of the particle size gradations from samples B5, B6, and B7 collected near to the proposed riprap chute (Stantec, 2017) (see Figure 1).

- For the MSOC, the D_{85} particle size was defined as 0.13 mm (0.005 inches) based on the average of the particle size gradations from samples TP-1 and TP-2 collected near the proposed outlet channel (Stantec, 2017) (see **Figure 2**).

The filter compatibility calculations were performed for the average D_{85} and D_{15} particle sizings for each base, filter, and riprap gradation.

Results

The results of the Terzaghi filter compatibility check for the Mill Site stormwater controls, including the riprap chute are summarized in **Table 3** and the results for the compatibility check for the MSOC are summarized in **Table 4**. These results show the following:

- The filters at the Mill Site meet the compatibility criteria at all locations except for riprap chute, where the Type I filter does not pass compatibility criteria for the subgrade.
- For the MSOC, filter compatibility is met for the Gabions and Type II filter but it is not met for the Type I filter and the subgrade based on the TP-1 sample. Filter compatibility is met for the subgrade using the average D_{85} particle size for the TP-1 and TP-2 samples.

The Nuclear Regulatory Commission (NRC) makes allowance to use granular filters that do not meet filter compatibility provided that there exists no potential for piping of fines and the interstitial flow velocities are insufficient to transport soil particles (Johnson, 2002). Per the NRC guidance, where computed interstitial velocities are less than 0.5 feet per second (ft/s) a filter layer may not be required. Interstitial velocities can be computed using the Leps (1973) equation for flow through rock fill as given in (Johnson, 2002):

$$V_v = Wm^{0.5}i^{0.54}$$

Where:

V_v = Average Interstitial Velocity (in/s)
W = an empirical constant for a specific riprap or rock mulch material (see Nelson et al, 1986)
m = the hydraulic mean radius (in)
i = the hydraulic gradient (in/in)

Nelson defines parameters for W only for rock sizes of 0.75 inches and greater, and for materials with over 30 percent of the particles less than one inch, Nelson et al. (1986) notes that flow through the material should be treated as flow through earthfill. Because the Type I material was too fine to be treated as rockfill, the interstitial velocities were analyzed for the Type II filter. Velocities in the Type I filter would intuitively be less than in the Type I filter.

For the riprap chute and MSOC, the hydraulic gradient through the Type II filter can be approximated as being equal to the chute slopes (5.3 percent and 3.7 percent, respectively). The computed interstitial velocities, shown in **Tables 5**

Client: *General Electric/United Nuclear Corporation*
Project: *NECR 60% Design*
Description: *Design of Repository Channels*

Sheet: *4* **of** *4*
Date: *03/31/2017*
Job No: *10508639*

and 6 are 0.2 ft/s and 0.1 ft/s, respectively. Because of these low computed velocities in the Type II filter, filter compatibility with the subgrade soils in the riprap chute and MSOC was determined to be unnecessary.

References

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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.

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: Riprap Gradation Limits

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

Note: from USDOT (1989)

Table 2: Granular Filter Gradation Limits

		Type I (Fine)		Type II (Coarse)	
Sieve Size	Opening Size (in)	Percent Passing			
		Max	Min	Max	Min
4.5 in	4.5	-	-	100	100
3 in	3	-	-	80	100
1.5 in	1.5	-	-	55	70
3/4 inch	0.75	-	-	30	50
3/8 inch	0.375	100	100	7	25
#4	0.187	90	100	0	5
#16	0.046	45	70	0	0
#50	0.012	4	25	-	-
#100	0.006	0	2	-	-
#200	0.003	0	0	-	-

Table 3: Mill Site Granular Filter Compatibility

Base	Filter	D_{15f} (in)	D_{85b} (in)	D_{15f}/D_{85b}	Result
Avg TP-3 and TP-4	Filter Type I Avg	0.013	0.028	0.459	GOOD
Avg Borrow Soils	Filter Type I Avg	0.013	0.006	2.201	GOOD
Avg (B5, B6, B7)	Filter Type I Avg	0.013	0.002	5.847	BAD
Filter Type I Avg	Filter Type II Avg	0.37	0.13	2.93	GOOD
Filter Type II Avg	3" Riprap Avg	1.50	2.75	0.55	GOOD
Filter Type II Avg	6" Riprap Avg	3.00	2.75	1.09	GOOD
Filter Type II Avg	9" Riprap Avg	4.50	2.75	1.64	GOOD
Filter Type II Avg	27" Riprap Avg	13.50	2.75	4.92	GOOD

Table 4: Mine Site Granular Filter Compatibility

Base	Filter	D_{15f} (in)	D_{85b} (in)	D_{15f}/D_{85b}	Result
TP-1	Filter Type I Avg	0.013	0.003	5.04	BAD
TP-2	Filter Type I Avg	0.013	0.008	1.65	GOOD
Avg TP-1 and TP-2	Filter Type I Avg	0.013	0.005	2.49	GOOD
Filter Type I Avg	Filter Type II Avg	0.37	0.13	2.93	GOOD
Filter Type II Avg	15" Riprap Avg	7	2.75	2.73	GOOD
Filter Type II Avg	6" Riprap Avg	3	2.75	1.09	GOOD

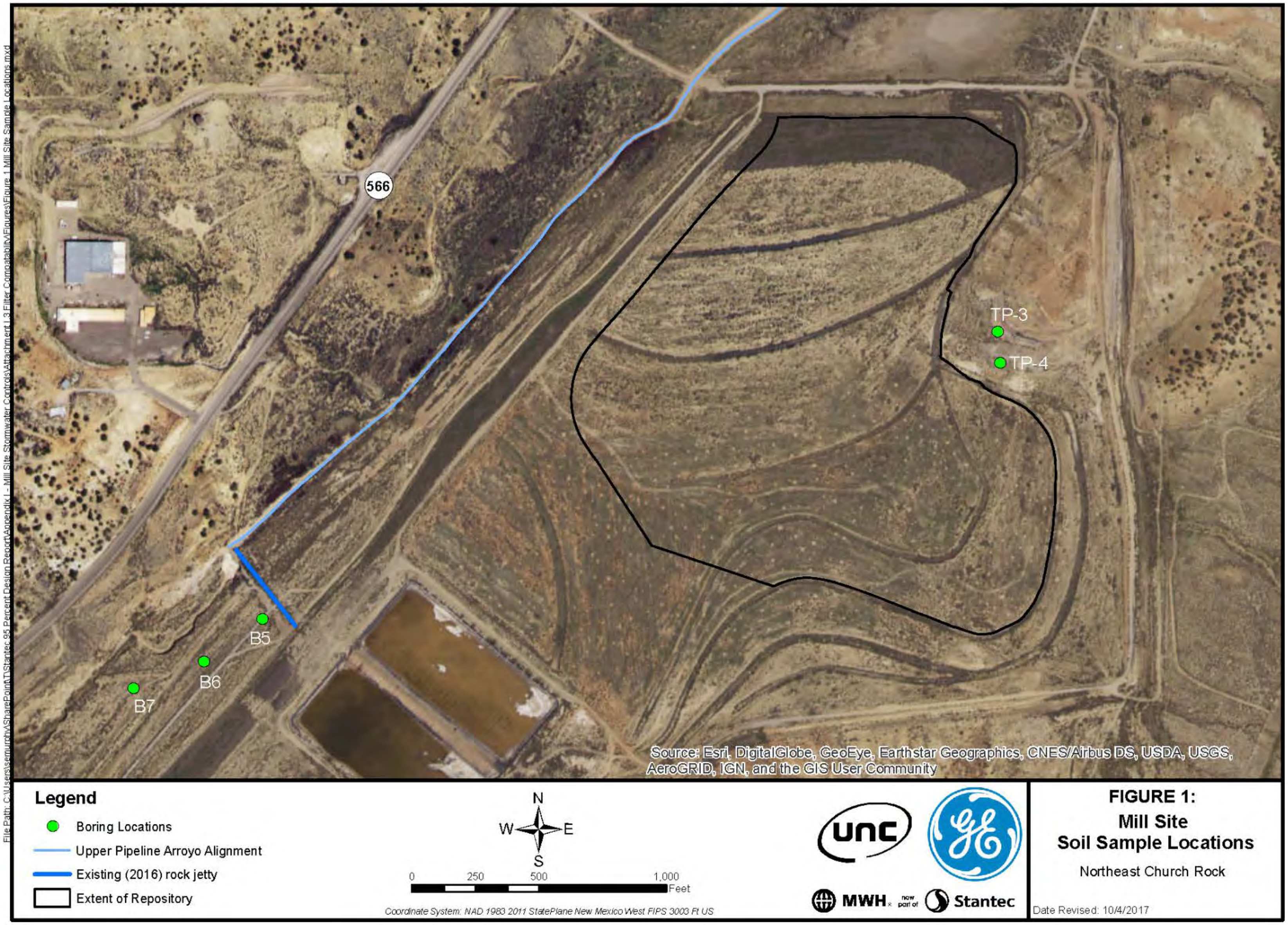
Table 5: Interstitial Velocity Calculation for Type II Filter for Riprap Chute

Type II Filter - Riprap Chute	
Median Particle Diameter , D_{50} (in) :	1.0225
Empirical Constant, W	33
Riprap Hydraulic Radius, m (in)	0.09
Hydraulic Gradient, i (in/in)	0.053
Average Interstitial Velocity, V_v (in/sec)	2.03
Average Interstitial Velocity, V_v (ft/sec)	0.2
Is a Filter Needed? --->	NO

Table 6: Interstitial Velocity Calculation for Type II Filter for Mine Site Outlet Channel

Type II Filter - MSOC	
Median Particle Diameter , D_{50} (in) :	1.0225
Empirical Constant, W	33
Riprap Hydraulic Radius, m (in)	0.09
Hydraulic Gradient, i (in/in)	0.037
Average Interstitial Velocity, V_v (in/sec)	1.67
Average Interstitial Velocity, V_v (ft/sec)	0.1
Is a Filter Needed? --->	NO

FIGURES



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

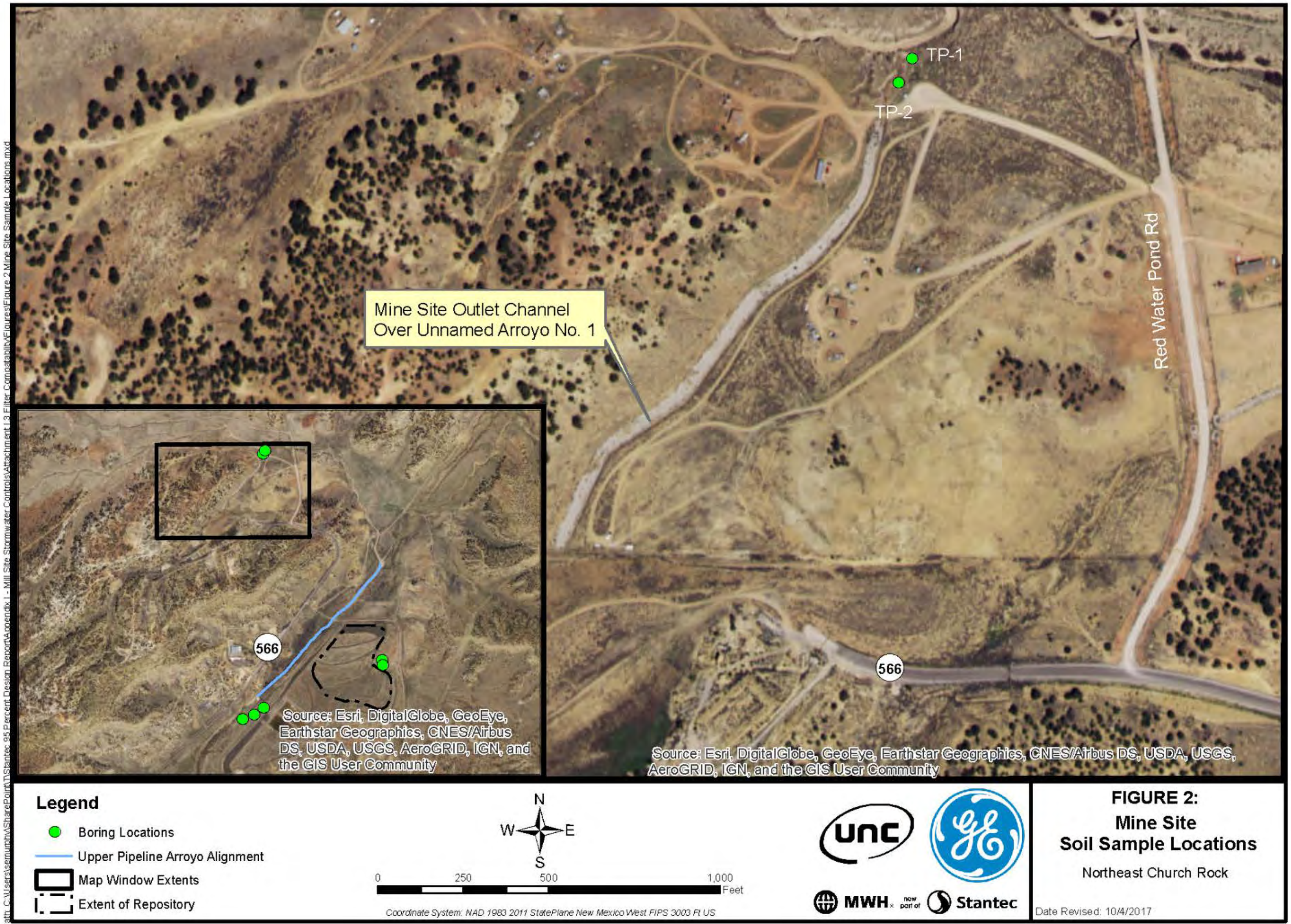
Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE 1:
Mill Site
Soil Sample Locations

Northeast Church Rock

Date Revised: 10/4/2017

File Path: C:\Users\semurphy\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.3 Filter Compatability\Figures\Figure 1 Mill Site Sample Locations.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 2:
Mine Site
Soil Sample Locations

Northeast Church Rock

Date Revised: 10/4/2017

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

Client: *General Electric/United Nuclear Corporation*
Project: *NECR 95% Design*
Description: *Analysis of Repository Channel Sediment Controls*

Sheet: *1* **of** *4*
Date: *09/19/2017*
Job No: *10508639*

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*
0	*09/19/2017*	*95% Design*	*J. Erickson*	*N. Haws*	*10/24/2017*

Revisions

Issue Date	Description
--	--

Location and Format

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

Table of Contents

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 Removal Action (RA). The proposed East Repository Channel will primarily follow the alignment of the existing Branch Swale C and North Cell Drainage Channel (See Drawing 9.01).

Currently, sediment accumulation along the reach in the existing Branch Swale C that runs along the base of the south side of Dilco Hill created localized high points in the swale that limit 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 source of the sediment is 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 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.

Stantec performed a relative sediment transport evaluation for the existing and modified cross section of the upper reach of the North Cell Drainage 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 Shields Analysis estimates the largest (critical) particle diameter that 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 provides a quantitative measure that can be used for relative comparison of channel sediment transport. Lichvar et al. (2006) suggests that the effective discharge, or the discharge responsible for the majority of sediment movement, is a low to moderate flow typically with a 2 to 10 year recurrence in arid systems. Stantec used the 2-year and 10-year flood events for this analyses to show sediment continuity through the likely upper and lower range of the potential effective discharge. The methods to estimate the 2-year and 10-year peak flow magnitudes are provided in a separate calculation brief (Attachment I.1). These peak flow magnitudes and are listed **Table 1**.

Stantec 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.

Stantec 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])

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

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

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.2.

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 and 2 times as great as the existing upper reach of the North Cell Drainage Channel during the 2-year and 10-year events, respectively. 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.

Conclusions

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.

References

Lichvar, R.W., Finnegan, D.C., Ericsson, M.P., Ochs, W. 2006. Distribution of Ordinary High Water Mark (OHWM) Indicators and Their Reliability in Identifying the Limits of “Waters of the United States” in Arid Southwestern Channels. US Army Corps of Engineers – ERDC\CRREL TR-06-5. February.

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)**	
Recurrence Interval (year)	**2**	**10**	**2**	**10**	**2**	**10**	**2**	**10**
Peak Flow (cfs)	3.92	22.11	3.92	22.11	0.088	1.297	0.030	0.591
Base Width (ft)	10	10	0	0	8	8	3	3
Side Slope (z:1)	3.2	3.2	6	6	3	3	3	3
Flow Depth (ft)	0.21	0.59	0.59	1.13	0.02	0.08	0.01	0.08
Critical Particle Diameter (mm)	9.0	25.0	25.0	48.0	3.9	19.0	4.3	25.0

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

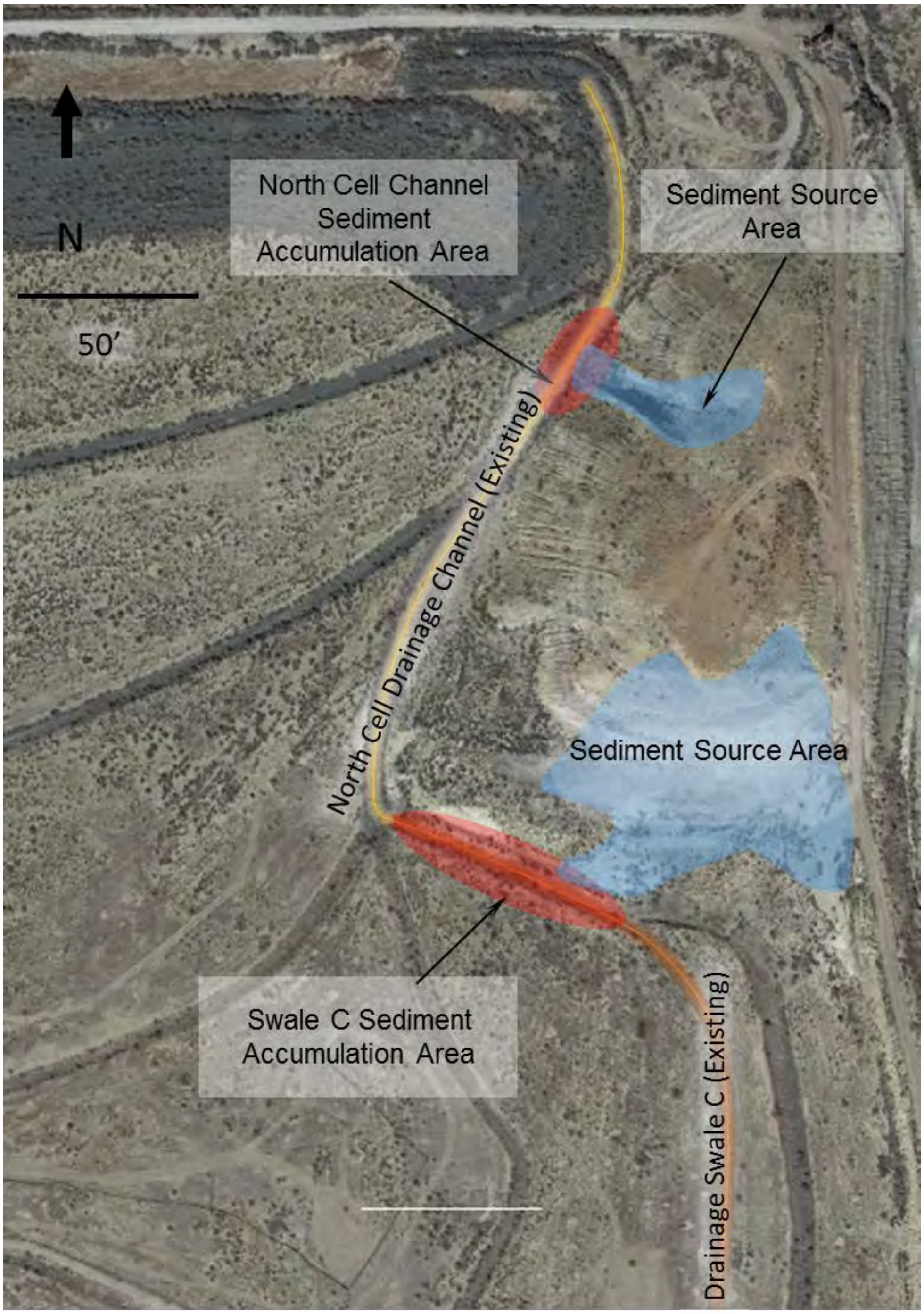


Figure 1: Existing Sediment Accumulation Areas

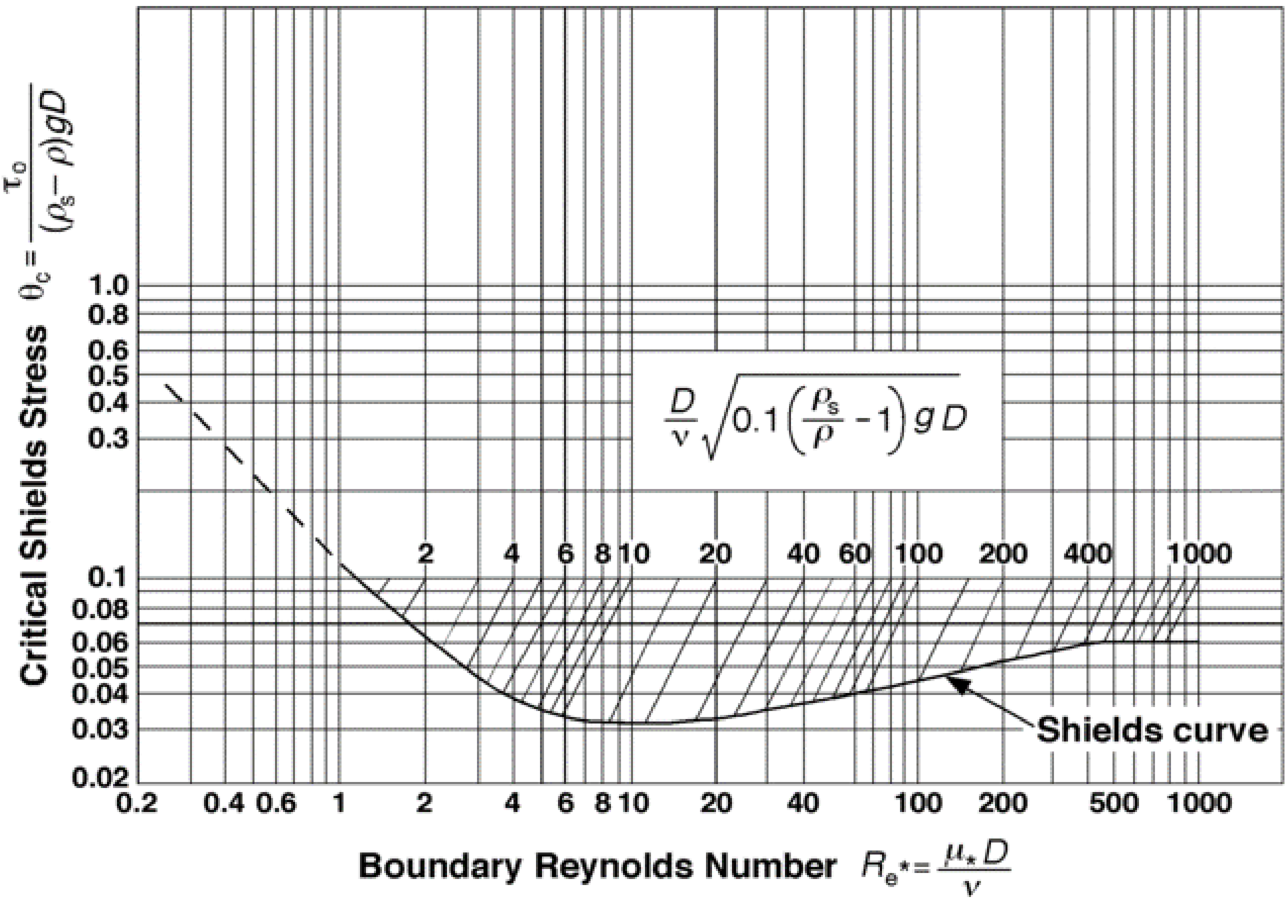


Figure 2: Shields Diagram

ATTACHMENT A

CALCULATION WORKSHEET

Shield’s 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		8.00		3.00		
Side Slope	z:1	3.20		3.00		3.00		3.00		
Low Flow Section Side Slope	z:1	-		6.00		-		-		
Low Flow Section Depth	feet	-		1.00		-		-		
Channel Slope	feet/feet	0.014		0.014		0.080		0.100		
Discharge	cfs	3.90	22.11	3.90	22.11	0.088	1.297	0.030	0.59	2-year and 10-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	0.59	0.59	1.13	0.02	0.08	0.01	0.08	Solved iteratively
Cross-section area	ft^2	2.26	7.05	2.11	7.55	0.12	0.64	0.04	0.27	Computed from flow depth
Wetted Perimeter	ft^2	11.78	14.98	7.21	12.96	8.12	8.62	3.11	3.66	Computed from flow depth
Hyd. Radius	ft^2	0.19	0.47	0.29	0.58	0.02	0.07	0.01	0.07	Computed from flow depth
Q-calc	cfs	3.90	22.11	3.90	22.11	0.088	1.297	0.030	0.59	Manning’s Calculated Q
SSE	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Iteration minimization
Shear Stress	lb/ft^2	0.18	0.52	0.52	0.98	0.08	0.39	0.09	0.51	
Shields Analysis										
Particle diameter of Interest	mm	9.00	25.00	25.00	48.00	3.90	19.00	4.30	25.00	
Particle diameter of Interest	in	0.35	0.98	0.98	1.89	0.15	0.75	0.17	0.98	Unit conversion
Boundary Reynolds Number (Re)	-	966.55	4474.78	4474.78	11904.85	275.71	2964.78	319.20	4474.78	
Shield’s Parameter, Θ_c :	-	0.06	0.06	0.06	0.06	0.058	0.06	0.058	0.06	
Critical shear	lb/ft^2	0.18	0.51	0.51	0.97	0.08	0.39	0.08	0.51	
Mobile ?		YES	YES	YES	YES	YES	YES	YES	YES	

ATTACHMENT I.5
Hydraulic Analysis of the North Diversion Channel

Client: *General Electric/United Nuclear Corporation*
Project: *NECR 95% Design*
Description: *Design of Repository Channels*

Sheet: *1* **of** *4*
Date: *10/05/2017*
Job No: *10508639*

ATTACHMENT I.5: HYDRAULIC ANALYSIS OF THE NORTH DIVERSION CHANNEL

Revisioning

Rev.	Date	Description	By	Checked	Date
0		*Preliminary (30%) Design*	*J. Erickson*	*C. Michalos*	
1	*10/05/2017*	*95% Design*	*J. Erickson*	*N. Haws*	*10/24/2017*

Revisions

Issue Date	Description
--	--

Location and Format

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

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

Table of Contents

Client: *General Electric/United Nuclear Corporation* **Sheet:** *2* **of** *4*
Project: *NECR 95% Design* **Date:** *10/05/2017*
Description: *Design of Repository Channels* **Job No:** *10508639*

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. Stantec 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

Stantec 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 9-05.

Stantec 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). Stantec 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. Stantec 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, Stantec estimated the maximum likely channel roughness values along each reach 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.

Client: *General Electric/United Nuclear Corporation*
Project: *NECR 95% Design*
Description: *Design of Repository Channels*
Sheet: *3* **of** *4*
Date: *10/05/2017*
Job No: *10508639*

Flow Conditions

Stantec 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.

The model was evaluated using a mixed flow regime considering both sub-critical and super-critical flows. To facilitate the mixed flow computations, Stantec entered initial boundary conditions at the upstream (Cross Section 6121) and downstream (Cross Section 1144) cross sections. The upstream boundary condition is the calculated normal depth established with a slope of 0.5 percent. The downstream boundary condition is also the calculated normal depth established with a slope of 4 percent.

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 2 through 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.

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	2,861
Middle	2,788
Upper	982

cfs = cubic feet per second

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

Reach	Velocity (fps)
Lower	29.3
Middle	10.7
Upper	11.4

fps = feet per second

FIGURES

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

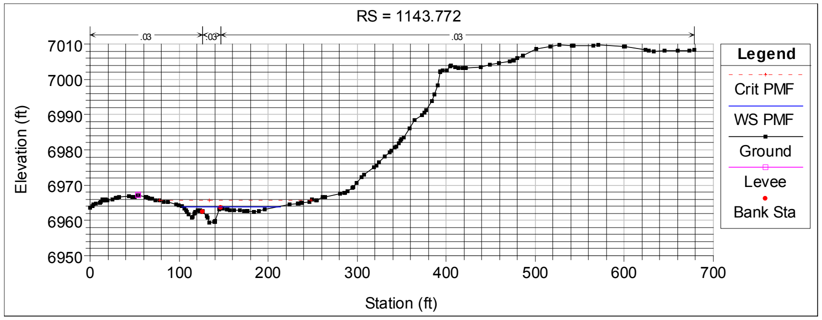


Figure 2: Cross Section 5 (River Station 1144)

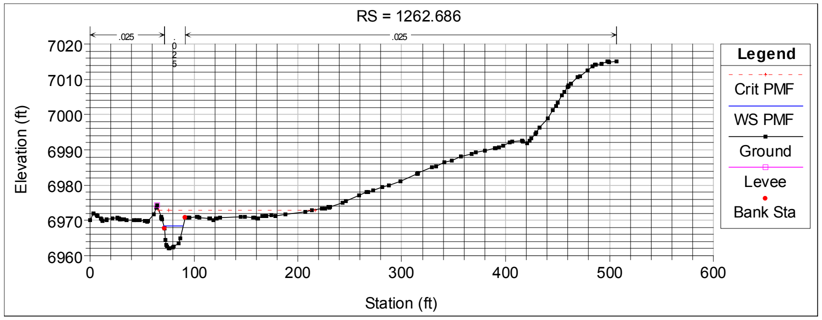


Figure 3: Cross Section 6 (River Station 1263)

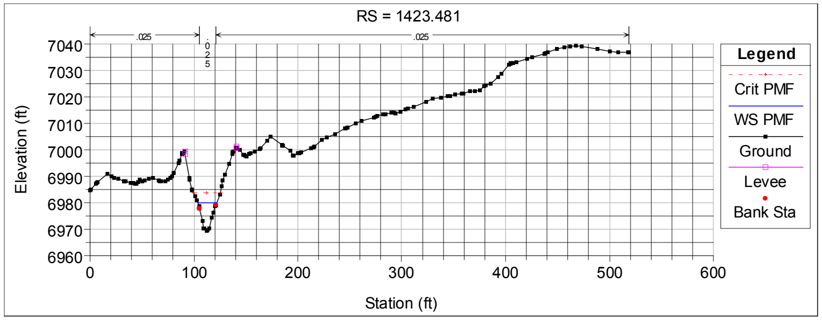


Figure 4: Cross Section 7 (River Station 1423)

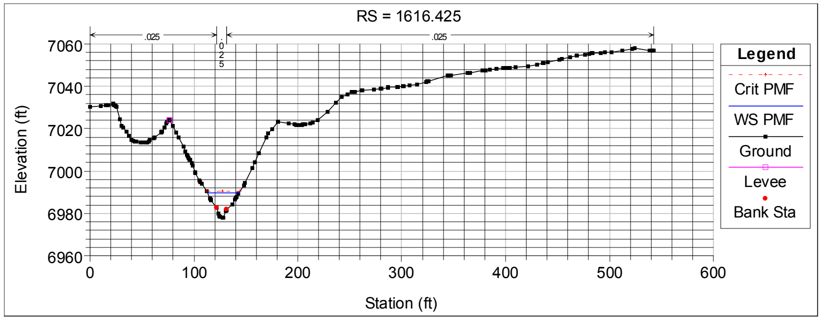


Figure 5: Cross Section 8 (River Station 1616)

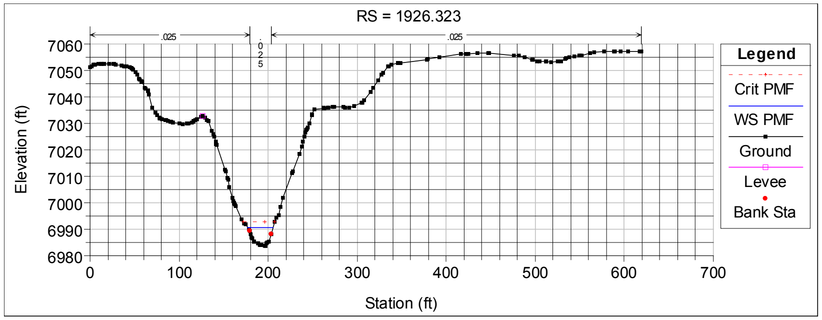


Figure 6: Cross Section 9 (River Station 1926)

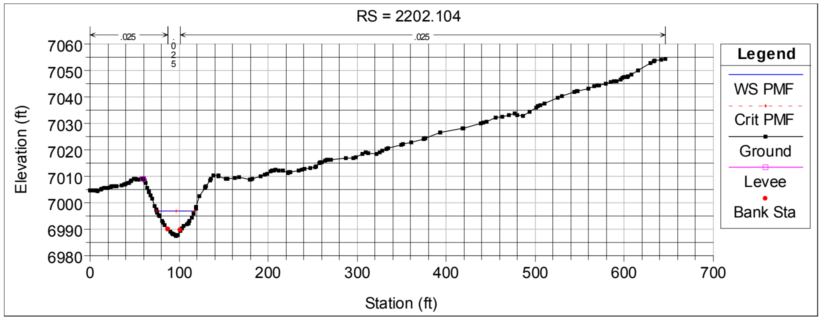


Figure 7: Cross Section 10 (River Station 2202)

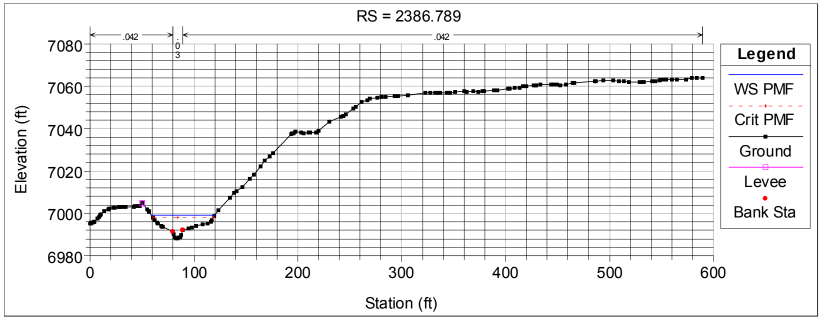


Figure 8: Cross Section 11 (River Station 2387)

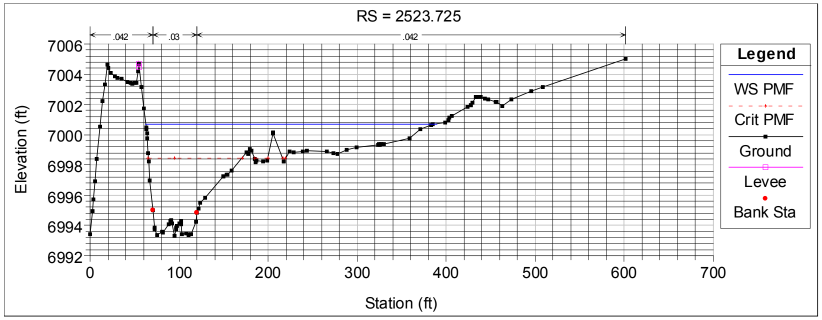


Figure 9: Cross Section 12 (River Station 2524)

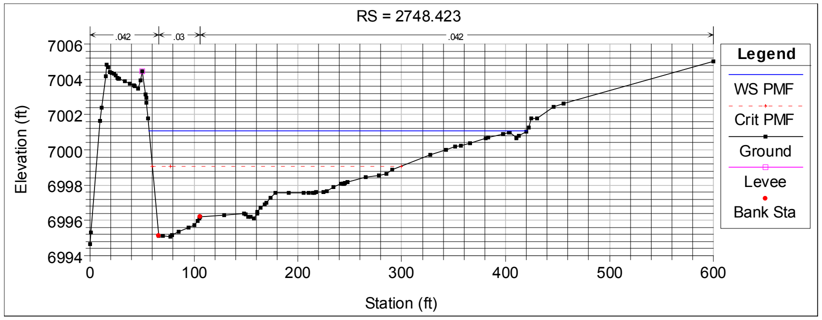


Figure 10: Cross Section 13 (River Station 2748)

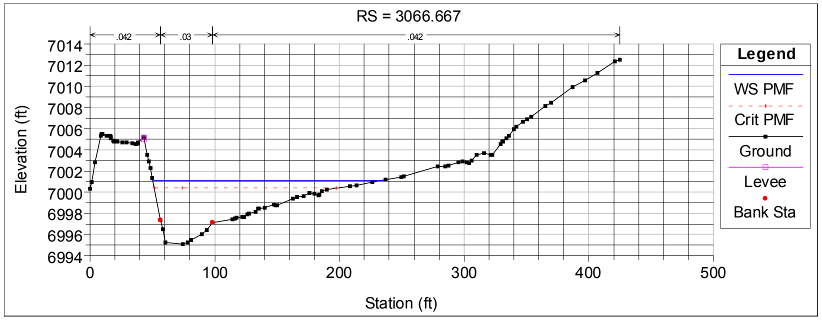


Figure 11: Cross Section 14 (River Station 3067)

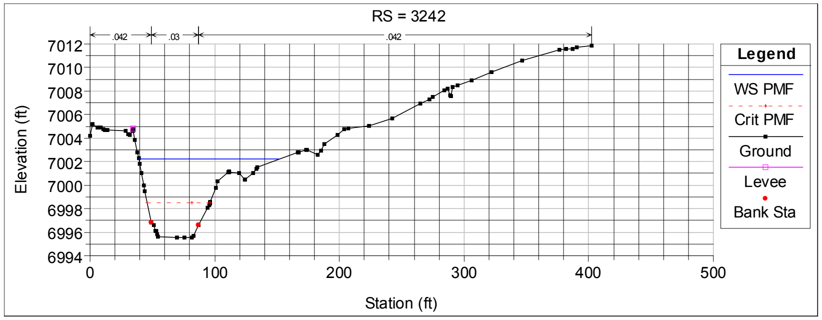


Figure 12: Cross Section 15 (River Station 3242)

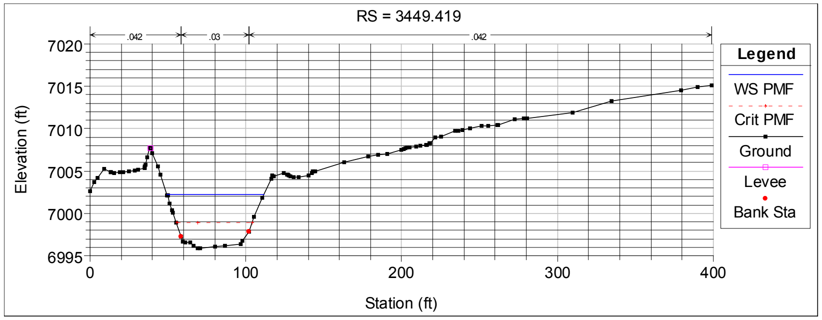


Figure 13: Cross Section 16 (River Station 3449)

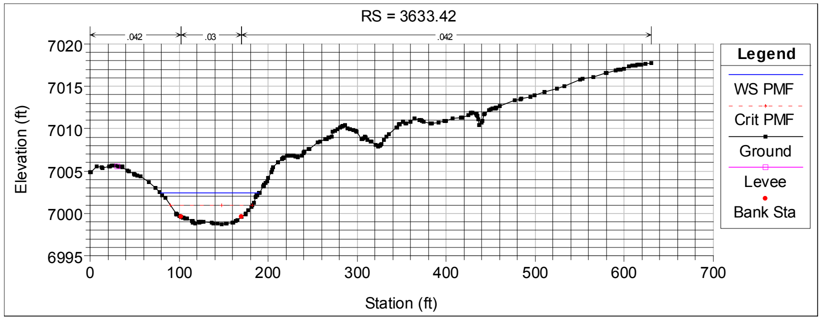


Figure 14: Cross Section 17 (River Station 3633)

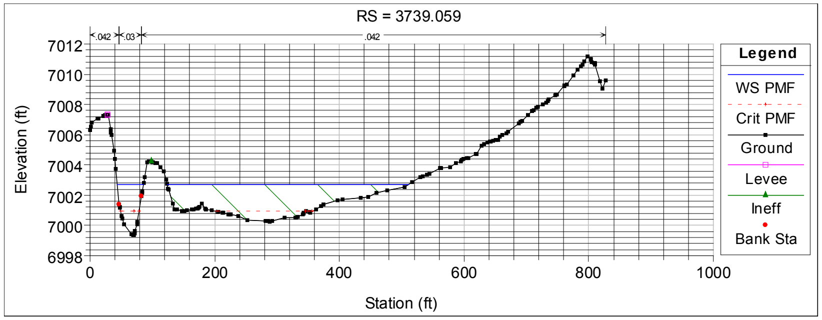


Figure 15: Cross Section 18 (River Station 3739)

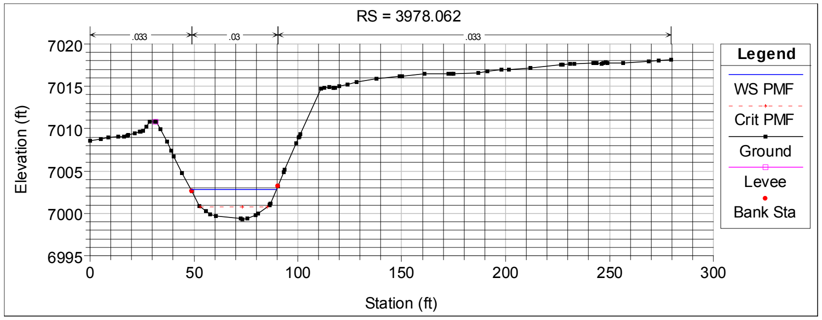


Figure 16: Cross Section 19 (River Station 3978)

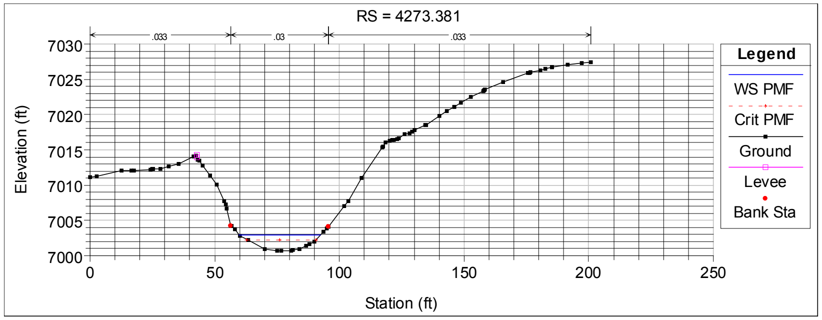


Figure 17: Cross Section 20 (River Station 4273)

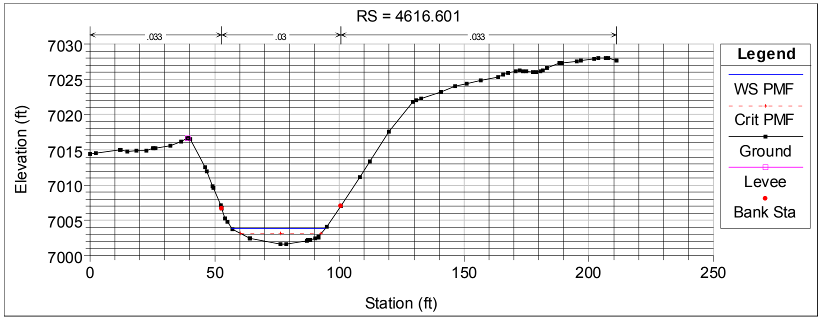


Figure 18: Cross Section 21 (River Station 4617)

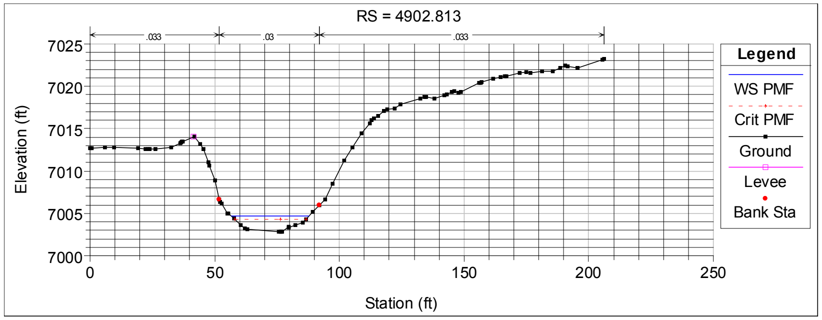


Figure 19: Cross Section 22 (River Station 4903)

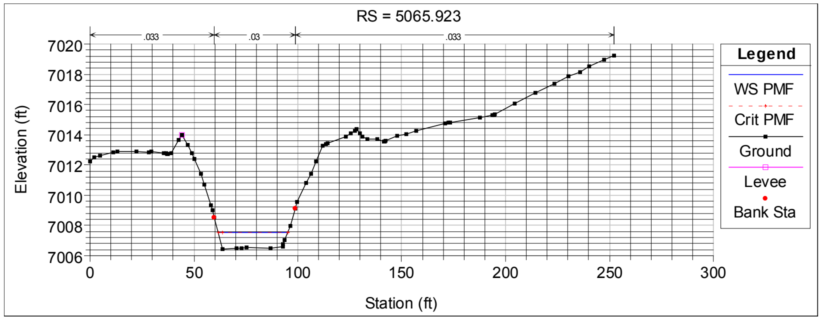


Figure 20: Cross Section 23 (River Station 5066)

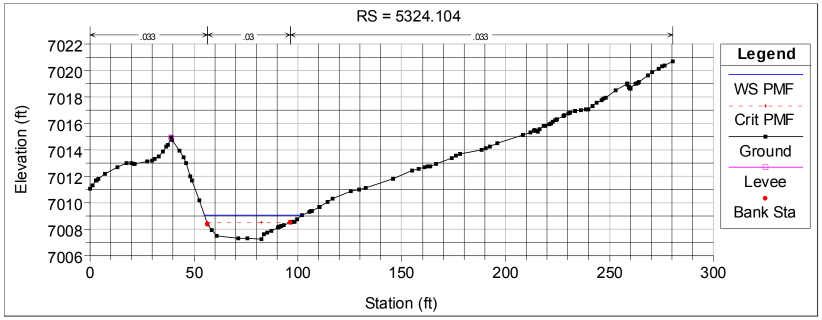


Figure 21: Cross Section 24 (River Station 5324)

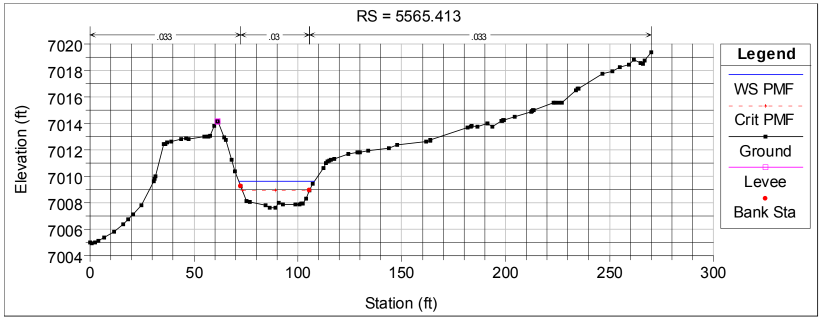


Figure 22: Cross Section 25 (River Station 5565)

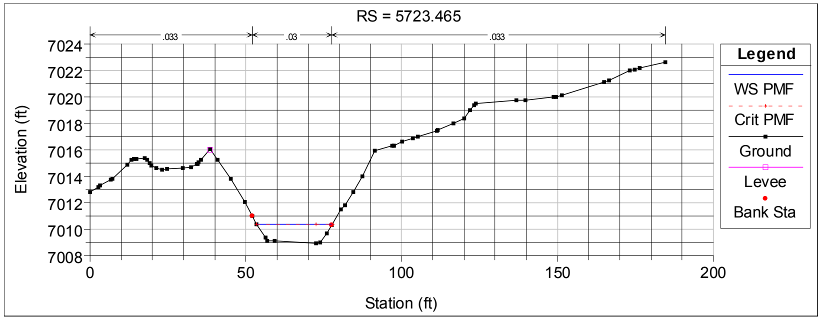


Figure 23: Cross Section 26 (River Station 5723)

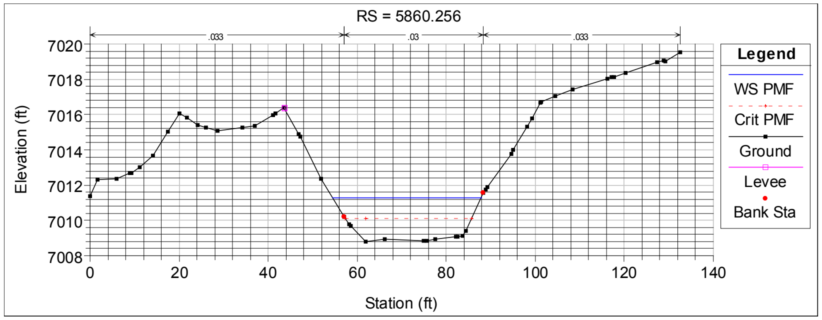


Figure 24: Cross Section 27 (River Station 5860)

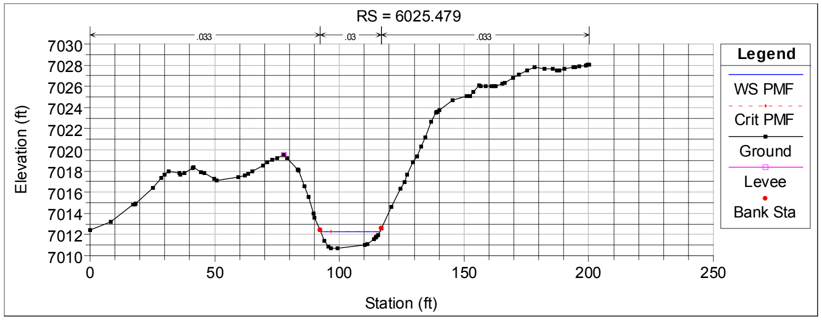


Figure 25: Cross Section 28 (River Station 6025)

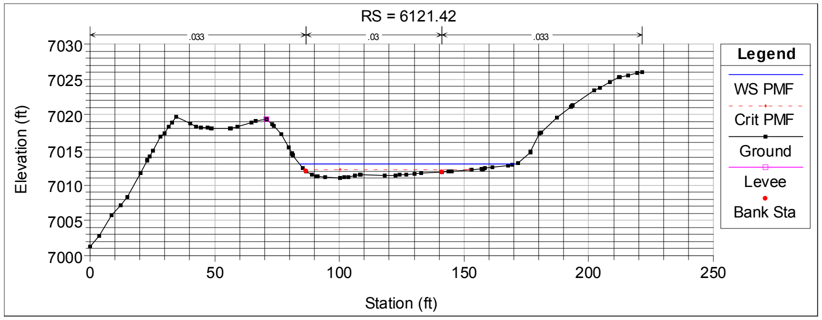


Figure 26: Cross Section 29 (River Station 6121)

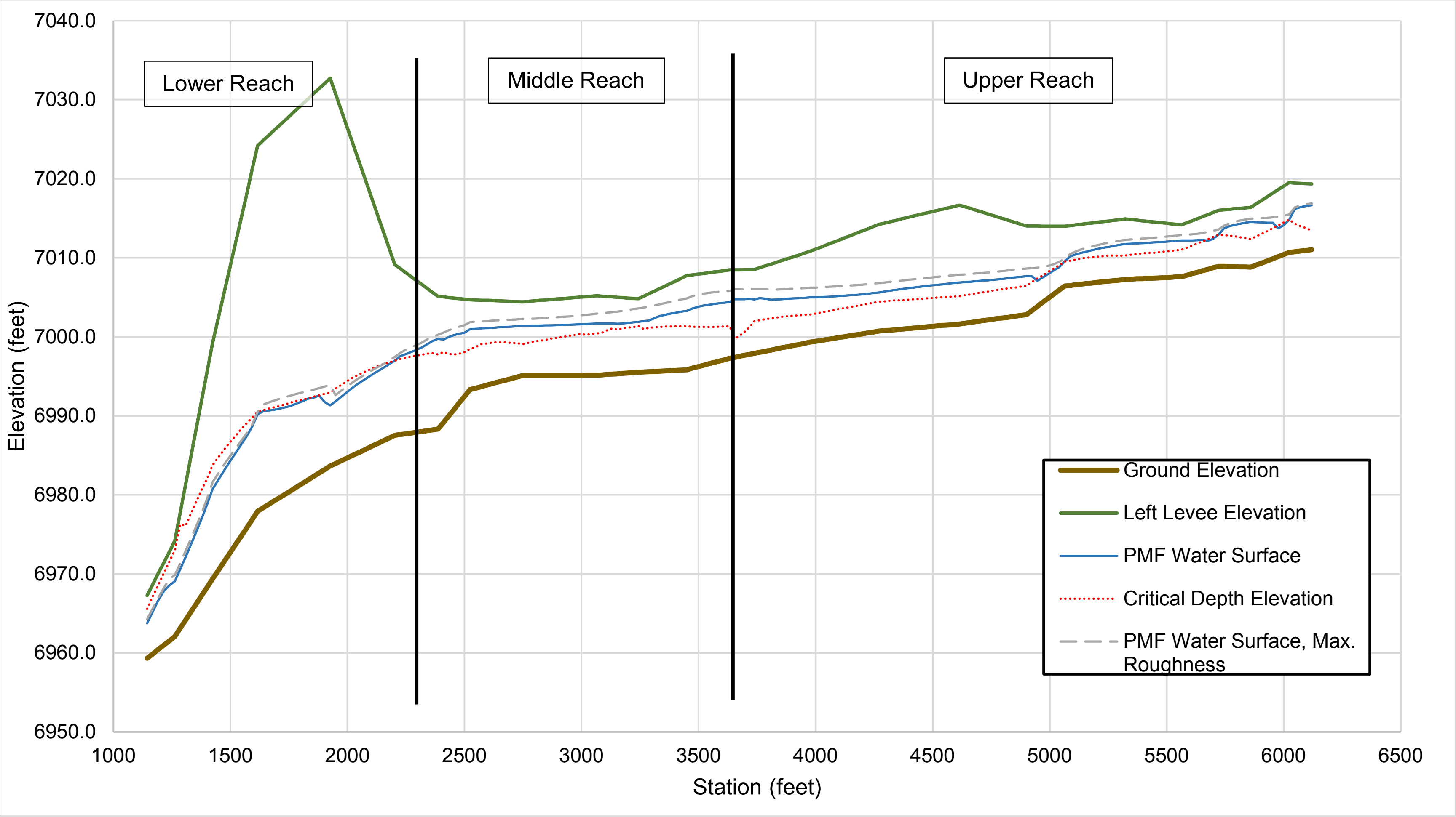


Figure 27: North Diversion Channel Water Surface, Critical Depth, and Left Levee Profile Plot

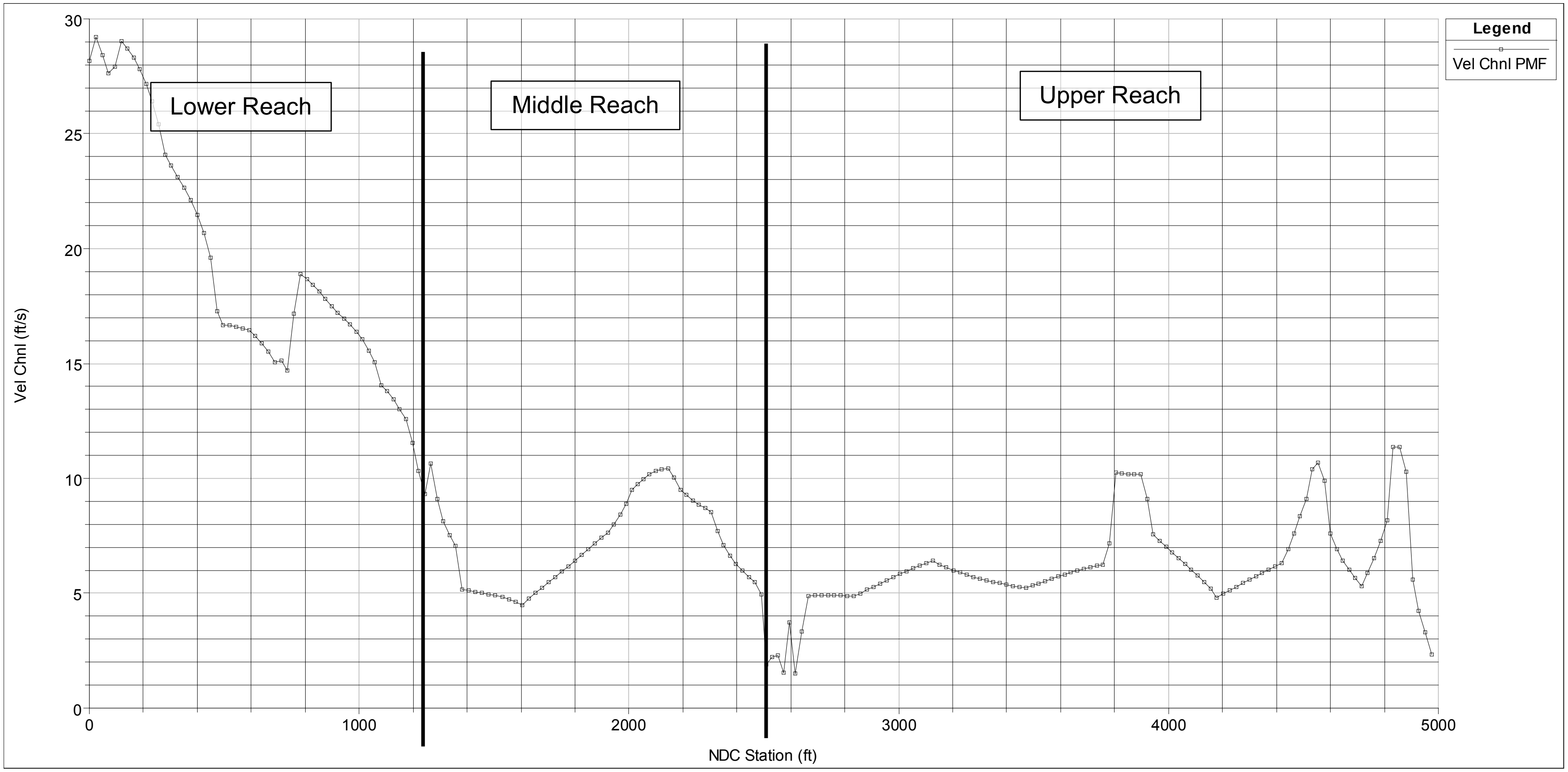


Figure 28: North Diversion Channel Velocity Profile

ATTACHMENT I.6

Upper Pipeline Arroyo Hydraulic Model

CALCULATIONS

Client: *General Electric/United Nuclear Corporation*
Project: *NECR 95% Design*
Description: *Upper NECR 2-D Hydraulic Model*

Sheet: *1* **of** *5*
Date: *10/13/2017*
Job No: *10508639*

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*
1	*8/8/2017*	*Preliminary (95%) Design*	*S. Murphy*	*N. Haws*	*10/20/17*

Revisions

Issue Date	Description
--	--

Location and Format

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

Calculations were generated using the following software:

- HEC-RAS – River Analysis System. Version 5.0.3 Feb 2016. U.S. Army Corps of Engineers Hydraulic Engineering Center
- ESRI ArcMap 10.2.2
- Microsoft Excel 2013
- HEC-HMS – Hydrologic Modeling System version 4.2.1, build 28. United States Army Corps of Engineers (USACE) Hydrologic Engineering Center

Table of Contents

Objective

Client: *General Electric/United Nuclear Corporation*
Project: *NECR 95% Design*
Description: *Upper NECR 2-D Hydraulic Model*

Sheet: *2* **of** *5*
Date: *10/13/2017*
Job No: *10508639*

The objective of these calculations is to estimate the water surface elevations, depths, shear stresses, and velocities in the Pipeline Arroyo upstream of the jetty structure, focusing on the area near the north cell of the Tailings Disposal Area (TDA) including the North Cell Drainage Channel and the Northern Alluvial Area.

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). The proposed Repository is located on the north cell of the TDA. Near the 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.

The North Cell Drainage Cell runs east to west along the northern boundary of the North Cell (See Sheet 9-01). After Removal Action (RA) and construction of the Repository, the North Cell Drainage Channel will receive discharge from the East Repository channel and convey it to the Pipeline Arroyo. Without improvements, the North Cell Drainage Channel could also be flooded in large flood events by overflow water from the alluvial floodplain to the north of the TDA.

This calculation brief describes the methods and simulation results for a two-dimensional (2D) hydraulic model that Stantec constructed to estimate the water surface elevation, maximum velocities, and maximum shear stress in the Upper Pipeline Arroyo and through the North Cell Drainage Cell.

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

The 2D flow simulations were performed using the United States Army Corps of Engineers Hydrologic Engineer Center River Analysis System (HEC-RAS) model, version 5.0.3. The 2D flood routing capabilities of HEC-RAS allow the user to perform a detailed 2D unsteady flow analysis for a floodplain. The model can analyze mixed flow regimes as well as the flow transitions from subcritical to supercritical flow as well as hydraulic jumps. The model uses an implicit finite volume algorithm that allows for 2D cells to be robust in wetting and drying scenarios. Stantec developed the model for unsteady flow analysis of the area north of the proposed jetty to analyze the hydraulics near the TDA and in the northern alluvial area. The model is comprised of the following data types: Terrain, Geometry, and Unsteady Flow Data. These three data types are compiled into unsteady flow analysis plans, which use terrain, geometric, and unsteady flow data types to simulate the system hydraulics over specified computation intervals.

Terrain Data

Stantec developed floodplain geometry for input into the 2D model 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-ft vertical (MWH, 2014). The topographic data was imported into HEC-RAS as a digital elevation map. Stantec created the terrain data for proposed remedial activities by converting CAD surfaces to GeoTIFF files and superimposing them onto the digital elevation map. The model terrain data for existing and proposed conditions can be seen in **Figures 1a and 1b**.

Geometric Data

The geometry data defines the computational mesh of the 2D model as well as the boundary condition locations and Manning's roughness (n) value regions for the model. Stantec added break lines to the model geometry editor to establish non-uniform grids in areas where the terrain is less uniform, such as a streambed. For all geometric data used in the model, the standard grid spacing is 20 feet in both the x-direction and y-direction. Twenty-foot spacing allows for reasonable model resolution and runtimes. Model boundary condition lines are the segments on the boundary of the computational mesh where flow is allowed to either enter or exit. The model computational area, initial conditions, and boundary condition locations are shown in **Figure 2**.

The HEC-RAS model uses Manning's roughness values to simulate resistance to flow within the floodplain. Values of roughness were estimated using Chow (1956) by selecting "average" roughness conditions for the base-case simulation. **Table 1** lists the estimated roughness values and the associated Manning's roughness regions used in the model.

Boundary Conditions

Stantec specified the following boundary conditions in the model (see **Figure 2**):

- Unsteady inflow condition representing inflow from the Pipeline Arroyo where the Pipeline Arroyo crosses the northern boundary of the model (labeled J-R12us in **Figure 2**)
- Unsteady inflow condition representing inflow from the Northern Diversion Channel where the Northern Diversion Channel runs behind Dilco Hill (labeled J-R11us in **Figure 2**)
- Outflow boundary condition along the southwestern boundary of the model
- Unsteady precipitation boundary condition over the entire model domain

Unsteady Flow Boundary Conditions (J-R12us and J-R11us)

The two unsteady flow boundary conditions apply the simulated flood hydrographs from the Pipeline Arroyo Watershed Model with flow hydrographs taken from model elements with the same names (see Attachment I.1). The simulated hydrographs for these two inflow points are shown in **Figure 3**. The model approximated the inflow at these boundaries to enter under normal flow conditions, with the friction slope equal to the bed slope. The bed slope at J-R11us is 0.021 feet per foot (ft/ft) and the bed slope at J-R12us is 0.0042 ft/ft.

Outflow Boundary Condition Along the Southwestern Boundary

Stantec set the outflow boundary condition to normal depth based on the bed slope of the Pipeline Arroyo where it crosses the boundary (0.0364 ft/ft).

Unsteady Precipitation Boundary Condition

Stantec added a precipitation boundary condition for each design storm using the net precipitation specified in the Pipeline Arroyo Watershed Model (Attachment I.1), where net precipitation was computed as the difference between the total precipitation and the average specified constant infiltration rate over the watershed area. The precipitation boundary condition hyetographs used in the model are listed in **Tables 2a and 2b**.

Initial Condition

Stantec set an initial water surface elevation as the initial condition for the model. Because the bottom boundary condition is based on the normal depth for the channel flow, the initial water surface is set so normal depth can be established downstream. The initial water surface elevation is set to 6,870-ft above mean sea level (amsl) (**Figure 2**), such that only a small extent of the model is wetted to begin the simulation. The initial condition helps provide numerical stability at the outflow boundary by artificially “wetting” the flow surface, preventing numerical instability in the model from a sudden inflow of water. Water surface elevation errors are insignificant because Stantec used the model to evaluate the maximum water depths and velocities, which occur after a significant amount of model time has passed. All increased water levels decrease to equilibrium within ten minutes of the 4.5 hours of simulation time. The initial condition assumes that the Pipeline Arroyo is dry at the beginning of the storm event.

Unsteady Flow Analysis Plans

The terrain, geometry, and unsteady flow data are associated with analysis plans for each model run. Each analysis plan contains associated geometric and unsteady flow data, a desired simulation time window, and a computation interval. The computation interval is the time step between model computations. Stantec set a computation interval for each plan to 0.5 seconds, which achieves a Courant value (C) of less than 1:

$$C = V_{max}\frac{\Delta t}{\Delta x}$$

Where:

V_{max} = maximum velocity in the model,
Δt = computation interval (seconds)
Δx = cell spacing (feet)

All model runs used the full momentum equations with a maximum of 100 iterations. Stantec set all other run parameters to the default options.

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

Maximum Velocity

For simulations of the PMP for proposed and existing mill site conditions, the proposed earthen berm produces significantly slower velocities around the repository. For existing conditions, Stantec simulated velocities in excess of 5 feet per second near the repository (**Figure 4a**). Stantec simulated velocities of about 2-3 ft/s near the embankment with the addition of the proposed improvements (**Figure 4b**).

Maximum Shear Stress

For simulations of the PMP for proposed and existing mill site conditions, the proposed earth berm significantly reduced the shear stresses simulated near the repository. For existing conditions, Stantec simulated stresses in excess of 1 lbs/ft^2 near the embankment (**Figure 5a**). Shear stresses generally remained below 0.5 lbs/ft^2 near the embankment for the proposed site configuration (**Figure 5b**).

Client: *General Electric/United Nuclear Corporation* **Sheet:** *5* **of** *5*
Project: *NECR 95% Design* **Date:** *10/13/2017*
Description: *Upper NECR 2-D Hydraulic Model* **Job No:** *10508639*

Reduced shear stresses and velocities are important to provide long-term erosion protection for the repository, and the earthen berm has been shown to significantly reduce both velocities and shear stresses on the soil near or on the repository.

Stantec developed figures displaying the 2D model analysis results for maximum depth during the PMF (**Figures 6a and 6b**), maximum velocity during the PMF (**Figures 4a and 4b**), and maximum shear stress (**Figures 5a and 5b**). Stantec determined the necessary height of the proposed earthen berm using the 2D model and the resulting water surface elevation during the PMF can be seen in **Figure 7**. The height of the berm and the repository ensures that the PMF will be contained within the North Cell Drainage Channel.

Stantec evaluated the flooding extents during the 10-year flood, 100-year flood, and PMF for proposed site conditions (**Figure I.6-1**) and for existing site conditions (**Figure 8**).

Conclusions

The results from the 2D analysis of the floodplain show that the proposed site improvements can reduce the potential for erosion near the repository and prevent the Pipeline Arroyo from migrating towards the north end of the TDA.

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.

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 Upper Pipeline Arroyo 2D Model

Roughness Regions	Roughness Value	Description*
Rock Chute, Repository Channels, Dilco Hill Channels, Alluvial Area, Drainage Swales	0.035	- Excavated Channel - Rock Cuts - Smooth and Uniform (Avg) - Flood plains – Scatter brush with heavy weeds (minimum coverage in channel)
Pipeline Arroyo, Roadways	0.025	- Minor Stream - Clean, Straight, full stage, no rifts or deep pools (min)
North Cell Drainage Channel	0.04	- Excavated Channel - Dense weeds or aquatic plants in deep channel (max)
Brushy/heavily vegetated areas	0.05	- Brush - scattered brush, heavy weeds (avg)

*Note: The reach description corresponds to Table 5-6 *Values of the Roughness Coefficient* from Chow (1959). Descriptions chosen to correspond to the site conditions.

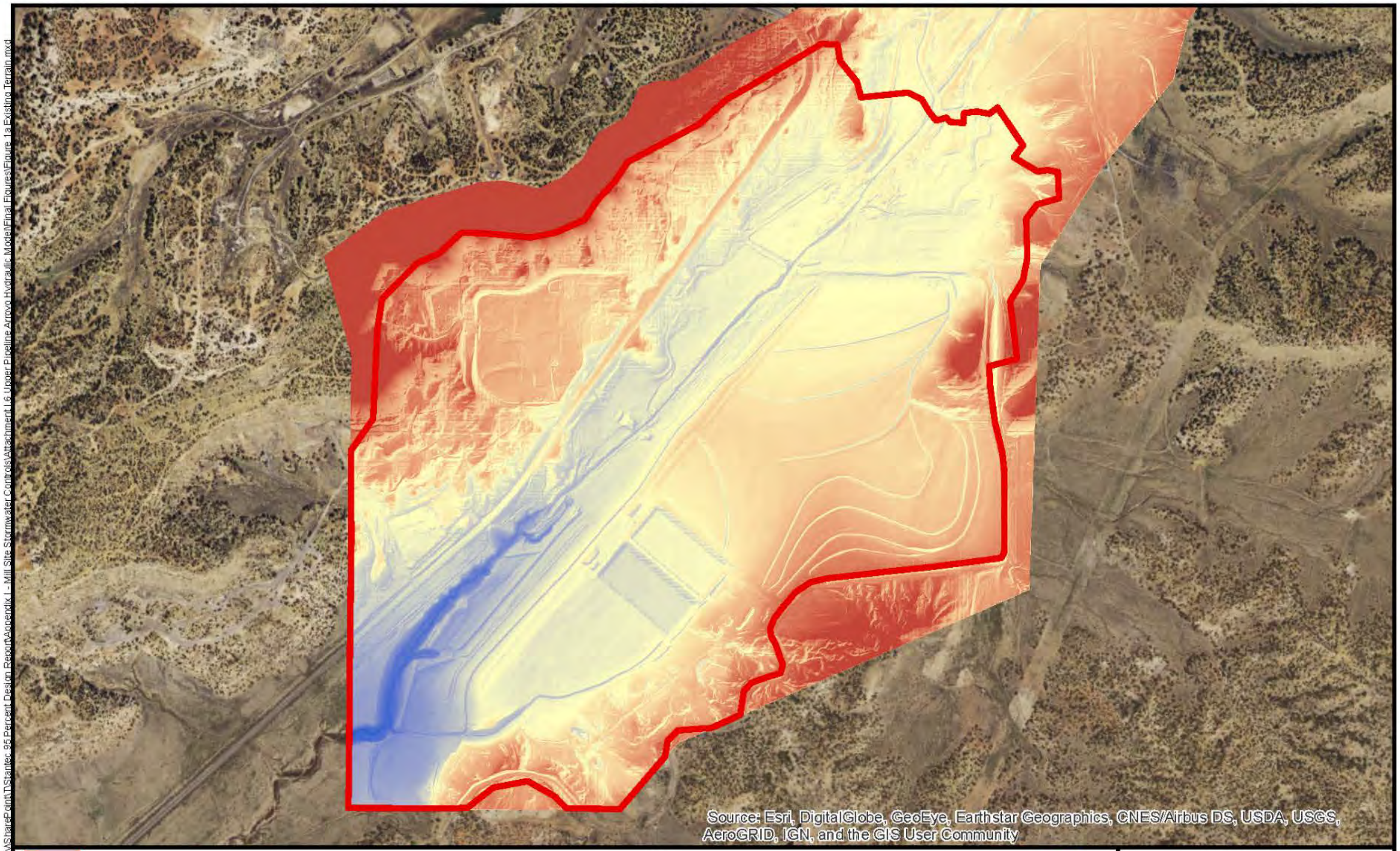
Table 2a: Net Precipitation Boundary Condition PMP Hyetograph

Time elapsed (min) min	Net Precipitation inches/10 minutes
0	0
10	0.694
20	0.894
30	1.444
40	1.134
50	0.764
60	0.694

Table 2b: Net Precipitation Boundary Condition Hyetograph for Different Return Periods

Time Elapsed	Net Precipitation (in/5min)		
Minutes	5 Year Storm	10 Year Storm	100 Year Storm
670	0	0	0
675	0	0	0
680	0	0	0
685	0	0	0
690	0	0	0
695	0	0	0.00234
700	0	0.00044	0.01284
705	0	0.01724	0.02904
710	0.00724	0.05155	0.05694
715	0.03624	0.15113	0.11364
720	0.11824	0.32647	0.27774
725	0.25724	0.08565	0.56524
730	0.06524	0.03092	0.16994
735	0.01824	0.00758	0.07954
740	0	0	0.04094
745	0	0	0.02004
750	0	0	0.00704
755	0	0	0
760	0	0	0
765	0	0	0
770	0	0	0

FIGURES



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

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MWH now part of Stantec

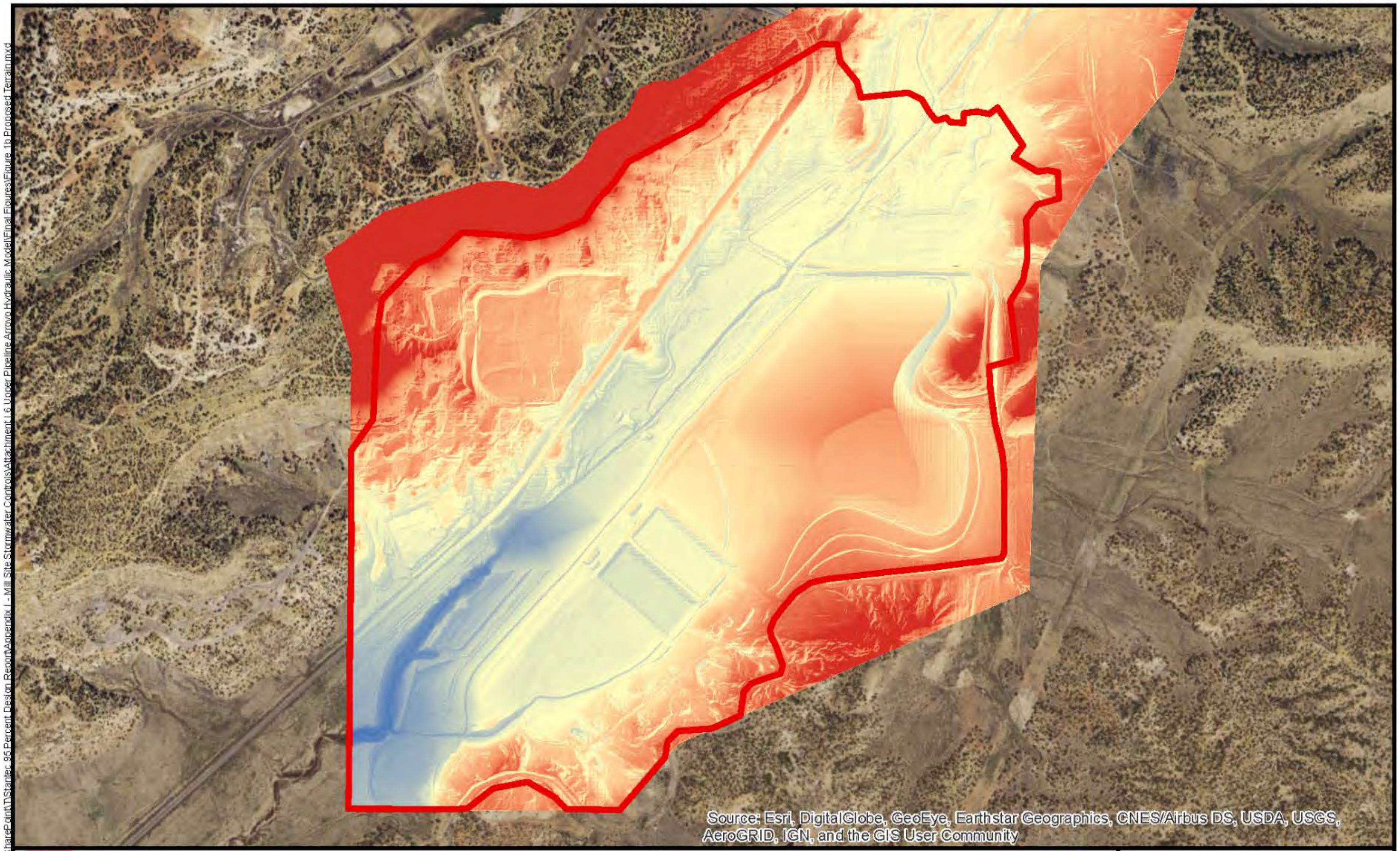
FIGURE 1a:

2D Model Terrain Existing Conditions

Northeast Church Rock

Date Revised: 10/3/2017

File Path: C:\Users\semumh\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 1a Existing Terrain.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

🟥 2D Model Area Extents

Elevations - Proposed (ft)

High : 7260

Low : 6860

N

W E

S

0 750 1,500 3,000 Feet

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

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FIGURE 1b:

2D Model Terrain for Proposed Conditions

Northeast Church Rock

Date Revised: 10/2/2017

File Path: C:\Users\semumh\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 1b Proposed Terrain.mxd

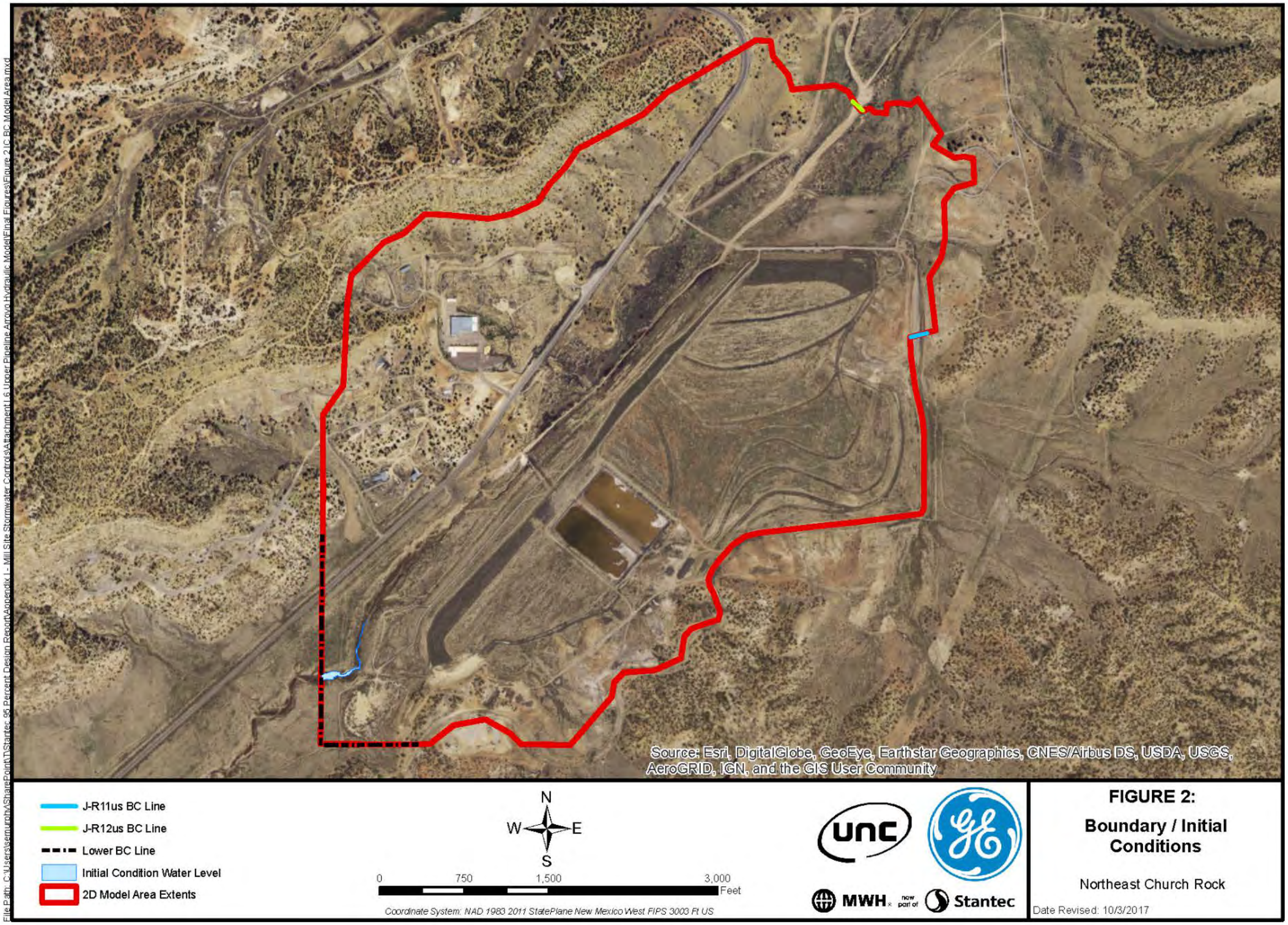


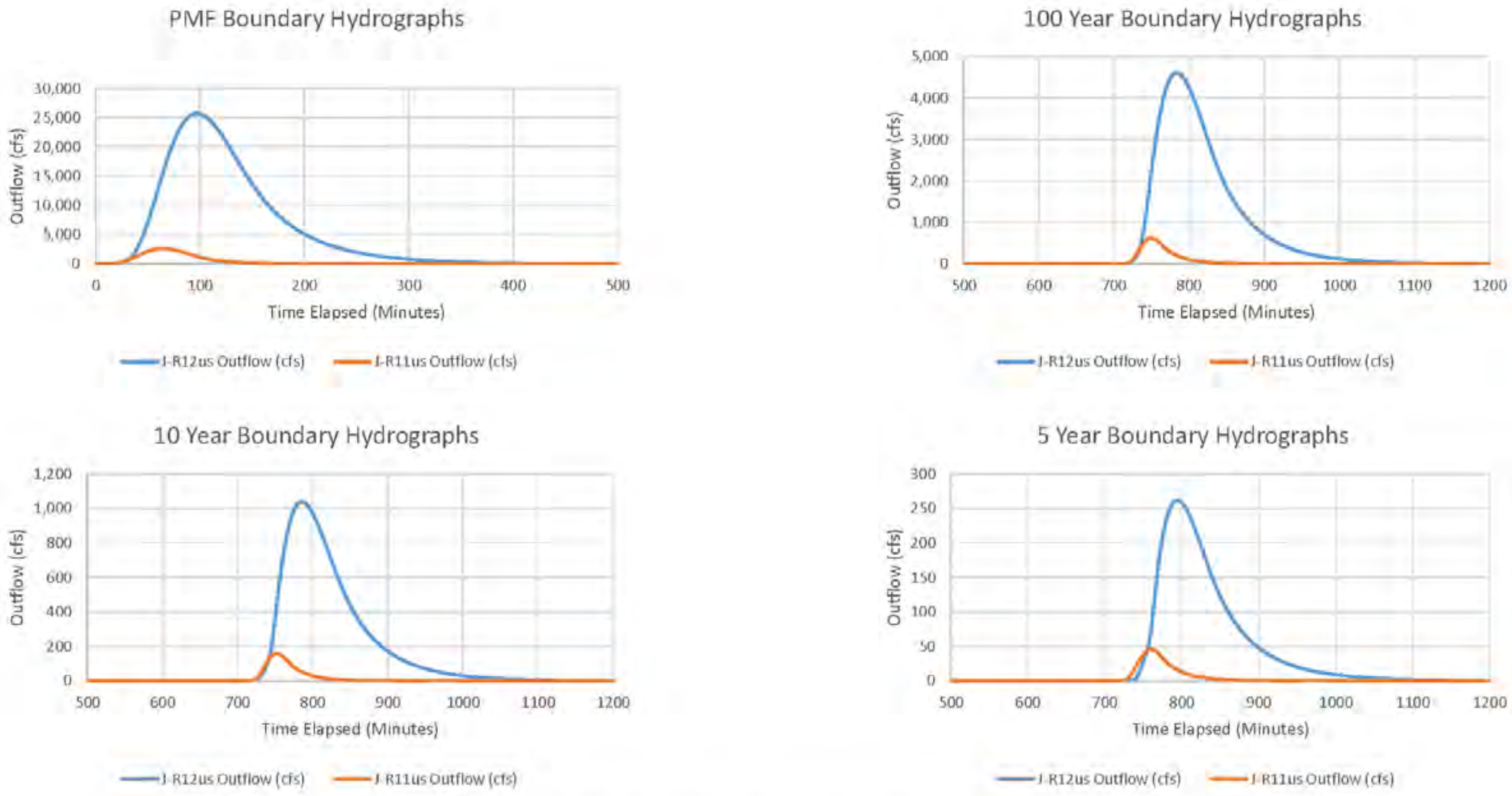
FIGURE 2:

Boundary / Initial Conditions

Northeast Church Rock

Date Revised: 10/3/2017

File Path: C:\Users\semurph\A\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 2 IC BC Model Area.mxd



PMF Boundary Hydrographs

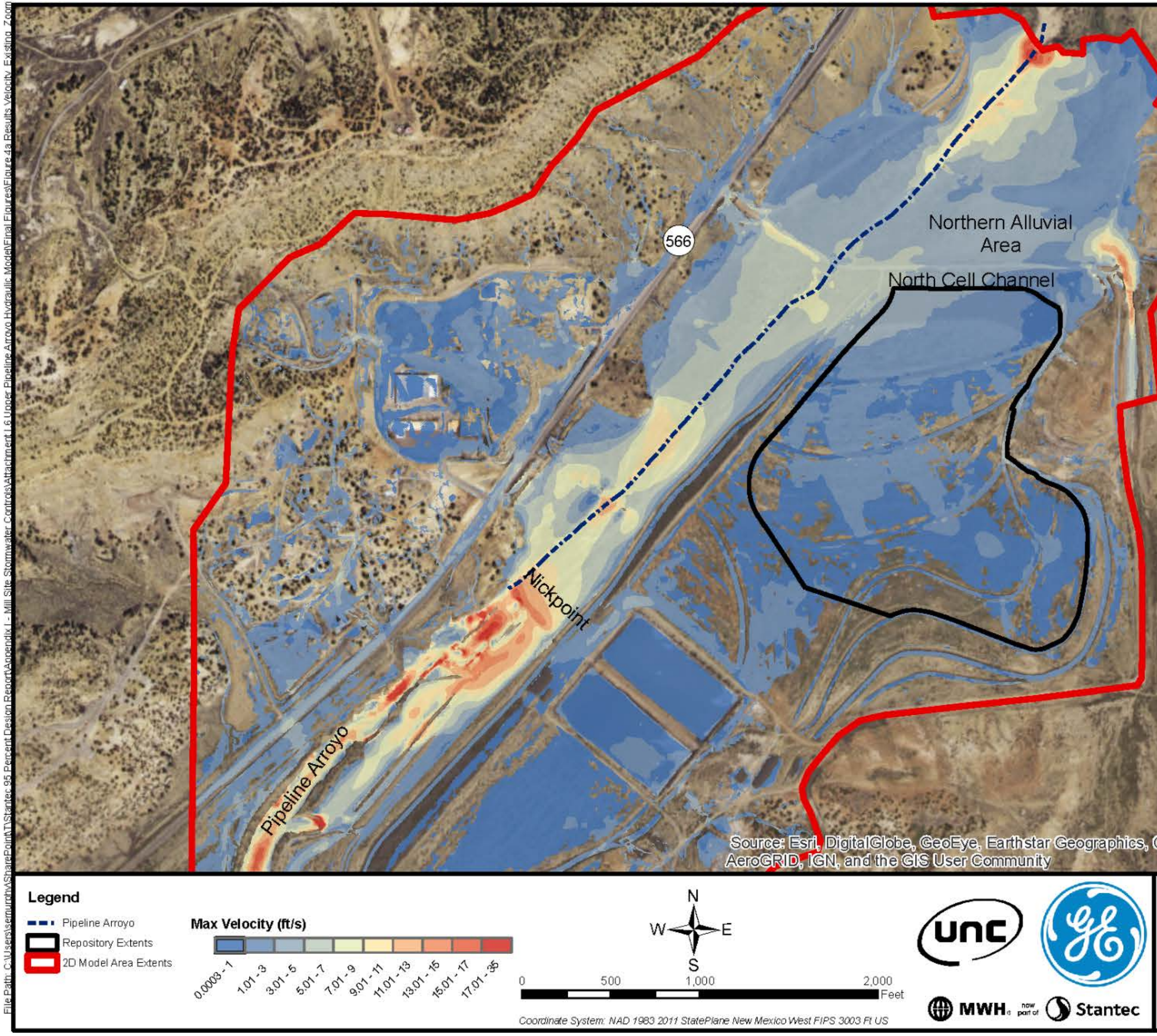
100 Year Boundary Hydrographs

10 Year Boundary Hydrographs

5 Year Boundary Hydrographs

Figure 3: Boundary Condition Hydrographs

See Figure 2 for locations of J-R11us and J-R12us



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

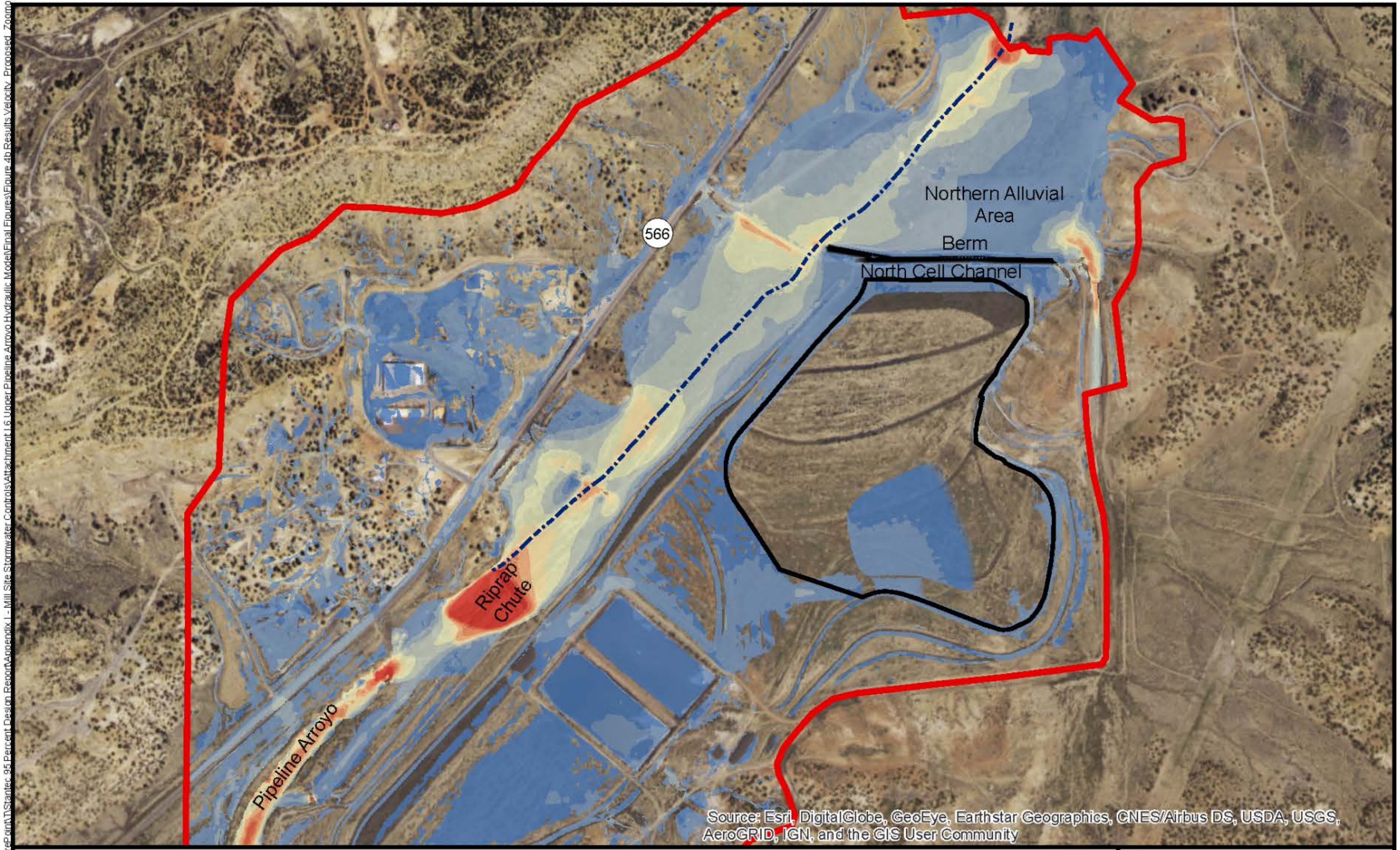
Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE 4a:
2D Model - PMF
Maximum Velocity -
Existing Conditions

Northeast Church Rock

Date Revised: 10/3/2017

File Path: C:\Users\semurphy\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 4a Results Velocity_Existing_Zoomout.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- 🟥 2D Model Area Extents
- ☐ Repository Extents
- - - Pipeline Arroyo Alignment

Max Velocity (ft/s)

0.0003 - 1
1.01 - 3
3.01 - 5
5.01 - 7
7.01 - 9
9.01 - 11
11.01 - 13
13.01 - 15
15.01 - 17
17.01 - 30

N
W E
S

0 500 1,000 2,000 Feet

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

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FIGURE 4b:
2D Model - PMF Maximum Velocity - Proposed Conditions

Northeast Church Rock

Date Revised: 10/3/2017

File Path: C:\Users\semurphy\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 4b Results Velocity_Proposed_Zoomout.mxd

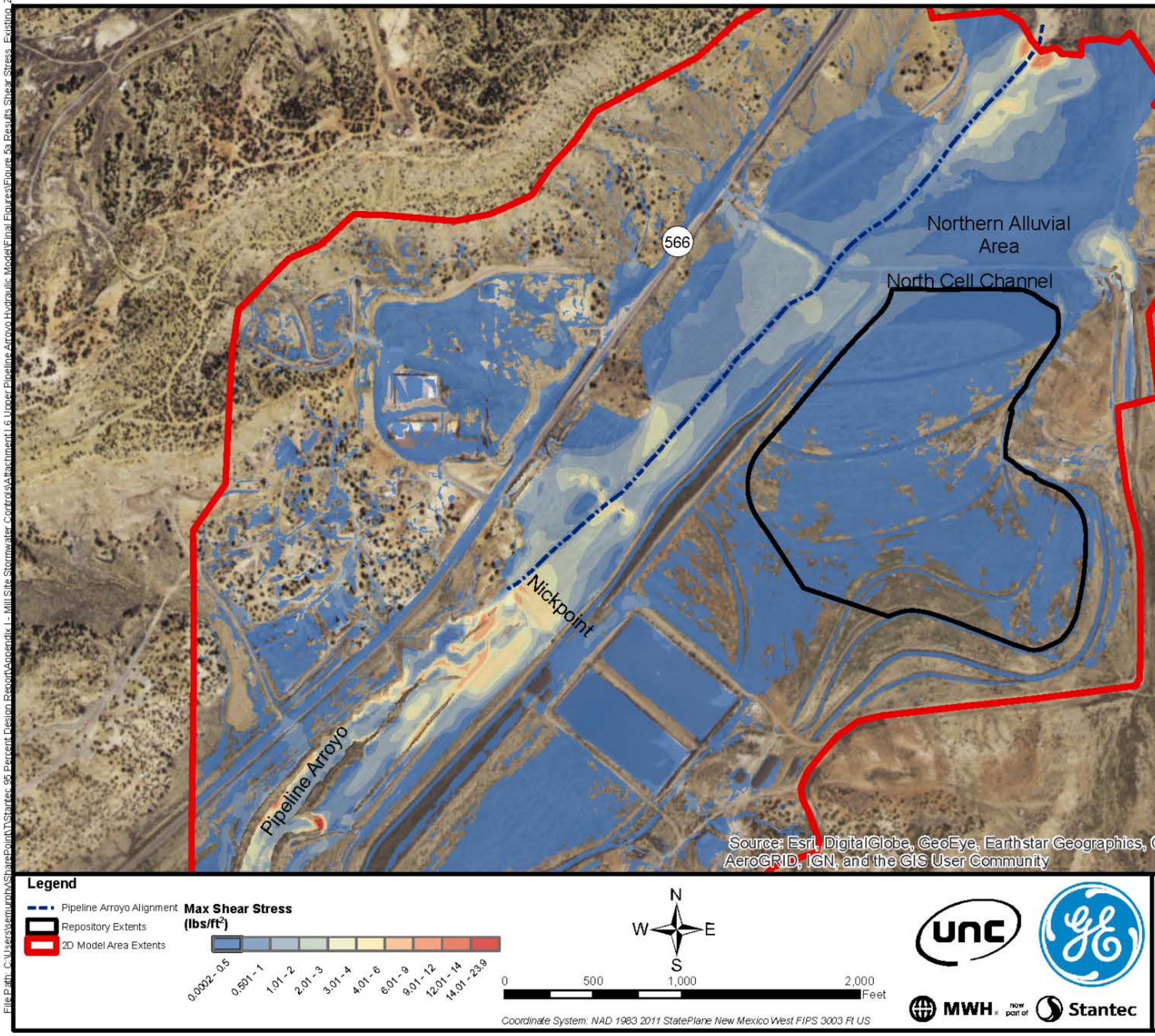

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FIGURE 5a:
2D Model - PMF
Maximum Shear -
Existing Conditions

Northeast Church Rock

Date Revised: 10/3/2017

File Path: C:\Users\semurph\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 5a Results Shear Stress_Existing_Zoomout.mxd

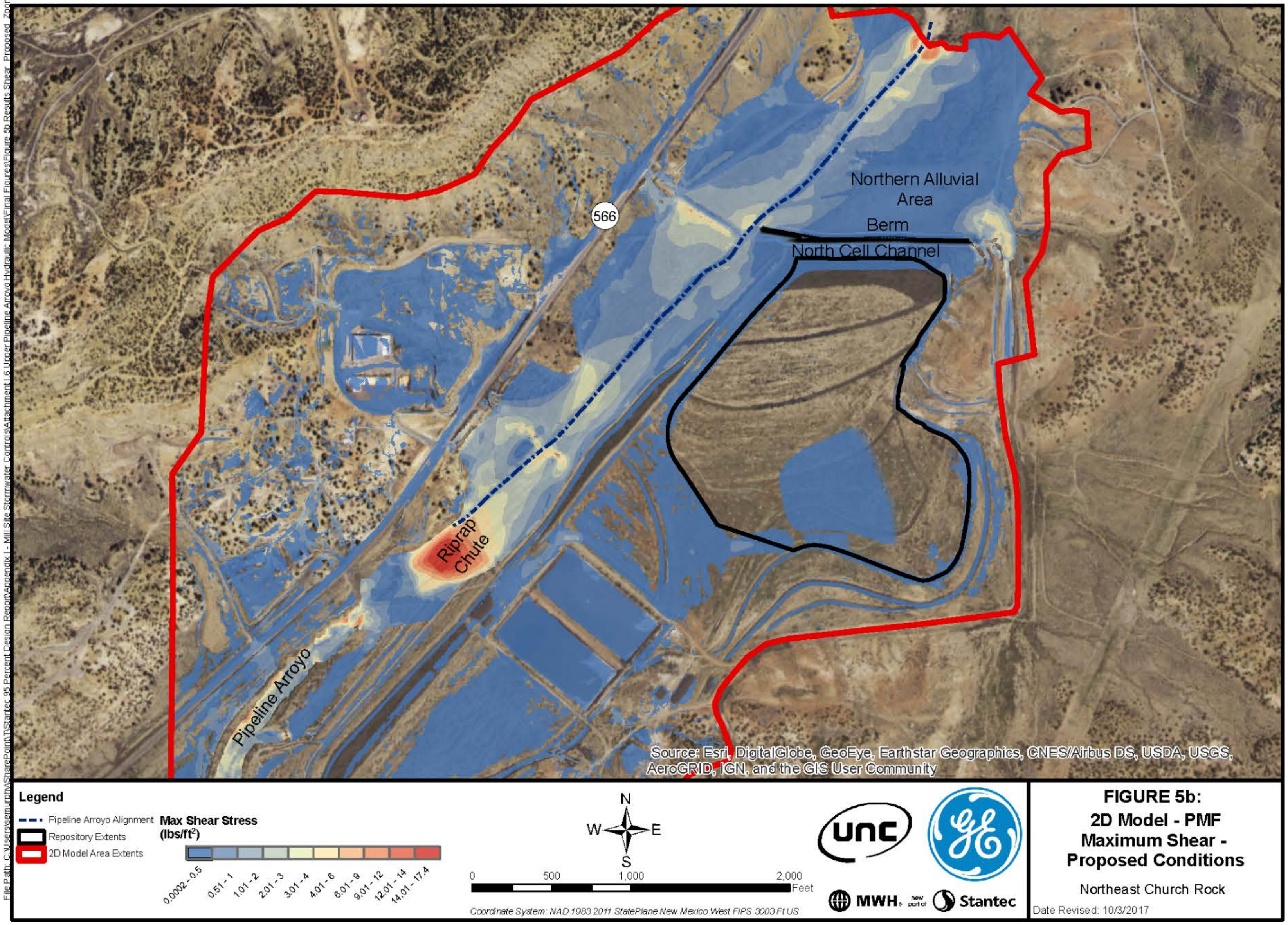


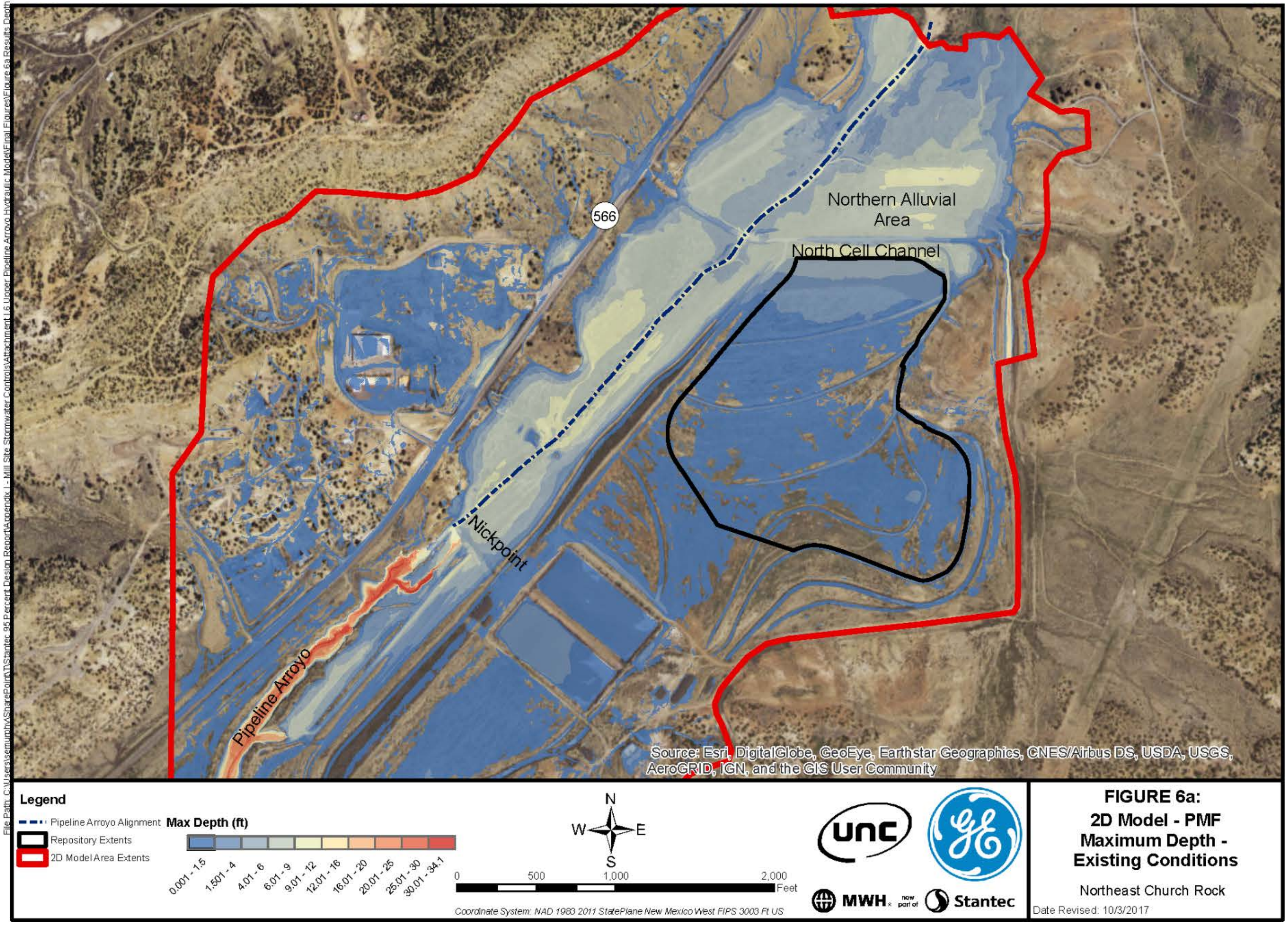
FIGURE 5b:
2D Model - PMF Maximum Shear - Proposed Conditions

Northeast Church Rock

Date Revised: 10/3/2017

File Path: C:\Users\semurph\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 5b Results Shear_Proposed_Zoomout.mxd

File Path: C:\Users\semurphy\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 6a Results Depth Existing.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

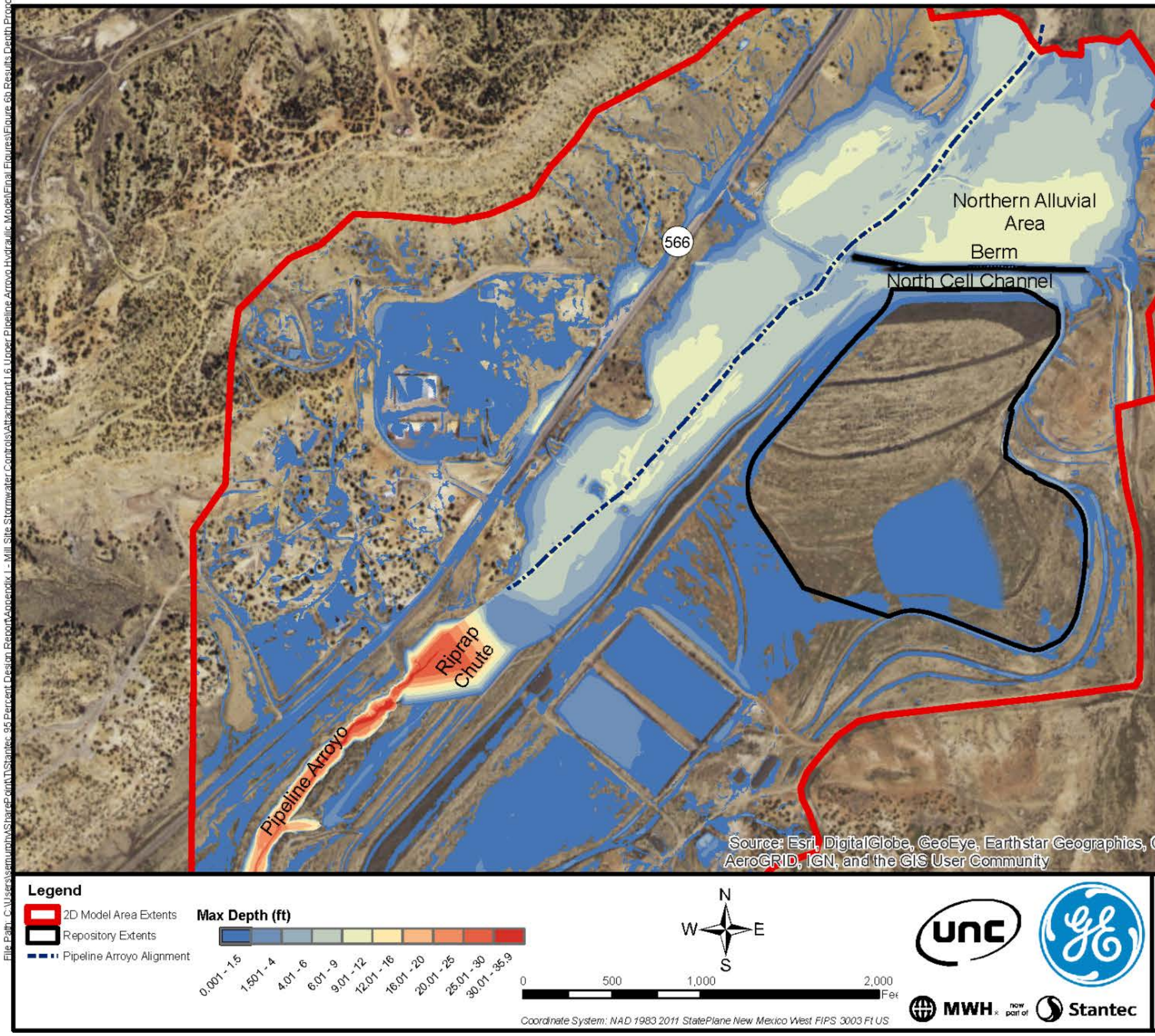
Coordinate System: NAD 1983 2011 StatePlane New Mexico West FIPS 3003 Ft US

FIGURE 6a:
2D Model - PMF
Maximum Depth -
Existing Conditions

Northeast Church Rock

Date Revised: 10/3/2017

File Path: C:\Users\semurphy\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 6b Results Depth Proposed.mxd



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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

FIGURE 6b:
2D Model - PMF
Maximum Depth -
Proposed Conditions

Northeast Church Rock

Date Revised: 10/3/2017

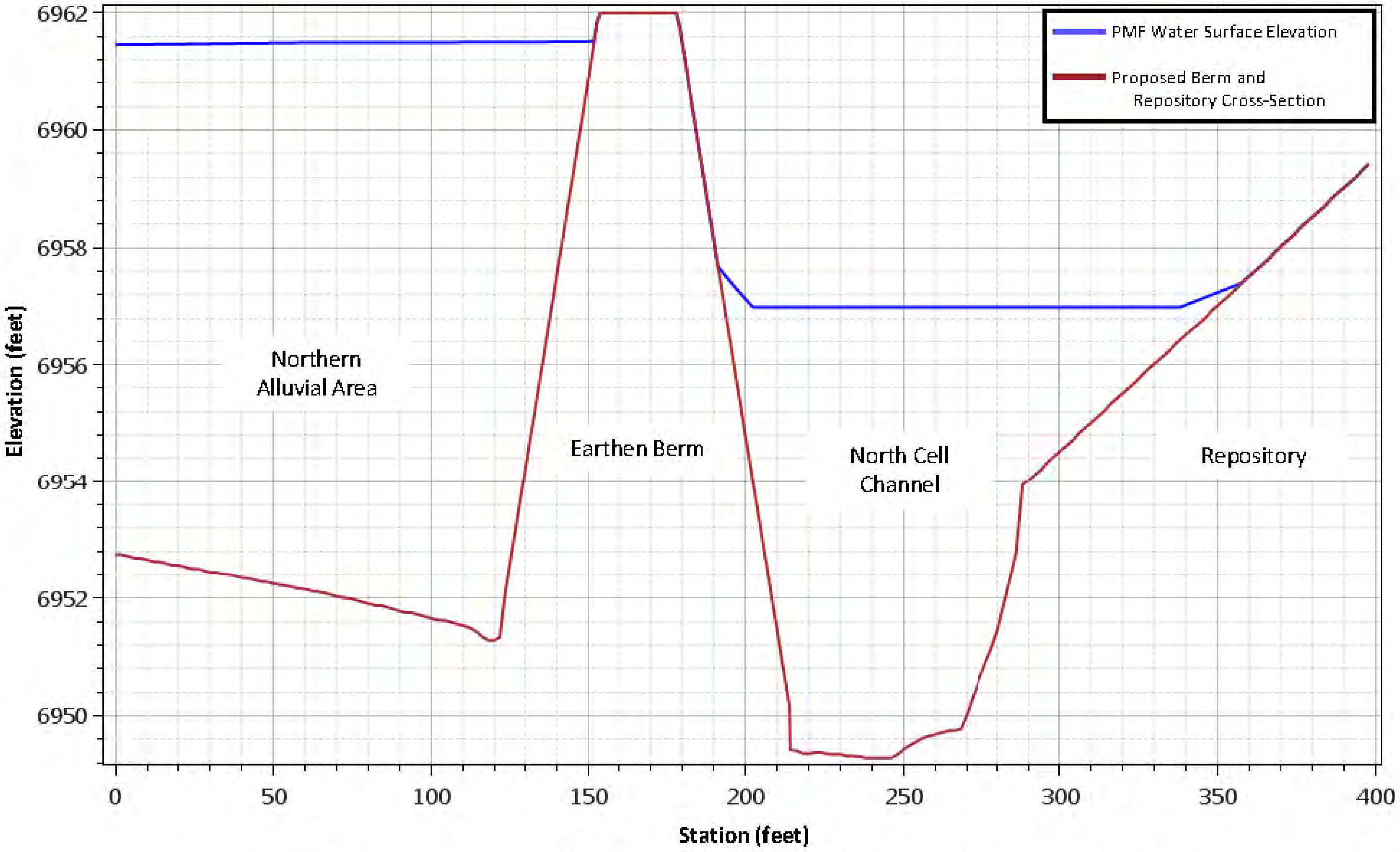
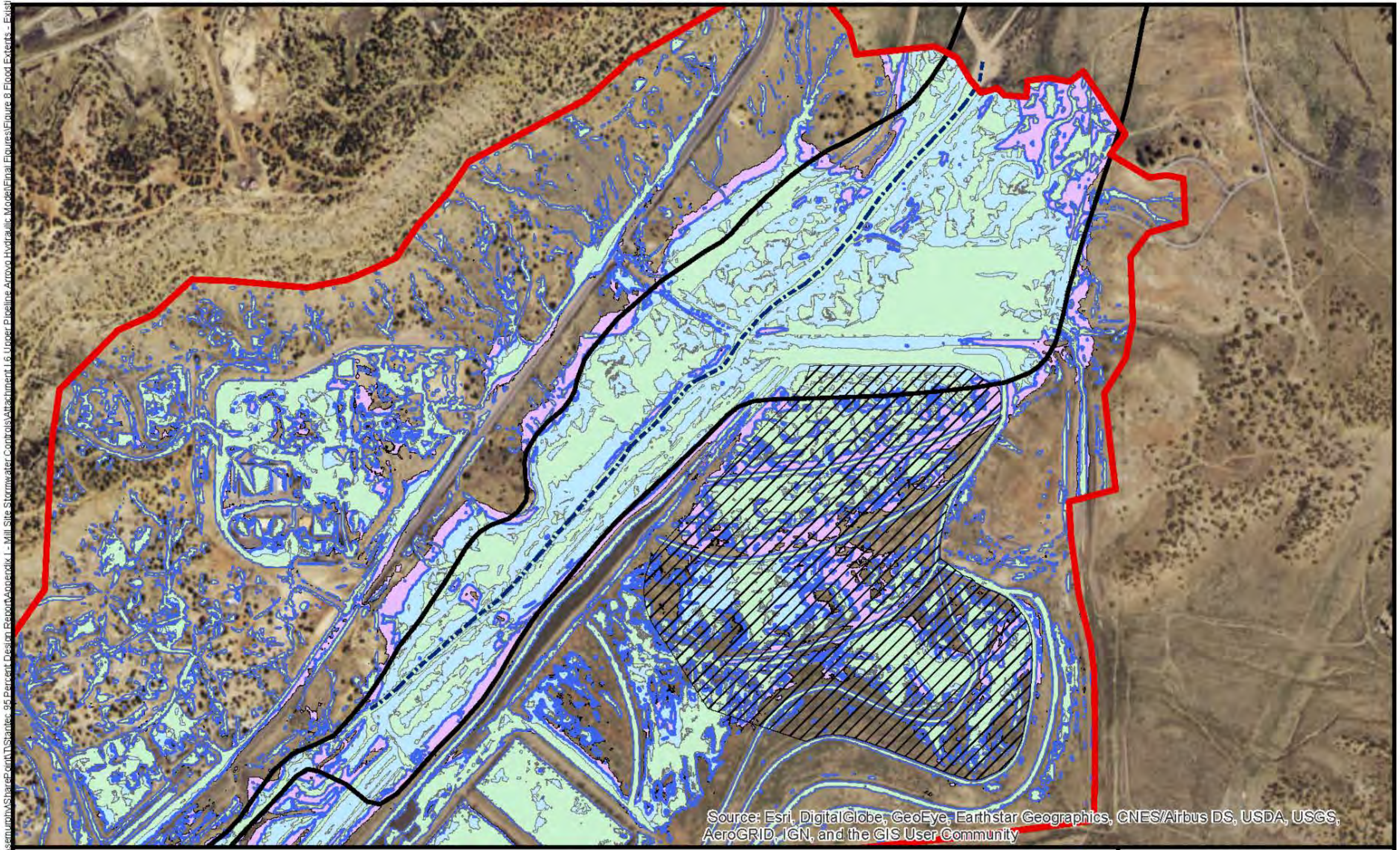


Figure 7: Water Surface Elevation During PMF Across Proposed Berm

File Path: C:\Users\semurphy\SharePoint\T\Stantec 95 Percent Design Report\Appendix I - Mill Site Stormwater Controls\Attachment I.6 Upper Pipeline Arroyo Hydraulic Model\Final Figures\Figure 8 Flood Extents - Existing.mxd


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- 🟥 2D Model Area Extents
- ▨ Repository Boundary
- ‒ · ‒ Pipeline Arroyo Alignment
- ━ Canonie PMF Flood Extents
- 🟩 5 Year Flood Extents
- 🟦 100 Year Flood Extents
- 🟪 PMF Flood Extents

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

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FIGURE 8:
Estimated Pipeline Arroyo Flood Extents - Existing Conditions

Northeast Church Rock

Date Revised: 10/3/2017

ATTACHMENT I.7
Hydraulic Analysis and Riprap Sizing for the Pipeline Arroyo Riprap Chute

ATTACHMENT I.7: HYDRAULIC ANALYSIS AND RIPRAP SIZING FOR THE PIPELINE ARROYO RIPRAP CHUTE

Revisioning

Rev.	Date	Description	By	Checked	Date
0	*04/11/2017*	*Preliminary (60%) Design*	*J. Bartels*	*N. Haws*	*4/12/17*
1	*10/3/2017*	*95% Design*	*J. Bartels/J. Erickson*	*N. Haws*	*10/24/2017*

Location and Format

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

Calculations were generated using the following software:

- Flow-3D v11 – developed by Flow Science, Inc.
- AutoCAD v14
- Microsoft Office Suite 2013

Table of Contents

Objective

Simulate the hydraulics and size riprap over the proposed Pipeline Arroyo riprap chute and through the proposed riprap basin for the design storm, the probable maximum flood (PMF), and other storm events (100 year, 200 year, 1,000 year, and 10,000 year).

Background

The recommended alternative for stabilizing the Pipeline Arroyo adjacent to the Tailings Disposal Area (TDA) is to construct a riprap chute with a riprap outlet basin. The selected configuration will capture flow from the Pipeline Arroyo channel and floodplain area and pass the flow down approximately 56 vertical feet at a 5.3 percent gradient. During a flood event, flows will span the wide floodplain upstream of the rock outcrop and will converge over the riprap chute to flow into the arroyo channel downstream. Stantec constructed a computational fluid dynamics (CFD) model of the riprap chute and outlet basin to evaluate the hydraulics of the chute and basin and to determine the required riprap size.

Methods

Hydraulic Modeling

The CFD modeling was conducted using the Flow-3D (version 11) computer program developed by Flow Science, Inc. Flow-3D provides a powerful tool for complex fluid modeling problems that uses structured, free-form rectangular gridding that provides some of the most highly accurate, free-surface modeling capabilities of all commercial CFD codes available today. The extents of the hydraulic analysis can be seen in **Figure 1**.

The CFD model of the riprap chute and basin was run under a one-fluid, free-surface flow condition utilizing the gravity and viscosity/turbulence options available within Flow-3D. This is the method recommended by Flow Science for these types of problems. Descriptions of the geometry and key numerical options used in this analyses are included in the following sections.

Model Geometry

The three-dimensional geometry of the existing river channel and proposed riprap chute were converted to a stereo lithographic file (STL) format in AutoCAD for use in Flow-3D.

Viscosity and Turbulence

Turbulence utilized the implicit renormalized group theory κ-ε model. This turbulence model is similar to the standard two-equation κ-ε model and is the model recommended by Flow Science for most hydraulic applications.

Pressure

Pressure calculations were made using the generalized minimum residual implicit pressure-velocity solver and the dynamically adjusted pressure convergence tolerance setting available within Flow-3D. This pressure solver setup is the default setting in Flow-3D and is recommended for most hydraulic applications.

Meshing

The existing channel and proposed riprap weir and basin were modeled using a series of two models. The upstream model was run first and included a portion of the upstream Pipeline Arroyo channel and floodplain area and extended approximately 1,200 feet upstream of the proposed riprap chute. The downstream model extended the upstream model an additional 1,200 feet downstream through the riprap chute and basin. The modeling was split into two parts to minimize the model run times.

Each model was composed of several separate runs (i.e. base model with multiple restart simulations) each consisting of linked, multi-block meshes of varying resolution. The coarser, less-defined base and initial restart models were used to get the flow moving quickly towards a steady-state condition. The finer, more-defined restart models were then run to increase the resolution of the ground surface through the jetty. The modeling approach utilized Cartesian (i.e. x-, y-, z-) coordinates with a mesh size of 2.0 feet in the x and y direction and mesh sizes of 1.0 foot (upstream model) and 0.5 foot (downstream model) in the z direction.

Boundary Conditions

Boundary conditions used in the upstream CFD model included a fixed volumetric flow rate and an outflow boundary condition (i.e. free discharge) applied at the upstream and downstream end of the model domain, respectively.
The model simulated the 100 year (4,932 cfs), 200 year (6,700 cfs), 1,000 year (10,200 cfs), 10,000 year (15,200 cfs) and PMF (27,600 cfs) storm events. The estimation of each value is described in Appendix I, Attachments I.1 and I-6.

The outflow boundary was chosen due to the steep slope of the proposed rock jetty (i.e. the flow maintains a supercritical flow regime with no tailwater effects).

Evaluation of Riprap Revetment

Stantec used the method presented by Abt and Johnson (1991) (Equation 1) to determine the minimum median stone diameter required for riprap revetment. This method is presented in NUREG-1623 and is recommended for use for sizing riprap for overtopping flows on steeps slopes.

$$D_{50f} = 5.23S^{0.43}q^{0.56} \qquad \text{Equation 1}$$

Where:

D_{50f} = minimum median riprap diameter at the threshold of displacement, inches
q = unit discharge, cubic feet per second per foot
S = chute slope, feet per feet (0.053)

The unit discharge (q) was taken as the product of hydraulic parameters (Depth-Averaged Velocity (V) and the Depth (D)) simulated in the CFD model.

Equation 1 gives the median riprap size that, for a give flow regime, will be at the threshold of displacement (D_{50f}). Using the results of Equation 1, the factor of safety (FS) of the median design riprap size (D_{50d}) to the median riprap size at the threshold of displacement (D_{50f}) can be computed as:

$$FS = \frac{D_{50d}}{D_{50f}} \qquad \text{Equation 2}$$

Assumptions

The following general assumptions were used in this analysis:

- The model was separated into upstream and downstream sections to help minimize model run times
- All flow rates into the model were held constant
- A relative roughness height of 12 inches was used for all surfaces
- All model simulations were run long enough to establish quasi-steady state conditions with respect to total system volume, surface area and both mass-averaged turbulent and mean kinetic energies
- Air entrainment was not modeled
- Sediment and debris were not considered

Results

Graphical results of the steady-state flow depths and depth-averaged velocities for the design storm event (PMF) are presented in **Figure 2** and **Figure 3**. The plots show depth-averaged velocity of 27 feet per second and flow depth of 6 feet at the critical location where flow concentrates on the northwest side of the ramp toward the downstream end.

Graphical results of the simulated Froude number during the design event (**Figure 4**) indicate a change in flow regime from subcritical to supercritical as flow enters the ramp and another regime change from supercritical to subcritical where a submerged hydraulic jump forms midway up the ramp. A graphical representation of the riprap sizing results for the different flood event using **Equation 1** are presented in **Figures 6a** to **6e.** The riprap sizing results in areas of subcritical flow upstream and downstream of the ramp section are not depicted graphically in the figures as the application of **Equation 1** is not appropriate for these areas. **Table 1** summarizes the FS for the different flood events using a design median riprap size of 27 inches. **Table 1** also summarizes the probability of exceedance of the flood events in 1,000 years and 200 years. From **Figure 4** and **Table 1**, the riprap diameter (D_{50f}) giving an FS of 1 during the PMF at the critical downstream section of the northwest portion of the ramp is 25.5 inches. Outside of the critical area the riprap diameter (D_{50f}) giving an FS of 1 ranges from approximately 15 inches to 20.8 inches for the PMF. For the 10,000-year event, which has a probability of exceedance in 1,000 years of 9.5 percent, the minimum FS for a 27 inch riprap is 1.30. For the 1,000-year and 100-year floods, the minimum FS is 1.49 and 1.90.

Graphical results of the depth-averaged velocity, flow depth, and Froude numbers for all other flood event considered in this design (100-year, 200-year, 1,000-year, and 10,000-year) are shown in **Figure 5** and **Figure 6**. These results indicate the depth-averaged velocity, and flow depth decrease with flow magnitude. Note that the location of the downstream hydraulic jump moves further downstream as flow decreases.

References:

Abt, S. R., T. L. Johnson. 1991. Riprap Design for Overtopping Flow. Journal of Hydraulic Engineering, (8). 959-972.

Table

Table 1: Summary of Riprap Sizing Evaluations

Flood Event		PMF	10,000-Yr	1,000-Yr	200-Yr	100-Yr
Exceedance Probability (%)	in 1,000 years	0.05	9.5	63.0	99.3	1.0
	in 200 years	0.001	2.0	18.0	63.0	87.0
Maximum Velocity (fps)	Inside Critical Area	27.0	24.0	22.0	20.0	19.0
	Outside Critical Area	25.0	19.0	17.0	16.0	14.0
Depth at the Location of Maximum Velocity (ft)	Inside Critical Area	6.0	4.5	4.0	3.5	3.0
	Outside Critical Area	4.5	4.0	3.0	2.8	2.3
D_{50f} (inches)	Inside Critical Area	25.5	20.4	18.1	16.0	14.2
	Outside Critical Area	20.8	16.7	13.4	12.3	10.2
Factor of Safety for D_{50} = 27 inches	Inside Critical Area	1.1	1.3	1.5	1.7	1.9
	Outside Critical Area	1.3	1.6	2.0	2.2	2.7

FIGURES

Supplement I.7.1

Graphical Results of Hydraulic Modeling for the 10,000-year, 1,000-year, 200-year, and 100-year Events

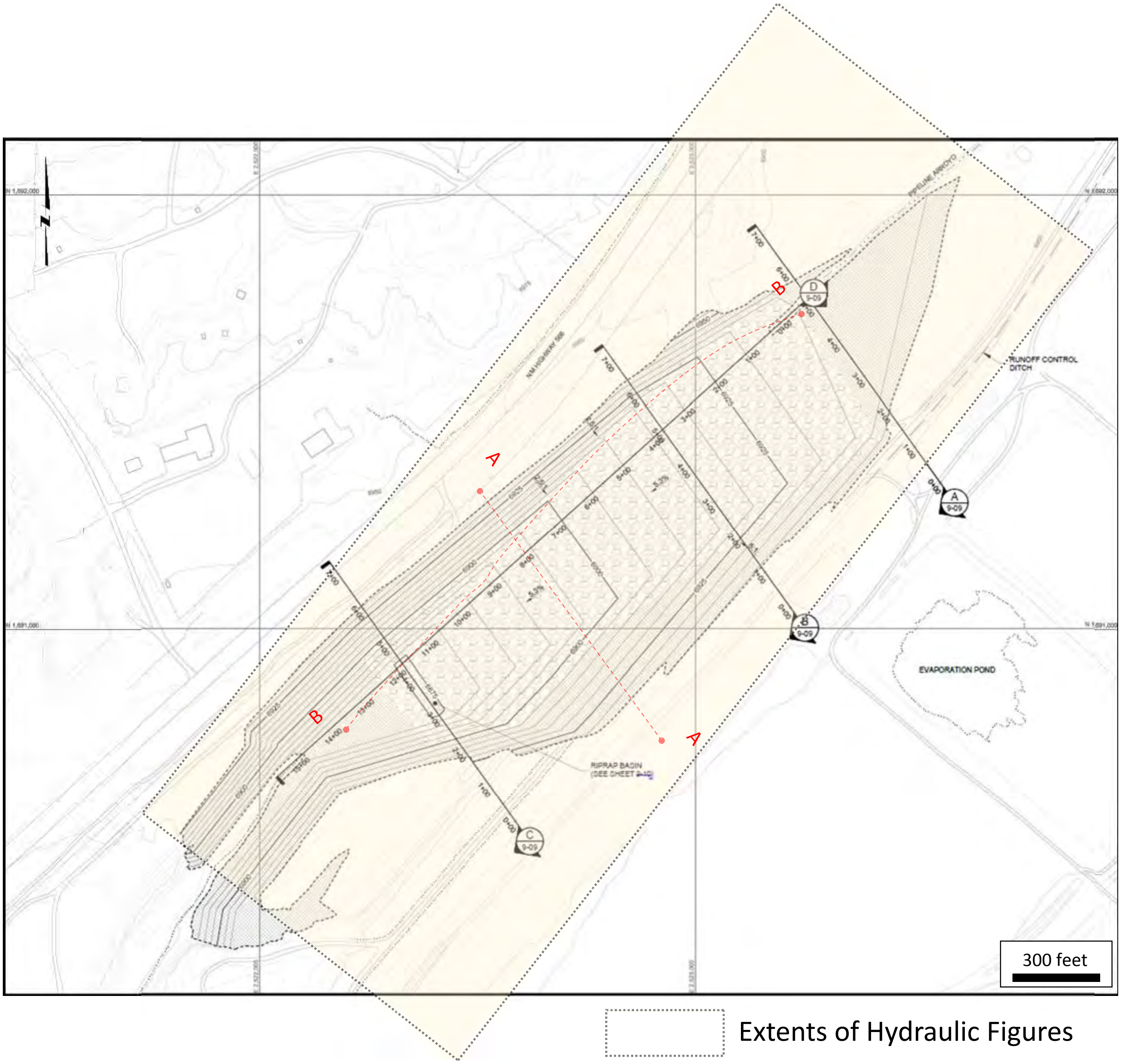
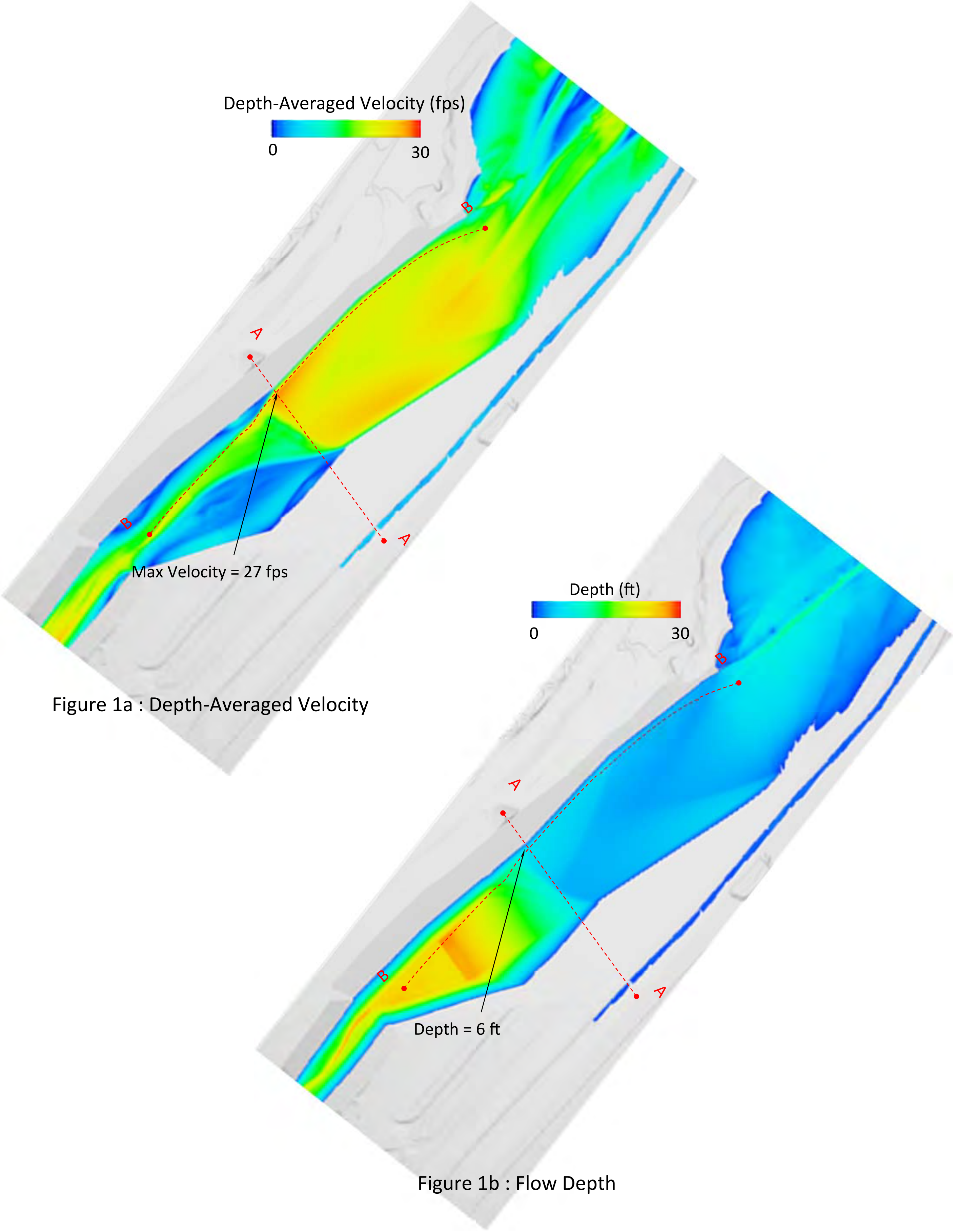


Figure 1: Plan View of Riprap Chute (See Sheet 9-08)
Showing Extents of Hydraulic Modeling Figures



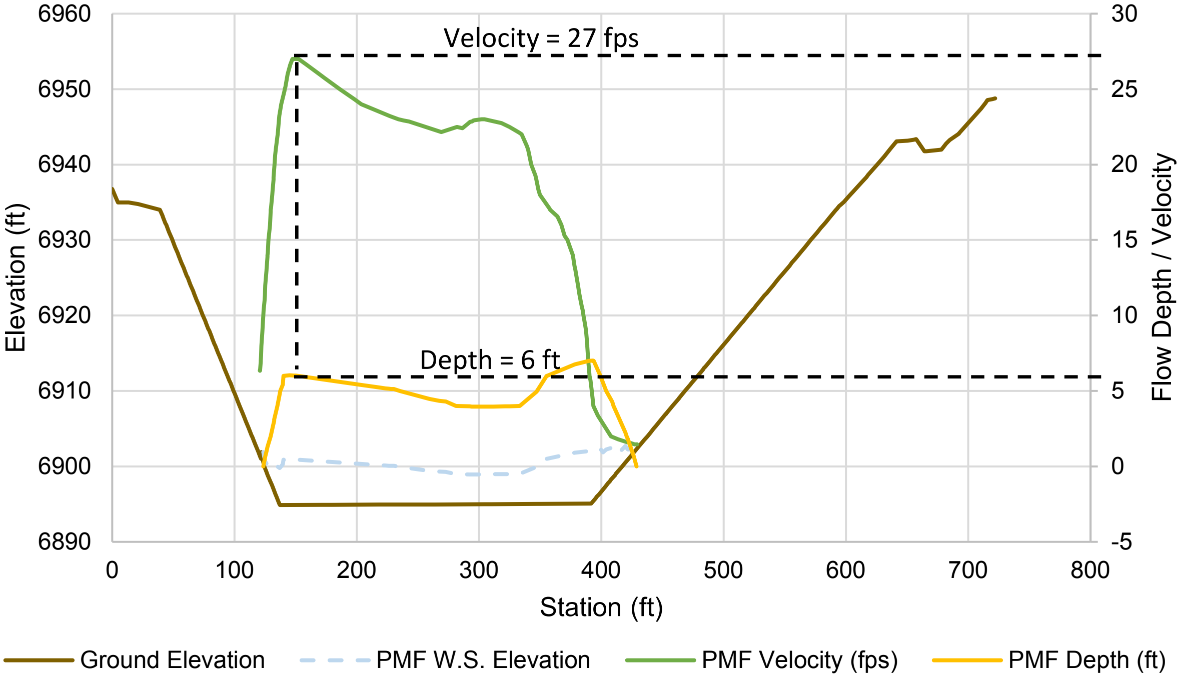
Max Velocity = 27 fps

Figure 1a : Depth-Averaged Velocity

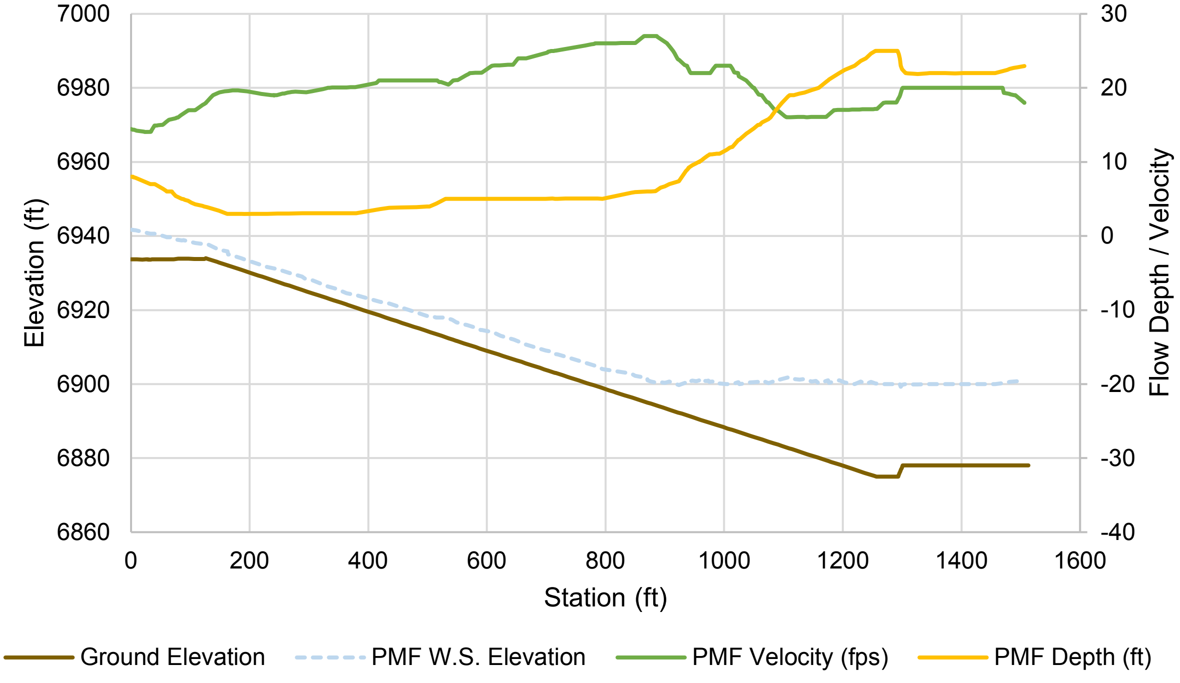
Depth = 6 ft

Figure 1b : Flow Depth

Figure 2 : Isoemetric View of Simulated Depth-Averaged Velocity and Depth for the PMF



Section A-A



Section B-B

Figure 3: Profile and Section Views for Simulated Depth-Averaged Velocity, Depth, and Water Surface Elevation for the PMF

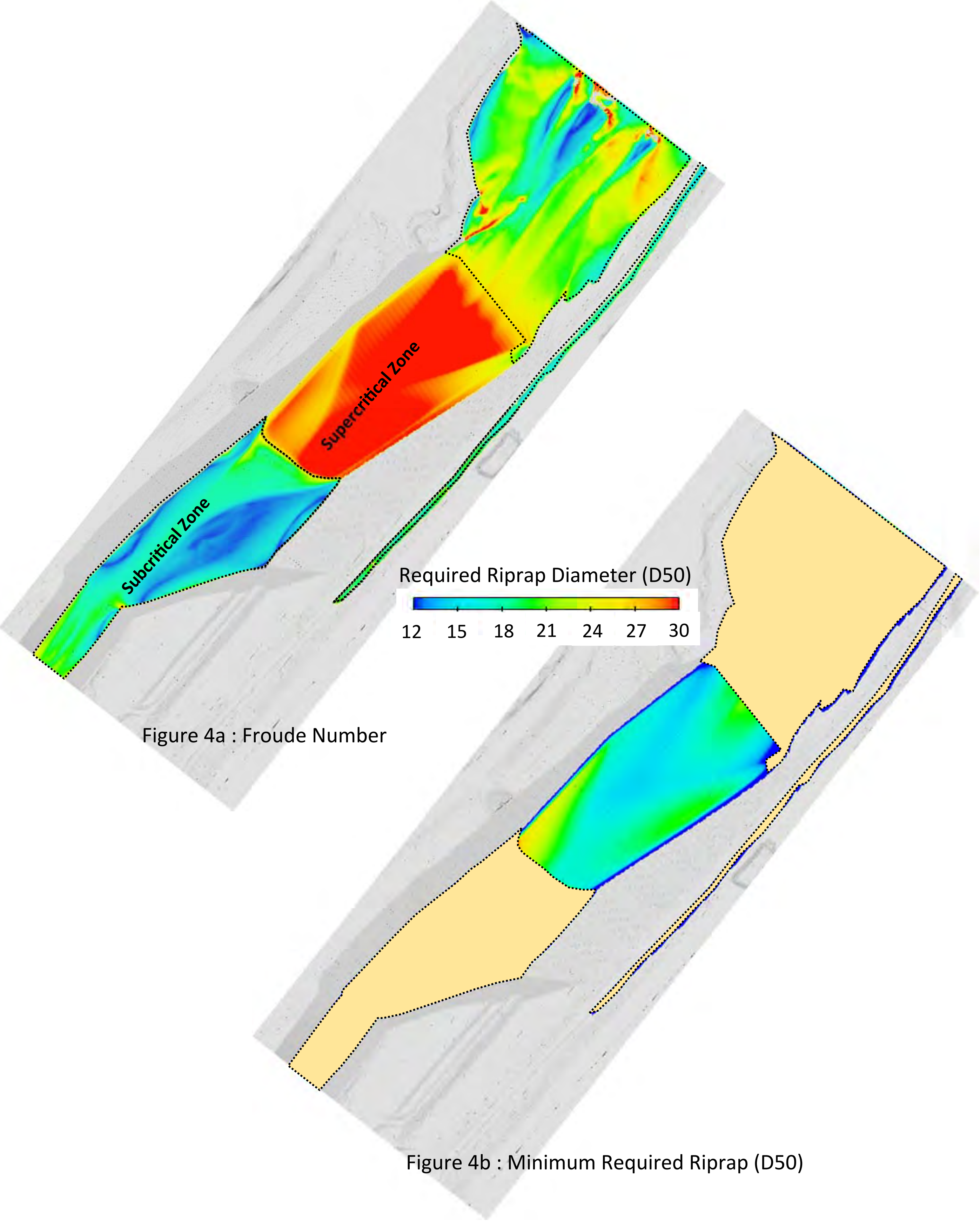


Figure 4a : Froude Number

Figure 4b : Minimum Required Riprap (D50)

Figure 4 : Isometric View of Simulated Froude Number and Minimum Riprap Size for PMF

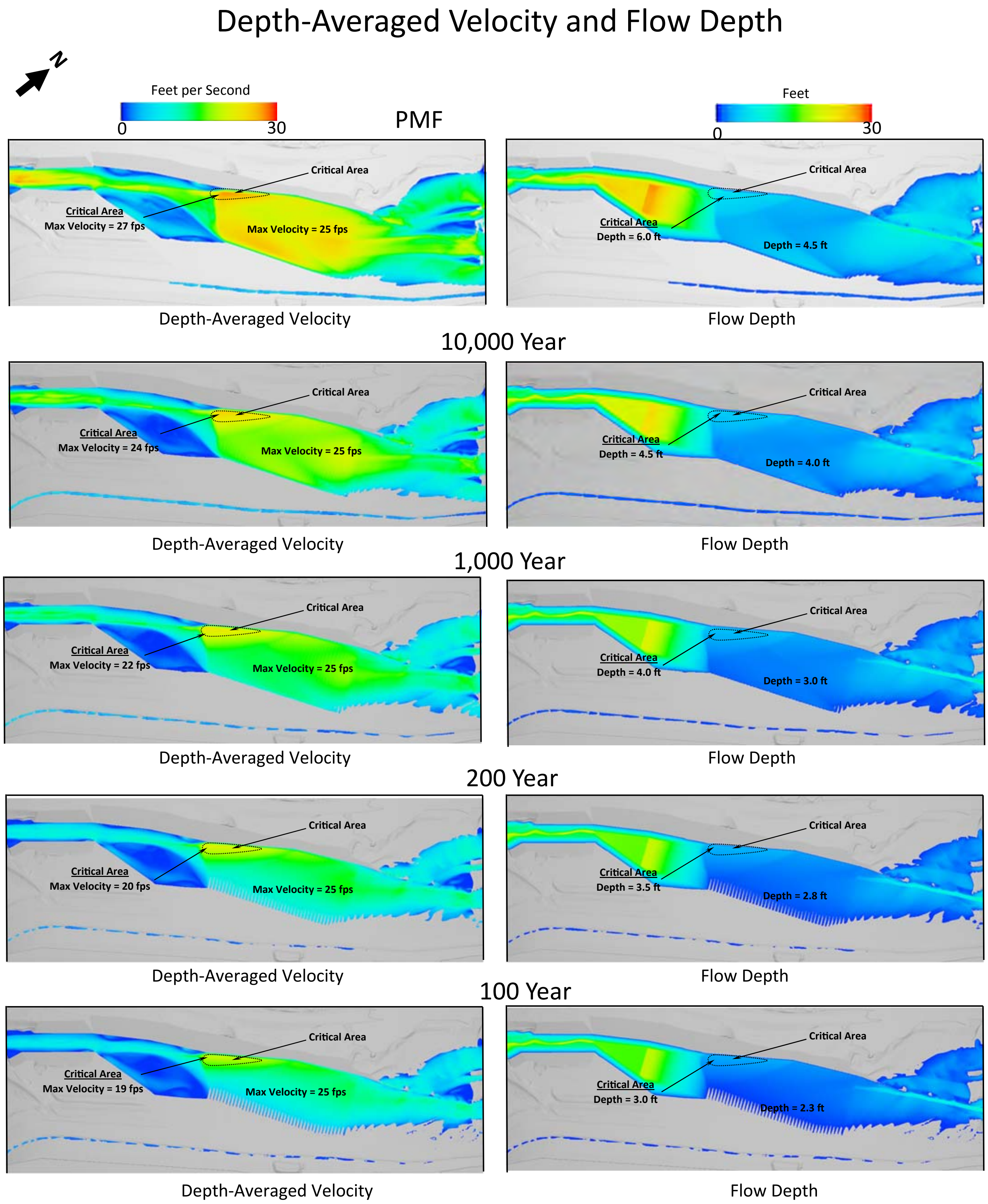
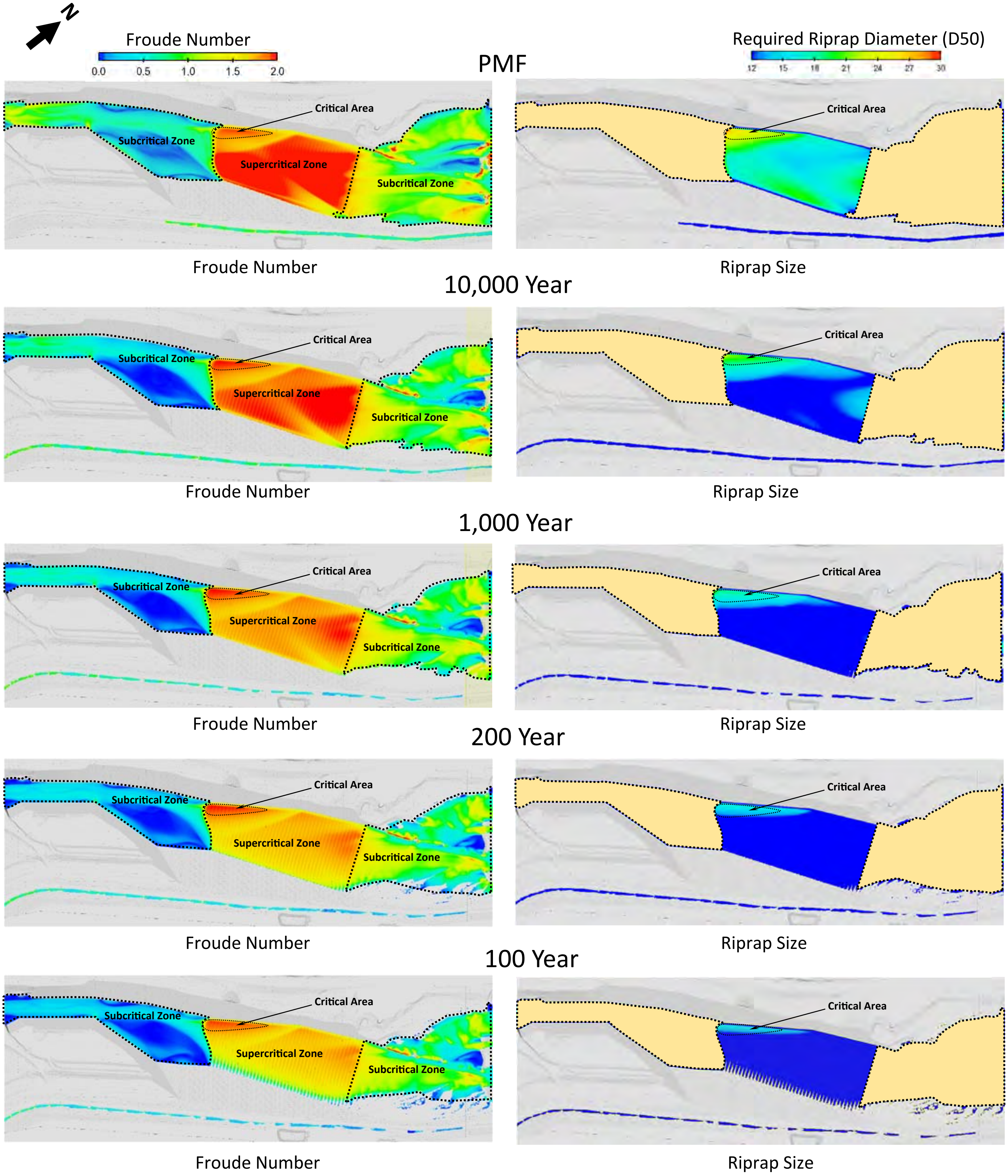


Figure 5: Simulated Depth-Averaged Velocity and Flow Depth For Simulated Flood Events

Froude Number and Calculated Riprap Size



PMF

Froude Number

Riprap Size

10,000 Year

Froude Number

Riprap Size

1,000 Year

Froude Number

Riprap Size

200 Year

Froude Number

Riprap Size

100 Year

Froude Number

Riprap Size

Figure 6: Simulated Froude Number and Calculated Minimum Riprap Size For Simulated Flood Events

ATTACHMENT I.8
Geotechnical Evaluation Report Church Rock Mill Site Jetty

Geotechnical Evaluation
Church Rock Mill Site Jetty

Additional Studies for the
Northeast Church Rock
Removal Action Design

Prepared for:
United Nuclear Corporation and
the General Electric Company

Prepared by:
Stantec Consulting Services Inc.

April 24, 2017

Revision	Description	Author		Quality Check	
0	Internal Draft	S. Downey	12.7.16	J. Cumbers	1.5.17
1	For Client Review	S. Downey	3.31.17	J. Cumbers	4.3.17

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Introduction

This report presents information collected during the geotechnical drilling and field sampling specific to the Pipeline Arroyo and buried rock Jetty area at the United Nuclear Corporation (UNC) Mill Site ("Mill Site"). This report also includes information on additional sampling at test pit locations for some of the proposed channels in the 30% Design (MWH, 2016a). Field notes, boring logs, and laboratory testing results are included in the appendices. Information presented in this report will be used to advance the design of the erosion protection measures around the "nickpoint" and jetty area in the Pipeline Arroyo, as well as channels near the Northeast Church Rock (NECR) Mine ("Mine Site") and the repository at the Mill Site.

Site Description

The Mine Site is a former uranium mine operated by UNC. The Mine Site and Mill Site are approximately one-half mile apart, and located approximately 16 miles northeast of Gallup, NM. Upon closure and reclamation of the Mill Site and tailings impoundment, stormwater controls were designed to protect the tailings impoundment. The buried rock "jetty" was designed as part of this reclamation design (Canonie, 1991) previously approved by the US Nuclear Regulatory Commission (NRC). The jetty is a buried rock slope located in the vicinity of the nickpoint within the flow path of the Pipeline Arroyo. The nickpoint is an area of outcropping sandstone that narrows the flow channel of the arroyo and forces flow eastward toward the tailings area. The existing jetty consists of basalt riprap with a median rock size (D_{50}) of 6 inches. The design of the jetty currently in-place is intended to prevent headcutting and erosion of the existing flow channel, but the design is not robust enough to manage large overtopping flows in the vicinity of the jetty.

Geotechnical Investigation

The field work for the NECR Jetty Investigation took place in November 2016, following US Environmental Protection Agency (USEPA) approval of the Work Plan for Geotechnical Sampling at Church Rock Mill Site Jetty (MWH, 2016b). Field activities included drilling, soil sampling and rock sampling at the Mill Site; test pitting at the Mill Site and north of the Mine Site; and mapping rock outcrops at the Mill and Mine Sites. The objective of the field investigation was to collect subsurface (soil and rock) information in the vicinity of the new jetty structure to supplement the existing subsurface information for the area. The intent was to develop a more complete picture of the rock surface in the area as well as collect samples of soil and rock for geotechnical laboratory testing to support the design.

Conclusions

The depth to underlying rock on the east side of the arroyo was further confirmed to be greater than 100 feet. Testing and petrographic analyses on the sandstone in the area of the proposed rock excavation indicates this material is not sufficiently durable to remain exposed. However, the properties of the rock in the jetty area indicate that a significant portion of the rock to be excavated may not be rippable. The proposed jetty excavation would result in a large volume of soil excavation that can potentially be used as borrow for other areas of the project.

Abbreviations

amsl	above mean sea level
ASTM	American Society for Testing and Materials
bgs	below ground surface
FSP	Field Sampling Plan
GE	General Electric Corporation
GPS	global positioning system
I.D.	inside diameter
NECR	Northeast Church Rock
NRC	US Nuclear Regulatory Commission
Mill Site	United Nuclear Corporation Mill Site
Mine Site	Northeast Church Rock Mine Site
MWH	MWH Americas, Inc. (now part of Stantec Consulting Services Inc.)
O.D.	outside diameter
OSHA	Occupational Safety and Health Administration
psi	pounds per square inch
RQD	rock quality designation
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
UNC	United Nuclear Corporation
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

1 INTRODUCTION

1.1 PURPOSE

This report has been prepared on behalf of General Electric Company and United Nuclear Corporation (GE/UNC) for submittal to the U.S. Environmental Protection Agency (USEPA), Region 9 as part of the work elements being conducted pursuant to the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery, United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site (USEPA, 2015), including the Statement of Work attached as Appendix D to the Administrative Order on Consent. Information collected will be used to advance the design of the erosion protection measures.

The report summarizes the geotechnical investigation and sampling conducted at the UNC Mill Site specific to the Pipeline Arroyo and rock Jetty area at the UNC Mill Site, as well as one location near the NECR mine and one location near the Dilco Hill. The field work for the NECR Jetty Investigation was completed in accordance with the USEPA-approved work plan (MWH, 2016b).

1.2 REPORT BACKGROUND

As part of the 30% design (MWH, 2016a), MWH reviewed existing geotechnical data in the rock jetty area and determined additional geotechnical characterization data was necessary to complete the design of the erosion protection structures. MWH identified the additional data needs and provided a work plan and field sampling plans (FSPs) to obtain data necessary to complete the design. The proposed 30% Design included replacing the existing rock jetty structure with a new riprap revetment and weir consisting of larger rock to handle overtopping flows. The design includes a large embankment armored with riprap revetment downstream of the jetty location and requires geotechnical characterization of the existing bedrock for depths and durability in the vicinity of the proposed erosion protection structure.

In addition, an FSP was provided for select test pits in proposed new and existing stormwater channels to obtain near-surface samples of the channel subgrade material. The laboratory gradation results of the channel subgrade materials are necessary to design filter layers between the subgrade and the erosion protection materials for the channels.

1.3 REPORT OBJECTIVES AND SCOPE

The objective of the geotechnical investigation was to obtain additional data required to progress the removal action design in the Pipeline Arroyo Rock Jetty area and proposed stormwater channels at the Mine and Mill sites. The purpose of this evaluation is to summarize physical and engineering properties of the soil and bedrock within the jetty area and proposed stormwater channels. This report contains an evaluation of soil properties, rock strengths, and stratigraphy of the subsurface conditions and their potential effect on the design improvements for the jetty area. Specifically, this report presents the following information:

- A summary of the investigation and sampling conducted
- The results of the investigation – boring logs and laboratory data
- Geotechnical recommendations for the jetty design improvements
- Petrographic analysis of three rock sources

The report contents include the following:

- Section 1 – Background and objectives
- Section 2 – Investigations and sampling conducted
- Section 3 – Results of the investigations and sampling
- Section 4 – Summary and conclusions
- Section 5 – References

Laboratory data reports, drilling and test pit logs, and field photographs documenting the investigation and sampling activities at the Mill and Mine Sites are included in the appendices.

2 SUBSURFACE EVALUATION

2.1 EVALUATION OF JETTY SUBSURFACE CONDITIONS

The NECR Jetty geotechnical evaluation was conducted November 8-16, 2016, following approval of the Work Plan for Geotechnical Sampling at Church Rock Mill Site Jetty (MWH, 2016b). Field activities included drilling, soil sampling and rock sampling at the Mill Site; test pitting at the Mill Site and north of the Mine Site; and mapping rock outcrops at the Mill and Mine Sites.

Activities were conducted in accordance with the work plan and applicable SOPs. Some minor changes to drilling and test pit locations were implemented due to field conditions. Details of activities conducted and any variations from the Work Plan are described in the following sections.

Geotechnical characterization of the existing bedrock for depths and durability in the proposed jetty stabilization design was required to progress the jetty design. The characterization included soil sampling and testing for index properties, and rock sampling and testing to evaluate rock hardness, durability, and degree and depth of weathering. A description of each task is provided below.

Drilling in the rock jetty area was performed by National Exploration, Wells, & Pumps (NEWP, "National") with a CME-85 truck-mounted drill rig. Seven boreholes were drilled during field work, three on the northwest side of the arroyo and four on the southeast side, as described in the work plan. The three on the northwest side of the arroyo were predominantly rock coring, as described in Section 2.1.1. The four on the southeast side of the arroyo were soil borings, with the goal of drilling to the top of bedrock, as described in Section 2.1.2. The location of B3 was shifted slightly to meet the minimum required distance from a nearby pipeline. The location of B6 was also shifted to the northwest for drill rig access. Figures 1 and 2 show the locations of the completed boreholes drilled in the field.

2.1.1 Rock Coring

The rock coring locations included B1 through B3. At B1, no overburden soil was present, and drilling began in rock using diamond wireline HQ (3.83-inch outside diameter (O.D.)) coring methods. Split barrels with 2.5-inch inside diameter (I.D.) and 10 feet in length were used for in-situ sampling of the rock core. Water was the only additive used to help advance the rock coring. The upper soil portion of locations B2 and B3 were drilled using hollow-stem auger drilling methods (described in Section 2.2.2). When contact with rock was reached, the drill rig was switched to diamond wireline HQ rock coring, and rock coring began at the location, using the methods described above.

Continuous (dry-core) samples of the overlying soil were logged, but no grab samples were taken from these locations. Standard penetration tests (SPTs) were performed in the overburden soil at B2 and B3 using California barrels with 2.5 inch O.D. at 5-foot intervals. Blow counts were recorded for each successive 6-inch increments and samplers were driven by an automatic 140-pound hammer falling 30 inches.

The recovered rock core samples were logged by a Stantec geologist and geotechnical engineer, placed in labeled core boxes and photographed. The rock core locations were backfilled with bentonite grout to the top of bedrock surface. In locations B2 and B3, the boreholes were backfilled with soil cuttings from the top of the rock surface to the original ground surface. Select rock core samples for laboratory testing; were removed from the core boxes, wrapped with plastic wrap, and labeled for testing. The core boxes were temporarily stored in the UNC Mill Site office area, away from work areas. A borehole summary is presented in Table 1.

Table 1 Summary of Completed Boreholes

Boring ID	Approximate Ground Surface Elevation (ft amsl)	Total Depth of Borehole (ft)	Hollow-stem Auger Drilled (ft)	Rock Coring (ft)	Estimated Top of Rock (ft bgs)
B1	6945	32.1	0	32.1	0
B2	6934	52.1	18.1	34	17.5
B3	6934	51.4	15.9	35.5	14.65
B4	6942	65.0	65.0	0	60
B5	6937	125.0	125.0	0	125+
B6	6934	126.5	126.5	0	125+
B7	6926	115.0	115.0	0	105.9

Note: Bedrock was not encountered within the depth of boreholes B5 and B6.
amsl = above mean sea level; bgs = below ground surface, ft = feet

2.1.2 Soil Borings

The soil borings included locations B4 through B7. The first 3 to 5 feet were hand-augered to verify that underground utilities were not present. Hollow-stem auger drilling methods were used to drill each soil boring location, and samples were collected by various methods. Drilling depths ranged from 65 feet to 126.5 feet, and bedrock was not reached in two locations (B5 and B6).

Continuous (dry-core) samples (4 inch I.D.) were collected as the primary sampling method. Dry-core samples were logged, and grab samples were collected from the dry-core, placed in plastic sealable bags and labeled. Standard penetration testing (SPT) was conducted with a 2.5-inch (O.D.) California split-spoon sampler was used to obtain undisturbed samples at select locations. Three-inch diameter Shelby tube samples were also collected during drilling. In locations where bedrock was reached (B4 and B7), the auger and continuous core barrel were advanced a minimum of 5 feet into the bedrock to confirm that bedrock was reached, as well as to log a description of the rock lithology.

Boreholes B5, B6, and B7 encountered groundwater during drilling. After drilling, boreholes that encountered water were backfilled with bentonite grout to a depth above the water table, then backfilled with cuttings. A stake was placed at each location, and the locations were surveyed using a handheld GPS unit in the field. Borehole logs and photographs are provided in Appendices A and B.

2.2 CHARACTERIZATION OF CHANNEL BASE MATERIALS

Test pits were excavated in select locations of proposed stormwater channels and samples were obtained of channel subgrade material at these locations. Test pits 1 and 2 were excavated north of the Mine Site on November 12, 2016. Test pits 3 and 4 were excavated near Dilco Hill on November 14, 2016. Test pits 5 and 6 in the jetty area were not excavated and sampled. It was determined in the field that sufficient soil data was collected from the nearby boring locations and the test pits and additional laboratory testing was unnecessary. Test pits were hand dug using a post-hole digger and shovel. The surface material was scraped off and placed adjacent to the test pit. The test pits were approximately 6 to 8 inches in diameter, and depths ranged from 1.1 feet to 2.2 feet. The materials excavated from the test pit were placed in a 5-gallon bucket for laboratory sampling for gradation and index properties.

Test pits 1 and 2 north of the Mine Site encountered a clay with silt and a clayey silt, each with a small percentage of sand. Test pit 3 near Dilco Hill encountered a poorly-graded sand with a small percentage of fines, and trace gravel. Test Pit 4 at the toe of Dilco Hill was a clay with sand and silt. All four test pits were fairly uniform in soil type, consistency, and moisture throughout the pit. Materials encountered during the excavation were logged and photographs of the test pit walls were taken. The test pit logs are provided in Appendix A.3, with photographs of the excavations and general test pit locations included in Appendix B.

After excavation and sampling, the test pits were backfilled with stockpiled material and other nearby surface material. The excavated area was compacted using the shovel and/or feet, and was graded to match the surrounding area. A stake was placed at each test pit location and the locations were surveyed using a handheld GPS.

3 SUBSURFACE CONDITIONS

3.1 SITE GEOLOGY

The discussion of geologic conditions contained in this section is based on published information for the site area and is provided for background on the bedrock in the vicinity of the jetty (New Mexico Bureau of Geology and Mineral Resources, 2016 and USGS, 1987). Subsurface details are based on the previously described geotechnical field exploration and laboratory test results. The NECR site is located on the Colorado Plateau, which consists of sedimentary rocks that have been sculpted into mesas, buttes, and canyons by water erosion. In New Mexico, the Colorado Plateau also includes the San Juan Basin, a source of oil, gas, coal, and uranium. The jetty area is predominantly alluvial deposits of the Holocene and Pleistocene as part of the Quaternary unit. These alluvial deposits are described by the USGS as pale-yellowish-brown and grayish-orange weathering alluvium deposited in graded stream valleys and on flood plains.

The rock units at the site consist of the Crevasse Canyon Formation and the Gallup Formation (D'Appolonia, 1981 and Canonie, 1987). The uppermost layer is the Dalton Sandstone Member, which is described as a massive clean white to buff, medium to coarse-grained sandstone. This sandstone outcrops at the site. Below the Dalton Sandstone is the Mulatto Tongue and Dilco Coal Member. The Mulatto Tongue is a dark gray mudstone and silty sandstone with scattered thin beds of sandstone. The Dilco Coal Member is comprised of paludal and fluvial deposits and primarily irregular buff to gray medium-grained sandstone, light gray clay, and lenticular coal beds and carbonaceous shales. The Dilco Coal is interfingered with the underlying Gallup Sandstone. The upper Gallup Sandstone Member (Zone 3) is predominantly light gray to buff, fine to coarse-grained sandstone, interbedded with gray siltstone and mudstone, and minor amounts of coal. The Zone 2 material is comprised of sandy marine shales and thin lenticular sandstones. Zone 1 is the lower Gallup Sandstone Member and is generally a buff to light gray, fine-grained and silty becoming gradually finer-grained towards the base. This evaluation did not go beyond the lower Gallup Sandstone (Zone 1).

3.2 STRATIGRAPHY

Data collected during the jetty investigation was used to update the estimated rock surface cross-sections shown in Figure 4 of the work plan. Additional sections were also developed to show sections through or near each boring location. The revised cross sections are shown in Figures 3 and 4.

The previously-created bedrock surface used to generate the sections shown in the work plan was updated in areas where new information was obtained. A Stantec geologist mapped the exposed bedrock in the jetty area, including any coal or shale layers that were exposed. The bedrock surface and top of Zone surfaces (i.e., Zone 3, and Zone 2) were updated based on the boring logs and the mapping that occurred in the jetty area.

The bedrock in the jetty area is sedimentary, consisting of primarily sandstone or siltstone and was observed to be moderately to slightly weathered throughout. Three borings (B1 through B3) were drilled on the northwest side of the existing arroyo to characterize the bedrock and to obtain samples of the bedrock for strength testing. The location of B1 was on a rock outcrop at an elevation of approximately 15 feet higher than locations B2 and B3. In location B1, the bedrock was typically a sandstone, varying from fine-grained to coarse-grained sand. A thin coal/shale layer (approximately 1.5 ft thick) was found at an elevation of 6932 feet amsl, and a siltstone/sandstone layer with abundant coal stringers was found from approximately 6926 ft amsl to 6922 ft amsl, where the bottom 2 inches consisted of coal. The borehole was terminated in a sandstone/siltstone material.

In locations B2 and B3, the bedrock was predominantly fine- to coarse-grained sandstone. The top of bedrock surface was reached at elevations 6916.5 feet amsl and 6919.4 feet amsl, respectively. The top of Zone 2 in B2 and B3 was reached at approximately 6895 feet amsl and 6900 feet elevation, respectively. The Zone 2 material consisted of a coal and organic clay layer less than 2 feet thick, followed by a 10 foot layer of claystone/siltstone. After the claystone/siltstone layer, there was another black coal layer approximately 1.5 feet to 2.5 feet thick. In B2, the borehole was terminated in siltstone just beyond the second coal layer. In B3, the borehole was terminated in a siltstone to sandstone material just beyond the second coal layer.

Four borings (B4 through B7) were drilled on the southeast side of the arroyo and existing jetty to characterize subsurface soil conditions and to determine the depth to the top of bedrock. The borehole locations B4 through B7 were predominantly native soil (alluvium), underlain by weathered bedrock. Boring B4 had approximately 10 to 15 feet of fill overlying the native soil. The bedrock surface was contacted in two locations, B4 and B7. The other two locations, B5 and B6, were drilled to the maximum depth of 125 feet (due to the amount of auger on site). Boring B6 was advanced to 126.5 feet using the SPT for the additional 1.5 feet.

The alluvium and fill generally consists of silty sands in the top portion of the borings. The alluvium grades to silts, then to clay with interbedded lenses of sands and silts. The sand was predominantly fine-grained sand, but occasional lenses of coarse-grained sands and gravels were encountered. In borings B5 and B7, a 15- to 20-foot-thick, high plasticity clay with silty sand lenses was encountered just below the groundwater level at each boring, starting at depths 75 feet bgs and 68 feet bgs, respectively. SPT blow counts for the upper 10 feet were generally very dense, and occasionally refusal was met in the first SPT at the 5 foot depth bgs. The soil in the upper 10 feet of the borehole was generally very dry and indurated. Beyond 10 feet bgs, the SPT blow counts showed medium dense (or stiff) soils, grading to loose to very loose (or soft) at depths greater than 50 feet bgs.

Where rock was encountered in B4 and B7, the sandstone consisted of fine-grained sand with some fines (silts and clays). The sandstone was highly to completely weathered when the bedrock was first encountered, with iron oxidation lamination or very thin bedding. In B4, the sandstone graded to a slightly to moderately weathered sandstone with decreasing iron oxidation and bedding. In B7, the sandstone was highly weathered throughout.

3.3 GROUNDWATER

Localized groundwater was encountered in three boreholes (B5, B6, and B7) while drilling. Groundwater levels encountered were at similar depths and elevations, ranging from 65 feet bgs to 73 feet bgs (6860 to 6869 feet amsl). Groundwater was not encountered in the remaining boreholes during or after drilling.

The 30% design analyses used groundwater levels from both the PDS report (MWH, 2014) and alluvial wells measured in 2016. From the PDS report, groundwater was encountered during drilling in two of the boreholes within the repository footprint (TI-B10 and TI-B11). The groundwater elevation in these boreholes was approximately 6,885 feet amsl. Groundwater was also encountered at approximately 6,903 feet amsl while drilling in boring B3. Alluvial wells 509D and EPA23 were measured on January 4, 2016 and showed a groundwater elevation of approximately 6,867 feet amsl. The alluvial wells downstream of the jetty area (GW 1, GW 2, GW 3, 0632, EPA 25, EPA 28, and 0624) showed groundwater elevations ranging from 6845 to 6855 feet amsl.

Alluvial wells 509D and EPA23 are nearest to the jetty boring locations, and water elevations encountered during drilling are similar to the water elevations measured in those wells in 2016.

3.4 LABORATORY TEST RESULTS

Geotechnical laboratory testing on the soil (borings and test pits) and rock core samples was conducted by Ninyo and Moore in Phoenix, AZ. Laboratory testing included sieve analysis with hydrometer, Atterberg limits, moisture and density, triaxial shear (consolidated undrained), and specific gravity of select soils. Laboratory testing included compressive strength, moisture and density, specific gravity and absorption, sodium sulfate, LA abrasion, and Schmidt hammer testing on the rock core samples. Laboratory testing on the bulk test pit samples included gradation and hydrometer. Test results are summarized in Tables 2 and 3 and are included in Appendix C.

Table 2 - Summary of Geotechnical Lab Results - Soil Samples

Borehole ID	General Location	Sample ID	Depth (ft)		Sample Type$^{(1)}$	Water Content (by mass, %)	Dry Density (pcf)	Atterberg Limits			USCS % Gravel	USCS % Sand	% Passing No. 200 Sieve	Triaxial Shear Strength Consolidated Undrained (peak friction angle (φ', degrees), cohesion (psf))$^{(2)}$	USCS Classification
								LL (%)	PL (%)	PI (%)					
B4	Jetty – SE Side of Pipeline Arroyo	B4-16.0-16.5	16.0	16.5	CA	10.4	77.6								
B5		B5-10.5-11.0	10.5	11.0	CA	5.2	82.9								
B5		B5-TW-25-27.0	25.0	27.0	ST	21.2	98.8	61	21	40				17.5, 478	CH
B5		B5-40.5-41.0	40.5	41.0	CA	22.7	99.6	49	20	29	0	1	99		CL
B6		B6-15.5-16.0	15.5	16.0	CA	10.7	93	42	17	25	0	10	90		CL
B6		B6-40.5-41.0	40.5	41.0	CA	17.9	97								
B7		B7-TW-5.0-6.5	5.0	6.5	ST	6.9	94.3								
B7		B7-10.5-11.0	10.5	11.0	CA	7.0	99.7				0	10	90		
B7		B7-30.5-31.0	30.5	31.0	CA	16.7	102.5	40	16	24					CL
TP1	N. of Mine Site	TP1	-		Bulk						0	10	90		
TP2		TP2	-		Bulk						0	43	57		
TP3	Dilco Hill	TP3	-		Bulk						3	56	41		
TP4		TP4	-		Bulk						2	46	52		

Notes:
(1) CA = California sample, ST = Shelby tube sample, bulk = bucket
(2) See Appendix C for results.
(3) LL = liquid limit, pcf = pounds per cubic foot, PI = plasticity index, PL – plasticity limit psf = pounds per square foot, USCS = Unified Soil Classification System

Table 3 - Summary of Geotechnical Lab Results - Sandstone Samples

Borehole ID	General Location	Sample ID	Depth (ft)		Sample Type(1)	Water Content (by mass, %)	Dry Density (pcf)	Specific Gravity	Absorption	Sodium Sulfate Soundness (% Loss)	LA Abrasion	Schmidt hammer	Compressive Strength (psi)
B1	Jetty – NW Side of Pipeline Arroyo	B1-5.3-5.95	5.3	6.0	Core	5.6	117.4	1.871	10.8	100	-	-	1,210
B1		B1-17.3-18.1	17.3	18.1	Core	2.8	135.3	2.096	7.4	81.8	note 2	note 2	2,560
B2		B2-26.45-27.25	26.5	27.3	Core	10.3	129.1	2.006	8.1	88.6			2,490
B3		B3-24.2-24.9	24.2	24.9	Core	3.9	115.6	1.937	9.3	87.7			1,390
B3		B3-24.9-25.6	24.9	25.6	Core	3.2	117.1	1.920	9.7	100			1,230

Notes: (1) core = rock core sample, pcf = pounds per cubic foot, psi = pounds per square inch

(2) LA Abrasion and Schmidt hammer testing was attempted, but results could not be quantified due to fragility of the rock. Lab indicated invalid test results.

3.5 ROCK DURABILITY

The jetty design includes an excavation downstream of the current location of the buried jetty that would be armored with riprap revetment. The riprap is proposed to be located on the bottom of the channel and approximately 10 vertical feet up both sideslopes. The design is expected to include a median rock size (D_{50}) of 24- to 30-inch diameter boulders. Two offsite rock sources were previously identified as borrow sources for this riprap. The sandstone within the proposed jetty area is being evaluated for long-term durability, for exposure in an open rock cut.

The sandstone samples obtained from drilling were scored for durability in accordance with NUREG-1623 (NRC, 2002), based on the results for specific gravity, absorption, LA abrasion, Schmidt hammer, sodium sulfate soundness, and Compressive Strength. The other two offsite rock sources identified for riprap were sampled and scored as part of the 30% Design Report (MWH, 2016a). These results are included in Appendix H of the 30% Design Report (MWH, 2016a). The results and scoring for the Zone 3 sandstone, encountered during drilling near the jetty are summarized in Table 4 below.

Table 4 - Summary of Rock Durability Scoring Results - Sandstone

Laboratory Test	**Result (a)**	**Score (b)**	**Weighting Factor (c)**	**Weighted Score**	**Maximum Score**
Bulk Specific Gravity	1.97	0	6	0	60
Absorption, %	9.1	0	5	0	50
Sodium Sulfate, %	92	3.5	3	10.5	30
LA Abrasion (100 revs.), %	-	-	8	-	-
Schmidt hammer	-	-	13	-	-
Compressive Strength (psi)	1,776	2	10	20	100
			TOTAL	30.5	240
				12.7%	**Score**
				REJECT	**Oversizing required?**

a.) 2017 test results provided by Ninyo and Moore; results are the average of five tests.

b.) Based on a range of 0 to 10

c.) From NUREG-1623 (2002) and DePuy (1965)

3.6 PETROGRAPHIC ANALYSIS

As part of this evaluation, petrographic analysis was conducted on the sandstone located in the vicinity of the jetty and the offsite granite and limestone samples identified in the 30% Design (MWH, 2016a). The petrographic analysis was completed in March 2017. The conclusions in the report indicate that from a petrographic standpoint the granite and limestone sources would be suitable options for erosion protection riprap, while the onsite sandstone, sampled during drilling in 2016 is not recommended. The petrographic analysis memo is included in Appendix D.

4 SUMMARY AND CONCLUSIONS

4.1 DESIGN CONSIDERATIONS FOR JETTY STRUCTURE

Based on groundwater levels encountered during drilling, the proposed excavations would not encounter groundwater during construction. The construction contractor however should anticipate the potential for large temporary stormwater flows in the arroyo when planning work. These conditions could result in fast-moving water, deep flows, and sloughing of the arroyo banks. Additionally, the arroyo banks in the current configuration are unstable. The construction contractor will be required to take precautions to stabilize the area prior to working with heavy equipment and personnel in, or near, the arroyo.

The construction contractor will be required to maintain protections for the existing gas pipeline along the west side of the proposed work area during excavation work.

4.1.1 East Side of Pipeline Arroyo

The east side of the pipeline arroyo will be cut a maximum of 40 to 50 vertical feet into primarily native soil at a 6.0:1 (H:V) slope. The lower portion of the slope (approximately 10-30 vertical feet from the bottom) will be armored with large riprap as an extension of the riprap layer on the base of the channel. The upper portions of the cut slopes will be armored with smaller rock. Boring B7 is the nearest to the maximum excavation depth, which shows a clay or sandy clay at the excavated depth. Boring B6 is also nearby, which shows varying clays and clays with sand or sand lenses near the excavation depth. These soils will be excavatable with typical heavy equipment to the design excavation depths. The proposed 6:1 slopes are anticipated to be stable for temporary and long-term conditions.

4.1.2 West Side of Pipeline Arroyo

The west side of the pipeline arroyo will be cut to a maximum of approximately 40 vertical feet (elevation 6890 ft amsl) into bedrock and overlying soil at a 2.5:1 slope. The lower portion of the slope (approximately 10-30 vertical feet from the bottom) will be armored with large riprap as an extension of the riprap layer on the base of the channel. The upper portions of the cut slopes will be armored with smaller rock. The proposed excavation is anticipated to extend into the upper Zone 2 shale layer, which starts at an elevation of around 6900 ft amsl.

Based on the petrographic analysis and the laboratory testing of the sandstone in the jetty area, the sandstone that will be exposed during the excavation is not durable enough to remain exposed long-term. Due to the poor quality of the sandstone anticipated to be exposed during the rock excavation, the riprap should extend up and be placed over the sandstone on the west side of the structure to prevent deterioration due to long-term weathering.

4.1.3 Excavation and Shoring

It is anticipated that the jetty excavation will extend through fill and native soils on the east side and decomposed rock progressing to more competent rock on the west. Temporary vertical cuts and excavations may stand for short periods of time, but should not be considered stable in any case. All excavations should be sloped, benched, shored, or shielded for the protection of workers. At a minimum, trenching and excavation activities should conform to OSHA Construction Standards for Excavations as well as other federal and local regulations.

The upper soils (sand, silt, and clay) encountered in the borings generally classify as a type “C” soil according to OSHA's Construction Standards for Excavations. In general, the maximum allowable temporary slope for shallow excavations greater than 4 feet and less than 20 feet in a type “C” soil is 1.5H:1V; although other provisions and restrictions may apply. If different soil or bedrock types are encountered, the maximum allowable slopes may be different.

The contractor (or the contractor’s Engineer) is responsible for designing any temporary excavation slopes or temporary shoring. The contractor must also be aware that slope height, slope inclination, and excavation depths (including utility trench excavations) should in no case exceed those specified in federal, state, or local safety regulations, such as OSHA Safety and Health Standards for Excavations, 29 CFR Part 1926, or successor regulations.

Surcharge loads from stockpiled soil and from equipment and vehicles around excavations must be kept a minimum distance of one-half (1/2) the depth of the excavation away from the top edge of the excavation. Excavations extending deeper than 20 feet below the ground surface or requiring surcharge loads within the minimum horizontal distance described will require design by a registered Professional Engineer. Such a design may include temporary earth retention. The design of permanent soil cut-slopes and/or other permanent soil slopes will be reviewed by a professional Geotechnical Engineer as part of the 95% Design.

4.1.4 Rippability

The sandstone is generally expected to be rippable within the limits of the jetty structure based on the information from the three borings performed in the area. The depths of rippability in the project area are based on information collected during this evaluation and estimated depths of rippable material are generally based upon a conservative evaluation of a number of criteria that correlate to rippability. For this evaluation, the depths of auger/sampler refusal, as well as rock quality designation (RQD %), and laboratory compressive strength of the core samples provided information on rippability. Compressive strengths of the core samples tested in the lab ranged from 1,210 psi to 2,560 psi. The average of the five tests was 1776 psi, with no significant variation by depth. RQD averaged approximately 51 percent above elevation 6912 feet and about 86 percent below 6912 feet. The upper rock can be considered a Class III-IV rock mass while the rock below elevation 6912 is anticipated to be a more consistent zone III rock mass. The rock above elevation 6912 may be rippable with a single tooth ripper on a Caterpillar D-8, or equivalent, but will likely require breaking by a hydraulic hammer on an excavator. More competent zones (Zone III rock mass) may require blasting to loosen. The rock within the excavation and below elevation 6912 is anticipated to require blasting to loosen. These estimates are based on the RQD and the compressive strength of the core samples (Waltham, 1996).

Generally, the depth at which auger refusal is reached during test hole drilling reliably provides a conservative estimate of the limits of rippability for a Caterpillar D-8 with a single tooth ripper. Therefore, it can also be assumed that material at depths greater than the point of auger refusal identified in the boring logs would not be rippable. Auger refusal was limited to locations B2 and B3, where rock coring was initiated.

4.1.5 Subgrade Preparation

Prior to placement of the riprap, the subgrade soil should be overexcavated as shown on the design drawings. Once the area is overexcavated and before fill placement, the top 12 inches of the ground surface in fill areas should be scarified, moisture conditioned, and compacted per the requirements for fill placement in this report.

Prior to fill placement on the 6:1 slopes, the subgrade should be proof rolled with a loaded tandem axle dump truck or equivalent (loaded water truck, loaded concrete mixer or motor grader). Any soft, yielding, or unsuitable areas should be compacted or removed and replaced with stable fill material similar in composition to the surrounding soils. The Geotechnical Engineer should observe the proof rolling and review the condition of prepared subgrade surfaces.

In order to achieve satisfactory compaction of the subgrade and fill materials, it may be necessary to adjust the water content of these materials at the time of construction. This may require either water to be added to soil that is too dry, or the scarification and aeration of soils that are too wet.

Any soft soils or unsuitable bearing materials should be compacted or removed and replaced with controlled fill similar in composition to the surrounding soils. If wet and/or soft soils are encountered which cannot be replaced with dry soils or scarified, they can typically be stabilized with materials such as recycled, crushed concrete or crushed stone that is clean, angular, and greater than 3 inches in size. This stabilization material is most effective when tracked into excavations with an excavator.

4.2 ENGINEERED FILL MATERIALS

The soil material to be excavated from the jetty area is suitable for reuse as engineered backfill and could be used as engineered fill on other areas of the project. Engineered fill placed on-site for construction of the jetty and riprap weir should be compacted using equipment appropriate for the type of material being placed and capable of producing the compactive energy to meet the requirements in Table 5. While most of the materials encountered in the vicinity of the jetty are suitable for reuse as engineered fill, moisture conditioning, wetting or drying, of the soils may be required to meet the water content criteria during compaction. In-situ water contents of samples from the area ranged from 5 to 22 percent which indicates some materials are likely several percent below or several percent above the range of optimum water contents for this soil. Proctor testing was not included with this evaluation. Some materials encountered in the proposed jetty excavation (B5-B7) may present challenges for moisture conditioning. These materials will be difficult to work with in wet conditions due to high plasticity (USCS classifications CH) and fines content (90 percent fines or greater).

Table 5 – Recommended Compaction Requirements for Engineered Fill

Fill Type	Soil Type	Soil Water Content (% from optimum)	Compaction Requirements
Structural fill and compacted subgrade	Clay	-3 to +3	90% of ASTM D698 6-inch compacted lifts
	Sand	-2 to +2	90% of ASTM D698 6-inch compacted lifts

4.2.1 Structural Fill

Engineered structural fill for use below riprap and filter layers may consist of granular or cohesive material. The material should have a maximum particle size of 2 inches and be free from organic matter, debris, and other deleterious material. Processed bedrock, if used, must be broken down to a soil-like consistency. Structural fill should form a compactable, uniform, and stable subgrade. The on-site overburden soils may be considered structural fill material as defined in this section, provided they are properly broken down, mixed and moisture conditioned. Sampling and testing of these materials after excavation and processing will be required for density testing and to confirm that the properties meet the structural fill criteria.

4.3 RIPRAP CHANNEL SUBGRADES

As part of the 30% Design (MWH, 2016a), a preliminary filter analysis was conducted for select channels located near the repository and the Mine Site. Actual subgrade conditions were verified during this investigation by sampling the subgrade materials and sending bulk samples to the laboratory for gradation testing. These samples were collected from the Dilco Hill area and the Mine Site Outlet Channel. The gradations of the subgrade will be used to design filter layers for the rock channels. The filter layers will prevent migration of subgrade particles during flow events.

Based on the relatively fine-grained nature of the native soil (41 to 90 percent fines) and the relatively coarse-grained nature (D_{50} from 4 to 8 inches) for the proposed channel lining material, filter analyses are needed to evaluate the compatibility of the adjacent materials and to design filter materials, if necessary, to transition between them. Grain-size distribution limits will be developed for the material that will line the channels based on the gradations of the subgrade materials during the 95% Design. The design will use applicable guidance and methods to determine the filter gradations.

5 REFERENCES

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FIGURES AND APPENDICES

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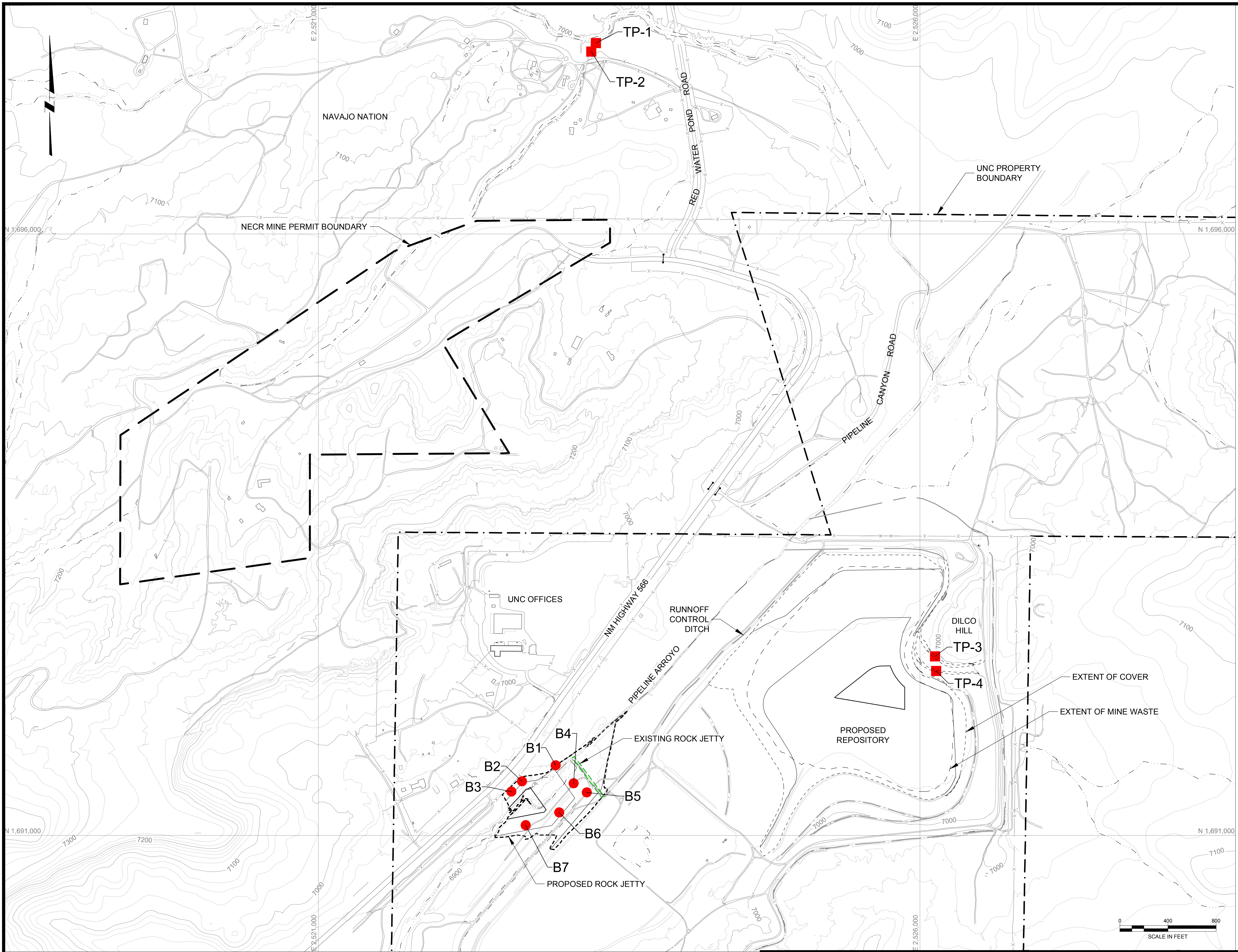


LEGEND:

7200	EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
7200	PROPOSED SURFACE CONTOUR & ELEVATION, FEET
— —	NECR MINE PERMIT BOUNDARY
— · —	UNC PROPERTY BOUNDARY
— · —	BRANCH SWALE
— —	DIVERSION CHANNEL
═	ROADS
- · -	NATURAL DRAINAGE
—x—	EXISTING FENCE
●—●	GATE
🟥	TEST PIT LOCATION (MWH, 2016)
●	BORING LOCATION (MWH, 2016)
- - - -	PROPOSED JETTY AREA

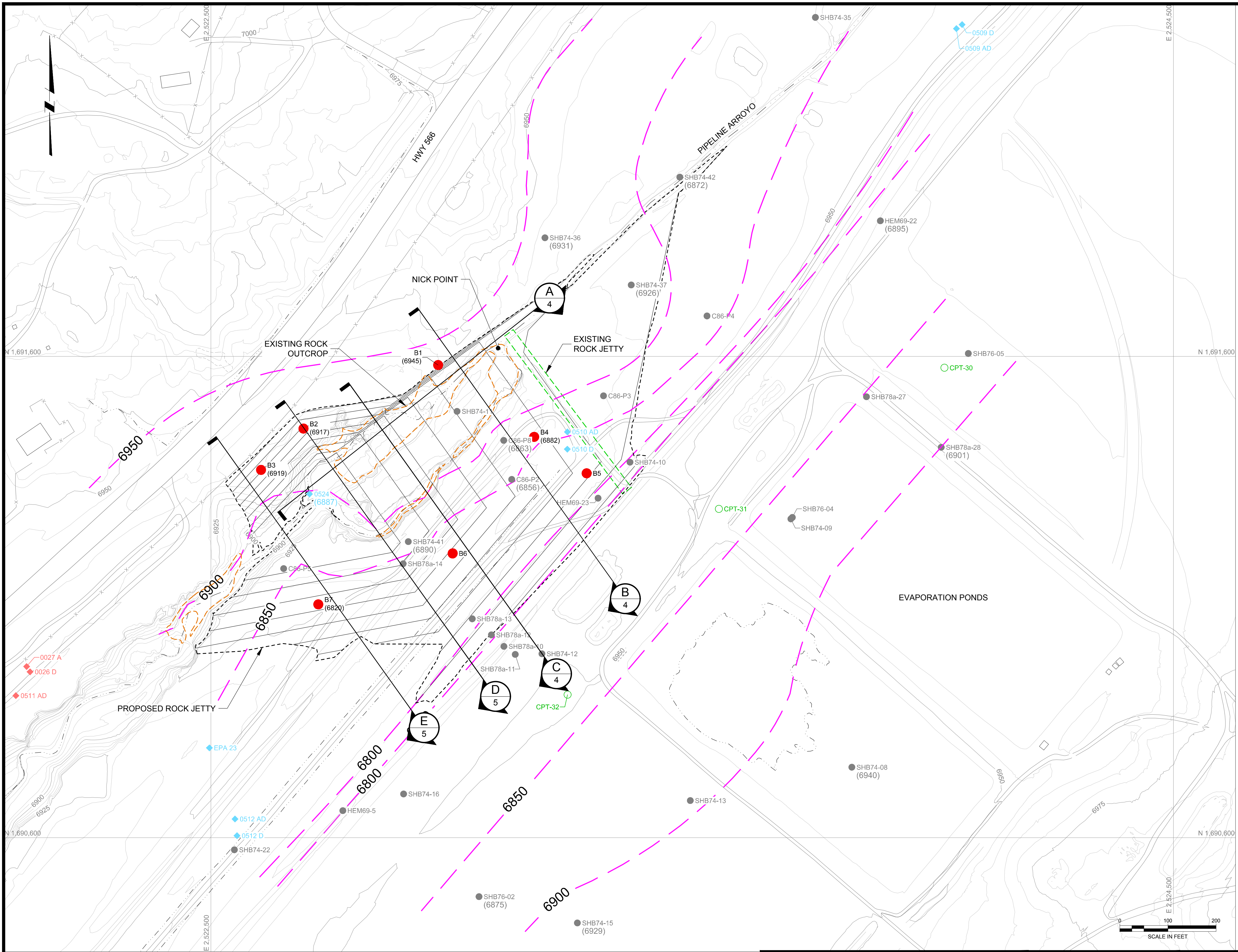
DESIGNED K REED
CHECKED S DOWNEY
APPROVED J CUMBERS

MWH now part of Stantec

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

JETTY GEOTECHNICAL EVALUATION
BORING AND TEST PIT LOCATIONS

FIGURE
1
10508639
DEC 2016



LEGEND:

7200	EXISTING GROUND SURFACE CONTOUR & ELEVATION, FEET
7200	PROPOSED SURFACE CONTOUR & ELEVATION, FEET
— —	DIVERSION CHANNEL
═	ROADS
-·-·-	NATURAL DRAINAGE
—x—	EXISTING FENCE
⬭	EXISTING ROCK OUTCROP
▭	EXISTING ROCK JETTY
◆	ALLUVIUM MONITORING WELL (NOTE 1)
◆	ZONE 1 MONITORING WELL
●	GEOTECHNICAL BORING (ROCK CONTACT ELEV.) (NOTES 1 AND 2)
○	CPT LOCATION (MWH, 2013)
— —	APPROXIMATE TOP OF ROCK CONTOURS
● B1 (6945)	BORING LOCATION (MWH, 2016) (ROCK CONTACT ELEVATION)
- - - -	PROPOSED JETTY AREA

NOTE(S):

1. WHERE ELEVATIONS ARE NOT SHOWN THE PREVIOUS GEOTECHNICAL BORINGS WERE TERMINATED IN ALLUVIUM.
2. SERGENT, HAUSKINS, AND BECKWITH, 1974 - 1978,
CANONIE, 1986
HEMPHILL CORPORATION, 1969.

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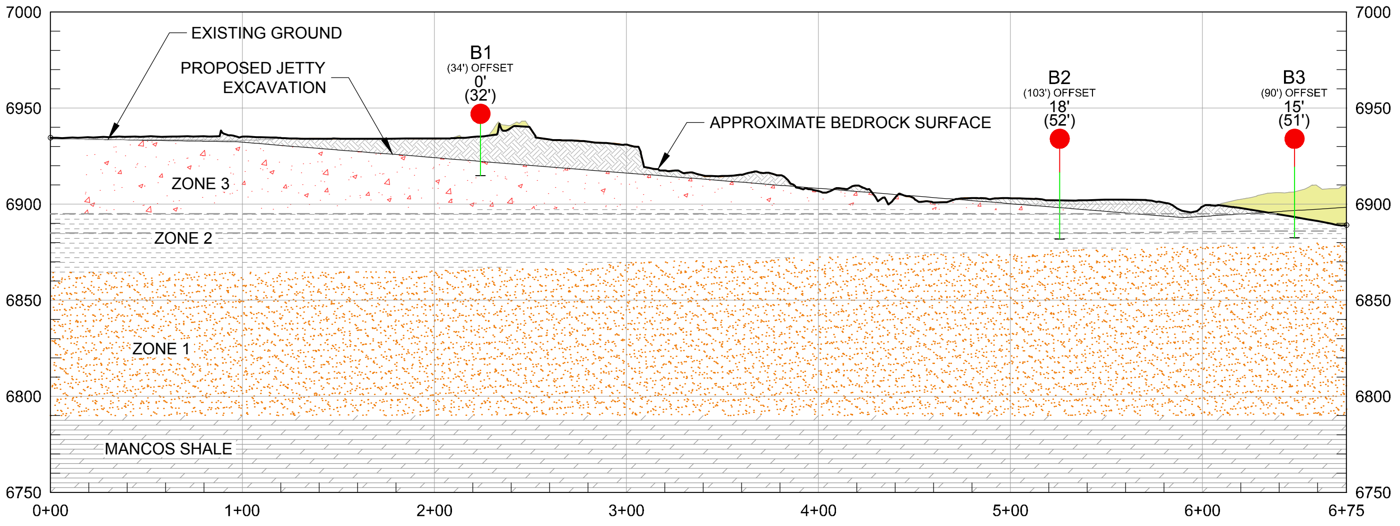
DESIGNED K REED
CHECKED S DOWNEY
APPROVED J CUMBERS

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

JETTY GEOTECHNICAL EVALUATION

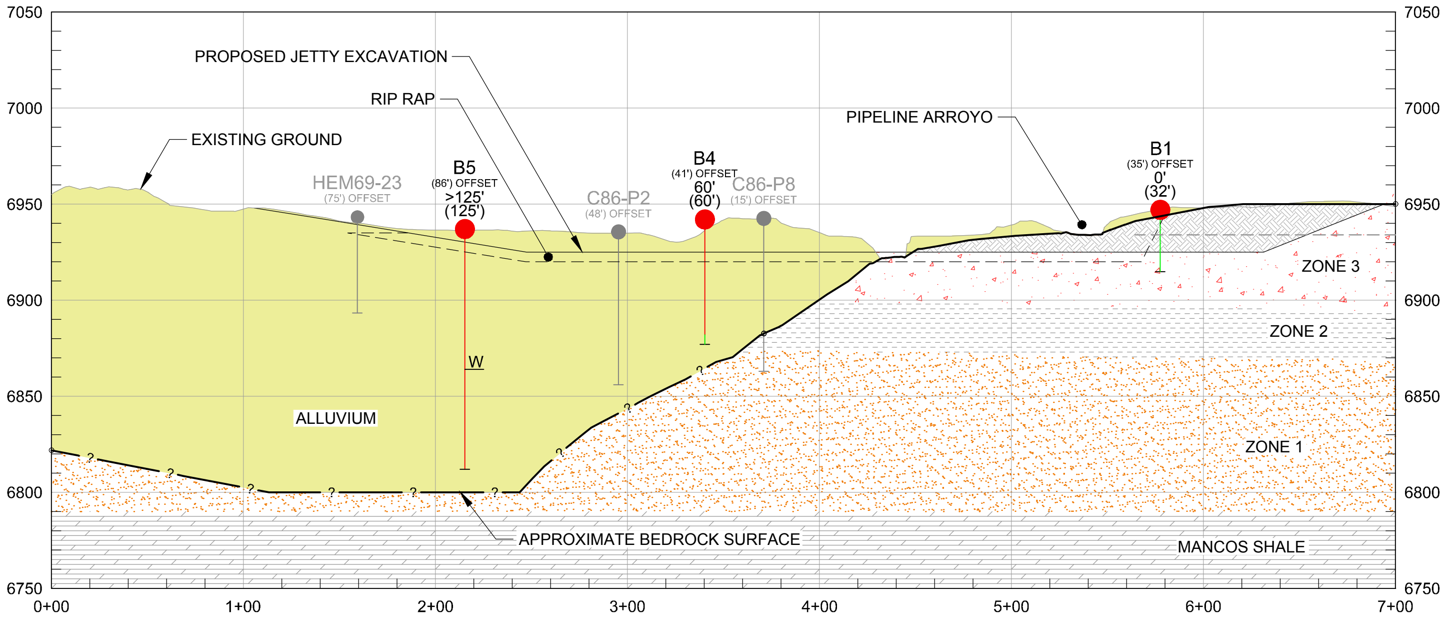
FIGURE
2
10508639
DEC 2016



A 4 CROSS SECTION A: NE-SW

(LOOKING EAST TOWARDS THE TAILINGS AREA)

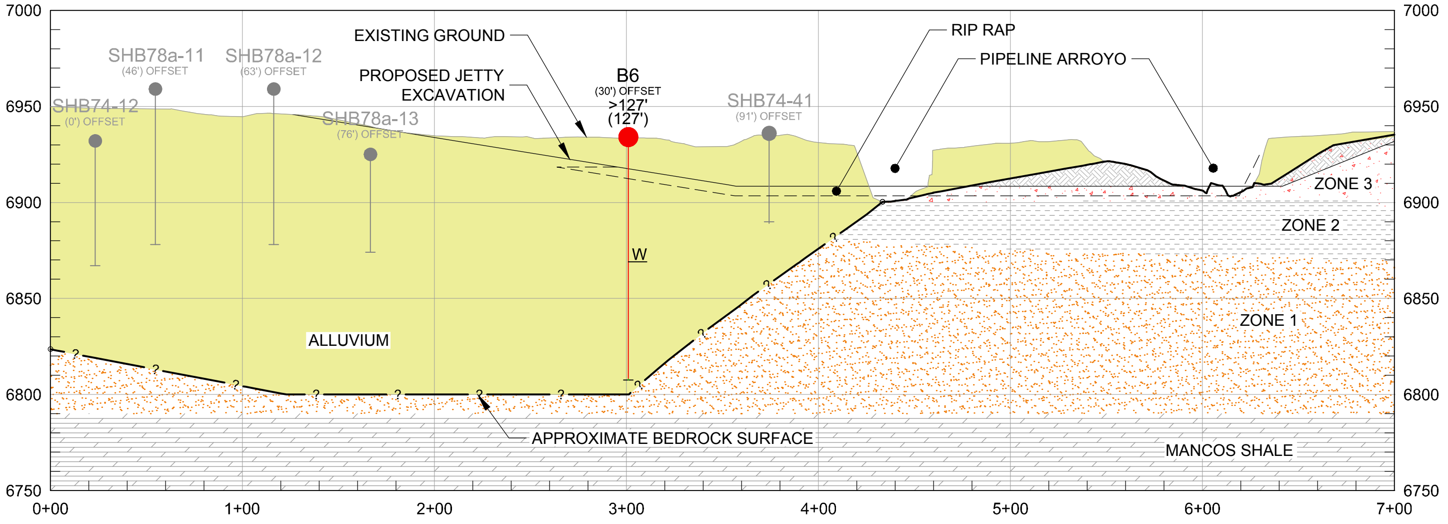
HORZ 0 50 100
VERT 0 50 100
SCALE IN FEET



B 4 CROSS SECTION B: SE-NW

(LOOKING DOWNSTREAM)

HORZ 0 50 100
VERT 0 50 100
SCALE IN FEET



C 4 CROSS SECTION C: SE-NW

(LOOKING DOWNSTREAM)

HORZ 0 50 100
VERT 0 50 100
SCALE IN FEET

LEGEND:

▨ AREAS OF POTENTIAL ROCK EXCAVATION (APPROXIMATE)

🟨 ALLUVIUM / FILL (UNDIFFERENTIATED)

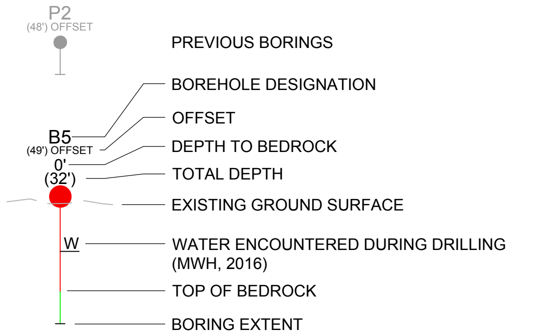
– – – APPROXIMATE LOCATION OF COAL LAYER

▨ ZONE 3 SANDSTONE

▨ ZONE 2 SHALE AND COAL

▨ ZONE 1 SANDSTONE

▨ MANCOS SHALE



NOTE(S):

1. DEPTHS SHOWN TO BEDROCK ARE APPROXIMATE BASED ON AVAILABLE INFORMATION.

DESIGNED K REED
CHECKED S DOWNEY
APPROVED J CUMBERS

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

JETTY GEOTECHNICAL EVALUATION
ESTIMATED ROCK SURFACE CROSS-SECTIONS (1 OF 2)

FIGURE
3
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DEC 2016

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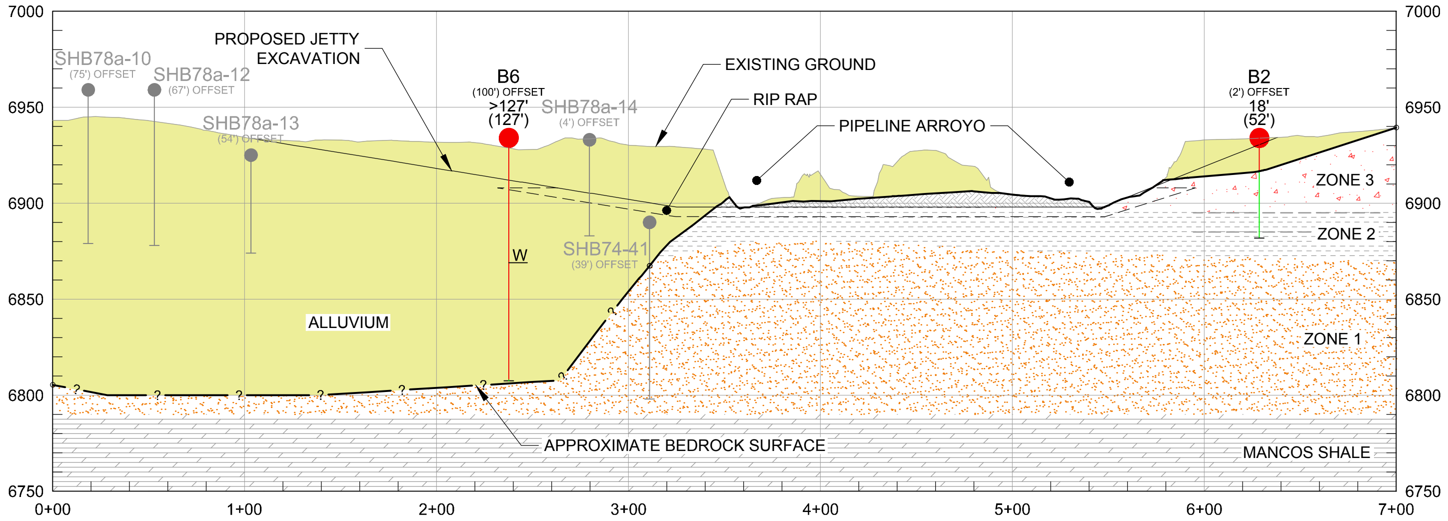
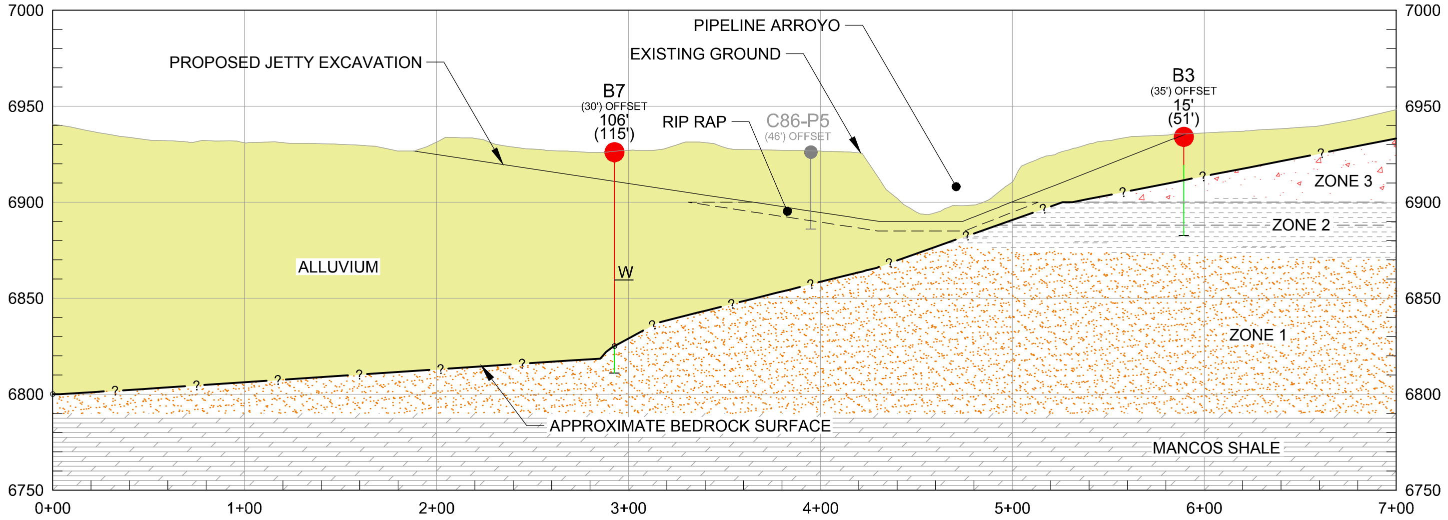


D 5 CROSS SECTION D: SE-NW
(LOOKING DOWNSTREAM)

HORZ 0 50 100
VERT 0 50 100
SCALE IN FEET

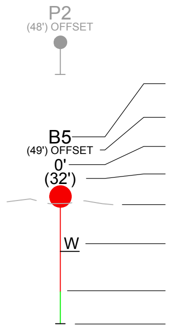


E 5 CROSS SECTION E: SE-NW
(LOOKING DOWNSTREAM)

HORZ 0 50 100
VERT 0 50 100
SCALE IN FEET

LEGEND:

▨	AREAS OF POTENTIAL ROCK EXCAVATION (APPROXIMATE)
🟨	ALLUVIUM / FILL (UNDIFFERENTIATED)
– – –	APPROXIMATE LOCATION OF COAL LAYER
▨	ZONE 3 SANDSTONE
▤	ZONE 2 SHALE AND COAL
▨	ZONE 1 SANDSTONE
▤	MANCOS SHALE



PREVIOUS BORINGS
BOREHOLE DESIGNATION
OFFSET
DEPTH TO BEDROCK
TOTAL DEPTH
EXISTING GROUND SURFACE
WATER ENCOUNTERED DURING DRILLING (MWH, 2016)
TOP OF BEDROCK
BORING EXTENT

NOTE(S):

1. DEPTHS SHOWN TO BEDROCK ARE APPROXIMATE BASED ON AVAILABLE INFORMATION.

DESIGNED K REED
CHECKED S DOWNEY
APPROVED J CUMBERS

MWH now part of Stantec

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

JETTY GEOTECHNICAL EVALUATION
ESTIMATED ROCK SURFACE CROSS-SECTIONS (2 OF 2)

FIGURE
4
10508639
DEC 2016

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APPENDIX A BORING LOGS AND CORE PHOTOS

BORING LOGS

MWH

Project: NECR UNC JETTY GEOTECH INVESTIGATION
Project Location: NECR JETTY
Project Number: 1050

ROCK CORE LOGGING FORM

BOREHOLE No.: B1
Sheet 1 of 4

Drilling Company: NATIONAL EWP	Inclination: 90°		Groundwater Level & Date Measured		Start Date: 8-NOV-2016
Driller: MATT CAIN	Azimuth: —	Water Level:	NA		Finish Date: 8-NOV-2016
Drilling Method: ROTARY	Northing: 12 S 0725716 UTM	Date:	—		Total Depth: 32.1
Drilling Rig: CME85	Easting: 3947688 NAD83	Time:	—		Logged By: J. VANPELT / S. DOWNS
Drill Bit Type/Size: HQ/HQ3 (PDC)	Elevation: HANDHELD GPS	Casing Depth	NA		Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven/Recovered	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Material Description
0	13:10								SANDSTONE, pale yellow (2.5Y 7/4) to yellow (2.5Y 7/6), fine-grained, with occasional grayish red purple (5RP 4/2) intervals, fine- to medium-grained, moderately to slightly weathered w/ iron oxidation, weak to moderately strong, moderately hard, very thinly to thinly bedded, locally laminated, moderately jointed, predominantly along bedding
1						7			
2						1			
3		1	1	3.95/5.30' (75%)	3.07/5.30' (58%)	3	W3-W2	R2-R3, H4	*Bedding at 60° to core axis
4						3			grayish red purple lamina banding
5	13:35								
5.3	13:48					2		R2	
6						>10		R0-R1	*Weak to [illegible]
7						3		R1	
8		2	1	5.00'/5.00 (100%)	2.53/5.00' (51%)	5	W2-W3	R2	
9						>10	W3	R0-R1	* Coal stringers. Iron oxidation/weathering
10									

DISCONTINUITY DATA

Depth (approx.)	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Remarks
0.7	NR								
1.8	75	J	VN	Fe	Sp	Pl	SR		
	85	J	VN	Fe	Sp	Pl	S		
	90	J	VN	Fe, Mn	Sp	Pl	S		
	85	J	VN	Fe	Sp	Pl	S		
2.8	65	J	VN	Fe, Mn	Sp	Pl	SR		
3.3	85	J	VN	Mn, Fe	Sp/Pa	Pl	S		
3.9	85	J	Vn	-	No	Pl	S		
4.0	60	J	Vn	Mn, Fe	F	Pl	Sr	C	
4.5	60	J	Vn	Mn, Fe	F	Pl	S	C	
5.0	85	J	Vn	Fe	St	Pl	S		
5.3	MB								B1-5.3-5.95 Sampled
5.9	90	J	Vn	No -	No	Pl	[illegible]		
6.0	BZ			No					
6.5	60	J	N-VN	No	No	Pl	SR		
	90	J	Vn	Fe Mn	St	Pl	S		
	90	J	VN	Fe Mn	St	Pl	S		
	90	J	Vn	Mn Fe	ST	Pl	S		
7.4	60	J	VN	Fe	St	Pl	S		
7.6	70	J	NW	Fe	Sp	Pl	R		
8.0	70	J	Vn	Fe Mn	Sp	Pl	S		
8.4	80	J	Vn	No	No	Pl	S		
8.8	90	J	Vn	No	No	Pl	S		
9.1	90	J	VN	No	No	Pl	S		
9.3	BZ			No	No				
9.7	90	MB							

DISCONTINUITY TYPE	APERATURE		INFILLING TYPE		INFILLING AMOUNT	SHAPE
F - Fault	Tight (T)	0	Bi - Biotite	Mn - Manganese	Clean (No)	Wa - Wavy
J - Joint (Discontinuity)	Very Narrow (Vn)	<0.05" (<1.3 mm)	Cl - Clay	My - Mylonite	Stained (Su)	Pl - Planer
Fz - Fractrue Zone	Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)	Ca - Calcite	No - None	Spotty (Sp)	St - Stepped
S - Shear	Open (O)	0.1-0.5" (2.5 - 12.7 mm)	Ch - Chlorite	Py - Pyrite	Partial Filled (Pa)	Ir - Irregular
Sz - Shear Zone	Wide (W)	>0.5" (>12.7 mm)	Ep - Epidote	Qz - Quartz	Filled (Fi)	
V - Vein			Fe - Iron Oxide	Sd - Sand	Cemented (Cm)	
Fo - Foliation			Gy - Gypsum	Si - Silt		
B - Bedding Joint			H - Healed	Un - Unknown		
MB - Mechanical Break						
BZ - Broken Zone						

ROUGHNESS	
Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING	
Extremely Wide (EW)	>6 ft
Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
Close (C)	2.4 in - 8 in
Very Close (VC)	0.75 in - 2.4 in
Extremely Close (Ex)	<0.75 in

WEATHERING	STRENGTH
Fresh (W1)	R0 Extremely weak
Slightly (W2)	R1 Very weak
Moderately (W3)	R2 Weak
Highly (W4)	R3 Moderately strong
Decomposed or Completely (W5)	R4 Strong
Residual Soil (W6)	R5 Very Strong
	R6 Extremely strong

MWH

Project: GE/UNC
Project Location:
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B1
Sheet 2 of 4

Drilling Company: SEE INFO ON
Driller: FIRST PAGE
Drilling Method: OF LOG
Drilling Rig:
Drill Bit Type/Size:

Inclination:
Azimuth:
Northing:
Easting:
Elevation:

Groundwater Level & Date Measured
Water Level:
Date:
Time:
Casing Depth

Start Date:
Finish Date:
Total Depth:
Logged By:
Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven/Recovered	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Material Description	Remarks
10	13:53 14:09					SP	W2			* 0.5' of Run Recovered in Run #4
11		3	2	4.05'/5.00' (81%)	2.07'/5.00' (41%)	7	W2-W3 W3 W2	R2-R3 R2	SANDSTONE, grayish red (5R 4/2) to pale yellowish brown (10YR 6/2) fine to medium-grained Slightly to moderately weathered, moderately strong, moderately hard. sub-angular quartz grains locally iron oxidation discoloration yellowish brown (10YR 5/8) moderately fractured.	
12						6	W2-W3?	R2 R1-R2	grades to very dark gray (N 3/0)	
13						2		R0	Organic CLAYSTONE /coal Black (N 2.5/0), very fine grained (clay) medium to high plasticity	
14						2	W2-W3	R3-R2	grades to ~14.0' Siltstone/claystone, light Brownish gray, very fine-grained Slightly weathered, (W2) Moderately strong to strong moderately soft to moderately hard, moderately to highly fractured, predominantly along bedding planes	
15	14:15 ~14:30 15:09					5		R3	14.8' grades to SANDSTONE, pinkish white (7.5YR 8/2) very fine-grained to fine grained slightly weathered, moderately strong	15.3 SWITCH TO HQ3 10' Barrel
16						1				B1-17.3-18.1
17						4				B1-17.3-18.1 Sampled (15.9-16.7)
18		4	2	7.35'/6.80' (108%)	5.00'/6.80' (74%)	4	W2	R3	← 1-inch SILTSTONE, gray (7.5YR 5/1) grades coarser to medium grained.	
19			19.65 3			7			grades finer to finer to fine-grained. grades coarser to med-gr.	
20										

DISCONTINUITY DATA

Depth (ft)	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness
	BZ			NO			
	MB						
11	0	J	VN	No	No	Pl	S
	50	q	VN	Fe	Sp	Pl	S
	90	J	VN	No	No	Pl	S
	90	J	VN	Fe	Sp	Pl	S
	85	J	VN	Fe	Sp	Pl	S
	30	J	VN	Fe	Fi	Pl	S
12	BZ						
	80	J	VN	Fe, Mn	Fi	Pl	S
	90	J	N	Fe Mn	Pa	Pl	R
	MB						
	MB at contact						
13	MB						
	90	J	VN	Mn Fe	Sp	Pl	Sm
14	90	J	VN	No	No	Pl	R
	90	J	VN	Mn	Sp	Pl	S
	BZ						
	MB			Mn			
15	80	J	VN	No	No	Pl	SR
	BZ						
	90	J	Vn	Mn Mi	Sp	Pl	S
	90	J	Vn	Mi	Sp	Pl	S
	90	J	Vn	Mi	Sp	Pl	S
16	MB						
17	90	J	VW	Mn, Mi	Fi	Pl	S
	90	J	VW	No, Mi	Fi	Pl	S
	90	J	VN	Fe Mi	Sp	Pl	S
	90	J	Vn	Fe, Mi	Sp	Pl	S
18	90	J	Vn	Mn			
	80	J	VW	Ca	Sp	Pl/St	R
	90	J	Vn	Fe	Sp	Pl	S
	90	J	Vn	Fe	Sp	Pl	S
19	90	J	Vn	No	No	Pl	S
	80-90 ↓	J	VN	Fe, Mn Mi	Pa	Pl	S-SR

Column headers with no entries: Fracture Drawing, Number, Spacing, Permeability, Well Details.

DISCONTINUITY TYPE
F - Fault
J - Joint (Discontinuity)
Fz - Fractrue Zone
S - Shear
Sz - Shear Zone
V - Vein
Fo - Foliation
B - Bedding Joint
MB - Mechanical Break
BZ - Broken Zone

APERATURE

Tight (T)	0
Very Narrow (Vn)	<0.05" (<1.3 mm)
Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)
Open (O)	0.1-0.5" (2.5 - 12.7 mm)
Wide (W)	>0.5" (>12.7 mm)

INFILLING TYPE
Bi - Biotite
Cl - Clay
Ca - Calcite
Ch - Chlorite
Ep - Epidote
Fe - Iron Oxide
Gy - Gypsum
H - Healed
Mn - Manganese
My - Mylonite
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand
Si - Silt
Un - Unknown

INFILLING AMOUNT
Clean (No)
Stained (Su)
Spotty (Sp)
Partial Filled (Pa)
Filled (Fi)
Cemented (Cm)

SHAPE
Wa - Wavy
Pl - Planer
St - Stepped
Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING

Extremely Wide (EW)	>6 ft
Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
Close (C)	2.4 in - 8 in
Very Close (VC)	0.75-in - 2.4 in
Extremely Close (Ex)	<0.75 in

WEATHERING
Fresh (W1)
Slightly (W2)
Moderately (W3)
Highly (W4)
Decomposed or Completely (W5)
Residual Soil (W6)

STRENGTH
R0 Extremely weak
R1 Very weak
R2 Weak
R3 Moderately strong
R4 Strong
R5 Very Strong
R6 Extremely strong

(Mi) = Mica

MWH

Project: GE/UNC NECR UNC JETTY
Project Location: Northeast Church Rock
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B1
Sheet 3 of 4

Drilling Company: SEE INFO	Inclination:	Groundwater Level & Date Measured			Start Date:
Driller: ON FIRST PAGE	Azimuth:	Water Level:			Finish Date:
Drilling Method: OF LOG	Northing:	Date:			Total Depth:
Drilling Rig:	Easting:	Time:			Logged By:
Drill Bit Type/Size:	Elevation:	Casing Depth			Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Recovered/Driven	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Lithology / Symbol	Material Description	Fracture Drawing	Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
20				↑	↑	3				SANDSTONE, CONTINUED			60	J	Vn	No	No	Pl	SR				
													MD 90	J	Vn	MnFe Mi	Pa	Pl	R				
21		4	3				W2	R3		Coal/organic clay stringers grades finer to very fine-grained SANDSTONE/SILTSTONE. abundant coal/organic clay stringers throughout slightly weathered, moderately strong, moderately hard.			90	J/B	Vn	Cl (org) Mi	Fi	Pl	S				
						4							90 ↓	J/B	Vn	Mn/Fe	Fi	Pl	Sm				
22	15:09												90 90 90 82	J/B J/B J/B J/B	Vn Vn Vn Vn	Coal/cl Coal/cl Coal/cl/Fe Coal/cl	Fi Fi Fi Fi	Pl Pl Pl Pl	S S S	VC			
						>10							90	J/B	Vn	coal/cl	Pa	Pl	S				
23		5	5	2.8/5.0 (56%)	0.7/5.0 (14%)								90	J/B	Vn	coal/cl	Fi	Pl	S				
						4	W2	R3					90 ↓	J/B	Vn	coal/Mi	Fi	Pl	S				
24										24			90 90 90 90 90	J/B J/B J/A J/B C/B	Vn Vn Vn Vn Vn	coal/Mi coal/Fe coal/Mi coal/Mi coal Fe	Fi Fi Pa Pa Fi	Pl Pl Pl Pl Pl	Sm S S S S				
						5				← coal, lignite/ Bituminous.													
25						>10																	
26													NR										
						>10																	
27	16:30						W2-3	R2-R3		SILTSTONE/SANDSTONE, As above, fewer coal stringers, gray (7.5YR 6/1), very fine grained.			90 90	J J	Vn N	Fe Fe	Fi Fi	Pl Pl	SR SR				
						4	W3	R0-R1					90 90	BZ	VW	Cl, Fe	Fi	Pl	S				
28				(110%)	(60%)					27.65 - 27.9 CLAY (cc) gray (7.5YR 6/1) weak to very weak/SOFT			90	J	VW	cl	Fi	Pl	S				
		6	3	5.50/5.00'	3.00/5.00'	4	W2-W3	R2-R3		increasing coal stringers, concretions.													
29													80 90 90	J J J	Vn Vn Vn	FeMnMi Fe Mi Fe Mi	Pl Pl Pl	SR SR R					
						3							90	J	Vn	Fe	Pa	S				B1-29.45-30.15 SAMPLED	
30																							

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DISCONTINUITY TYPE	APERATURE		INFILLING TYPE		INFILLING AMOUNT	SHAPE
F - Fault	Tight (T)	0	Bi - Biotite	Mn - Manganese	Clean (No)	Wa - Wavy
J - Joint (Discontinuity)	Very Narrow (Vn)	<0.05" (<1.3 mm)	Cl - Clay	My - Mylonite	Stained (Su)	Pl - Planer
Fz - Fractrue Zone	Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)	Ca - Calcite	No - None	Spotty (Sp)	St - Stepped
S - Shear	Open (O)	0.1-0.5" (2.5 - 12.7 mm)	Ch - Chlorite	Py - Pyrite	Partial Filled (Pa)	Ir - Irregular
Sz - Shear Zone	Wide (W)	>0.5" (>12.7 mm)	Ep - Epidote	Qz - Quartz	Filled (Fi)	
V - Vein			Fe - Iron Oxide	Sd - Sand	Cemented (Cm)	
Fo - Foliation			Gy - Gypsum	Si - Silt		
B - Bedding Joint			H - Healed	Un - Unknown		
MB - Mechanical Break						
BZ - Broken Zone						

ROUGHNESS		DISCONTINUITY SPACING		WEATHERING	STRENGTH
Slickensided (Slk)	Visual evidence of polishing, striations	Extremely Wide (EW)	>6 ft	Fresh (W1)	R0 Extremely weak
Smooth (S)	Surface appears and feels smooth	Wide (W)	2 ft - 6 ft	Slightly (W2)	R1 Very weak
Slightly rough (Sr)	Asperities are distinguishable and can be felt	Moderate (M)	8 in - 2 ft	Moderately (W3)	R2 Weak
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive	Close (C)	2.4 in - 8 in	Highly (W4)	R3 Moderately strong
Very rough (Vr)	Near-vertical ridges occur on surface	Very Close (VC)	0.75 in - 2.4 in	Decomposed or Completely (W5)	R4 Strong
		Extremely Close (Ex)	<0.75 in	Residual Soil (W6)	R5 Very Strong
					R6 Extremely strong

MWH

Project: NECR UNR JETTY GEO TECH INVEST Project Location: Project Number:		**ROCK CORE LOGGING FORM**	BOREHOLE No.: B1 Sheet 3 of 4

Drilling Company: SEE INFO ON	Inclination:		Groundwater Level & Date Measured						Start Date:
Driller: FIRST PAGE	Azimuth:	Water Level:							Finish Date:
Drilling Method: OF LOG	Northing:	Date:							Total Depth:
Drilling Rig:	Easting:	Time:							Logged By:
Drill Bit Type/Size:	Elevation:	Casing Depth							Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Recovered/Driven	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Lithology / Symbol	Material Description	Fracture Drawing	Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
30										- SILTSTONE/SANDSTONE, CONT.													
						1							MB										
													80	J	VN	Fe	Pa	Wa	SR				
31		6	4	5.50/5.00'	3.10/5.00'		W2-W3	R2-R3					80	J	VN	Fe Mn	Pa	Pl/St	R				
													90	J	VN	Fe	Sp	Pl	S				
						5							90	J	VN	Mn Fe Mi	Pa	Pl	S				
													90	J	VN	Fe Mi Mn	Pa	Ir/St	R				
32	15.09																						
6912 El.										TOTAL DEPTH 32.10 feet Bgs													
33																							

DISCONTINUITY TYPE
- F - Fault
- J - Joint (Discontinuity)
- Fz - Fractrue Zone
- S - Shear
- Sz - Shear Zone
- V - Vein
- Fo - Foliation
- B - Bedding Joint
- MB - Mechanical Break
- BZ - Broken Zone

APERATURE

Tight (T)	0
Very Narrow (Vn)	<0.05" (<1.3 mm)
Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)
Open (O)	0.1-0.5" (2.5 - 12.7 mm)
Wide (W)	>0.5" (>12.7 mm)

INFILLING TYPE

Bi - Biotite	Mn - Manganese
Cl - Clay	My - Mylonite
Ca - Calcite	No - None
Ch - Chlorite	Py - Pyrite
Ep - Epidote	Qz - Quartz
Fe - Iron Oxide	Sd - Sand
Gy - Gypsum	Si - Silt
H - Healed	Un - Unknown

INFILLING AMOUNT
- Clean (No)
- Stained (Su)
- Spotty (Sp)
- Partial Filled (Pa)
- Filled (Fi)
- Cemented (Cm)

SHAPE
- Wa - Wavy
- Pl - Planer
- St - Stepped
- Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING

Extremely Wide (EW)	> 6 ft
Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
Close (C)	2.4 in - 8 in
Very Close (VC)	0.75-in - 2.4 in
Extremely Close (Ex)	< 0.75 in

WEATHERING
- Fresh (W1)
- Slightly (W2)
- Moderately (W3)
- Highly (W4)
- Decomposed or Completely (W5)
- Residual Soil (W6)

STRENGTH
- R0 Extremely weak
- R1 Very weak
- R2 Weak
- R3 Moderately strong
- R4 Strong
- R5 Very Strong
- R6 Extremely strong

MWH

Client: GE/UNC NECK JETTY

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B2

Sheet 1 of 6

Drilling Company: National
Drillers (day / night): M. Cain
Field Representitive (day / night): S. Downey
Drilling Rig: CME-85
Drilling Method: HSA
Core Diameter: 4" ID / 9" OD
Bit Type: HSA-SOIL
Logged by: S. DOWNEY / J. VANREIT
Start Date: 11/9/16
Finish Date: 11/9/16
Total Depth: 52.1

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
0					SP	poorly graded sand (SP), brown (10 YR 5/3) to yellowish brown (10YR 5/4), very loose to loose; dry, predominantly fine sand, medium sand (10%), trace silt and clay, non cemented, angular to subangular [illegible]		Hand auger to 5 ft depth Began drilling @ 0915	
1									
2									
3									
4									
	MOD-CAL 2" ID	3	6			As Above.		cal-mod	
5		6	6						
		11	6						
6									
7									
8									
9									
		6	6						
10									

			Description	Symbol
COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded² gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded² gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded² gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded² gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded² sands, gravelly sands, little or no fines	SW
			Poorly-graded² sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded² sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded² sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

²Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B2

Sheet 2 of 6

Drilling Company: National
Drillers (day / night): M. Cain
Field Representitive (day / night): S. Downey
Drilling Rig: CME 85
Drilling Method: HSA
Core Diameter:
Bit Type: HSA
Logged by: S Downey
Start Date: 11/9/16
Finish Date: 11/9/16
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	qu (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
10	MOD-CAL 2" ID	6	10		SP?	similar to above very fine-grained sand			
		7	6			10.7 ft. coarse sand-sized caliche nodules			
11									
12									
13									
14									
	MOD-CAL 2" ID	6	10						
15		12	6						
		30	6						
16						At 16 ft. moderate cementation/induration			
					SS	weathered bedrock at 16.5'		~16.5' driller notes possible bedrock	
17									
	MOD-CAL	50	3			Bedrock at 17.5' Sandstone, very pale brown (10YR 7/4) to yellow (10YR 7/6), fine- to medium-grained, moderately to highly weathered with iron oxidation, weak to very weak, soft to moderately soft, very thinly bedded to laminated		switch over to rock coring at 17.75', begin core logs	
18									
19						COMPLETE HOLLOW STEM AUGERING AT 18.1' bgs. SET HWT CASING TO CONTINUE DRILLING INTO BEDROCK. LOG CONTINUED ON NEXT PAGE			
20									

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Project: GE/UNC NECR
Project Location: Church Rock, NM
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B2
Sheet 3 of 6

Drilling Company: National
Driller: M. Cain
Drilling Method: Diamond Wireline
Drilling Rig: CME-85
Drill Bit Type/Size: PDC HQ

Inclination: 90
Azimuth: —
Northing: 12 S 0725632 UTM
Easting: 3947645 Nad83
Elevation: Handheld GPS

Groundwater Level & Date Measured					
Water Level:	NA				
Date:	—				
Time:	—				
Casing Depth	18.1'				

Start Date: 11/9/16
Finish Date: 11/9/2016
Total Depth: 52.1 feet
Logged By: S. Downey / S. VanKLT
Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven / Recovered	RQD Total > 4-in. / Driven	Fractures / foot	Weathering	Strength	Material Description
15–17.75'									
18	1112	1	1	3.35/4.00 (84%)	2.65/4.00 (66%)	>10 1 1 2	W2-W3 W3 W2-W3	R3	LOG CONTINUED FROM PREVIOUS PAGE 18 SANDSTONE, very pale brown (10YR 8/2) with reddish yellow (7.5YR 7/8) iron oxidation banding fine- to coarse-grained, coarsens downward slightly to moderately weathered, local Fe oxide, weak to moderately strong, moderately hard, very thin to thickly bedded, w/ local cross-bedding. bedding at 80° to 60° to core axis) Sub-angular quartz grains
22	1116 1131 1144	2	1	9.70/10.00 (97%)	8.90/10.00 (89%)	5 2 1	W2-3	R1-R2 R2 R1-R2	22.9-23.3 feet grades fine- to medium-to fine-grained 23.8-26.0 Weakly cemented.

Depth	Fracture Drawing Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
18		NR										
		85	BZ									
		90	J	Vn	Fe	Sp	Pl	SR				
19		75	J	Vn	Fe, Mi	Sp	Pl	S				
			MB									
20			MB									
			MB									
		60	J/B	VN	Fe	Sp	Pl	S				
21		60	J/B	VN	Fe	Sp	Pl	S				
		80	J	VN	Fe	Pa	Pl/St	SR				
22		NR										
		80	J	VN	No	No	Pl	S				
23		80	J	VN	Fe	Pa	Pl					
			MB									
24		60	J/B	VN	No	No	Pl	S				
		90										
			MB MB MB MB MB									
25												

DISCONTINUITY TYPE
- F - Fault
- J - Joint (Discontinuity)
- Fz - Fractrue Zone
- S - Shear
- Sz - Shear Zone
- V - Vein
- Fo - Foliation
- B - Bedding Joint
- MB - Mechanical Break
- BZ - Broken Zone

APERATURE

Tight (T)	0
Very Narrow (Vn)	<0.05" (<1.3 mm)
Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)
Open (O)	0.1-0.5" (2.5 - 12.7 mm)
Wide (W)	>0.5" (>12.7 mm)

INFILLING TYPE
- Bi - Biotite
- Cl - Clay
- Ca - Calcite
- Ch - Chlorite
- Ep - Epidote
- Fe - Iron Oxide
- Gy - Gypsum
- H - Healed
- Mn - Manganese
- My - Mylonite
- No - None
- Py - Pyrite
- Qz - Quartz
- Sd - Sand
- Si - Silt
- Un - Unknown

Mi - Mica

INFILLING AMOUNT
- Clean (No)
- Stained (Su)
- Spotty (Sp)
- Partial Filled (Pa)
- Filled (Fi)
- Cemented (Cm)

SHAPE
- Wa - Wavy
- Pl - Planer
- St - Stepped
- Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING

Extremely Wide (EW)	>6 ft
Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
Close (C)	2.4 in - 8 in
Very Close (VC)	0.75-in - 2.4 in
Extremely Close (Ex)	<0.75 in

WEATHERING
- Fresh (W1)
- Slightly (W2)
- Moderately (W3)
- Highly (W4)
- Decomposed or Completely (W5)
- Residual Soil (W6)

STRENGTH
- R0 Extremely weak
- R1 Very weak
- R2 Weak
- R3 Moderately strong
- R4 Strong
- R5 Very Strong
- R6 Extremely strong

MWH

Project: GE/UNC
Project Location: NECR
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B2
Sheet 4 of 6:

Drilling Company: SEE INFORMATION
Driller: ON PAGE ONE OF
Drilling Method: LOG
Drilling Rig:
Drill Bit Type/Size:

Inclination:
Azimuth:
Northing:
Easting:
Elevation:

Groundwater Level & Date Measured
Water Level:
Date:
Time:
Casing Depth

Start Date:
Finish Date:
Total Depth:
Logged By:
Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven/Recovered	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Material Description	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
25									SANDSTONE, CONTINUED		B2									
						3		R1-R2			MB MB MB									
26									26.0' grades finer	MB										
			1			0													B2-26.45-27.25 Sampled	
27										80	J	N-Vn	Cl, Fe	Fi 2mm	Pl	S				
				(97%)	(89%)	1														
28		2		9.70/10.0	8.90/10.0	0	W2-W3	R3												
29						0				MB										
30			2			0													B2-30.25-31.1 Sampled	
31						1				85	J	Vn	Fe	Sp	Pl	S				
32	1144 1201 1224									MB										
				(100%)	(92%)	1				70	J/B	VN	No	No	Pl	S				
33		3		10.00'/10.00'	9.15'/10.00'	0	W2	R3-												
34						1					MB MB									
								R1-R2	34.6 grades coarser	80	J	VN	Coal/Fe	Sp	Pl	S				
35																				

DISCONTINUITY TYPE	APERATURE		INFILLING TYPE		INFILLING AMOUNT	SHAPE
F - Fault	Tight (T)	0	Bi - Biotite	Mn - Manganese	Clean (No)	Wa - Wavy
J - Joint (Discontinuity)	Very Narrow (Vn)	<0.05" (<1.3 mm)	Cl - Clay	My - Mylonite	Stained (Su)	Pl - Planer
Fz - Fractrue Zone	Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)	Ca - Calcite	No - None	Spotty (Sp)	St - Stepped
S - Shear	Open (O)	0.1-0.5" (2.5 - 12.7 mm)	Ch - Chlorite	Py - Pyrite	Partial Filled (Pa)	Ir - Irregular
Sz - Shear Zone	Wide (W)	>0.5" (>12.7 mm)	Ep - Epidote	Qz - Quartz	Filled (Fi)	
V - Vein			Fe - Iron Oxide	Sd - Sand	Cemented (Cm)	
Fo - Foliation			Gy - Gypsum	Si - Silt		
B - Bedding Joint			H - Healed	Un - Unknown		
MB - Mechanical Break						
BZ - Broken Zone						

ROUGHNESS	
Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING		WEATHERING	STRENGTH
Extremely Wide (EW)	>6 ft	Fresh (W1)	R0 Extremely weak
Wide (W)	2 ft - 6 ft	Slightly (W2)	R1 Very weak
Moderate (M)	8 in - 2 ft	Moderately (W3)	R2 Weak
Close (C)	2.4 in - 8 in	Highly (W4)	R3 Moderately strong
Very Close (VC)	0.75-in - 2.4 in	Decomposed or Completely (W5)	R4 Strong
Extremely Close (Ex)	<0.75 in	Residual Soil (W6)	R5 Very Strong
			R6 Extremely strong

MWH

Project: GE/UNC
Project Location: NECR
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B2
Sheet 5 of 6 :

Drilling Company: SEE INFORMATION
Driller: ON FIRST PAGE OF
Drilling Method: LOG
Drilling Rig:
Drill Bit Type/Size:

Inclination:
Azimuth:
Northing:
Easting:
Elevation:

Groundwater Level & Date Measured
Water Level:
Date:
Time:
Casing Depth

Start Date:
Finish Date:
Total Depth:
Logged By:
Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Recovered/Driven	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Material Description	Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
35									SANDSTONE, CONTINUED		80	J	VN	Coal	Pa	IR	R				
						3						MB									
36												MB									
						1					80	J	VN	Coal	Pa	Pl	SR				
37			2	(97%)	(92%)		W2-W3	R2	← coal xenoliths		60	J	VN	No	No	Pl	S				
						1						MB									
38		3		9.70/10.00	9.15/10.00	0														- Return water color change to black @ 38.3' - Abrupt change from sandstone to coal @ 38.83'	
39									COAL & ORGANIC CLAY, black (N 2.5/0) to brown (7.5YR 5/2) very fine grained/clayey, very soft to soft, locally antracitic			MB									
						0															
40			3			0		R2	CLAYSTONE/SANDSTONE, brown (7.5YR 5/2) interbedded fine to very fine sand slightly to moderately weathered weak, moderately hard, slightly to moderately jointed preferentially along bedding planes; laminated to thinly bedded												
41												MB									
						1					80	J	VN	FeCl	Pa	Pl	S				
42	1224 1237 1304										NR									B2-42.0-42.5 Sampled	
						4															
43								R2													
						2	W2	R1	43.5-43.65' very soft clay		80	J/B	N	Cl	Fi	Pl	S				
44		4	3	(98%) 9.75/10.00	(73%) 7.25/10.00						80	J/B	Vn	Cl	Fi	Pl	S				
						1		R2													
45											60	J	Vn	Fe	Su	Pl	S				

DISCONTINUITY TYPE
F - Fault
J - Joint (Discontinuity)
Fz - Fractrue Zone
S - Shear
Sz - Shear Zone
V - Vein
Fo - Foliation
B - Bedding Joint
MB - Mechanical Break
BZ - Broken Zone

APERATURE

Tight (T)	0
Very Narrow (Vn)	<0.05" (<1.3 mm)
Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)
Open (O)	0.1-0.5" (2.5 - 12.7 mm)
Wide (W)	>0.5" (>12.7 mm)

INFILLING TYPE
Bi - Biotite
Cl - Clay
Ca - Calcite
Ch - Chlorite
Ep - Epidote
Fe - Iron Oxide
Gy - Gypsum
H - Healed
Mn - Manganese
My - Mylonite
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand
Si - Silt
Un - Unknown

INFILLING AMOUNT
Clean (No)
Stained (Su)
Spotty (Sp)
Partial Filled (Pa)
Filled (Fi)
Cemented (Cm)

SHAPE
Wa - Wavy
Pl - Planer
St - Stepped
Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING

Extremely Wide (EW)	> 6 ft
Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
Close (C)	2.4 in - 8 in
Very Close (VC)	0.75 in - 2.4 in
Extremely Close (Ex)	< 0.75 in

WEATHERING
Fresh (W1)
Slightly (W2)
Moderately (W3)
Highly (W4)
Decomposed or Completely (W5)
Residual Soil (W6)

STRENGTH
R0 Extremely weak
R1 Very weak
R2 Weak
R3 Moderately strong
R4 Strong
R5 Very Strong
R6 Extremely strong

MWH

Project: GE/UNC
Project Location: NECR
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B2
Sheet 6 of 6

Drilling Company: SEE INFORMATION	Inclination:	Groundwater Level & Date Measured		Start Date:	
Driller: ON FIRST PAGE OF	Azimuth:	Water Level:		Finish Date:	
Drilling Method: LOG	Northing:	Date:		Total Depth:	
Drilling Rig:	Easting:	Time:		Logged By:	
Drill Bit Type/Size:	Elevation:	Casing Depth		Checked By:	

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven/Recovered	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Lithology / Symbol	Material Description	Fracture Drawing Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
45										CLAYSTONE/SILTSTONE cont.												
						0																
46								R2														
			5									85 MB	J/ B	Vn	Cl	Fi	Pl	S				
						4		R3 R1														
47				(98%)	(73%)							80	J/B	Vn	Fe	Pa	Pl	S				
						3						80	J/B	Vn-N	Fe	Fi	Pl-Cu	Sr				
												65	J	Vn	Fe	Fi	Pl	S				
48							W2	R2				85	J	Vn	Gy	Pa	Pl	S				
		4		9.75/10.00	7.25'/10.00'	4						80	J	Vn	Fe	Pa	Pl	S				
												70	J	Vn	Fe	Fi	Pl	S				
49										grades to		75	J MB	Vn	Fe	Fi	Pl	S				
						3				Coal, black (N 2.5/0) Bituminous/Lignite brittle, moderately hard occasional very narrow veins of anhydrite and pyrite		80	J	Vn	Fe	Fi	Pl	S				
50			4									70	J	Vn	Fe	Fi	SR	R				
						5							MB									
								R1, R4				BZ	BZ		Py Gy						Anhydrite	
51												70	J	Vn	Py Gy	Pa	St	R				
						3						80 80	J J	Vn Vn	Fe Fe	Pa Pa	Pl Pl	S S				
										grades to CLAYSTONE, as above			MB									
52	1304									TOTAL DEPTH = 52.10 feet BGS												
53																						
54																						
55																						

DISCONTINUITY TYPE
- F - Fault
- J - Joint (Discontinuity)
- Fz - Fractrue Zone
- S - Shear
- Sz - Shear Zone
- V - Vein
- Fo - Foliation
- B - Bedding Joint
- MB - Mechanical Break
- BZ - Broken Zone

APERATURE

Tight (T)	0
Very Narrow (Vn)	<0.05" (<1.3 mm)
Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)
Open (O)	0.1-0.5" (2.5 - 12.7 mm)
Wide (W)	>0.5" (>12.7 mm)

INFILLING TYPE

Bi - Biotite	Mn - Manganese
Cl - Clay	My - Mylonite
Ca - Calcite	No - None
Ch - Chlorite	Py - Pyrite
Ep - Epidote	Qz - Quartz
Fe - Iron Oxide	Sd - Sand
Gy - Gypsum	Si - Silt
H - Healed	Un - Unknown

INFILLING AMOUNT
- Clean (No)
- Stained (Su)
- Spotty (Sp)
- Partial Filled (Pa)
- Filled (Fi)
- Cemented (Cm)

SHAPE
- Wa - Wavy
- Pl - Planer
- St - Stepped
- Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING

Extremely Wide (EW)	> 6 ft
Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
Close (C)	2.4 in - 8 in
Very Close (VC)	0.75-in - 2.4 in
Extremely Close (Ex)	< 0.75 in

WEATHERING
- Fresh (W1)
- Slightly (W2)
- Moderately (W3)
- Highly (W4)
- Decomposed or Completely (W5)
- Residual Soil (W6)

STRENGTH
- R0 Extremely weak
- R1 Very weak
- R2 Weak
- R3 Moderately strong
- R4 Strong
- R5 Very Strong
- R6 Extremely strong

MWH

Client: GE/UNC
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B3
Sheet 1 of 6

Drilling Company: National
Drillers (day / night): M. Cain
Field Representitive (day / night): S. Downey
Drilling Rig: CME-85
Drilling Method: HSA
Core Diameter: HSA ~9" / HQ3
Bit Type: HSA / CME
Logged by: S. Downey / J. Van Pelt
Start Date: 11/9/16
Finish Date: 11/10/2016
Total Depth: 51.4 feet

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
0					SP	poorly graded sand (SP), yellowish brown (10YR 5/4), very loose to loose, predominantly fine sand, medium sand (20%-30%), trace silt and clay, small roots throughout		Hand auger top 5 ft Begin 14:57	
1									
2									
3									
4									
	MOD-CAL 2" ID	4	6		SP				
5		4	6						
		6	6						
6									
7									
8									
9									
	MC 2" ID	5	6		SP				
10									

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

** = 140 pound hammer dropped 30 inches*

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B3

Sheet 2 of 6

Drilling Company: SEE INFO ON
Drillers (day / night): FIRST PAGE
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
10	MODCAL 2" ID	8	6		SP	10.7'-11.0' moderately cemented, caliche			
		11	6						
11									
12									
13								13.5' - driller notes weathered bedrock [illegible]	
14									
	2"	50	2		SS	refusal at 14.65' sandstone white (7.5YR 8/1), fine- to medium-grained, moderately weathered with iron oxidation, weak to very weak, soft to moderately soft,		finish - 1530	
15						14.65 - 15.9 ft bgs - NO RECOVERY			
16						COMPLETED HOLLOW STEM AUGER DRILLING at 14.65 feet bgs. SET HWT CASING TO CONTINUE DRILLING INTO BEDROCK			
						LOG CONTINUED ON NEXT PAGE			
17									
18									
19									
20									

			Description	Symbol
COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Project: GE/UNC NECR JETTY GEOTECH INV.
Project Location:
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B3
Sheet 3 of 6

Drilling Company: National	Inclination: 90	Groundwater Level & Date Measured		Start Date: 11/9/16	
Driller: M. Cain	Azimuth: –	Water Level:	NA	Finish Date: 11/10/2016	
Drilling Method: Diamond Wireline	Northing: 12S 0725600 UTM	Date:	–	Total Depth: 51.4 feet	
Drilling Rig: CME-85	Easting: 3947618 NAD 83	Time:	–	Logged By: J. Van Pelt / S. Downey	
Drill Bit Type/Size:	Elevation: Handheld GPS	Casing Depth	17.7'	Checked By:	

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Recovered/Driven	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Material Description	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
15									CONTINUED FROM PREVIOUS PAGE										11/9/16 - drilled to 17.7' w/ HWT pipe/casing depth	
16	11/10/16 0815					>10			SANDSTONE, very pale brown (10YR 8/2) with reddish brown (7.5YR 7/8) iron oxidation banding fine to coarse grained, with several coarsening downward sequences. slightly weathered locally moderately weathered weak to moderately strong moderately hard, very thin to thickly bedded, with local cross bedding. Bedding typically 65°-85° to core axis. sub-angular quartz grains											
17						>10				BZ	T/B		Fe	Sp-Pa		S-Sr				
18										80	MB J/B	Vn	Fe	Su	Pl	S				
										90	J/B	Vn	Fe	Su	Pl	S				
										80	J/B	Vn	Fe	Su	Pl	S				
										85	J/B	Vn	Fe	Sp	Pl	S				
				4.5'/5.4' (83%)	2.25'/5.4' (42%)	7				85	J/B	Vn	Fe	Sp	Pl	S				
19		1	1				W2	R1-R2			MB									
										80	J/B	Vn	Fe	Su	Pl	S				
						2				70	J/B	Vn	Fe	Sp	Pl	S				
20											MB									
										75	J/B	Vn	Fe	Su	Pl	S				
						2					MB									
21										80	J/B	Vn	Fe	Pa/Sp	Pl	S				
	0823									MB										
	0836 0844					1				65	J/B	Vn	Fe	Su	Pl	S				
22										90	J/B	Vn	Fe	Su	Pl	S				
				10.2'/10.0' (102%)	9.75'/10.0' (98%)	2				80	J/B	Vn	Fe	Sp	Pl	S				
23						0	W2	R1-R2												
		2	1																	
24																			B3-24.2-24.9 Sampled	
						1				75	J/B	Vn	Fe	Su	Pl	S				
25																			SAMPLED →	

DISCONTINUITY TYPE
F - Fault
J - Joint (Discontinuity)
Fz - Fractrue Zone
S - Shear
Sz - Shear Zone
V - Vein
Fo - Foliation
B - Bedding Joint
MB - Mechanical Break
BZ - Broken Zone

APERATURE

Tight (T)	0
Very Narrow (Vn)	<0.05" (<1.3 mm)
Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)
Open (O)	0.1-0.5" (2.5 - 12.7 mm)
Wide (W)	>0.5" (>12.7 mm)

INFILLING TYPE
Bi - Biotite
Cl - Clay
Ca - Calcite
Ch - Chlorite
Ep - Epidote
Fe - Iron Oxide
Gy - Gypsum
H - Healed
Mn - Manganese
My - Mylonite
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand
Si - Silt
Un - Unknown

INFILLING AMOUNT
Clean (No)
Stained (Su)
Spotty (Sp)
Partial Filled (Pa)
Filled (Fi)
Cemented (Cm)

SHAPE
Wa - Wavy
Pl - Planer
St - Stepped
Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
Slightly rough (Sr)	Asperities are distinguishable and can be felt
Rough (R)	Asperities are clearly visible, some ridges evident, suface feels abrasive
Very rough (Vr)	Near-vertical ridges occur on surface

DISCONTINUITY SPACING

Extremely Wide (EW)	>6 ft
Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
Close (C)	2.4 in - 8 in
Very Close (VC)	0.75 in - 2.4 in
Extremely Close (Ex)	<0.75 in

WEATHERING
Fresh (W1)
Slightly (W2)
Moderately (W3)
Highly (W4)
Decomposed or Completely (W5)
Residual Soil (W6)

STRENGTH
R0 Extremely weak
R1 Very weak
R2 Weak
R3 Moderately strong
R4 Strong
R5 Very Strong
R6 Extremely strong

MWH

Project: GE / UNC
Project Location:
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B3
Sheet 4 of 6

Drilling Company: SEE INFO ON
Driller: FIRST PAGE
Drilling Method: OF LOG
Drilling Rig:
Drill Bit Type/Size:

Inclination:
Azimuth:
Northing:
Easting:
Elevation:

Groundwater Level & Date Measured
Water Level:
Date:
Time:
Casing Depth

Start Date:
Finish Date:
Total Depth:
Logged By:
Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven/Recovered	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Lithology / Symbol	Material Description	Fracture Drawing	Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
25			1							SANDSTONE CONTINUED												B3-24.9-25.6 Sampled	
						2							80	J/B	VN	No	No	Pl	S				
													75	J/B	VN	Fe	Pa	Pl	S				
26													MB										
						0																	
27		2		(102%)	(98%)																		
						0																	
28			2	10.20/10.00'	9.75/10.00'	1	W2	R1-R2															
													85	J/B	VN	Org. clay	Pa	Pl	S			B3-28.8-29.5 Sampled	
29						0																	
30						1																	
31													70	J/B	VN	No	No	Pl					
	08:44 09:05 09:33					0																	
32										Bedding ~90-80°			MB										
				(97%)	(79%)	1							80	J/B	VN	No	No	Pl	S				
33							W2	R1-R2					70	J/B	VN	Fe	Sp	Pl	S				
		3	2	9.70/10.00'	7.90/10.00'	4							20-25	J	W	Cl, Fe Mn	F.	Pl	S				
34										COAL, Black (N 2.5/0), Lignitic to bitumous			85	C	N	Fe						contact w/coal	
						1	W3	R1-R0		ORGANIC CLAY ← fine gravel and coarse sand bedrock clasts, angular													
35																							

DISCONTINUITY TYPE
F - Fault
J - Joint (Discontinuity)
Fz - Fractrue Zone
S - Shear
Sz - Shear Zone
V - Vein
Fo - Foliation
B - Bedding Joint
MB - Mechanical Break
BZ - Broken Zone

APERATURE

Tight (T)	0
Very Narrow (Vn)	<0.05" (<1.3 mm)
Narrow (N)	0.05-0.1" (1.3 - 2.5 mm)
Open (O)	0.1-0.5" (2.5 - 12.7 mm)
Wide (W)	>0.5" (>12.7 mm)

INFILLING TYPE
Bi - Biotite
Cl - Clay
Ca - Calcite
Ch - Chlorite
Ep - Epidote
Fe - Iron Oxide
Gy - Gypsum
H - Healed
Mn - Manganese
My - Mylonite
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand
Si - Silt
Un - Unknown

INFILLING AMOUNT
Clean (No)
Stained (Su)
Spotty (Sp)
Partial Filled (Pa)
Filled (Fi)
Cemented (Cm)

SHAPE
Wa - Wavy
Pl - Planer
St - Stepped
Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
Smooth (S)	Surface appears and feels smooth
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DISCONTINUITY SPACING

Extremely Wide (EW)	> 6 ft
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Moderate (M)	8 in - 2 ft
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Very Close (VC)	0.75-in - 2.4 in
Extremely Close (Ex)	< 0.75 in

WEATHERING
Fresh (W1)
Slightly (W2)
Moderately (W3)
Highly (W4)
Decomposed or Completely (W5)
Residual Soil (W6)

STRENGTH
R0 Extremely weak
R1 Very weak
R2 Weak
R3 Moderately strong
R4 Strong
R5 Very Strong
R6 Extremely strong

MWH

Project: GE/UNC NECK JETTY
Project Location:
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B3
Sheet 5 of 6 :

Drilling Company: SEE INFO ON
Driller: FIRST PAGE
Drilling Method: OF LOG
Drilling Rig:
Drill Bit Type/Size:

Inclination:
Azimuth:
Northing:
Easting:
Elevation:

Groundwater Level & Date Measured
Water Level:
Date:
Time:
Casing Depth

Start Date:
Finish Date:
Total Depth:
Logged By:
Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven/Recovered	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Lithology / Symbol	Material Description	Fracture Drawing	Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
35			2							ORGANIC CLAY, cont. greenish black (10Y 2.5-1) to dark greenish gray (10Y 4/1) very soft to soft, weathered													
						1							90	T/B	Vn	Cl, Fe	Pa	Pl	Vr				
									o°	← fine gravel													
36										grades to CLAYSTONE/SILTSTONE very dark gray (10Y 3/1), to light brownish gray (10Y 6/2) very fine grained, slightly to moderately weathered with iron oxidation along bedding and fractures.													
						1							80	J/B	Vn	Fe	Fi	Pl	R				
37				(97%)	(79%)																		
						0																	
38													85	J/B	Vn	Cl	Pa	Pl	Sr				
		3	3	9.70/10.00	7.90/10.00	1	W2-W3	R1															
39																							
						0																	
40											40												
						3							90	J		Fe	Pa	Pl	Sr				
													5	J		Fe	Fi	Wa	S				
													80	J		Fe	Sp	Pl	Sr				
41													50	J		Gy, Fe	Sp	Cu	S				
	0933																						
	0948 1019					4							MB										
													85	J/B	Vn	Fe	Sp	Pl	S				
													45	J	N	Gy	Sp	Pl	S				
													85	J/B	Vn	Fe	Su	Pl	S				
42				(102%)	(85%)					← fine gravels of siltstone bedrock													
						>10		R0-R1						BZ									
									°o°	← fine gravels of siltstone bedrock.													
43			3	10.20/10.00'	8.45/10.00'		W2-W3						55	J	Vn	Fe	Pa	Pl	S				
													90	J	Vn	Fe	Sp	Pl	S				
		4				4		R1					85	J/B	Vn	Fe	Pa	Pl	Sr				
													85	J/B	Vn	Fe	Pa	Pl	Sr				
44													80	J/B	Vn	Fe	Su	Pl	S				
						3							80	J/B	Vn	Fe	Sp	Pl	R				
			4										75	J	Vn	Fe	Fi	Pl	S				
45																							

DISCONTINUITY TYPE
F - Fault
J - Joint (Discontinuity)
Fz - Fractrue Zone
S - Shear
Sz - Shear Zone
V - Vein
Fo - Foliation
B - Bedding Joint
MB - Mechanical Break
BZ - Broken Zone

APERATURE

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Wide (W)	>0.5" (>12.7 mm)

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Bi - Biotite
Cl - Clay
Ca - Calcite
Ch - Chlorite
Ep - Epidote
Fe - Iron Oxide
Gy - Gypsum
H - Healed
Mn - Manganese
My - Mylonite
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand
Si - Silt
Un - Unknown

INFILLING AMOUNT
Clean (No)
Stained (Su)
Spotty (Sp)
Partial Filled (Pa)
Filled (Fi)
Cemented (Cm)

SHAPE
Wa - Wavy
Pl - Planer
St - Stepped
Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
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Wide (W)	2 ft - 6 ft
Moderate (M)	8 in - 2 ft
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Extremely Close (Ex)	< 0.75 in

WEATHERING
Fresh (W1)
Slightly (W2)
Moderately (W3)
Highly (W4)
Decomposed or Completely (W5)
Residual Soil (W6)

STRENGTH
R0 Extremely weak
R1 Very weak
R2 Weak
R3 Moderately strong
R4 Strong
R5 Very Strong
R6 Extremely strong

MWH

Project: GE/UNC
Project Location:
Project Number:

ROCK CORE LOGGING FORM

BOREHOLE No.: B3
Sheet 6 of 6

Drilling Company: SEE INFO
Driller: ON FIRST PAGE
Drilling Method: OF LOG
Drilling Rig:
Drill Bit Type/Size:

Inclination:
Azimuth:
Northing:
Easting:
Elevation:

Groundwater Level & Date Measured

Water Level:					
Date:					
Time:					
Casing Depth					

Start Date:
Finish Date:
Total Depth:
Logged By:
Checked By:

Depth / Elevation	Drill Time, 24-hr (Rate, ft/hr)	Run No.	Box No.	Recovery Driven/Recovered	RQD Total > 4-in./Driven	Fractures / foot	Weathering	Strength	Lithology / Symbol	Material Description	DISCONTINUITY DATA Fracture Drawing	Number	Dip / Core Axis	Type of Disc.	Width	Type of Infilling	Amount of Infilling	Surface Shape	Roughness	Spacing	Permeability	Remarks	Well Details
45										CLAYSTONE CONTINUED													
						1							90	J/B	Vn	Fe	Pa	Pl	S				
46																							
										grades to black coal @ 46.1'			95	J/B	Vn	Fe	Sp	Pl	Sr				
													15	J	Vn	Fe, An	Sp	Pl	S				
													80	J/B	Vn	Fe, Gy	Su	Pl	S				
						6							80	J/B	Vn	Fe, Gy	Su	Pl	S				
47				(102%)	(85%)		W2-W3	R1-R2					85	J	Vn	Fe, Gy	Sp	St	S				
						6							85	J	Vn	Fe	Su	St	S				
48		5	4										85	J	Vn	Fe	Sp	Pl	S				
				10.20/10.00	8.45/10.00	1							90	J	Vn	Fe	Fi	Pl	S				
49							W2-W3	R1-R2		SILTSTONE, to SANDSTONE very dark gray (10YR 3/1) with abundant black (N 2.5/0) coal stringers. very fine to fine-grained, slightly to moderately weathered, moderately strong to weak													
						1							75	J	Vn	No	No	Pl	Sr				
50																						B3-49.9-50.6 Sampled	
						1							80	J	Vn	No	No	Pl	Sr				
51																							
	1019									51.4'													
										TOTAL DEPTH 51.4 feet below ground surface.													
52																							
53																							
54																							
55																							

DISCONTINUITY TYPE
F - Fault
J - Joint (Discontinuity)
Fz - Fractrue Zone
S - Shear
Sz - Shear Zone
V - Vein
Fo - Foliation
B - Bedding Joint
MB - Mechanical Break
BZ - Broken Zone

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Cl - Clay
Ca - Calcite
Ch - Chlorite
Ep - Epidote
Fe - Iron Oxide
Gy - Gypsum
H - Healed
Mn - Manganese
My - Mylonite
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand
Si - Silt
Un - Unknown

An - Anhydrite

INFILLING AMOUNT
Clean (No)
Stained (Su)
Spotty (Sp)
Partial Filled (Pa)
Filled (Fi)
Cemented (Cm)

SHAPE
Wa - Wavy
Pl - Planer
St - Stepped
Ir - Irregular

ROUGHNESS

Slickensided (Slk)	Visual evidence of polishing, striations
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DISCONTINUITY SPACING

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Moderate (M)	8 in - 2 ft
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WEATHERING
Fresh (W1)
Slightly (W2)
Moderately (W3)
Highly (W4)
Decomposed or Completely (W5)
Residual Soil (W6)

STRENGTH
R0 Extremely weak
R1 Very weak
R2 Weak
R3 Moderately strong
R4 Strong
R5 Very Strong
R6 Extremely strong

MWH

Client: GE/UNC

Project Number: NECR Jetty

Hollowstem

SOIL BORING LOG FORM

BOREHOLE No.: B4

Sheet 1 of 7

Drilling Company: National

Drillers (day / night): M. Cain

Field Representitive (day / night): S. Downey / J. VanPelt

Drilling Rig: CME-85

Drilling Method: Continuous Core

Core Diameter:

Bit Type: Auger 6 in ID HSA

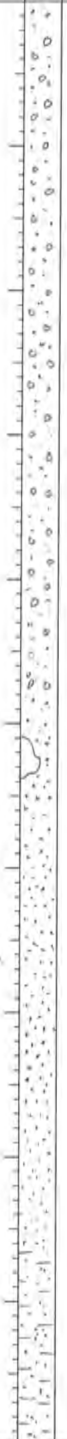
Logged by: S. Downey / J. VanPelt

Start Date: Nov 10 2016

Finish Date: Nov 11 2016

Total Depth: 65 ft

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
0					SP	Poorly graded sand with gravel (SP) brown (7.5YR 5/3), medium dense, dry, coarse gravel (5%), fine gravel (20%), predominantly fine sand (60%) trace medium sand (10%) trace silt (5%)		Start @ 1429 hand auger to 2 ft bgs	
1								12S 0728763, 3947644 Location surveyed using handheld GPS (UTM NAD83)	
2									
3									
4									
5	2" ID MOD CAL	10	6			← cobble ← — — — grades to poorly graded sand (SP),			
	B4- 5.5-6.0 10-NOV-2016 (550)	24	6		SP	reddish yellow (7.5YR 7/6), very stiff, dry, predominantly fine sand, trace silt and clay, weakly to moderately cemented			
6		21	6			at 6' moderately cemented at 6.5' increasing fine gravel, weakly cemented			
7									
8						← cobble 8-8.5' decreasing fine gravel			
					SP-SC	fine sand with clay and silt (SP-SC) very pale brown (10YR 7/4), med dense			
9									
10									



4
5
5

COARSE-GRAINED SOILS <50% passed #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passed #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE / UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B4

Sheet 2 of 7

Drilling Company: SEE INFO ON PAGE 1

Drillers (day / night):

Field Representitive (day / night):

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

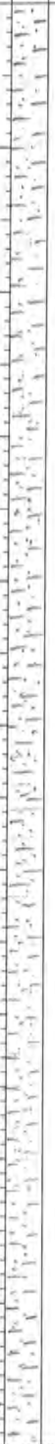
Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
10		4	6		SP-SC	trace caliche fine gravels			
		5	6						
11		5	6			increase in cementation to weakly to moderately cemented			
12									
13									
						increase in cementation to moderately cemented			
14									
15	MOD. CAL 2" ID	4	6		SP-SM	increase in fine sands, very fine grained poorly graded sand with silt, trace clay (SP-SM)			
		5	6						
16	B6 16.0-16.5 10-NOV-2016 (SSO)	6	6						
					SP-SC	@16.5 increase in clay, very fine SAND with clay and silt (SP-SC), non cemented, weakly indurated			
17									
18						18.3 – 19.4 weakly cemented			
19						19.4 dark yellowish brown (10YR 4/4), weakly to moderately cemented increase in very fine sands, still significant clay			
20									



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			Organic silts and clays of low plasticity	OL
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	soft	2-4	2-4	2-4
	medium stiff	4-8	4-8	4-8
	stiff	8-15	9-17	9-18
	very stiff	15-30	17-39	18-42
	hard	30-60	39-78	42-85
	very hard	>60	>78	>85

DENSITY (Sands and Gravels)	Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
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	loose	4-10	5-12	7-18
	medium dense	10-30	12-37	18-51
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* = 140 pound hammer dropped 30 inches

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	Coarse gravel	19 to 75	3/4 to 3
	Fine gravel	4.75 to 19	3/16 to 3/4
	Coarse sand	2.0 to 4.75	1/16 to 3/16
	Medium sand	0.425 to 2.0	1/64 to 1/16
	Fine sand	0.075 to 0.425	0.003 to 1/64
	Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS: Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY: Nonplastic, Low, Medium, High

MOISTURE	Term	Field Test
	Dry	Absence of moisture, dry to touch
	Moist	Damp, does not wet palm
	Wet	Visible Free Water

CEMENTATION	Term	Field Test
	Weak	Crumbles or breaks with handling or slight finger pressure.
	Moderate	Crumbles or breaks with considerable finger pressure.
	Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

5

MWH

Client: GE / UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B4

Sheet 3 of 7

Drilling Company: SEE INFO ON PAGE 1

Drillers (day / night):

Field Representitive (day / night):

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
20	2" ID MOD CAL	5	6		SP	poorly graded very fine sand (SP)			
	B4 20.5-21.0 10-NOV-2016 (SSD)	4	6						
21		6	6		ML	grades to clayey SILT with sand (ML) very fine sand very thinly bedded, breaks along thin bedding planes, weak to moderately cemented			
22									
23						moderately indurated, trace caliche ↓			
24									
25						increase in caliche throughout ↓			
26					SM	26.2-26.8 silty sand (SM) yellowish brown (10YR 5/6)			
27					SM	dark yellowish brown (10YR 4/4) clayey silt with sand (SM) traces of caliche, breaks along thin bedding planes, dry to moist			
28									
29									
30									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC Project Number:		**SOIL BORING LOG FORM**	BOREHOLE No.: B4 Sheet 4 of 7
Drilling Company: SEE INFO ON	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): PAGE 1	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
30	2" ID MOD CAL	5	6		SM	slight increase in caliche (~5%)			
	B4 30.5-31.0 10-NOV-2016 (SSO)	8	6						
31		7	6			decrease in caliche, trace amounts			
						trace amounts of coal/organic material present, dry to moist			
32									
33									
34									
35					ML	silt with sand (ML), very fine sands, weakly cemented, dry to moist, yellowish brown (10YR 5/4),			
36									
37									
38									
39					SP-SM	increase in sand content Poorly graded sand with silt (SP-SM), yellowish brown (10YR 5/6)			
40									

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handing or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE / UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B4

Sheet 5 of 7

Drilling Company: SEE INFORMATION ON
Drillers (day / night): PAGE ONE OF LOG
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
40	1" ID MODULE	4	6		CL	increasing clay content 40-40.5' Silty CLAY (CL), dark grayish brown (10YR 4/2) dry to moist, slightly indurated.			
	B4 40.5 - 41.5 10-Nov-2016 (SSO)	5	6						
41		6	6		SP-SM	Poorly-graded SAND with silt (SP-SM), yellowish brown (10YR 5/4), dry to moist, some clay			
42						grades to weakly to moderately cemented			
43						coarse gravel			
44									
45	B4-45.0-49.0 (CS) 10-Nov-2016				CL	Lean CLAY (CL), brown (10YR 4/3), dry to moist, sand (5-10%), silt (15%), medium plasticity			
46									
47									
48									
49					SP-SM	Poorly-graded SAND with silt (SP-SM), brown (10YR 4/3), dry to moist, trace fine gravel, clay (5-10%) weakly to moderately cemented, trace caliche.			
50									

COARSE-GRAINED SOILS >50% retained #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B4

Sheet 6 of 7

Drilling Company: SEE INFO ON
Drillers (day / night): PAGE 1
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	qu (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
50	2" ID MOD CAL	3	6		SP-SM	increase in caliche, slight iron oxide staining, slight increase in clay content (10-15%), predominantly fine-grained sand w/ silt, brown (10YR 5/3), dry to moist, very loose		end of day 11/10/16 @ 1630, end at 51.5' 11/11/16 - begin drilling at 51.5 feet @ 08:05	
	B4 50.5-51.0 10-Nov-2016 (SSO)	6	6						
51		7	6						
52	B4-51.5-52.5 11-Nov-2016 (GS)				CL	grades to lean clay with sand (CL), predominantly very fine sand (15%) trace medium sand (<5%), silt (20%), low plasticity, weakly cemented, brown (10YR 4/3)			
53						lean clay with sand (CL) yellowish brown (10YR 5/4), very fine sand (10%), silt (20%), low to medium plasticity, medium stiff			
54				0.75		or coarse gravel As Above, brown (10YR 4/3), trace organic content, trace coarse sand			
55	B4-TW-55.0-57.2 11-Nov-2016								
56									
57				3.0	SC	57-58' increase in sand content clayey sand (SC), brown (10YR 4/3), trace fine gravel/coarse sand, fine-grained sand (60%), silt (20%), clay (15%), no to low plasticity			
58					CL	58.0-58.8 lean clay with sand (CL) yellowish brown (10YR 5/4), very fine-grained sand, low to medium plasticity, trace fine gravel			
59					CL	58.8' grades to sandy lean clay (CL), increase in sand content, trace fine to coarse gravel			
					SC	59.2 grades to clayey sand (SC), brown (10YR 4/3) iron oxidation grades to very pale brown (10YR 8/2), weathered bedrock			
60									

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)
▼ Depth to water after drilling (time and date)

MWH

Client: GE / UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B4

Sheet 7 of 7

Drilling Company: SEE INFO ON
Drillers (day / night): PAGE 1
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
60	[illegible] M.C.	50	3		SS	sandstone pale yellow (2.5Y 8/4), poorly graded silty sand (SM), predominantly fine grained sand, >15% fines, highly weathered (W4) to moderately weathered (W3), very weak (R1) to weak (R2), soft to moderately soft (H6-H5) laminated to very thinly bedded with iron oxidation, weakly cemented			
61									
62									
63									
64					SS	63.7 grades to slightly to moderately weathered (W2-W3), weak to moderately strong (R2-R3), moderately soft to moderately hard (H5-H4), moderately to strongly cemented, spotty iron oxidation (~10%)		complete borehole @ 0900 11/11/10	
65						TOTAL DEPTH = 65.0 feet below ground surface 11-NOV-2010 Boring backfilled with cuttings to surface 11-NOV-2010			

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:	SOIL BORING LOG FORM	BOREHOLE No.: B5 Sheet 1 of 13

Drilling Company: National	Drilling Rig: CME 85	Bit Type:	Start Date: 11/13/16
Drillers (day / night): M Cain	Drilling Method: CC	Logged by: S. Downey/J. Van Pelt	Finish Date:
Field Representitive (day / night): S. Downey/J. VanPelt	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
0					SM	silty SAND (SM), yellowish brown (10YR 6/2), loose, dry, coarse sand to fine gravel (10%), predominantly fine grained sand		Hand auger to 3 ft Start at 0820 start drilling at 0840 12S 0725797, 3947622 Location surveyed w/ hand held GPS (UTM NAD 83)	
1									
2									
3									
					SM	grades to dark yellowish brown (10YR 4/4), clay (20%), low to moderate plasticity			
4									
5	2" ID Mod CAL	18	6			grades to yellowish brown (10YR 5/4), very stiff to hard, trace sandstone lenses and Fe oxide staining, trace organics			
	B5-5.5-6.0 (SSO) 13-Nov-2016	34	6						
6		50/5.5"	6		SP	Poorly graded SAND (SP), very pale brown (10YR 8/3), loose, dry, predominantly fine sand, trace fine gravel, trace organics			
7									
8					SM	same as 3.5-5', slightly indurated, dry to moist			
9						grades to yellowish brown (10YR 5/4), slightly to moderately indurated very thinly bedded with caliche and iron staining, moderately cemented, hard, clay,			
	B5-9.7-10.0 (GS) 13-Nov-2016								
10									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B5
Sheet 2 of 13

Drilling Company: See info on first
Drillers (day / night): Page of Log
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
10	2.0" MOD CAL	10	6		SM	Same as above, very pale brown (10YR 7/4)			
	BS-10.5-11.0 (SSO) 13-Nov-2016	9	6						
11		8	6			grades to yellowish brown (10YR 5/4), low plasticity, clay (5-10%)			
					ML	SILT (ML), light yellowish brown (10YR 6/4), soft, dry, trace sand (5%), clay (20-30%), low to moderate plasticity			
12									
					☒	NR			
13						trace clay, weakly cemented			
					SM	sandy SILT (SM), brown (10YR 5/3), medium stiff, very dry, predominantly fine sand, trace clay, non plastic			
14	BS-13.7-15.0 (GS) 13-Nov-2016								
15	2" ID MOD CAL	5	6		ML	SILT (ML), same as 11.5', trace caliche (5%), clay lense (10-50°) 1-1.5cm thick, moderate cementation			
	BS-15.5-16.0 (SSO) 13-Nov-2016	7	6						
16		10	6			grades to weakly cemented			
					☒	No Recovery			
17					ML	same as above 11.5', brownish yellow (10YR 6/6)			
18									
	BS-18.2-20.0 (GS) 13-Nov-2013				CL	CLAY (CL), yellowish brown (10YR 5/4), hard, very dry, medium plasticity, trace white material (caliche?), very thinly bedded, moderately indurated			
19									
20									

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded[1] gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded[1] gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded[1] gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded[1] gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded[1] sands, gravelly sands, little or no fines	SW
			Poorly-graded[1] sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded[1] sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded[1] sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

[1] Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)
▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:	**SOIL BORING LOG FORM**	BOREHOLE No.: B5 Sheet 3 of 13

Drilling Company: See info on first	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): Page of log	Drilling Method:	Logged by:	Finish Date:
Field Represenitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
20	MOD-CAL 2" ID	8	6	>4.5	CL	same as above			
		12	6						
21	B5-21.0-21.5 (GS) 13-Nov-2016	17	6						
						grades to brownish yellow (10YR 6/8), laminated, caliche stringers (<2%)			
22									
23	B5-21.5-25.0 (GS) 13-Nov-2016								
24									
25	B5-TW-25.0-27.0 (TW) 13-Nov-2016								
26						grades to yellowish brown (10YR 5/4), dry to moist			
27	B5-27.0-30.0 (GS) 13-Nov-2016				CL	same as above, dry to moist, no caliche stringers			
28									
29									
30									

COARSE-GRAINED SOILS >50% retained #200 sieve: GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded[1] gravels, gravel-sand mixtures, little or no fines	GW
		Poorly-graded[1] gravels, gravel-sand mixtures, little or no fines	GP
	GRAVELS with >15% fines	Silty gravels, poorly-graded[1] gravel-sand-silt mixtures	GM
		Clayey gravels, poorly-graded[1] gravel-sand-clay mixtures	GC
SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded[1] sands, gravelly sands, little or no fines	SW
		Poorly-graded[1] sands, gravelly sands, little or no fines	SP
	SANDS with >15% fines	Silty sands, poorly-graded[1] sand-gravel-silt mixtures	SM
		Clayey sands, poorly-graded[1] sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve: SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
		Organic silts and clays of low plasticity	OL
SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
		Inorganic clays of high plasticity, fat clays	CH
		Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS		Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

*Note: * = 140 pound hammer dropped 30 inches*

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

[1] Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)
▼ Depth to water after drilling (time and date)

MWH

Client: GE / ONC
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B5
Sheet 4 of 13

Drilling Company: See info on
Drillers (day / night): first page of log
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
30	MOD-CAL 2" ID	6	6	4.0, 3.75	CL	same as above			
		11	6						
31		14	6			grades to trace caliche (<5%), black organic matter (5-10%)			
32	B5-31.5-35.0 (GS) 13-Nov-2016								
33									
34									
35						same as above			
36									
37					ML	Clayey SILT (ML), yellowish brown (10YR 5/6) soft, dry to moist, trace fine-grained sand (<10%), medium plasticity, noncemented			
					SM	Silty SAND (SM), light yellowish brown (10YR 6/4) to yellowish brown (10YR 5/4), loose, dry to moist, pred fine-grained sand			
38					ML	Clayey SILT (ML), same as above (36.8')			
					SM	Silty SAND (SM), same as above (37.6'-38')			
39	B5-38.7-40.0 (GS) 13-Nov-2016								
40									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)
▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B5

Sheet 5 of 13

Drilling Company: See info on	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): first page of log.	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
40	2" ID MODCAL	5	6		CL	Silty CLAY (CL), light yellowish brown (10YR 6/4), soft to medium stiff, dry to moist, some fine-grained sand (10-15%), moderate plasticity			
	B5-40.5-41.0 (SGV) 13-Nov-2016	6	6						
41		10	6			same as above, grades to stiff, drier			
						No Recovery			
42									
43					CL	grades to yellowish brown (10YR 5/4), fine-grained sand (5%-10%)			
44					ML	Sandy SILT (ML), yellow (10YR 8/6), loose, dry to moist, fine-grained sand			
					CL	Silty CLAY (CL), same as above @ 40'			
45						small sandy silt lense at 45'			
					SM	Sandy SILT (SM), light yellowish brown (10YR 6/4), loose, dry to moist, clay (20%-30%) moderate plasticity			
46									
47					CL	Silty CLAY (CL), same as above @ 40'			
48					ML	Clayey SILT (ML) with sand, brownish yellow (10YR 6/6), soft, dry to moist, fine-grained sand, lenses of black organic matter			
49	B5-49.0-50.0 (GS) 13-Nov-2016				SM	Sandy SILT (SM), yellowish brown (10YR 5/6), same as above (45-47')			
50									

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:	**SOIL BORING LOG FORM**	BOREHOLE No.: B5 Sheet 6 of 13

Drilling Company: See info on	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): first Page of Log	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
50						No Recovery			
51									
52					CL	Silty CLAY (CL), same as 160' small lenses of black organic matter			
					SM	Silty SAND (SM) lense with clay (10-30%)			
53	B5-52.6-53.9 (GS) 13-Nov-2016				ML	Clayey SILT (ML) with sand, yellowish brown (10YR 5/4), same as 48.8', low to moderate plasticity			
54					SM	Silty SAND (SM), yellowish brown (10YR 5/6), loose, dry to moist, predominantly fine grained sand, clay (0-10%), non plastic			
55						No Recovery			
56									
57					SM	Silty SAND (SM), light yellowish brown (10YR 6/4), loose, dry to moist, fine-grained sand, little to no clay			
58					ML	Clayey SILT (ML) w/ sand, same as 52.6'			
59					ML	Sandy SILT (ML), yellowish brown (10YR 5/4), same as 57.1'			
60					SP	Poorly-graded SAND (SP), yellowish brown (10YR 5/6), loose,		dry to moist, fine gravel to coarse sand (10%)	

COARSE-GRAINED SOILS >50% passed #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines — GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines — GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures — GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures — GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines — SW
			Poorly-graded¹ sands, gravelly sands, little or no fines — SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures — SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures — SC
FINE-GRAINED SOILS >50% passed #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity — ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays — CL
			Organic silts and clays of low plasticity — OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt — MH
			Inorganic clays of high plasticity, fat clays — CH
			Organic silts and clays of medium to high plasticity — OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content — PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/DNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B5

Sheet 7 of 13

Drilling Company: See info on first
Drillers (day / night): Page of Log
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
60	2" ID MOD CAL	4	6		CL	CLAY(CL), brown (10YR 4/3), soft, moist, black organic matter (10-15%) grades to poorly graded SAND (SP), same as 59.9', no coarse sand or gravel			
	B5-60.5-61.0 (SSO) 13-Nov-2014	4	6						
61		12	6		ML SP	Clayey SILT(ML), same as 52.6' poorly-graded SAND (SP), as above, with some coarse sand and fine gravel (5-10%)			
						No recovery			
62					SP	Poorly graded SAND (SP), same as 59.9', no coarse sand or gravel			
					SM	Silty SAND (SM), same as 57.1		Interbedded silty sand and poorly graded sand lenses	
63	B5-63.0-63.6 (GS) 13-Nov-2014				SP	Poorly graded SAND (SP), same as above 62.2'			
64					SM SP	Silty SAND, see above Poorly graded SAND, see above			
65						No recovery			
66									
67					SP	Poorly graded SAND (SP), yellowish brown (10YR 5/6), loose, dry to moist, coarse and fine gravel (15%-20%) angular Fe staining			
					SM	Silty SAND (SM), see above			
68					SM	yellowish brown (10 YR 5/6), coarse sand and fine gravel (5-10%)			
69	B5-68.9-69.9 (GS) 13-Nov-2014				CL	Silty CLAY (CL) with sand, yellowish brown (10YR 5/4), soft, moist, fine-grained sand (10-20%) medium plasticity			
					ML	Clayey SILT (ML) with sand, dark yellowish brown (10YR 4/4), very stiff, dry to moist, fine-grained sand (10-20%)			
70									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
	HIGHLY ORGANIC SOILS		Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

Client: GE/UNC Project Number:		**SOIL BORING LOG FORM**	BOREHOLE No.: B5 Sheet 8 of 13

Drilling Company: See info on	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): first Page of	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): Log	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
70						No Recovery			
71									
72									
73					ML	same as above, black organic matter (20%)	▽		
74					CL SP-SM	~~CLAY~~ (CL) lense w/ silt and sand, mod to high plasticity Poorly graded SAND with silt and gravel (SP-SM), dark yellowish brown (10YR 4/4), loose, moist, coarse gravel (30%), coarse sand, fine grained sand cobble			
75	B5-75.0-77.6 (GS) 13-Nov-2016				CH	Fat CLAY (CH) dark yellowish brown (10YR 4/4), medium stiff to stiff, dry to moist, laminated with black organic matter and FE staining			
76									
77					SP-SM	poorly graded SAND with silt (SP-SM), dark yellowish brown (10YR 4/4), loose, moist, non plastic, fine-grained sands			
78					CH	CH, same as above			
					SP-SM	SP-SM, same as above, dark yellowish brown (10YR 4/4), moist to wet			
79					SC-CL	Clayey SAND (SC) to sandy clay (CL), dark yellowish brown (10YR 4/4), loose, soft, moist to wet, medium to high plasticity			
80									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

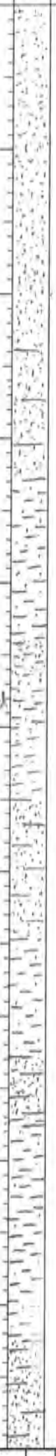
Client: GE / UNC
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B5
Sheet 9 of 13

Drilling Company: See info on first	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): Page of Log	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
80	MOD-CAL 2" 10	3	0		☒	No recovery			
		3	0		SP	Poorly graded SAND (SP), yellowish brown (10YR 5/4), loose, wet			
81		4	0						
82									
					SP-SM	Poorly graded SAND with silt (SP-SM), same as 77.6'			
83									
					CH	Fat CLAY with sand (CH), same as 75', trace black organic matter, Fe staining (10%)			
84									
					CL	Sandy CLAY (CL), yellowish brown (10YR 5/6), soft, moist, medium plasticity			
					CH	same as 83.3, very dark brown (10YR 2/2), laminated with yellowish brown (10YR 5/6) lenses			
85					☒	No recovery			
					SM	Silty SAND (SM), dark yellowish brown (10YR 4/4), loose, wet, predominantly fine sand			
86									
					CH	same as above 83.3'			
87									
					SM	Silty SAND (SM), same as above, trace clay			
					CH	Fat CLAY (CH), same @ 75', yellowish brown (10YR 5/6)			
88									
89									
					SM	Silty SAND, same as above			
90									



COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:	SOIL BORING LOG FORM	BOREHOLE No.: B5 Sheet 10 of 13

Drilling Company: See info on first	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): Page of Log	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
90						N. recovery			
91									
92					SM	Silty SAND (SM), yellowish brown (10YR 5/4), loose, wet, predominantly fine sand			
93	B5-93.1-95.0 (GS) 13-Nov-2016				SP	Poorly graded sand (SP), yellowish brown (10YR 5/4) loose, wet, trace organic lamination			
94									
95						No recovery			
96									
97									
98					CH	Fat CLAY with sand (CH), same as 83.3'		*driller notes heaving sands	
99					SM	Silty SAND (SM), same as above			
100									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:	SOIL BORING LOG FORM	BOREHOLE No.: B5 Sheet 11 of 13

Drilling Company: See info on first	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): Page of log	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night):	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
100	MOD-CAL 2" ID	7	0			No recovery			
		4	6		SM	Same as above			
101	B5-101.0-101.5 (SSO) 13-Nov-2016	8	6						
						No recovery			
102									
103									
					CL	Sandy CLAY (CL), brown (10YR 4/3) medium stiff, moist to wet, fine grained sand medium plasticity, laminated w/ black organic matter			
104									
					SM	Silty sand (SM), same as above, brown (10YR 4/3) wet			
					CL	Sandy CLAY (CL), same as above			
105						No recovery			
106									
107									
108									
					CL	Sandy CLAY (CL), same as above			
					SM	Silty SAND (SM), same as above			
109									
110									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays) Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels) Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

GRAIN SIZE Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS: Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE / UNUC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B5

Sheet 12 of 13

Drilling Company: See info on first

Drillers (day / night): Page of log

Field Representitive (day / night):

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
110					CL	Silty CLAY(CL), dark yellowish brown (10YR 4/4), moist, soft, medium to high plasticity, laminated w/ re oxidation and black organic matter (5-10%)			
111									
					CL	Sandy CLAY(CL), same as above			
112					CL	Silty CLAY(CL), same as above			
						Same as above, wet, trace fine-grained sand			
113									
						same as above, moist			
114									
					CL	Sandy CLAY (CL), same as above, moist			
115						No recovery			
116					CL	Silty CLAY(CL), moist to wet			
117									
118					ML	Sandy SILT(ML) to silty SAND(SM), yellowish brown (10YR 5/4), clay (10-15%)			
119									
120									

COARSE-GRAINED SOILS >50% retained on #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded² gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded² gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded² gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded² gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded² sands, gravelly sands, little or no fines	SW
			Poorly-graded² sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded² sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded² sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

** = 140 pound hammer dropped 30 inches*

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

²Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B5

Sheet 13 of 13

Drilling Company: See info on first

Drillers (day / night): Date of log

Field Representitive (day / night):

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth: 125

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
120	MOD-CAL 2" ID	3	3"		NR				
					SM	silty SAND (SM), brown (10YR 4/3)			
		6	6						
121		9	6			grades to brown (10YR 5/3), clay (10%)			
						No recovery			
122					SM	Silty SAND (SM)			
123						grades with increasing clay (5-10%)			
					CL	Silty CLAY (CL), as above			
					SM CL SM CL SM CL	INTERBEDDED CLAY (CL) and silty SAND (SM) as described above			
124									
125								TD 125' END AT 1620	

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note: Well-graded = poorly sorted; Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 1 of 13

Drilling Company: National EWP	Drilling Rig: CME-85	Bit Type: Auger	Start Date: 11/14/16
Drillers (day / night): M. Cain	Drilling Method: Cont Core	Logged by:	Finish Date: 11/15/16
Field Representitive (day / night): S. Downey/J. Van Pelt	Core Diameter: 3 in	S. Downey / J. Van Pelt	Total Depth: 126.5 ft

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
0					SP	Poorly graded SAND (SP)		Hand auger to ~3ft Start drilling @ 1300 12S 0725729, 3947569 Location surveyed w/ handheld GPS (UTM NAD83)	
1									
2									
3									
					SP-SM	Poorly graded SAND with silt and gravel (SP-SM), brown (7.5YR 4/3) loose, dry, coarse gravel (15%), fine gravel (15%), fine grained sand, trace clay			
4									
						grades to fine gravel (10-15%), clay (10-15%) moderately indurated, weak cementation			
5		42	4		ML	Clayey SILT (ML), brown (7.5YR 4/3), soft, dry, trace caliche, moderate to low plasticity			
		50/3	3		SP	Poorly graded SAND (SP), very pale brown (10YR 5/2), very loose, dry, predominantly fine-grained sand		hit boulder or large cobble	
6						No recovery			
7	B6-7.0-9.3 (GS) 14-Nov-2016				SM	Silty SAND (SM), yellowish brown (10YR 5/6), dense, dry, clay (5-10%) fine-grained sand, trace organics, caliche, and Fe staining, moderate to highly indurated			
8									
9					CL	Silty CLAY with sand (CL), brown (10YR 5/3) stiff, dry, fine-grained sand (10%), caliche (10%) fine to coarse gravel (10-20%), trace coarse sand, moderately indurated			
10									

COARSE-GRAINED SOILS >50% retained #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 2 of 13

Drilling Company: SEE INFORMATION ON

Drillers (day / night): FIRST PAGE OF

Field Representitive (day / night): LOG

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
10		9			CH	grades to Fat CLAY(CH), brown (10YR 4/3), very hard, dry, caliche stringers, some silt, highly plastic			
	B6-10.5-11.0 (SS0) 14-Nov-2016	12							
11		17				grades with increasing caliche (10%)			
						same as above			
12					CL	Silty CLAY(CL), yellowish brown (10YR 5/4), loose, dry, medium plasticity			
13	B6-12.8-13.5 (GS) 14-Nov-2016				SP	Poorly graded SAND (SP), pale brown (10YR 6/3), very loose, dry			
					CH	CH, same as above, brown (10YR 4/3), hard			
14	B6-13.5-15.0 (GS) 14-Nov-2016								
15		10			CH	CH, same as above, hard			
	B6-15.5-16.0 (SS0) 14-Nov-2016	12							
16		15				grades w/ decreasing caliche stringers (5%)			
						SAA, dry to slightly moist			
17									
18	B6-16.5-20.0 (GS) 14-Nov-2016								
19									
20									

COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >12% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	(SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	(SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

Blows/ft*

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH	Client: GE/UNC Project Number:	**SOIL BORING LOG FORM**	BOREHOLE No.: B6 Sheet 3 of 13

Drilling Company: SEE INFORMATION ON	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): LOG	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
20		14			CL	SAA, caliche stringers (10-15%)			
	B6-20.5-21.0 (SSO) 14-Nov-2016	20							
21		21				grades w/ decreasing caliche (5%)			
22									
23									
24				>4.5					
25						SAA			
26									
	B6-26.6-30.0 (GS) 14-Nov-2016					SAA, medium stiff to stiff, slightly moist			
27									
28									
29									
30									

			Description	Symbol
COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a *range* of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA: same as above

MWH

Client: GE/UNL
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6
Sheet 4 of 13

Drilling Company: SEE INFORMATION ON	Drilling Rig:	Bit Type:		Start Date:	
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:		Finish Date:	
Field Representitive (day / night): LOG	Core Diameter:			Total Depth:	

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
30	B6-TW-30.0-32.0 (TW) 14-Nov-2016			3.0					
31									
32					CL	SAA			
33									
34									
					SC	Clayey SAND (SC), dark yellowish brown (10YR 4/4), loose, soft, slightly moist to moist, low plasticity			
35						No recovery			
36									
37									
	B6-37.5-38.4 (GS) 14-Nov-2016				SP	Poorly graded SAND (SP), dark yellowish brown (10YR 4/4), very loose, slightly moist to moist			
38									
					CL	Lean CLAY (CL), dark yellowish brown (10YR 4/4), very soft, slightly moist to moist, medium plasticity, fine-grained sand (10%) SAA, laminated w/ black organic matter, trace Fe staining			
39									
					SP	SP, SAA			
				1.5	CH	CH, SAA			
40									

COARSE-GRAINED SOILS				
GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded gravels, gravel-sand mixtures, little or no fines	GW
		Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
	GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
		Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
		Poorly-graded sands, gravelly sands, little or no fines	SP
	SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
		Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS			
SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
		Organic silts and clays of low plasticity	OL
SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
		Inorganic clays of high plasticity, fat clays	CH
		Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS		Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY: Nonplastic, Low, Medium, High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = Same as above

MWH	Client: GE/UNC Project Number:	**SOIL BORING LOG FORM**	BOREHOLE No.: B6 Sheet 5 of 13

Drilling Company: SEE INFORMATION ON	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): LOG	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
40		5	6		CH	SAA			
					SC	grades to clayey SAND (SC), yellowish brown (10YR 5/4), loose, slightly moist, fine-grained sand			
	B6-40.5-41.0 (SSO) 14-Nov-2014	8	6						
41		10	6		CL	Sandy CLAY (CL), dark yellowish brown (10YR 4/4) soft, slightly moist			
						grades to CLAY		intermitent sand lenses, very thin	
					CL	Sandy CLAY (CL), brown (10YR 4/3), stiff to medium stiff, slightly moist, fine-grained sand (20%), medium plasticity			
42									
43	B6-42.3-43.8 (GS) 14-Nov-2014								
44					SP	Poorly graded SAND (SP), SAA, trace silt or clay			
					CL	Sandy CLAY (CL), SAA, soft			
45				1.0		No recovery			
46					CL	CLAY (CL), brown (10YR 4/3), stiff to very stiff, slightly moist to moist, moderate plasticity			
47	B6-47.0-48.9 (GS) 14-Nov-2014			1.5	CL	Silty CLAY (CL), yellowish brown (10YR 5/4), medium stiff, slightly moist to moist, moderate plasticity			
48									
49					SM	Silty SAND (SM), brown (10YR 4/3), loose, slightly moist to moist			
50									

COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly graded = well sorted

PLASTICITY: Nonplastic, Low, Medium, High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 6 of 13

Drilling Company: SEE INFORMATION ON	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): LOG	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	τ (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
50						No Recovery			
51									
52	B6-52.2-53.6 (GS) 14-Nov-2016				SP	Poorly-graded SAND (SP), light yellowish brown (10YR 6/4), very loose, dry			
53					CL-SC SP	Sandy CLAY (CL) to clayey SAND(SC) lense, very thinly bedded w/ black organic material Poorly graded SAND(SP), SAA			
54									
55					CL	Sandy CLAY(CL) to clayey SAND(SC), SAA, laminated No recovery			
56					SM	Silty SAND (SM), yellowish brown (10YR 5/4), loose, slightly moist to moist, fine-grained sand			
57	B6-57.2-59.4 (GS) 14-Nov-2016				CL-SC	Sandy CLAY(CL) to clayey SAND(SC), SAA, no bedding or lamination.			
58									
59					SP CL-SC	Poorly graded SAND (SP), 10YR 5/4, loose, dry to moist, trace fine gravel & coarse sand CL-SC, SAA (57.2')			
60									

COARSE-GRAINED SOILS >50% retained #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	Blows/ft* 2.0"ID	Blows/ft* (modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 7 of 13

Drilling Company: SEE INFORMATION ON
Drillers (day / night): FIRST PAGE OF
Field Representitive (day / night): LOG
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
60		7			SP-SM	Poorly graded SAND with silt (SP-SM), yellowish brown (10YR 5/4), loose, dry to moist,			
	B6-60.5-61.0 (SS0) 14-Nov-2016	14							
61		14			GW	Well graded GRAVEL with sand (GW), yellowish brown (10YR 5/4), loose, dry, fine to coarse gravel (50%), fine grained sand, coarse sand			
					SP-SM	grades to SP-SM, SAA			
62					SP-SM	Poorly graded sand with silt and gravel (SP-SM), dark yellowish brown (10YR 4/4), loose, dry to moist, coarse gravel (10-20%)			
63					SP	Poorly graded SAND (SP), brown (10YR 5/3), loose, dry to moist, fine-grained sand			
					SC	Sandy CLAY (SC), dark yellowish brown (10YR 4/4), soft, dry to moist			
					SP	Poorly graded SAND (SP) with gravel, yellowish brown (10YR 5/4), loose		dry to moist, fine gravel (15%)	
64					CL	CLAY (CL), trace black organic matter (5%)			
					SP-SM	Poorly graded SAND with silt (SP-SM), SAA (60)			
65						No recovery		water at 65 ft bgs	
66						cobble			
					GC	Clayey GRAVEL with sand (GC), dark yellowish brown (10YR 4/4), stiff, dense, moist, angular to sub-angular gravel, predominantly coarse gravel, fine grained sand, medium plasticity.		Cobble and gravels are likely sandstone well indurated	
67					CL	grades to Gravelly lean CLAY with sand (CL), fine gravel, trace coarse gravel, trace black organics, fine-grained sand, gravel is sub-angular to sub-rounded			
68					SP	Poorly graded sand (SP), yellowish brown (10YR 5/4), loose, moist, clay (5-10%), coarse sand to fine gravel (5-10%), possible weathered bedrock			
69									
70									

COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	0-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH

Client: GE/UNC

Project Number:

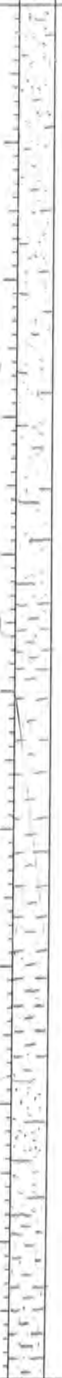
SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 8 of 13

Drilling Company: SEE INFORMATION ON
Drillers (day / night): FIRST PAGE OF
Field Representitive (day / night): LOG
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
70						No recovery			
71									
72	B6-72.0-73.6 (GS) 14-Nov-2016				SC	Clayey SAND (SC), dark yellowish brown (10YR 4/4), loose, moist to wet, trace fine gravel to coarse sand (sandstone clasts, weak induration),			
73									
					SM	Silty SAND (SM), yellowish brown (10YR 5/4), loose, moist to wet, fine-grained sand			
74									
					CL	grades to silty CLAY (CL), trace fine-grained sand, medium plasticity			
75						No recovery			
76									
77					CL	Silty CLAY (CL), SAA, dark yellowish brown (10YR 4/4), very thinly bedded to laminated, trace black organics, FE staining.			
78					SM	Silty SAND (SM), SAA, dark yellowish brown (10YR 4/4), wet			
79					CL	grades to silty CLAY (CL), SAA			
80									



COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 9 of 13

Drilling Company: SEE INFORMATION ON

Drillers (day / night): FIRST PAGE OF

Field Representitive (day / night): LOG

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
80		8			CL	grades to silty CLAY with sand (CL), SAA with fine-grained sand (10-20%), medium plasticity		end day 11/14/16 @ 1640; 81.5' bgs	
						grades to silty CLAY (CL), SAA			
	B6-80.5-81.0 (SSO) 14-Nov-2016	7							
81		9		1.5		grade to silty CLAY with sand (CL), SAA		Begin 11/15/16 @ 0820	
						grades to silty CLAY (CL), SAA			
					☒	No recovery			
82									
					ML	Sandy SILT (ML), brown (10YR 4/3), soft, wet, fine-grained sand (30%)			
					SM	Silty SAND (SM), SAA @ 73.6', wet			
83									
84					SM	grades to silty SAND (SM) with decreasing silt			
					CL	Silty CLAY (CL), SAA @ 74.9'			
85					SM	Silty sand (SM), SAA 83.8', very wet			
86									
87									
					SM	grades to silty SAND with clay (SM), SAA, clay (10-20%)			
88									
					CL	Silty CLAY (CL), SAA, laminated			
89									
90									

COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded: gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded: gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded: gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded: gravel-sand-clay mixtures	GC
	SANDS >50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded: sands, gravelly sands, little or no fines	SW
			Poorly-graded: sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded: sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded: sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well graded = poorly sorted
Poorly graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH

Client: GE/UNL

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 10 of 13

Drilling Company: SEE INFORMATION on	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): LOG	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
90						No recovery			
91					ML	clayey SILT (ML), brown (10YR 4/3), very soft, very wet, clay (20-30%), medium plasticity			
92					CL	Silty CLAY with sand (CL), SAA, increase in Fe oxidation and organic material, non laminated, fine-grained sand (10%)			
93									
94									
					CL	SAA, increasing sand (20-30%), organic content (10%), low plasticity			
95					SM	Silty SAND (SM), dark yellowish brown (10YR 4/4), very loose, wet, fine-grained sand, black organics (5-10%)			
96									
97									
98									
99									
					CL	Silty CLAY (CL), SAA @ 76.9', laminated to very thinly bedded, fine-grained sand (5-10%)			
100									

COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH	Client: GE/UNL Project Number:	**SOIL BORING LOG FORM**	BOREHOLE No.: B6 Sheet 11 of 13

Drilling Company: SEE INFORMATION ON	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): LOG	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
100		5			SP	Poorly graded SAND (SP), brown (10YR 4/3), very loose, wet, fine grained sand			
	B6-100.5-101.0 (SSO) 15-Nov-2016	10							
101		20			ML	Clayey SILT (ML) with sand, brown (10YR 4/3), low plasticity, soft			
					SM	grades to silty SAND (SM), trace organics & Fe			
	B6-101.5-105.0 (GS) 15-Nov-2016				SP-SM	grades to poorly graded SAND with silt (SP-SM), dark yellowish brown (10YR 4/4), very loose, very wet			
102									
103									
104									
105						No recovery		* driller notes heaving sands	
106									
107									
108						Poorly graded sand (SP), SAA, very wet			
109						grades to moist, black organic matter (10-20%)			
110									

COARSE-GRAINED SOILS	**GRAVELS** <50% coarse fraction passes #4 sieve	**GRAVELS** with little or no fines	Well-graded gravels, gravel sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	**SANDS** with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	**SILTS AND CLAYS** liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH	Client: GE/UNC Project Number:	**SOIL BORING LOG FORM**	BOREHOLE No.: BU Sheet 12 of 13

Drilling Company: SEE INFORMATION ON	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): LOG	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
110						No recovery			
111									
					CL	Silty CLAY (CL), SAA @ 769', laminated to very thinly bedded, silty lenses ~1cm thick			
112									
113					SP-SM	Poorly graded sand with silt (SP-SM), brown (10YR 4/3), loose, wet, trace clay			
					SP	Poorly graded sand (SP), brown (10YR 4/3), loose, wet, trace silt			
114									
115						No recovery			
116									
117									
					CL	CLAY (CL) with silt, dark grayish brown (10YR 4/2), soft, moist, trace sand, med plasticity			
					SM	Silty SAND (SM), brown (10YR 4/3), very loose, wet, fine-grained sand			
118					SM	Silty SAND with clay (SM), brown (10YR 4/4), medium dense, dry to moist, clay (10%), very thinly bedded to laminated w/black organic mat'l and Fe oxidation, nonplastic			
119									
120									

COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS ≥50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well graded = poorly sorted
Poorly graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA - same as above

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B6

Sheet 13 of 13

Drilling Company: SEE INFORMATION ON	Drilling Rig:	Bit Type:	Start Date:
Drillers (day / night): FIRST PAGE OF	Drilling Method:	Logged by:	Finish Date:
Field Representitive (day / night): LOG	Core Diameter:		Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
120.0						No recovery			
121									
122									
123					SM	Silty SAND (SM), brown (10YR 4/3), very loose, moist to wet, v. thinly bedded to laminated w/ organics and Fe			
					ML	Sandy SILT (ML), brown (10YR 4/3), very soft, wet, v. thinly bedded to laminated w/ black organic & Fe			
					SM	Silty SAND (SM), SAA			
124									
125		15			SP	Poorly graded SAND (SP), brown (10YR 4/3), loose, moist to wet, trace fine gravel			
		44			SW	grades to well graded SAND with gravel (SW), dark yellowish brown (10YR 4/4), loose, moist, fine to coarse gravel (40-50%)			
		50/2			GW	grades to well graded GRAVEL with sand (GW), SAA, increasing gravel, angular to sub-angular gravel pieces		TD @ 126.5 end at 1130	
						TOTAL DEPTH = 126.5 feet bgs			

COARSE-GRAINED SOILS	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded sands, gravelly sands, little or no fines	SW
			Poorly-graded sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

Note:
Well graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

SAA = same as above

MWH

Client: GEI UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7

Sheet 1 of 12

Drilling Company: National
Drillers (day / night): M. Cain
Field Representitive (day / night):

Drilling Rig: CME-85
Drilling Method: Continuous Core
Core Diameter: 3-INCH

Bit Type: HSA
Logged by: S. Downey / J. Van Pelt

Start Date: 11/11/16
Finish Date: 11/12/16
Total Depth: 115.0'

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
0						Clayey SAND		11/11/16 - start @ 1050 hand auger ~3 ft	
1								12 S 0725645, 3947534 Location surveyed using hand held GPS (UTM NAD 83)	
2									
3					SC	clayey sand (SC), light yellowish brown (10YR 6/4), loose, dry, predominantly fine-grained sand, moderately cemented, low to medium plasticity			
4									
5	B7-TW-5.0-6.5 (TW) 11-Nov-2016								
6									
	2" ID Modcal	19	6		ML	sandy silt (ML), brown (10YR 5/3), low plasticity, moderately cemented, thinly bedded to laminated, trace caliche, trace organic black material			
7	B7-7.0-7.5 (SSO) 11-Nov-2016	37	6						
		23	6		SM	Sandy SILT, pale brown (10YR 6/3), low to moderately cemented, clay (10%)			
8	B7-8.0-10.0 (GS) 11-Nov-2016				ML	Sandy SILT (ML), light yellowish brown (10YR 6/4), clay (20-30%), low plasticity, moderately cemented, trace fine gravel to coarse sand, angular, fine-grained sandstone			
9									
10									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:	**SOIL BORING LOG FORM**	BOREHOLE No.: B7 Sheet 2 of 12

Drilling Company: See info on	Drilling Rig:	Bit Type:		Start Date:	
Drillers (day / night): first page of	Drilling Method:	Logged by:		Finish Date:	
Field Representitive (day / night): log	Core Diameter:			Total Depth:	

17
31
24

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
10	2" ID MOD CAL	17	6			trace organic black material, laminated to very thinly bedded			
	B7-10.5-11.0 (SSO) 11-Nov-2016	31	6						
11		26	6		ML	Sandy SILT (ML), clay (5%), non plastic			
					CL	Sandy CLAY (CL), light yellowish brown (10YR 6/4), dry, medium plasticity, weakly cemented, loose, trace fine gravel (5%), angular			
12									
13									
14	B7-14.0-15.0 (GS) 11-Nov-2016					trace coarse sand, fine sand (30%), clay (25-30%), medium plasticity, weakly cemented			
15	MOD-CAL 2" ID	14	6		SC	trace caliche and black organic material, weak to moderately cemented, very pale brown (10YR 7/4) clayey sand (SC), fine-grained sands, clay (10%), low plasticity			
		16	6			grades to weakly cemented, non cemented			
16	B7-16.0-16.5 (SSO) 11-Nov-2016	11	6						
					CL	silty clay (CL) with trace sand (5%), light yellowish brown (10YR 6/4), dry, stiff, moderately to strongly cemented, medium plasticity, trace organic material (black), small roots present, clay (30-40%)			
17									
18	B7-18.0-20.0 (GS) 11-Nov-2016					grades to moderately cemented			
19									
20									

COARSE-GRAINED SOILS <50% passes #200 sieve				
GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded² gravels, gravel-sand mixtures, little or no fines	GW
		Poorly-graded² gravels, gravel-sand mixtures, little or no fines	GP
	GRAVELS with >15% fines	Silty gravels, poorly-graded² gravel-sand-silt mixtures	GM
		Clayey gravels, poorly-graded² gravel-sand-clay mixtures	GC
SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded² sands, gravelly sands, little or no fines	SW
		Poorly-graded² sands, gravelly sands, little or no fines	SP
	SANDS with >15% fines	Silty sands, poorly-graded² sand-gravel-silt mixtures	SM
		Clayey sands, poorly-graded² sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve: SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
		Organic silts and clays of low plasticity	OL
SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
		Inorganic clays of high plasticity, fat clays	CH
		Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS		Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

²Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GS/UNC
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7
Sheet 3 of 12

Drilling Company: See info on first
Drillers (day / night): Page of Log
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
20	Mod-Cal 2"ID	9	6		ML	Sandy silt (ML), very pale brown (10YR 7/4), fine-grained sand (10%), predominantly [illegible], very low plasticity, dry to moist, weakly cemented			
		17	6						
21	B7-21.0-21.5 (SSO) 11-Nov-2016	18	6			brownish yellow (10YR 6/6), dry to moist, weak to moderately cemented			
					CL	silty clay (CL), light yellowish brown (10YR 6/4), trace fine gravel, dry to moist, low plasticity			
22									
23					GC	coarse gravel, angular			
	B7-23.2-25.0 (GS) 11-Nov-2016				CL	23.2 - 25 sandy clay (CL), brown (10YR 5/3), very fine-grained sand (10%), high plasticity, dry to moist, moderately indurated, weakly cemented			
24									
25					CL	sandy clay (CL), dark yellowish brown (10YR 4/4) very fine-grained sand, medium plasticity, very thinly bedded			
26									
27									
	B7-27.5-29.2 (GS) 11-Nov-2016					sandy clay (CL), yellowish brown (10YR 5/4) and grayish brown (10 YR 5/2), strong color differentiation in some locations; roots (5%)			
28									
29						29.2 sandy clay (CL), yellowish brown (10YR 5/4), moderate to high plasticity			
30									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)
▼ Depth to water after drilling (time and date)

46 7

MWH

Client: GS / UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7

Sheet 4 of 12

Drilling Company: See info on first

Drillers (day / night): Page of log

Field Representitive (day / night):

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
30	2"ID MOD-CAL	5	6	4.5	CL	Lean clay (CL) with some silt, yellowish brown (10YR 5/4), trace caliche and black organic matter, medium to high plasticity, stiff, dry to moist			
	B7-30.5-31.0 (SSO) 11-NOV-2016	9	6	2.25					
31		13	6			grades to moist			
32						32' grades to brown (10YR 5/3)			
33	B7-32.7-35.0 (GS) 11-NOV-2016					grades to brown (10YR 4/3)			
34									
35	B7-35.0-37.0 (GS) 11-Nov-2016			3.0	CL	lean clay (CL), yellowish brown (10YR 5/4) moist			
36									
37					CL	Sandy clay (CL) with fine gravel (<5%), sandstone, medium sand, medium to high plasticity, dark yellowish brown (10YR 4/4), fine-grained sand			
38						high plasticity, very fine grained sand			
39									
40									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7
Sheet 5 of 12

Drilling Company: See info on
Drillers (day / night): first page of
Field Representitive (day / night): log
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
40	2" ID MOD CAL	4	6		CL	Sandy clay (CL), light yellowish brown (10YR 6/4), medium to fine-grained sand, medium plasticity			
	B7-40.5-41.0 (SS0) 11-Nov-2016	6	6	1.5					
41		7	6			Sandy CLAY, brown (10YR 5/3), very fine-grained sands, high plasticity, medium stiff, moist			
42									
43	B7-TW-42.5-43.5 (TW) 11-Nov-2016								
44						Sandy CLAY (CL) predominantly medium to fine-grained sand, fine and coarse gravel (5%), gravel is sandstone w/ iron oxidation spotted on surface at 44'-44.3' very thinly bedded, trace caliche and iron oxidation (5-10%)			
					SS	44.3-45' sandstone very thinly bedded to laminated, spotty to partially filled iron oxidation, medium to coarse-grained sand, very pale brown (10YR 8/2)			
45					CL	sandy clay (CL) with very fine-grained sand, brown (10YR 5/3), medium plasticity, trace fine gravel (sub-rounded to sub-angular)			
46									
47									
48						brown (10YR 5/3), trace caliche, no gravel, fine to medium grained sand			
					CL	trace coarse sand (sub-rounded) 48.6-49' increase in sand content sandy clay (CL), low to medium plasticity, fine to medium grained sand (10-20%), trace fine gravel (sub-angular)			
49						lean clay (CL), brown (10YR 5/3), very stiff, trace very fine-grained sand, medium to high plasticity			
50									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
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Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

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Some	30-45
Mostly	50-100

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
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CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
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▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7

Sheet 6 of 12

Drilling Company: See info on

Drillers (day / night): first page of

Field Representitive (day / night): log

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
50	2"ID MOD CAL	3	6	2.25		trace caliche and organic material			
	B7-50.5-51.0 (SSO) 11-Nov-2016	7	6	1.75					
51		11	6			yellowish brown (10YR 5/4)			
52	B7-51.5-55.0 (GS) 11-Nov-2016								
53									
54				2.25					
55	B7-TW-55.0-57.0 (TW) 11-Nov-2016								
56									
57					CL	Lean clay (CL) with sand / sandy clay, yellowish brown (10YR 5/4), medium sand (25%), coarse sand (5%)			
58						Sandy clay (CL), dark yellowish brown (10YR 4/4), loose, dry to moist, medium to fine-grained sand (30%)			
59						decrease in sand (~20%), brown (10YR 4/3), loose to stiff			
						decrease in sand, lean clay (CL) with very fine-grained sand, medium plasticity, stiff to very stiff			
60									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:		**SOIL BORING LOG FORM**	BOREHOLE No.: B7 Sheet 7 of 12	
Drilling Company: See info on	Drilling Rig:	Bit Type:		Start Date:	
Drillers (day / night): first page of	Drilling Method:	Logged by:		Finish Date:	
Field Representitive (day / night): log	Core Diameter:			Total Depth:	

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
60	2" ID 400 lbs	4	6		SP-SC	Poorly graded sand with clay (SP-SC), yellow (10YR 8/6), very loose to loose, dry to moist, predominantly medium sand with some clay (10%), low plasticity, no cementation			
	B7-60.5-61.0 (SSO) 11-Nov-2016	6	6						
61		6	6		CL	Sandy clay (CL), brown (10YR 5/3), soft to medium stiff, fine grained to medium grained sands, trace fine and coarse gravel organic black matter (5-10%), medium plasticity, mostly moist			
62						61.5 no gravel, stiff to very stiff			
63						moist, yellowish brown to dark yellowish brown (10YR 5/4 - 4/4) lean clay (CL), brown (10YR 4/3), soft, moist to wet, very-fine-grained sands (10%), trace black organic matter/coal			
64	B7-64.2-65.0 (GS) 11-Nov-2016				SM	yellowish brown (10YR 5/4), black organic matter (20-25%) Silty sand (SM), yellowish brown (10YR 5/4), soft, moist to wet, nonplastic			
65						no recovery			
66					SP-SM	poorly graded sand with silt (SP-SM), dark yellowish brown (10YR 4/4), very soft, non plastic		▼ 15:30	
67					CL	lean clay (CL) with sand, brown (10YR 4/3), soft to medium stiff, moderately plastic			
68									
69	B7-68.6-70.0 (GS) 11-Nov-2016				CH	Fat clay (CH) brownish yellow (10YR 6/6), very stiff, dry to moist, laminated to very thinly bedded with black organic matter striping, black organic matter (5-10%) Fe staining laminated to very thinly bedded, high plasticity			
70									

COARSE-GRAINED SOILS <50% passes #200 sieve				
GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
		Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
	GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
		Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
		Poorly-graded¹ sands, gravelly sands, little or no fines	SP
	SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
		Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve			
SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
		Organic silts and clays of low plasticity	OL
SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
		Inorganic clays of high plasticity, fat clays	CH
		Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS		Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
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Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7

Sheet 8 of 12

Drilling Company: See info on	Drilling Rig:	Bit Type:		Start Date:	
Drillers (day / night): first page of	Drilling Method:	Logged by:		Finish Date:	
Field Representitive (day / night): log	Core Diameter:			Total Depth:	

Depth	Sample Number	Blow Count	Recovery (in.)	qu (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
70	2" ID ModCal	7	6		CH	Fat CLAY, continued.			
	B7-70.5-71.0 (sso) 11-Nov-2016	7	6						
71		8	6	1.75				11/11/16 - end of day 1600 @ 71.5'	
					⊠	71.5 - 72.5' No recovery (NR)		11/12/16 begin at 0820	
72					CH	same as above, CH dark yellowish brown (10YR 4/4), moist to wet			
73					SM	silty sand (SM), moist to wet, predominantly fine grained sand, trace organic material, trace clay			
74					CH	sandy fat clay (CH), same as above, moist to wet, fine-grained sand (20-30%), medium plasticity, stiff			
						Fat clay (CH), same as above 68.6-71.5', brown (10YR 4/3), trace root material			
75				3.0	⊠	NR			
76					CH	Same as above (CH) 74.3'			
						sandy fat clay (CH), same as above (73.8')			
77						decrease in sand (10%), sandy fat clay, stiff			
	B7-77.2-78.4 (GS) 12-Nov-2016				SM	silty sand (SM), same as above, dark yellowish brown (10YR 4/4)			
78	B7-78.4-80.0 (GS) 12-Nov-2016				CH	Same as above, 77-77.2', sandy fat clay (CH)			
79									
80									

COARSE-GRAINED SOILS <50% passed #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
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FINE-GRAINED SOILS >50% passed #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
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DENSITY (Sands and Gravels)

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▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7

Sheet 9 of 12

Drilling Company: See info on

Drillers (day / night): first page of

Field Representitive (day / night): log

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
80	2" ID Mod Cal	7	6	1.25	CH	increase in iron oxidation staining, slight increase in sand (15-20%), yellowish brown (10YR 5/6), organics (10-20%),			
	B7-80.5-81.0 (SSO) 12-Nov-2014	11	6	2.5					
81		15	6		CH	same as 68.6-71.5', less interbedded organics and Fe			
						same as above?, dark grayish brown (10YR 4/2)			
82									
83	B7-81.5-84.9 (GS) 12-Nov-2014			2.5					
84									
					CH	interlayered, interbedded fat clay with sand (CH), very fine-grained sand (10%), see 77-77.7' interlayered with silty sand (SM), dry to moist, see 77.2' grades to gray (10YR 5/1)			
85									
86									
87									
88									
					SM	silty sand (SM), same as above 77', moist to wet, less silt than @ 77', more sand			
89	B7-88.4-90.0 (GS) 12-Nov-2014								
90									

COARSE-GRAINED SOILS >50% passed #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passed #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC
Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7
Sheet 10 of 12

Drilling Company: See info on	Drilling Rig:	Bit Type:	Start Date:		
Drillers (day / night): first page of	Drilling Method:	Logged by:	Finish Date:		
Field Representitive (day / night): log	Core Diameter:		Total Depth:		

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
90	2.0" Mod CAL	5	6		SM	wet to very wet grades to wet			
	B7-90.5-91.0 (SSO) 12-Nov-2016	10	6						
91		14	6			increase in clay (10%) and organics			
						same, brown (10YR 5/3), wet, trace clay, trace organics			
92	B7-91.5-95.0 (GS) 12-Nov-2016								
93									
94									
95						same as above			
96					SM	silty sand (SM), dark yellowish brown (10YR 4/4), trace organics, one small sand stone clast, slow to rapid dilatancy, moist, loose, predominantly fine-grained sand			
97									
98									
99						same as above, increase in organic material, black (10%)			
						/ very thin lamination (1.5cm) of black organic material, increased iron oxidation, dry to moist			
100									

COARSE-GRAINED SOILS >50% retained #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

SOIL BORING LOG FORM

BOREHOLE No.: B7

Sheet 11 of 12

Drilling Company: See info on

Drillers (day / night): first page of

Field Representitive (day / night): log

Drilling Rig:

Drilling Method:

Core Diameter:

Bit Type:

Logged by:

Start Date:

Finish Date:

Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
100	2" ID MODCAL	15	6		SP-SM	poorly graded sand with silt (SP-SM), trace medium to coarse sand, predominantly fine grained sand, dark yellowish brown (10YR 4/4), loose to med dense			
	B7-100.5-101.0 (SSO) 12-Nov-2016	19	6						
101		16	6		SM	increase in coarse sand and fine gravel grades to silty sand with clay (SM), increase in iron oxide staining, low plasticity, weakly cemented			
	B7-101.5-104.0 (GS) 12-Nov-2016				SP-SM	same as above SP-SM, increase in black organic material (10-20%), trace fine to coarse gravel, moist			
102									
103									
104					CH	FAT CLAY (CH), same as 48.0'			
					SS	SANDSTONE, very pale brown (10YR 8/2), fine-grained sand, highly to completely weathered (W4-W5) extremely weak (R0), very soft to soft (H7-H6), interbedded, very thinly to thinly laminated, inclined bedding (20-30°) with iron oxidation, yellowish brown (10YR 5/8)			
105					CL	Lean CLAY with sand (CL), light brownish gray, (10YR 6/2), soft, dry to moist, fine-grained sand, low plasticity, interbedded with iron staining (dark yellowish brown (10YR 4/6)			
106					SS	SANDSTONE, same as above 104.3', fine to medium grained sand, weak to very weak, soft, very thinly bedded to laminated with iron oxidation, yellow (10YR 7/8)			
107									
108					SS	SANDSTONE, same as 104.3', decrease in interbedding, some clasts size of coarse gravel			
109	B7-108.9-110.0 (GS) 12-Nov-2016				SS	SANDSTONE, yellow (2.5YR 7/6), same as 104.3', non laminated or bedded			
110									

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

** = 140 pound hammer dropped 30 inches*

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below:

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH	Client: GE/UNC Project Number:	SOIL BORING LOG FORM	BOREHOLE No.: B7 Sheet 12 of 12

Drilling Company: See info on first
Drillers (day / night): Page of log
Field Representitive (day / night):
Drilling Rig:
Drilling Method:
Core Diameter:
Bit Type:
Logged by:
Start Date:
Finish Date:
Total Depth:

Depth	Sample Number	Blow Count	Recovery (in.)	q_u (tsf)	Lithology / Symbol	Description	Graphic	Remarks	Well Details
110	MODCAL 2" ID	14	6		SS	SANDSTONE, light yellowish brown (10YR 6/4), same as 104.3'			
		50	4.5			increase in clay, light yellowish brown (2.5Y 6/4), course gravel (10%), clay (20-30%)		Bedrock 1140 AM 110.85'	
111						decrease in clay, moist			
					SS	SANDSTONE, olive yellow (2.5Y 6/6), fine-grained sand, highly weathered (W4), very weak (R1), soft (H6), laminated to very thinly bedded			
112									
113						SANDSTONE, very pale brown (10YR 7/3), coarse gravel, fine-grained sand, trace organics and Fe staining			
114						increase in clay, yellowish brown (10YR 5/4), some highly weathered sandstone clasts			
115						TOTAL DEPTH= 115.0 feet bgs.		TD 115 ft end at 1145 AM	

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages as below.

Term	%
Trace	<5
Few	5-10
Little	15-25
Some	30-45
Mostly	50-100

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
Nonplastic
Low
Medium
High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

CORE PHOTOS

1. **B1 – 0 ft bgs to 10.3 ft bgs**

2. **B1 – 10.3 ft bgs to 19.65 ft bgs**

3. B1 – 19.65 ft bgs to 30.4 ft bgs

4. B1 – 30.4 ft bgs to 32.1 ft bgs

5. B2 – 18.1 ft bgs to 28.3 ft bgs

6. B2 – 28.3 ft bgs to 37.5 ft bgs

7. B2 – 37.5 ft bgs to 47.4 ft bgs

8. B2 – 47.4 ft bgs to 52.1 ft bgs

9. B3 – 15.9 ft bgs to 25.7 ft bgs

10. B3 – 25.7 ft bgs to 35.2 ft bgs


NECR
UNC
JETTY
BORING B3
BOX No. 3
FROM 35.2 to 44.1 Feet
DATE DRILLED 10-Nov-2016

11. **B3 – 35.2 ft bgs to 44.1 ft bgs**


NECR
UNC
JETTY
BORING B3
BOX No. 4
FROM 44.1 to 51.3 Feet
DATE DRILLED 10-Nov-2016

12. **B3 – 44.1 ft bgs to 51.3 ft bgs**

TEST PIT LOGS

MWH

Client: GE / UNC - NECR UNC JETTY GEOTECH

Project Number:

TEST PIT LOG FORM

TEST PIT No.: TP1

Sheet 1 of 1

Location: UNNAMED ARROYO

Northing: 12 S 0725759

Easting: 3949521

Contractor: MWH / AMEC FW

Operator: J. VAN PELT / R. SPITZ

Dimensions: 1.0'

Depth: 2.0' 1.0'

Start Date: 12-Nov-2016

Finish Date: 12-Nov-2016

Total Depth: 2.0 feet

Logged by: J. Van Pelt

Face

Depth	Sample Number	Lithology Symbol	Description	Remarks	Graphic
0			CLAY with silt (CL), dark greenish brown, hard, dry, CLAY (60-70%) silt 25% medium to high plasticity	Shovel & Post-hole digger used to excavate & collect sample	
1	TP1	CL			
2			TD = 2.0' bgs		
3					

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

*= 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Sand/Gravel (Silt) Term	% fines
trace	<5
little	5-15
some	15-30
clayey / silty	>30

Silt/Clay Term	% coarse
trace	<5
little	5-15
some	15-30
sandy / gravelly	>30

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC NECR JETTY GEOTECH

Project Number:

TEST PIT LOG FORM

TEST PIT No.: TP2

Sheet 1 of 1

Location: UNNAMED ARROYO

Northing: 12 S 0725748

Easting: 3949499

Contractor: MWH/AMEC FW

Operator: J. VanPelt/B. SPITZ

Dimensions: 1.0'

Depth: 2.2' 1.0

Start Date: 12-Nov-2016

Finish Date: 12-Nov-2016

Total Depth: 2.2 feet

Logged by: J. VanPelt

Face

Depth	Sample Number	Lithology Symbol	Description	Remarks	Graphic
			Clayey SILT WITH Sand (ML) medium yellowish brown, dry, low plasticity Silt, Clay: 20%-25%, fine sand (	Excavated using shovel and posthole digger	
	TP2	ML	-increasing fine sand w/depth		
			TD=2.2' bgs		

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded¹ sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

* = 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Sand/Gravel (Silt) Term	% fines
trace	<5
little	5-15
some	15-30
clayey / silty	>30

Silt/Clay Term	% coarse
trace	<5
little	5-15
some	15-30
sandy / gravelly	>30

¹Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY

- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UNC

Project Number:

TEST PIT LOG FORM

TEST PIT No.: TP3

Sheet 1 of 1

Location: PILCO HILL

Northing: 12 S 0726668

Easting: 3947995

Contractor: MWH

Operator: J.VanPelt/S.DOWNEY

Dimensions: 1.0

Depth: 1.8' 1.0

Start Date: 14-NOV-2016

Finish Date: 14-NOV-2016

Total Depth: 1.8'

Logged by: J.VanPelt/S.DOWNEY

Face

Depth	Sample Number	Lithology Symbol	Description	Remarks	Graphic
		Qcl	Qcl	Excavated using Shovel and post-hole digger	
	T3	SP	Poorly-graded SAND with silt, brown (7.5YR 5/4), sl. moist, loose to medium dense fine to medium sand, (10%) coarse sand trace gravel, silt (10%) trace clay. at 0.9' becomes moist		
			TOTAL DEPTH = 1.8 feet BGS.		

COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded[1] gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded[1] gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded[1] gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded[1] gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded[1] sands, gravelly sands, little or no fines	SW
			Poorly-graded[1] sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded[1] sand-gravel-silt mixtures	SM
			Clayey sands, poorly-graded[1] sand-gravel-clay mixtures	SC
FINE-GRAINED SOILS >50% passes #200 sieve	SILTS AND CLAYS liquid limit <50		Inorganic silts/very-fine sands, silty or clayey fine sands, silts with slight plasticity	ML
			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL
			Organic silts and clays of low plasticity	OL
	SILTS AND CLAYS liquid limit >50		Inorganic silts, micaceous or diatomaceous fine sand or silt	MH
			Inorganic clays of high plasticity, fat clays	CH
			Organic silts and clays of medium to high plasticity	OH
HIGHLY ORGANIC SOILS			Peat, humus, swamp soils with high organic content	PT

CONSISTENCY (Silts and Clays)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very soft	0-2	0-2	0-2
soft	2-4	2-4	2-4
medium stiff	4-8	4-8	4-8
stiff	8-15	9-17	9-18
very stiff	15-30	17-39	18-42
hard	30-60	39-78	42-85
very hard	>60	>78	>85

DENSITY (Sands and Gravels)

Term	Blows/ft* (SPT) 1.4"ID	2.0"ID	(modCAL) 2.5"ID
very loose	0-4	0-5	0-7
loose	4-10	5-12	7-18
medium dense	10-30	12-37	18-51
dense	30-50	37-60	51-86
very dense	>50	>60	>86

*= 140 pound hammer dropped 30 inches

GRAIN SIZE

Term	Size (mm)	Size (inches)
Boulders	>300	>12
Cobbles	75 to 300	3 to 12
Coarse gravel	19 to 75	3/4 to 3
Fine gravel	4.75 to 19	3/16 to 3/4
Coarse sand	2.0 to 4.75	1/16 to 3/16
Medium sand	0.425 to 2.0	1/64 to 1/16
Fine sand	0.075 to 0.425	0.003 to 1/64
Silt / clay (fines)	<0.075	<0.003

SOIL TYPE MODIFIERS

Sand/Gravel (Silt) Term	% fines
trace	<5
little	5-15
some	15-30
clayey / silty	>30

Silt/Clay Term	% coarse
trace	<5
little	5-15
some	15-30
sandy / gravelly	>30

[1] Note:
Well-graded = poorly sorted
Poorly-graded = well sorted

PLASTICITY
- Nonplastic
- Low
- Medium
- High

MOISTURE

Term	Field Test
Dry	Absence of moisture, dry to touch
Moist	Damp, does not wet palm
Wet	Visible Free Water

CEMENTATION

Term	Field Test
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
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▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

MWH

Client: GE/UMC

Project Number:

TEST PIT LOG FORM

TEST PIT No.: TP4

Sheet 1 of 1

Location: TP4 Dilco Hill
Northing: 12S 0726672
Easting: 3947958 UTM NAD83
Contractor:
Operator:

Dimensions: 1 ft

Depth: 1.1 ft

1ft

Start Date: 14-Nov-2016
Finish Date: 14-Nov-2016
Total Depth: 1.1 ft
Logged by: S. Downey / J. Van Pelt

Face

Depth	Sample Number	Lithology Symbol	Description	Remarks	Graphic
0	TP4	Qcl CL	CLAY (CL) with sand and silt, light yellowish brown (10YR 6/4), dry, low to moderate plasticity, fine grained sand (10-15%), stiff to very stiff, caliche stringers from 0.3'-1.1' cobble (sandstone) TD = 1.1 ft bgs	Excavated using shovel and post-hole digger	
1					
2					

COARSE-GRAINED SOILS >50% passes #200 sieve	GRAVELS <50% coarse fraction passes #4 sieve	GRAVELS with little or no fines	Well-graded¹ gravels, gravel-sand mixtures, little or no fines	GW
			Poorly-graded¹ gravels, gravel-sand mixtures, little or no fines	GP
		GRAVELS with >15% fines	Silty gravels, poorly-graded¹ gravel-sand-silt mixtures	GM
			Clayey gravels, poorly-graded¹ gravel-sand-clay mixtures	GC
	SANDS <50% coarse fraction passes #4 sieve	SANDS with little or no fines	Well-graded¹ sands, gravelly sands, little or no fines	SW
			Poorly-graded¹ sands, gravelly sands, little or no fines	SP
		SANDS with >15% fines	Silty sands, poorly-graded¹ sand-gravel-silt mixtures	SM
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Nonplastic
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Medium
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MOISTURE

Term	Field Test
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CEMENTATION

Term	Field Test
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Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

▽ Depth to first water (time and date)

▼ Depth to water after drilling (time and date)

DAILY FIELD LOGS

MWH	Project: NERC JETTY GEOTECH INVESTIGATION	**DAILY FIELD ACTIVITY LOG**	Date: 8-Nov-2016 Project Number: 1050

Field Representitive: JENNIFER VAN PELT

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

ON SITE:

JEN VAN PELT	(MWH)
STEPHANIE DOWNEY	(MWH)
JANET BROOKS.	(EPA)
LANE Andrews	(AE)
GREGG SMITH	(NAVARRO)
BINOD CHAUDHURY	(NAVAJO MN)
MATT CAIN	(NATIONAL)
D. Martinez	(N'EWP)
A. Cortez	(N.EWP

Boring	Description / Work Unit	Quantity
B1	CORE (feet)	32.1
	Core Boxes (ea)	4

07:05 - ON site - drillers not on site - having to pick up new vehicle to replace their truck which blew the turbo.

07:15 Trip down to jetty area to recon boring locations 2 gas lines marked w/ newer plastic/fiberglass markers Conoco Phillips (CP) has maked 2 lines w/ yellow flagging between B2 & B3. There are also 2 lines marked w/ older steel bollards (orange/white?) may be abandond Spoke w/ driller to call CP Rep to be available for drilling. B1 will be accessable and w/in bedrock and we should be able locate to east of gas lines

* Walked upper Jetty area to look at stratigraphy & begun mapping Zone 2 coal seam pinches out - may be coal seam in Zone 1, Zone 3 may or may not be visible along jetty walk out

09:00 at mine office to look at old cores. drillers not on site yet.

09:40 drillers arrive on site, transfer equipment from broken truck began to setup for drilling.

10:30 site walk to boring locations w/ Rick and drillers confirm locations of boring B1 to B3 are away from gas lines (conoco phillips) Matt (National) called contact at CP to confirm lines sited all borings ≥ 15 feet from gas lines, and Moved B1 to Bedrock outcrop. All borings on other side of Jetty (East) look accessible

11:30 drillers continue setup, will begin at B1 fill water truck & mobe equip to site

13:30 Begin drilling on B1

16:45 complete drilling on B1 at 32.1 ft bgr.

[illegible] Drillers prep to mobe to next boring B2

15:30 leave site

Date: 8-Nov-2016

MWH

Project: GE/UNC NECR JETTY INVESTIGATION

DAILY FIELD ACTIVITY LOG

Date: 9-NOV-2016

Project Number:

Field Representitive: Jen VanPelt, S. Downey

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

ON SITE

J. VAN PELT	(MWH)
S. DOWNEY	(MWH)
J. BROOKES	(EPA)
L. ANDROSS	(EA)
M. CAIN	(NEWP)
D. MARTINEZ	(NEWP)
A. CORTEZ	(N.EWP)
R. SPITZ	(AMEC FW)

07:00 ON SITE, brief tailgate

07:15 DRILLER MOBE TO B2, finish logging B1

09:15 Began drilling B2

13:04 Complete drilling B2 at 52.1 feed bgs.
Mobe to B3

14:55 Began drilling B3

15:30 at bed rock driller switches to
coring

16:30 drillers ready to core - will start tomorrow

17:00 leave site

Boring	Description / Work Unit	Quantity
B2	soil	18.1
	core	34.0
	core boxes	4

Date:

MWH

Project: NECR UNR JETTY GEOTECHNICAL

DAILY FIELD ACTIVITY LOG

Date: 10-Nov-2016

Project Number:

Field Representitive: JEN VAN PELT, STEPHANIE DOWNEY

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

ON SITE

J. VANPELT	(MWH)
S. DOWNEY	(MWH)
J. BROOKES	(EPA)
L. AMBROST	(EA)
M. CAIN	(N.EWP)
DAN Martinez	(NEWP)
ART Cortez	(NEWP)
RICK SPITZ	(AMEC FW)
BINOD CHAUDHURY	(NAVAJO NTN. EPA)

SAMPLES

B4 - 5.5 - 6.0	(SSO) → 2" ID
B4 - 16.0 - 16.5	(SSO)
B4 - 20.5 - 21.0	(SSO)
B4 - 30.5 - 31.0	(SSO)
B4 - 40.5 - 41.0	(SSO)
B4 - 41.0 - 43.6	(GS)
B4 - 45.0 - 49.0	(GS)
B4 - 50.5 - 51.0	(SSO)

Boring	Description / Work Unit	Quantity
B3	CORE (ft)	
	Boxes (EA)	4
B4	SPT / MOD Cal Sampling	7
	Retained MOD BRASS Cal	6
B4	CONT. CORE CME/ HSA. DRILLING	50.0

BINOD CHAUDHURY (N.N. EPA)

07:00 MEET AT office, prep for day.
07:15 Mobe to site, setup for drilling
07:45 SAFETY MTG.
08:00 PREP FOR DRILLING / CORING B3 at 17.7' bgs
08:15 DRILLING B3 at 15.9' bgs
10:20 coring completed on B3.
drillers packing up gear to mobe machine and equipment to other side of jetty
complete logging on B3.
11:50 pack up gear. photography of core
13:00, break for lunch
13:15 begin mobe to B4
14:30 drilling B4
16:30 halt CME drilling for day. drillers winterize rig, continue securing core gear on trailers
17:25 leave site.

Date: 10-Nov/2016

MWH	Project: GE/UNC NECR JETTY GEOTECH	DAILY FIELD ACTIVITY LOG	Date: 11-Nov-2016 Project Number:

Field Representitive: JEN VAN PELT / STEPHANIE DOWNEY

505 991-3578

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

ONSITE:

J. VANPELT	(MWH)
S. DOWNEY	(MWH)
L. ANDROSS	(EA)
M. CAIN	(N, EWP)
D. MARTINEZ	(N, EWP)
A. CORTEZ	(N, EWP)
R. SPITZ	(AMEC FW)

SAMPLES

B4-51.5-52.5	(GS)
B4-52.5-54.0	(GS)
B4-TW-55.0-57.2	(TW)
B7-TW-5.0-6.5	(TW)
B7-7.0-7.5	(SSO)
B7-8.0-10.0	(GS)
B7-10.5-11.0	(SSO)
B7-14.0-15.0	(GS)
B7-16.0-16.5	(SSO)
B7-18.0-20.0	(GS)
B7-21.0-21.5	(SSO)
B7-23.2-25.0	(GS)
B7-27.5-29.2	(GS)

Boring	Description / Work Unit	Quantity
B4	CME CONT. CORE HSA	15 ft
B4	MOD/CAL Sampling	1
B4	SHELBY TUBE	1

07:00 onsite.

07:15 mobe to site prep for continued drilling

08:00 Tailgate

08:15 continue drilling B4

09:00 complete drilling B4 TD = 65.0 ft bgs. ~5' into weathered bedrock.

09:10 Drillers tripping out prep to mobe to next boring

09:55 Back filled w/cuttings.

10:05 Mobe rig to B7 set up.

10:40 Hand auger to ~3'

11:00 Begin drilling B7

15:30 Encounter ground water at ~65' bgs. driller is concerned about requirement for permit. halts drilling to consult with his PM Re permitting. If permit required May have to wait until Monday as it is Veterans day & weekend.

15:45 contact Jason C. Re issue, plan to Auger/CME core in borings until ground water, then abandon. When permit is granted, will Auger down to last depth and continue w/ CME Core

16:00. Agree ~~to~~ continue drilling to 125' will revisit additional coring equipment tomorrow. encounter Bedrock ~

Samples CONT.

B7-30.5-31.0	(SSO)
B7-32.7-35.0	(GS)
B7-35.0-37.0	(GS)
B7-40.5-41.0	(SSO)
B7-TW-42.5-43.5	(TW)
B7-50.5-51.0	(SSO)
B7-51.5-55.0	(GS)
B7-TW-55.0-57.0	(TW)
B7-60.5-61.0	(SSO)
B7 64.2-65.0	(GS)
B7 68.6-70	(GS)
B7-70.5-71.0	(SSO)

Date: 11-Nov-2016

MWH

Project: NECR UNR JETTY GEOTECH INVEST

DAILY FIELD ACTIVITY LOG

Date: 12-Nov-2016

Project Number:

Field Representitive: J. Van Pelt / S. Downey

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

ONSITE:

J. VAN PELT	(MWH)
S. DOWNEY	(MWH)
L. ANDROS	(AE)
M. CAIN	(N.EWP)
D. MARTINEZ	(N.EWP)
DJ. MARTINEZ	(N.EWP)
R. SPITZ	(AMEC FW)

SAMPLES

B7 - 77.2 - 78.4	(GS)
B7 - 78.4 - 80.0	(GS)
B7 - 80.5 - 81.0	(SSO)
B7 - 81.5 - 84.4	(GS)
B7 - 88.4 - 90	(GS)
B7 - 90.5 - 91.0	(SSO)
B7 - 91.5 - 95	(GS)
B7 - 100.5 - 101.0	(SSO)
B7 - 101.5 - 104	(GS)
B7 - 108.9 - 110.0	(GS)

Boring	Description / Work Unit	Quantity
B7	71.5 - 115'	43.5'
B7	BRASS	3

07:00 on site at Admin. Sign in

Drillers prep, head to site

07:30 Retrieve DJ & Return to office for safety induction Re: Radiation

08:05 Tailgate

08:25 continue drilling, B7 at 71.5'

10:45 At 100' bgs, driller called his PM RE: FOOTAGE over 100

11:45 At 115' bgs, weathered Bedrock.

12:00 Drillers break for lunch.

12:30 PREP for trip out of hole.

12:40 Mixing grout - 24 gal/50 lb sack (CETCO) High solids Bentonite grout

12:50 TREMMIE GROUT,

13:30 Pulled 6 rods/Augers, tremmied again.

178 total gallons of grout - backfill to surface w/cuttings.

14:30. Mapped Jetty area while drillers continued w/ cleanup & mobe

16:30 driller mobed to B5 to begin drilling on Sunday Morning

17:00 leave site

178 gal (2.78 gal/ft)
= 64 feet
grout to 51 ft bgs
Back fill to surface w/cuttings

Date: 12-Nov-2016

MWH	Project: NECR UNC JETTY GEOTECH INVEST.	DAILY FIELD ACTIVITY LOG	Date: 13-Nov-2016 Project Number:

Field Representitive: J. VAN PELT

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

ON SITE:

J. VANPELT	(MWH)
S. DOWNEY	(MWH)
L. ANDROSS	(EA)
M. CAIN	(NEWP)
D. MARTINEZ	(NEWP)
DJ. MARTINEZ	(N,EWP)
R. SPITZ	(AMEC FW)

SAMPLES

B5-5.5-6.0	(SSO)
B5-9.2-10.0	(GS)
B5-10.5-11.0	(SSO)
B5-13.7-15.0	(GS)
B5-15.5-16.0	(SSO)
B5-18.2-20	(GS)
B5-21.0-21.5	(SSO)
B5-21.5-25.0	(GS)
B5-TW-25.0-27.0	(TW)
B5-27.0-30.0	(GS)
B5-30.5-31.0	(SSO)
B5-31.5-35	(GS)
B5-38.7-40.0	(GS)

Boring	Description / Work Unit	Quantity
B5	CME Continuous Core	125'
	2" ID BRASS Samp	8 ea
	Shelby 24"	1 ea

07:00 ON site sign in
drillers prep for drilling B5 @ 0'

08:10 Tail gate

08:30 Hand auger B5 to ~3' bgs

08:45 Drilling B5.

12:30 JVP w/ Rick to dig test pits at UNNAMED ARROYO at Navajo Res.

13:15 Continue to MINE SHAFT SITE TO MAP BED ROCK

14:55 Return to B5. at 105' bgs - still no bed rock.

15:15 NEAR MISS - DRILLERS TRIPPING in rod for CME core, ~20' of rod being lifted from ground. connector pin came loose as cable neared top dropping 15' of rod at back of rig. close to driller.

16:30 at 125' bgs. No sign of bedrock - contacted Jason Re: terminating boring desided to move B6 toward Jetty - in effort to potentially encounter bed rock.
drillers pull CME ROD - will grout in morning

SAMPLES CONT

B5-40.5-41.0	(SSO)
B5-49.0-50.0	(GS)
B5 52.6-53.9	(GS)
B5-63.0-63.6	(GS)
B5-68.9-69.5	(GS)
B5-60.5-61.0	(SSO)
B5-75.0-77.6	(GS)
B5-93.1-95.0	(GS)
B5-101.0-101.5	(SSO)

Date: 13-Nov-2016

MWH	Project: NECR UMC Jetty Geotech Invest	DAILY FIELD ACTIVITY LOG	Date: 14-Nov-2016 Project Number:

Field Representitive: J. Van Pelt S. Downey

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

On Site:

J. VanPelt	(MWH)
S. Downey	(MWH)
L. Andross	(EA)
M. Ca...	(NEWP)
D. Martinez	(N.EWP)
DJ. Martinez	(N.EWP)

To Do: B6 to bed rock.?
TP-3 ✓
TP-4 ✓
Core Prep ✓
GPS Borings & Test Pits. ✓

GPS - All Locations.
UTM NAD 83

B1	12 S	0725716	3947688
B2	12 S	0725632	3947645
B3	12 S	0725606	3947618
B4	12 S	0725763	3947644
B5	12 S	0725797	3947622
B6	12 S	0725729	3947569
B7	12 S	0725645	3947534
TP1	12 S	0725759	3949521
TP2	12 S	0725748	3949499
TP3	12 S	0726668	3947995
TP4	12 S	0726672	3947958

Boring	Description / Work Unit	Quantity
B6	CME cont. core	80'
B6	Mod Cal 2" ID	6
B6	Thin Wall Shelby	1
B6	Grab Samples	10

07:00 on site, meet w/ Rick. Borrow Post hole digger for Test pits.

Drillers prepping for day - getting water. will grout B5 to ~60' bgs, & back fill w/ Cuttings.

08:10 Tailgate - STRETCHING discuss Near miss from sun bags

08:30 - Begin by pulling 2 augers (10') to blow slough out of bottom of Augers.

09:48 drillers have added ~196 gallons at 2.74 gal/ft grouts hole to ~54' bgs, water table estimated to be at ~71' bgs.

10:00 Dilco Hill - take samples (5 gal) for TP3 & 4

11:15 Return to B5 - drillers continue to decon augers getting ready for move to B6

12:00 select core for lab work, pack into box for transport.

13:00 Begin drilling B6

16:30 halt drilling for day drillers winterize equip for over-night.

17:00 leave site.

CORE SAMPLES

B3 - 24.2-24.9 (CORE) SS
B3 - 24.9-25.6 (CORE) SS
B3 28.8 29.5 (CORE) SS
B3 - 49.9 - 50.6 (CORE) SS/SH
B2 26.45 - 27.25 (CORE) SS
B2 42.0 - 42.5 (CORE) SH
B2 30.25 - 31.1 (CORE) SS
B1 17.3 - 18.1 (CORE) SS
B1 5.3 - 5.95 (CORE) SS
B1 29.45 - 30.15 (CORE) SS/SH

SAMPLES

B6 - 7.0 - 9.3 (GS)
B6 10.5-11.0 (SSO)
B6 12.8-13.5 (GS)
B6 13.5-15 (GS)
B6 15.5-16.0 (SSO)
B6 - 16.5-20.0 (GS)
B6 - 20.5-21.0 (SSO)
B6 - 26.6-30 (GS)
B6-TW-30.0-320 (TW)
B6 - 37.5-38.4 (GS)
B6 - 40.5-41.0 (SSO)
B6 -42.3-43.8 (GS)
B6 -47.0-48.9 (GS)
B6 52.2-53.6 (GS)
B6 -57.2-59.4 (GS)
B6 - 60.5 - 61.0 (SSO)
B6 - 72 - 73.6 (GS)
B6 - 80.5 - 81.0 (SSO)

Date: 14-Nov-2016

MWH

Project: GE/UMC JETTY GEOTECH INVEST

DAILY FIELD ACTIVITY LOG

Date: 15-Nov-2016

Project Number:

Field Representitive: JEN VANPELT, STEPHANIE DOWNEY

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

ON SITE:

J. VanPelt	(MWH)
S. Downey	(MWH)
L. Andross	(EA)
M. CAIN	(N.EWP)
D. Martinez	(N.EWP)
DJ. Martinez	(N.EWP)
R. SPITZ	(AMEC FW)

SAMPLES

B6-100.5-101.0	(SSO)
B6-101.5-105	(GS)

07:00 on site - sign in, drillers prep for site
discuss storage of core w/ Rick. - who will pick up and store.

08:10 Tailgate, last day of drilling. anticipated schedule - drillers may have to wait 24hrs before driving rig back to yard.
Stretching

08:30 drilling at 80-feet onward, B6.

09:30 Rick picked up core for storage.

10:40 Max of AMEC scans vehicle and samples.

11:00 leave site

Boring	Description / Work Unit	Quantity
B6	CME (80-125?)	45'?

Date: 15-Nov-2016

MWH	Project: NECR Jetty Geotech Investigation	**DAILY FIELD ACTIVITY LOG**	Date: 15-Nov-2016 Project Number:

Field Representitive: S. Downey

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

On site:

S. Downey	(MWH)
L. Andress	(EA)
M. Cain	(NEWP)
D. Martinez	(NEWP)
DJ Martinez	(NEWP)

1100 - Jennifer Van Pelt left site
1130 - Finish drilling B6 @ 126.5 ft bgs
1200 to 1230 - drillers take lunch
1230 - begin grouting and pulling auger
1400 - drillers added ~192 gallons of grout total. At 2.75 gal/ft, hole grouted to 56.7 ft bgs, water table estimated at 65 ft bgs
- Continue to pull and decon auger, L. Andress leaves site
1530 - auger pulled and deconned, drillers continue to decon other equipment, drill rig, and clean up site/prep for demobilization
1600 - RSO (Max), AMEC, scanned car, tables, chairs, boots, other equipment
1700 - leave site

Boring	Description / Work Unit	Quantity

Date: 15-Nov-2016

MWH	Project: NECR Jetty Geotech Investigation	DAILY FIELD ACTIVITY LOG	Date: 16-Nov-2016 Project Number:

Field Representitive: S. Downey

Note activities, weather conditions, visitors, variances, safety issues, communications, mechanical issues, scheduling issues, etc.

On site:

S. Downey	(MWH)
M. Cain	(NEWP)
D. Martinez	(NEWP)
DJ. Martinez	(NEWP)

0700 - Arrive on site, drillers had their own tailgate safety meeting
- continue demob and decon
- I worked in UNC office

0830 - Drillers demob from site and have all equip. at UNC office lot, including porta potty

0900 - leave site
- Drillers loaded equip. onto trailers and finish decon., get scanned by RSO

* Drillers dailies note they finished @ 1100

* Drillers required to take 24 hour layover before driving equipment back to yard in Peralta, NM Left UNC site on 17-Nov-2016

Boring	Description / Work Unit	Quantity

Date: 16-Nov-2016

APPENDIX B FIELD PHOTOS

1. **PIPELINE ARROYO, LOOKING DOWNSTREAM**

2. **PIPELINE ARROYO, LOOKING UPSTREAM**

3. SIDEWALL OF ARROYO, LOOKING WEST-SOUTHWEST

4. EXPOSED COAL LAYER BELOW BORING B1 LOCATION

5. EXISTING JETTY EXPOSED IN THE EROSIONAL FLOW PATHWAY, PARALLEL TO JETTY

6. DRILLING OPERATIONS

7. DRILLING OPERATIONS, GROUTING BOREHOLE B6

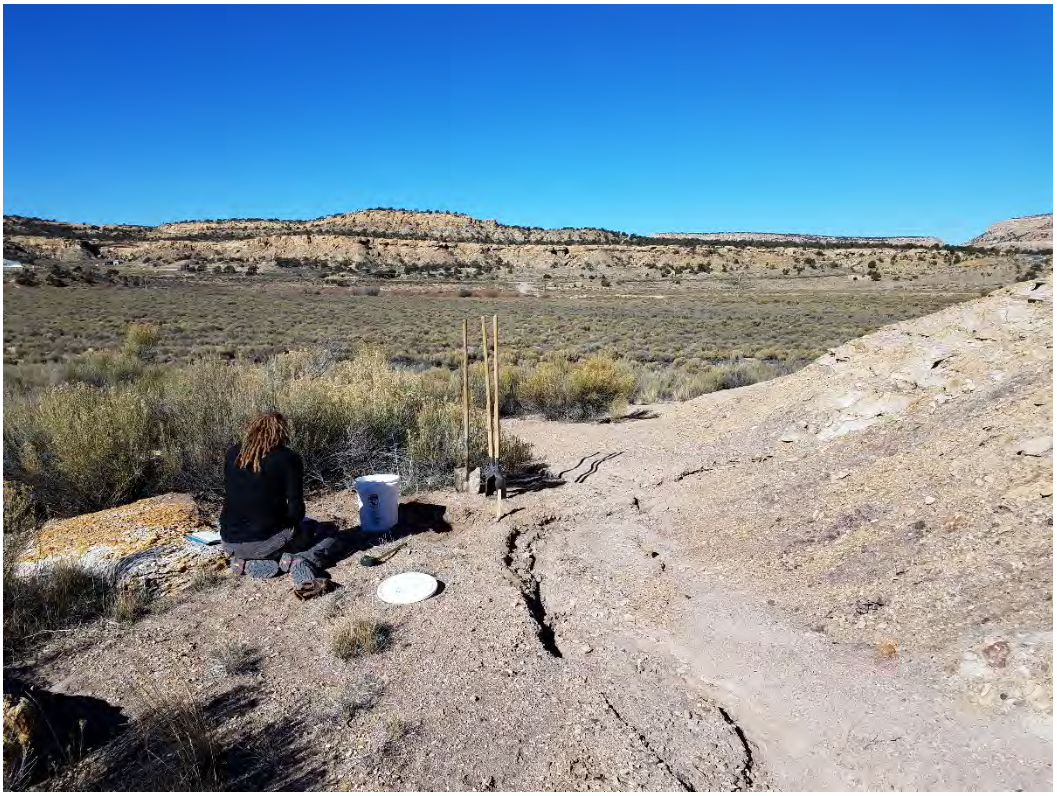
8. GENERAL AREA OF DRILL SITE, LOCATION B6

9. TEST PIT 1

10. TEST PIT 2

11. TEST PIT 3

12. GENERAL LOCATION OF TEST PIT 3, LOOKING SOUTHEAST



13. GENERAL AREA OF TEST PIT 3 NEAR DILCO HILL, LOOKING NORTHWEST

14. TEST PIT 4 NEAR DILCO HILL

APPENDIX C   LABORATORY DATA

SAMPLE LOCATION	SAMPLE DEPTH (FT)	FIELD CLASS	MOISTURE (%)	DRY DENSITY (pcf)
B-4	16.0-16.5	--	10.4	77.6
B-5	10.5-11.0	--	5.2	82.9
B-5 (TRIAXIAL)	TW 25.0-27.5	--	21.2	98.8
B-5	40.5-41.0	--	22.7	99.6
B-6	15.5-16.5	--	10.7	93.0
B-6	40.5-41.0	--	17.9	97.0
B-7	TW 5.0-6.5	--	6.9	94.3
B-7	10.5-11.0	--	7.0	99.7
B-7	30.5-31.0	--	16.7	102.5

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2937 & ASTM D 2216

Ninyo & Moore		MOISTURE - DENSITY TEST DATA	FIGURE
PROJECT NO.	DATE	STANTEC/MWH/LAB TESTING PHOENIX, ARIZONA	
604667003	3/17		

WEIGHT OF SAMPLE DISPERSED:	51.2	SPECIFIC GRAVITY OF SOLIDS:	2.650	Assumed
PERCENT PASSING #10 SIEVE:	100.0			

HYDROMETER RESULTS (% PASSING)

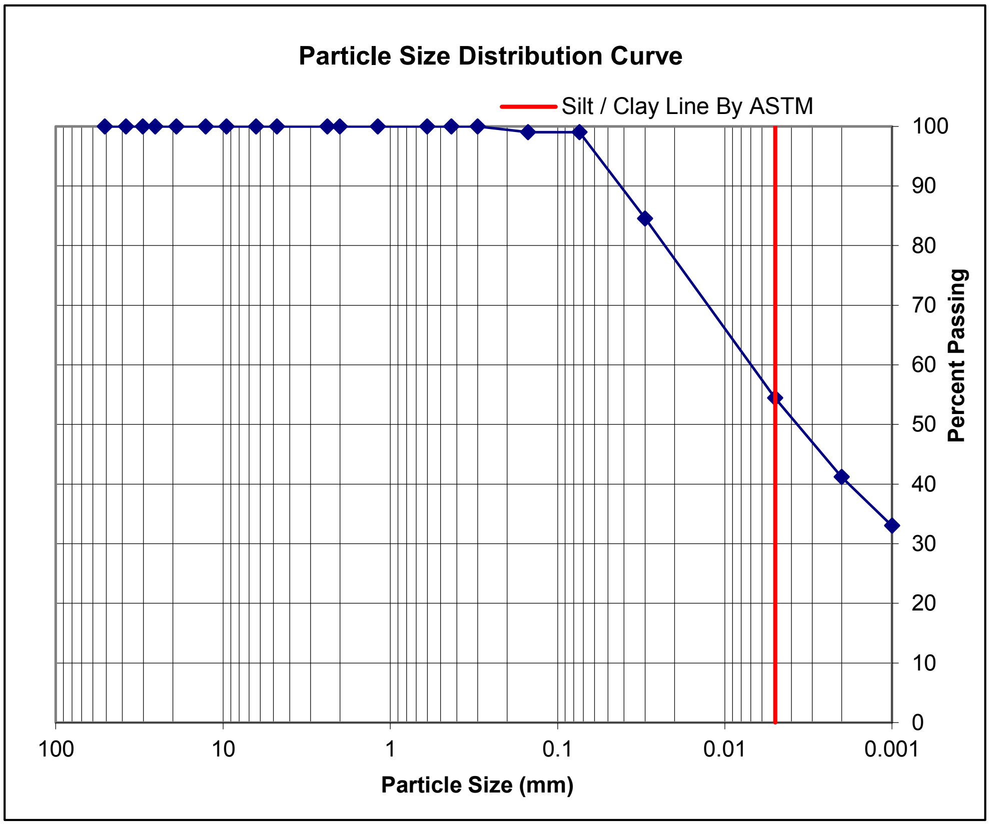
PARTICLE SIZE (DIA. mm)	**0.0438**	**0.0283**	**0.0168**	**0.0123**	**0.0089**	**0.0046**	**0.0020**	**0.0014**
PERCENT SAMPLE TESTED	87.9	84.0	78.2	70.3	65.5	52.8	41.0	37.1
PERCENT TOTAL SAMPLE	87.9	84.0	78.2	70.3	65.5	52.8	41.0	37.1

MECHANICAL SIEVE ANALYSIS AFTER HYDROMETER (% PASSING)

SCREEN SIZE	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**
PERCENT TOTAL SAMPLE	99.0	99.4	99.6	99.6	99.8	100.0	100.0

FULL SIEVE ANALYSIS
MECHANICAL SIEVE
& HYDROMETER

	% Pass	Spec
2 IN	100	
1 1/2 IN	100	
1 1/4 IN	100	
1 IN	100	
3/4 IN	100	
1/2 IN	100	
3/8 IN	100	
1/4 IN	100	
# 4	100	
# 8	100	
# 10	100	
# 16	100	
# 30	100	
# 40	100	
# 50	100	
# 100	99	
# 200	99	
0.03 mm	84.6	
0.005 mm	54.4	
0.002 mm	41.2	
0.001 mm	33.0	



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
	B-5	40.5-41.0	49	20	29	--	--	0.007	--	--	99.0	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)

FIGURE

PROJECT NO.	DATE
604667003	3/17

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

WEIGHT OF SAMPLE DISPERSED:	50.0	SPECIFIC GRAVITY OF SOLIDS:	2.650	Assumed
PERCENT PASSING #10 SIEVE:	100.0			

HYDROMETER RESULTS (% PASSING)

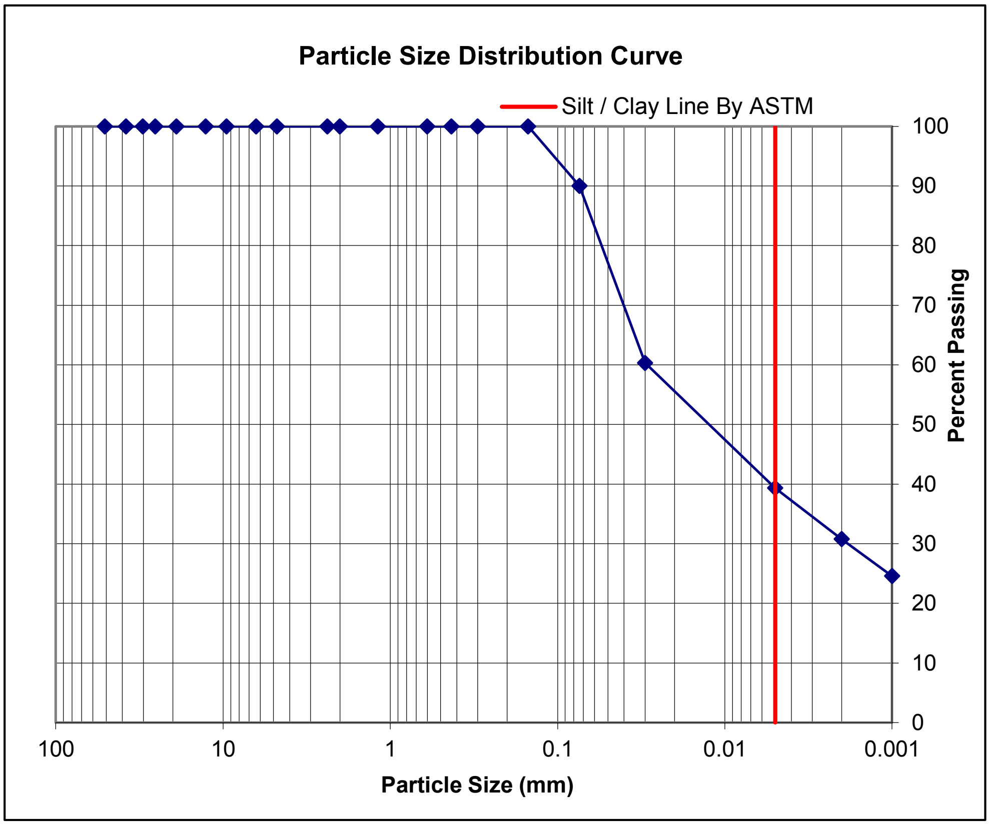
PARTICLE SIZE (DIA. mm)	0.0485	0.0315	0.0187	0.0134	0.0096	0.0048	0.0021	0.0015
PERCENT SAMPLE TESTED	68.0	61.0	54.0	50.0	46.0	39.0	31.0	28.0
PERCENT TOTAL SAMPLE	68.0	61.0	54.0	50.0	46.0	39.0	31.0	28.0

MECHANICAL SIEVE ANALYSIS AFTER HYDROMETER (% PASSING)

SCREEN SIZE	#200	#100	#50	#40	#30	#16	#10
PERCENT TOTAL SAMPLE	89.8	99.6	99.8	100.0	100.0	100.0	100.0

FULL SIEVE ANALYSIS MECHANICAL SIEVE & HYDROMETER

	% Pass	Spec
2 IN	100	
1 1/2 IN	100	
1 1/4 IN	100	
1 IN	100	
3/4 IN	100	
1/2 IN	100	
3/8 IN	100	
1/4 IN	100	
# 4	100	
# 8	100	
# 10	100	
# 16	100	
# 30	100	
# 40	100	
# 50	100	
# 100	100	
# 200	90	
0.03 mm	60.3	
0.005 mm	39.3	
0.002 mm	30.8	
0.001 mm	24.6	



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
	B-6	15.0-16.0	42	17	25	--	0.002	0.029	--	--	90.0	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

FIGURE

PROJECT NO.	DATE
604667003	3/17

WEIGHT OF SAMPLE DISPERSED: 50.0
PERCENT PASSING #10 SIEVE: 100.0

SPECIFIC GRAVITY OF SOLIDS: 2.650 Assumed

HYDROMETER RESULTS (% PASSING)

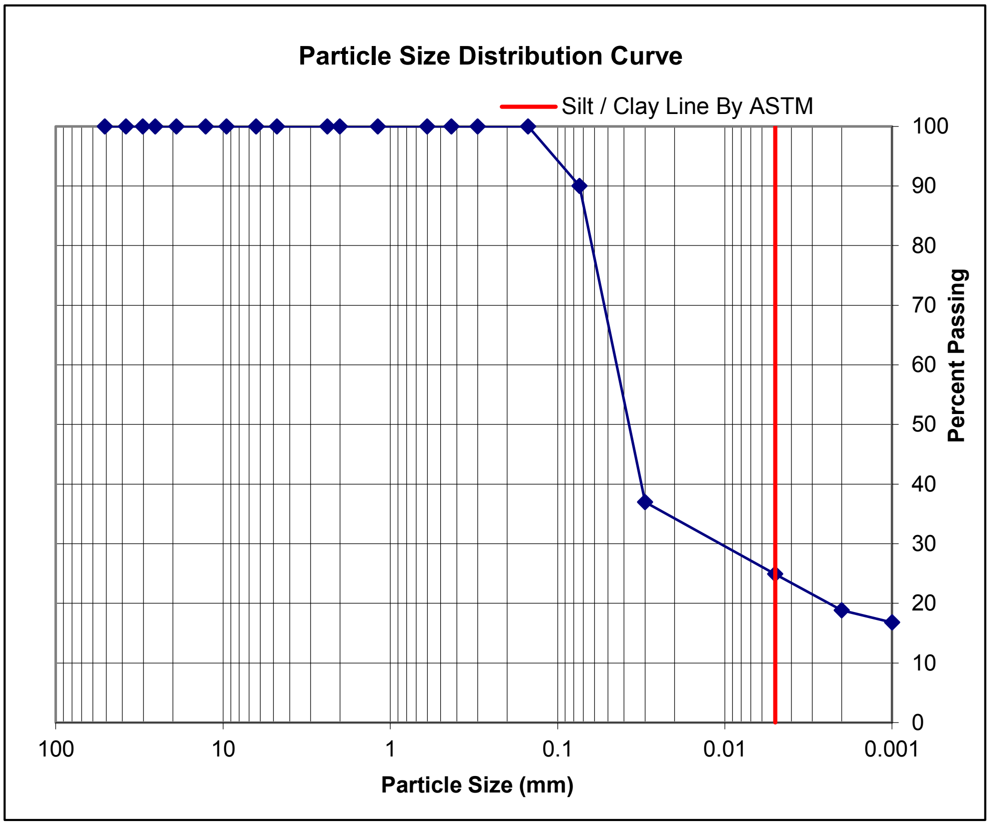
PARTICLE SIZE (DIA. mm)	**0.0535**	**0.0343**	**0.0201**	**0.0143**	**0.0102**	**0.0051**	**0.0021**	**0.0015**
PERCENT SAMPLE TESTED	42.0	38.0	34.0	32.0	29.0	25.0	19.0	18.0
PERCENT TOTAL SAMPLE	42.0	38.0	34.0	32.0	29.0	25.0	19.0	18.0

MECHANICAL SIEVE ANALYSIS AFTER HYDROMETER (% PASSING)

SCREEN SIZE	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**
PERCENT TOTAL SAMPLE	89.8	99.6	99.8	100.0	100.0	100.0	100.0

FULL SIEVE ANALYSIS
MECHANICAL SIEVE
& HYDROMETER

	% Pass	Spec
2 IN	100	
1 1/2 IN	100	
1 1/4 IN	100	
1 IN	100	
3/4 IN	100	
1/2 IN	100	
3/8 IN	100	
1/4 IN	100	
# 4	100	
# 8	100	
# 10	100	
# 16	100	
# 30	100	
# 40	100	
# 50	100	
# 100	100	
# 200	90	
0.03 mm	37.0	
0.005 mm	24.9	
0.002 mm	18.8	
0.001 mm	16.8	



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
	B-7	10.5-11.0	--	--	N Test	--	0.011	0.044	--	--	90.0	

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)

FIGURE

PROJECT NO.	DATE
604667003	3/17

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

WEIGHT OF SAMPLE DISPERSED:	49.8	SPECIFIC GRAVITY OF SOLIDS:	2.650	Assumed
PERCENT PASSING #10 SIEVE:	100.0			

HYDROMETER RESULTS (% PASSING)

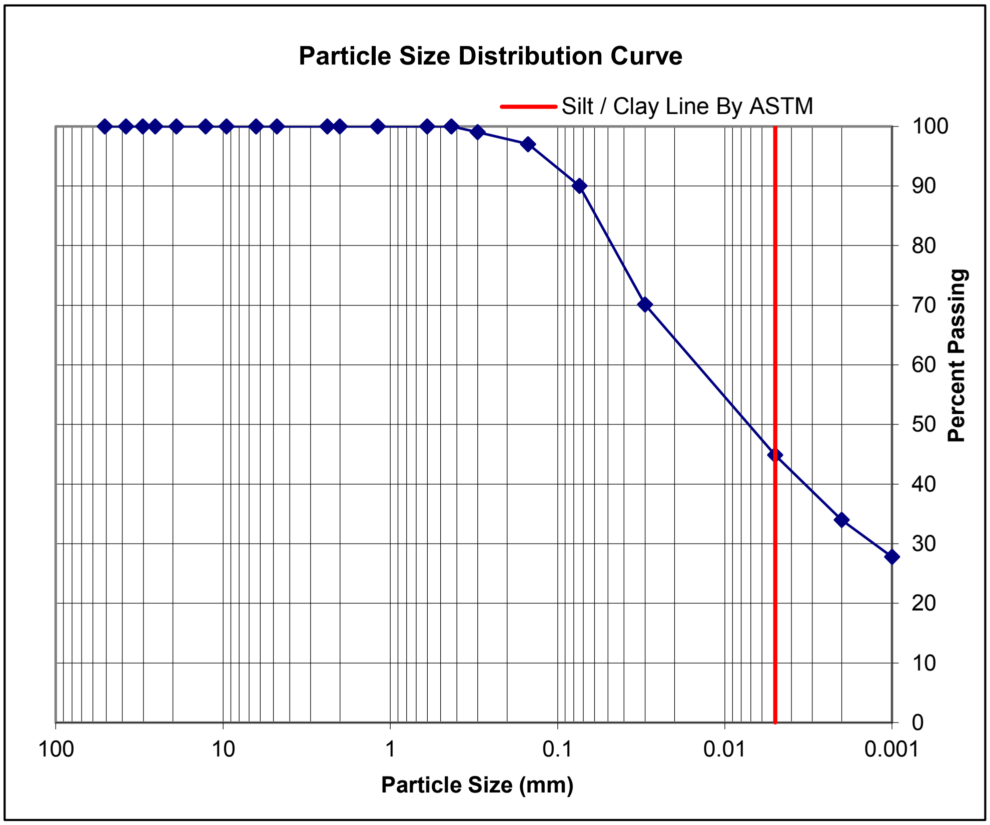
PARTICLE SIZE (DIA. mm)	**0.0470**	**0.0304**	**0.0181**	**0.0131**	**0.0094**	**0.0048**	**0.0020**	**0.0015**
PERCENT SAMPLE TESTED	75.3	70.3	63.2	57.2	53.2	44.2	34.1	31.1
PERCENT TOTAL SAMPLE	75.3	70.3	63.2	57.2	53.2	44.2	34.1	31.1

MECHANICAL SIEVE ANALYSIS AFTER HYDROMETER (% PASSING)

SCREEN SIZE	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**
PERCENT TOTAL SAMPLE	90.0	97.0	99.4	99.6	99.6	99.8	100.0

FULL SIEVE ANALYSIS MECHANICAL SIEVE & HYDROMETER

	% Pass	Spec
2 IN	100	
1 1/2 IN	100	
1 1/4 IN	100	
1 IN	100	
3/4 IN	100	
1/2 IN	100	
3/8 IN	100	
1/4 IN	100	
# 4	100	
# 8	100	
# 10	100	
# 16	100	
# 30	100	
# 40	100	
# 50	99	
# 100	97	
# 200	90	
0.03 mm	70.1	
0.005 mm	44.9	
0.002 mm	34.0	
0.001 mm	27.8	



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
	TP-1	BUCKET	--	--	N Tested	--	0.001	0.015	--	--	90.0	

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore		PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)	FIGURE
PROJECT NO.	DATE	STANTEC/MWH/LAB TESTING PHOENIX, ARIZONA	
604667003	3/17		

WEIGHT OF SAMPLE DISPERSED: 54.5
PERCENT PASSING #10 SIEVE: 99.8

SPECIFIC GRAVITY OF SOLIDS: 2.650 Assumed

HYDROMETER RESULTS (% PASSING)

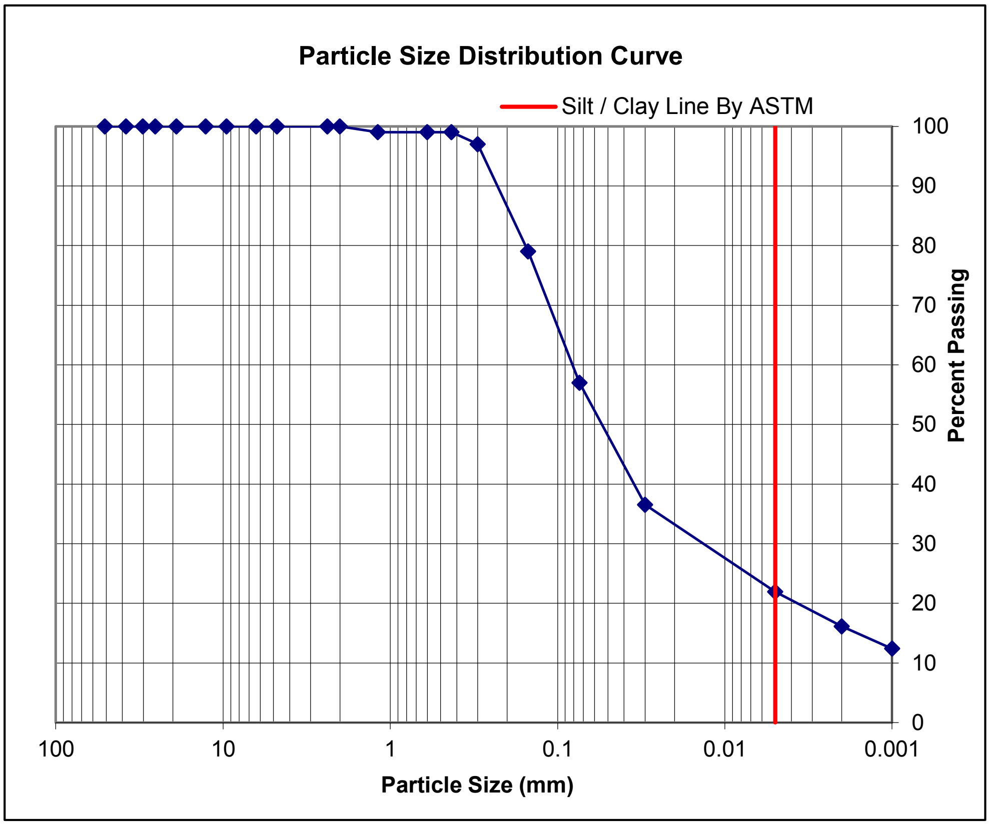
PARTICLE SIZE (DIA. mm)	**0.0531**	**0.0339**	**0.0199**	**0.0142**	**0.0102**	**0.0051**	**0.0021**	**0.0015**
PERCENT SAMPLE TESTED	40.4	37.6	33.0	31.2	27.5	22.0	16.5	14.7
PERCENT TOTAL SAMPLE	40.3	37.5	33.0	31.1	27.5	22.0	16.5	14.6

MECHANICAL SIEVE ANALYSIS AFTER HYDROMETER (% PASSING)

SCREEN SIZE	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**
PERCENT TOTAL SAMPLE	56.8	79.3	96.5	98.5	99.1	99.4	99.8

FULL SIEVE ANALYSIS
MECHANICAL SIEVE
& HYDROMETER

	% Pass	Spec
2 IN	100	
1 1/2 IN	100	
1 1/4 IN	100	
1 IN	100	
3/4 IN	100	
1/2 IN	100	
3/8 IN	100	
1/4 IN	100	
# 4	100	
# 8	100	
# 10	100	
# 16	99	
# 30	99	
# 40	99	
# 50	97	
# 100	79	
# 200	57	
0.03 mm	36.5	
0.005 mm	21.9	
0.002 mm	16.1	
0.001 mm	12.4	


Particle Size Distribution Curve

Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
	TP-2	BUCKET	--	--	N Tested	--	0.013	0.081	--	--	57.0	

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

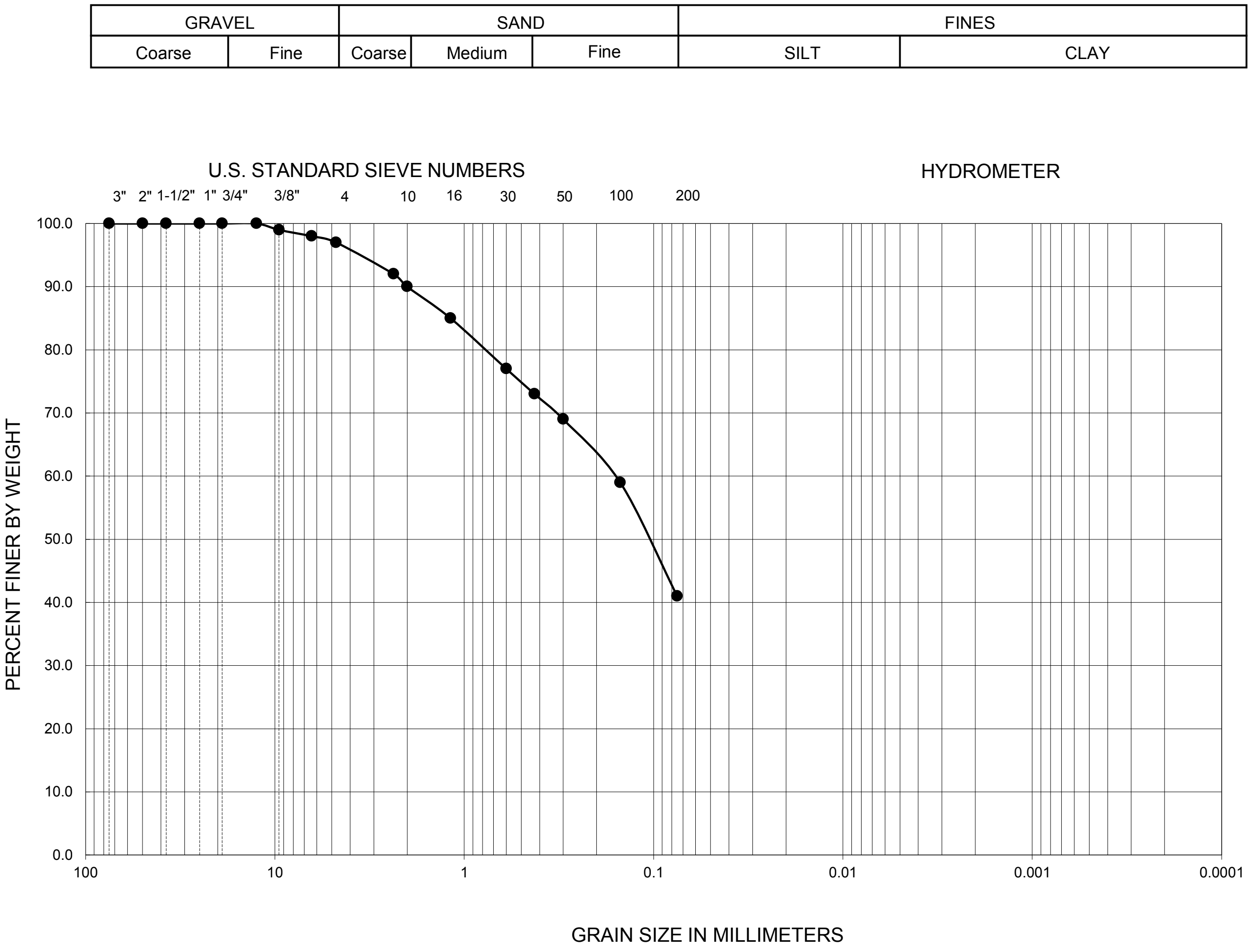
Ninyo & Moore

PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

FIGURE

PROJECT NO.	DATE
604667003	3/17



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
●	TP-3	BUCKET	--	--	NT	--	--	0.16	--	--	41.0	

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 AND C117

Ninyo & Moore		GRADATION TEST RESULTS	FIGURE
PROJECT NO.	DATE	STANTEC/MWH/LAB TESTING	
604667003	3/17	PHOENIX, ARIZONA	

WEIGHT OF SAMPLE DISPERSED: 51.8
PERCENT PASSING #10 SIEVE: 94.9

SPECIFIC GRAVITY OF SOLIDS: 2.650 Assumed

HYDROMETER RESULTS (% PASSING)

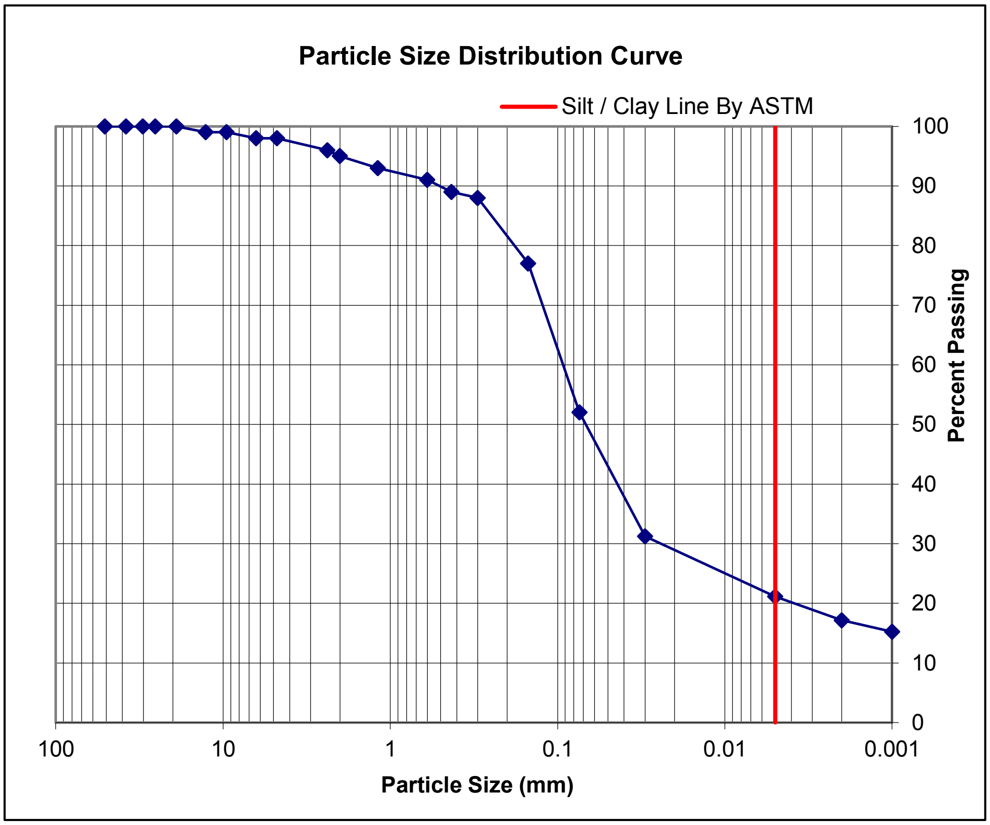
PARTICLE SIZE (DIA. mm)	**0.0544**	**0.0347**	**0.0204**	**0.0145**	**0.0103**	**0.0051**	**0.0022**	**0.0015**
PERCENT SAMPLE TESTED	35.7	32.8	27.0	27.0	24.1	21.2	17.4	16.4
PERCENT TOTAL SAMPLE	33.9	31.1	25.6	25.6	22.9	20.1	16.5	15.6

MECHANICAL SIEVE ANALYSIS AFTER HYDROMETER (% PASSING)

SCREEN SIZE	**#200**	**#100**	**#50**	**#40**	**#30**	**#16**	**#10**
PERCENT TOTAL SAMPLE	51.7	76.8	87.7	89.4	91.0	92.9	94.9

FULL SIEVE ANALYSIS
MECHANICAL SIEVE
& HYDROMETER

	% Pass	Spec
2 IN	100	
1 1/2 IN	100	
1 1/4 IN	100	
1 IN	100	
3/4 IN	100	
1/2 IN	99	
3/8 IN	99	
1/4 IN	98	
# 4	98	
# 8	96	
# 10	95	
# 16	93	
# 30	91	
# 40	89	
# 50	88	
# 100	77	
# 200	52	
0.03 mm	31.2	
0.005 mm	21.1	
0.002 mm	17.2	
0.001 mm	15.2	



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	USCS
	TP-4	BUCKET	--	--	N Tested	--	0.024	0.093	--	--	52.0	

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422

Ninyo & Moore

PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)

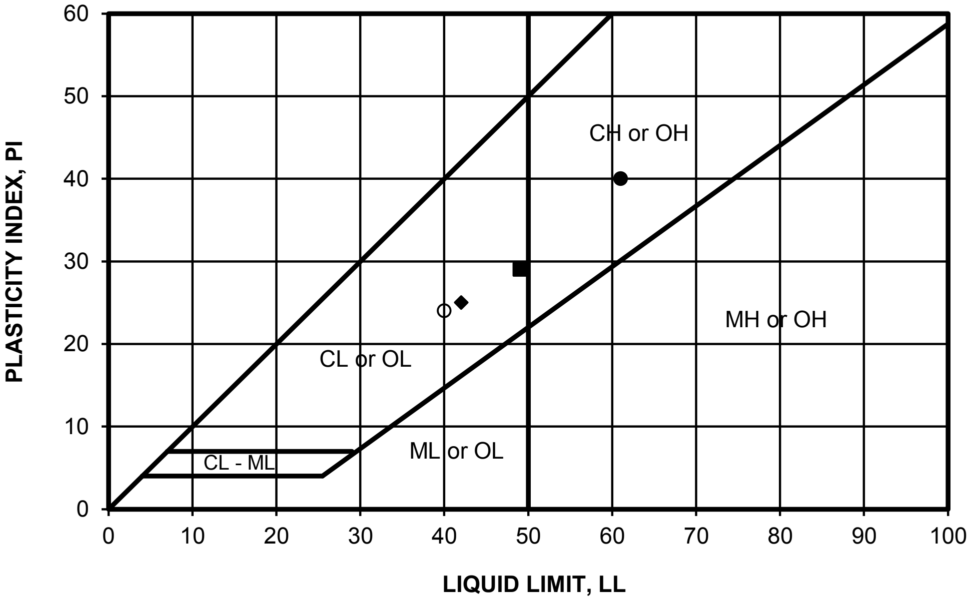
STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

FIGURE

PROJECT NO.	DATE
604667003	3/17

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-5	TW 25-27	61	21	40	CH	CH
■	B-5	40.5-41.0	49	20	29	CL	CL
◆	B-6	15.0-16.0	42	17	25	CL	CL
○	B7	30.5-31.0	40	16	24	CL	CL

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

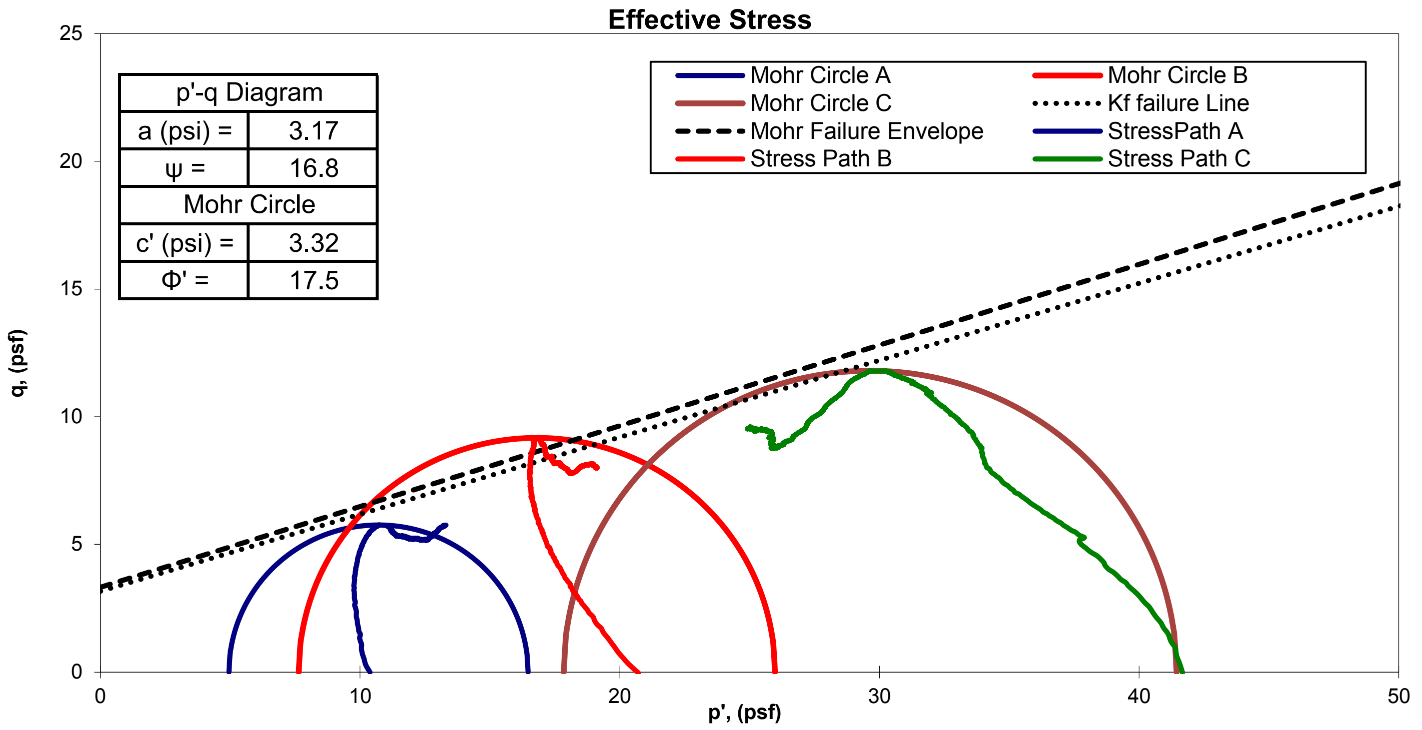
Ninyo & Moore

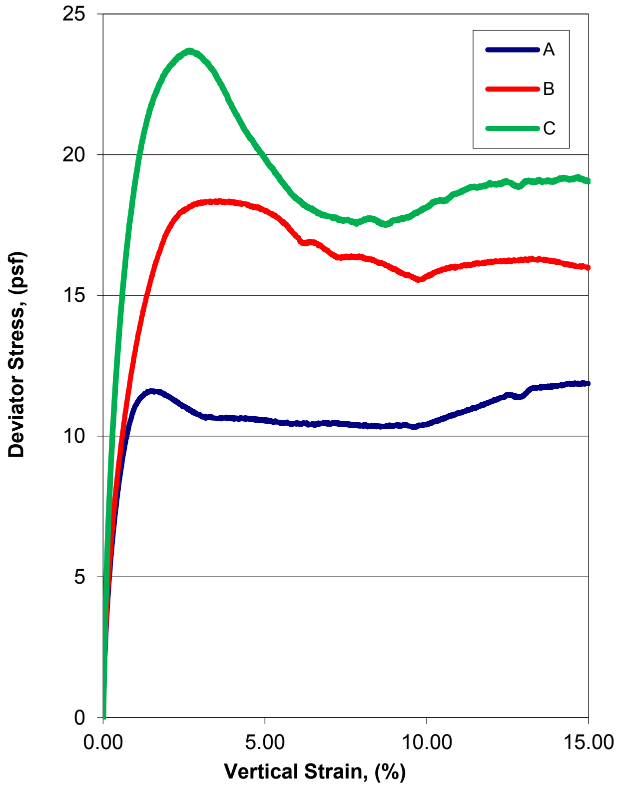
ATTERBERG LIMITS TEST RESULTS

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

PROJECT NO.	DATE
604667003	3/17

FIGURE





	Location:	B-5		
	Sample Depth:	TW 25.0-27.0		
	Lab Technican:	JCE		
	Checked By:	HJG		
	Sample ID	A	B	C
	Date Tested	2/25/2017	2/25/2017	2/25/2017
Initial	Diameter, in	2.88	2.88	2.87
	Height, in	5.68	5.71	5.68
	Water Content %	21.3%	21.5%	20.8%
	Dry Density, pcf	99.1	98.3	99.0
	Saturation, %	82.3%	81.2%	80.0%
	Void Ratio	0.700	0.714	0.701
Before Shear	Water Content %	26.1%	25.9%	25.0%
	Dry Density, pcf	96.8	98.5	98.4
	Saturation, %	100.0%	100.0%	100.0%
	Void Ratio	0.741	0.710	0.712
	Back pressure, psf	50	50	50
	Obliquity Effective Failture %	1.28	3.32	2.89
	Obliquity Total Failture %	1.28	3.32	2.89
	Effective Confinement, psi	10.4	20.7	41.7
	B- Value	0.95	0.95	0.95
	Strain Rate, %/min	0.05	0.05	0.05

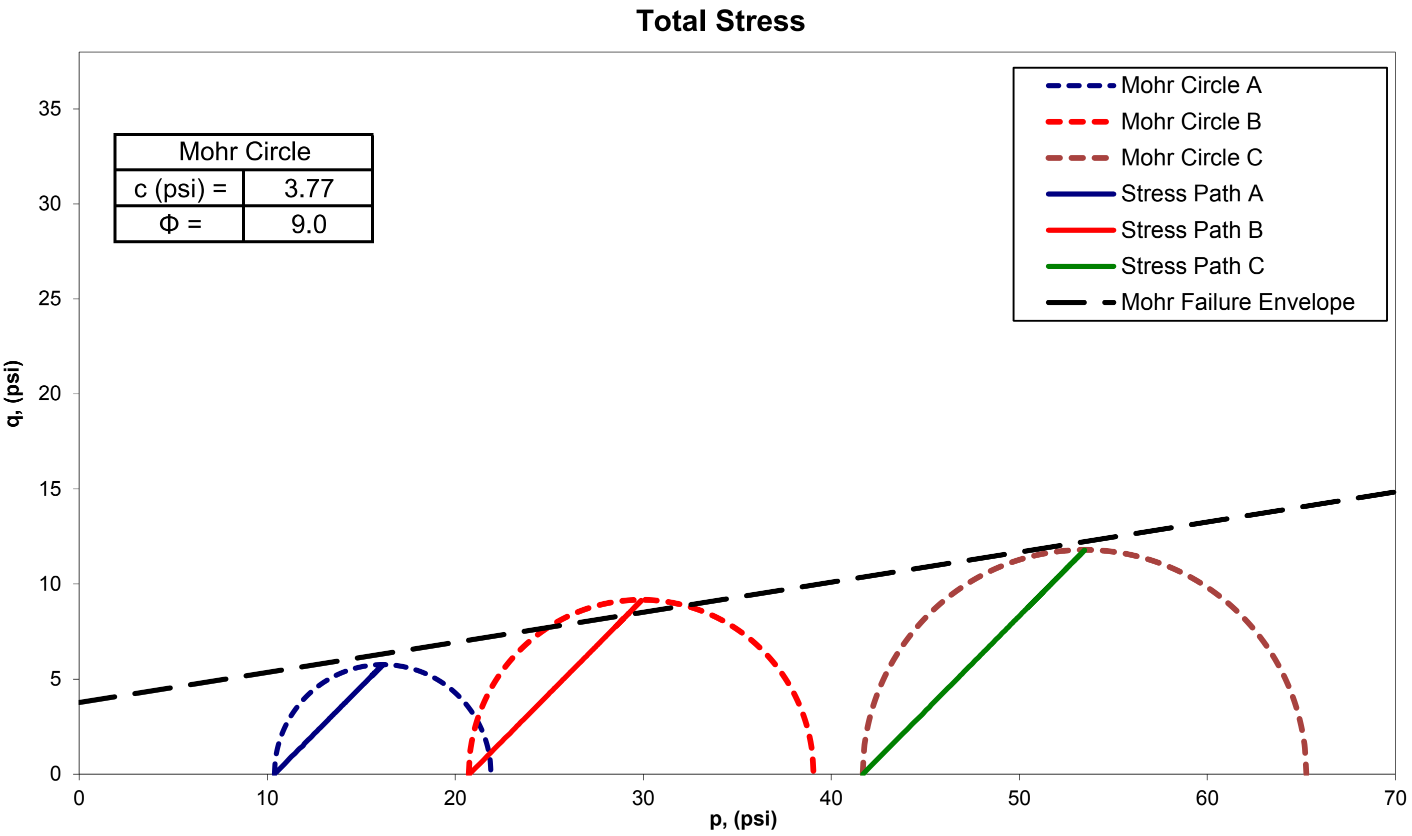
Ninyo & Moore

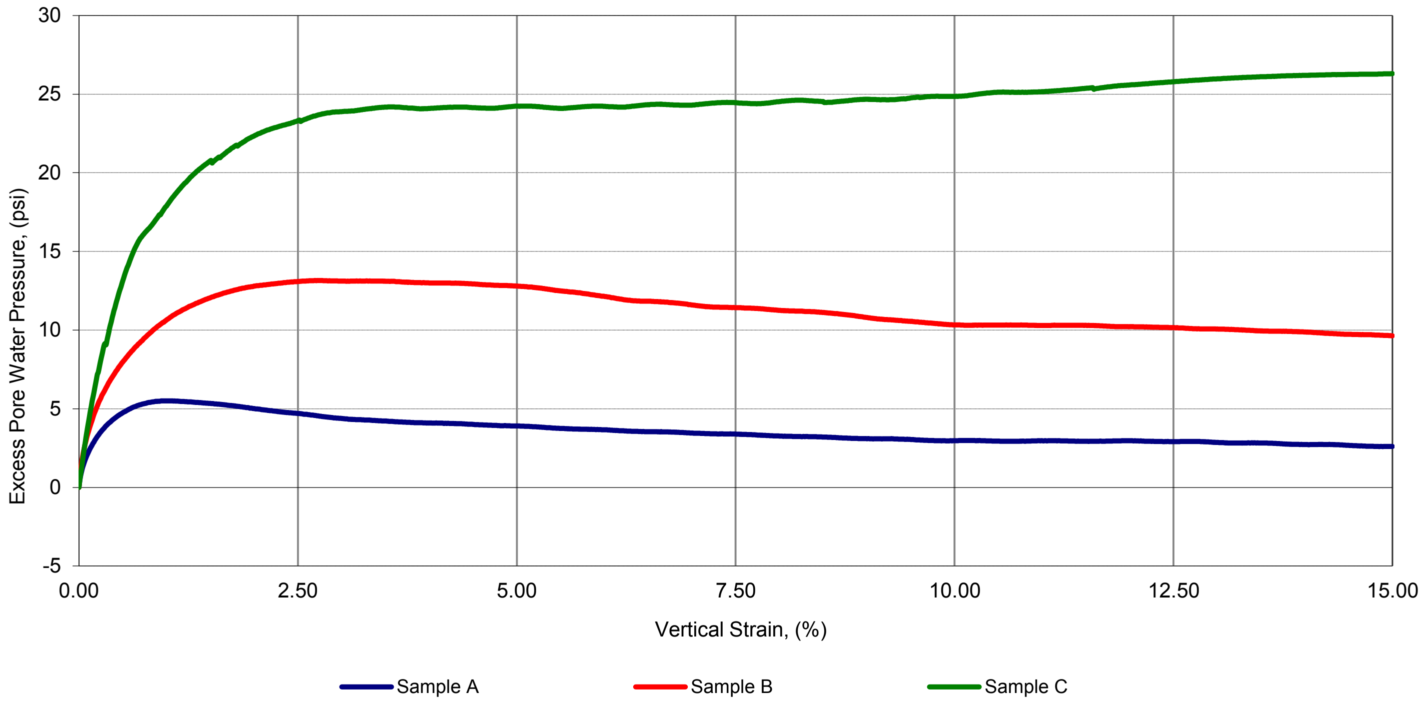
Project Number	Date
604667003	3/17

Consolidated Undrained Triaxial Test Data Sheet

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

Figure





Ninyo & Moore

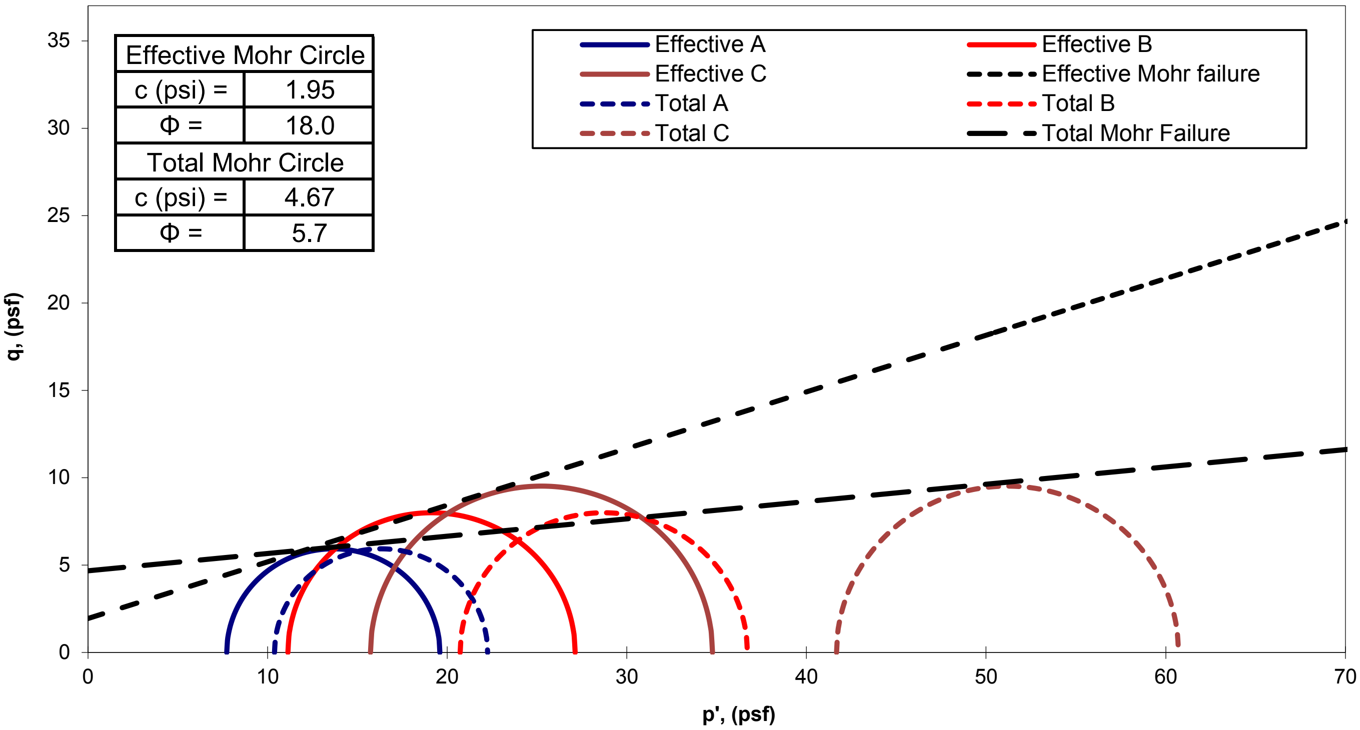
Location:	B-5
Sample Depth (ft):	TW 25.0-27.0
Project Number:	604667003
Date:	3/17

Consolidated Undrained Triaxial Test Data Sheet

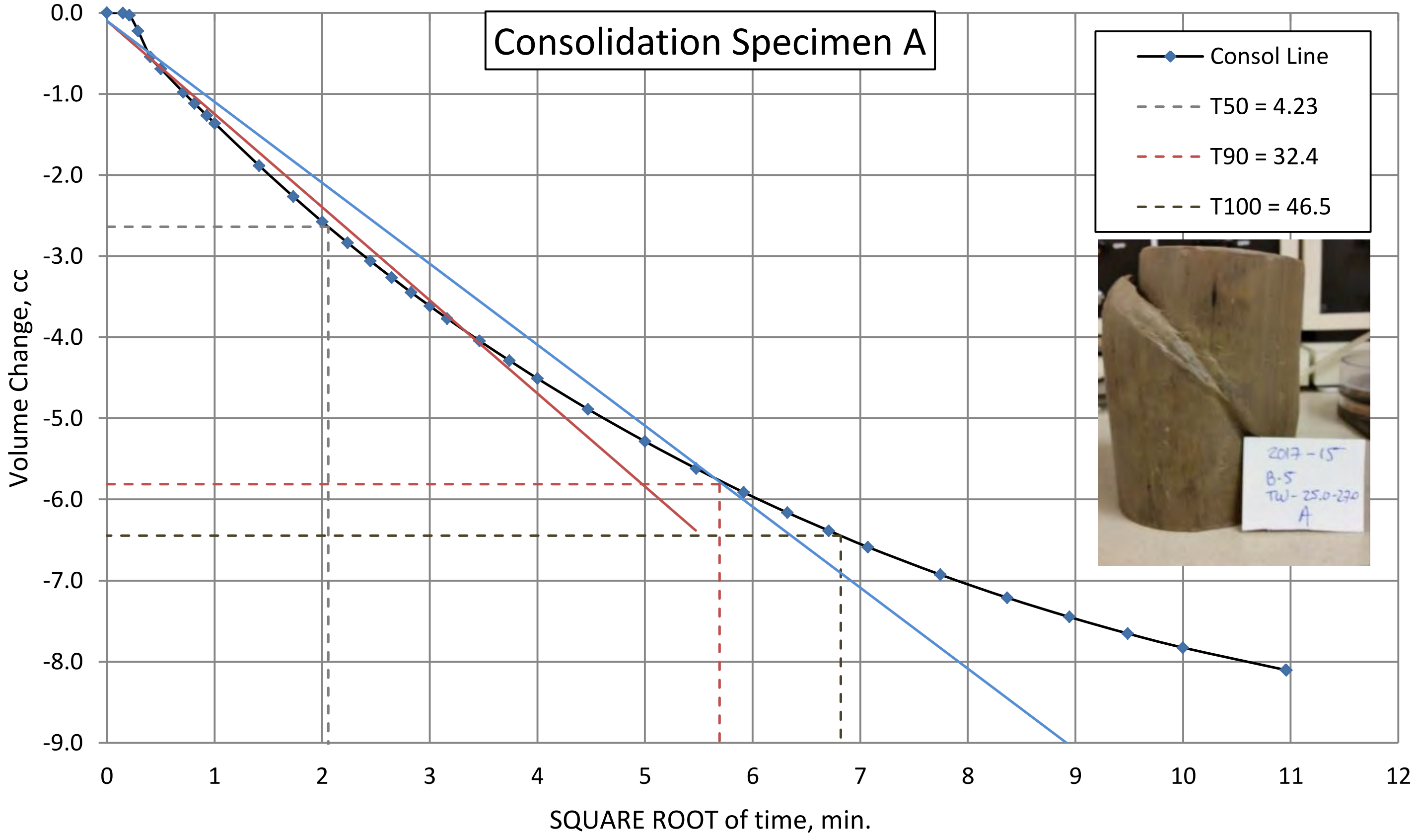
STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

Figure

Effective & Total Stress at 15% Shear



Effective Mohr Circle	
c (psi) =	1.95
Φ =	18.0
Total Mohr Circle	
c (psi) =	4.67
Φ =	5.7



Ninyo & Moore

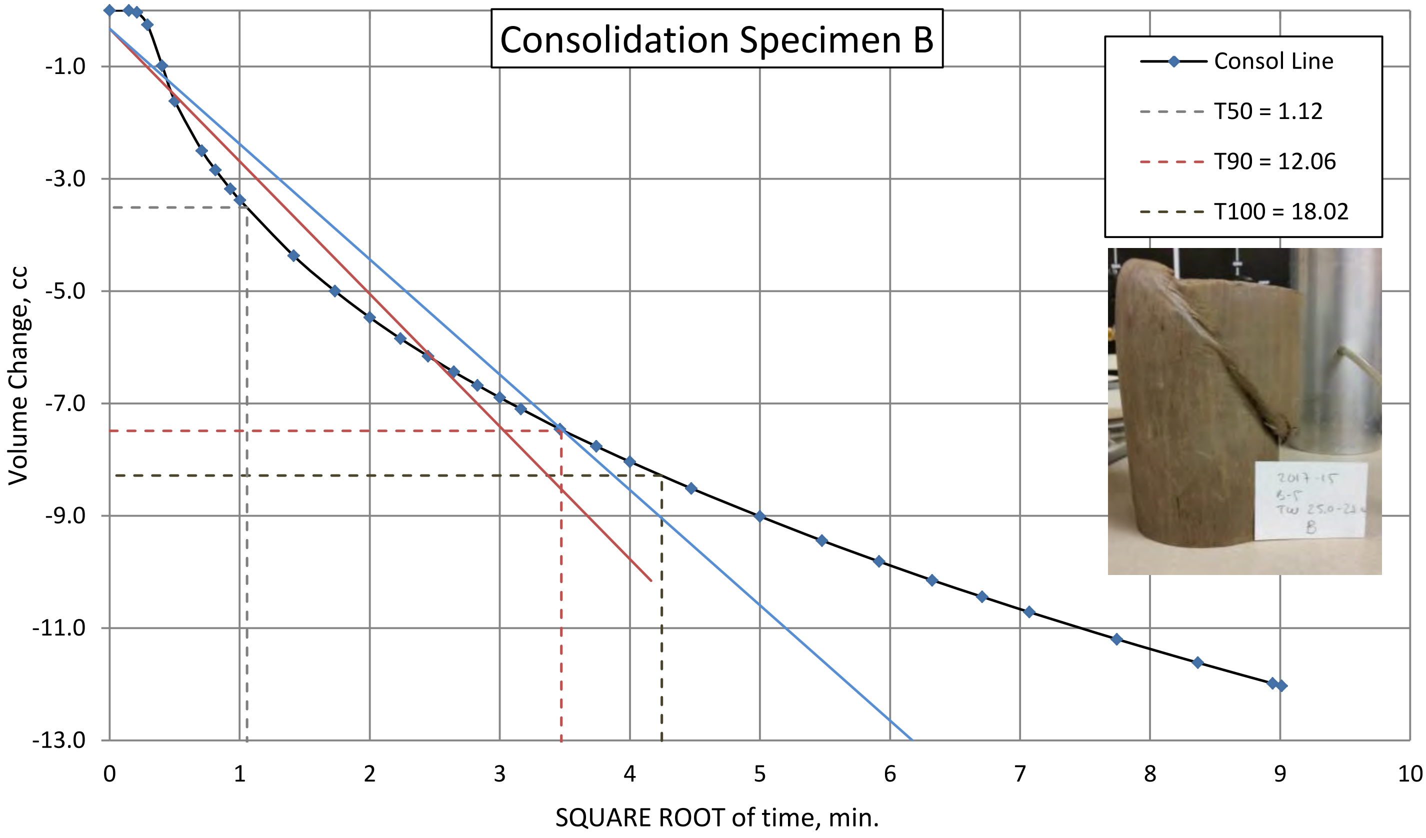
Location:	**B-5**
Sample Depth (ft):	**TW 25.0-27.0**
Project Number:	**604667003**
Date:	**3/17**

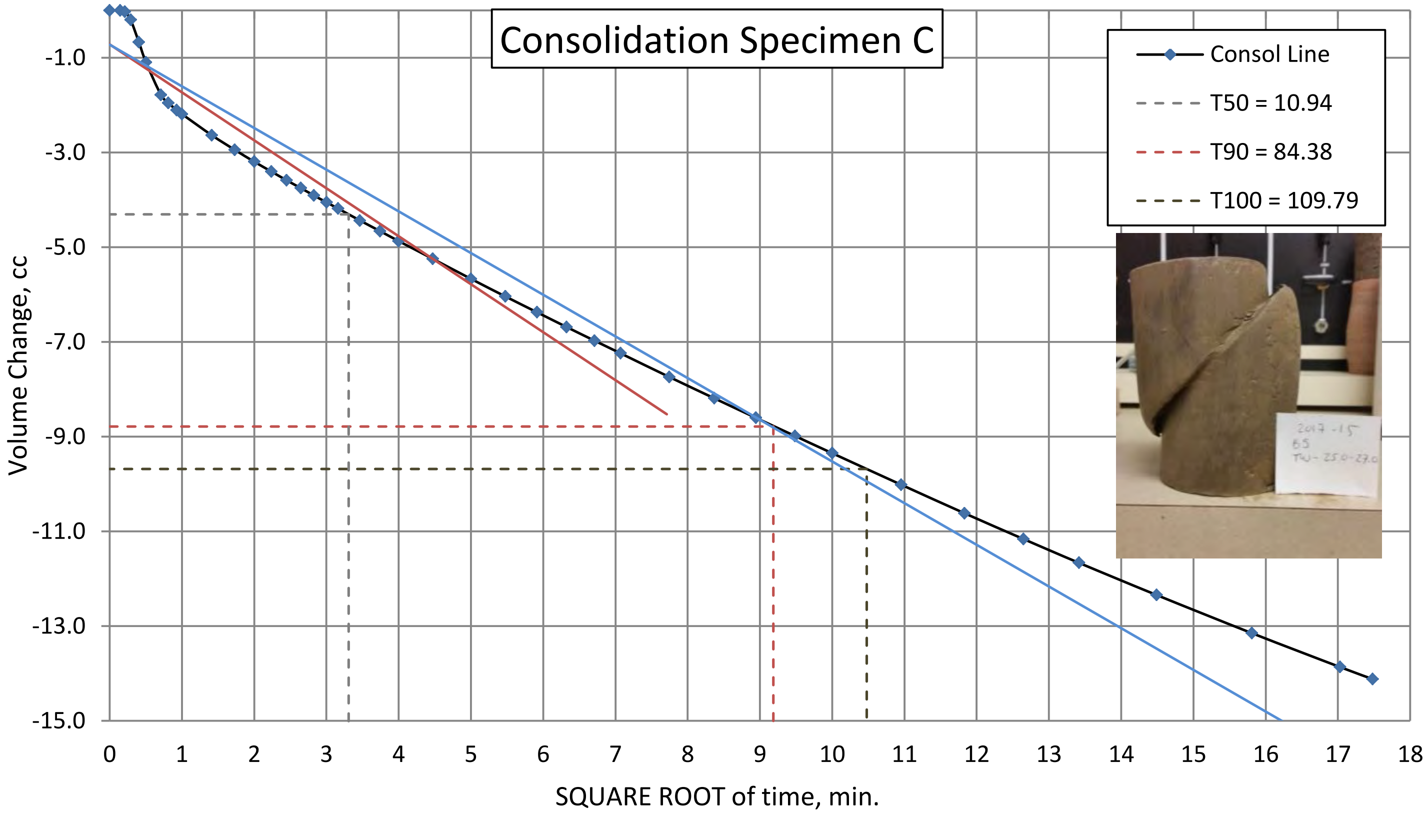
Consolidated Undrained Triaxial Test Data Sheet

STANTEC/MWH/LAB TESTING

PHOENIX, ARIZONA

Figure





Ninyo & Moore

Location:	B-5
Sample Depth (ft):	TW 25.0-27.0
Project Number:	604667003
Date:	3/17

Consolidated Undrained Triaxial Test Data Sheet

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

Figure

SAMPLE LOCATION	COMPRESSION STRENGTH Lb/ft2	VOLUMETRIC DENSITY pcf	SPECIFIC GRAVITY	ABSORPTION %	INITIAL MOISTURE %	SULFATE SOUNDNESS % LOSS
B-1 5.3-9.5	1210	117.4	1.871	10.8	5.6	100.0
B-1 17.3-18.0	2560	135.3	2.096	7.4	2.8	81.8
B-2 26.45-27.25	2490	129.1	2.006	8.1	10.3	88.6
B-3 24.2-24.9	1390	115.6	1.937	9.3	3.9	87.7
B-3 24.9-25.6	1230	117.1	1.920	9.7	3.2	100.0

Ninyo & Moore

COMPRESSIVE STRENGTH OF SOIL SPECIMENS

FIGURE

PROJECT NO.	DATE
604667003	3/17

STANTEC/MWH/LAB TESTING
PHOENIX, ARIZONA

APPENDIX D PETROGRAPHIC ANALYSIS FOR RIRPAP SOURCES

Memo

To:	UNC/GE	From:	Stantec Consulting Services Inc.
File:	NECR Removal Action 60% Design Petrographic Analysis	Date:	April 24, 2017

Introduction

This memorandum has been prepared to assess the suitability of three rock samples for durability and long-term weathering for the project. The three samples analyzed were an igneous rock, a carbonate, and a sandstone. The igneous rock and the carbonate are from offsite quarries. The sandstone is from a rock core sample collected near the buried rock jetty area. The conclusions presented in this document are the results of hand sample and microscopic examination of thin sections analyses of the three samples. Two pieces of the each rock were chosen for thin sections (2 cm x 4 cm) and studied under the petrographic microscope.

Summary

Sandstone – Sampled from the UNC Mill Site

Modal analyses showed that the sandstone is a quartz arenite according to the classification of Folk (1974). The original sample was collected from 2-inch diameter core. The sandstone is fine (0.1mm) to medium (0.25 mm) grained, moderately well sorted, and loosely packed. The sandstone has a weak structure due to the fact that most quartz grains have poorly developed secondary quartz overgrowths, with additional weak cementation resulting from iron oxide and clay formation in the pore spaces.

The bulk of the sandstone is primarily composed of quartz. Subordinate constituents are iron oxides, clays, and rare calcite minerals. Abundant porosity results from the point-to-point grain contacts throughout the sample. These pores appear to be well connected in the two dimensional framework of the thin section, and are probably commonly interconnected in three dimensions. Unlike typical quarts arenites, secondary quartz overgrowths are rare, resulting in a highly friable rock with little competency.

Carbonate (Tampico Limestone)

The limestone sample contains predominately calcite with notable amounts of dolomite. The original rock fragment was approximately 20 cm in diameter and had a pink to rose color. The sample composed of interlocking very fine (0.05 mm) to medium (0.25 mm) grained carbonate crystals, numerous fractures and vugs are filled with large grained recrystallized calcite. The pink coloration is a result of trace amount of iron oxide within the limestone.

With the exception of trace amounts of iron oxide the sample contained only massively interlocking carbonate (calcite and dolomite) grains. The natural filled fractures do not provide structural weakness or a natural flowpath. Rare, isolated, small (0.1mm) pore spaces were observed; however no pore spaces were noted to be connecting, suggesting that the rock has very low effective porosity.

Igneous Rock (Page Granite)

Modal mineral analysis of the igneous sample showed that it is a granite. The original rock fragment was approximately 20 cm in diameter and had a dark pink to red color. The sample composed of fine (0.1 mm) to medium (0.25 mm) grained interlocking crystals. In decreasing abundance the granite contained quartz, orthoclase, plagioclase, hornblende, mica, and hematite. The red coloration results from the abundance of orthoclase (which is pink) and trace amount of iron oxide observed staining some of the grain boundaries. Rare, isolated, small (0.1mm) pore spaces were observed; however, no pore spaces were noted to be connecting, suggesting that the rock has very low effective porosity.

Conclusions

Sandstone

The sandstone is friable and not structurally competent from a mineralogical perspective. The sandstone is judged to be poor material for riprap, equal to a clay cemented sandstone. Figure 1 presents a subjective assessment of the suitability of the sandstone for riprap material. This sandstone is considered to be approximately 3 in terms of its suitability for riprap material.

Limestone

With the exception of the potential for the limestone to react (and dissolve) under acidic conditions, the limestone sample would make good rip-rap material, slightly less competent than a quartzite. The absence of fractures or effective porosity suggests that freeze/thaw will not cause fracturing of the rock. Because of its potential reactivity, this limestone is subjectively judged to be approximately 7 in terms of its suitability for riprap material (Figure 1).

Granite

The granite is very competent and is judged to be excellent material for riprap. This granite is considered to be 10 in terms of its suitability for riprap material. It is considered to be a “10” because of the low porosity (both primary and secondary), the interlocking nature of the grains, lack of sulfide minerals (Figure 1).

Methods

The samples to be examined were chosen by the petrographer and then cut with a diamond saw to expose fresh, flat surfaces. A rectangular billet was cut out of each of the samples with a diamond saw and mounted on a glass slide. The mounted rocks were then ground to about 30 microns on a lapidary wheel; final polishing was completed with a fine lapidary lap by an automatic procedure and then by hand. The thin sections were impregnated with blue-epoxy in a heated laboratory vacuum oven. Following evacuation, atmospheric pressure was used to force the blue epoxy into the pores of the samples.

Thin sections were examined using a Leica Ortholux II petrographic microscope. Color photomicrography was done using a Leica EC3 automatic digital camera mounted on top of the petrographic microscope. Photomicrographs were calibrated by use of an E. Leitz Wetzlar stage micrometer with a 0.01 mm graduated scale. Point counts of the two stained thin sections were made by inserting the thin section into a thin section holder, which was attached to the microscope stage. The holder was adjusted so that the slide would move in increments adjusted to the grain size (approximately one increment per grain) of the samples so that the modal analyses would be representative of the samples. Minerals at the points were recorded on a Lab-Count Denominator.

Point counts consisted of 300 points per thin section. Folk (1974) recommended for purposes of statistical accuracy that at least 300 points are necessary to reflect the mineralogy of a sample in a modal analysis.

Holes in sandstone are called “pores”. The pores in these are primary pores created by packing of the grains (in the case of the sandstone) or isolated ‘vugs’ in the granite or limestone sample. These pores are generally no larger than the size of the original feldspar grain or rock fragment (approximately 0.10 to 0.20 mm). Although Folk (1974) recommends that up to 1,000 points in pores be counted per thin section to most accurately assess the amount of porosity, this amount of point-counting is cost prohibitive. Furthermore, when porosity consists of very small moldic pores formed by grain dissolution as in this study, the percentage of porosity acquired from 300 grain pore counts is close enough to the true porosity to be statistically meaningful.

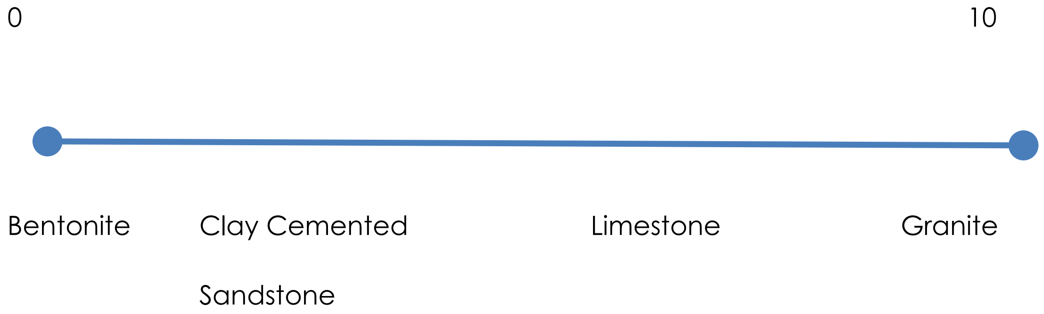


Figure 1. Subjective Estimate of Riprap Suitability

Petrography of the samples

Sample 1. Quartz arenite

Description of sandstone in thin section: Moderately well sorted; poorly-cemented sandstone with predominately 'point-to-point' contacts with cementation dominated by clays and some carbonates. The sample is comprised of mainly quartz with very little altered rock fragments or feldspar; well-developed porosity.

Framework Minerals

Quartz – Fine to medium grained; no quartz overgrowths, long edge to edge contacts rare.

K-feldspar – Angular; very fine grained; one.

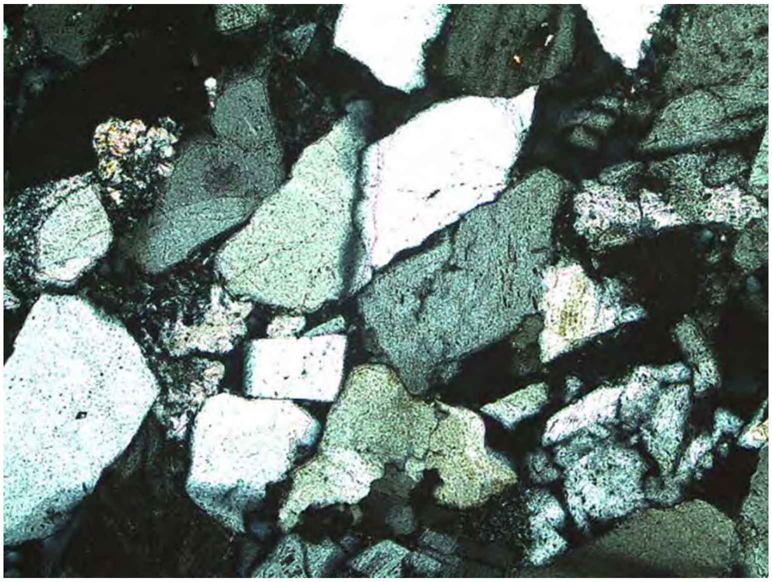
Siltstone rock fragment – Fine grained; subrounded; trace.

Metamorphic rock fragment – Fine grained; mica and quartz; subrounded; trace. Muscovite –0.1 to 0.5 mm long; rare.

Cement

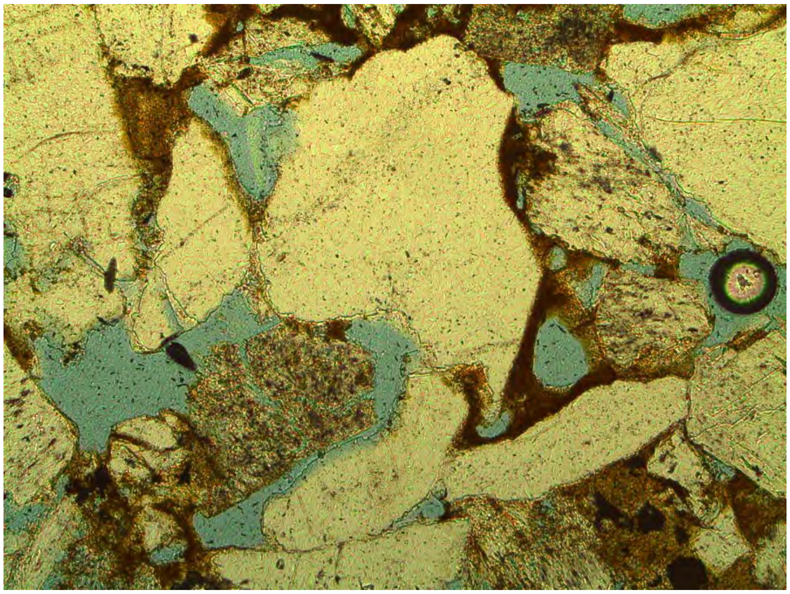
Clay – Clay minerals unidentifiable in thin-section; iron oxide stained; on edges of vugs and in grains.

Iron oxides – Orange-red; pore filling; common.



Photograph 1. Grain-supported quartz matrix, feldspar grain and calcite grains. XP, 100x, FL 1.0 mm.

Photograph 2. Grain-supported quartz matrix (same field of view as Figure 1); feldspar grain and calcite grains identified all other grains are quartz. Blue is epoxy showing pore spaces. LP, 100x, FL 1.0 mm.



Photograph 3. Quartz showing abundant porosity and cementation by iron oxides and clays. PL, 100x, FL 1.0 mm.

XP = Crossed polarizers
PL = Polarized light

100x = Magnification
FL = Long dimension of image

Sample 2. Limestone

Description of sandstone in thin section: Very fine to medium grained; angular to subangular; close packed (long highly sutured contacts); carbonate grains are intergrown and locally recrystallized; Rare porosity (<1%).

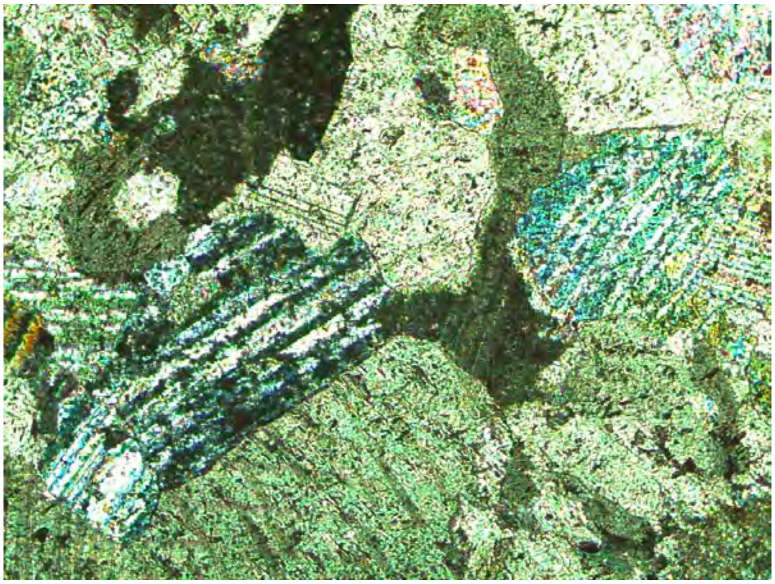
Framework Minerals

Calcite – Occurs in the original rock matrix intergrown with dolomite and recrystallized as fine grained fracture filling.

Dolomite - Occurs in the original rock matrix intergrown with calcite.

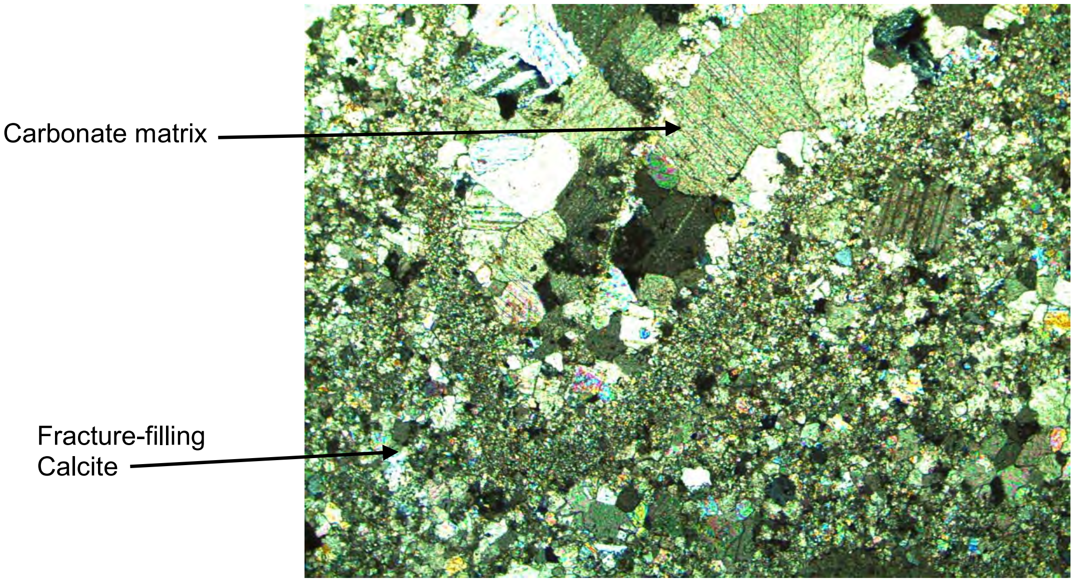
Accessory Minerals

None noted.



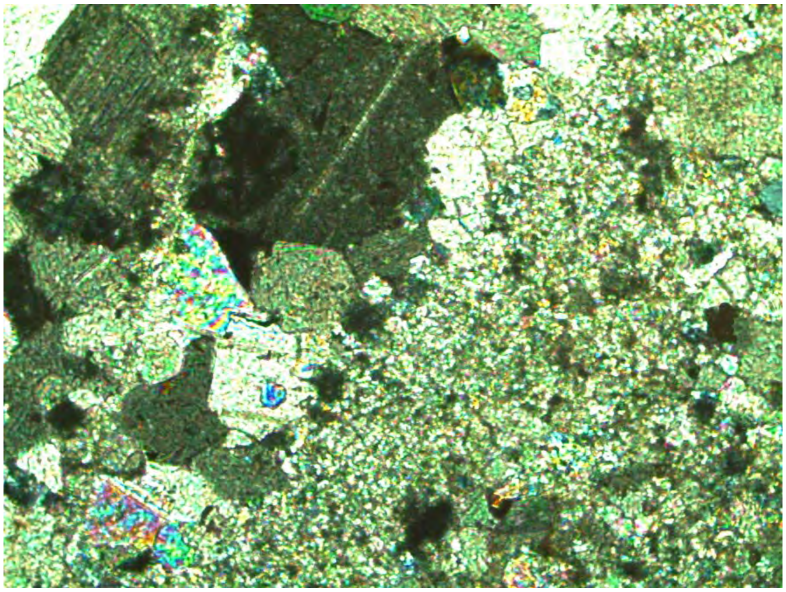
Photograph 4. Interlocking and intergrown carbonate minerals.

XP, 100x, FL 1.0 mm.



Photograph 5. Very fine grained calcite fracture filling.

XP, 40x, FL 2.5 mm.



Photograph 6. Close-up of Figure 5. Note intergrown crystals.

XP, 100x, FL 1.0 mm.

XP = Crossed polarizers
PL = Polarized light
100x = Magnification

FL = Long dimension of image

Sample 3. Granite

Description of sample in thin section: The sample composed of fine (0.1 mm) to medium (0.25 mm) grained interlocking crystals. In decreasing abundance the granite contained quartz, orthoclase, plagioclase, hornblende, mica, and hematite. The red coloration results from the abundance of orthoclase (which is pink) and trace amount of iron oxide observed staining some of the grain boundaries.

Framework Minerals

Quartz – Angular; interlocking with surrounding grains (approximately60%).

K-feldspar – Untwinned and twinned; angular; fine grained; fresh (approximately 20%).

Plagioclase – Twinned; angular; fine grained; fresh (approximately 15%).

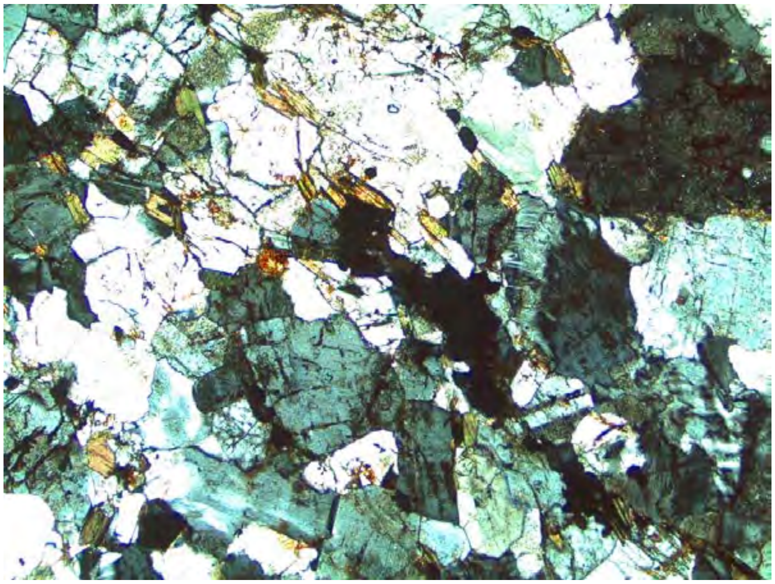
Hornblende – Very fine grained (approximately 3%).

Biotite– some individual grains (approximately1%).

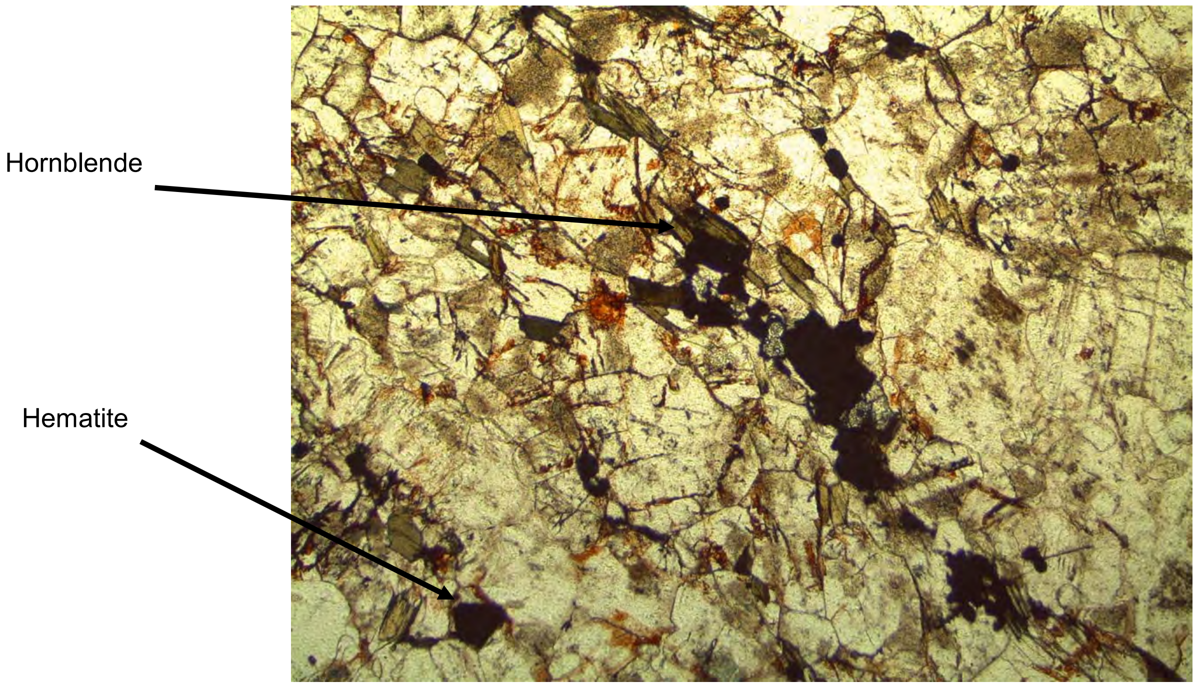
Accessory Minerals

Hematite – Fine-grained (<0.1mm) opaque angular grains; trace

Iron oxides – Orange-brown; clay size; common.



Photograph 7. Granite, showing interlocking euhedral grains.
XP, 100x, FL 1mm.



Photograph 8. Granite, showing interlocking euhedral grains. Note: Opaque hematite and associated hornblende, PL, 100x, FL 1mm.

XP = Crossed polarizers
PL = Polarized light
100x = Magnification
FL = Long dimension of image

References

Folk, R., L., 1974, Petrology of Sedimentary Rocks. Austin, Texas: Hemphill's Book Store, 182 pp.