Northeast Church Rock
95% Design Report

Appendix J:
Technical Specifications

MWH® now part of Stantec

This page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
ARAR	Applicable or Relevant and Appropriate Requirement
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NRC	US Nuclear Regulatory Commission
PTW	principal threat waste
RAO	Removal Action Objective or Remedial Action Objective
ROD	Record of Decision
SOW	Statement of Work
USEPA	US Environmental Protection Agency

J.1 INTRODUCTION

This appendix to the Northeast Church Rock 95% Design Report summarizes the technical specifications that have been developed for the construction activities required for execution of the Removal Action at the Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site). Specifically, this appendix lists the technical specifications and outlines select specifications as noted in other design appendices. The organization of the technical specifications follows a format used successfully for remediation and reclamation of other uranium mine and mill sites in the western US.

J.2 PERFORMANCE STANDARDS

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

Table J.2-1: Task Specific Performance Standards

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
2	2015 AOC SOW, Paragraph 17 – Soil Transportation and Management	Soil Transport and Management	In the Design, Respondents shall provide detailed plans and specifications explaining how mine waste from the NECR Site and other materials (including borrow, backfill, and cover materials) will be managed and transported. Respondents shall include details for ensuring that Principal Threat Waste from the NECR Site, as described in the 2011 Action Memo, is not transported to the UNC Site or disposed at the Tailings Disposal Area.	Mine waste will be excavated and transported to the Repository as discussed in Appendix C. Materials characterized as principal threat waste (PTW) (see Appendices C and T) will be stockpiled for removal from the Mine Site as discussed in Appendix C. Technical specifications have been developed for construction activities, including mine waste excavation and disposal. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
4	2015 AOC SOW, Paragraph 19 – Site Controls and Security	Site Controls and Security	In the Design, Respondents shall include plans and specifications for security for the SA Site to prevent access by unauthorized humans and livestock during the construction of the remedy. Respondents shall include plans and specifications for a fence, cattle guards and other security features, as needed.	Site security and access controls are provided through fencing, gates, and institutional controls. See Appendix M. Technical specifications have been developed for construction activities, including construction of access controls Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
5	2015 AOC SOW, Paragraph 20 – Site Preparation Activities	Site Preparation	In the Design, Respondents shall include detailed plans and specifications for the following site preparation activities: a. An underground utility survey for the identification and verification of the location of subsurface utilities in SA Site areas that will be used for consolidation or disposal; b. A land survey that will delineate the parts of the Tailings Disposal Area that will be used for NECR Site contaminated soil and mine waste disposal; c. A description of construction activities to be undertaken on the portion of the SA Site that is at the UNC Site in order to prepare for placement of the NECR Site contaminated soil and mine waste in the Tailings Disposal Area; d. A description of the methods that will be used to decontaminate existing structures such as culverts, catch basins, foundations, and vaults; and, where decontamination is not practicable, a description of methods that shall be used to disassemble these structures, demolish and remove these structures, or include these structures within the Tailings Disposal Area.	a. See Appendix B – Construction Support Facilities b. See Appendix G – Mine Waste Repository Design c. See Appendix G – Mine Waste Repository Design d. See Appendix C – Mine Site Removal Excavations and Demolition Technical specifications have been developed for construction activities. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
9	2015 AOC SOW, Paragraph 24 – Air Monitoring	Air Monitoring	In the Design, Respondents shall include detailed plans and specifications for air monitoring stations to be installed around the perimeter of the SA Site during the response action. Respondents' detailed plans and specifications shall ensure that perimeter air monitoring stations will be positioned and operated to monitor emissions during dust-or emission-generating activities, including site preparation, construction activities, excavation and backfill, stockpiling (staging), loading of bulk-carriers, stockpile management, consolidation, cap construction and	Technical specifications have been developed for construction activities, including dust control performance standards and/or reference to appropriate plans incorporation of appropriate refer. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1. Additionally, air monitoring and dust control are addressed in such as the

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
			regrading. Respondents shall ensure that their detailed plans and specifications also include dust prevention and dust suppression controls that will be implemented to maintain a safe working environment and to protect human health and the environment.	Air Monitoring and Dust Control Plan (Appendix Q).
11	2015 AOC SOW, Paragraph 26 – Acceptance Criteria	Administrative	For the part of the Tailings Disposal Area that is to contain the mine waste from the NECR Site and for the part of the current tailings cell that may be disturbed during implementation of the remedy, Respondents shall include, in their Design, detailed plans and specifications to meet and demonstrate compliance with Acceptance Criteria consistent with Section 5.1 of NU REG 1620.	See Appendix G – Mine Waste Repository Design Technical specifications have been developed for construction activities Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
12	2015 AOC SOW, Paragraph 27 – Site Restoration	Site Restoration	In the Design, Respondents shall include detailed plans and specifications for restoration of the Tailings Disposal Area and borrow areas on the UNC Site and for restoration of the NECR Site. Respondents shall also include plans and specifications for contouring to promote drainage, and for re-vegetation of the Tailings Disposal Area, borrow pits and NECR Site with native species. Respondents shall include plans and specifications for backfilling and regrading of disturbed (e.g., excavated) areas in the NECR Site and the UNC Site for erosion and storm water control, including re-vegetation of those areas with native species	See Appendix U – Revegetation Plans Technical specifications have been developed for construction activities, including revegetation. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
70	2013 ROD, Table 1	Waste Disposal	10 CFR 61.52(a)(4), 52(a)(5), 52(a)(7), 52(a)(8) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard have been developed for construction activities. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
46	2013 ROD, Table 1	Closure	10 CFR 61.52(a)(9) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard has been developed for construction activities. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
68	2013 ROD, Table 1	Waste Disposal	10 CFR 61.52(a)(10) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard has been developed for construction activities. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
69	2013 ROD, Table 1	Waste Disposal	10 CFR 61.52(a)(11) Land Disposal Facility Operation and Disposal Site Closure. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard has been developed for construction activities. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
97	2013 ROD, Table 1	Waste Disposal	10 CFR 61.56(b) through 56(b)(3) Waste Characteristics. See www.ecfr.gov.	Technical specifications consistent with the listed performance standard have been developed for construction activities. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.
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 Processed Primarily for Their Source Material Content - Criterion 4. Refer to www.ecfr.gov.	Technical specifications consistent with the listed performance standard has been developed for construction activities. Section J.3.2 contains a list of technical specifications and the specifications are included in Attachment J.1.

*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)

J.3 TECHNICAL SPECIFICATIONS

J.3.1 Organization

The technical specifications will be organized into divisions as follows:

DIVISION 01 - GENERAL REQUIREMENTS

DIVISION 02 - SITEWORK

DIVISION 03 - CONCRETE

DIVISION 04 – MASONRY (NOT USED)

DIVISION 05 – METALS (NOT USED)

DIVISION 06 – WOOD AND PLASTIC (NOT USED)

DIVISION 07 – THERMAL AND MOISTURE PROTECTION (NOT USED)

DIVISION 08 – DOORS AND WINDOWS (NOT USED)

DIVISION 09 – FINISHES (NOT USED)

DIVISION 10 – SPECIALTIES (NOT USED)

DIVISION 11 – EQUIPMENT (NOT USED)

DIVISION 12 – FURNISHINGS (NOT USED)

DIVISION 13 – SPECIAL CONSTRUCTION (NOT USED)

DIVISION 14 – CONVEYING SYSTEMS (NOT USED)

DIVISION 15 – MECHANICAL (NOT USED)

DIVISION 16 – ELECTRICAL (NOT USED)

DIVISION 17 – INSTRUMENTATION AND CONTROLS (NOT USED)

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

Section 1: General

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

Section 2: Products

- Material and product requirements

Section 3: Execution

- Performance requirements for execution of the work
- Quality control inspection and testing specifics
- Quality assurance inspection and testing specifics

J.3.2 Specification List

DIVISION 01 - GENERAL REQUIREMENTS
01010 Summary of Work
Note: The Summary of Work specification provides an overall summary of the removal action work items for the benefit of the Construction Contractor during bidding. This specification will be developed concurrent with final bid documents and is not included with the 95% design report.

01015 Removal Action Design Plans
01018 Construction Surveying and Staking
01060 Permits
01070 Abbreviations of Institutions *(this administrative specification is not included with 95% design)*
01090 Reference Standards *(this administrative specification is not included with 95% design)*
01300 Contractor Submittals
01301 Schedule of Values *(this administrative specification is not included with 95% design)*
01310 Construction Schedule
01400 Quality Control
01505 Mobilization
01510 Temporary Utilities
01525 Construction Support Facilities
01530 Protection of Existing Facilities
01532 Site Conditions Surveys – *Not Used, pertinent requirements incorporated into Section 01530*
01551 Construction Access and Haul Roads
01552 Staging and Stockpile Areas
01560 Temporary Environmental Controls
01570 Construction Stormwater Pollution Prevention Plan
Note: This specification will direct the Construction Contractor to comply with the requirements in Appendix E – Stormwater Control Plan and repeats and refers to the information therein. This specification will be completed upon approval or the Stormwater Management Plan and concurrent with final bid documents.

01575 Spill Prevention Control and Countermeasure Plan
01585 Green and Sustainable Practices
01600 Products, Materials, Equipment and Substitutions *(this administrative specification is not included with 95% design)*
01700 Project Closeout *(this administrative specification is not included with 95% design)*

DIVISION 02 - SITEWORK
02000 Control of Dust – *Not used, requirements incorporated in Section 01560*
02050 Demolition – *Not Used, pertinent requirements incorporated into Section 2205.*
02100 Site Preparation
02105 Borrow Areas – *Not used, requirements incorporated in Section 02200.*
02120 Road, Staging, and Parking Area Maintenance
02140 Dewatering and Control of Water – *Not Used, pertinent requirements incorporated into Sections 2200/2205.*
02160 Sediment and Erosion Control – *Not Used, pertinent requirements incorporated into Section 01570.*

J.4 REFERENCES

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

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

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

ATTACHMENT J.1
Technical Specifications

SECTION 01015 – REMOVAL ACTION DESIGN PLANS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall review and conduct all WORK in substantial compliance with COMPANY provided Removal Action Design Plans (RADPs) included in the Contract Documents.

B. The RADPs present the organization, objectives, and activities associated with the implementation of the Selected Remedy at the Northeast Church Rock Site.

1. The objectives of the RADPs include:

   a. Identifying the elements, tasks, activities, and construction sequencing to implement the removal action

   b. Defining the scope of each task and the associated procedures for successful completion of each task

   c. Establishing methods and controls for meeting the established removal action objectives

C. The RADP's listed in this Section are directly related to WORK conducted by the CONTRACTOR. Individual specification sections, where appropriate, call the CONTRACTOR's attention to the related RADP's to facilitate compliance. The following RADP's are included with the Contract Documents:

1. Stormwater Management Plan
2. Health and Safety Plan
3. Traffic Safety and Security Plan
4. Permitting and Compliance Plan
5. Dust Control and Air Quality Monitoring Plan
6. Release, Contingency and Prevention Plan
7. Labor Plan
8. Construction Quality Assurance Plan (CQAP)
9. Cleanup Verification Plan
10. Revegetation Plan

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 01018 – CONSTRUCTION SURVEYING AND STAKING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The WORK under this Section includes providing all labor, materials, tools and equipment necessary to perform all surveying and staking necessary for the completion of the Project in conformance with the Drawings and Specifications and standard engineering and surveying practices, including all calculations required to accomplish the WORK.

B. The Construction Survey work shall include:

1. Verification of design survey control points shown on the Drawings.

2. Staking, referencing and all other actions as may be required to preserve and restore land monuments and property corners which are situated within the Project area.

3. Establishing construction control points as shown on the Drawings and as otherwise needed to provide adequate staking as to perform the WORK.

4. Performing construction staking.

5. Performing construction as-built surveys.

6. Performing construction quantity surveys.

C. The Construction Staking work shall include slope staking for grading operations and offset staking for grades, structures and alignments and other items shown on the Drawings and as required to perform the WORK.

D. Horizontal survey control is New Mexico State Plane West, NAD83, US feet (NM83-WF)

E. Spatial data must be prepared in unprojected coordinates using decimal degree format.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. New Mexico Department of Transportation, Standard Specifications for Highway and Bridge Construction, 2014 Edition. Herein referred to as NMDOT Standard Specifications.

1.3 CONTRACTOR SUBMITTALS

A. Submit in accordance with Section 01300 – Contractor Submittals.

B. The CONTRACTOR shall submit an electronic copy of all surveyors' notes on a quarterly basis. Surveyor's notes shall be scanned and submitted in Adobe Acrobat PDF format.

C. **As-Built Drawings and Survey Data Submittals**

1. Drawings and Survey Data from quarterly and annual as-built surveys conducted in accordance with Paragraph 3.4 of this Section shall be submitted within 30 days of completion of survey. Each As-Built submittal package shall include a CD, DVD or USB drive with the following electronic files:

   a. All raw survey data.

   b. ACAD Drawings of topographic surfaces (AutoCad 2017 Format).

   c. Scanned Adobe Acrobat PDF files of all field/survey notes.

   d. Photographs, or other field data collected by the survey crew.

D. Unacceptable Drawings

1. As-Built survey shall be reviewed by the ENGINEER and incomplete As-Built Drawings will not be accepted.

2. The CONTRACTOR shall revise rejected drawings and resubmit within 10 Days.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 ACCURACY OF SURVEYS

A. Points for cross sections and topographic surveys shall be located to the nearest 0.1 ft horizontally and vertically.

B. Vertical elevation surveys shall close within 0.01 ft times the square root of the length of the circuit in miles.

C. All grade stakes shall be set to 0.1 ft.

D. Alignment of tangents and curves shall be within 0.1 ft.

E. Points for structures shall be set to the nearest 0.1 ft, except where operational function of special features require closer tolerances.

F. Tolerances for all other Work shall be as shown or as specified in individual specification sections.

G. Survey instruments shall be accurate and shall be subject to inspection by ENGINEER for proper operation.

1. Electronic distance measuring (EDM) instruments used by CONTRACTOR on the Site shall be checked for calibration a minimum of once per month on an established base line approved by ENGINEER. Calibration results shall be kept in a log book, available for ENGINEER’s review, showing the date and distances measured on the base line. An EDM shall not be used if it does not meet the minimum advertised accuracy published by the manufacturer of the EDM.

2. Defective instruments shall be promptly replaced, repaired, or adjusted to operate within the tolerances of the instrument manufacturer.

H. All work not performed with the methods and equipment as submitted by CONTRACTOR and accepted by ENGINEER shall be removed and replaced by CONTRACTOR at his own expense.

I. The ENGINEER may randomly spot-check the CONTRACTOR'S surveys, staking and computations at the ENGINEER'S discretion. After the survey or staking has been completed, the CONTRACTOR shall provide the ENGINEER with a minimum of 24 hours notice prior to performing any WORK, and shall furnish the appropriate data as required, to allow for such random spot-checking; however, the COMPANY assumes no responsibility for the accuracy of the WORK.

3.2 SURVEY CONTROL

A. All surveying involving property lines or monuments shall be done by, or under the direction of, a Registered Land Surveyor licensed in the New Mexico.

B. The CONTRACTOR shall use competent, qualified personnel and suitable equipment for the layout work required and shall furnish all stakes, templates, straightedges and other devices necessary for establishing, checking and maintaining the required points, lines and grades.

C. The COMPANY shall supply information relative to the approximate locations of monuments and corners, but final responsibility for locations, referencing, and restoration shall rest with the CONTRACTOR.

D. The CONTRACTOR shall not destroy, remove, or otherwise disturb any existing survey markers or other existing street or roadway markers without proper authorization. No excavation or other work shall be started until all survey or other permanent marker points that will be disturbed by the excavation or work have been properly referenced. Survey markers or points disturbed by the CONTRACTOR shall be accurately restored after the work has been completed.

E. In the event the CONTRACTOR does not replace the survey monuments and property corners disturbed by the CONTRACTOR'S operations, the COMPANY may, after first notifying the CONTRACTOR, replace the monuments in question. The cost of such replacements shall be deducted from payments to the CONTRACTOR.

F. The CONTRACTOR shall obtain all information necessary for as-built plan production, from actual measurements and observations made by its own personnel, including Subcontractors.

G. The CONTRACTOR shall verify the design survey control points shown on the Drawings and review the survey control verification information with the ENGINEER prior to commencing construction staking.

3.3 CONSTRUCTION STAKING

A. The CONTRACTOR shall perform all staking necessary to delineate clearing and/or grubbing limits; all cross sections necessary for determination of excavation and embankment quantities, including intermediate and/or remeasure cross sections as may be required; all slope staking; all staking of culverts and drainage structures, including the necessary checking to establish the proper location and grade to best fit the conditions on site; the setting of such finishing stakes as may be required; the staking of right-of-way; the staking, reference and other actions as may be required to preserve or restore land monuments and property corners; and all other staking necessary to complete the project.

3.4 AS-BUILT SURVEYS

A. The CONTRACTOR shall perform and provide topographic surveys of all completed excavations, including stockpiles (all types), overburden piles, borrow pits, mine waste excavation areas, contaminated soil and sediment excavation areas.

B. **Repository and Mine Waste Excavation As-Built Surveys**

1. In addition to as-built surveys required by paragraph 3.4A, the CONTRACTOR shall perform and provide topographic surveys of the completed mine waste excavation areas and the associated waste placement area in the Repository at the completion of each phase of excavation (Phase 1 through 6).

    a. These surveys may utilize data collected under Paragraph 3.5A.

2. The CONTRACTOR shall perform as-built topographic surveys of the completed mine waste fill and soil cover of the Repository and will be required to perform multiple iterations of the cover survey prior to demobilization to monitor for settlement.

3. Settlement surveys will be required of the mine waste during placement to monitor for settlement resulting from placement of the mine materials, prior to cover placement. The number of surveys will be determined by the ENGINEER based on the CONTRACTOR's proposed placement schedule.

3.5 QUANTITY SURVEYS

A. As-built surveys required by Paragraph 3.4 shall be used as the basis for verifying final quantities of excavations and fills for the WORK in the subject areas. Calculations and quantities shall be provided to the ENGINEER for review.

B. The CONTRACTOR shall conduct additional quantity surveys as needed of all borrow areas and fill areas not subject to the as-built surveys required by Paragraph 3.4. Quantity surveys shall include topographical surveys of these areas before the WORK commences and upon completion of the construction phase or completion of the WORK in the subject area. Calculations and quantities shall be provided to the ENGINEER for review.

C. Surveys for construction quantities shall be conducted:

1. after clearing activity

2. after completion of finished grade

D. At each centerline coordinate for haul and access roads, the CONTRACTOR shall survey a cross section of the existing topography extending 50 feet on either side of the staked road centerline. Vertical data must be accurate to within 1 inch. Horizontal data must be accurate to within 6 inches.

3.6 SURVEY NOTES

A. Field notes shall be kept in standard bound notebooks in a clear, orderly and neat manner, consistent with standard engineering and surveying practices. The CONTRACTOR'S field books shall be available for inspection by the ENGINEER at any time.

B. All field survey notes, including those which become source documentations for which quantities for payment are computed, shall be recorded by a notekeeper furnished by the CONTRACTOR. The notekeeper shall be thoroughly familiar with generally accepted standards of good survey notekeeping practice.

C. The CONTRACTOR shall make all field survey notes available for inspection if requested by the ENGINEER.

D. The CONTRACTOR shall submit copies of all field survey notes on a quarterly basis during the WORK in accordance with Paragraph 1.3C of this Section.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 01060 – PERMITS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall comply with the conditions and requirements of all ARARs and substantive requirements of permits that would be required absent CERCLA. If CONTRACTOR fails to comply with the conditions and requirements of any ARARs and substantive requirements of permits that would be required absent CERCLA and such failure to comply results in fines, penalties, and/or suspension of WORK by a regulatory agency, all liability for such fines, penalties and delays shall be the sole responsibility of the CONTRACTOR.

B. The CONTRACTOR shall comply with the the following Removal Action Design Plan provided with the Contract Documents:

1. Permitting and Compliance Plan

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. CONTRACTOR shall submit all CONTRACTOR obtained permits to the COMPANY and ENGINEER.

1.3 CONTRACTOR OBTAINED PERMITS

A. The CONTRACTOR is responsible for researching and complying with all ARARs and substantive requirements of permits that would be required absent CERCLA, and obtaining all permits as may be required by National and local law for performing the WORK. Duly executed copies of all permits obtained by the CONTRACTOR shall be submitted to the COMPANY and ENGINEER for information only.

1.4 RESPONSIBILITY AND COORDINATION

A. The CONTRACTOR shall contact all national and local agencies to obtain permitting requirements for construction related activities and become familiar with permitting requirements that must be met for the performance of the Contract WORK. The CONTRACTOR shall perform all coordination and documentation, as well as all engineering to obtain the required permits.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 01300 - CONTRACTOR SUBMITTALS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. Wherever submittals are required by the Contract Documents, CONTRACTOR shall submit them to the ENGINEER in accordance with the requirements of this Section. The requirements of this Section apply to all Submittals unless specifically noted on the Drawings or in individual specification sections.

B. Several specific CONTRACTOR plans are required by the Contract Documents and these specifications and shall be submitted in accordance with the requirements of this section. These include, but may not be limited to, the following:

1. Submittals required by the various Removal Action Design Plans referenced in Section 01015.

2. Construction Support Facilities. Refer to Section 01525.

3. Construction Storm Water Pollution Prevention Plan (CSWPPP). Refer to Section 01570.

4. Construction Spill Prevention, Control, and Countermeasures Plan. Refer to Section 01575.

5. Green and Sustainable Practices. Refer to Section 01585.

C. Within 14 days after the date of commencement as stated in the Notice to Proceed, CONTRACTOR shall submit the following items for review:

1. Submittal Schedule

   a. Submit a preliminary schedule of Shop Drawings, Samples, and proposed Substitutes ("or equal") submittals listed in the Bid. Where multiple Submittals are expected under a particular specification section each package should be identified in the Submittal Schedule.

   b. Base the schedule of submittals on CONTRACTOR's priority, planned construction sequence and schedule, long-lead items, and size of submittal package.

   c. Allow time for resubmittals.

2. Submit a list of permits and licenses the CONTRACTOR shall obtain, indicating the agency required to grant the permit and the expected date of submittal for the permit and required date for receipt of the permit.

1.2 PRECONSTRUCTION CONFERENCE SUBMITTALS

A. At the preconstruction conference, CONTRACTOR shall submit the following items to the ENGINEER for review:

1. Revised schedule of Shop Drawings, Samples, and proposed Substitution ("or-equal") submittals listed in the Bid;

2. List of permits and licenses the CONTRACTOR shall obtain, indicating the agency required to grant the permit, the expected date of submittal for the permit, and required date for receipt of the permit (Refer to Specification Section 01060 – Permits);

3. Preliminary Schedule of Values in accordance with Section 01301 – Schedule of Values;

4. a 120-day bar chart plan of operation schedule in accordance with Section 01310 – Construction Schedule; and,

5. a project overview bar chart in accordance with Section 01310 – Construction Schedule;

6. Submittal Register

1.3 SHOP DRAWINGS AND GENERAL SUBMITTALS

A. Wherever called for in the Contract Documents or where required by the ENGINEER, CONTRACTOR shall furnish an email electronic copy of each Submittal. Electronic submittals shall be in Adobe Acrobat portable document format (pdf) and shall be printed directly from the software generating the information. Illegible pdf documents made by scanning of hard copies, and which are not easily readable, shall be rejected.

B. Shop Drawings include detail design calculations, shop-prepared drawings, fabrication and installation drawings, erection drawings, lists, graphs, catalog sheets, data sheets, and similar items.

C. CONTRACTOR shall provide at least one full-size hardcopy of each final, approved, reinforcing steel submittal to the ENGINEER.

D. Whenever the CONTRACTOR is required to submit design calculations as part of a submittal, such calculations shall bear the signature and seal of an engineer registered in the appropriate branch and in the State of New Mexico, unless otherwise indicated.

E. Transmittal Form

1. Shop drawing submittals shall be accompanied by the ENGINEER's standard submittal transmittal form, a reproducible copy of which is available from the ENGINEER.

2. A submittal without the form, or where applicable items on the form have not been completed, shall be returned for resubmittal.

F. Organization

1. Use a single submittal transmittal form for each technical specification Section or item or class of material or equipment for which a submittal is required.

2. A single submittal covering multiple Sections shall not be accepted, unless the primary specification references other Sections for components: For example, if a pump Section references other Sections for the motor, shop-applied protective coating, anchor bolts, local control panel, and variable frequency drive, a single submittal would be accepted, whereas a single submittal covering vertical turbine pumps and horizontal split-case pumps would not be accepted.

3. On the transmittal form, index the components of the submittal and insert tabs in the submittal to match the components.

4. Relate the submittal components to specification paragraph and subparagraph, Drawing number, detail number, schedule title, room number, or building name, as applicable.

5. Unless otherwise indicated, match terminology and equipment names and numbers used in the submittals with those used in the Contract Documents.

G. Format

1. Minimum sheet size shall be 8-1/2 inches by 11 inches, and maximum sheet size shall be 24 inches by 36 inches.

2. Number every page in a submittal in sequence.

3. Collate and staple or bind, as appropriate, each copy of a submittal; the ENGINEER shall not collate sheets or copies.

4. Where product data from a manufacturer is submitted, clearly mark which model is proposed, with complete pertinent data capacities, dimensions, clearances, diagrams, controls, connections, anchorage, and supports.

5. Present a sufficient level of detail for assessment of compliance with the Contract Documents.

6. Numbering

a. Assign to each Submittal a unique number as follows:

1) five-digit number corresponding to the Specification Section to which the Submittal is responding,

2) followed by a two-digit submittal number in sequential order,

3) followed by a two-digit submittal number in sequential order to distinguish between the original Submittal and each resubmittal.

b. For example, 03300-03.01 indicates that the Submittal responds to the requirements of Section 03300 – Cast-In-Place Concrete (03300), is the third (03) Submittal under that section and is the first (01) resubmittal of the product(s) of the unique Submittal.

c. Number the Submittals sequentially for each Specification section, with the submittal numbers clearly noted on the transmittal.

H. Disorganized submittals that do not meet the requirements of the Contract Documents shall be returned without review.

I. ENGINEER's Review

1. Except as otherwise indicated, the ENGINEER shall return prints of each submittal to the CONTRACTOR with comments noted thereon, within 21 Days following receipt by the ENGINEER.

2. It is considered reasonable that the CONTRACTOR shall make a complete and acceptable submittal to the ENGINEER by the first resubmittal on an item.

3. The COMPANY reserves the right to withhold monies due to the CONTRACTOR to cover additional costs of the ENGINEER's review beyond the first resubmittal.

4. The ENGINEER'S maximum review period for each submittal or resubmittal shall be 21 Days; thus, for a submittal that requires 2 resubmittals before it is complete, the maximum review period could be 63 Days.

J. If a submittal is returned to the CONTRACTOR marked "NO EXCEPTIONS TAKEN," formal revision and resubmission shall not be required.

K. If a submittal is returned marked "MAKE CORRECTIONS NOTED," the CONTRACTOR shall make the corrections on the submittal, but formal revision and resubmission shall not be required.

L. Resubmittals

1. If a submittal is returned marked "AMEND-RESUBMIT," the CONTRACTOR shall revise the submittal and resubmit the required number of copies.

2. Resubmittal of portions of multi-page or multi-drawing submittals shall not be accepted: For example, if a Shop Drawing submittal consisting of 10 drawings contains one drawing noted as "AMEND-RESUBMIT," the submittal as a whole is deemed "AMEND-RESUBMIT," and 10 drawings are required to be resubmitted.

3. Every change from a submittal to a resubmittal or from a resubmittal to a subsequent resubmittal shall be identified and flagged on the resubmittal.

M. Rejected Submittals

1. If a submittal is returned marked "REJECTED-RESUBMIT," it shall mean either that the proposed material or product:

a. does not satisfy the Specification,

b. the Submittal is so incomplete that it cannot be reviewed,

c. is disorganized,

d. is illegible, or

e. is a substitution request not submitted in accordance with Section 01600 – Products, Materials, Equipment, and Substitutions.

2. In the first four cases, the CONTRACTOR shall prepare a new submittal and shall submit the required number of copies.

3. In the latter case, the CONTRACTOR shall submit the substitution request according to the requirements of Section 01600 – Products, Materials, Equipment, and Substitutions.

4. The resubmittal of rejected portions of a previous submittal shall not be accepted.

N. Construction, fabrication or procurement of an item may commence only after the ENGINEER has reviewed the pertinent Submittals and returned the Submittal to the CONTRACTOR marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED." Starting construction, fabrication or procurement of an item marked as "MAKE CORRECTIONS NOTED" may commence only if the CONTRACTOR accepts all corrections noted, otherwise further discussion and resubmittal is required. Commencing construction, fabrication or procurement of items of Submittals marked as "MAKE CORRECTIONS NOTED" and not accepted by the CONTRACTOR, "AMEND-RESUBMIT" or "REJECTED-RESUBMIT" shall be at the sole risk of the CONTRACTOR.

O. Corrections indicated on submittals shall be considered as changes necessary to meet the requirements of the Contract Documents and shall not be taken as changes to the contract requirements.

P. Review by CONTRACTOR

1. Submittals shall be carefully reviewed by an authorized representative of the CONTRACTOR prior to submission to the ENGINEER.

2. Each submittal shall be dated and signed by the CONTRACTOR as being correct and in strict conformance with the Contract Documents.

3. For Shop Drawings, each sheet shall be so dated and signed.

4. Any deviations from the Contract Documents shall be noted on the transmittal sheet.

5. The ENGINEER shall only review submittals that have been so verified by the CONTRACTOR.

6. Non-verified submittals shall be returned to the CONTRACTOR without action taken by the ENGINEER, and any delays caused thereby shall be the total responsibility of the CONTRACTOR.

Q. Conformance

1. Corrections or comments made on the CONTRACTOR's Shop Drawings during review shall not relieve the CONTRACTOR from compliance with Contract Drawings and Specifications.

2. Review is for conformance to the design concept and general compliance with the Contract Documents only.

3. The CONTRACTOR shall be responsible for confirming and correlating quantities and dimensions, fabrication processes and techniques, coordinating WORK with the trades, and satisfactory and safe performance of the WORK.

1.4 SAMPLES

A. Quantity

1. The CONTRACTOR shall submit the number of samples indicated by the Specifications.

2. If the number is not indicated, submit not less than 3 samples.

3. Where the quantity of each sample is not indicated, submit such quantity as necessary for proper examination and testing by the methods indicated.

B. Identification and Distribution

1. Individually and indelibly label or tag each sample, indicating the salient physical characteristics and the manufacturer's name.

2. Upon acceptance by the ENGINEER, one set of the samples shall be stamped and dated by the ENGINEER and returned to the CONTRACTOR, one set of samples shall be retained by the ENGINEER, and one set shall remain at the Site in the ENGINEER's field office until completion of the WORK.

C. Selection

1. Unless otherwise indicated, the ENGINEER shall select colors and textures from the manufacturer's standard colors and standard materials, products, or equipment lines.

2. If certain samples represent non-standard colors, materials, products, or equipment lines that shall require an increase in Contract Times or Price, the CONTRACTOR shall clearly state so on the transmittal page of the submittal.

D. The CONTRACTOR shall schedule sample submittals such that:

1. Sample submittals for color and texture selection are complete so the ENGINEER has 30 Days to assemble color panels and select color- and texture-dependent products and materials without delay to the construction schedule; and,

2. After the ENGINEER selects colors and textures, the CONTRACTOR has sufficient time to provide the products or materials without delay to the construction schedule.

3. The Contract Times shall not be extended for the CONTRACTOR's failure to allow enough review and approval or selection time, failure to submit complete samples requiring color or texture selection, or failure to submit complete or approvable samples.

1.5 TECHNICAL MANUAL (NOT USED)

1.6 SPARE PARTS LIST (NOT USED)

1.7 CONTRACTOR RED-LINE DRAWINGS

A. Maintain one set of full-size Contract Drawings at the Site for the preparation of Redline Drawings.

1. On this set, mark changes to location, configuration, material, dimension, and any other change or deviation to the drawing details, cross-sections and plan views which may differ from the Contract Drawings at the time of award except as noted below.

a. Grading changes do not require recording on Redline Drawings.

b. Contaminated soil and sediment excavation limits do not require recording on Redline Drawings.

c. Give special attention to recording the horizontal and vertical location of the following:

1) Buried utilities that differ from the locations indicated, or that were not indicated on the Contract Drawings.

2) Depths and locations of sumps.

3) Pipelines and pipe appurtenances.

2. Supplement the Redline Drawings with any detailed sketches as necessary or as directed, in order to fully indicate the WORK as actually constructed.

3. Use red ink or pencil for alterations and notes.

4. Notes shall identify relevant Change Orders, Substitutions, and RFI's by number and date.

B. The Redline Drawings are the CONTRACTOR's representation of as-built conditions, shall include revisions made by addenda and change orders, and shall be maintained up-to-date during the progress of the WORK.

C. On-site Redline Drawings shall be accessible to the ENGINEER during the construction period for review.

D. Information submitted by the CONTRACTOR shall be assumed to be correct, and the CONTRACTOR shall be responsible for the accuracy of such information.

E. Final Payment

1. Final payment shall not be acted upon until the Redline Drawings and supplemental information has been completed, verified and submitted to the ENGINEER.

2. Redline Drawings are subject to review by the ENGINEER. CONTRACTOR shall revise and resubmit Redline Drawings based upon the ENGINEER'S review.

1.8 AS-BUILT SURVEYS

A. As-Built Surveys shall be conducted and submitted in accordance with Specification Section 01018 – Construction Survey and Staking.

1.9 QUALITY CONTROL (QC) SUBMITTALS

A. Quality control submittals are defined as those required by the Specifications to present documentary evidence to the ENGINEER that the CONTRACTOR has satisfied certain requirements of the Contract Documents.

B. Unless otherwise indicated, QC submittals shall be submitted:

1. Before delivery and unloading, for the following types of submittals:

a. Manufacturers' installation instructions

b. Manufacturers' and Installers' experience qualifications

c. Ready mix concrete delivery tickets

d. Design calculations

e. Affidavits and manufacturers' certification of compliance with indicated product requirements

f. Laboratory analysis results

g. Factory test reports

2. Within 30 Days of the event documented for the following types of submittals:

a. Manufacturers' field representative certification of proper installation

b. Field measurement

c. Field test reports

d. Receipt of permit

e. Receipt of regulatory approval

C. The ENGINEER shall record the date that a QC submittal was received and review it for compliance with submittal requirements, but the review procedures above for Shop Drawings and samples shall not apply.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

SECTION 01310 – CONSTRUCTION SCHEDULE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall schedule the WORK in accordance with the contract documents.

B. Where submittals are indicated, submit 6 copies of each item.

1.2 PLAN OF OPERATION SCHEDULE

A. The CONTRACTOR shall prepare a work plan to complete the WORK within the Contract Time. The CONTRACTOR shall generate a computerized Critical Path Method (CPM) schedule in the Precedence Diagram Method (PDM) format for the WORK. The computerized format shall be generated with a current version of Primavera or other scheduling software as approved by the ENGINEER In addition to the construction activities, the schedule shall include activities for furnishing all required submittals. The Construction Schedule and supporting narrative shall be submitted for approval within ten calendar days after Award of Contract. Failure of the CONTRACTOR to have a Contract Schedule approved by the COMPANY shall be considered cause for withholding progress payment.

B. To the extent that the Construction Schedule or any revisions thereof contains anything not jointly agreed upon in writing, or fails to show anything jointly agreed upon in writing, it shall not be considered to have the approval of the COMPANY. Failure to include any WORK item required for performance of this contract shall not excuse the CONTRACTOR from completion of all WORK within applicable completion dates, regardless of the COMPANY's approval of the schedule.

C. Float is not for the exclusive use of either the COMPANY or the CONTRACTOR, but is jointly owned by both and is a resource available to and shared by both parties as needed to meet contract milestones and the contract completion date.

D. The COMPANY reserves the right to rely on the accuracy of completed, current, and future activities depicted in the Construction Schedule.

E. Failure of the CONTRACTOR to comply with schedule requirements contained in this section shall be considered cause for withholding progress payment or termination for default.

1.3 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit two schedule documents at the preconstruction meeting that shall serve as the CONTRACTOR's plan of operation for the contract time and shall identify the manner in which the CONTRACTOR intends to complete the WORK within the contract time. The CONTRACTOR shall submit the applicable schedule-related reports and requests listed in Section 1.3.B.

B. Submit the following as indicated:

1. Construction Schedule (with narrative)

2. Monthly Progress Report

3. Construction Schedule Change Request

4. “As-Built” Construction Schedule

5. Two-week look ahead schedule with narrative

1.4 PRODUCT

A. Plot and Report Format

1. All plots and reports shall contain the project name, CONTRACTOR name, update number and data date, and scheduled finish date.

2. All plots shall be 11x17 in. size Color plots are preferred, but not required.

3. All plots shall be time-scaled, with a time-line at the top of each page.

4. All reports shall be produced on 8-1/2X11 inch paper.

5. The initial schedule plots shall contain the following minimum information: activity number, activity description, original duration, early start, early finish, total float and the graphical depiction of the schedule.

1.5 EXECUTION

A. The Construction Schedule shall be a computerized CPM schedule in a format that includes the following:

1. The description, order, sequence, and interdependence of all significant WORK items (activities) including construction; procurement, testing, and inspection and delivery of critical or special materials and equipment; submittals and approvals of procedures, or other documents that could have a schedule impact. Tasks shall be limited to not more than fifteen working day durations unless otherwise agreed upon by the COMPANY, and shall identify specific tasks for assessing actual progress of the WORK. The schedule shall include progress milestones which conform to the milestone summary schedule provided by the COMPANY to denote completion of individual work packages.

2. Work items that shall be performed by subcontractors, utilities, and other third parties that may affect or be affected by CONTRACTOR’s activities.

3. Activities organized according to Work Breakdown Structure provided by the COMPANY. Proper referencing/coding of all WORK items to identify applicable geographical work areas, responsibilities such as subcontractors or other performing parties, type of work, and any other project-specific codes mutually agreed to between the COMPANY and the CONTRACTOR.

4. Resource quantities and cost for all estimated labor, equipment and material quantities assigned the individual work items which shall require the resource.

5. A narrative that explains the basis for the CONTRACTOR’s determination of construction logic and estimated duration and man-hours. It shall include estimated quantities and production rates, hours per shift, work days per week, weather allowances, planned holidays, and types, number, and capacities of major construction equipment to be used.

B. The Construction Schedule shall be prepared to include the total duration, from Notice to Proceed through Final Completion, and the critical path shall be identified. No activity other than these milestones shall be open-ended. Each activity shall have predecessor and successor ties.

C. The CONTRACTOR shall submit the following documents upon completion of preparation of the Construction Schedule to the COMPANY and the ENGINEER:

1. A plotted bar chart, with time scale, of the CPM schedule network in PDM format. The WORK items shall be organized by Work Breakdown Structure.

2. A time-scaled plot of the CPM schedule network in PDM format showing all logic ties. The network shall be sorted by "Early Start" date and shall show a continuous flow from left to right, with no logic ties running from right to left.

3. Various computer generated Schedule Reports that contain the following data for each WORK item: identification, description, responsibility, duration, early start and early finish, late start and late finish, and total float. The WORK items shall be sorted by float, early start, project area, Subcontractor, or other sorts mutually agreed to. The reports shall also show the logic ties of successor and predecessor WORK items.

4. An electronic version of the deliverable shall be submitted.

5. The narrative described in Section 1.5.A.5.

1.6 PROGRESS REPORTING

A. At the end of each month, the CONTRACTOR and COMPANY shall agree on the progress of the WORK and the CONTRACTOR shall update the Schedule accordingly. The updated Schedule is a prerequisite to the submittal of the CONTRACTOR's Application for Progress Payment. The schedule shall be made in accordance with Section 1.5.

B. The CONTRACTOR shall send paper or electronic copies of the monthly Progress Report consisting of a written narrative and various schedule reports and plotted charts. This Report shall be reviewed in a meeting between the CONTRACTOR, ENGINEER, COMPANY and Subcontractors.

1. The narrative report shall describe overall progress of the WORK, the percentage completion status based upon actual physical work completed, and provide a critical path analysis. The narrative report shall also discuss significant problems including current and anticipated delaying factors and proposed corrective actions. In addition, the report shall describe all revisions to schedule logic, sequence, and activity duration, with reasons/justification for each change.

2. The schedule reports shall include reports as outlined in Section 1.3.B.

3. Plotted charts shall be provided showing CONTRACTOR's project status. Show progress on each WORK item.

4. Electronic copies shall be provided as described in Section 1.5.

C. The CONTRACTOR shall provide a short-term, two-week look ahead bar chart and narrative. The two-week look ahead shall cover three weeks in total – activities that were completed in the one week preceding, and activities that are active in the two weeks following the week ending data date. The narrative shall provide clarification of planned or completed work (actual dates) dates of the start or completion of planned activities. The CONTRACTOR shall include the mobilization and demobilization of each piece of equipment and a weekly summary of the workforce by supervisory position or craft. The two-week look ahead schedule is to be updated weekly and revised as necessary and be resubmitted to the ENGINEER and COMPANY.

D. If the latest completion time for any significant work item does not fall within the time allowed by the Contract Schedule, the sequence of WORK and/or duration shall be revised by the CONTRACTOR through concurrent operations, additional manpower, additional shifts, or overtime, additional equipment or alternative construction method until the schedule produced indicates that all significant contract completion, occupancy dates, and milestones shall be met. No additional costs shall be allowed if such expediting measures are necessary to meet the agreed completion date or dates, except as provided elsewhere in the Contract Documents.

E. After the updated schedule is approved by the COMPANY, it shall become the approved contract Construction Schedule.

1.7 SCHEDULE CHANGES

A. The CONTRACTOR's request for Construction Schedule changes shall be made on the latest approved construction schedule and be accompanied by a narrative description and justification for the change. Minor revisions submitted at monthly progress review meetings are not considered as changes in this context.

B. The Construction Schedule may be changed when one or more of the following occur:

1. When a Change Order significantly affects the Contract Completion date or sequence of WORK items.

2. When the CONTRACTOR changes the sequence or duration of WORK items affecting the critical path, such changes shall require prior approval of the CONTRACTOR, ENGINEER, and COMPANY.

3. When the COMPANY directs a change that alters the length of a critical path.

1.8 CONTRACT EXTENSIONS

A. Any determination of a time extension shall be based upon analysis of the schedule current at the time the impacting event occurs, and upon all relevant data. If the COMPANY grants the CONTRACTOR an extension of time for Contract completion under the provisions of the Contract, the extension and relevant data shall be incorporated into the next monthly update of the schedule.

B. The CONTRACTOR acknowledges and agrees that delays in WORK items which, according to the schedule analysis, do not in fact actually affect the Contract completion date shown on the CPM network at the time of the delay, shall not be the basis for a contract extension or for a compensable delay or other compensation adjustment.

1.9 DOCUMENTATION

A. After all Contract Work items are complete, the CONTRACTOR shall submit along with final application for payment, an "as-built" Contract Schedule showing actual start and finish dates for all WORK items.

1.10 PAYMENT

A. No separate payment shall be made for WORK under this Section. The cost of the WORK described in this Section shall be included in the applicable bid item or lump sum contract price.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 01400 - QUALITY CONTROL

PART 1 -- GENERAL

1.1 SUMMARY

A. CONTRACTOR shall establish a Quality Control (QC) system to perform sufficient inspection and tests of all work, including that of subcontractors, to ensure conformance with the Contract Documents.

B. Specific quality control requirements for the WORK are indicated throughout the Contract Documents. The term "Quality Control" includes inspection, sampling and testing, and associated requirements of the Specifications.

1.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

A. CONTRACTOR shall review and comply with the following Removal Action Design Plan included with the Contract Documents:

1. Construction Quality Assurance Plan (CQAP), included with the Contract Documents.

B. **QC Manager:** CONTRACTOR shall provide a Quality Control Manager (CQM), responsible for coordinating the CONTRACTOR'S QC system and coordinating QC activities with the ENGINEER. The CQM shall be a member of the CONTRACTOR'S daily on-site staff. The CQM shall be responsible for:

1. Confirming tests and inspections are performed in accordance with the Technical Specifications
2. Reviewing QC reports, tests, and inspection results to determine compliance with design plans and Technical Specifications, and other contractual documents
3. Documenting CQC activities, and supplying this documentation to the CQA team
4. Rectifying nonconformance in a timely fashion
5. Ensuring that CC and subcontractor CQC personnel conducting inspections are adequately trained and understand assignment limits and time frames

C. **QC Technicians.** CONTRACTOR shall provide QC Technicians to support the QCM. The QCM may assume the role of the QC Technician, which includes the following functions:

1. Inspect materials, construction, and equipment for conformance with the Technical Specifications
2. Perform CQC tests, as required by the Technical Specifications

D. **Documentation**: The CONTRACTOR'S CQM shall manage CONTRACTOR'S QC documentation. Sufficient records shall be prepared and maintained as WORK is performed to furnish documentary evidence of the quality of construction and laboratory analysis.

1. QC documentation shall include, at a minimum, the following:

   a. Description or title of the inspection activity

b. Location of the inspection activity or location from which the sample was obtained

c. Recorded observation or test data

d. Results of the inspection activity

e. Personnel involved in the inspection activity

f. Indication of compliance or non-compliance with the Contract Documents

g. Signature of the responsible QC Technician and the QCM

E. **Submittals:** Submit an electronic copy of CONTRACTOR QC documentation to the ENGINEER within 2 days of the generation of such documentation.

F. **Control of Records**: CONTRACTOR shall furnish and maintain a fire-resistant file box at the Project site for storage of CONTRACTOR QC documentation for the duration of the WORK.

G. **CONTRACTOR Inspection and Testing**:

1. The CONTRACTOR shall inspect materials or equipment upon the arrival on the job site and immediately prior to installation, and reject damaged and defective items.

2. The CONTRACTOR shall verify measurements and dimensions of the WORK, as an integral step of starting each installation.

3. Where installations include manufactured products, the CONTRACTOR shall comply with manufacturer's applicable instructions and recommendations for installation, to whatever extent these are more explicit or more stringent than applicable requirements indicated in Contract Documents.

4. Reports of testing shall be submitted to the ENGINEER in accordance with Paragraph 1.2 D.

5. For samples and tests required for CONTRACTOR'S use, the CONTRACTOR shall make arrangements with an independent firm for payment and scheduling of testing. The cost of sampling and testing for the CONTRACTOR'S use shall be the CONTRACTOR'S responsibility.

H. **Notifications:** The CONTRACTOR shall notify ENGINEER a minimum of 24 hours prior to the expected time for operations requiring inspection and laboratory testing services so that technicians can be mobilized to the site.

1. However, Work requiring inspection and laboratory services may be suspended by the ENGINEER for a period of up to 24 hours at the CONTRACTOR’S expense if such notification was not proved to the ENGINEER and technicians are not available.

1.3 INSPECTION AT PLACE OF MANUFACTURE

A. Unless otherwise indicated, all products, materials, and equipment shall be subject to inspection by the ENGINEER at the place of manufacture.

B. The presence of the ENGINEER at the place of manufacturer, however, shall not relieve the CONTRACTOR of the responsibility for providing products, materials, and equipment which comply with all requirements of the Contract Documents. Compliance is a duty of the CONTRACTOR, and said duty shall not be avoided by any act or omission on the part of the ENGINEER.

1.4 SAMPLING AND TESTING

A. The COMPANY shall be defined as UNC/GE and has responsibility for procuring consultants and contractors to perform the RA work, including budgeting and securing the necessary funds, and assuring that the requirements of the RA are met. The COMPANY is responsible for executing administrative aspects of the RA construction contract.

1. The COMPANY shall contract an independent firm to perform inspections, testing, and other services as required by the ENGINEER.

B. Unless otherwise indicated, all sampling and testing shall be in accordance with the methods prescribed in the current standards of the ASTM, as applicable to the class and nature of the article or materials considered; however, the COMPANY reserves the right to use any generally-accepted system of sampling and testing which, in the opinion of the ENGINEER shall assure the COMPANY that the quality of the workmanship is in full accord with the Contract Documents.

C. Any waiver by the COMPANY of any specific testing or other quality assurance measures, whether or not such waiver is accompanied by a guarantee of substantial performance as a relief from the testing or other quality assurance requirements originally indicated, and whether or not such guarantee is accompanied by a performance bond to assure execution of any necessary corrective or remedial WORK, shall not be construed as a waiver of any requirements of the Contract Documents.

D. Notwithstanding the existence of such waiver, the ENGINEER reserves the right to make independent investigations and tests, and failure of any portion of the WORK to meet any of the requirements of the Contract Documents, shall be reasonable cause for the ENGINEER to require the removal or correction and reconstruction of any such WORK in accordance with the General Conditions.

1.5 CONTRACTOR'S INSPECTION AND TESTING SERVICE

A. Inspection and testing laboratory service shall comply with the following:

1. Unless indicated otherwise by the Technical Specifications, the CONTRACTOR shall appoint, employ, and pay for services of an independent firm to perform inspection and testing or shall perform inspection and testing itself.

2. The COMPANY, or independent firm, shall perform inspections, testings, and other services as required by the ENGINEER under Paragraph 1.4C above.

3. The CONTRACTOR shall cooperate with the COMPANY or independent firm and furnish samples of materials, design mix, equipment, tools, storage, and assistance as requested.

4. Retesting required because of non-conformance to requirements shall be performed by the same independent firm on instructions by the ENGINEER. The CONTRACTOR shall bear all costs from such retesting.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

SECTION 01505 - MOBILIZATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. CONTRACTOR shall mobilize as required for the proper performance and completion of the WORK and in accordance with the Contract Documents.

B. Mobilization shall include at least the following items:

1. Moving the CONTRACTOR's plant and equipment necessary for the implementation of the removal action onto the Site.
2. Installing temporary construction power, wiring, and lighting facilities.
3. Establishing fire protection system.
4. Developing construction water supply.
5. Providing field offices complete with furnishings, equipment, and utility services.
6. Providing on-site sanitary facilities and potable water facilities.
7. Arranging for and erection of CONTRACTOR's WORK and storage yards.
8. Constructing and implementing security features.
9. Obtaining required permits.
10. Posting OSHA required notices and establishing safety programs.
11. Having the CONTRACTOR's superintendent at the Site full time.
12. Submitting initial submittals.

C. Mobilization for construction shall include all additional or replacement equipment, plant, camp, materials and supplies required for completion of the WORK in accordance with the Contract Documents.

D. At the conclusion of each construction phase, the CONTRACTOR shall remove all equipment, plant and materials from the site that are not required for future phases of the WORK.

E. At the conclusion of the final remedial phase, all equipment, plant, camp, materials, and supplies shall be removed from the Site and the Site left in its pre-existing condition, except for constructed features. All rubbish shall be removed from the site.

1.2 SUBMITTALS

A. Submittals indicated below shall conform to Section 01300 - Contractor Submittals.

B. As soon as practicable after receipt of the Notice to Proceed, the CONTRACTOR shall submit a mobilization document to the ENGINEER for approval, which shall show the estimated value of each major component of mobilization. When approved by the

ENGINEER, the mobilization document shall be the basis for initial progress payments in which mobilization is included.

1.3 PAYMENT FOR MOBILIZATION

A. Two percent of the Contract Price shall be deducted from any payment due the CONTRACTOR as progress payments until mobilization items listed in Paragraph 1.1 B above have been completed. The aforementioned amount shall be retained by the COMPANY as the agreed, estimated value of completing the mobilization items listed. Any such retention of money for failure to complete such mobilization items shall be in addition to the retention from any payments due to the CONTRACTOR in accordance with the General Conditions.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

SECTION 01510 - TEMPORARY UTILITIES

PART 1 -- GENERAL

1.1 GENERAL

A. The types of utility services required for general temporary use at the Site include the following:

1. Water service (potable and non-potable)

2. Electric power service

3. Communications service

PART 2 -- PRODUCTS

2.1 MATERIALS

A. The CONTRACTOR shall provide either new or used materials and equipment, that are in substantially undamaged condition and without significant deterioration and which are recognized in the construction industry by compliance with appropriate standards, as being suitable for intended use in each case. Where a portion of temporary utility is provided by utility company, the CONTRACTOR shall provide the remaining portion with matching and compatible materials and equipment and shall comply with recommendations and requirements of the utility company.

PART 3 -- EXECUTION

3.1 INSTALLATION OF TEMPORARY UTILITY SERVICES

A. **General**: Wherever feasible, the CONTRACTOR shall engage the utility company to install temporary service to the Site, or as a minimum, to make connection to existing utility service; locate services where they shall not interfere with WORK, including installation of permanent utility services; and maintain temporary services as installed for required period of use; and relocate, modify or extend as necessary from time to time during that period as required to accommodate WORK in progress.

B. **Approval of Electrical Connections:** Temporary connections for electricity shall be subject to approval of the power company representative, and shall be removed in like manner at the CONTRACTOR's expense prior to final acceptance of the WORK.

C. **Separation of Circuits:** Circuits used for power purposes shall be separate from lighting circuits.

D. **Construction Wiring:** Wiring for temporary electric light and power shall be properly installed and maintained and shall be securely fastened in place. Electrical connections shall be in accordance with good electrical practice and the National Electrical Code.

3.2 INSTALLATION OF POWER DISTRIBUTION SYSTEM

A. **Power:** The CONTRACTOR shall provide power required for its operations under the Contract and shall provide and maintain temporary power lines required to perform the WORK in a safe and satisfactory manner.

1. CONTRACTOR plans for connection to existing site utilities shall be submitted in accordance with Section 01300 – Contractor Submittals for review and approval prior to making any such connection.

B. **Generators**: Generators shall be model year 2011 or newer and shall be compliant with 40 CFR Part 1039 - CONTROL OF EMISSIONS FROM NEW AND IN-USE NONROAD COMPRESSION-IGNITION ENGINES. Generators shall comply with the applicable portions of Specification Section 01585 – Green and Sustainable Practices.

3.3 INSTALLATION OF LIGHTING

A. **Construction Lighting:** WORK conducted at night or under conditions of deficient daylight shall be suitably lighted to insure proper performance and to afford adequate facilities for inspection and safe working conditions.

B. **Temporary Lighting**: The CONTRACTOR shall provide a general, weatherproof, grounded temporary lighting system in every area of construction as soon as overhead floor/roof deck structure has been installed to provide sufficient illumination for safe working and traffic conditions. The CONTRACTOR shall run circuit wiring generally overhead, and rise vertically in locations where it shall be least exposed to possible damage from construction operations on grade, floors, decks, or other areas of possible damage or abuse.

3.4 WATER SUPPLY

A. **Water Supply Connections**: The OWNER shall allow connection to the site well for CONTRACTOR use.

B. CONTRACTOR shall provide a construction water submittal for ENGINEER review and acceptance. The submittal shall include, at a minimum:

1. Distribution piping material, sizes, and layout.

2. Water storage tank locations and product data.

3. Control valve products and locations.

C. The CONTRACTOR shall provide and operate pumping facilities, pipelines, valves, hydrants, storage tanks, and other equipment necessary for the adequate development and operation of the water supply system. Potable and non-potable water systems shall be clearly labeled and kept separate. Water used for domestic purposes shall be free of contamination and shall conform to the requirements of the State and local authorities for potable water. Non-potable water only may be used for dust control in mine-affected (contaminated) areas and only with the approval of the ENGINEER. The CONTRACTOR shall be solely responsible for the adequate functioning of its water supply system and shall be solely liable for any claims arising from the use of same, including discharge or waste of water therefrom.

D. CONTRACTOR shall provide water storage facilities to provide sufficient construction water to support construction and dust suppression water demand. The water storage facilities shall have the following operational features:

1. Closed top storage shall be used to limit evaporative loss and shall be portable 21,000 gallon closed top storage tanks, or other system proposed by the CONTRACTOR and approved by the ENGINEER.

2. Tanks shall be interconnected and mechanically connected to the site well for continuous supply. Automatic controls shall be provided to fill the storage system and prevent overfill.

E. Discrete connection stations shall be provided for water trucks operating in contaminated and uncontaminated areas.

F. **Water Connections**: The OWNER shall allow connection to the site well for CONTRACTOR use.

3.5 INSTALLATION OF SANITARY FACILITIES

A. **Toilet Facilities:** Fixed or portable chemical toilets shall be provided wherever needed for the use of CONTRACTOR's employees. Toilets at construction sites shall conform to the requirements of Subpart D, Section 1926.51 of the OSHA Standards for Construction.

B. **Sanitary and Other Organic Wastes**: The CONTRACTOR shall establish a regular collection of sanitary and organic wastes. Wastes and refuse from sanitary facilities provided by the CONTRACTOR or organic material wastes from any other source related to the CONTRACTOR's operations shall be disposed of away from the Site in accordance with laws and regulations pertaining thereto.

3.6 INSTALLATION OF FIRE PROTECTION

A. **Fire Protection:** The construction plant and the WORK shall be connected with the CONTRACTOR's temporary water supply system and shall be adequately protected against damage by fire. Hose connections and hose, water casks, chemical equipment, or other sufficient means shall be provided for suppressing fires in the temporary structures and other portions of the WORK, and responsible persons shall be designated and instructed in the operation of such fire apparatus so as to prevent or minimize the hazard of fire.

B. CONTRACTOR shall maintain a minimum of 10,000 gallons of water and appropriate distribution equipment for fire suppression water storage. Fire suppression water storage shall be part of the construction water storage system or other storage method as approved by the ENGINEER.

3.7 INSTALLATION OF COMMUNICATIONS

A. There is no telephone service at the Mine Site. Cellular telephone service at the Mine and Mill sites is spotty at best and may be non-existent, depending on service provider. The CONTRACTOR shall verify usefulness of cellular telephone service.

B. During the progress of the WORK the CONTRACTOR shall provide and maintain not less than one satellite telephone, in good working order, on Site at all times during construction activities.

A. Radio communications shall be used on Site to provide reliable communications to all parts of the Project Site. Provide the ENGINEER with two good and functional radios, with holsters, and one charger to allow communication with the CONTRACTOR on Site.

3.8 **Internet Services:** The CONTRACTOR shall provide and maintain during the progress of the WORK internet service with not less than 10 mbps download speed and not less than 2 mbps upload speed, and not less than 60 MB monthly data usage allowance. The CONTRACTOR shall provide and maintain a wireless network for use by the COMPANY to access internet services.

3.9 OPERATIONS AND TERMINATIONS

A. **Inspections**: Prior to placing temporary utility services into use, the CONTRACTOR shall inspect and test each service and arrange for governing authorities' required inspection and tests, and obtain required certifications and permits for use thereof.

B. **Protection**: The CONTRACTOR shall maintain distinct markers for underground lines, and protect from damage during excavating operations.

C. **Termination and Removal**: When need for a temporary utility service or a substantial portion thereof has ended, or when its service has been replaced by use of permanent services, or not later than time of substantial completion, the CONTRACTOR shall promptly remove installation unless requested by ENGINEER to retain it for a longer period. The CONTRACTOR shall complete and restore WORK which may have been delayed or affected by installation and use of temporary utility, including repairs to construction and grades and restoration and cleaning of exposed surfaces.

D. **Removal of Water Connections:** Before final acceptance of the WORK on the project, temporary connections and piping installed by the CONTRACTOR shall be entirely removed, and affected improvements shall be restored to original condition or better, to the satisfaction of the ENGINEER and to the agency owning the affected utility.

- END OF SECTION –

SECTION 01525 – CONSTRUCTION SUPPORT FACILITIES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide labor, equipment, and materials to construct the construction support facilities as shown on the Drawings.

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

1.2 REFERENCE REMOVAL ACTION DESIGN PLANS

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

1. Construction Support Facilities and Early Works

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

2. Traffic Safety and Security Plan

   a. This plan includes security and decontamination performance requirements.

3. Dust Control and Air Monitoring Plan

   a. This plan includes dust control and construction water storage requirements.

1.3 CONSTRUCTION FACILITY REQUIREMENTS

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

B. A list of Construction Support Areas and uses are provided in the table below for the CONTRACTOR'S reference:

Area Designation	Function/Use
Security Shacks (North and South)	Access control to Site for all RA related traffic. Scale used for PTW transport and imported materials verification.
Parking	Parking for daily personnel and visitors.
Construction Offices	Area for construction offices (for contractor foremen, site engineer, etc.) Shall be used as the primary sign-in location for all Site visitors (does not include Site worker sign-in/out).
Fuel Farm Area	This area shall be used for bulk fuel storage for mobile fuel trucks. Located within the Support Area to facilitate deliveries without decontamination of delivery trucks. The

Area Designation	Function/Use
	area shall be adjacent to the Support Area perimeter fence to facilitate filling of fuel trucks located within the Exclusion Area.
Water Storage	This area shall be used for bulk water storage. Located within the Support Area to facilitate filling of water trucks operating in the Support Area and the Exclusion Area.
Parking and Yard	Area for: (1) Construction crew to be dropped off and picked up by shuttle vehicles, (2) Exclusion Area vehicle parking, and (3) construction support equipment, maintenance work, storage units, support trailers, etc.
Decontamination Shack	Decontamination equipment storage and maintenance area.
Crew Lunch Area	Area for: (1) Contractor trailers for crew lunches, safety meetings, etc., and (2) sanitary facilities.
Crew Decontamination Area	Area for decontamination trailers and laundry facilities. Flow of personnel to/from this area shall be controlled by fencing and gates. Construction crew shall sign in/sign out when moving through decontamination trailer at lunch breaks and shift changes.
Vehicle Decontamination Area (Primary)	Area for scanning and decontamination of vehicles and equipment leaving the Exclusion Area. This area shall include a paved pad and sump, for collecting impacted water and separating sediment.
Security Shack – Mine	Security and check-in point for access to the work area from NM 566.
Vehicle and Equipment Contamination Control Point	Area for scanning and removal of loose contamination of heavy equipment and vehicles leaving the Mine Site. Dry decontamination methods only. Small support trailer shall include an area where the driver can scan out and sign out.
Mine Site Support Area	Area for: construction support equipment, maintenance work, storage units, support/office trailers, etc.
PTW Staging Area	Area for stockpiling and loading PTW material into highway transport trucks for off-site disposal. Loaded trucks must remain clean or be decontaminated prior to leaving site. All highway trucks shall use the Mill Yard scale to verify optimal loading.
Contractor Clean Yards (north and west)	Clean laydown in the Support Area immediately north or west of the tailings disposal area to be used for construction materials storage, clean borrow or imported material stockpiles, construction support equipment, maintenance, storage units, support trailers, clean vehicle parking, etc.

1.4 SUBMITTALS

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

1. Plan layout and grading of proposed construction support facilities

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

3. Product data for the decontamination pad hot mix asphalt and pre-cast concrete sump.

4. Product data and shop drawings for all temporary facility structures and trailers.

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

6. Any other information required to demonstrate compliance with the requirements of this Section.

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

1.5 ENGINEER'S FIELD OFFICE SCHEDULE

A. The ENGINEER's field office shall be provided by the OWNER.

PART 2 -- PRODUCTS

2.1 COMMUNICATIONS

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

2.2 DECONTAMINATION FACILITIES

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

B. **Vehicle Decontamination Area:** The vehicle decontamination area shall be paved with asphalt concrete and shall drain to a collection sump. The collection sump shall collect impacted water from the vehicle decontamination procedures, and stormwater runoff from the paved decontamination pad. A heated structure shall be provided for screening equipment storage.

C. **Personnel Decontamination Area:** Personnel decontamination facilities shall be located as depicted on the Drawings. The facilities in this area shall include: scanning equipment, showers, lockers (for changing from civilian clothes into work clothes and vice versa), restroom, and laundry facilities.

2.3 TRAILERS, SHACKS AND OFFICES

A. CONTRACTOR shall provide a sufficient number and type of portable and temporary structures appropriate for the required uses listed in Part 1.3.

2.4 CONSTRUCTION AND FIRE SUPPRESSION WATER

A. CONTRACTOR shall provide construction and fire suppression water storage in accordance with Section 01510 – Temporary Utilities.

PART 3 -- EXECUTION

3.1 AREA DESIGNATION AND CONTROLS

A. Support facilities shall provide contamination control through segregation of contaminated and non-contaminated materials and activities. Support facilities shall be organized in areas using the following terms and definitions for the various work areas:

1. Support: Area(s) free of contamination.

2. Controlled: Area(s) with potential contamination.

3. Exclusion: Area(s) with contamination subject to the RA (Mine Site and Repository).

4. Decontamination Area: The transition area between the Controlled area and the Support area. This is where personnel enter and exit the Controlled Area and where most decontamination activities take place.

B. Fencing, gates, and concrete barriers shall be constructed as shown on the Drawings, or as otherwise approved by the ENGINEER, to segregate and control entry and exit into the areas designated in Paragraph 3.1 A.

3.2 TRAILERS, SHACKS AND OFFICES

A. CONTRACTOR shall provide portable and temporary structures appropriate for the required use.

B. All portable and temporary structures shall be founded on sound and graded surfaces and secured from movement according to manufacturer recommendations.

C. Portable and temporary structures shall be in good operating condition and in compliance with applicable OSHA regulations.

D. Sanitation shall be accordance with Section 01510 – Temporary Utilities.

3.3 GENERAL

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

B. Grading, fill placement, gravel surfacing, drainage work shall be constructed as shown on the Drawings and performed in accordance with Section 02200 – Earthwork.

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

D. Concrete work shall be performed in accordance with Section 03300 – Cast-In-Place Concrete or Section 03495 – Precast Concrete.

E. Fencing and gates work shall be performed in accordance with Section 02831 – Chain Link Fencing and Gates

- END OF SECTION –

SECTION 01530 – PROTECTION OF EXISTING FACILITIES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall protect all existing utilities and improvements not designated for removal and shall restore damaged or temporarily relocated utilities and improvements to a condition equal to or better than prior to such damage or temporary relocation, all in accordance with the Contract Documents.

B. Any damage to the COMPANYs' facilities caused by the CONTRACTOR's activities shall be repaired by the CONTRACTOR. Any resulting financial loss to the COMPANY shall be reimbursed by the CONTRACTOR.

1.2 RIGHTS-OF-WAY

A. The CONTRACTOR shall not do any WORK that would affect any water pipeline; any telephone, or electric transmission line; any fence; or any other structure, nor shall the CONTRACTOR enter upon the rights-of-way, permitted land-use area, or area otherwise defined by an access agreement, involved until notified that the COMPANY has secured authority therefore from the proper party.

B. After authority has been obtained, the CONTRACTOR shall give said party due notice of its intention to begin work, if required by said party, and shall remove, shore, support, or otherwise protect such pipeline, transmission line, ditch, fence, or structure, or replace the same.

1.3 PROTECTION OF SURVEY MARKERS

A. The CONTRACTOR shall not destroy, remove, or otherwise disturb any existing survey markers or other existing street or roadway markers without proper authorization. No excavation or other work shall be started until all survey or other permanent marker points that shall be disturbed by the excavation or work have been properly referenced. Survey markers or points disturbed by the CONTRACTOR shall be accurately restored after the work has been completed.

1.4 EXISTING UTILITIES AND IMPROVEMENTS

A. **General:** The CONTRACTOR shall protect underground utilities and other improvements which may be impaired during construction operations, regardless of whether or not the utilities are indicated on the Drawings. The CONTRACTOR shall take all possible precautions for the protection of unforeseen utility lines to provide for uninterrupted service and to provide such special protection as may be necessary.

1. Except where the Drawings indicate utilities have been field located during design or where certain utility locations shall be exposed as part of the WORK, the CONTRACTOR shall be responsible for exploratory excavations as it deems necessary to determine the exact locations and depths of utilities which may interfere with its work. All such exploratory excavations shall be performed as soon as practicable after Notice to Proceed and, in any event, a sufficient time in advance of construction to avoid possible delays to the CONTRACTOR's progress. When such exploratory excavations show the utility location as shown on the Drawings to be in error, the CONTRACTOR shall so notify the ENGINEER.

2. The number of exploratory excavations required shall be that number which is sufficient to determine the alignment and grade of the utility.

B. **Utilities to be Moved:** In case it shall be necessary to move the property of any public utility or franchise holder, such utility company or franchise holder shall, upon request of the CONTRACTOR, be notified by the COMPANY to move such property within a specified reasonable time. When utility lines that are to be removed are encountered within the area of operations, the CONTRACTOR shall notify the ENGINEER a sufficient time in advance for the necessary measures to be taken to prevent interruption of service.

C. **Utilities to be Removed:** Where the proper completion of the WORK requires the temporary or permanent removal and/or relocation of an existing utility or other improvement which is indicated, the CONTRACTOR shall remove and, without unnecessary delay, temporarily replace or relocate such Utility or improvement in a manner satisfactory to the ENGINEER and the COMPANY of the facility. In all cases of such temporary removal or relocation, restoration to the former location shall be accomplished by the CONTRACTOR in a manner that shall restore or replace the utility or improvement as nearly as possible to its former locations and to as good or better condition than found prior to removal.

D. **COMPANY's Right of Access:** The right is reserved to the COMPANY and to the COMPANIES of public utilities and franchises to enter at any time upon any public street, alley, right-of-way, or easement for the purpose of making changes in their property made necessary by the WORK of this Contract.

E. **Underground Utilities Indicated:** Existing utility lines that are indicated or the locations of which are made known to the CONTRACTOR prior to excavation and that are to be retained, and all utility lines that are constructed during excavation operations shall be protected from damage during excavation and backfilling and, if damaged, shall be immediately repaired or replaced by the CONTRACTOR, unless otherwise repaired by the COMPANY of the damaged utility. If the COMPANY of the damaged facility performs its own repairs, the CONTRACTOR shall reimburse said COMPANY for the costs of repair.

F. **Underground Utilities Not Indicated:** In the event that the CONTRACTOR damages existing utility lines that are not indicated or the locations of which are not made known to the CONTRACTOR prior to excavation, a verbal report of such damage shall be made immediately to the ENGINEER and a written report thereof shall be made promptly thereafter. The ENGINEER shall immediately notify the COMPANY of the damaged Utility. If the ENGINEER is not immediately available, the CONTRACTOR shall notify the utility COMPANY of the damage.

1. Costs of locating and repairing damage not due to failure of the CONTRACTOR to exercise reasonable care, and removing or relocating such Utility facilities not indicated in the Contract Documents with reasonable accuracy, and for equipment on the project which was actually working on that portion of the WORK which was interrupted or idled by removal or relocation of such Utility facilities, and which was necessarily idled during such work shall be paid for as extra work in accordance with the Contract Documents.

G. **Approval of Repairs:** All repairs to a damaged utility or improvement are subject to inspection and approval by an authorized representative of the utility or improvement COMPANY before being concealed by backfill or other work.

H. **Maintaining in Service:** Unless indicated otherwise, oil and gasoline pipelines, power, and telephone or the communication cable ducts, gas and water mains, irrigation lines, sewer lines, storm drain lines, poles, and overhead power and communication wires and cables encountered along the line of the WORK shall remain continuously in service during all the operations under the Contract, unless other arrangements satisfactory to the ENGINEER are made with the COMPANY of said pipelines, duct, main, irrigation line, sewer, storm drain, pole, or wire or cable. The CONTRACTOR shall be responsible for and shall repair all damage due to its operations, and the provisions of this Section shall not be abated even in the event such damage occurs after backfilling or is not discovered until after completion of the backfilling.

1.5 TREES WITHIN PROJECT LIMITS

A. General: Except where clearing is indicated, the CONTRACTOR shall exercise all necessary precautions so as not to damage or destroy any trees, including those lying within rights-of-way and Project limits, and shall not trim or remove any trees unless such trees have been approved for trimming or removal by the ENGINEER.

B. Trimming: Symmetry of the tree shall be preserved; no stubs or splits or torn branches left; clean cuts shall be made close to the trunk or large branch. Spikes shall not be used for climbing live trees. Cuts over 1-1/2 inches in diameter shall be coated with a tree paint product that is waterproof, adhesive, and elastic, and free from kerosene, coal tar, creosote, or other material injurious to the life of the tree.

1.6 CULTURAL RESOURCES

A. All cultural resources sites in the vicinity of the work areas must be fenced under supervision of a qualified archaeologist prior to any ground disturbing activities. See Section 02100 Site Preparation for details.

1.7 NOTIFICATION BY THE CONTRACTOR

A. Prior to any excavation in the vicinity of any existing underground facilities, including all water, sewer, storm drain, gas, petroleum products, or other pipelines; all buried electric power, communications, or television cables; all traffic signal and street lighting facilities; and all roadway and state highway rights-of-way, the CONTRACTOR shall notify the respective authorities representing the COMPANIES or agencies responsible for such facilities not less than three days nor more than seven days prior to excavation so that a representative of said COMPANIES or agencies can be present during such work if they so desire.

1.8 FIRE HAZARD REDUCTION MEASURES

A. **Welding**: Welding, cutting, or drilling of metal components shall only be conducted in staging areas, or within areas where vegetation has been cleared to a minimum distance of 30 feet around the center of the work area unless the area has been watered to eliminate the fire danger.

B. **Parking and Staging Areas**: Parking and staging shall be in areas that have been cleared and graded. Any such area, as well as small stationary engine sites shall be cleared of all extraneous flammable materials.

C. **Spark Arrestors and Mufflers**: Each internal combustion engine shall be equipped with a spark arrester, qualified and rated under USDA – Forest Service, Standard 5100-1, unless it is:

1. Equipped with a turbine-driven exhaust supercharger such as the turbocharger. There shall be no exhaust bypass.

2. A multi-position engine, such as on chainsaws, which is equipped with a screen arrester.

3. A passenger-carrying vehicle or light truck intended primarily for use on roads, and equipped with a factory designed muffler and exhaust system.

4. A heavy duty truck, such as a dump or log truck, or other vehicle used for commercial hauling, used only on roads and equipped with a factory designed muffler and with a vertical stack exhaust system extending above the cab.

5. Exhaust equipment described in this subsection, including spark arresters and mufflers, shall be properly installed and consequently maintained in serviceable condition.

D. **Fueling Areas:** Mobile refueling shall only occur in designated staging areas, or in areas that have been cleared of vegetation. All fuel trucks shall be equipped with an ABC fire extinguisher with a 35-pound minimum weight.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION –

SECTION 01551 – CONSTRUCTION ACCESS AND HAUL ROADS

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall make its own investigation of the condition of available public and private roads and of clearances, restrictions, bridge load limits, and other limitations affecting transportation and ingress and egress to the site of the WORK.

B. CONTRACTOR shall construct and maintain construction access roads and haul roads as required for the use by the CONTRACTOR and as indicated on the Drawings.

C. The CONTRACTOR, utilizing CONTRACTOR labor and CONTRACTOR-provided equipment and materials shall plan, manage, supervise and perform all temporary traffic control activities needed to support the Work of the Contract. The CONTRACTOR shall provide flaggers, spotters and all other personnel required for traffic control activities and not otherwise specified.

D. CONTRACTOR shall provide and maintain a construction haul road crossing at New Mexico Highway 566 (NM 566) as required for the use by the CONTRACTOR and as indicated on the Drawings.

E. CONTRACTOR shall provide and maintain a relocated temporary connection to Pipeline Canyon Road at NM 566 for use by public traffic as indicated on the Drawings.

F. CONTRACTOR shall develop and implement a traffic control system for the Mine Waste Haul road traffic control.

1.2 REFERENCE REMOVAL ACTION WORK PLANS

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

1. Traffic Control and Security Plan

a. Special consideration shall be given to the Performance Standards listed in the above referenced plans. CONTRACTOR provided facilities and traffic control methods shall comply with these standards.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. The CONTRACTOR shall submit a Traffic Control Plan (TCP) showing all pertinent traffic control for construction traffic or work which interferes with use of public roads. The CONTRACTOR's TCP shall be reviewed by the ENGINEER and then submitted, after subsequent revision(s) if any, for approval to the New Mexico Department of Transportation in accordance with Paragraph 1.3D. The ENGINEER shall review the TCP and return comments within 7 Days.

C. The CONTRACTORS TCP shall include as a separate section the plan for control of Mine Waste Haul Road traffic and shall specifically address:

1. Safety measures and controls for all haul road traffic at the intersection of NM-566.

2. Safety measures and controls for use of the haul road by light construction vehicles.

3. Safety measures and controls for the transition areas between the one- and two-lane road segments including at a minimum:

   a. Procedures and equipment for haul truck communications.

   b. Signage, lights, flaggers or other controls that will be implemented at and/or before the transition from two to one lanes at STA 21+00 to 22+00 of the Mine Waste Haul Road.

4. The communication system to be implemented for haul road traffic.

5. Driver safety training.

D. The CONTRACTORS TCP shall be submitted to NMDOT as part of a NMDOT District 6 Work Permit Application, with a completed NMDOT Traffic Control/Roadway Work Permit (Form No. A-66). Work that interferes with use of public roads shall not be conducted until NMDOT has provided an approved Traffic Control/Roadway Work Permit.

1.4 USE OF EXISTING ACCESS ROADS:

A. CONTRACTOR shall be allowed to use public roads upon obtaining all required haul permits and approval of the Traffic Control/Roadway Work Permit. CONTRACTOR shall abide by all rules, regulations and plan requirements in using these public roads.

B. CONTRACTOR shall not interrupt public traffic on any public road unless the interruption is included in the approved Traffic Control/Roadway Work Permit.

C. Prevent interference with traffic on existing roads and parking areas. At all times, keep access roads and entrances serving the Site clear and available to ENGINEER, emergency vehicles, and other subcontractors. Do not use these areas for parking or storage of materials.

D. CONTRACTOR shall indemnify and hold harmless COMPANY from expenses caused by CONTRACTOR'S operations over existing roads and parking areas.

E. Schedule deliveries to minimize use of driveways and entrances.

1.5 TRAFFIC CONTROL

A. The CONTRACTOR shall provide signs and other traffic control devices complying with national Standards as contained in the Manual of Uniform Traffic Control Devices (MUTCD). The CONTRACTOR shall erect and maintain all construction signs, warning signs, detour signs, and other traffic control devices necessary to warn and protect the public at all times from injury or damage as a result of the CONTRACTOR's operations, which may occur on or adjacent to highways and roads. No Work shall be done on or adjacent to any traveled way until all necessary signs and traffic control devices are in place.

B. The CONTRACTOR shall be responsible for providing adequate labor, sufficient signs, and other traffic control devices, and for performing traffic control procedures needed for the protection of the Work and the public at all times regardless of whether or not the labor, devices or procedures have been ordered by the COMPANY or the ENGINEER.

C. Wherever possible when performing Contract Work, the CONTRACTOR's equipment shall follow normal and legal traffic movements. The CONTRACTOR's ingress and egress of the Work area shall be accomplished with as little disruption to traffic as possible. Traffic control devices shall be removed by picking up the devices in a reverse sequence to that used for installation. This may require moving backwards through the work zone. When located behind barrier or at other locations shown on approved traffic control plans, equipment may operate in a direction opposite to adjacent traffic.

D. The CONTRACTOR shall comply with the conditions and requirements of all permits required by National, State, Tribal, and local governing agencies in the performance of this Contract. If CONTRACTOR fails to comply with the conditions and requirements of any permit and such failure to comply results in fines, penalties, and/or suspension of work by a regulatory agency, all liability for such fines, penalties and delays shall be the sole responsibility of the CONTRACTOR.

E. Warning signs shall be used to control traffic approaching the Work area from either direction and also from side accesses having standard rectangular or trapezoidal-shaped route markers with horizontal numbering, standard MUTCD shapes, colors, sizes and legends should be used.

F. Hazards incidental to the Work within or on the traveled way, shoulders, or turnouts shall be marked with hazard identification markers, illuminated beacons, and other MUTCD devices to safely guide road users through the area. The CONTRACTOR shall also mark work segments not completed on a daily basis appropriately for night travel. Proper authorization should be obtained before commencing Work at night.

G. Advisory speed plates may be used to control traffic through the Work area.

H. Public traffic delays shall be a maximum of 15 minutes. School buses shall not be delayed.

1.6 ONE WAY TRAFFIC CONTROL

A. The project Work may require that traffic be maintained on a portion of the roadway during the progress of the Work using one-way traffic control. If this is the case, the CONTRACTOR's operation shall be confined to one-half of the roadway, permitting traffic on the other half. If shown on an approved TCP or directed by the ENGINEER, one-way traffic control, in accordance with the MUTCD, shall be provided and shall also conform to the following requirements:

B. In any one-way traffic control configuration, side roads and approaches shall be closed or controlled by a flagger or by appropriate approved signing. A side road flagger shall coordinate with end flaggers where there is line of sight and with the pilot car where the end flaggers cannot be seen. Properly equipped, trained, and certified flaggers should be used where the traffic is required to stop before proceeding. When flag control is used, advance warning signs are required.

C. Queues of vehicles shall be allowed to take turns passing through the work zone in the single open lane. When one-way traffic control is in effect, Contractor vehicles shall not use the open traffic lane except while following the same rules and routes required of the public traffic.

D. As conditions permit, the CONTRACTOR shall, at the end of each day, leave the Work area in such condition that it can be traveled without damage to the Work, without danger to traffic, and without one-way traffic control. If, in the opinion of the ENGINEER, one-way traffic control cannot be dispensed with after working hours, then the operation shall be continued throughout the non-working hours.

1.7 CONSTRUCTION SIGNS

A. All construction signs required by approved TCPs, as well as any other appropriate signs directed by the ENGINEER or COMPANY shall be furnished by the CONTRACTOR. The CONTRACTOR shall provide the posts or supports and erect and maintain the signs in a clean, neat, and presentable condition until the need for them has ended. Post-mounted signs shall be installed as shown in Standard Plans. When the need for construction signs has ended, the CONTRACTOR, upon approval of the ENGINEER, shall remove all signs, posts, and supports from the project and they shall remain the property of the CONTRACTOR.

B. No passing zones on the existing Roadway that are marked with paint striping and which striping is to be obliterated by construction operations shall be replaced by “Do Not Pass” and “Pass With Care” signs. The CONTRACTOR shall provide and install the posts and signs. The signs shall be maintained by the CONTRACTOR until they are removed or until the Contract is Physically Completed. When the project includes striping by the CONTRACTOR, the signs and posts shall be removed by the CONTRACTOR when the no passing zones are reestablished by striping. The signs and posts shall become the property of the CONTRACTOR.

C. All existing signs, new permanent signs installed under this Contract, and construction signs installed under this Contract that are inappropriate for the traffic configuration at a given time shall be removed or completely covered. Construction signs shall be divided into two classes. Class A construction signs are those signs that remain in service throughout the construction or during a major phase of the Work. They are mounted on posts, existing fixed structures, or substantial supports of a semi-permanent nature. Class A signs shall be designated as such on the approved TCP. “Do Not Pass” and “Pass With Care” signs are classified as Class A construction signs. Sign and support installation for Class A signs shall be in accordance with the Contract Plans or the Standard Plans. Class B construction signs are those signs that are placed and removed daily, or are used for short durations which may extend for 1 to 3 days. They are mounted on portable or temporary mountings. Tripod-mounted signs in place more than 3 days in any one location, unless approved by the ENGINEER, shall be required to be post-mounted and shall be classified as Class A construction signs.

D. Where it is necessary to add weight to signs for stability, sand bags or other similar ballast may be used, but the height shall not be more than 4 inches above the Roadway surface, and shall not interfere with the breakaway features of the device. The CONTRACTOR shall follow the manufacturer’s recommendations for sign ballasting.

E. Signs, posts, or supports that are lost, stolen, damaged, destroyed, or which the ENGINEER deems to be unacceptable while their use is required on the project shall be replaced by the CONTRACTOR at the CONTRACTOR’S expense.

F. Equipment

1. All vehicles and machinery operating on or from the traveled way or road shoulder shall be equipped with flashing lights, strobes, or rotary beacons operated continuously while Work is in progress. Headlights shall be used at all times when trucks are operating. Backup horns are required on all self-propelled equipment in excess of 5 metric tons (5½ tons).

2. Vehicles and machinery not used in maintenance operation shall be parked off the traveled way at approved locations to minimize interference with normal use.

1.8 PROTECTION OF EXISTING ROADS

A. The CONTRACTOR, except as noted below, shall not be responsible for damage to existing public roads as long as all permits are obtained and CONTRACTOR abides by all rules and regulations that govern these roads.

1. CONTRACTOR shall reconstruct, or otherwise repair, NM 566 at the location of the haul road crossing to remedy damage from haul trucks. Reconstruction and/or repair work shall be as required by NMDOT.

B. The CONTRACTOR shall be responsible for any damage to private roads resulting from its construction activities. The CONTRACTOR shall repair all damages to the roads in accordance with the requirements of the ENGINEER.

C. Damage to public or private culverts, headwalls or other ancillary roadway structures caused by construction activity shall be repaired by the CONTRACTOR to the satisfaction of the ENGINEER at no extra cost.

1.9 1.9 TEMPORARY CONSTRUCTION ACCESS ROADS

A. The CONTRACTOR may be allowed to construct temporary access roads not indicated on the Drawings for their operations, if written approval is obtained from the ENGINEER.

B. If temporary access roads are approved and constructed, then the CONTRACTOR is required to maintain these roads throughout construction.

C. Construction, maintenance, removal, and reclamation of temporary construction access roads shall be at the CONTRACTOR'S expense.

1.10 HAUL AND ACCESS ROAD CONSTRUCTION

A. Construction of haul and access roads shall be in accordance with Section 02200 – Earthwork.

1.11 HAUL ROADS ON THE EXISTING TAILINGS DISPOSAL AREA COVER

A. Borrow haul roads on the existing Mill Site tailings disposal area (TDA) shall be located as shown on the Drawings or as otherwise approved by the ENGINEER.

B. The CONTRACTOR shall delineate haul roads on the TDA and restrict all vehicle and equipment traffic on the existing TDA to within these delineations.

1.12 REMOVALS AND RESTORATION

A. Roads that are installed or existing roads that are improved for construction access or other remedial action work shall be removed and restored as directed by the ENGINEER.

B. Each temporary access road shall be winterized prior to demobilization for a temporary shutdown. Winterization methods shall incorporate the use of best management practices (BMPs) as defined in the CONTRACTOR’s Stormwater Pollution Prevention Plan (CSWPPP).

1. Removals

   a. Remove haul roads, access roads and staging areas. Return these areas to pre-construction condition unless otherwise required by the Drawings.

   b. Remove temporary gates, fencing, and traffic controls associated with temporary roads and parking areas.

2. Restoration

   a. Repair vegetation on the TDA cover damaged by borrow haul activity to required conditions. All restoration shall be approved by the ENGINEER.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

SECTION 01552 – STAGING AND STOCKPILE AREAS

PART 1 -- GENERAL

1.1 SUMMARY

A. CONTRACTOR shall furnish staging and stockpile areas as required by the Contract or as required to perform the WORK.

1.2 STAGING AREAS

A. The CONTRACTOR shall establish their staging area, including any temporary shop and office facilities, as required by the Drawings or as approved by the ENGINEER.

B. Staging areas for the use by the CONTRACTOR and Subcontractors are as shown on the Drawings. Other staging areas not shown shall be allowed only as approved by the ENGINEER.

C. CONTRACTOR shall provide gravel surfacing and drainage at staging areas to be used for equipment and vehicle parking in accordance with Section 02200 – Earthwork.

D. Any clearing, grubbing, or grading in the staging, stockpile, borrow, and disposal areas performed by the CONTRACTOR for setting up and maintaining this area shall be approved by the ENGINEER, and shall be performed in accordance with and Section 02100 – Site Preparation.

E. Stripping and stockpiling surface soils from staging and stockpile areas shall be in accordance with Section 02100 – Site Preparation.

F. The CONTRACTOR shall make its own arrangements for any necessary off-site storage or shop areas necessary for the proper execution of the work.

1.3 STOCKPILE AREAS

A. The CONTRACTOR shall establish their stockpile areas as required in the Drawings or as approved by the ENGINEER.

1. Major stockpiling areas used for long-term storage shall be established at the locations shown on the Drawings.

2. Minor or short-term stockpiling areas may be used by the CONTRACTOR under the following conditions:

a. Areas shall not extend disturbance areas beyond limits shown on the Drawings, unless approved by the ENGINEER.

b. Areas shall not block, constrict or otherwise limit the flow of traffic on public roads unless approved by the ENGINEER and coordinated as required by the Traffic Control Plan.

c. Areas shall not block, constrict or otherwise limit the flow of surface waters. Drainages shall not be blocked.

B. Any clearing, grubbing, or grading in the staging and stockpile areas performed by the CONTRACTOR for setting up and maintaining this area shall be approved by the ENGINEER, and shall be performed in accordance with Section 02100 – Site Preparation.

C. Stripping and stockpiling surface soils from staging and stockpile areas shall be in accordance with Section 02100 – Site Preparation.

D. Stockpiles shall be constructed in accordance with Section 02200 – Earthwork.

E. Stockpile removal and restoration shall be in accordance with Section 02200 – Earthwork.

1.4 SECURITY

A. The CONTRACTOR is responsible for securing staging and stockpile areas. The CONTRACTOR shall provide any security measures they deem necessary to protect these WORK areas. All security fences and gates, if used by the CONTRACTOR, shall be removed by the CONTRACTOR at the end of construction. The CONTRACTOR shall provide keys for any locks used to the ENGINEER, or access to allow the ENGINEER to place its own padlock on a chain. In any case, the CONTRACTOR shall provide means for ENGINEER access at all times.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

SECTION 01560 - TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 -- GENERAL

1.1 SUMMARY

A. This section covers environmental controls and procedures required to be put in place and followed by the CONTRACTOR including hauling requirements, dust abatement, storm water pollution prevention, water pollution prevention, use of herbicides and pesticides, control of rubbish, noise abatement, and procedures for dealing with cultural resources if such are discovered in the course of the WORK.

1.2 ABATEMENT OF AIR POLLUTION

A. The CONTRACTOR shall comply with the COMPANY'S Air Quality Control and Monitoring Plan provided with the Contract Documents.

B. The CONTRACTOR shall comply with all ARARs and substantive requirements of permits that would otherwise be required absent CERCLA. These shall include all applicable National and local laws and ordinances and regulations concerning the prevention and control of air pollution.

C. In conducting construction activities and operation of equipment, the CONTRACTOR shall utilize such practicable methods and devices as are reasonably available to control, prevent, and otherwise minimize atmospheric emissions or discharges of air contaminants.

D. The CONTRACTOR shall avoid engine idling and use machinery with automatic idle-shutdown devices. Additional requirements for the reduction of air emissions shall be in accordance with Section 01585 – Green and Sustainable Practices.

1.3 DUST ABATEMENT

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

1. Air Quality Monitoring Plan

B. The CONTRACTOR shall prepare, implement and maintain its own Site-specific Dust Control Plan for the Site.

1. The CONTRACTOR shall submit two copies of the Site-specific Dust Control Plan to the ENGINEER for approval. Deliver these documents to the ENGINEER no less than twenty-one (21) days before the start of construction.

2. The ENGINEER will submit the Dust Control Plan to the USEPA for concurrent review.

3. The ENGINEER will review the Dust Control Plan within 14 days. Submittals will be returned to the CONTRACTOR, and marked as either requiring modification or as approved by the ENGINEER.

C. The emission of dust into the atmosphere shall be minimized during hauling, processing, handling and storage of construction materials, and the CONTRACTOR shall use such methods and equipment as are necessary to minimize or prevent dust during these operations to levels consistent with project permit requirements.

D. **Storage Piles**: The CONTRACTOR shall enclose, cover, water (as needed), or apply non-toxic soil binders according to manufacturer's specifications on material piles (i.e. gravel, sand, dirt) with a silt content of 5 percent or greater.

E. **Active Areas of Site**: The CONTRACTOR shall water active construction areas and unpaved roads as needed and as requested by ENGINEER.

F. **Inactive Areas of Site**: The CONTRACTOR shall apply non-toxic soil stabilizers according to manufacturer's specifications to inactive construction areas, or water as needed to maintain adequate dust control.

G. **Vehicle Loads**: Vehicles carrying materials to or from the Site shall be secured and covered in compliance with 40 CFR 49.126(d).

H. **Roads**: When there is visible track-out onto a paved public road, install wheel washers where the vehicles exit and enter the paved roads and wash the undercarriage of trucks and any equipment leaving the Site on each trip. Sweep the paved road at the end of each shift with a **Mobil Athey** or similar water spray pick-up broom-type street sweeper as necessary or as directed by ENGINEER.

1. Site speed limits shall be 20 mph or as otherwise required by the ENGINEER to effectively abate dust.

I. **Dust Suppression Water**: Dust suppression water for use in uncontaminated areas, or areas that have been verified as clean, including the borrow areas and clean haul roads, shall be from the on-site water supply well, or other source approved by the ENGINEER.

1.4 STORMWATER POLLUTION PREVENTION

A. CONTRACTOR shall prepare, implement and maintain a Construction Storm Water Pollution Prevention Plan (SWPPP) in accordance with Section 01570 – Storm Water Pollution Prevention Plan.

1.5 PREVENTION OF WATER POLLUTION

A. The CONTRACTOR shall prepare, implement, and comply with a Spill Prevention Control and Counter Measure Plan (SPCCP) in compliance with Specification Section 01575 - Spill Prevention Control and Counter Measure Plan.

1.6 RUBBISH CONTROL

A. During the progress of the WORK, the CONTRACTOR shall keep the Site and other areas for which it is responsible in a neat and clean condition and free from any accumulation of rubbish. The CONTRACTOR shall dispose of rubbish and waste materials in accordance with Part 1.7.

1.7 WASTE DISPOSAL

A. **Contractor Generated Waste:**

1. The CONTRACTOR is responsible for proper disposal of all construction waste generated by the CONTRACTOR'S operations.

2. **Clean (uncontaminated) Areas of the Construction Support Zone (“Outside the Fence”)**:

   a. All CONTRACTOR-generated waste shall be disposed of in a proper manner via the use of onsite dumpsters supplied by the CONTRACTOR. The CONTRACTOR shall provide removal services by a licensed solid waste management firm.

   b. Dumpsters shall be emptied a minimum of once per week and more often if necessary, unless otherwise approved by the ENGINEER. CONTRACTOR generated waste materials shall be disposed of in an approved solid-waste facility or other approved facility.

   c. It shall be the responsibility of the CONTRACTOR to make necessary arrangements with private parties and with local officials pertinent to locations and regulations of area landfills in the vicinity of the project. Fees or charges required to be paid for disposal of materials shall be paid by the CONTRACTOR. In the event that certain materials cannot be disposed of in the area waste disposal facility, the CONTRACTOR shall identify a suitable alternative approved waste disposal facility and shall dispose of the material at such facility at no additional cost to the COMPANY.

3. **Areas Within the Contaminated Area (“Inside the Fence”)**:

   a. Large items of construction generated waste such as haul truck tires shall be decontaminated to the extent practicable.

   b. Waste that cannot be decontaminated shall be disposed of in the Repository in areas and with methods approved by the ENGINEER.

B. **Non-Mine Hazardous Wastes:** All hazardous materials used for the construction shall be stored, handled, and applied per the manufacturer’s printed instructions and per all applicable Federal, State, and local codes. The CONTRACTOR shall ensure that the CONTRACTOR’S onsite work crews and subcontractors are trained and knowledgeable in the proper manner of disposal for hazardous wastes. The disposal of hazardous wastes from the Site shall be the responsibility of the CONTRACTOR and be performed by a licensed hazardous waste management firm.

C. **Record Keeping**: The CONTRACTOR shall maintain records of the type and quantity of waste materials disposed from the Site, the disposal firm, and other information required by Federal, State, and local regulations. These records shall be maintained in the CONTRACTOR’S construction trailer during the entire construction period and available for inspection. A copy of the records shall be transferred to the COMPANY at the end of the construction period.

1.8 SANITATION

A. Sanitary facilities shall be provided in accordance with Section 01510 – Temporary Utilities.

1.9 CHEMICALS

A. Chemicals used on the WORK or furnished for facility operation, whether defoliant, soil sterilant, herbicide, pesticide, disinfectant, polymer, reactant, or of other classification, shall show approval of either the U.S. Environmental Protection Agency or the U.S.

Department of Agriculture. Use of such chemicals and disposal of residues shall be in strict accordance with the printed instructions of the manufacturer.

1.10 ABATEMENT OF NOISE

A. The CONTRACTOR shall comply with all ARARs and substantive requirements of permits that would otherwise be required absent CERCLA. These shall include Tribal regulations, applicable National and local laws and ordinances, orders, and regulations concerning the prevention, control, and abatement of excessive noise.

B. Construction activities shall be performed only during COMPANY approved working hours.

1.11 CULTURAL RESOURCES

A. In the event potential cultural resources are discovered during subsurface excavations at the Site, the following procedures shall be instituted:

1. The COMPANY shall issue a temporary Notice to Suspend Work directing the CONTRACTOR to cease construction operations at the location of identified potential cultural resources.

2. The suspension Notice shall contain the following:

a. A clear description of the WORK to be suspended.

b. Instructions regarding issuance of further orders by the CONTRACTOR for material services.

c. Guidance as to the action to be taken on subcontracts.

d. Suggestions to the CONTRACTOR to minimize incurred costs.

e. Estimated duration of the temporary suspension.

3. Such suspension shall be effective until such time as a qualified archeologist can assess the value of the potential cultural resources and appropriate actions have been determined.

B. Changes to the Contract Price and Contract Times for suspension due to discovery of a potential cultural resource shall be made in the following manner:

1. Contract Times

a. If the WORK temporarily suspended is on the “critical path”, the total number of Days for which the suspension is in effect shall be added to the Contract Times.

b. If a portion of WORK at the time of such suspension is not on the “critical path”, but subsequently becomes WORK on the critical path, the Contract Times shall be computed from the date such WORK is classified as on the critical path.

2. Contract Price

a. If, as a result of a cultural resources suspension, the CONTRACTOR sustains a loss that could not have been avoided by judicious handling of forces and equipment or redirection of forces or equipment to perform other WORK on the contract, there shall be paid an amount based on time and materials for the loss in accordance with the following:

1) Idle Time of Equipment: Compensation for equipment idle time shall be determined in accordance with the General Conditions for equipment time and equipment rental time.

2) Idle Time of Labor: Compensation for idle time of workers shall be determined in accordance with the General Conditions for labor.

b. Costs of labor shall be compensated only to the extent such cost was in fact caused by the suspension.

c. Compensation for loss due to idle time of either equipment or labor shall not include markup for profit.

d. The hours for which compensation shall be paid shall be the actual normal working time during which such suspension lasts, but shall in no case exceed eight hours in any single day.

e. The days for which compensation shall be paid exclude Saturdays, Sundays, and legal holidays during the suspension.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 01575 – SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The WORK described in this section shall consist of providing all labor, equipment, materials, and services to prepare, implement, and maintain a Construction Spill Prevention Control and Countermeasures Plan (CSPCCP) for the Project.

B. All construction activities shall be conducted in compliance with the ENGINEER approved CSPCCP and the measures identified therein. This specification section provides a minimum standard and requirement for the CONTRACTOR to develop and implement the CSPCCP.

1.2 RELATED SPECIFICATION SECTIONS

A. 01570 – Construction Storm Water Pollution Prevention Plan (CSWPPP)

B. 01560 – Temporary Environmental Controls

1.3 REFERENCES

A. The CSPCCP shall be developed in accordance with 40 CFR Part 112.

1.4 SUBMITTALS

A. Submit two signed copies of the CSPCCP to the ENGINEER for approval no less than forty-five (45) days before construction begins.

1. The ENGINEER will submit the CSWPPP to the USEPA for concurrent review.

2. The ENGINEER will review the CSPCCP submittals within thirty (30) days. CSPCCP Submittals will be returned to the CONTRACTOR, and marked as either requiring modification or as approved by the ENGINEER.

PART 2 -- SPILL PREVENTION CONTROL AND COUNTERMEASURES

2.1 CSPCCP CONTENTS

A. The CSPCCP shall address prevention of pollution that stems from the storage, use, containment, cleanup, and disposal of hazardous material, including oil products related to construction activities and equipment. Refer to 40 CFR 117 and 302 for listing of hazardous materials. Collate Material Safety Data Sheets in one location and reference location in CSPCCP.

B. List the types and quantities of equipment and cleanup materials available on site. Include a list and location map of cleanup materials, at each different work site and readily available off site (main site, material site, batch plant, storage yard, explosives dump, equipment or fueling yard, etc.).

C. Specify the line of authority and designate a field representative for spill response, and one representative for each subcontractor.

D. List and give the location of hazardous materials, including office materials, to be used or stored on site, and estimated quantities. Store hazardous materials in covered storage areas.

E. Detail methods of disposing of waste petroleum products and other hazardous materials generated by the project.

F. Identify the locations where storage, fueling and maintenance activities will take place, describe the maintenance activities, and list controls to prevent the accidental spillage of oil, petroleum products and other hazardous materials.

G. Detail procedures for containment and cleanup of hazardous substances. Detail a plan for the prevention, containment, cleanup, and disposal of soil and water contaminated by accidental spills. Detail a plan for dealing with unexpected contaminated soils and water encountered during construction.

2.2 WASTE DISPOSAL

Waste disposal from the construction site for CONTRACTOR generated wastes, sanitary wastes, chemicals, and non-mine hazardous wastes shall be conducted in accordance with Section 01560 – Temporary Environmental Controls.

PART 3 -- EXECUTION

3.1 SPILL PREVENTION

A. <u>Hazardous Materials</u>: The following additional housekeeping practices shall be followed for hazardous construction materials:

1. Hazardous materials shall be stored separately from non-hazardous materials onsite.

2. Products shall remain in their original containers with the original legible product label attached to the container.

3. All products shall be used before disposal of the container.

4. The handling and storage of all hazardous materials shall follow the manufacturer's written instructions, the project specifications, or applicable governmental codes, whichever is most stringent.

5. Hazardous materials, including diesel fuel, must be stored in contained areas which are able to contain 150 percent of the volume of the largest container's contents. If the area is not exposed to stormwater, the volume of the containment area shall be 110 percent of the volume of the largest container's contents. Each hazardous material shall be stored in its own containment area. Under no circumstances shall hazardous materials be used or stored within 100 feet of any water supply well, unless specifically permitted by the ENGINEER and governing Federal, State, or local agency.

   a. At a minimum, the containment area shall be constructed with dikes and lined with a material resistant to the properties of the hazardous material being contained. Before removal of any stormwater from the containment area, a representative sample of the water shall be tested for contamination by the hazardous material stored in that containment area. If the stormwater is found to be contaminated, as defined above, the CONTRACTOR shall follow the spill control measures for this hazardous material.

6. The CONTRACTOR shall maintain all manufacturer's storage, handling, use, and disposal recommendations and post the Material Safety Data Sheets of all hazardous materials at the CONTRACTOR'S construction trailer.

7. The CONTRACTOR shall inspect the hazardous materials storage area on a daily basis to ensure proper storage of the hazardous materials.

8. The CONTRACTOR shall maintain an inventory of hazardous materials stored onsite. The inventory shall be kept in the CONTRACTOR'S construction trailer and be available for inspection by the ENGINEER.

9. When transferring or unloading hazardous materials, the CONTRACTOR shall ensure that the area is either protected from stormwater and that the materials transfer operation shall not cause contamination (as defined above) to stormwater. The hazardous materials handling operation shall occur in a contained area on the construction site. If any spillage or leakage occurs during the materials handling operation, the CONTRACTOR shall follow the spill control practices listed in the approved CSWPPP.

10. During adverse weather, as described in the General Conditions of the Contract Documents, and against the possibility thereof, the CONTRACTOR shall take all necessary precautions to insure the protection of the hazardous materials storage areas.

B. **Product Specific Practices:** Special stormwater management specific practices shall be utilized for specific products. These products are discussed in the following sections.

1. <u>Petroleum-Based Products</u>: All onsite vehicles shall be properly maintained and checked for any leaks of fluids or petroleum-based products. If a leak is found, the vehicle shall be repaired immediately or removed from the site. Diesel fuel shall be considered a hazardous material and stored in a containment area as indicated above.

2. <u>Acid and Base Chemicals</u>: All acid and base chemicals are considered hazardous materials and shall be stored in containment areas as described above. Disposal of acid or base chemicals shall, under no circumstances occur via the storm drain system, but instead through proper hazardous materials disposal procedures.

3. <u>Paints, Thinners and Solvents</u>: Paints, thinners and solvents shall be stored in their original containers. Unused paints, thinners, and solvents shall not be dumped onsite. Disposal of unused paints, thinners and solvents shall be through proper hazardous materials disposal procedures.

4. <u>Concrete Trucks</u>: The washdown of concrete trucks or the disposal of unused or unacceptable concrete from a concrete truck will be permitted onsite only if the CONTRACTOR has set aside a specific area, with dikes to prevent contact between the washdown water or excess concrete and stormwater, for this purpose. Once the solids in the area have hardened, the CONTRACTOR shall dispose of the solids in a proper manner as approved by the ENGINEER.

C. **Spill Control Practices:** In addition to good housekeeping practices, hazardous materials practices, and the product specific practices described above, the CONTRACTOR shall implement all practices defined in the Agency approved Spill Prevention, Control, and Countermeasures Plan. At a minimum the following practices shall be followed:

1. Any and all spills shall be cleaned immediately.

2. The CONTRACTOR shall notify the ENGINEER, COMPANY, and all applicable governmental agencies if a spill occurs, particularly if a hazardous material spill occurs.

3. Manufacturer's printed instructions for the cleanup of a spill shall be kept onsite by the CONTRACTOR at all times. The CONTRACTOR'S work crews and subcontractors shall be required to be familiar with the requirements and procedures for spill cleanup. Equipment necessary for spill cleanup, such as gloves, metal containers, mops, etc., shall be maintained onsite by the CONTRACTOR. The cleanup instructions and the location of the cleanup equipment shall be posted onsite at the CONTRACTOR'S construction trailer during construction activities.

4. Workers involved in the cleanup of a spill shall be properly protected by protective suits, ventilation masks, goggles, and other necessary equipment, prior to contact with the spilled material.

5. The CONTRACTOR shall name an employee or employees who will be onsite full-time throughout the duration of the project as the spill cleanup coordinators. The spill cleanup coordination will be responsible for notifying the proper personnel and agencies of a spill and obtaining the proper equipment and personnel to clean up the spill. The name and phone number where the spill cleanup coordinator can be reached at all times shall be posted on the construction site. The spill cleanup coordinator shall be properly trained in spill cleanup procedures.

6. The CONTRACTOR shall maintain material data safety sheets for all hazardous materials in the CONTRACTOR'S trailer. The spill cleanup coordinator shall have access to the material data safety sheets at all times during construction. The CONTRACTOR shall provide the ENGINEER with a copy of all the material data safety sheets.

7. After a spill is contained and cleaned up, a spill occurrence report shall be completed by the onsite inspector. A copy of the form is attached. The CSPCCP shall be modified to prevent a reoccurrence of a type of spill.

- END OF SECTION -

Spill Incident Report

NOTE: ALL EMERGENCY NOTIFICATIONS TO LOCAL, STATE, OR FEDERAL AGENCIES ARE TO BE MADE BY THE SITE MANAGER, OR DESIGNEE.

Date:____

Report by / Title: ____

Date of Incident: ____

Location: ____

Contractor(s) Involved: ____

Were there injuries as a result of the spill?

☐ No ☐ Yes If yes, specify:

Was there a fire or explosion?

☐ No ☐ Yes

Were SPCC regulated materials involved?

☐ No ☐ Yes If yes, specify:

Briefly describe the succession of events:

Briefly describe the cause of the spill:

Briefly describe the corrective actions taken:

Indicate which notifications were made:

☐ National Response Center
(800) 424-8802

☐ NM State Police 24-hour Dispatch

☐ USEPA

☐ NRC

☐ NNEPA

☐ NMDOT

☐ McKinley County Sheriff

☐ Other:

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 01585 – GREEN AND SUSTAINABLE PRACTICES

PART 1 -- GENERAL

1.1 GENERAL DESCRIPTION

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

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

Materials Management	Paper reduction Recycling Equipment Reuse
Water Management	Water treatment plant effluent for site water uses, as appropriate
Air Emissions Reduction	Ultra-low sulfur diesel fuel for vehicles and equipment Vehicle and equipment "no-idling" policy Vehicle speed limit Worker Transportation (carpool/rideshare) Emissions reduction measures for temporary generators Non-road diesel equipment fleet requirements

1.2 REFERENCES AND STANDARDS

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

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

2. National Primary Drinking Water Standards 40 CFR Part 141.61-.63

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

1.3 SUBMITTALS

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

1. Comply with Section 01300 – Contractor Submittals.

2. **Materials Management Plan**: Include plans to maximize use of electronic format for communications and submittals, and to minimize paper uses (i.e., provide double-sided prints). Include recycling plans for collection of plastics, paper, cardboard, and aluminum. This plan should identify locations within the project where materials and equipment can be re-used rather than purchasing new equipment for every task. This plan should include fulfilling items listed in Section 3.1 below.

3. **Emissions Reduction Plan:** Verify the existence of and contract with a local low-sulfur diesel supplier for all vehicles and equipment used; provide worker transportation plan, include carpool or rideshare parking area(s) in centralized location(s); and no-idle and speed limit policies. Outline an emissions reduction education plan for workers, include benefits of not idling (e.g., reduction in emissions). Include a section titled "Emission Reduction Plan for Temporary Generators" outlining policies to minimize power uses from temporary fuel-powered generators that will be needed before power drops are available at the construction support facilities. The plan shall include provisions to comply with EPA emission requirements for non-emergency stationary engines (excluding those already in use at the Site) as well as procedures and guidelines for optimizing the use of temporary generator sets for heating, lighting, tools, and equipment (include guidelines for reducing idling time, following manufacturer's recommended maintenance and engine warm-up and cool-down times, and optimize generator size given anticipated needs). The plan will also include a plan to ensure appropriately sized equipment is used for tasks in order to minimize unnecessary emissions and fuel use.

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

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

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

7. **Construction Support Facilities:** In accordance with Section 01300 Contractor Submittals, a list of construction support facilities required for execution of the work will be submitted. Where available and cost effective, LEED®-certified structures will be utilized, if LEED®-certified structures are not available the contractor will include a valid reason and in-place include LEED® principles that will be followed in order to reduce energy use and emissions.

1.5 LABOR TRANSPORTATION COORDINATION

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

PART 2 -- NOT USED

PART 3 -- EXECUTION

3.1 MATERIALS MANAGEMENT

A. Reduce paper use:

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

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

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

B. Construction Materials

1. Use 'Green' concrete which will include a percentage of coal waste (i.e. fly ash) in place of Portland cement.

2. Sequence construction activities to avoid unnecessary movement of materials and stockpiles.

3. Use of geotextile fabric and/or drainage tubing composed of 100% recycled materials rather than virgin material for lining, erosion control and drainage.

3.2 EMISSIONS REDUCTION

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

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

C. **No-idling Polic**y

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

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

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

c) There is a safety issue.

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

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

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

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

G. **Non-road Diesel Powered Construction Equipment Fleet Requirements**. Non-road diesel fleet vehicles will be required to be compliant with EPA Tier 2 non-road compression-ignition engines (EPA-420-B-16-022).

H. **Minimize Emissions and Energy Use from Construction Support Facilities**. LEED®-certified portable structures for construction support facilities. If contractors demonstrate that LEED®-certified portable structures are not available or are cost prohibitive, LEED® principles shall be followed including the use of Energy Star compliant equipment, low energy light bulbs, passive cooling and lighting, re-use of old and recycled materials where possible, use of in-place facilities instead of bringing in new temporary facilities where possible.

I. Contractors should size equipment correctly with task in order to minimize use of oversized equipment.

3.3 CLEAN WATER MANAGEMENT

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

- END OF SECTION -

SECTION 02100 - SITE PREPARATION

PART 1 -- GENERAL

1.1 SUMMARY

A. Site Preparation shall include clearing, grubbing, stripping; and re-grading certain areas, in accordance with the Contract Documents.

B. The CONTRACTOR shall protect existing fences, structures and associated improvements, roads, and utilities downslope of construction area from damage due to boulders, trees, or other objects dislodged during Site Preparation.

C. The CONTRACTOR shall locate and protect subsurface utilities in accordance with Section 01530 – Protection of Existing Facilities.

1. CONTRACTOR confirms that power lines have been de-energized to remove or relocation overhead power lines within the work areas subject to excavation.

D. The CONTRACTOR shall place temporary construction erosion and stormwater controls in accordance with Section 01570 –SWPPP.

E. The CONTRACTOR shall flag areas around capped historical mine shafts in NECR-1 and NECR-2 areas, and vents as shown on the Drawings.

1.2 SITE INSPECTION

A. Prior to mobilizing onto the Site, the CONTRACTOR shall inspect the Site conditions and review maps delineating the COMPANY's property and right-of-way lines.

PART 2 -- NOT USED

PART 3 -- EXECUTION

3.1 PRIMARY SITE ACCESS

A. The CONTRACTOR shall develop any necessary access to the Site, including access road improvements and access barriers to prohibit entry of unauthorized persons.

B. **Public Utility Interference:** Where existing public utilities interfere with the WORK, the CONTRACTOR shall notify the utility owner and the ENGINEER before proceeding in accordance with the General Conditions.

3.2 CULTURAL RESOURCES SITES

A. Site boundaries will be identified under the direction of a qualified archeologist. The CONTRACTOR must temporarily fence off the perimeter of the defined areas prior to ground disturbing activities.

B. All ground disturbing activities must avoid the sites by a minimum of 50-ft from the site boundaries.

3.3 TIMBERING

A. CONTRACTOR shall not remove and salvage merchantable timber unless otherwise directed by the ENGINEER in writing.

3.4 CLEARING AND GRUBBING

A. General

1. Clearing limits shall be marked by the CONTRACTOR and approved by the ENGINEER prior to starting any clearing and grubbing activity.

2. Trees and other natural vegetation outside clearing limits shall be protected from damage during construction.

3. Burning of cleared and grubbed debris shall not be allowed.

B. **Areas Not Subject to Excavation of Contaminated Soils and Sediments**

1. Construction areas shall be cleared of structures, trees, logs, and any other objectionable material which would interfere with the performance or completion of the WORK or create a hazard to safety. Trees, shrubs, and debris removed during clearing operations shall be stockpiled on Site at locations designated by the ENGINEER. Trees and other natural vegetation outside the actual lines of construction shall be protected from damage during construction.

2. Within the limits of clearing, the areas below the natural ground surface shall be grubbed to a depth necessary to remove stumps, roots, buried logs, and other objectionable material. Material removed during clearing and grubbing shall be hauled to on-Site stockpile locations designated by the ENGINEER.

3. Brush and cleared debris shall be chipped for use as mulch.

C. **Areas Subject to Excavation of Contaminated Soil and Sediments:**

1. Prior to clearing and grubbing, CONTRACTOR shall survey and delineate the excavation and clearing limits shown on the Drawings.

2. Contaminated soil and sediment excavation and disposal shall be conducted in accordance with Section 02205 – Mine Waste Excavation and Disposal.

3. Areas subject to excavation of contaminated soils and sediments shall be cleared of structures, trees, logs, and any other objectionable material which would interfere with the performance or completion of the WORK or create a hazard to safety. Trees, shrubs, and debris removed during clearing operations in contaminated areas shall be considered contaminated and shall be stockpiled at a location designated by the ENGINEER.

4. Areas subject to excavation of contaminated soil and sediment shall not be subject to grubbing. Surface vegetation remaining in these areas after clearing shall be removed as part of the excavation of contaminated soil and sediments.

5. Brush and vegetative debris, including leftover slash from timbering, shall be chipped and disposed of in the Repository as unclassified waste in accordance with Section

02205 – Mine Waste Excavation and Disposal. Chipped material shall be placed in lifts of less than 6-inch thickness and mixed with the backfill.

3.5 STRIPPING

A. Areas subject to excavation of contaminated soils and sediment shall not be subject to stripping.

B. For all other areas, upon completion of grubbing operations, areas to be affected by construction shall be stripped to a depth of 1.5 feet below the existing ground contours, or as otherwise directed by the ENGINEER. The stripped materials shall be stockpiled at a location designated by the ENGINEER for re-use upon site restoration.

3.6 OVEREXCAVATION, REGRADING, AND BACKFILL UNDER FILL AREAS

A. After the fill areas have been cleared, grubbed, and stripped, the areas to receive fill may require over-excavation to remove wet, soft, or otherwise undesirable material prior to fill placement.

B. Material removed during over-excavation shall be stockpiled at on-site locations designated by the ENGINEER.

C. The excavated ground surface shall be re-contoured for keying the fill and removing severe or abrupt changes in the topography of the Site. The over-excavated areas shall be backfilled with compacted fill in accordance with the requirements of Section 02200 - Earthwork.

- END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 02120 – ROAD AND STAGING AREA MAINTENENCE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall perform grading and maintenance on existing and new haul roads, staging areas and parking areas throughout construction. This WORK shall include all appurtenant work and equipment including the furnishing and placement of graders, backhoes, compaction equipment, surfacing material, and disposal of excess or waste material, all in accordance with the Contract Documents.

B. CONTRACTOR shall execute the WORK in a manner that does not result in contamination of roads, staging or parking areas that are indicated in the Contract Documents as uncontaminated or “clean.”

PART 2 -- PRODUCTS

2.1 ROAD SURFACING

A. Crushed Gravel shall conform to Section 02200 – Earthwork

PART 3 -- EXECUTION

3.1 MAINTENANCE OF ROADS

A. **General:**

1. CONTRACTOR shall maintain temporary roads and parking to continuously provide Site access for construction vehicles and trucks, ENGINEER vehicles, deliveries for ENGINEER, emergency vehicles, and parking areas for ENGINEER’S personnel.

2. Public roads shall be passable at all times unless a road closure is allowed in writing by ENGINEER.

3. When temporary roads and parking without hard surfacing become contaminated with soil and create a nuisance, the CONTRACTOR shall remove contaminated material and replace it with clean aggregate as required.

B. Dust resulting from CONTRACTOR’S activities shall be controlled in accordance with Section 01560 – Temporary Environmental Controls.

C. The CONTRACTOR shall provide temporary, heavy-duty steel roadway plates to protect existing manholes, handholes, valve boxes, vaults, and similar buried facilities.

3.2 ROAD SUBGRADE REPAIR

A. In areas of temporary construction roads and public roads where the road subgrade has deteriorated, CONTRACTOR shall repair these areas using the materials, methods and compaction requirements per Section 02200 - Earthwork.

3.3 COVER

A. Maintain a minimum of two feet of cover over culverts and buried utilities unless otherwise noted in the Drawings. Material for the cover shall be as per Section 02200 - Earthwork.

3.4 CUTTING

A. CONTRACTOR shall cut the entire road surface, edge to edge, to a sufficient depth as to remove all superficial potholes and washboards. All cut material shall be windrowed to the center or outside edge of the roadway.

3.5 LAY BACK

A. Windrowed material shall be spread uniformly across both lanes to provide a normal centerline crown. Windrowed material shall not be bladed over the road shoulder into the drainage ditch.

3.6 COMPACTION

A. CONTRACTOR shall ensure that road subgrade and surfacing repaired or replaced is evenly graded and compacted. The compaction requirements shall be as per Section 02200 - Earthwork.

3.7 SHAPE

A. The final road cross section shall be as shown on the Drawings.

3.8 SAFETY BERMS

A. Safety berms shall be provided and maintained on the banks of roadways where a drop-off exists of sufficient grade or depth to cause a vehicle to overturn or endanger persons in equipment or as otherwise shown on the Drawings.

B. Safety berms shall be at least mid-axle height of the largest equipment which usually travels the roadway.

C. Safety berms shall be maintained throughout construction.

D. Safety berms shall be replaced when removed by maintenance activities.

E. Safety berm material shall be as indicated on the Drawings. Compaction shall be as needed to retain shape and reduce erosion.

3.9 SAFETY BARRIERS AND SIGNAGE

A. Safety barriers must be maintained during construction and not damaged by grading operations. The ENGINEER shall be notified immediately if safety barriers are damaged or if repairs are required.

3.10 CULVERT AND DITCH MAINTENANCE

A. Culvert and ditch maintenance shall be conducted in accordance with the CONTRACTOR'S CSWPPP.

B. Culvert and ditch maintenance must only occur when culverts and ditches are dry.

- END OF SECTION -

SECTION 02200 – EARTHWORK

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall perform the following specific earthwork as indicated and required for construction of the WORK, complete and in place, in accordance with the Contract Documents.

B. Preparation of the mine waste repository to receive waste shall be conducted in accordance with this section.

C. Cover placement over mine waste shall be conducted in accordance with this section.

D. All uncontaminated fill materials shall be placed in accordance with this section. Riprap is specified in 02273.

E. Excavation and disposal of mine waste materials shall be conducted in accordance with Section 02205 – Mine Waste Excavation and Disposal.

1.2 REFERENCE REMEDIAL ACTION DESIGN PLANS

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

1. Stormwater Management Plan

2. Dust Control and Air Monitoring Plan

3. Construction Quality Assurance Plan

4. Cleanup Verification Plan

5. Revegetation Plan

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. ASTM C117 - Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

B. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

C. ASTM D75 – Standard Practices for Sampling Aggregates.

D. ASTM D422 – Standard Test Method for Particle-size Analysis of Soil.

E. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.

F. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

G. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes.

H. ASTM D3665 – Standard Practice for Random Sampling of Construction Materials.

I. ASTM D4220 – Standard Practices for Preserving and Transporting Soil Samples.

J. ASTM D4718 – Standard Practice for Correction of Unit Weight and Water Content for Soil Containing Oversize Particles.

K. ASTM D6913 – Standard Test Method for Particle Size Distribution (Gradation) Using Sieve Analysis.

L. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.4 CONTRACTOR SUBMITTALS

A. Submit in accordance with Section 01300 – Contractor Submittals.

B. Submit CONTRACTOR's Detailed Shoring Plan as follows:

1. The CONTRACTOR, prior to beginning any trench or structure excavation 4 feet deep or deeper, shall submit to the ENGINEER and shall be in receipt of the ENGINEER's written acceptance of the CONTRACTOR's detailed plan showing the design of shoring, bracing, sloping of the sides of excavation, or other provisions for worker protection against the hazard of caving ground during the excavation of such trenches or structure excavation.

2. If such plan varies from the shoring system standards established by OSHA, such alternative systems plans shall be prepared by a civil or structural engineer licensed in the State of New Mexico.

3. The ENGINEER’s acceptance of said plan shall be for verification of submittal of the plan with this requirement.

C. Submit product Information for imported and on-site processed materials including pertinent information to evaluate proposed materials for compliance with the specifications such as grain-size distribution, soil classification, durability data, and other pertinent material information.

D. Samples: The CONTRACTOR shall submit samples of materials proposed for the WORK, if requested by the ENGINEER.

PART 2 -- PRODUCTS

2.1 FILL AND BACKFILL MATERIAL REQUIREMENTS

A. Fill and backfill materials and placement locations shall conform to the Drawings.

B. Fill materials that are to be placed within 6 inches of any structure or pipe shall be free of rocks or unbroken masses of earth materials having a maximum dimension larger than 3 inches.

2.2 DEFINITIONS

A. Suitable Materials:

1. Materials not defined below as unsuitable shall be considered as suitable materials and may be used in fills, backfilling, and embankment construction subject to the indicated requirements. Suitable materials may be obtained from on-Site borrow areas and excavations, or may be processed on-Site materials.

2. Suitable materials may be imported. If imported materials are required by this Section or are required in order to meet the quantity requirements of the WORK, the CONTRACTOR shall provide imported materials as part of the WORK, unless a unit price item is included for imported materials in the Bidding Schedule.

B. Unsuitable materials:

1. Materials that in the opinion of the ENGINEER 1) exhibit poor strength or durability qualities; 2) are compressible or expansive; 3) are too wet or dry to be placed or compacted properly; 4) are frozen; 5), contain contaminants, organics, debris, or other deleterious materials; 6) are corrosive or react with concrete or steel; or 7) are otherwise not suitable for the intended use of the material. Unsuitable material placed as fill in unapproved areas shall be removed and replaced with suitable material in accordance with these Specifications at the CONTRACTOR's expense.

C. General Fill:

1. Except as noted below, General Fill and shall consist of suitable materials with no cobbles or rock larger than 3 inches.

   a. General fill used for haul and access road embankment fill may contain particles greater than 3 inches in size upon approval by the ENGINEER.

D. Soil Cover:

1. Soil Cover shall consist of suitable materials from the approved borrow areas, with no cobbles or rock larger than 1.5 inches.

E. Soil Cover with Rock (Admixture)

1. Soil Cover with rock shall consist of Soil Cover as defined in Paragraph 2.2D, mixed with rock material of the specified D_{50}. The mixed material shall contain 33 percent rock by volume. The rock for the admixture layer may be crushed or rounded rock.

2. The following rock gradations shall be used:

   a. D_{50} = 1.5-inch.

D-*sizes* Percent Passing	Minimum Diameter (in)
d_0 0% Passing	0.75
d_{50} 50% Passing	1.5
d_{100} 100% Passing	3.0

This gradation may be field adjusted by the ENGINEER based on the gradation of rock salvaged in accordance with Part 3.5 of this Section.

b. D_{50} = 2 inches:

D-*sizes* Percent Passing	Minimum Diameter (in)
D_0 0% Passing	1.0
d_{50} 50% Passing	2.0
d_{100} 100% Passing	4.0

c. D_{50} = 3 inches:

D-*sizes* Percent Passing	Minimum Diameter (in)
d_0 0% Passing	1.5
d_{50} 50% Passing	3.0
d_{100} 100% Passing	5.0

3. All rock used for cover erosion protection must meet NRC durability requirements described in Section 02273 – Riprap.

4. Mixing methods shall be determined by the CONTRACTOR and approved by the ENGINEER prior to initial mixing.

5. Rock material shall be from on-site stockpiles or be imported materials and shall be approved by the ENGINEER.

   a. Rock by volume in the admixture in-place on the cover shall be confirmed by survey measurement of the layer thicknesses prior to mixing (Tolerance -5% to +5% on 33% rock by volume).

   b. The rock must be thoroughly and uniformly incorporated into the soil by mixture, the adequacy of the mixing method to provide a uniform mixture shall be approved by the ENGINEER prior to large-scale implementation.

   c. Volume of rock in the mixture will be confirmed after mixing by test-pitting the full depth of the mixture layer in-place to sample the mixture (Tolerance -5% to +5% on 33% rock by volume). One sample per acre from the cover on a grid pattern with equidistant spacing of points. The ENGINEER must approve the sample locations prior to sampling.

d. The quality control (QC) method utilized to verify uniformity of the rock and soil in the admixture layer must be submitted by the CONTRACTOR and approved by the ENGINEER prior to initiation of placement of the admixture layer.

e. If the CONTRACTOR proposes to mix the materials off the cover, volume testing to confirm the volumes are correct in the mixture is required from material stockpiles prior to materials being moved to the cover AND subsequently following placement on the cover to ensure the materials do not segregate during transport to the cover.

6. The CONTRACTOR must prepare an additional 1000 CY of the 2-inch soil rock mixture and 12,000 CY of the 1.5-inch soil rock mixture to stockpile for the O&M period to address cover repairs, if necessary.

a. This material is to be stockpiled in a location approved by the ENGINEER.

F. Rock Cover with Soil (Admixture)

1. Rock cover with soil shall consist of rock material of the specified D_{50} = 1.5 inches mixed with Soil Cover as defined in Paragraph 2.2D. The mixed material shall contain 15 percent soil by volume.

2. The following rock gradations shall be used:

a. D_{50} = 1.5-inch. This gradation may be field adjusted by the ENGINEER based on the gradation of rock salvaged in accordance with Part 3.5 of this Section.

D-*sizes* **Percent Passing**	**Minimum Diameter (in)**	**Maximum Diameter (in)**
d_{15} 15% Passing	0.75	1.0
d_{50} 50% Passing	1.5	2.0
d_{100} 100% Passing	3.0	4.0

3. The rock cover with soil is only for use on the 5:1 (20%) Repository slope.

4. Mixing methods shall be determined by the CONTRACTOR and approved by The ENGINEER prior to initial mixing.

a. Rock by volume in the admixture in-place on the cover shall be confirmed by survey measurement of the layer thicknesses prior to mixing (Tolerance -5% to +5% on 15% soil by volume).

b. The soil must be thoroughly incorporated into the rock by mixture, the adequacy of the mixing method to provide a uniform mixture will be approved by the ENGINEER prior to large-scale implementation.

c. Volume of soil in the mixture will be confirmed after mixing by test-pitting the full depth of the mixture layer in-place to sample the mixture. One sample per acre from the cover on a grid pattern with equidistant spacing of points. The ENGINEER must approve the sample locations prior to sampling.

d. If the CONTRACTOR proposes to mix the materials off the cover, volume testing to confirm the volumes are correct in the mixture is required from material stockpiles prior to materials being moved to the cover AND subsequently following placement on the cover to ensure the materials do not segregate during transport to the cover.

G. Crushed Gravel

1. Crushed Gravel shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying.

2. Crushed Gravel shall be uniformly graded, and shall meet the following gradation requirements.

Sieve Size	**Percentage Passing**
1 1/4-inch	100
1-inch	80 -100
5/8-inch	50 – 80
No. 4	25 – 45
No. 40	3 – 18
No. 200	Less than 7.5

H. Culvert Bedding

1. General fill shall be used for culvert bedding unless otherwise noted on the Drawings.

I. Rip Rap and Filter

1. Rip Rap and Filter materials shall conform to Section 02273 – Rip Rap and the Drawings. These materials shall not contain any unsuitable material.

2.3 MATERIALS TESTING

A. Testing of on-site processed materials and imported materials to verify conformance to specified standards shall be performed by the CONTRACTOR and submitted to the ENGINEER for approval.

B. Soils testing of samples submitted by the CONTRACTOR shall be performed by a testing laboratory approved by the ENGINEER.

C. The ENGINEER may direct the CONTRACTOR to supply samples for testing of any material used in the WORK.

D. Particle-size analysis of soils and aggregates shall be performed per section 3.17

E. Sample Collection and Handling

1. Samples shall be collected in accordance with ASTM D75.

2. Samples selection shall be conducted in accordance with ASTM D3665.

3. Samples shall be preserved and transported in accordance with ASTM D4220.

2.4 SOIL CLASSIFICATION

A. Soils Classification for all aspects of the WORK, including references in these Specifications and the Drawings to soil classification types and standards shall have the meanings and definitions indicated in ASTM D 2487.

B. Rock Classifications for all aspects of the WORK, including references in these Specifications and the Drawings to rock classification types and standards shall have the meanings and definitions indicated in the U.S. Bureau of Reclamation (USBR) Field Manual, unless specifically noted otherwise.

C. The CONTRACTOR shall be bound by applicable provisions of ASTM D 2487 and the U.S. Bureau of Reclamation (USBR) Field Manual in the interpretation of soil and rock classifications.

PART 3 -- EXECUTION

3.1 SURFACE PREPARATION

A. Clearing, grubbing, and stripping shall be conducted in accordance with Section 02100 – Site Preparation prior to performing any excavation or placing any fill.

B. Surfaces to receive fill materials shall be smooth and firm, free of brush, trees, stumps, and other objectionable material, and shall be brought to the line and grade indicated.

C. Frozen Material

1. Do not place material on surfaces that are muddy, frozen, or contain frost and/or ice.

2. Fill containing any frozen materials shall be considered unsuitable material.

3.2 DRAINAGE

A. At all times, site grading shall promote drainage. Surface runoff shall be diverted from excavations. Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and be pumped or drained by gravity from the excavation to maintain a bottom free from standing water.

B. Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry.

C. Construct any storm drainage features at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils.

D. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new suitable material as specified herein. It is the responsibility of the CONTRACTOR to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

E. Dewatering of trenches and other excavations shall be considered as incidental to the construction of the WORK and all costs thereof shall be included in the various contract unit and lump sum prices in the price bid, unless a separate bid item has been established for dewatering.

3.3 TEMPORARY STOCKPILES

A. The CONTRACTOR shall establish their stockpile areas in accordance with Section 01552 – Staging and Stockpile Areas.

B. Inactive stockpiles shall be stabilized in accordance with the Construction Stormwater Pollution Prevention Plan (CSWPPP). The CONTRACTOR shall keep stockpiles in a neat and well-drained condition, giving due consideration to drainage at all times.

C. The CONTRACTOR shall protect stockpiles of suitable materials from contamination which may destroy the quality and fitness of the stockpiled material.

D. If the CONTRACTOR fails to protect the stockpiles, and any material becomes unsuitable, remove and replace such material with suitable material from approved sources.

E. Removal and Restoration:

1. Permanent stockpiles shall not be allowed.

2. Upon depletion of any stockpile, the CONTRACTOR shall grade the area to match the surrounding topography. Stockpile areas shall be revegetated in accordance with Section 2970 – Revegetation.

3. The CONTRACTOR shall repair or replace drainage paths and other landscaping items affected by temporary stockpiles.

4. All restoration shall be approved by the ENGINEER.

3.4 HAUL AND ACCESS ROAD GRADES AND ALIGNMENTS

A. The CONTRACTOR shall construct haul and access roads to the lines and grades shown on the Drawings.

B. Coordinates along the centerline of the Mine Waste Haul Road shall be provided to the CONTRACTOR by the ENGINEER.

C. The CONTRACTOR and the ENGINEER shall review and discuss the survey information and examine the centerline in the field at a mutually agreed upon date(s) prior to clearing activity.

1. All adjustments to plan and profile shall be proposed in writing.

D. Uniform grade adjustments of less than 5 feet; and horizontal alignment changes of less than 10 feet, if approved by the ENGINEER, may be conducted in the field and shall not require revisions to the design drawings.

3.5 REPOSITORY PREPARATION

A. The existing radon barrier above the tailings in the TDA shall be prepared to serve as the foundation layer for the Repository.

B. **Rock Mulch Removal:** The erosion protection layer overlying the radon barrier is a nominal 6-inch-thick layer of rock mulch that consists or soil mixed with rock that has a D_{50} of 1.5 inches.

1. The rock mulch on the surface of the radon barrier shall be excavated in a manner that minimizes removal of the underlying radon barrier material.

2. Excavated material shall be screened on-site to separate the rock (D_{50}=1.5 inches) from the soils. Screening methods shall be proposed by the CONTRACTOR and shall result in the separation of rock greater than 0.75-inch size from the soil.

3. Rock and soil shall be stockpiled for re-use in accordance with Paragraph 3.5D.

4. Water shall be added, as necessary, for dust control during rock mulch removal.

C. **Riprap Removal:** Riprap (D_{50}=1.5 inches) lining the existing swales shall be removed and screened to separate residual soils and vegetation from rock material. Rock shall be combined with the rock separated from the rock mulch.

D. **Re-Use of Materials:**

1. The residual soils from the existing erosion protection layer shall be reused as General Fill on the Repository cover construction, to fill in the swales located on the existing cover, or for other fill use at the Repository.

2. Soil materials shall be used as General Fill in the swales located on the existing cover or in cover soils.

3. The rock shall be reused on the new cover or used for erosion protection on other areas of the site.

E. Potential to Expose Existing Tailings

1. The CONTRACTOR shall take care to not expose tailings by observing all excavtions into the radon barrier during the process of removing rock from the cover layer and swales.

2. In general, tailing can be identified by a light gray color and differs in appearance from the soil cover.

3. If the CONTRACTOR suspects that tailings are exposed during the process, work must stop so the RSO may conduct a radiological scan of the ground surface in the work area.

4. Material that is confirmed to be tailing must be returned to beneath the existing radon barrier. This will be accomplished by excavating an area of the existing cover approved by the ENGINEER (likely in one of the existing swales), placing the material, and recompacting the radon barrier in 6-inch conditioned lifts. The radon barrier in the area of exposed tailings shall also be reconstructed in compacted lifts to match the original design.

5. The work area must then be confirmed by scans that the tailing material has been removed from the surface.

F. **Subgrade (Improved Radon Barrier) Conditioning:** The subgrade (improved radon barrier) shall be graded, moisture conditioned and compacted prior to placement of mine waste.

1. Grading: The excavated surface of the subgrade (improved radon barrier) shall be graded where necessary to smooth the surface for compaction.

2. Compaction: The subgrade (improved radon barrier) surface shall be compacted to achieve 95 percent of standard Proctor dry density for the material in the top 6 inches of the subgrade (improved radon barrier). The water content for the subgrade (improved radon barrier) shall be below optimum moisture.

   a. Additional reworking or excavation or ripping into the subgrade (improved radon barrier) shall not be allowed due to the potential for contact with and exposure of underlying tailings.

   b. Water shall be added, as necessary, for dust control during subgrade (improved radon barrier) compaction. Excessive watering shall not be allowed.

3.6 GENERAL EXCAVATION

A. General:

1. Perform excavation of every type of material encountered within the limits of the project to the lines, grades, elevations, and tolerances indicated and as specified. Except when specifically provided to the contrary, excavation shall include the removal of materials, including obstructions that would interfere with the proper execution and completion of the WORK.

2. Excavate unsuitable materials encountered within the limits of the Work below grade and replace with Suitable materials as directed. Include such excavated material and the suitable material ordered as replacement in excavation.

3. Excavations shall commence from high to low elevation with a horizontal working surface and an elevated surface at the downhill portion of the active excavation area to retain storm water within the excavation area.

4. Excavate material required for fill, embankment, or cover in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas as designated by the ENGINEER.

B. Ditches, Channels and Sediment Ponds

1. Finish excavation of ditches, channels and sediment ponds by cutting accurately to the cross sections, grades, and elevations shown on the Drawings. Do not excavate ditches or channels below grades shown.

2. Backfill any excessive open ditch or channel excavation with thoroughly compacted suitable material to grades shown.

3. Maintain excavations free of leaves, brush, sticks, trash, and other debris until final acceptance of the Work.

C. Over-Excavation:

1. Indicated: Where areas are indicated to be over-excavated, excavation shall be to the depth indicated, and fill shall be installed to the grade indicated.

2. Not Indicated: When ordered to over-excavate areas deeper and/or wider than required by the Contract Documents, the CONTRACTOR shall over-excavate to the dimensions ordered and fill to the indicated grade.

3. Neither Indicated nor Ordered: Any over-excavation carried below the grade that is neither ordered or indicated shall be filled and compacted to the required grade with the indicated material as part of the WORK and at the CONTACTOR'S expense.

D. Rock Excavation

1. Rock excavation shall include removal and stockpiling at an on-site location designated by the ENGINEER of the following items:

   a. Boulders measuring 1/3 of a cubic yard or more in volume;

   b. Rock material in ledges, bedding deposits, and un-stratified masses that cannot be removed using conventional equipment as defined herein and which require systematic drilling and blasting for removal;

   c. Conglomerate deposits or weathered bedrock that are so firmly cemented that they possess the characteristics of solid rock and cannot be removed using conventional equipment as herein defined and require systematic drilling and blasting for removal.

2. Explosives and Blasting: Blasting shall not be permitted unless authorized in writing by the ENGINEER.

3.7 TRENCH EXCAVATION

A. General

1. Excavate the trench as shown on the Drawings.

2. The CONTRACTOR shall furnish, place, and maintain supports and shoring required to maintain stability of all aspects of the excavations.

3. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable state safety requirements and the requirements of OSHA Safety and Health Standards for Construction (29 CFR 1926).

4. Below the top of pipe elevation, do not exceed a trench width of 24 inches plus pipe outside diameter (O.D.) for pipes of less than 18 inches inside diameter, and do not exceed 36 inches plus pipe O.D. for sizes larger than 18 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the CONTRACTOR. The CONTRACTOR is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the OWNER.

B. Trenching in Embankments, Fills and Structural Backfills:

1. Where pipelines are to be installed in embankments, fills, or structure backfills, the fill shall be constructed to a level at least one foot above the top of the pipe before the trench is excavated.

2. Upon completion of the embankment or structural backfill, a trench conforming to the appropriate detail shall be excavated and the pipe shall be installed.

C. Trench Bottom Preparation:

1. Grade the bottoms of trenches accurately and uniformly to an elevation 6 inches below the bottom of pipe.

2. Remove particles of 3 inches or greater, unless otherwise specified by the pipe manufacturer, to avoid point bearing.

3. Removal of unsuitable material: Where Unsuitable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with General Fill. When removal of unsuitable material is required due to the CONTRACTOR's fault or neglect in performing the Work, the CONTRACTOR is responsible for excavating the resulting material and replacing it at the expense of the CONTRACTOR.

D. Open Trenches

1. Trenches shall be fully backfilled at the end of each day or, in lieu thereof, shall be covered by heavy steel plates adequately braced and capable of supporting vehicular traffic in those locations where it is impractical to backfill at the end of each day.

2. These requirements for backfilling or use of steel plate shall be waived in cases where the trench is located further than 100 feet from any traveled roadway or occupied structure; in such cases, however, barricades and warning signs meeting appropriate safety requirements shall be provided and maintained.

E. Trench Shield

1. If a moveable trench shield is used during excavation operations, the trench width shall be wider than the shield such that the shield is free to be lifted and then moved horizontally without binding against the trench sidewalls and causing sloughing or caving of the trench walls.

2. If the trench walls cave or slough, the trench shall be excavated as an open excavation with sloped sidewalls or with trench shoring, as indicated and as required by the pipe structural design.

3. If a moveable trench shield is used during excavation, pipe installation, and fill operations, the shield shall be moved by lifting the shield free of the trench bottom or fill and then moving the shield horizontally.

4. The CONTRACTOR shall not drag trench shields along the trench causing damage or displacement to the trench sidewalls, the pipe, or the bedding and fill.

3.8 EXCAVATION BENEATH RIPRAP, STRUCTURES AND EMBANKMENTS:

A. The subgrade areas beneath fills and embankments shall be excavated to remove all deleterious, loose, and otherwise unsuitable material and not less than the top 6 inches of native material. Where such subgrade is sloped, the native material shall be benched.

B. After the required excavation or over-excavation for fills and embankments has been completed, the exposed surface shall be scarified to a depth of 6 inches, brought to -5% to +2% of optimum moisture content, and rolled with heavy compaction equipment to obtain 95 percent of maximum density as determined by the Standard Proctor Test (ASTM D 698).

C. Ensure that foundation and footing subgrades have been inspected and approved by the ENGINEER prior to concrete placement.

D. Notification of ENGINEER:

1. The CONTRACTOR shall notify the ENGINEER at least 3 Days in advance of completion of any structure or roadway excavation and shall allow the ENGINEER a review period of at least one day before the exposed foundation is scarified and compacted or is covered with fill or with any construction materials.

3.9 BORROW AREA EXCAVATION (COVER SOILS)

A. CONTRACTOR shall establish of stormwater and erosion control features at each borrow area locations in accordance with the CSWPPP and the Stormwater Management Plan.

B. Surface vegetation and topsoil shall be stripped to a depth of 12 inches from the proposed excavation placed in a topsoil stockpile adjacent to each borrow area. The stockpiled topsoil shall be reused during borrow area reclamation activities.

C. Excavations shall provide drainage away from the current borrow area working face to minimize disruption of the borrow activities due to stormwater.

D. Sloped excavations shall be completed to the grades (to a maximum 3H:1V slope) and elevations shown on the Drawings.

E. To the extent possible, excavated borrow materials shall be loaded directly into haul trucks, transported, and placed within the repository.

1. Exceptions to this requirement include:

a. Stockpiling of borrow material prior to cover material placement to meet project schedule requirements

b. Stockpiling of excavated sandy material from Jetty borrow to be screened and used as filter materials in stormwater control channels site-wide.

F. Borrow Areas Reclamation

1. Each borrow area shall be reclaimed upon completion of excavation, and concurrent with the development of the subsequent borrow area.

2. Post-excavation grading surfaces for each of borrow areas shall be as shown on the Drawings.

3. Topsoil stockpiled at each borrow area shall be placed in a uniform lift over the graded disturbed area and revegetated in accordance with Section 02970 – Revegetation.

3.10 FILL – ALL TYPES

A. Pre-Placement Conditions

1. Surface preparation beneath structures and embankments shall conform to Part 3.8 of this specification.

2. Except for drain gravel being placed in over-excavated areas or trenches, fill shall be placed after water is removed from the excavation and the trench sidewalls and bottom have been dried to a moisture content suitable for compaction.

3. Immediately prior to placement of fill materials, the bottoms and sidewalls of trenches and structure excavations shall have any loose, sloughing, or caving soil and rock materials removed.

4. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of fill materials.

B. Placement

1. Fill shall not be dropped directly upon any structure or pipe.

2. Fill shall not be placed around nor upon any structure until the concrete has attained sufficient strength to withstand the loads imposed.

3. Fill around water-retaining structures shall not be placed until the structures have been tested, and the structures shall be full of water while backfill is being placed.

4. Fill materials shall be placed and spread evenly in horizontal lifts, and shall be mixed as necessary to promote uniformity of material.

5. Unless otherwise indicated, when compaction is achieved using mechanical equipment, the horizontal lifts shall be evenly spread such that when compacted each horizontal lift shall not exceed 12 inches in compacted thickness.

C. Moisture Content

1. Where the fill material moisture content is below the specified moisture content range, water shall be added before or during spreading until the proper moisture content is achieved.

2. Where the fill material moisture content is above the specified moisture content range, the material shall be dried until the proper moisture content is achieved.

3.11 TRENCH BACKFILL

A. General

1. Backfill trenches as approved by the ENGINEER to the grade shown.

2. Replacement of Unyielding Material – Replace unyielding material removed from the bottom of the trench with General Fill.

3. Replacement of Unstable Material – Replace unstable material removed from the bottom of the trench or excavation with General Fill as directed in lifts not exceeding 6 inches in uncompacted thickness.

4. Immediately prior to placement of fill materials, the bottoms and sidewalls of trenches shall have any loose, sloughing, or caving soil and rock materials removed.

5. Trench sidewalls shall consist of excavated surfaces that are in a relatively undisturbed condition before placement of fill materials.

B. Trench Shield:

1. If a moveable trench shield is used during fill operations, the shield shall be lifted to a location above each layer of fill material prior to compaction of the layer.

C. Definitions

1. Pipe Bedding Zone: The bedding is defined as that portion of the trench between a plane 6-inches below the bottom of the pipe and a plane 12 inches above the top of the pipe.

2. Trench Backfill Zone: The trench backfill zone is defined as fill in the trench cross-sectional area from the top of the bedding zone to final grade, or subgrade.

D. Bedding:

1. General Fill shall be used for the Bedding Zone backfill and shall be compacted to the density specified in Part 3.15 A.

2. Bedding shall be placed in two or more lifts. The first lift shall provide 6 inches compacted thickness under the pipe, and shall be placed, spread, and compacted before the pipe is installed so that the pipe is uniformly supported along the barrel. Subsequent lifts of pipe bedding, of not more than 6 inches in thickness shall be placed and compacted along the sides. Lifts shall be brought up together on both sides of the pipe and shall be worked carefully under the pipe haunches and then compacted.

E. Trench Backfill Zone Fill: Fill the remainder of the trench as designated below:

1. Beneath Roadways/Embankments/Structures: Place General Fill backfill up to the required subgrade elevation as specified. Deposit backfill in lifts of a maximum of 12 inches loose thickness. Do not permit water flooding or jetting methods of compaction. Spread each lift uniformly and moisten or aerate as necessary and compact to the density specified in Part 3.15 A.

2. Open Areas: Place General Fill backfill up to the required subgrade elevation as specified. Deposit backfill in lifts of a maximum of 12 inches loose thickness. Do not permit water flooding or jetting methods of compaction. Spread each lift uniformly and moisten or aerate as necessary and compact to the density specified in Part 3.15 A.

3.12 COMPACTED GENERAL FILL

A. Fill for appurtenances and structures shall be placed and spread evenly in horizontal lifts, and shall be mixed as necessary to promote uniformity of material, with each lift moistened and aerated as necessary.

B. Unless otherwise approved by the ENGINEER, no lifts shall exceed 12 inches of compacted thickness.

C. Compacted General Fill shall be compacted to the density specified in Part 3.15 A.

1. Flooding, ponding, and jetting shall not be used for fill around structures, for final fill materials, or aggregate base materials.

D. Embankment Fill

1. Fill for roads and stormwater control embankments shall be placed and spread evenly in horizontal lifts, and shall be mixed as necessary to promote uniformity of material, with each lift moistened and aerated as necessary.

2. When an embankment is to be constructed and compacted against hillsides or fill slopes steeper than 4:1, the slopes of the hillsides or fills shall be horizontally benched in order to key the embankment to the underlying ground.

E. Appurtenances

1. After a box culvert, inlet, outlet or similar structure has been constructed and the concrete has been allowed to cure in accordance with Section 03000 – Cast-in-Place Concrete, place, backfill in such a manner that the structure is not damaged by the shock of falling earth. Deposit the backfill material, compact it as specified, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

F. Heavy Equipment:

1. Equipment weighing more than 10,000 pounds shall not be used closer to walls than a horizontal distance equal to the vertical depth of the fill above undisturbed soil at that time.

2. Hand-operated power compaction equipment shall be used where the use of heavier equipment is impractical or restricted due to weight limitations.

3.13 CRUSHED GRAVEL PLACEMENT

A. The following roads shown on the Drawings shall receive gravel surfacing:

1. Mine Waste Haul Road

2. Mine Waste Haul Road Spur

3. Clean Access Road

4. Clean Access Ramp

5. Pipeline Canyon Road Improvement

B. Ensure areas to be surfaced are free from debris, snow, ice and water and that ground surfaces are not in a frozen condition.

C. Do not place gravel over ponded water or existing subgrade surfaces which are yielding, disturbed or softened.

D. Placing of gravel shall be suspended when the climatic conditions shall not allow proper placement and compaction of fill.

E. Place properly moisture conditioned gravel in a horizontal layers which do not exceed 6 inches in thickness. Spread evenly and mix thoroughly during spreading to ensure uniformity of material in each layer.

F. Compaction shall be accomplished with suitable equipment. The compacted material shall be visually moist and compacted over the full width of each layer until visual displacement ceases. Gravel shall be compacted to the density indicated in part 3.15.

3.14 REPOSITORY COVER PLACEMENT

A. Soil Cover and General Fill shall be placed over compacted mine waste as shown on the Drawings.

B. Any equipment that contacts mine waste shall be decontaminated before contacting cover material.

C. Placement

1. Soil Cover

a. Place the material in successive horizontal lifts of loose material not more than 12 inches in depth. Spread each lift uniformly and moisten or scarify as necessary to achieve the compaction specified in Part 3.15.

b. Placement, spreading, and compaction shall be performed with equipment appropriate to achieve the required level of compaction for the cover.

c. Soil cover placement shall commence in a manner that prevents runoff from mine waste to flow onto cover soils.

2. Admixture Layers

a. Lifts to be mixed in-place shall be no thicker than 9 inches once compacted, following mixing. Each lift must meet specifications (density and moisture) before placement of additional materials.

b. Placement, spreading, and compaction shall be performed with equipment appropriate to achieve the required level of compaction for the cover.

D. Finishing and Plantings

1. Finishing and planting shall conform to Section 02970 – Revegetation.

2. Finished surface shall be graded with a uniform surface to the slopes and grades shown on the drawings.

3.15 COMPACTION REQUIREMENTS

A. The following compaction requirements shall be in accordance with the Standard Proctor test (ASTM D 698). If more than 30% of the material is larger than ¾-inch in size, an oversize correction shall be applied in accordance with ASTM D4718.

TRENCHES	% of Maximum Dry Density	% Optimum Moisture
Pipe Bedding Zone	90 (min)	+2 to -5%
Trench Backfill Zone: Beneath Roads/Structures/Embankments	95 (min)	+2 to -5%
Trench Backfill Zone: Open Areas	90 (min)	+/- 5%

REPOSITORY and COVER	% of Maximum Dry Density	% Optimum Moisture
Radon Barrier (existing)	95 (min)	Dry of Optimum
Soil Cover (Approved Borrow)	88-93	Dry of Optimum
Soil Cover – Admixture Layers	88-93	Dry of Optimum

FILL/BACKFILL	% of Maximum Dry Density	% Optimum Moisture
General Fill	90 (min)	+0 to -5%
Compacted General Fill	95 (min)	+0 to -5%
Safety Berms	Compact with bucket tamping or other methods to retain shape and reduce erosion	

GRAVEL AND FILTERS	% of Maximum Dry Density	% Optimum Moisture
Crushed Gravel	95 (min)	N/A
Filter Type I/II	95 (min)	+/-3%

B. Equipment that is capable of achieving the required degree of compaction shall be used and each layer shall be compacted over its entire area while the material is within the specified moisture content range.

C. Cover material tested and found to be compacted to greater than the range of percentages for maximum dry density for the material must be scarified and retested, prior to the placement of additional fill.

D. Moisture and density testing shall be completed as close to the time of placement of the next lift of material as practical, to ensure the materials are not adversely affected during delays.

E. Materials tested for density and moisture must meet the specifications at the time of placement for subsequent lifts. If weather, traffic or other impacts affect the fill density and moisture, following testing and before additional fill is placed, the CONTRACTOR will be required to rework, recompact, and retest the materials, in order to meet the specifications, at the discretion of the ENGINEER.

3.16 TEST FILLS

A. Method specifications for compaction of rock fill or materials that contain more than 30% by weight material greater than ¾-inch in size may be used when authorized in writing by the ENGINEER.

B. Method specifications for compaction of soil and debris mixtures may be used when authorized in writing by the ENGINEER

C. A test fill shall be used to define appropriate placement procedures including :

1. Lift thickness

2. Compaction equipment type

3. Number of passes

4. Moisture conditioning

D. Test Fills shall be conducted in the presence of the ENGINEER.

3.17 FIELD TESTING

A. Field testing shall be performed by the CONTRACTOR or a CONTRACTOR-retained testing laboratory.

B. When test results indicate that compaction is not as specified, recompact the materials, or if necessary remove the material, replace and recompact. Tests shall be performed on recompacted areas to determine conformance with Specification requirements.

C. The following number of tests, if performed at the appropriate time, shall be the minimum acceptable for each type operation. Additional testing may be required at the discretion of the ENGINEER.

1. Gradation:

a. Gradation of fill and backfill material determined in accordance with ASTM C117, ASTM C136, or ASTM D6913 as appropriate for the material being tested.

b. Compacted General Fill:

1) Roads, Appurtenances, Miscellaneous Uses: One test per 10,000 cubic yards of stockpiled or in-place source material, or, in the determination of the ENGINEER, as source materials change.

c. Crushed Gravel: One test per 10,000 cubic yards of material imported or stockpiled or, in the determination of the ENGINEER, as source materials change.

d. Filters: One test per 5,000 cubic yards of material imported or stockpiled or, in the determination of the ENGINEER, as source materials change.

2. Cover mixture volumes:

a. Measurements must determine the volume of the total admixture sample and volume of the rock added, to determine the percent by volume of rock in the mixture (Tolerance -5% to +5% on 33% rock by volume, each test).

b. Sample sizes per ASTM C136. If the sample size is smaller than recommended in ASTM C136, the sample size shall be appropriate for the QC method utilized and approved by the Engineer.

c. Admixture mixed <u>on</u> the cover requires 1 volume test per acre of cover.

d. Admixture mixed <u>off</u> the cover requires 1 volume test per 6,000 CY prior to placement AND 1 test per acre post-placement.

e. Volume test results from tests conducted on the cover that do not fall within the specified tolerance for rock by volume, require 4 additional retested samples, each from 50-foot grid points centered on the location of the failed test.

f. Once defined, the area with the mixture that is outside the specified tolerance shall be remixed to remedy, and resampled/retested.

3. Optimum Moisture and Laboratory Maximum Density (Proctor)

a. Where soil or admixture material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content shall be determined in accordance with the Standard Proctor test (ASTM D 698) with rock corrections as applicable.

b. Tests for each type material or source of material including borrow material shall be performed to determine the optimum moisture and laboratory maximum density values as listed below:

1) **Radon Barrier:** One representative test per 150,000 square feet of conditioned radon barrier surface.

2) **Soil Cover and Admixture:** Three tests minimum per cover mixture.

3) **Trench Fill**: One representative test shall be performed per material used of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

4) **Compacted General Fill**

a) <u>Roads, Appurtenances, Miscellaneous Uses</u>: One test per 10,000 cubic yards of stockpiled or in-place source material, or, in the determination of the ENGINEER, as source materials change.

b) <u>Soil Cover</u>: A minimum of three (3) representative tests per borrow area, or, in the determination of the ENGINEER, as source materials change.

5) **Crushed Gravel:** One test per 10,000 cubic yards of material imported or stockpiled or, in the determination of the ENGINEER, as source materials change.

4. Placed Density

a. Field density in-place tests shall be performed with the nuclear density gauge method (ASTM D 6938), or by such other means acceptable to the ENGINEER.

b. Field density test results will be compared with laboratory results for each soil type from Section 3.17 (3).

c. CONTRACTOR must provide geo-located (GPS) locations for all density tests, in an electronic format acceptable to the ENGINEER.

d. Frequency

1) **Radon Barrier:** One test per 30,000 square feet of conditioned radon barrier surface.

2) **Soil Cover and Admixture:** One test per 30,000 square feet, or fraction thereof, of each lift of fill, or as otherwise directed by the ENGINEER.

3) **Trench Fill**: One test per each lift for each culvert, or other frequency approved by the ENGINEER.

4) **Compacted General Fill**:

a) One test per 100,000 square feet, or fraction thereof, of each lift of fill of compacted general fill used as cover soil.

b) One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines and backfill around appurtenances.

c) One test per 500 linear feet, or fraction thereof, of each lift of structural fill beneath roadways.

5) **Crushed Gravel**

a) One test per 10,000 square feet, or fraction thereof, of gravel surfacing.

b) One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines and backfill beneath or around appurtenances.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 02205 – MINE WASTE EXCAVATION AND DISPOSAL

PART 1 -- GENERAL

1.1 SUMMARY

A. The WORK under this Section includes excavation of mine waste materials, contaminated soils, and sediments, and disposal of these materials in the Repository.

B. Other mine waste materials associated with the WORK including demolition debris, waste and debris from historical mining operations, cleared vegetation from areas subject to excavation of contaminated soils and sediments, and CONTRACTOR generated waste that cannot be decontaminated, shall be disposed of in accordance with this section.

1.2 REFERENCE REMEDIAL ACTION WORK PLANS

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

1. Stormwater Management Plan

2. Construction Quality Assurance Plan

3. Cleanup Verification Plan

a. The CONTRACTOR's attention is brought to the sampling and verification procedures and sequencing contained in the Cleanup Verification Plan. Areas subject to excavation of contaminated soil and sediments shall require verification and final cleanup. CONTRACTOR shall coordinate the WORK with these requirements and shall execute the WORK in a manner that does not re-contaminate areas that have been verified as clean.

1.3 REFERENCE STANDARDS

A. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.

B. ASTM D6913 – Standard Test Method for Particle-size Distribution (Gradation) Using Sieve Analysis.

1.4 DISPOSAL OF NON-MINE WASTE MATERIALS

A. Cleared vegetation from areas <u>not subject</u> to excavation of contaminated soils and sediments shall be disposed of in accordance with Section 02100 - Site Preparation

B. Contractor generated waste materials shall be disposed of in accordance with Section 01560 – Temporary Environmental Controls.

1.5 CLASSIFICATION OF MINE WASTE MATERIALS

A. Mine Waste Materials shall include those materials which are excavated from the designed excavations at the site which are contaminated soils and sediments; sediments removed from erosion control devices; surface mine debris and structures, including concrete, building foundations, pipes, waste piles, and other scrap metal debris; and other construction debris.

B. Mine Waste Materials include cleared vegetation from areas subject to excavation of contaminated soil and sediments.

C. Materials to be disposed of shall be classified as defined below:

1. **Principal Threat Waste (PTW):**

a. Soils and debris with Ra-226 values greater than 200 pCi/g and/or greater than 500 milligrams per kilogram (mg/kg) of total uranium.

b. The location of PTW waste to be excavated is shown on the Drawings.

c. PTW material shall not be disposed of in the Mill Site repository. PTW stockpiling, handling and disposal shall be in accordance with Part 3.3 of this Section.

2. **Unclassified Waste:**

a. Soils and debris with Ra-226 concentrations above the field screening level (FSL) of 2.24 pCi/g and below 200 pCi/g and/or uranium between 230 mg/kg and below 500 mg/kg.

b. Unclassified waste includes surface mine debris and structures and cleared vegetation from areas subject to excavation of contaminated soils and sediments.

c. Unclassified Mine Waste shall be disposed of in the Mill Site repository.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall execute the WORK in a manner that does not result in the re-contamination of areas already remediated or contamination of areas that were previously uncontaminated. Areas where mine wastes have been remediated shall be barricaded, flagged, or otherwise marked as needed to prevent re-contamination from construction traffic.

B. The CONTRACTOR shall survey and delineate in the field the excavation areas indicated on the Drawings. Survey shall be in accordance with Section 01018 – Construction Survey and Staking.

1. Topographic surveys of the placed mine waste are required to monitor for settlement per 01018 – Construction Surveying and Staking.

3.2 MINE WASTE EXCAVATION

A. Excavation of Mine Waste shall be conducted in phases and by location as shown in the Drawings.

1. Mine Wastes to be excavated as part of Phase 1 includes removal of the PTW material.

2. Mine Wastes to be excavated as part of Phase 2 through 6 includes removal of Unclassified Mine waste. Additional PTW waste may be identified by the ENGINEER during Phase 2 through 6.

B. To the extent practicable, excavated materials shall be direct loaded into haul vehicles, transported, and placed within the PTW staging area or the Mill Site repository without stockpiling. When direct haul is not practical, excavated materials shall be temporarily stockpiled at approved locations for impacted soils as defined by the ENGINEER prior to placement within the mine waste containment areas.

C. Radiological scanning for verification of removal of mine waste shall be conducted by the COMPANY in accordance with the Cleanup Verification Plan included with the Contract Documents.

D. Once an area has been excavated to the satisfaction of the ENGINEER, the CONTRACTOR shall barricade or otherwise delineate the area as closed to further activity while verification surveys are conducted by the COMPANY. Activity within these areas shall only be conducted upon the authorization of the ENGINEER.

E. CONTRACTOR shall execute the WORK in a manner that does not result in re-contamination of areas that have been verified as clean. Any area that is re-contaminated due to CONTRACTOR activities shall require excavation of contaminated materials and additional verification. The cost of excavation and verification of re-contaminated areas shall be borne by the CONTRACTOR.

F. Areas verified as clean shall be graded to the contours shown on the Drawings using equipment that has been properly decontaminated for use in clean areas.

G. No impacted material shall be left in place without approval of the Engineer. If impacted material, confirmed to be above the RAL, remains after proposed removal depths are reached, the Contractor shall continue to excavate until impacted material is removed, but no more than ten feet below the final Mine Site grading plan. If impacted material, confirmed to be above the RAL, is approved to be left in-place, the excavation must be scanned, marked with a geotextile barrier, geo-located and covered, with a minimum of 10 feet of non-impacted soil.

H. Revegetation shall conform to Section 02970 – Revegetation.

3.3 PTW STAGING, STOCKPILING AND HANDLING

A. PTW material shall not be placed in the Repository. PTW shall either be reprocessed to reclaim metals and radionuclides or be transported off-site to a licensed and controlled disposal facility meeting the performance standard, as defined by the USEPA, under the Off-Site Rule 40 CFR § 300.440. PTW shall be removed from the site within 6 months of the completion of PTW removals during Phase 1. **Hauling and disposal of PTW waste shall be conducted under a separate contract.**

B. PTW material identified for Phase 1 removal shall be stockpiled at, and removed from, the site within 6 months of the completion of PTW removals during Phase 1.

C. PTW encountered during the remaining phases shall be excavated and hauled to the PTW staging area for temporary storage.

D. The PTW staging area shall be located at the Mine Site as shown on the Drawings.

E. PTW material shall be placed in the stockpiled in controlled lifts not exceeding 3 feet in thickness. Each lift shall be track walked with a bulldozer equivalent to a Caterpillar D-6 or larger. Mechanical compaction in addition to track walking shall not be required.

F. PTW Stockpile side slopes shall not exceed 2H:1V.

G. Temporary stormwater run-on/runoff controls and dust control measures shall be implemented to mitigate the risk of releasing contaminated material in accordance with the CONTRACTOR'S CSWPPP and the Stormwater Management Plan.

H. Water shall be used for dust control for active areas of the PTW stockpile. Temporary dust control fencing is required along the northern site boundary in the vicinity of the PTW stockpile area to prevent windblown material from leaving the site.

I. Inactive piles must be stabilized per the CSWPPP. The PTW stockpile must be covered to prevent wind-blown material or contact water from leaving the area, each time it will not be actively worked for 48-hours, or more.

J. PTW material shall be loaded at the PTW staging area into covered trucks or sealed intermodal shipping containers. The CONTRACTOR shall use loading methods that minimize the need for truck or container decontamination. CONTRACTOR shall be required to adjust loading methods if, at the discretion of the ENGINEER, excessive contamination of trucks or containers is occurring.

K. PTW loading shall not be conducted when conditions are too rainy or muddy to adequately control runoff or contamination within the loading area.

L. Loaded trucks or intermodal containers shall be inspected by the COMPANY for external contamination prior to staging for transfer to highway vehicles.

M. Highway vehicles shall not be allowed to enter the mine exclusion area or the controlled area of the Mine Haul Road.

3.4 MINE WASTE DISPOSAL

A. PTW material shall not be placed in the Repository. PTW stockpiling, handling and disposal shall be in accordance with Part 3.3 of this Section.

B. Unclassified mine waste shall be disposed of in the Mill Site repository constructed on the tailings disposal area as shown on the Drawings. Preparation for the Repository to receive waste materials shall be in accordance with Section 2200 – Earthwork.

C. Unclassified waste shall be placed in the Repository as it is excavated according to the phased sequence described in Paragraph 3.2 and as shown on the Drawings.

D. Soils and sediments shall be hauled, dumped and spread in uniform horizontal lifts with a maximum loose thickness of 12-inches and compacted to minimum 90% Standard Proctor density as determined by ASTM D698. Compacted moisture shall be dry of optimum. Appropriate mechanical compaction equipment shall be used to obtain the required compaction.

E. Soils and sediments determined to be wetter than their optimum water content shall be scarified and/or mixed with drier materials, then retested prior to the placement of additional fill over the area.

F. Moisture and density testing shall be completed as close to the time of placement of the next lift of material as practical, to ensure the materials are not adversely affected during delays.

G. Materials tested for density and moisture must adequately meet the specifications at the time of placement for subsequent lifts. If weather, traffic or other impacts affect the fill density and moisture, following testing and before additional fill is placed, the CONTRACTOR will be required to rework, recompact, and retest the materials, in order to meet the specifications, at the discretion of the ENGINEER.

H. Soils removed from mine Area 7 (Phase 2) Sediment Pad, Area 6 (Phase 3) Sandfill 1, and Area 9 (Phase 4) Pond 1 cannot be placed within 200 feet of the outer cover slope of the Repository.

I. Disposal of Debris

1. Demolition debris shall be comingled with the backfill, to minimize the void spaces. Method specifications for compaction of soil and debris mixtures may be used when authorized in writing by the ENGINEER

2. Demolition debris shall be distributed throughout designated areas of the backfill to avoid concentrated areas of debris.

3. No debris is to be placed within:

    a. 100 feet of the Repository perimeter

    b. within 3 feet of the bottom of the cover layers

    c. within 2 feet vertically from the radon barrier (a lift of mine waste soil must be placed for separation)

4. Material Sizing

    a. The maximum size of demolition debris shall not exceed 20 feet in the longest dimension. Smaller dimensions may be necessary for loading, handling, hauling, and placement of material in the disposal cell.

    b. Debris that is larger than 12 inches shall be placed and backfilled in and around the debris with soil or mine waste. Debris larger than 12 inches may extend through compacted 12-inch layers.

5. Compressible Debris

    a. Compressible materials shall be crushed and then covered with backfill. Incompressible materials shall be placed in the disposal area, with the void spaces outside of the materials filled with backfill.

    b. Materials such as pipe and tubing have a varying degree of compressibility, depending on the diameter and wall thickness of the pipe. Pipe with a 12-inch diameter or larger shall be crushed or filled with soil for burial, and pipe with smaller diameter shall be crushed before burial.

    c. Vessels and tanks shall either be crushed (if thin-walled and compressible) or cut open (if thick-walled and incompressible). Vessels that are to be cut open and filled, shall be placed in the disposal area such that fill can also be placed around them and compacted. Thick-walled tanks or vessels that cannot be cut open due to cutting difficulties or worker health concerns shall be placed in the designated area of disposal, with interior voids spaces filled with soil or grout.

6. Incompressible Debris

   a. Metallic debris shall be placed by sizes so that larger pieces are not stacked on top of each other at angles. Large structural shapes shall either be laid edge to edge so that they can be covered by backfill or they shall be spaced far enough apart that equipment can operate between them to spread backfill. Long structural (incompressible) members shall be oriented horizontally.

3.5 COVER SYSTEM PLACEMENT

A. Cover System placement for mine waste containment areas and regraded areas shall be in accordance with the following sections:

   1. Section 02200 – Earthwork

3.6 QUALITY CONTROL TESTING

A. Quality control testing shall be performed by the CONTRACTOR or a CONTRACTOR retained testing laboratory.

B. When test results indicate that compaction is not as specified, recompact or scarify the tested material to meet Specification requirements. Tests shall be performed on reworked areas to determine conformance with Specification requirements.

C. The following number of tests, if performed at the appropriate time, shall be the minimum acceptable for each type operation:

   1. Density:

      a. Where soil material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content shall be determined in accordance with the Standard Proctor test (ASTM D 698).

         1) Frequency: One test per 100,000 cubic yards of material excavated or, in the determination of the ENGINEER, as source materials change.

      b. Field density in-place tests shall be performed with the nuclear density gauge method (ASTM D 6938), or by such other means acceptable to the ENGINEER.

         1) Frequency: One test per 100,000 square feet, or fraction thereof, of each lift of fill of compacted mine waste.

      c. CONTRACTOR must provide geo-located (GPS) locations for all density tests, in an electronic format acceptable to the ENGINEER.

- END OF SECTION –

SECTION 02271 - GABIONS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide wire mesh baskets or containers known as gabions and all appurtenant work, including the furnishing and placement of all stone fill, geotextiles, compacted embankment or other fill material, excavation, and disposal of excess or waste material, all in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. All CONTRACTOR submittals shall be in accordance with the requirements of Section 01300 - Contractor Submittals.

B. The CONTRACTOR shall submit specifications of the proposed gabion baskets and associated components including stiffeners, tying components, anchoring systems, etc. to the ENGINEER for review prior to ordering.

C. The CONTRACTOR shall submit specifications and samples of the proposed geotextile fabric to the ENGINEER for review prior to ordering.

PART 2 -- PRODUCTS

2.1 WOVEN MESH GABIONS

A. Coated Steel Tensor Wire (Zinc-5% aluminum-mischmetal [Zn-5% Al-MM] alloy) Coated:

1. All tests on the wire must be performed prior to manufacturing of the mesh.

- *Tensile strength*: the wire used for the manufacturing gabions and lacing wire, shall have a maximum tensile strength of 75,000 psi (515 MPa), in accordance with ASTM A856/A856M.
- *Elongation*: the test must be carried out on a sample at least 12 in. (30 cm) long. Elongation shall not be less than 12%, in accordance with ASTM A370.
- *Coating*: minimum Zn-5% Al-MM alloy coating quantities according to ASTM A856/A856M, Class III soft temper coating.
- *Adhesion of coating*: the adhesion of the coating to the wire shall be such that, when the wire is wrapped six turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with the bare fingers, in accordance with ASTM A856/A856M.

B. PVC (Polyvinyl Chloride) Coating

1. *Specific gravity: 81-84 pcf (1.30-1.35 kg/dm3,) in accordance with ASTM D792, Table 1*
2. *Hardness*: between 50 and 60 Shore D, according to ASTM D 2240
3. *Tensile strength*: not less than 2,985 psi (20.6 MPa), according to ASTM D412
4. *Modulus of elasticity*: not less than 2,700 psi (18.6 MPa), according to ASTM D412

5. *Abrasion resistance*: the percentage of the weight loss shall be less than 12%, according to ASTM D1242.

6. *Heat Aging Test*: prior to UV and abrasion degradation, the PVC polymer coating shall have a projected durability life of 69 years when tested in accordance with UL 746B.

7. The accelerated aging tests are:
   - *Salt spray test*: test period 3,000 hours, test method ASTM B117
   - *Exposure to UV rays*: test period 3,000 hours at 145°F (63°C), test method ASTM D1499 and ASTM G152
   - *Brittleness temperature*: no higher than 15°F (- 9°C), or lower temperature when specified by the purchaser, when tested in accordance with ASTM D746

8. The properties after aging tests shall be as follows:
   - *Appearance of coated mesh*: no cracking, stripping or air bubbles, and no appreciable variation in color
   - *Specific gravity*: variations shall not exceed 6%
   - *Hardness*: variations shall not exceed 10%
   - *Tensile strength*: variations shall not exceed 25%
   - *Modulus of elasticity*: variations shall not exceed 25%
   - *Abrasion resistance*: variations shall not exceed 10%
   - *Brittleness temperature:* shall not exceed + 64°F (+18°C).

C. Zn-5% Al-MM alloy coating and PVC coated wire mesh gabions:

1. *PVC coating thickness*: Nominal – 0.02 in. (0.5 mm), Minimum – 0.015 in. (0.38 mm)

2. *Mesh Wire*: Diameter – 0.106 in. (2.70 mm) internal, 0.146 in. (3.70 mm) external

3. *Selvedge Wire*: Diameter – 0.134 in. (3.40 mm) internal, 0.174 in. (4.40 mm) external

4. *Mesh Opening*: Nominal Dimension D = 3.25 in. (83 mm), as per Fig. 1.

D. Zn-5% Al-MM alloy and PVC coated lacing wire and internal stiffeners:

1. *PVC coating thickness:* Nominal – 0.02 in. (0.5 mm), Minimum – 0.015 in. (0.38 mm)

2. *Lacing wire:* Diameter – 0.087 in. (2.20 mm) internal, 0.127 in. (3.20 mm) external

3. *Cross Tie/Stiffener wire:* Diameter - 0.087 in. (2.20 mm) internal, 0.127 in. (3.20 mm) external

4. *Preformed Stiffener:* Diameter – 0.134 in. (3.4 mm) internal, 0.174 in. (4.4 mm) external

E. Steel Mesh properties

1. Steel mesh shall comply with the below minimum strength requirements:

Minimum Strength Requirements of Mesh and Connections		
Test Property	**Test Method**	**Minimum Test Value**
Mesh Tensile Strength	ASTM A975	3425 lb/ft (50.0 kN/m)
Punch Test Resistance	ASTM A975	5300 lb (23.6 kN)
Connection to Selvedges	ASTM A975	1200 lb/ft (17.5 kN/m)

Panel to Panel Connection	ASTM A975	1200 lb/ft (17.5 kN/m)

F. Spenax Fasteners (Overlapping Fasteners):

1. Stainless Steel overlapping fasteners may be used in lieu of, or in conjunction with lacing wire for basket assembly and installation.

2. High tensile strength fasteners shall be installed at nominal spacing of 4 in. (100 mm), not to exceed 6 in (150 mm). This is based on a 1,200 lb/ft (17.5 kN/m) pull apart resistance for Zn-5% Al-MM alloy and PVC coated wire mesh with this spacing (ASTM A975 section 13.1.2).

3. Field samples of fasteners used for assembly and installation shall be tested for compliance with the ASTM A975 section 13.1.2.2 Pull-Apart Resistance. Producer or supplier of the wire mesh shall provide certification no later than 15 days prior of starting construction.

4. When tested in accordance with section 13.1.2.1, the average maximum resistance of the fasteners from the field shall not be lower than 90% of the resistance provided in the certification.

5. Stainless Steel Fasteners: Diameter = 0.120 in. (3.05 mm), according to ASTM A313/A313M, Type 302, Class I.

6. Tensile strength: 222,000 to 253,000 psi (1530-1744 MPA) in accordance with ASTM A313 Table 5.

7. Proper installation of rings: A properly formed Spenax fastener shall have a nominal overlap of one (1) in. after closure (Fig. 2).

G. Tolerances

1. *Wire*: Zn-5% Al-MM alloy coating, in accordance with ASTM A856/A856M, Class III soft temper coating.

2. *Gabions*: ± 5 % on the length, width, and height.

3. *Mesh opening*: Tolerances on the hexagonal, double twisted wire mesh opening shall not exceed ± 10% on the nominal dimension D values (see Fig.1):

Fig. 1

Mesh Type	Nominal Dimension D
8 x 10	3.25 in. (83 mm)

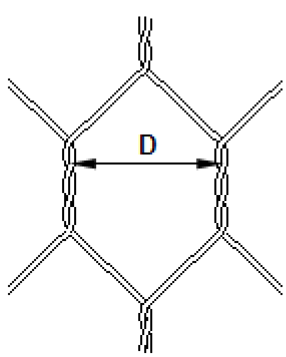
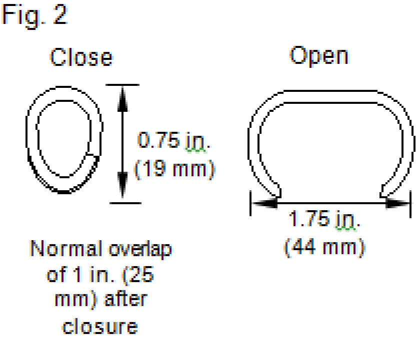


Fig. 2



H. Standard Unit Size

Typical Gabion Sizes			
L=Length ft (m)	**W=Width ft (m)**	**H=Height ft (m)**	**# of cells**
12 (3.6)	3 (0.9)	3 (0.9)	4
9 (2.7)	3 (0.9)	3 (0.9)	3
6 (1.8)	3 (0.9)	3 (0.9)	2
4.5 (1.4)	3 (0.9)	3 (0.9)	1
9 (2.7)	3 (0.9)	1.5 (0.45)	3
9 (2.7)	3 (0.9)	1 (0.3)	3

All sizes and dimensions are nominal. Tolerances of ± 5% of the width, and length height of the gabions shall be permitted.

I. Fabrication

1. Gabions shall be manufactured and shipped with all components mechanically connected at the production facility. The front, base, back and lid of the gabions shall be woven into a single unit. The ends and diaphragm(s) shall be factory connected to the base. All perimeter edges of the mesh forming the basket and top, or lid, shall be selvedged with wire having a larger diameter.

2. The gabion is divided into cells by means of diaphragms positioned at approximately 3 ft (1 m) centers. The diaphragms shall be secured in position to the base so that no additional lacing is necessary at the jobsite. See Figure 3.

3. Where indicated in the drawing set, an additional layer of wire mesh shall be woven to the top (lid) of the gabion basket.

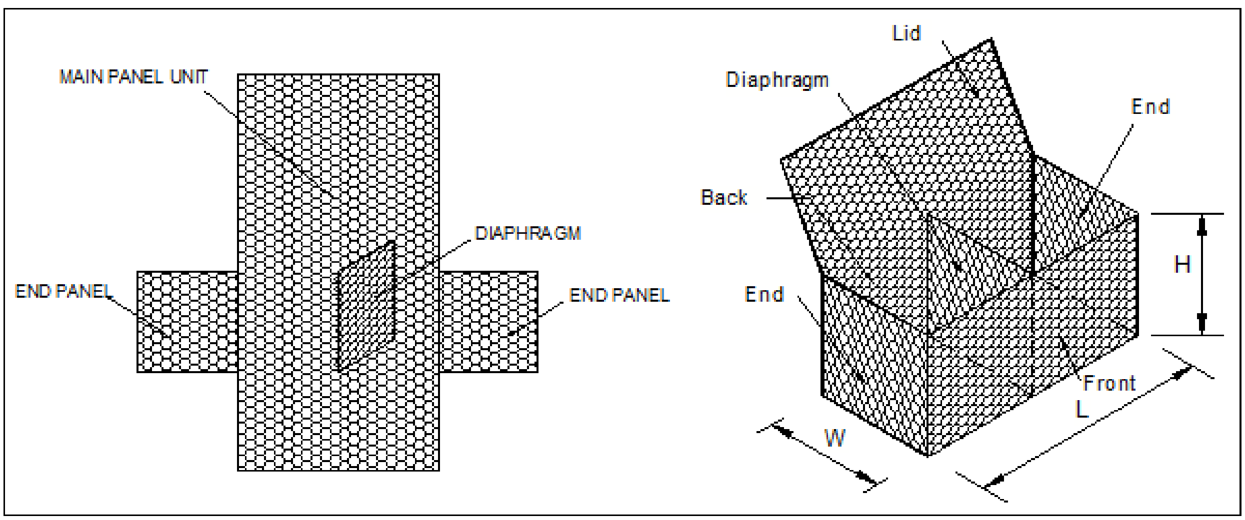


Fig. 3

2.2 ROCK

A. The rock used in gabions shall be hard, angular to round, durable and of such quality that they shall not disintegrate on exposure to water or weathering during the life of the structure.

B. Gabion rocks shall conform to the size types as follows:

6-inch Gabion rocks shall range between 4 in. (0.10 m) and 8 in. (0.20 m)

The range in sizes shall allow for a variation of 5% oversize and/or 5% undersize rock, provided it is not placed on the gabion exposed surface. The size shall be such that a minimum of three layers of rock must be achieved when filling the gabions.

PART 3 -- EXECUTION

3.1 FOUNDATION PREPARATION

A. The foundation areas for the gabions shall be excavated and backfilled to the slopes, lines and grades shown and prepared in accordance with the applicable requirements of Section 02200 - Earthwork. Geotextile shall be placed on prepared soil foundation surfaces in accordance with the requirements of Section 02274 - Geotextiles. Geotextiles shall not be required for intact stone foundation surfaces.

3.2 ASSEMBLY AND INSTALLATION OF GABIONS

A. The Gabion units shall be assembled individually by erecting the sides, ends and diaphragms ensuring that all panels are in the correct position and the tops of all sides are aligned. The four corners of the unit shall be connected first, followed by the internal diaphragms, or stiffeners, to the sides as the basket is filled as shown in Fig 4. All connections should be accomplished using lacing wire or fasteners.

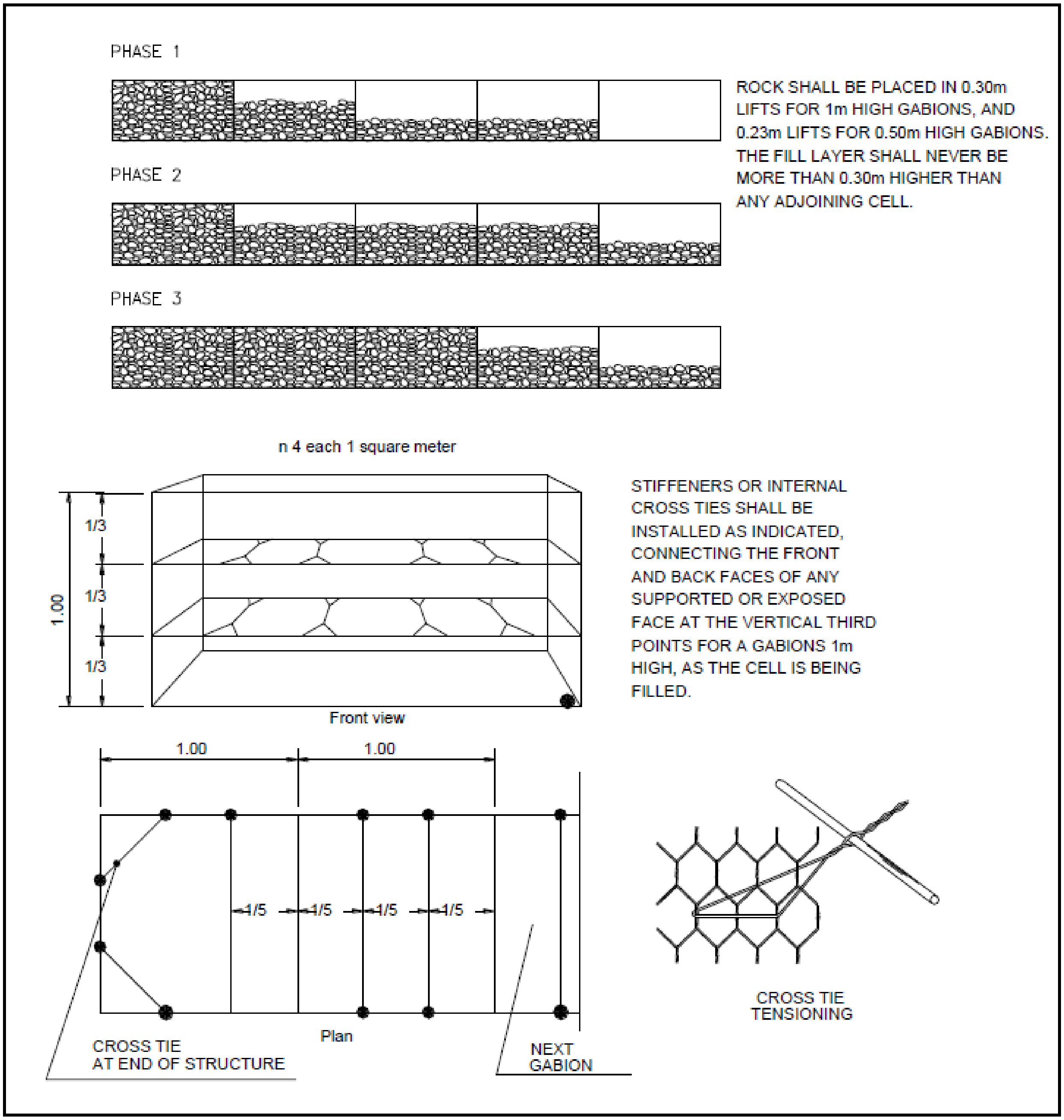


FIG. 4

B. The recommended procedure to apply lacing wire consists of first cutting a sufficient length of wire. Secure one end of the wire by looping and twisting, then proceed to lace with alternating single and double loops every mesh opening (approximately every 4 in. (100 mm)) and securely fasten the other end of the lacing wire. The installation of the fasteners specified in Section 2.1.6 shall be in accordance with the manufacturer's recommendations. See Fig. 5.

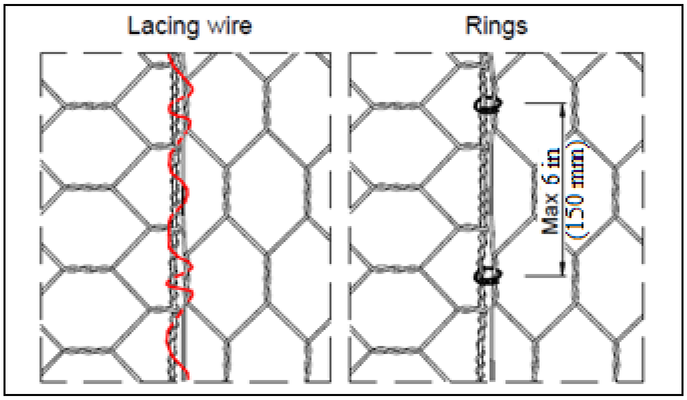


FIG. 5

C. Installation

1. Initial assembly should occur with the gabion mats in their final position. The adjacent empty mats must be securely joined together using the same connecting procedure(s) described in Section 3.1 along the vertical, top and bottom edges of their contact surfaces.

D. Filling

1. Gabion mats shall be filled with rock as specified in Section 2.2. During the filling operation some manual stone placement is required to minimize voids. Care shall be taken when placing fill material to ensure that the PVC sheathing is not damaged. The baskets should be overfilled by 1 to 2 in. (25 to 50 mm) to allow for settlement of the rock.

2. The cells in any row shall be filled in stages so that local deformation may be avoided. To avoid localized deformation, the basket units in any row are to be filled in stages consisting of maximum 12-inch courses, and at no time shall any cell be filled to a depth exceeding one foot more than the adjoining cell. The maximum height from which the stone may be dropped into the basket units shall be 36 inches.

3. Along all exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to insure a neat and compact appearance. All stones used on exposed faces shall have no dimension smaller than the mesh opening size.

4. Each partitioned section of the gabion shall be filled and leveled at the 1/3 point for 3-foot high gabions or the 1/2 point for 1-foot or 1.5-foot high gabions and shall be cross tied through the middle with connecting wire from end to end and side to side. Connecting wires shall be looped around one mesh opening at each basket face and the wire terminals shall be securely twisted to prevent their loosening.

E. Lid Closing

1. Once the mats are completely full, the lids shall be pulled tight using a tool such as a lid closer until the lid meets the perimeter edges of the mattress. The lid shall then be tightly laced and/or fastened along all edges, ends and tops of diaphragms in the same manner as described in Section 3.1.

2. Where indicated in the drawing set, a double layer of wire mesh shall be attached to the basket lid.

F. Mesh cutting and folding

1. Where shown on the drawings or otherwise directed by the engineer, the gabion mat mesh shall be cut, folded and fastened together to suit existing site conditions. The mesh must be cleanly cut and the surplus mesh folded back and neatly wired to an adjacent gabion mat. The cut edges of the mesh shall be securely fastened together with lacing wire or fasteners in the manner described in Section 3.1. Any reshaped gabion mats shall be assembled, installed, filled and closed as specified in the previous sections

3.3 PROTECTION OF THE WORK

A. The construction sequence shall be planned and carried out in such a manner that no tracked or wheeled vehicles, nor any heavy equipment, shall travel over or on a completed gabion.

- END OF SECTION -

SECTION 02273 – RIPRAP

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide riprap, including associated earthwork, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

NUREG 1623	Design of Erosion Protection for Long-term Stabilization, USNRC
ASTM D 5240	Standard Test Method for Testing Rock Slabs to Evaluate Soundness of Riprap by use of Sodium Sulfate or Magnesium Sulfate
ASTM D 5519	Standard Test Methods for Particle Size Analysis of Natural and Man-Made Riprap Materials
ASTM D 6825	Standard Guide for Placement of Riprap Revetments
ASTM C 88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 535	Standard Test Method for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
AASHTO T 85	Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 210	Method of Test for Aggregate Durability Index.

1.3 CONTRACTOR SUBMITTAL

A. Furnish submittals in accordance with Section 01300 – Contractor Submittals.

B. Proposed source of riprap and riprap bedding.

C. Test Certifications from a qualified testing agency shall be submitted prior to acceptance of the rock source(s) to be used for construction at the Mill Site to verify conformity to the requirements of the Contract Documents. Evaluation shall include the following:

1. Petrographic evaluation by a geologist experienced in petrographic analyses.

2. Laboratory durability testing:

    a. L.A. Abrasion (ASTM C535, modified for 100 revolutions)

    b. Bulk specific gravity and absorption (ASTM C127)

    c. Sodium Sulfate (ASTM C88)

d. Schmidt Hammer (ASTM D5873)

e. Or alternates per NUREG 1623, approved by ENGINEER

D. Test frequencies per Section 2.6.

PART 2 -- PRODUCT

2.1 PARTICLES FOR RIPRAP

A. Particles shall be graded in size to produce a reasonably dense mass. Riprap shall consist of dense, natural rock fragments. Rock pieces shall be angular or sub-angular rock fragments with at least 90 percent of the face area freshly broken. Particles shall be resistant to weathering and to water action; free from overburden, spoil, shale, and organic material; and shall meet the gradation requirements below. Shale and particles with shale seams are not acceptable.

B. Riprap shall conform to the size types as follows:

1. D_{50} = 3-inch Riprap:

D-*sizes* **Percent Passing**	**Minimum Diameter (in)**	**Maximum Diameter (in)**
d_{15} 15% Passing	1.0	2.0
d_{50} 50% Passing	3.0	3.5
d_{85} 85% Passing	3.5	4.0
d_{100} 100% Passing	4.5	6.0

2. D_{50} = 6-inch Riprap:

D-*sizes* **Percent Passing**	**Minimum Diameter (in)**	**Maximum Diameter (in)**
d_{15} 15% Passing	2	4
d_{50} 50% Passing	6	7
d_{85} 85% Passing	8	9
d_{100} 100% Passing	10	11

3. D_{50} = 9-inch Riprap:

D-*sizes* **Percent Passing**	**Minimum Diameter (in)**	**Maximum Diameter (in)**
d_{15} 15% Passing	4	6
d_{50} 50% Passing	9	11

D-*sizes* Percent Passing	Minimum Diameter (in)	Maximum Diameter (in)
d_{85} 85% Passing	11	13
d_{100} 100% Passing	14	16

4. D_{50} = 15-inch Riprap:

D-*sizes* Percent Passing	Minimum Diameter (in)	Maximum Diameter (in)
d_{15} 15% Passing	6	9
d_{50} 50% Passing	15	18
d_{85} 85% Passing	18	21
d_{100} 100% Passing	22	26

5. D_{50} = 24-inch Riprap:

D-*sizes* Percent Passing	Minimum Diameter (in)	Maximum Diameter (in)
d_{15} 15% Passing	10	15
d_{50} 50% Passing	24	28
d_{85} 85% Passing	29	34
d_{100} 100% Passing	36	41

6. D_{50} = 27-inch Riprap:

D-*sizes* Percent Passing	Minimum Diameter (in)	Maximum Diameter (in)
d_{15} 15% Passing	11	17
d_{50} 50% Passing	27	31
d_{85} 85% Passing	33	38
d_{100} 100% Passing	41	46

C. The greatest dimension of 50 percent of the particles shall be at least two-thirds but not more than 1-1/2 times the diameter of the average size. Neither the breadth nor thickness of any piece of riprap shall be less than one-third its length. Material shall be of shapes which shall form a stable protection structure of required depth. Rounded boulders or cobbles shall not be used.

D. Particles shall consist of durable, sound, hard, angular rock and rock for the Mill Site must rate with a minimum score of 65 per NUREG-1623, rock rating below 80 will require oversizing.

E. Less durable riprap, may be acceptable for applications at the Mine Site, with approval by the ENGINEER.

F. Control of gradation shall be by visual inspection. The CONTRACTOR shall furnish a sample of the proposed gradation of at least 5 tons or 10 percent of the total riprap weight, whichever is less. If approved, the sample may be incorporated into the finished riprap at a location where it can be used as a frequent reference for judging the gradation of the remainder of riprap.

G. The acceptability of the stones and gradation shall be determined by the ENGINEER prior to placement. Any difference of opinion between the ENGINEER and the CONTRACTOR shall be resolved by dumping and checking the gradation of two random truckloads of particles. Arranging for and the costs of mechanical equipment, a sorting site, and labor needed in checking particles and gradation shall be the CONTRACTOR's responsibility.

2.2 FILTER MATERIAL

A. Filter material shall be clean and free from organic matter. It shall be crushed rock or gravel, durable and free from slaking or decomposition under the action of alternate wetting or drying. The material shall be uniformly graded and shall conform to the following gradation:

1. Type I

Size	**Percentage Passing**
No. 4	90-100
No. 16	45-70
No. 50	4-25
No. 100	0-2

2. Type II

Size	**Percentage Passing**
3-inch	80 – 100
1.5-inch	55-70
¾-inch	30-50
3/8-inch	7-25
No. 4	0-5

2.3 SURFACE PREPARATION

A. Surfaces to receive riprap shall be smooth and firm, free of brush, trees, stumps, and other objectionable material identified by the ENGINEER, and shall be brought to the line and grade indicated.

B. If a boulder is encountered during excavation of areas where large riprap is to be placed, the CONTRACTOR shall excavate around the boulder. If the boulder is larger than the largest allowable stone size for that area, the CONTRACTOR shall break up the boulder to an acceptable size or remove it entirely.

2.4 PLACEMENT OF FILTER BLANKET

A. Area of riprap placement shall be excavated to the bottom of the filter blanket as indicated and in accordance with Section 02200 – Earthwork. The finished grade shall be even, self-draining, and in conformance with the slope of the finished grade.

B. Filter material shall be placed, spread, and compacted in lifts of a minimum of 6 inches. Where filter material is indicated to be 12 inches thick or greater, lift placement shall not exceed 12 inches.

C. The CONTRACTOR shall remove any portion of the filter blanket that has been disturbed to the degree that the layers become mixed. The CONTRACTOR shall replace the removed portion with the required sizes.

D. No filter material is required if riprap is placed directly on bedrock.

2.5 PLACEMENT OF RIPRAP

A. Placement of riprap shall begin at the toe of the slope and proceed up the slope. The particles may be placed by dumping and may be spread by bulldozers, excavators, or other suitable equipment as long as the underlying material is not displaced. Particles shall be placed so as to provide a minimum of voids. Smaller particles shall be uniformly distributed throughout the mass. Sufficient hand work shall be done to produce a neat and uniform surface, true to the lines, grades, and sections indicated.

B. Provide laborers during placement for rearrangement of loose rock fragments, ”chinking” of void spaces and hand placement as necessary to create a well-keyed and stable layer of rock riprap.

C. Where riprap is placed over a Geotextile, the riprap shall be placed so as to avoid damage to the Geotextile. Particles shall not be dropped from a height greater than 3 feet, nor shall large particles be allowed to roll downslope.

2.6 FIELD AND LAB TESTING

A. Field testing shall be performed by the CONTRACTOR or a CONTRACTOR-retained testing laboratory.

B. When test results indicate that compaction is not as specified, recompact the materials, or if necessary remove the material, replace and recompact. Tests shall be performed on recompacted areas to determine conformance with Specification requirements.

C. The following number of tests, if performed at the appropriate time, shall be the minimum acceptable for each type operation.

1. Petrographic Analysis (rock):

    a. Results from the selected rock source must be submitted by the CONTRACTOR to the ENGINEER for approval, prior to initiating production.

    b. Rock source must rank as “fair”, or better, based on the petrography (see NUREG-1623), before durability testing.

2. Durability tests (rock):

   a. Each test listed in 1.3, shall be performed on samples prior to production (for approval of the source), and at ¼, ½ and ¾ of the total produced volume.

   b. Alternate tests may be substituted, if approved by the ENGINEER.

3. Gradation (filters):

   a. Gradation of fill and backfill material determined in accordance with ASTM C117, ASTM C136, or ASTM D6913 as appropriate for the material being tested.

   b. Frequency: One test per 5,000 cubic yards of material imported or stockpiled or, in the determination of the ENGINEER, as source materials change.

4. Compaction requirements (filters)

   a. Where soil or admixture material is required to be compacted to a percentage of maximum density, the maximum density at optimum moisture content shall be determined in accordance with the Standard Proctor test (ASTM D 698).

      1) Frequency: Minimum of 3 representative tests must be performed per material used of filters, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

5. Density (Filters):

   a. Field density in-place tests shall be performed with the nuclear density gauge method (ASTM D 6938), or by such other means acceptable to the ENGINEER.

   b. Field density test results will be compared with laboratory Proctor results for each soil type.

   c. The following compaction requirements shall be in accordance with the Standard Proctor test (ASTM D 698). If more than 30% of the material is larger than ¾-inch in size, an oversize correction shall be applied in accordance with ASTM D4718.

FILTERS	% of Maximum Dry Density	% Optimum Moisture
Filter Type I/II	95 (min)	+/-3%

   d. CONTRACTOR must provide geo-located (GPS) locations for all density tests, in an electronic format acceptable to the ENGINEER.

   e. Frequency: One test per 2,000 cubic yards of material imported or stockpiled or, in the determination of the ENGINEER, as source materials change.

- END OF SECTION -

SECTION 02274 - GEOTEXTILES

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide and install geotextiles as shown on the Drawings.

B. **Definitions:** The following definitions apply to the WORK of this Section:

1. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

2. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile provided.

3. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile provided.

4. Nondestructive Sample: Sample representative of finished geotextile, prepared for testing without destruction of geotextile.

5. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

6. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D 4884.

7. Woven geotextile: A geotextile fabric composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern.

8. Nonwoven geotextile: A geotextile fabric composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The following standards are referenced in this Section:

ASTM D 4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon-Arc Type Apparatus
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D 4354	Standard Practice for Sampling of Geosynthetics for Testing
ASTM D 4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D 4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

ASTM D 4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D 4759	Standard Practice for Determining the Specifications Conformance of Geosynthetics
ASTM D 4833	Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D 4884	Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Sewn Geotextiles
ASTM D 4886	Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding Block Method)
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. Prior to material delivery to project site, the CONTRACTOR shall provide the ENGINEER with a written certification or manufacturer's quality control data which displays that the geotextile meets or exceeds minimum average roll values (MARV) specified herein.

PART 2 -- PRODUCTS

2.1 WOVEN GEOTEXTILE

A. Woven geotextile shall be composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. Sheet Edges: Selvaged or finished to prevent outer material from separating from sheet.

D. Unseamed Sheet Width: Minimum 12 feet.

E. Nominal Weight per Square Yard: 8 oz.

F. Physical Properties: Conform to requirements below unless otherwise specified in the Drawings or by the ENGINEER.

Physical Property Requirements for Woven Geotextile		
Property	**Requirement**	**Test Method**
Apparent Opening Size (AOS)	No. 70 to No. 100 U.S. Standard Sieve Size	ASTM D 4751
Water Permittivity	0.7 to 3.34 sec.$^{-1}$, MinARV	ASTM D 4491 (Falling Head)
Vertical Waterflow Rate	50 gpm/sq ft, MinARV	
Wide Width Strip Tensile Strength	60 to 1,500 lb/in.-width, MinARV	ASTM D 4595
Wide Width Strip Elongation	14 to 60 percent, MaxARV	
Trapezoidal Tear Strength	70 to 200 lb, MinARV	ASTM D 4533
Puncture Strength	50 to 250 lb, MinARV	ASTM D 4833
Abrasion Resistance	5 to 25 percent loss, 250 cycles, MaxARV	ASTM D 4886
Ultraviolet Radiation Resistance	70 to 90 percent strength retention, MinARV after 500 hours	ASTM D 4355

2.2 NONWOVEN GEOTEXTILE

A. Nonwoven geotextile shall be composed of a pervious sheet of polymeric fibers interlaced to form a planar structure with uniform random fiber pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.

B. Polymeric yarn shall be long-chain synthetic polymers (polyester, polypropylene, or polyethylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

C. **Minimum Nominal Weight per Square Yard:**

Application	Geotextile
Not Used	32 oz/sy
Not Used	16 oz/sy
Beneath Gabions	8 oz/sy

D. **Geotextile Edges:** Selvaged or finished to prevent outer material from separating from sheet.

E. **Unseamed Sheet Width:** Minimum 12-feet.

F. **Physical Properties:** Conform to requirements below.

Tested Property	Test Method	Frequency	MARV		
			32 oz/sy	**16 oz/sy**	**8 oz/sy**
Mass per Unit Area, oz/sy	ASTM D 5261	90,000 sf	32	16	8
Grab Tensile Strength	ASTM D 4632	90,000 sf	600	390	220
Grab Elongation, %	ASTM D 4632	90,000 sf	50	50	50
CBR Puncture Strength, lb	ASTM D 6241	90,000 sf	2,287	1,125	575
Trapezoidal Tear Strength, lb	ASTM D 4533	90,000 sf	270	150	90
UV Resistance, % retained after 500 hrs	ASTM D4355	90,000 sf	70	70	70
Apparent Opening Size, Sieve No. (mm)	ASTM D 4491	540,000 sf	N/A	100 (0.150)	80 (0.180)
Water Flow Rate, gpm/sf	ASTM D 4491	540,000 sf	N/A	45	95
Permitivity, sec^{-1}	ASTM D 4491	540,000 sf	N/A	0.60	1.30

2.3 SEWING THREAD

A. Sewing thread shall be polypropylene, polyester, or Kevlar thread with durability equal to or greater than durability of geotextile sewn.

2.4 SECURING PINS

A. Securing pins shall be steel rods or bars conforming to the following:

1. 3/16-inch diameter.

2. Pointed at one end; head on other end, sufficiently large to retain washer.

3. Minimum Length: 12 inches.

B. Steel washers for securing pins shall be:

1. Outside Diameter: Not less than 1-1/2 inches.

2. Inside Diameter: ¼ inch.

3. Thickness: 1/8 inch.

C. Steel Wire Staples

1. U-shaped.

2. 10-gauge.

3. Minimum Length: 6 inches.

PART 3 -- EXECUTION

3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify manufacturer and product name or number.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in a way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

3.2 LAYING GEOTEXTILE

A. Notify the ENGINEER whenever geotextiles are to be placed. Geotextile shall not be placed prior to obtaining ENGINEER's approval of the underlying surface.

B. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.3 ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

B. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and extend at least 18 inches beyond the toe of slope.

3.4 JOINTS

A. Unseamed Joints

1. Unseamed joints shall be overlapped to the following dimensions unless otherwise indicated:

a. Foundation/Subgrade Stabilization: Minimum 18 inches.

b. Riprap: Minimum 18 inches.

c. Drain Trenches: Minimum 18 inches, except overlap shall equal trench width if trench width is less than 18 inches.

d. Other Applications: Minimum 12 inches.

B. Sewn seams shall be used wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by ENGINEER, also may be used instead of overlap at joints for applications that do not require stress transfer.

1. Seam efficiency shall be minimum 70 percent, verified by preparing and testing minimum of one set of nondestructive samples per acre of each type and weight of geotextile provided. Test according to ASTM D 4884.

2. Type: "J" type seams are preferred, but flat or butterfly seams are acceptable.

3. Stitch Count: Minimum 3 to maximum 7 stitches per inch.

4. Stitch Type: Double-thread chainstitch, Type 401, Federal Standard No. 751a.

5. Stitch Location: 2 inches from geotextile sheet edges, or more if necessary to develop required seam strength.

6. Sewing Machines: Capable of penetrating four layers of geotextile.

3.5 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sand bags or other means approved by ENGINEER.

B. Securing Pins

1. Insert securing pins with washers through geotextile, midway between edges of overlaps and 6 inches from free edges.

2. Spacing

Slope	Maximum Pin Spacing, feet
Steeper than 3H:1V	2
3H:1V to 4H:1V	3
Flatter than 4H:1V	5

3. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.

4. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.

3.6 PLACING PRODUCTS OVER GEOTEXTILE

A. Notify ENGINEER before placing material over geotextile. Do not cover installed geotextile prior to receiving approval of the geotextile installation from the ENGINEER.

B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as indicated below.

3.7 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way that will completely envelop granular drain material to be placed in trench and with indicated overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain material is placed to grade, fold geotextile over top of granular drain material, unless otherwise indicated. Maintain overlap until overlying fill or backfill is placed.

3.8 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile. Repair damaged geotextile by placing patch of undamaged geotextile over damaged area plus at least 18 inches in all directions beyond damaged area. Remove interfering material as necessary to expose damaged geotextile for repair. Secure patches with pins and washers, as indicated above for securing geotextile, or by other means approved by ENGINEER.

3.9 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere with its intended function. Remove and replace contaminated geotextile with clean geotextile as directed by ENGINEER.

- END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 02460 – HOT MIX ASPHALT PAVEMENT AND BASE

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall construct hot mix asphalt (HMA) pavement and base, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. New Mexico Department of Transportation, Standard Specifications for Highway and Bridge Construction, 2014 Edition. Herein referred to as NMDOT Standard Specifications.

1.3 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit, in writing, materials testing reports, proposed HMA mix (refer to Part 2), and other pertinent information satisfactory to the ENGINEER demonstrating that materials and methods CONTRACTOR proposes to utilize shall comply with the provisions of this Section. Submittals shall be in accordance with Section 01300 - Contractor Submittals.

B. **Suitability Tests of Proposed Materials:** Tests for conformance with the Specifications shall be performed prior to start of the WORK. The samples shall be identified to show the name of the material, aggregate source, name of the supplier, and contract number. Results of all tests shall be submitted to the ENGINEER for approval. Materials to be tested shall include aggregate base, coarse and fine aggregate for paving mixtures, mineral filler, and asphalt materials.

PART 2 -- PRODUCTS

2.1 AGGREGATE BASE COURSE

A. Base course shall be Crushed Gravel as defined in Specification 02200 – Earthwork.

2.2 ASPHALT MATERIALS, AGGREGATES, AND MIX DESIGN

A. CONTRACTOR shall propose for ENGINEER approval a hot mix asphalt product and mix design that conforms to the requirements of NMDOT Standard Specifications, Section 423 – Hot Mix Asphalt.

PART 3 -- EXECUTION

3.1 SUBGRADE PREPARATION

A. The subgrade shall be prepared as specified in the Section 02200 - Earthwork as applicable to gravel surfacing. The surface of the subgrade after compaction shall be hard, uniform, smooth, and true to grade and cross-section. Subgrade for base material shall not vary more than 0.04-foot from the required grade and cross section.

3.2 BASE COURSE

A. Aggregate base shall be provided as indicated on the drawings and to the thickness indicated. Segregation shall be avoided and the base shall be free of pockets of coarse or fine material. Where the required thickness is 6 inches or less, the base materials may be spread and compacted in one layer. Where the required thickness is more than 6 inches, the base material shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 6 inches. The relative compaction of each layer of aggregate base shall be not less than 95 percent of maximum density when measured in accordance with ASTM D 1557. The compacted surface of the finished aggregate shall be hard, uniform, smooth and at any point shall not vary more than 0.02 foot from the indicated grade or cross-section.

3.3 TACK COAT

A. A tack coat shall be applied to existing paved surfaces where new hot mix asphalt is to be placed on existing pavement. It shall also be applied to the contact surfaces of all cold pavement joints, curbs, gutters, manholes and the like immediately before the adjoining asphalt pavement is placed. Care shall be taken to prevent the application of tack coat material to surfaces that shall not be in contact with the new hot mix asphalt pavement. Diluted emulsified asphalt shall be applied at the rate of 0.05 to 0.15 gal/sq. yd. Undiluted emulsified asphalt shall be applied at the rate of 0.025 to 0.075 gal/sq. yd. Paving asphalt shall be applied at the rate of approximately 0.05 gal/sq. yd.

3.4 HOT MIX ASPHALT

A. At the time of delivery to the Site, the temperature of mixture shall not be lower than 260 degrees F or higher than 320 degrees F, the lower limit to be approached in warm weather and the higher in cold weather.

B. Hot mix asphalt shall not be placed when the atmospheric temperature is below 40 degrees F or during unsuitable weather.

C. The hot mix asphalt shall be evenly spread upon the base to such a depth that, after rolling, it shall be of the required cross section and grade of the course being constructed.

   1. Hot mix asphalt shall be placed in 2 lifts, with a minimum compacted thickness of 1 inches per lift.

D. The depositing, distributing, and spreading of the hot mix asphalt shall be accomplished in a single, continuous operation by means of a self-propelled mechanical spreading and finishing machine designed for that purpose. The machine shall be equipped with a screed or strike-off assembly capable of being accurately regulated and adjusted to distribute a layer of the material to a definite pre-determined thickness. When paving is of a size or in a location that use of a self-propelled machine is impractical the ENGINEER may waive the self-propelled requirement.

E. Spreading, once commenced, shall be continued without interruption.

F. The mix shall be compacted immediately after placing. Initial rolling with a steel-wheeled tandem roller, steel three-wheeled roller, vibratory roller, or a pneumatic-tired roller shall follow the paver as closely as possible. If needed, intermediate rolling with a pneumatic-tired roller shall be done immediately behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In areas too small for the roller a vibrating plate compactor or a hand tamper shall be used to achieve thorough compaction.

G. Upon completion the pavement shall be true to grade and cross-section. When a 10-ft straightedge is laid on the finished surface parallel to the center of the roadway, the surface shall not vary from the edge of the straightedge more than 1/8 inch except at intersections or changes of grade. In the transverse direction, the surface shall not vary from the edge of the straightedge more than ¼ inch.

H. The relative density after compaction shall be 95 percent of the density obtained by using ASTM D 1188 or D 2726. A properly calibrated nuclear asphalt testing device shall be used for determining the field density of compacted hot mix asphalt, or slabs or cores may be laboratory tested in accordance with ASTM D 1188.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 02567 - CORRUGATED PIPE

PART 1 -- GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall provide corrugated metal and high density polyethylene (HDPE) pipe and appurtenant WORK, complete in place, in accordance with the Contract Documents.

B. Corrugated pipe shall include round pipe, round stand-pipe, pipe arch, and underdrain pipe, with or without a paved invert, and including fittings, couplings, stand-pipe lids, and related accessories

C. Corrugated metal pipe shall include corrugated steel.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. The following standards are referenced in this Section:

AASHTO M-36	Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
AASHTO M-252 Type C	Specification for Corrugated HDPE (3" - 10") single wall w/ plain ends for downdrains
AASHTO M-252 Type S	Specification for Corrugated HDPE (3" - 10") double wall, w/ plain end "soil tight" or bell/spigot "water tight" ends for sewers and drains
AASHTO M-294 Type C	Specification for Corrugated HDPE (12" - 24") single wall w/ plain ends for downdrains
AASHTO M-294 Type S	Specification for Corrugated HDPE (12" - 48") double wall, w/ plain end "soil tight" or bell/spigot "water tight" ends for sewers and drains
ASTM D2321	Installation of HDPE
ASTM D3212	Water-tight Joint Testing Specification
ASTM D3350	HDPE Resin Specification
ASTM F477	Gasket Specification

New Mexico Department of Transportation, Standard Specifications for Highway and Bridge Construction, 2014 Edition. Herein referred to as NMDOT Standard Specifications.

1.3 CONTRACTOR SUBMITTALS

A. Shop Drawings and catalog data submittals shall be made in accordance with Section 01300 - Contractor Submittals.

B. A manufacturer's or fabricator's Certificate of Compliance shall be furnished stating that samples representing each lot have been tested and inspected in accordance with the Contract Documents and have been found to meet the requirements for the material described.

PART 2 -- PRODUCTS

2.1 CORRUGATED STEEL PIPE

A. Corrugated steel pipe and coupling bands and fittings for each type, shall conform to the requirements of AASHTO M-36, and shall be fabricated from zinc-coated steel sheet with nominal size as indicated in the Drawings.

B. Requirements: Unless otherwise indicated, corrugated metal pipe shall meet the following requirements:

1. Type of pipe: Circular
2. Pipe material: Steel
3. If steel, type of coating: Zinc
4. Size: As Indicated
5. Wall thickness: 0.064-inch (16 gage)
6. Corrugation dimension: 2-2/3” x ½” for pipe less than 48-inch diameter; 3”x1” for pipe 48-inch diameter or greater, or as otherwise indicated
7. Fittings and bends shall be manufacturer standard products.

2.2 CORRUGATED HDPE PIPE

A. M252 Type C and Type S Pipes

1. Corrugated polyethylene drain pipe, couplings and fittings shall meet the requirements of AASHTO M 252 Type C (Single Wall - corrugated both inside and outside w/ plain ends) or Type S (Double Wall - corrugated outer wall and smooth inner liner). The maximum size pipe shall be 10" in diameter.
2. HDPE pipe with plain ends and split couplers shall meet the requirements of "soil tight".
3. HDPE pipe with bell and spigot ends shall meet the requirements of ASTM D3212 water tight joint testing specification (10.8 psi).
4. Fittings and bends shall be manufacturer standard products.

B. M294 Type C and Type S Pipes

1. Corrugated polyethylene drain pipe, couplings and fittings shall meet the requirements of AASHTO M 252 Type C (Single Wall - corrugated both inside and outside w/ plain ends) or Type S (Double Wall - corrugated outer wall and smooth inner liner). Pipe diameter shall be 12" through 48".

2. HDPE pipe with plain ends and split couplers shall meet the requirements of "soil tight".

3. HDPE pipe with bell and spigot ends shall meet the requirements of ASTM D3212 water tight joint testing specification (10.8 psi).

4. Fittings, bends, and end sections shall be manufacturer standard products.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Pipeline trench excavation shall be in accordance with the requirements of Section 02200 - Earthwork, including the situation where pipelines are to be installed in embankment or structure fills.

B. Pipe bedding shall be in accordance with the requirements of Section 02200 - Earthwork, and shall have a thickness of 6 inches under the pipe, unless otherwise indicated.

C. All pipe shall be transported, stored, and handled with care. The pipe shall not be rolled or dragged over gravel or rock, and during placement, shall be prevented from striking rock or other hard objects. Special care shall be taken in handling and placing coated pipe to avoid damaging the coating.

D. Pipe laying shall begin at the downstream end of the line and proceed upstream. Pipe shall be laid carefully and true to line and grade. Pipe shall be placed with longitudinal seams at the sides and with outside laps of circumferential joints upgrade.

E. Pipe sections shall be laid in the trench with a maximum spacing between sections of 1-1/2 inches. Pipe bends shall be located and installed as to not produce excessive strain on connected sections. Connecting bands shall be placed with clamping angles and bolts at top of the pipe. The pipe coupling corrugations or projections shall properly engage the pipe sections before bolts are tightened. Care shall be taken to ensure that dirt or other particles do not get between the outside of the pipe and the coupling. For watertight joints, the band and gasket material shall be placed in accordance with the manufacturer's recommendations.

F. Pipe trench backfill shall be in accordance with the requirements of Section 02200 - Earthwork. Particular care shall be taken to assure that specified compaction is attained under the haunches of the pipe.

G. End sections shall be installed in a careful workmanship like manner. The strap or rod shall be securely tightened around the pipe. The toe wall shall be placed in narrow trench. The invert of the end section shall be supported evenly by the bedding. The alignment of the end section shall match that of the pipe. The installation shall be completed by proper compaction of the backfill around the end section.

- END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 02831 – FENCING AND GATES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall design, furbish, and install chain link fencing, gates and appurtenances as indicated on the Drawings in accordance with the Contract Documents.

B. Chain link fencing, gates, accessories, fittings, and fastenings shall be products of a single manufacturer.

C. The CONTRACTOR shall design, furbish, and install barbed wire fence as indicated on the Drawings. New barbed wire fence shall be of similar construction and materials to existing barbed wire fence.

D. The CONTRACTOR shall design, furbish and install temporary pipe gates as indicated on the Drawings,

1.2 CONTRACTOR SUBMITTALS

A. General: Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. Shop Drawings

Submit Manufacturer’s technical data, product specifications, standard details, certified product test results, installation instructions and general recommendations.

Submit scale layout of fencing, gates, and accessories. Drawings shall show fence height, post layout, including sizes and sections; post setting and bracing configuration, details of gates and corner construction, barbed wire support arms; and other accessories which may be necessary.

PART 2 -- PRODUCTS

2.1 FENCE CONFIGURATIONS

A. Existing Site Perimeter Security Fence

New fence segments, replacement fence segments, and new gates shall match the height and configuration of the existing fence and gates.

New gates installed at access road and haul road locations shall provide an equivalent level of security from unauthorized vehicle and personnel access as the existing perimeter fence. Gate configurations shall be determined by the CONTRACTOR and approved by the ENGINEER.

B. Construction Support Facility Fencing

New chain link fence installed for the temporary construction facilities shall have a height of 6 feet. Gates shall be chain-link, lockable, swing-gates conforming to the requirement of this section.

Barbed wire top is not required for any new chain link fencing.

C. Perimeter Barbed Wire Fence

New fence segments, replacement fence segments, and new gates shall match the height and configuration of the existing fence and gates.

2.2 GENERAL

A. Dimensions indicated herein for roll-formed pipe and H-sections are outside dimensions, excluding coatings.

B. Fence fabric height shall be the same as existing chain link fence on the site.

C. Fencing materials shall be hot-dip galvanized after fabrication.

D. Fencing shall be topped with 3 lines of barbed wire on single supporting arms, sloped outward at a 45-degree angle.

2.2 STEEL FABRIC

A. Fence fabric shall be No. 9 gauge steel wire, 2-inch mesh, with top selvages knuckled and bottom selvages twisted and barbed.

B. Fabric shall be galvanized in conformance with ASTM A 392 - Zinc-Coated Steel Chain Link Fence Fabric, Class II, with not less than 2.0 ounces zinc per square foot of coated surface.

2.3 FENCING AND ACCESSORIES

A. **Steel Framework, General**: Unless otherwise indicated, framework components shall be fabricated of galvanized steel conforming to ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless, or ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products, with not less than 1.8 ounces zinc per square foot of coated surface.

Fittings and accessories shall be galvanized in accordance with ASTM A 153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware, with zinc weights per Table I of that standard, except that no coating shall be less than 1.8-ounce zinc per square foot of coated surface.

B. **End, Corner and Pull Posts**: Posts shall be one-piece without circumferential welds, 3-inch schedule 40 pipe, 5.79 pounds per linear foot.

C. **Line Posts**:

Chain link line posts shall be spaced no more than 10-feet on center and shall be 2-1/4 inch “H” column section, 4.1-pounds per linear foot, or schedule 40, 2-1/2 inch pipe, 3.65-pounds per linear foot.

Barbed wire line posts shall be standard T- or U-section posts with a steel anchor plate. Fence wires should be fastened to steel posts only by steel clips manufactured for this purpose. Line posts shall be spaced to allow no more than 3-inches of sag in the barbed wire.

D. **Gate Posts**: Gate post dimensions shall be according to manufacturer recommendations or 4-inch schedule 40 pipe, 9.1-pounds per linear foot, whichever is greater.

E. **Top Rail**: Top railing shall be provided in manufacturer's longest lengths, with expansion type couplings, approximately 6-inches long, for each joint. Fence design shall provide positive, secure attachment of top rail to each gate post, corner post, pull post and end post. Top rail and braces shall be 1-5/8 inch schedule 40 pipe, 2.27-pounds per linear foot, or 1-1/2 inch "H" column section, 2.00-pounds per linear foot.

F. **Tension Wire**: Tension wire shall be located at the bottom of the fabric and shall consist of No. 7 gauge coated coil spring wire of metal and finish to match fabric. Tension wire shall be interlaced with the fabric or attached to the fabric along the extreme bottom of the fence. Tension wire attachment shall be with fabric tie wires at a spacing of no more than 24-inches apart.

G. **Fabric Tie Wires**: Fabric tie wires shall be No. 9 gauge galvanized steel wire of the same finish as the fabric. Aluminum ties shall not be used. Ties shall be spaced 14-inches apart on posts and 24-inches apart on rails.

H. **Post Brace Assembly**: Post brace assembly shall be manufacturer's standard adjustable brace assembly provided at each end post, gate post and at both sides of each corner post and intermediate brace post. Material used for brace shall be same as top rail. Truss bracing between line posts shall be achieved with 0.375-inch diameter rod and adjustable tensioner.

I. **Post Tops**: Post tops shall be weather-tight closure caps, designed for containment of top rail and positive permanent attachment to post. One cap shall be provided for each post.

J. **Stretcher Bars**: Stretcher bars shall be one-piece lengths equal to the full height of the fabric, with minimum cross-section of 3/16-inch by 3-1/2 inch. One stretcher bar shall be provided for each gate and end post, and 2 for each corner and intermediate brace post.

K. **Stretcher Bar Bands**: Stretcher bar bands shall be one-piece fabrications designed to secure stretcher bars to end, corner, intermediate brace, and gate posts. Bands shall have a minimum cross-section of 1/8-inch by 3/4-inch. Stretcher bar bands shall be spaced no more than 15-inches on center.

L. **Barbed Wire Supporting Arms**: Supporting arms shall be manufacturer's standard fabrication, of metal and finish to match fence framework, with provision for anchorage to each post and attachment of three rows of barbed wire to each arm. Supporting arms may be either attached to posts or integral with post top weather cap. Supporting arm shall be single 45-degree arm type and shall be capable of withstanding 250 pounds of downward pull at outermost end.

M. **Barbed Wire**: Barbed wire shall be 2-strand, No. 12-1/2 gauge zinc-coated steel or iron wire with four-point, 14-gauge barbs spaced no more than 5-inches apart.

2.4 CHAIN LINK FENCE GATES

A. **Fabrication**: Perimeter frames of gates shall be fabricated from same metal and finish as fence framework. Gate frames shall be assembled by welding or with fittings and rivets for rigid, secure connections. Welds shall be ground smooth. Gate frames and any ungalvanized hardware, shall be hot-dip galvanized after fabrication. Horizontal and vertical members shall be provided to ensure proper gate operation and attachment of fabric, hardware and shall be hot-dip galvanized after fabrication.

B. Fabric for gates shall match fence fabric, unless otherwise indicated. Fabric shall be installed with stretcher bars at all perimeter edges. Stretcher bars shall be attached to gate frame with stretcher bar bands spaced no more than 15-inches on center.

C. Each gate shall be diagonally cross-braced with a 3/8-inch diameter adjustable length truss rod to ensure frame rigidity without sag or twist.

D. Where barbed wire is indicated above gates, vertical members shall be extended and fabricated as required to receive barbed wire supporting arms.

E. **Swing Gates**: Perimeter frames of swing gates shall be constructed of the same pipe or “H” column members as the top rails and shall be fabricated by welding. Welds shall be ground smooth prior to hot-dip galvanizing. Hardware and accessories shall be provided for each gate, galvanized in conformance with ASTM A 153, and in accordance with the following:

F. **Hinges:** Hinges shall be of size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Three hinges shall be provided for each leaf 6-feet or more in height.

G. **Latch:** Latch shall be forked type or plunger-bar type, permitting operation from either side of the gate, with padlock eye as an integral part of the latch.

H. **Keeper:** Keeper shall be provided which automatically engages the gate leaf and holds it in the open position until it is manually released.

I. **Double Gates:** Gate stops shall be provided for double gates, consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage center drop rod or plunger bar. Locking device and padlock eyes shall be provided as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.

2.5 PIPE GATES:

A. Pipe gates shall be fabricated as shown on the Drawings, or as otherwise approved by the ENGINEER.

2.6 RELATED ITEMS

A. **Concrete:** Concrete shall be provided according to Section 03300 - Cast-In-Place Concrete.

B. Nuts, bolts and screws shall be steel, minimum size 3/8-inch diameter, hot-dip galvanized after fabrication.

2.7 MANUFACTURERS

A. **Manufacturer’s Qualifications**: Chain link fencing and gates shall be products of a single manufacturer which has been successfully engaged in the production of such items for a period of at least 5 years.

B. **Installer's Qualifications**: Installation of the chain link fence shall be by the manufacturer or by a firm accepted and licensed by the manufacturer.

C. Manufacturers, or equal

1. **American Fence Corp.**

2. **Anchor Fence, Inc.**

3. **United States Steel**

PART 3 -- EXECUTION

3.1 INSPECTION

A. Prior to commencing installation, the CONTRACTOR shall inspect all areas and conditions within which WORK of this Section shall be performed. Dimensions and clearances shall be verified. Final grading shall be completed and all earth, brush, or other obstructions which interfere with the proper alignment and construction of fencing shall be removed.

3.2 INSTALLATION

A. **General**: Unless otherwise indicated, all posts shall be set in concrete. Gate and related posts, corner posts, and other critical elements shall be provided with concrete foundations which are designed to safely accommodate the loads to which they shall be subjected.

B. **Excavation**: Holes for posts shall be drilled or hand excavated to the diameters and spacings indicated, in firm, undisturbed or compacted soil. Post foundations shall comply with the following:

1. Holes shall be excavated to a diameter not less than 12-inches or not less than 5 times the largest dimension of the item being anchored, whichever is larger.

2. Excavated depth for holes shall be a minimum of 4-inches lower than the post bottom, with bottom of posts set not less than 36-inches below finish grade surface.

C. **Setting Posts**: Line posts shall be spaced at not more than 10-foot intervals, measured from center to center of the posts, parallel to the ground slope. Posts shall be set plumb and shall be centered in holes, 4-inches above the bottom of the excavation, with posts extending not less than 36-inches below finish grade surface.

1. Corner posts shall be installed where changes in the fence lines equal or exceed 15 degrees, as measured in a horizontal plane.

2. Each post shall be properly aligned vertically and its top aligned parallel to the ground slope. Posts shall be maintained in proper position during placement and finishing operations.

D. **Concrete:**

1. Concrete for footings may be placed without forms, providing the ground is firm enough to permit excavation to neat line dimensions. Prior to placing concrete, the earth around the hole shall be thoroughly moistened.

2. Encasement concrete for footings shall be placed immediately after mixing in a manner such that there shall be no concentration of the large aggregates. The concrete shall be consolidated by tamping or vibrating.

3. Concrete footings shall have a neat appearance and shall be extended 2-inches above grade and troweled to a crown to shed water.

4. A minimum of 7 days shall elapse after placing the concrete footings before the fence fabric or barbed wire is fastened to the posts.

E. **Bracing**: Bracing shall be provided at all ends, corners, gates, and intermediate brace posts. Corner posts and intermediate brace posts shall be braced in both directions. Horizontal brace rails shall be set midway between the top rail and the ground, running from the corner, end, intermediate brace or gate post to the first line post. Diagonal tension members shall connect tautly between posts below horizontal braces.

1. Braces shall be so installed that posts remain plumb when diagonal rod is under proper tension.

F. **Intermediate Brace Posts**: Where straight runs of fencing exceed 500-feet, intermediate brace posts shall be installed, spaced equally between ends or corners; with additional posts provided as required, such that the spacing between intermediate brace posts does not exceed 500-feet. Intermediate brace posts shall be equivalent in size to corner posts and shall be braced with horizontal brace rails and diagonal tension members in both directions.

G. **Top Rails**: Top rails shall be run continuously through post caps, bending to radius for curved runs. Expansion couplings shall be provided as recommended by the fencing manufacturer.

H. **Tension Wire**: Continuous bottom tension wire shall be stretched tight with turnbuckles at end, gate, intermediate, and corner posts. Tension wire shall be installed on a straight grade between posts, with approximately 2-inches of space between finish grade and bottom selvage, unless otherwise indicated. Tension wire shall be tied to each post with not less than 6 gauge galvanized wire.

I. **Fabric:**

1. Chain-link fabric shall be fastened on the secured side of the posts.

2. Fabric shall be stretched and securely fastened to posts. Between posts, top and bottom edges of the fabric shall be fastened to the top rail and bottom tension wire, respectively.

3. Fabric shall be stretched and anchored in such a manner that it remains in tension after the pulling force is released.

J. **Tie Wires**: Tie wire shall be bent to conform to the diameter of the pipe to which it is attached, clasping pipe and fabric firmly with ends twisted at least two full turns. Ends of wire shall be bent back to minimize hazard to persons or clothing.

1. Fabric shall be tied to line posts with tie wires spaced at 12-inches on center.

2. Fabric shall be tied to rails and braces with tie wires spaced at 24-inches on center.

3. Fabric shall be tied to tension wires, with hog rings spaced 24-inches on center.

K. **Stretcher Bars**: Fabric shall be fastened to end, corner, intermediate brace, and gate posts with stretcher bars. Bars shall be threaded through or clamped to fabric at 4-inches on center and secured to posts with stretcher bar bands spaced no more than 14-inches on center.

L. **Fasteners:** Nuts for tension bands and hardware bolts shall be installed on the side of fence opposite the fabric side. Ends of bolts shall be peened or the threads scored to prevent removal of nuts.

M. Galvanized coating damaged during construction of the fencing shall be repaired by application of **Galvo-Weld**; **Galvinox**; or equivalent.

N. **Barbed Wire, Staples, and Wire Tension**. Barbed wire should be 2-point, 12.5-gauge with 4 to 5 inches between 14-gauge wire barbs. Staples shall be 1.5 inches long. All line wires should be dead-ended on gate, corner, angle, or line-brace posts. The ends shall be wrapped twice around the post, stapled, and twisted back on the stretched wire to prevent the post from twisting. Wire should be tensioned according to ambient air temperature. Wire tensioned too tight on warm days may be stretched beyond the yield point on cold days, and it may sag the next warm season. The wire must be supported on each post by loose staples or a nail during tensioning to relieve the weight of wire and to assure that wire is in the correct position.

O. **Wire Fence Braces**. Line braces should be installed at all breaks in alignment, or at least every 1,320 feet. Guy wires consist of two complete strands of 9-gauge annealed, or soft, galvanized wire.

3.3 GROUNDING

A. Fences crossed by power lines of 600 volts or more shall be grounded at or near the point of crossing and at distances not exceeding 150-feet on each side of the crossing.

B. Fences, gates and appurtenances enclosing electrical equipment areas, gas yards, or other hazardous areas shall be electrically continuous and grounded.

C. Ground conductor shall consist of No. 8 AWG solid copper wire. Grounding electrodes shall be 3/4-inch by 10-foot long copper-clad steel rod. Electrodes shall be driven into the earth so that the top of the electrode is at least 6-inches below grade.

D. Where driving is impracticable, electrodes shall be buried a minimum of 12-inches deep and radically from the fence. Top of electrode shall be not less than 2-feet or more than 8-feet from the fence.

E. Ground conductor shall be clamped to the fence and electrodes with bronze grounding clamps so as to create electrical continuity between fence posts, fence fabric, and ground rods. After installation, the total resistance of fence to ground shall not be greater than 25 ohms.

- END OF SECTION -

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 02970 - REVEGETATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide temporary vegetative erosion protection and final stabilization of finished slopes including seeding, plantings, and mulching for all disturbed areas that are not to be otherwise treated.

1.2 REFERENCE PLANS OF OPERATION

A. The work under this section shall be conducted in substantial compliance with the following Removal Action Design Plan included as part of the Contract Documents:

1. Revegetation Plans including:

a. Mine Site Revegetation Plan

b. Mill Site Revegetation Plan

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals for approval.

B. Submit written certification that all equipment used for revegetation has been pressure washed off-site for control of noxious weeds.

C. **Materials List:** A list of all materials to be used in the revegetation operations together with the source of those materials. The list shall include mulches, soil amendments, seed mixtures, sod species, and erosion control blanketing. Manufacturer's literature showing physical characteristics, applications, and installation instrumentation shall be included.

D. **Reports**: Certified reports of inspections and laboratory tests, prepared by an independent testing agency, including analysis and interpretation of test results. Each report shall be properly identified. Test methods used and compliance with recognized test standards shall be described. Reports for the following materials shall be included:

1. Seed: For mixture, percent pure live seed, minimum percent germination and hard seed, maximum percent weed content, date tested and state certification.

E. **Certificates:** Certificates of compliance that materials meet the indicated requirements prior to the delivery of materials.

1.4 MAINTENANCE OF PLANTING PRIOR TO ACCEPTANCE OF WORK

A. **General:** The CONTRACTOR shall be responsible for protecting, watering, and maintaining seeded areas and plantings until final acceptance of the WORK.

B. **Protection:** The CONTRACTOR shall provide adequate protection to all newly seeded planted areas including the installation of approved temporary fences to prevent trespassing and damage.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Materials shall be first-grade, commercial quality and shall have certificates indicating the source of material, analysis, quantity, or weight attached to each sack or container or furnished with each delivery.

B. Delivery certificates shall be given to the ENGINEER as each shipment of material is delivered. A list of the materials used, together with typical certificates of each material, shall be submitted to the ENGINEER prior to final acceptance.

2.2 FERTILIZER AND ADDITIVES

A. Composted cow manure shall conform to the requirements of the Revegetation Plan

2.3 MULCH (NOT USED)

2.4 SEED MIXTURES

A. All seed shall conform to the requirements of the approved Revegetation Plan.

B. The CONTRACTOR shall furnish the seed supplier's guaranteed germination of each variety listed in the seed mixture.

C. Seed which has become wet, moldy, or otherwise damaged prior to use shall not be accepted.

D. Seed shall be fresh, clean, and new-crop seed composed of the following varieties mixed in the proportions by weight as indicated. Seed shall be tested for compliance with the minimum percentage of purity and germination requirements. All rates specified shall be pure live seed (PLS).

E. Seed shall be delivered in original unopened packages bearing an analysis of the contents.

F. Seed mixture contains no more than 0.01% other seed, whether identified or not.

G. Any deviation of the indicated seed mixture composition shall be approved by the ENGINEER prior to delivery to the Site.

H. The CONTRACTOR is warned that this seed mixture is composed of native grass and grass-like species, but some lead time may be necessary to locate a distributor and have the seed mix prepared.

2.5 PESTICIDE

A. Pesticides shall not be used.

PART 3 -- EXECUTION

3.1 GENERAL

A. Delivery of seed and plantings shall only begin after approval by the ENGINEER.

B. Seeding and planting shall not be performed at any time when it may be impaired by climatic conditions.

C. Seeding and planting shall be conducted after October 15 and prior to November 30 unless otherwise approved by the ENGINEER.

3.2 NOXIOUS WEED CONTROL

A. To prevent the spread of non-native and noxious plant species the CONTRACTOR shall clean all equipment used in revegetation work by thoroughly pressure washing at an off-site location. Certify to the ENGINEER that cleaning has been done and allow for inspection at an off-site location in accordance with Part 1.3 of this section.

3.3 SURFACE PREPARATION

A. Cover soils or other final grade surface soils shall be placed in accordance with Section 02200 – Earthwork.

B. The seeding shall not begin until the CONTRACTOR has repaired all areas of settlement, erosion, rutting, etc. and the soils have been placed, compacted (if required), and contoured to finish grade. The ENGINEER shall be notified of areas that prevent the planting work from being executed.

C. Compost shall be applied at a rate of 2 tons/acre (dry weight) and incorporated by disking, tilling or ripping to 3-6 inches depth.

D. Any unusual subsoil condition that shall require special treatment shall be reported to the ENGINEER.

3.4 SEEDING UNITS

A. The CONTRACTOR'S attention is brought to the following requirements: Seed mix requirements are different for areas within the Mine Site and areas within the Mill Site. These areas and the associated seed mixes are defined in the Revegetation Plan.

3.5 SEEDING

A. No seeding shall be done when wind velocity exceeds 4 mph, within 4 hours after rain, or if the surface has been compacted without first loosening the ground.

B. The ENGINEER shall inspect and approve the soil preparation prior to commencing with seeding. The CONTRACTOR shall prepare only enough ground that can be planted within 24 hours thereafter.

C. Seeding on cover slopes less than 6% shall be accomplished using drilling techniques following final contouring and compost application. On cover slopes greater than 6%, or areas other than the cover system, seeding can be accomplished using either broadcasting or drilling techniques (as recommended on the seed mix), following final contouring and compost application. Increased application rates apply.

D. Sow seed at the application rates indicated in the approved Revegetation Plan. Equal quantities of seed shall be sown in two directions at right angles to each other to produce an even distribution of seed over the entire area.

3.6 SEEDING COMPLETION

A. Harrowing shall be conducted upon completion of broadcast seeding.

3.7 HYDROSEEDING

A. Hydroseeding shall be used on the 5H:1V slope on the east side of the Repository.

B. Equipment: Mixing shall be performed in a tank. The tank shall have a built-in continuous agitation and circulation system, of sufficient operating capacity to produce a homogenous slurry of mulch, seed, and water in the designated unit proportions for a minimum coverage of one half acre. The tank shall have a discharge system which will permit attachment of at least 500-feet of hose extensions, a change of elevation of 150-feet in height from tank to discharge nozzle, and still retain enough pressure to apply the slurry to the areas at a continuous and uniform rate.

C. Proportions:

1. Wood Cellulose Fiber: Mulch shall not contain any growth or germination inhibiting factors and shall be dyed an appropriate color to aid visual monitoring during application. Composition on air dry weight basis: 9 to 15 percent moisture and pH range from 4.5 to 6.0. Mulch shall be applied at a rate of 2 tons/acre.

2. Seed: Seed mix per the Revegetation plan.

D. Application

1. Two-pass application is required. First pass with the seed mix. Second pass with the mulch and tackifier.

2. With agitation system operating at part speed, water shall be added to the tank and good recirculation shall be established. Materials shall be added in such a manner that they are uniformly blended into the mixture.

3. Slurry distribution shall begin immediately. Application of slurry shall be done only when rain is not anticipated for at least three days after slurry application.

4. The entire tank of each batch of slurry shall be emptied and the slurry evenly applied to areas to be hydroseeded within a 2 hour period following the mixing of each slurry batch. Slurry batches not applied during this time will be rejected.

- END OF SECTION -

SECTION 03300 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. The CONTRACTOR shall provide cast-in-place concrete, joints in concrete, reinforcement steel, formwork, and appurtenant work in accordance with the Drawings and these Specifications.

B. The following types of concrete are covered in this Section:

1. **Structural Concrete**: Concrete to be used for walls, pavements, drainage channel cut-off walls, and other concrete items not indicated otherwise in the Contract Documents.

2. **Sitework Concrete**: Concrete to be used for anchor posts, fence and guard post embedment, unless otherwise indicated.

1.2 APPLICABLE CODES AND STANDARDS

A. The following standards are referenced in this Section:

1. American Concrete Institute (ACI):

ACI 117	Standard Specifications for Tolerances for Concrete Construction and Materials
ACI 211.1	Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 211.5R	Guide for Submittal of Concrete Proportions
ACI 301	Specifications for Structural Concrete
ACI 304R	Guide for Measuring, Mixing, transporting, and Placing Concrete
ACI 304.2R	Placing Concrete by Pumping Methods
ACI 306.1	Standard Specification for Cold Weather Concreting
ACI 306R	Guide to Cold Weather Concreting
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318/318R	Building Code Requirements for Structural Concrete and Commentary
ACI 347R	Guide to Formwork for Concrete
ACI 546.2R	Guide to Underwater Repair of Concrete

2. American Society for Testing and Materials (ASTM):

ASTM A 615	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM C 29	Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 143	Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C 150	Standard Specification for Portland Cement
ASTM C 172	Practice for Sampling Freshly Mixed Concrete
ASTM C 231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 311	Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 595	Specification for Blended Hydraulic Cements
ASTM C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 721	Test Method for Average Particle Size of Alumina and Silica Powders by Air Permeability
ASTM C 989	Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

ASTM C 1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1116	Standard Specification for Fiber-Reinforced Concrete
ASTM C 1240	Specification for Silica Fume Used in Cementitious Mixtures
ASTM C 1260	Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM D 695	Standard Test Method for Compressive Properties of Rigid Plastics
ASTM D 2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C 1611	Test Method for Slump Flow of Self-Consolidating Concrete

3. Concrete Reinforcing Steel Institute (CRSI):

   Manual of Standard Practice

1.3 DEFINITIONS

A. "Cementitious material" as used herein shall include all Portland cement, pozzolan, ground granulated blast furnace slag, silica fume, and fly ash.

B. "Defective Concrete": Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements.

C. “Design strength” (f’c) is the specified compressive strength of concrete to meet structural design criteria.

1.4 CONTRACTOR SUBMITTALS

A. All submittals shall be made at least 30 Days in advance of initiation of WORK unless expressly indicated below. Any changes or revisions to previously approved submittals shall be submitted immediately. The CONTRACTOR shall submit the following for ENGINEER review and approval:

1. Shop Drawings

   a. Shop bending diagrams, placing lists, and drawings of reinforcing steel prior to fabrication.

   b. Details of reinforcing steel for fabrication and erection shall conform to ACI 315 and the requirements herein. The shop bending diagrams shall show the actual lengths of bars, to the nearest inch measured to the intersection of the extensions (tangents for bars of circular cross section) of the outside surface. Include bar placement diagrams which clearly indicate the dimensions of each bar splice. Placement diagrams shall show all embedded metals or pipes and all temporary blockouts shown or necessary to complete the WORK.

c. Where mechanical couplers are permitted to be used to splice reinforcing steel, submit manufacturer's literature which contains instructions and recommendations for installation for each type of coupler used; certified test reports which verify the load capacity of each type and size of coupler used; and Shop Drawings that show the location of each coupler with details of how they are to be installed in the formwork.

d. Manufacturer's information demonstrating compliance with requirements of the following:

1) Mill tests for reinforcing steel

2) Mill tests for cement

3) Admixture certification. Chloride ion content shall be included.

4) Aggregate gradation test results and certification

5) Grout materials

2. Mix Designs: Prior to beginning the WORK, submit concrete materials and mix designs in accordance with the guidelines of ACI 211.5R. When a water reducing admixture is to be used, the CONTRACTOR shall furnish mix designs for concrete both with and without the admixture.

3. Concrete Placement Plan: If requested by the ENGINEER, the CONTRACTOR shall submit a Concrete Placement Plan detailing means and methods that the CONTRACTOR shall use in placing concrete. Adequate numbers of personnel, equipment and supplies shall be on Site and dedicated to the concrete placement. The plan shall provide and discuss, but not be limited to, the following items, which shall be considered mandatory:

a. Detail equipment to be used, including backup equipment.

b. Detail how concrete requirements for slump, temperature, time of placement from time of batching, etc. shall be monitored and how decisions shall be made to enable field adjustments to the batching process to be made and how communication with the batch plant shall be made.

c. Detail contingency plans to be used in the event of breakdowns or other untimely events.

d. Each lift described shall be identified with a unique identification number that is included in the construction CPM schedule (Section 01310).

e. Estimated volume of concrete included in each lift.

4. Delivery Tickets: Where ready-mix concrete is used, the CONTRACTOR shall furnish certified delivery tickets at the time of delivery of each load of concrete. Each ticket shall show the state certified equipment used for measuring, and the total quantities, by weight, of cement, sand, each class of aggregate, admixtures, and the amounts of water in the aggregate, added at the batching plant, and the amount allowed to be added at the Site for the specific design mix. In addition, each certificate shall state the mix number, total yield in cubic yards, and the time of day, to the nearest minute,

corresponding to the time when the batch was dispatched, when it left the plant, when it arrived at the Site, when unloading began, and when unloading was finished.

1.5 QUALITY ASSURANCE

A. Testing of Materials

1. Tests on component materials and for compressive strength of concrete shall be performed as indicated herein. Tests for determining slump shall be in accordance with the requirements of ASTM C 143. Unless otherwise noted herein, test samples for compliance shall be taken at the point of placement.

2. Tests for determining the air content of concrete shall be in accordance with ASTM C 231.

3. Testing for aggregate shall include reactivity, organic impurities, abrasion resistance, and soundness in accordance with ASTM C 33 and sand equivalent value in accordance with ASTM D 2419. Testing of the cement-pozzolan-aggregate combination of materials proposed for the WORK shall be in accordance with ASTM C 1567.

4. The cost of laboratory tests on cement, aggregates and admixtures shall be arranged for and paid by the CONTRACTOR. The cost of laboratory tests on concrete as delivered to the Site shall be arranged for and paid by the COMPANY. However, the CONTRACTOR shall pay the cost of any additional tests and investigations on WORK that does not meet the Specifications. The laboratory shall meet or exceed the requirements of ASTM C 1077.

5. Concrete for testing shall be supplied by the CONTRACTOR at no cost to the COMPANY, and the CONTRACTOR shall assist in providing access, obtaining samples, and disposal and cleanup of excess material.

B. Field Compression Tests

1. Compression test specimen sets shall be taken during construction from the first placement of each class of concrete herein and for every 50 cubic yards thereafter to insure continued compliance with these specifications. Each set of test specimens shall be a minimum of four (4) cylinders.

2. Compression test specimens for concrete shall be made in accordance with ASTM C 31. Specimens shall be cylinders 6-inches in diameter and 12-inches high.

3. Compression tests shall be performed in accordance with ASTM C 39. One test cylinder shall be tested at 7 days and two test cylinders shall be tested at 28 days. The remaining cylinder shall be held to verify test results, if needed. The 7-day cylinder shall be used as an indication of normal strength gain and shall not have associated acceptance criteria.

C. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 301 and as indicated herein.

2. If any concrete fails to meet these requirements, immediate corrective action shall be taken to increase the compressive strength for subsequent batches of the type of concrete affected.

3. Concrete that fails to meet the ACI requirements and these Specifications is subject to removal and replacement at no additional cost to the COMPANY.

D. Construction Tolerances: The CONTRACTOR shall set and maintain concrete forms and perform finishing operations so that the concrete is within the tolerances herein. Tolerance is the permissible variation from lines, grades, or dimensions indicated on the Drawings. Where tolerances are not stated in the Specifications, permissible deviations shall be in accordance with ACI 117.

1. The variation from required lines or grades shall not exceed 1/4-inch in 10 feet and there shall be no offsets or visible waviness in the finished surface.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Refer to ACI 301. Protect materials from contaminants such as grease, oil, and dirt. Ensure materials can be accurately identified after bundles are broken and tags removed.

PART 2 -- PRODUCTS

2.1 FORM MATERIALS

A. Except as otherwise expressly accepted by the ENGINEER, lumber brought on the Site for use as forms and bracing shall be new material.

B. Unless otherwise indicated, exterior corners in concrete members shall be provided with 3/4-inch chamfers.

2.2 REINFORCEMENT STEEL

A. General: Reinforcement steel for cast-in-place reinforced concrete construction shall conform to the following requirements:

1. Bar reinforcement and anchor bars shall conform to the requirements of ASTM A 615, Grade 60.

B. Accessories

1. Accessories shall include all necessary chairs, concrete blocks, tie wires, dips, supports, spacers, and other devices to position reinforcement during concrete placement. Bar supports shall meet the requirements of the CRSI Manual of Standard Practice.

2. Concrete blocks (dobies) used to support and position reinforcement steel shall have the same or higher compressive strength than required for the concrete in which they are located. Where concrete blocks are used on concrete surfaces exposed to view, the color and texture of the concrete blocks shall match that required for the finished surface. Wire ties shall be embedded in concrete block bar supports.

2.3 MECHANICAL COUPLERS

A. Mechanical couplers shall be provided where approved by the ENGINEER. Couplers shall be in accordance with ACI 318 and shall develop a tensile strength that exceeds 125 percent of the yield strength of the reinforcing bars being spliced at each splice.

2.4 CONCRETE MATERIALS

A. Materials shall be delivered, stored, and handled so as to prevent damage by water or breakage. Cement reclaimed from cleaning bags or leaking containers shall not be used. Cement shall be used in the sequence of receipt of shipments.

B. Materials for concrete shall conform to the following requirements:

1. Cement shall be standard brand Portland cement conforming to ASTM C 150, Type I/II low alkali or Type V low-alkali. A single brand of cement shall be used throughout the WORK, to the extent possible, and prior to its use, the brand shall be accepted by the ENGINEER. If, over the course of the Project, the cement becomes unavailable or is proposed to be substituted with a new cement, the CONTRACTOR shall provide submittals and certifications for the new cement in accordance with these Specifications. The cement shall be suitably protected from exposure to moisture until used. Cement that has become lumpy shall not be used. Sacked cement shall be stored in such a manner so as to permit access for inspection and sampling. Certified mill test reports for each shipment of cement to be used shall be submitted to the ENGINEER, if requested, regarding compliance with these Specifications.

2. Pozzolan shall conform to ASTM C 618, Class N or F, except that the maximum allowable loss on ignition shall be 6 percent. The minimum pozzolan content shall be at least 15 percent of the total cementitious material by mass. In lieu of adding pozzolan independently the cement type indicated 1 subparagraph 1 above may be substituted with cement Type IP conforming to ASTM C 595, which shall contain 15 percent pozzolan by mass. Testing of the cement and aggregate combination is required per ASTM C 1567.

3. Silica fume, if used, shall conform to ASTM C 1240 with a maximum loss of ignition of 6 percent. The material may be supplied in dry or slurry form. The water content in the slurry shall be included in the water-cement ratio. Silica fume shall not exceed 12 percent by weight of cement.

4. Ground Granulated Blast Furnace Slag (GGBFS) shall conform to ASTM C 989 Grade 100 or 120. GGBFS shall not exceed 50 percent by weight of cementitious materials

5. Water for mixing and curing shall be potable, clean, and free from objectionable quantities of silty organic matter, alkali, salts, and other impurities, and shall meet the requirements of ASTM C 1602. The water shall be considered potable, for the purposes of this Section only, if it meets the requirements of the local governmental agencies.

6. Aggregates shall be obtained from a single source pit or quarry acceptable to the ENGINEER and shall conform to the requirements of ASTM C 33.

   a. Coarse aggregates shall be graded to comply with ASTM C 33 and consist of clean, hard, durable gravel, crushed gravel, crushed rock, or a combination thereof. The coarse aggregates shall consist of Size Number 67 (3/4 in. to No. 4) unless otherwise approved by the ENGINEER or specified.

b. Fine aggregates shall be natural sand or a combination of natural and manufactured sand that is hard and durable and shall meet the requirements of ASTM C 33. When tested in accordance with ASTM D 2419, the sand equivalent value shall not be less than 75 for an average of 3 samples, nor less than 70 for an individual test.

c. Combined aggregates shall be well graded from coarse to fine sizes and shall be uniformly graded between screen sizes to produce a concrete that has optimum workability and consolidation characteristics.

d. Aggregates shall not contain any substance that may be deleteriously reactive with the alkalis in the cement unless effective mitigating measures are taken to control reactivity.

e. Aggregates shall show expansions less than 0.10 percent at sixteen (16) Days when tested in accordance with ASTM C 1260 using a cement with an alkali content above 0.8 percent (expressed as sodium oxide), and shall not possess properties or constituents that are known to have specific unfavorable effects in concrete when tested in accordance with ASTM C 295.

f. If mitigating measures are required to control reactivity, submit satisfactory test results from ASTM C 1567 to determine if the combination of cementitious materials is adequate to mitigate deleterious reactivity.

7. All admixtures, if used, shall be compatible. Admixtures shall be used in accordance with manufacturers' recommendations. Admixtures shall not contain thiocyanates nor more than 0.05 percent chloride ion, and shall be non-toxic after 30 Days.

a. Air-entraining agent meeting the requirements of ASTM C 260 - Air-Entraining Admixtures for Concrete shall be used. Sufficient air-entraining agent shall be used to provide the specified air content in the concrete, as placed in the WORK, when tested in accordance with ASTM C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method. The ENGINEER reserves the right, at any time, to sample and test the air-entraining agent received on the job by the CONTRACTOR. The air-entraining agent shall be added to the batch in a portion of the mixing water. The solution shall be batched by means of a mechanical batcher capable of accurate measurement. AIR ENTRAINING ADMIXTURE SHALL NOT BE USD FOR UNDERWATER PLACED CONCRETE

b. Water reducing and set retarding admixture (WRA) shall conform to ASTM C 494, Types A, E or F. Water reducing and set retarding admixture shall be used in all concrete at the rate recommended by the admixture manufacturer based on the time from batching to delivery on Site.

c. High Range Water Reducer (HRWRA - Superplasticizers) shall conform to ASTM C494 Types F or G, or ASTM C1017 Types 1 or 2.

d. Accelerating admixtures shall conform to ASTM C 494, Type C.

e. Retarding admixtures shall conform to ASTM C494, Types B, D, or G.

f. Anti-washout / Rheoplastic Admixture (AWA) shall be specially formulated and so indicated to be an anti-washout admixture to increase cohesion and to resist cement washout and concrete segregation and bleeding. AWA shall be compatible with other admixtures and so confirmed by the admixture manufacturers.

1) Rheoplastic concrete is concrete with a plasticity (slump) in the range of 8 to 11 inches, is non-segregating and exhibits little or no bleeding.

2) Use rheoplastic admixtures of the second or third generation type that control slump loss to within 3 inches for at least one and one half hours after batching for concrete temperatures up to 100 degrees F.

3) Second generation rheoplastic admixtures control the rise in concrete temperature for a minimum of one and one half hours from the time of batching.

4) Third generation rheoplastic admixtures shall not, when compared to a reference concrete of equal slump, significantly retard the set of concrete throughout their recommended dosage range and at varying concrete temperatures.

5) Add rheoplastic admixtures at the batch plant unless specifically recommended by the manufacturer.

8. Ready-mix concrete shall conform to the requirements of ASTM C 94 - Ready-Mixed Concrete.

2.5 CURING COMPOUND

A. Curing compound shall conform to ASTM C 309, Type 1, Class B.

2.6 EPOXY GROUT

A. Grout for grouting anchor bars shall be specifically formulated for such application, for the moisture condition, application temperature and orientation of the hole to be filled. Epoxy grout shall be Epcon A7 Acrylic Adhesive as manufactured by ITW Ramset/Read Head, Power-Fast Epoxy Injection Gel as manufactured by Powers Fasteners, Five Star RS Anchor Gel manufactured by Five Star Industries, Pro-Poxy 400 manufactured by Unitex, or ENGINEER-approved equal.

2.7 CONCRETE DESIGN REQUIREMENTS

A. General

1. Concrete shall be composed of cement, admixtures, aggregates, and water of the qualities indicated. In general, the mix shall be designed to produce a concrete capable of being deposited so as to obtain maximum density and minimum shrinkage, and where deposited in forms, to have good consolidation properties and maximum smoothness of surface. The proportions shall be changed whenever necessary or desirable to meet the required results at no additional cost to the COMPANY. Mix changes shall be subject to review by the ENGINEER.

2. The CONTRACTOR is cautioned that the limiting parameters below are NOT a mix design. Admixtures may be required to achieve workability required by the CONTRACTOR's construction methods and aggregates. The CONTRACTOR is responsible for providing concrete with the required workability.

3. Concrete Properties: The specified compressive strength and other requirements shall be not less than the following tabulations:

a. Structural Concrete:

Specified 28-Day Compressive Strength, psi	5,000
Max. Size Aggregate, inches	¾
Cement Content per cu. yd., pounds, minimum	600
Max. W/C Ratio (by weight)	0.40
Slump (inches) prior to addition of WRA and HRWRA	4 +/- 1
Air Entrainment (percent)	5 to 7.5

b. Sitework Concrete:

Specified 28-Day Compressive Strength, psi	4,000
Max. Size Aggregate, inches	1
Cement Content per cu. yd., pounds, minimum	254
Max. W/C Ratio (by weight)	0.45
Slump (inches) prior to addition of WRA and HRWRA	4 +/- 1
Air Entrainment (percent)	5 to 7.5

4. Aggregate Reactivity: The cement-pozzolan-aggregate combination to be used in the proposed mix shall be tested as indicated herein. Mitigating measures shall be employed for all mixes using aggregates from pits with reactive aggregates.

2.10 CONSISTENCY

A. Consistency of the various classes of concrete in successive batches shall be determined by slump and air-content tests in accordance with ASTM C 143 and ASTM C 231, respectively.

2.11 MEASUREMENT OF CEMENT AND AGGREGATE

A. The amount of cement and of each separate size of aggregate entering into each batch of concrete shall be determined by direct weighing equipment furnished by the CONTRACTOR and acceptable to the ENGINEER; provided that, where batches are so proportioned as to contain an integral number of conventional sacks of cement, and the cement is delivered at the mixer in the original unbroken sacks, the weight of the cement contained in each sack may be taken without weighing as 94 pounds.

2.12 MEASUREMENT OF WATER

A. The quantity of water entering the mixer shall be measured by a suitable water meter or other measuring device of a type acceptable to the ENGINEER and capable of measuring the water in variable amounts within a tolerance of one percent.

2.13 READY-MIXED CONCRETE

A. At the CONTRACTOR's option, ready-mixed concrete may be used if it meets the requirements as to materials, batching, mixing, transporting, placing, the supplementary requirements as required herein, and is in accordance with ASTM C 94.

B. Ready-mixed concrete shall be delivered to the WORK, and discharge shall be completed within one hour after the addition of the cement to the aggregates or before the drum has been revolved 250 revolutions, whichever is first. In hot weather, or under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85 degrees F or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed 45 minutes.

C. Each batch of concrete shall be mixed in a truck mixer for not less than 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. Materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.

D. Each batch of ready-mixed concrete delivered to the WORK shall be accompanied by a delivery ticket furnished to the ENGINEER in accordance with Paragraph 1.4.A.4 entitled "Delivery Tickets."

E. The use of non-agitating equipment for transporting ready-mixed concrete shall not be permitted. Combination truck and trailer equipment for transporting ready-mixed concrete shall not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the ENGINEER.

PART 3 -- EXECUTION

3.1 GENERAL FORMWORK REQUIREMENTS

A. Forms to confine the concrete and shape it to the required lines shall be used wherever necessary. The CONTRACTOR shall assume full responsibility for the adequate design of forms, and any forms which are unsafe or inadequate in any respect shall promptly be removed from the WORK and replaced at the CONTRACTOR's expense. A sufficient number of forms of each kind shall be available to permit the required rate of progress to be maintained. The design and inspection of concrete forms shall comply with applicable local, state and federal regulations. Design, construction, maintenance, preparation, and removal of forms shall follow the guidelines contained in ACI 347 and the requirements herein.

B. Forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade, and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete.

3.2 CONSTRUCTION

A. Vertical Surfaces: Vertical surfaces of concrete members shall be formed.

B. Construction Joints: Concrete construction joints shall not be permitted at locations other than those indicated, except as may be approved by the ENGINEER.

C. Form Ties

1. Embedded Ties: Wire ties for holding forms shall not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete members. The use of snap-ties which cause spalling of the concrete upon form stripping or tie removal shall not be permitted. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 1-inch back from the formed face or faces of the concrete.

2. Removable Ties: Where taper ties are approved for use, after the taper tie is removed, the hole shall be thoroughly cleaned and roughened for bond. A precast neoprene or polyurethane tapered plug shall be located at the wall centerline. The hole shall be completely filled with non-shrink or regular cement grout. Exposed faces of walls shall have at least the outer 2-inches of the exposed face filled with a cement grout which shall match the color and texture of the surrounding wall surface.

3.3 REUSE OF FORMS

A. Forms may be reused only if in good condition and only if acceptable to the ENGINEER. Light sanding between uses shall be required wherever necessary to obtain uniform surface texture on exposed concrete surfaces. Exposed concrete surfaces are defined as surfaces which are permanently exposed to view.

3.4 REMOVAL OF FORMS

A. Careful procedures for the removal of forms shall be strictly followed, and this WORK shall be done with care so as to avoid injury to the concrete. No heavy loading on green concrete shall be permitted. Forms for vertical surfaces shall remain in place at least 48 hours after the concrete has been placed. Forms for parts of the WORK not specifically mentioned herein shall remain in place for periods of time as recommended in ACI 347.

3.5 REINFORCEMENT FABRICATION

A. General

1. Reinforcement steel shall be accurately formed to the dimensions and shapes indicated, and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318, except as modified by the Drawings.

2. The CONTRACTOR shall fabricate reinforcement bars for structures in accordance with bending diagrams, placing lists, and placing drawings. Said drawings, diagrams, and lists shall be prepared by the CONTRACTOR.

3. Unless otherwise indicated, dowels shall match the size and spacing of the spliced bar.

B. Bending or Straightening: Reinforcement shall not be straightened or rebent in a manner which shall damage the reinforcing bar. Bars shall be bent or straight as indicated. Do not use bends different from the bends indicated. Bars shall be bent cold unless otherwise permitted by the ENGINEER. No bars partially embedded in concrete shall be field-bent except as indicated or specifically permitted by the ENGINEER.

3.6 REINFORCEMENT PLACING

A. Reinforcement steel shall be accurately positioned as indicated and shall be supported and wired together to prevent displacement, using annealed iron wire ties or suitable clips at intersections. Reinforcement steel shall be supported by concrete, plastic or metal supports, spacers or metal hangers which are strong and rigid enough to prevent any displacement of the reinforcement steel. Where concrete is to be placed on the existing concrete, supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the bars without settlement, but in no case shall such support be continuous. Concrete blocks used to support reinforcement steel shall be tied to the steel with wire ties which are embedded in the blocks.

B. Tie wires shall be bent away from the forms and surfaces of concrete in order to provide the required concrete cover.

C. Bars additional to those indicated, which may be found necessary or desirable by the CONTRACTOR for the purpose of securing reinforcement in position, shall be provided by the CONTRACTOR at his own expense.

D. Unless otherwise indicated, reinforcement placing tolerances shall be within the limits specified in ACI 117.

E. The minimum spacing requirements of ACI 318 shall be followed for reinforcing steel.

3.7 REINFORCEMENT SPLICING

A. General: Reinforcement bar splices shall only be used at locations indicated. When it is necessary to splice reinforcement at points other than where indicated, the character of the splice shall be reviewed and accepted by the ENGINEER. Full lap splices shall be allowed across construction joints (CJs) considering “top bar” and “other reinforcement” development length modification factors per ACI 318.

B. Splices of Reinforcement: The length of lap for reinforcement bars, unless otherwise indicated, shall be in accordance with ACI 318 for a Class B splice.

3.8 REINFORCEMENT CLEANING AND PROTECTION

A. Reinforcement steel shall at all times be protected from conditions conducive to corrosion until concrete is placed around it.

B. The surfaces of reinforcement steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed. Where there is delay in depositing concrete, reinforcing shall be reinspected and, if necessary recleaned.

3.9 CONCRETE BATCHING, MIXING AND DELIVERY

A. Batching, mixing, and delivery of concrete shall conform to requirements of ASTM C 94, as specified otherwise herein, or as otherwise approved by the ENGINEER.

B. Retempering: Retempering of concrete, which has partially hardened, shall not be permitted.

3.10 PREPARATION OF SURFACES FOR CONCRETING

A. Moisture Conditioning: At least 24 hours prior to placement of concrete, existing concrete surfaces shall be thoroughly wetted by sprinkling, prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon. The surface shall be free from standing water, debris and other matter that would be detrimental to bond at the time of placing concrete.

B. Joints in Concrete: Concrete surfaces upon or against which concrete is to be placed, where the placement of the concrete has been stopped or interrupted so that, as determined by the ENGINEER, the new concrete cannot be incorporated integrally with that previously placed, are defined as construction joints. Existing concrete against which concrete is to be placed shall be thoroughly cleaned of sediment, loose concrete and aggregates, and other materials that would affect bonding of the concrete to the existing substrate. Initial preparation shall be by one of the following methods:

1. High-Pressure Water Jetting: A stream of water under a pressure of not less than 6,000 psi.

2. Mechanical Methods: Mechanical methods, such as using “whirl-away” equipment or bush hammering.

C. Rock surfaces upon which concrete is to be placed shall be clean, free from drummy rock, debris, and loose, semidetached, unsound fragments. Immediately before the concrete is placed, all rock surfaces shall be cleaned thoroughly by the use of water jets.

D. Placing Interruptions: When placing of concrete is to be interrupted long enough for the concrete to take a set, the working face shall be given a shape by the use of forms or other means, that shall secure proper union with subsequent WORK; provided that construction joints shall be made only where acceptable to the ENGINEER.

E. Embedded Items

1. No concrete shall be placed until all formwork, reinforcement steel, and preparation of surfaces involved in the placing have been completed and accepted by the ENGINEER at least 4-hours before placement of concrete. Surfaces of forms that have become encrusted with dried grout from previous usage shall be cleaned before the surrounding or adjacent concrete is placed.

2. Reinforcement and anchor bars shall be set and secured in the forms at locations indicated on the Drawings or by Shop Drawings and shall be acceptable to the ENGINEER before any concrete is placed. Accuracy of placement is the responsibility of the CONTRACTOR.

F. No concrete shall be placed until all water entering the space to be filled with concrete has been properly cut off or has been diverted by pipes, or other means, and carried out of the forms, clear of the WORK. No concrete shall be deposited underwater nor shall the

CONTRACTOR allow still water to rise on any concrete until the concrete has attained its initial set. Water shall not be permitted to flow over the surface of any concrete in such manner and at such velocity as shall damage the surface finish of the concrete. Pumping or other necessary dewatering operations for removing ground water, if required, shall be subject to the review of the ENGINEER.

3.11 HANDLING, TRANSPORTING, AND PLACING OF CONCRETE

A. General: Placing of concrete shall conform to the applicable requirements of ACI 301, the CONTRACTOR's Concrete Placement Plan, and the requirements of this Section. Concrete shall not be allowed to be placed until the CONTRACTOR's Placement Plan has be reviewed and accepted by the ENGINEER. No aluminum materials shall be used in conveying any concrete.

B. Non-Conforming Work or Materials: Concrete which during or before placing is found not to conform to the requirements indicated herein shall be rejected and immediately removed from the WORK. Concrete which is not placed in accordance with these Specifications, or which is of inferior quality, shall be removed and replaced.

C. Unauthorized Placement: No concrete shall be placed except in the presence of the ENGINEER. The CONTRACTOR shall notify the ENGINEER in writing at least 24-hours in advance of placement of any concrete.

D. Conveyor Belts and Chutes: Ends of chutes, hopper gates, and other points of concrete discharge throughout the CONTRACTOR's conveying, hoisting, and placing system shall be so designed and arranged that concrete passing from them shall not fall separated into whatever receptacle immediately receives it. Conveyor belts, if used, shall be of a type acceptable to the ENGINEER. Chutes longer than 50-feet shall not be permitted. Minimum slopes of chutes shall be such that concrete of the required consistency shall readily flow in them. If a conveyor belt is used, it shall be wiped clean by a device operated in such a manner that none of the mortar adhering to the belt shall be wasted. Conveyor belts and chutes shall be covered.

E. Temperature of Concrete: The temperature of concrete when it is being placed shall be not more than 90 degrees F nor less than 40 degrees F in moderate weather, and not less than 50 degrees F in weather during which the mean daily temperature drops below 40 degrees F. Concrete ingredients shall not be heated to a temperature higher than that necessary to keep the temperature of the mixed concrete, as placed, from falling below the required minimum temperature. If concrete is placed when the weather is such that the temperature of the concrete would exceed 90 degrees F, the CONTRACTOR shall employ effective means, such as precooling of aggregates and mixing water, using ice, or placing at night, as necessary to maintain the temperature of the concrete, as it is placed, below 90 degrees F. The CONTRACTOR shall not be entitled to additional compensation on account of the foregoing requirements.

F. Cold Weather Placement

1. Placement of concrete shall conform to ACI 301 and the following.

   a. Foundations shall be free from snow, frost or ice when concrete is placed upon or against them.

   b. Maintain the concrete temperature above 50 degrees F for at least 72-hours after placement.

3.12 PUMPING OF CONCRETE

A. General

1. If the pumped concrete does not produce satisfactory end results, the CONTRACTOR shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.

2. Pumping Equipment

a. The pumping equipment shall have 2 cylinders and be designed to operate with one cylinder only in case the other one is not functioning. In lieu of this requirement, the CONTRACTOR may have a standby pump on the Site during pumping.

b. The minimum diameter of the hose conduits shall be in accordance with ACI 304.2R - Placing Concrete by Pumping Methods.

c. Pumping equipment and hoses conduits that are not functioning properly shall be replaced.

d. Aluminum conduits for conveying the concrete shall not be permitted.

3.13 CONCRETE CONSOLIDATION

A. As concrete is placed, it shall be thoroughly settled and compacted throughout the entire depth of the layer which is being consolidated, into a dense, homogeneous mass, filling all corners and angles, thoroughly embedding the reinforcement, eliminating rock pockets, and bringing only a slight excess of water to the exposed surface of concrete. Vibrators shall be high-speed power vibrators (8,000 to 12,000 rpm) of an immersion type in sufficient number and with at least one standby unit.

3.14 FINISHING CONCRETE SURFACES

A. General: Surfaces shall be free from fins, bulges, ridges, offsets, honeycombing, or roughness of any kind, and shall present a finished, smooth, continuous hard surface. Allowable deviations from plumb or level and from the alignment, profiles, and dimensions indicated are defined as tolerances and are indicated above. These tolerances are to be distinguished from irregularities in finish as described herein. Aluminum finishing tools shall not be used.

B. Unformed Surfaces: After proper and adequate vibration and tamping, unformed top surfaces of slabs shall be brought to a uniform surface with suitable tools. After sufficient stiffening of the screeded concrete, surfaces shall be float finished with wood or metal floats. Excessive floating of surfaces while the concrete is plastic and dusting of dry cement and sand on the concrete surface to absorb excess moisture shall not be permitted. Floating shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities shall not exceed 1/4-inch.

3.15 CURING OF CONCRETE

A. General: Concrete shall be cured for not less than 14 Days after placing. The surface shall be either (1) be covered with burlap mats, which shall be kept wet with water for the duration of the curing period or (2) have a liquid membrane-forming curing compound applied at the coverage rate specified by the manufacturer and shall not be used on surfaces to receive additional concrete or cementitious finishing materials.

B. The CONTRACTOR may submit alternate methods of curing which maintain the concrete in a continuously wet condition for acceptance by the ENGINEER.

3.16 PROTECTION OF CONCRETE

A. The CONTRACTOR shall protect concrete against injury until final acceptance.

B. Fresh concrete shall be protected from damage due to water immersion, dripping water or any other cause. The CONTRACTOR shall provide such protection until the concrete receives its initial set.

3.17 CARE AND REPAIR OF CONCRETE

A. The CONTRACTOR shall protect concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until final acceptance. Particular care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damaging the surface. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed WORK, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete at the CONTRACTOR's expense.

3.19 ENGINEER NOTIFICATION

A. The ENGINEER shall inspect the placement area during preparatory phases of the Work, during concrete placements and during subsequent work. CONTRACTOR shall notify the ENGINEER 24 hours in advance of each concrete placement.

3.22 CLEANUP

A. Concrete trucks shall be washed/cleaned only in area(s) so designated by the ENGINEER. The ENGINEER shall provide lighting at the cleanup area if so requested one week in advance of such need. Such solidified concrete shall be removed from the site at completion of the WORK.

B. Upon completion of the WORK each area shall be thoroughly cleaned of debris and foreign material, as acceptable to the ENGINEER, and such material shall be removed from the Site.

- END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 03495 - PRECAST CONCRETE

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide precast concrete culverts vaults, complete and in place, in accordance with the Contract Documents.

1.2 SPECIFICATIONS, CODES AND STANDARDS

A. New Mexico Department of Transportation, Standard Specifications for Highway and Bridge Construction, 2014 Edition. Herein referred to as NMDOT Standard Specifications.

B. Commercial Standards

CI 318/318R	Building Code Requirements for Structural Concrete and Commentary
ASTM C 150	Portland Cement
ASTM C 443	Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C 890	Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
ASTM C 913	Standard Specification for Precast Concrete Water and Wastewater Structures

1.3 CONTRACTOR SUBMITTALS

A. **General:** Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. **Shop Drawings**

1. Show dimensions, locations, lifting inserts, reinforcement, and joints.

2. Structural design calculations for vaults, signed by a registered professional engineer in the State of New Mexico

C. Manufacturer’s Certification for Vaults: Written certification that the vault complies with the requirements of this Section.

1.4 QUALITY ASSURANCE

A. **Inspection:** After installation, the CONTRACTOR shall demonstrate that culverts and vaults have been properly installed, level, with watertight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

PART 2 -- PRODUCTS

2.1 CONCRETE BOX CULVERTS

A. Precast concrete box culverts shop drawings, calculations, and products shall comply with the requirements of NMDOT Standard Specifications, Section 517 – Precast Concrete Structures.

2.2 VAULTS

A. The CONTRACTOR shall provide water-tight, precast vaults designed for the indicated applications and of the sizes indicated.

B. The minimum structural member thickness for vaults shall be 5-inches. Cement shall be Type V portland cement as specified in ASTM C 150. The minimum 28-day concrete compressive strength shall be 4,000 psi. All reinforcing steel shall be embedded in the concrete with a minimum clear cover as recommended by ACI 318.

C. Design Loading: Vaults in areas subject to vehicular traffic shall be designed for H-20 traffic loading. Vaults in other areas shall be designed for a vertical live load of 300 psf. Lateral loads on vaults in all areas shall be calculated from:

L = 90 h, plus surcharge of 240 psf in areas of vehicular traffic

Where L = loading in psf

and h = depth of fill in feet

D. Where joints are designed in pre-cast concrete vaults, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil through the joint. Structural sections at joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.

E. Where openings for access to the vault are required, the full clear space opening indicated shall be provided, without obstructions from brackets or supports. For large openings where brackets or supports are designed to protrude into the opening for support of required covers, such brackets or supports shall be designed to be easily removed and replaced with a minimum of effort and without cutting or welding.

F. Covers for access openings shall be provided. Frames for covers shall be fabricated from steel, galvanized after fabrication, and shall be integrally cast into the vault concrete sections. All covers shall be tight fitting to prevent the entrance of dirt and debris. Where edge seams are permitted, no gaps greater than 1/16-inch between edges shall be accepted. All covers, except round, heavy-weight, cast iron manhole covers, shall have securing mechanisms to hold the covers firmly in place against the effects of repetitious live loads such as pedestrian or vehicle traffic.

G. Where penetration of the pre-cast concrete vault are required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or thin-wall knock-out sections. All openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing. Vaults need not be designed to resist thrust from piping passing through the vault.

H. Warning Signs

1. The entrance to every manhole and vault shall be fitted with a permanently affixed, plastic warning sign, located above and centered on the top step. Each sign shall be in accordance with the design drawings.

2. Sign Manufacturer, or Equal

a. **W. H. Brady Company**

b. **Seton Nameplate Corporation**

2.3 CRYSTALLINE WATERPROOFING

A. Crystalline waterproofing shall be as indicated in Section 03300 – Cast-In-Place Concrete.

PART 3 -- EXECUTION

3.1 GENERAL

A. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer's written recommendations. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended. Where no lifting devices are provided, the CONTRACTOR shall follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.

B. Excavation and backfill for precast concrete box culverts shall comply with the requirements of NMDOT Standard Specifications, Section 206 – Excavation and Backfill for Culverts and Minor Structures.

C. Buried pre-cast concrete vaults shall have a crystalline waterproofing applied to their exterior surfaces in accordance with Section 03300 – Cast-In-Place Concrete and the manufacturer's application instructions.

D. Buried pre-cast concrete vaults shall be assembled and placed in excavations on properly compacted soil foundations as indicated. Pre-cast concrete vaults and culverts shall be set to grade and oriented to provide the required dimensions and clearances from pipes and other structures.

E. Prior to backfilling, all cracks and voids in pre-cast concrete vaults shall be filled with non-shrink grout or polyurethane sealant, or both.

F. Unless otherwise indicated, around pipe and conduit penetrations, openings shall be sealed with polyurethane sealant. With the authorization of the ENGINEER, grout or a closed-cell flexible insulation may be used as filler material prior to placing a final bed of polyurethane sealant.

- END OF SECTION –

THIS PAGE INTENTIONALLY LEFT BLANK.

SECTION 05500 – MISCELLANEOUS METALWORK

PART 1 -- GENERAL

1.1 DESCRIPTION

A. This Section covers materials, fabrication, and installation of miscellaneous metalwork and appurtenances, complete and in place, in accordance with the Contract Documents. Miscellaneous metal items shall include, but not be limited to, guardrails and anchor bolts.

B. The CONTRACTOR shall provide miscellaneous metalwork and appurtenances, complete and in place, as indicated in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. American Fence Association (AFA)

B. American Institute of Steel Construction

AISC Manual of Steel Construction

C. American Iron and Steel Institute (AISC)

AISI Design of Light Gauge, Cold-Formed Steel Structural Members

D. ASTM International (ASTM)

ASTM A 36	Carbon Structural Steel
ASTM A 123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 167	Stainless Steel and Heat-Resisting Chromium Nickel Steel Plate
ASTM A 307	Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM B209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

E. International Building Code (IBC), 2009

1.3 SUBMITTALS

A. All items shall be submitted in accordance with the requirements of Section 01300 – Contractor Submittals.

B. Submit shop drawings and erection plan for all fabricated items, including bolts and guard rails Show dimensions and reference materials of construction by ASTM designation and grade.

1.4 SYSTEM DESCRIPTION

A. Design Criteria

1. Structural Connections and Framing: AISC “Specifications for Structural Steel Buildings – Allowable Stress Design” (ninth edition).

2. Guardrails: OSHA or IBC, whichever is more stringent.

1.5 QUALITY ASSURANCE

A. Shop quality control documentation shall be available in the fabricator’s shop for review.

PART 2 -- MATERIALS

2.1 GENERAL REQUIREMENTS

A. Steel

1. Wide Flange Shapes: ASTM A 992

2. Shapes, Plates, Bars: ASTM A 36

3. HSS: ASTM A 500 Grade B

B. Corrosion Protection: All steel metalwork for the Project shall be hot-dip galvanized after fabrication.

C. Stainless Steel: Unless otherwise indicated, stainless metalwork and bolts shall be fabricated from ASTM A 193, Type 316.

D. Cast Iron: Unless otherwise indicated, iron castings shall conform to the requirements of ASTM A 48, Class 50B or better.

E. Hot Stick Galvanizing Rod: Rods shall nominally contain 50 percent zinc and 50 percent tin. Products that contain lead will not be allowed.

F. Aluminum

1. Unless noted otherwise, aluminum metalwork shall be fabricated from Alloy 6061-T6 to the applicable ASTM standards B209 and B308.

G. Screws

1. Screw threads for screws, nuts, and related hardware shall conform to ANSI B1.1.

H. Bolts and Anchors

1. General: Bolts shall be the same general material or coating as the part being joined or anchored, e.g., hot-dip galvanized steel for hot-dip galvanized steel fabrications and stainless steel for stainless steel applications. Otherwise insulating kits shall be used to isolate dissimilar joined/anchored materials, e.g., hot dip galvanized steel with stainless steel or aluminum and carbon steel.

2. Bolt Requirements

   a. The bolt and nut material shall be free-cutting steel.

   b. The nuts shall be capable of developing the full strength of the bolts.

   c. Threads shall be Coarse Thread Series conforming to the requirements of the American Standard for Screw Threads.

   d. Bolts and cap screws shall have hexagon heads and nuts shall be Heavy Hexagon Series.

   e. Bolts and nuts shall be installed with washers fabricated of material matching the base material of bolts, except that hardened washers for high strength bolts shall conform to the requirements of the AISC Specification.

   f. Lock washers fabricated of material matching the bolts shall be installed where indicated.

   g. The length of each bolt shall be such that the bolt extends at least 1/8 inch beyond the outside face of the nut before tightening, except for anchor bolts which shall be flush with the face of the nut before tightening. After the joint is made up, the length of the bolt shall be such that the bolt extends in no case more than 1/2-inch beyond the nut.

3. Unless otherwise indicated, bolts, anchor bolts, washers, and nuts shall be steel as indicated.

4. Threads on galvanized bolts and nuts shall be formed with suitable taps and dies such that they retain their normal clearance after hot-dip galvanizing.

5. Except as otherwise indicated, steel for bolt material, anchor bolts, and cap screws shall be in accordance with the following:

   a. Structural connections: ASTM A 307, Grade A or B, hot-dip galvanized.

   b. Anchor Bolts: ASTM A 307, Grade A or B, or ASTM A 36, hot-dip galvanized.

   c. High strength bolts where indicated: ASTM A 325.

   d. Pipe and equipment flange bolts: stainless steel, ASTM A193, Grade B8M, Class 2 with ASTM A194, Grade 8M and nuts.

6. Unless otherwise indicated, stainless steel bolts, anchor bolts, nuts, and washers shall be Type 316 stainless steel, Class 2, conforming to ASTM A 193 for bolts and to ASTM A 194 for nuts. Threads on stainless steel bolts shall be protected with an anti-seize lubricant shall be Husky Lube O Seal by Husk-ITT Corporation, or equal.

7. Buried bolts shall be coated the same as the buried pipe.

8. Adhesive Anchors

   a. Epoxy adhesive anchors are required for drilled anchors for indoor and outdoor installations, in submerged, wet, splash, overhead, and corrosive conditions, and for anchoring handrails and reinforcing bars. Threaded rod shall be hot-dip galvanized for general purpose applications or stainless steel Type 316 per the requirements above. Epoxy anchors shall not be permitted in areas where the concrete temperature is in excess of 100 degrees F or higher than the limiting temperature recommended by the manufacturer, whichever is lower. Epoxy anchors shall not be used where anchors are subject to vibration or fire. Embedment depth shall be as the manufacturer recommends for the load to be supported.

b. Adhesive shall be a two-component, non-sag paste, moisture insensitive when cured and shall be Ramset /Redhead Epcon A7 Acrylic Adhesive or equal, conforming to ASTM C881, Type IV, Grade 3, Classes A, B and C with the exception of gel time and epoxy content. No substitutions will be considered unless accompanied with ICBO report verifying strength and material equivalency.

9. Expanding-Type Anchors: Expanding-type anchors if indicated or permitted, shall be hot-dip galvanized steel expansion type Hilti "Kwik Bolt 3", or equal. Lead caulking anchors will not be permitted. Size shall be as indicated and if not indicated shall be 3/4-inch minimum unless otherwise approved by the ENGINEER. Embedment depth shall be as the manufacturer recommends for the load to be supported.

PART 3 -- EXECUTION

3.1 STORAGE OF MATERIALS

A. Store structural material, either plain or fabricated, above ground on platforms, skids, or other supports. Keep material free from dirt, grease, and other foreign matter and protect from corrosion.

3.2 FABRICATION AND INSTALLATION REQUIREMENTS

A. General: Except as otherwise indicated, the fabrication and erection of structural steel shall conform to the requirements of the American Institute of Steel Construction "Manual of Steel Construction" and manufacturer requirements.

B. Fabricate miscellaneous metal items to straight lines and true curves. Do not leave burrs or deformations when drilling and punching. Continuously weld permanent connections along the entire area of contact. Exposed work shall have a smooth finish with welds ground smooth. Joints shall have a close fit with corner joints coped or mitered and shall be in true alignment. Unless specifically indicated on the Drawings, do not provide twists, or open joints in any finished member nor any projecting edges or corners at intersections. Conceal fastenings wherever possible. Built-up parts shall be free of warp. Exposed ends and edges of metal shall be slightly rounded. All bolt holes shall be 1/8-inch in diameter larger than bolt size, unless otherwise noted. Measure cast-in-place bolt locations in the field before drilling companion holes in structural steel beam or assembly.

C. Clean the surfaces of metalwork to be in contact with concrete of rust, dirt, grease, and other foreign substances before placing concrete.

D. Set embedded metalwork accurately in position when concrete is placed and support it rigidly to prevent displacement or undue vibration during or after the placement of concrete. Unless otherwise specified, where metalwork is to be installed in recesses in formed concrete, said recesses shall be made, metalwork installed, and recesses filled in conformance with Section 03300 – Cast-In-Place Concrete.

3.3 GALVANIZING

A. Unless otherwise noted, all structural steel plates, shapes, bars, and fabricated assemblies shall be galvanized after the steel has been thoroughly cleaned of rust and scale in accordance with the requirements of ASTM A 123. Any galvanized part that becomes warped during the galvanizing operation shall be straightened. Bolts, anchor bolts, nuts, and similar threaded fasteners, after being properly cleaned, shall be galvanized in accordance with the requirements of ASTM A 153.

B. Field repairs to field welded and damaged galvanizing shall be made by preparing the surface and applying a coating.

1. Surface preparation shall consist of removing oil, grease, soil, and soluble material by cleaning with water and detergent (SSPC SP1) followed by brush off blast cleaning (SSPC SP7), over an area extending at least 4-inches into the undamaged area.

2. Repairs shall be made using the specified hot stick galvanizing repair rod. The coating area to be repaired shall be thoroughly cleaned and applied in accordance with ASTM A 780 and the rod manufacturer's application instructions.

3.4 BOLTING

A. Drive bolts accurately into the holes without damaging the thread. Protect boltheads from damage during driving. Boltheads and nuts shall rest squarely against the metal. Where bolts are to be used on beveled surfaces having slopes greater than 1 in 20 with a plane normal to the bolt axis, provide beveled washers to give full bearing to the head or nut.

B. Draw boltheads and nuts tight against the work. Tap boltheads with a hammer while the nut is being tightened. After final tightening, lock the nuts.

3.5 INSTALLING ANCHORS AND ANCHOR BOLTS

A. Preset bolts and anchors by the use of templates. For mechanical equipment (pumps, compressors, blowers), do not use concrete anchors set in holes drilled in the concrete after the concrete is placed.

B. For static items, use preset anchor bolts or drilled wedge anchors as shown on the Drawings.

C. After anchor bolts have been embedded, protect their threads by applying grease and by having the nuts screwed on until the time of installation of the equipment or metalwork.

3.6 DRILLED ANCHORS

A. Drilled anchors and reinforcing bars shall be installed in strict accordance with the manufacturer's instructions. Holes shall be roughened with a brush on a power drill, cleaned and dry. Drilled anchors shall not be installed until the concrete has reached the required 28-day compressive strength. Adhesive anchors shall not be loaded until the adhesive has reached its indicated strength in accordance with the manufacturer's instructions.

3.7 FABRICATION OF STRUCTURAL STEEL

A. Carefully perform shearing and cutting, and neatly finish all portions of the work which will be exposed to view after completion. Re-entrant cuts shall be filleted before cutting.

B. Punching, drilling, reaming, and riveting shall be in accordance with best commercial practice for the type of work concerned.

C. Sharp kinks or bends will be cause for rejection of the material.

D. If straightening is necessary it shall be done by methods that will not injure the metal.

3.8 INSTALLING HANDRAILS AND GUARDRAILS

A. Provide handrail components to complete the installation for the various types of handrail.

3.9 ALUMINUM FABRICATION

A. Fabricate aluminum in accordance with the AA Aluminum Design Manual, Part I-A, Specification for Aluminum Structures, Allowable Stress Design, Sections 6 and 7.

B. Structural aluminum materials shall not be heated unless the requirements of the AA Specification for Aluminum Structures, Allowable Stress Design, Paragraph 6.3 are met and written approval is obtained from the ENGINEER. Oxygen cutting shall not be used on aluminum alloys.

C. Welding of aluminum shall be by the gas metal arc (MIG) or gas tungsten arc (TIG) processes as described in the American Welding Society's "Welding Handbook" as supplemented by other pertinent standards of the AWS. Qualification of welders shall be in accordance with the AWS Standards governing same.

– END OF SECTION–

Northeast Church Rock
95% Design Report

Appendix K:
Removal Action Schedule

This page intentionally left blank

TABLE OF CONTENTS

TABLE

FIGURE

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
ARAR	Applicable or Relevant and Appropriate Requirements
CY	cubic yards
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NRC	US Nuclear Regulatory Commission
PTW	principal threat waste
RAO	Remedial Action Objective or Removal Action Objective
ROD	Record of Decision
SOW	Statement of Work
USEPA	US Environmental Protection Agency

K.1 INTRODUCTION

This appendix to the Northeast Church Rock 95% Design Report provides a schedule in support of the design for the Removal Action at the Northeast Church Rock Mine Site (Mine Site) and Repository construction at the Church Rock Mill Site (Mill Site). This schedule is intended to be used as a high-level planning tool and generally illustrates the work activity layout (organized in a manner consistent with the Design Drawings), work activity interrelationships, and reasonable durations which the Removal Action could be conducted, based on the 95% design. This schedule is not intended to be a construction schedule and does not show sufficient detail to execute the work. The schedule is presented in Figure K.1-1.

K.2 PERFORMANCE STANDARDS

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

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

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
17	2015 AOC SOW, Paragraph 37 – Preliminary Design	Preliminary Design	Respondents shall include the following elements in their Preliminary Design: k. A preliminary construction schedule, including a schedule for applicable permit requirements;	The pre-final construction schedule is included as Figure K.1-1.

*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)

K.3 SCHEDULE

K.3.1 Schedule Format

This schedule was developed using Microsoft Project and is presented in Gantt chart format, with task durations and task dependencies indicated. The organization of tasks is generally consistent with the Sections in the 95% Design Drawings to aid in identifying the location of tasks within the design documents.

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

K.3.2 Schedule Inputs and Assumptions

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

- A generic yearly schedule was assumed, with procurement beginning in January of Year 1.
- The schedule is presented in “working” days.
- USEPA design approval, US Nuclear Regulatory Commission (NRC) License Amendment approval, and EPA Consent Decree finalization prior to procurement start.
- Permitting for the transport of principal threat waste (PTW) to the disposal facility is assumed to require 6 months.
- Permitting for local traffic control is assumed to require 1 month.
- Construction sequence and duration assumptions:
    - The first 4-5 months of construction is limited to activities that do not expose or transport contaminated materials. This includes early works, haul and access roads, Repository preparation activities, and several drainage improvement activities in the vicinity of the Repository. This allows for the establishment of drainage controls around the Repository and development and adjustment of dust control measures prior to transporting mine waste.
    - Construction hours are based on five 8-hour shifts per week based on dust control water limitations discussed in Appendix Q and an assumption that a Construction Contractor would elect to conduct the work without the use of labor overtime.
    - Mine waste removal is based on an average haul capacity of 2,700 cubic yards (CY) per day assuming the use of a fleet of between five and ten, 30 CY, articulated trucks operating 7 hours per day as noted in Section K.3.2.1. The Mine Site excavation areas are not well suited to high volume excavation fleets such as scrapers or large haul trucks. Sufficient excavation and placement capacity was assumed to support haul capacity. Haul volumes are increased by 25% for loose in-truck volumes.
    - Mine waste hauling and PTW loading would not occur at the same time. 90 working days of delay have been included in the schedule for PTW loading. This assume 10 minutes of loading time per 40 ton container; 70,000 tons of PTW; 2 tons/CY. This delay may occur incrementally or as a single occurrence depending on contractor operations.
    - Radon barrier conditioning, PTW removal, and borrow area development are shown as continuous operations on the schedule, but are likely to be conducted in several discrete events within the duration shown.
    - Cover construction consists of hauling and placement of the cover soils and the erosion protection layer. This activity is expected to be conducted in phases, concurrently with mine waste placement. For scheduling purposes,

it is shown as a continuous activity concurrent with mine waste placement. It has been estimated to take 60 days to complete cover placement after completion of mine waste placement.

- Jetty construction was assumed to be completed at the same time as cover placement completion (concurrent finish). This task potentially requires an available disposal area for material that is excavated from the Jetty area and is too sandy for use in the Repository cover. A concurrent finish with cover placement results in Jetty excavation after depletion of at least one other borrow area. Riprap production was assumed to occur in the year prior to Jetty construction. Conservative durations of 130 days (6 months of working days) were estimated for both Jetty excavation and riprap placement.
- Durations not specifically noted above are based on engineering and construction experience.

K.3.2.1 Mine Waste Haul and Excavation Productivity

Haul productivity per truck was estimated as listed in Table K.3-1. Travel time to and from the Mine Site are based on performance data for a typical 30 CY articulated haul truck for the design road length and grades. Total round-trip time per truck is estimated to be 34 minutes.

Table K.3-1: Estimation of Haul Productivity per Truck

Action	Time	Productivity
Mine Site maneuver/wait	5 minutes	12 trips per 7 hour haul day = 360 CY/truck/day Fleet of 5 = 1,800 cy/day; Fleet of 10 = 3,600 CY/day Estimated average = 2,700 CY/day Assumptions: 25% expansion of excavated in-situ soils for haul. ½ mile average distance from Mine to Frisk Point, 10 MPH Haul Road average speed
Load	2 minutes	
Travel to Frisk Point	3 minutes	
Frisk at Haul Road	5 minutes	
Haul to Repository	5 minutes	
Repository maneuver/wait	3 minutes	
Dump	1 minutes	
Frisk at Haul Road	5 minutes	
Return to Mine	5 minutes	

K.3.3 Schedule Delays

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

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

K.4 REFERENCES

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

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

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

FIGURE

ID	Task Name	Duration	Predecessors
1	NRC License Amendment Approval/EPA Consent Decree	0 days	
2	**PROCUREMENT**	**308 days**	
3	Prepare Bid Documents	22 days	1
4	Site Walk	2 days	3FS+5 days
5	Contractors Prepare Bids	33 days	3
6	Bid Review and Award	10 days	5
7	Contract Negotiation and Execution	21 days	6
8	Pre-construction Submittals (including SWPPP)	22 days	7
9	Traffic Control Permits (NMDOT, NDOT, County)	22 days	7
10	PTW Transport and Disposal Permits	132 days	7FS+90 days
11	**REMOVAL ACTION**	**773 days**	**1**
12	Construction Notice-To-Proceed	0 days	7
13	**Early Works and Construction Support Facilities (Section 2)**	**729 days**	**12**
14	Mobilization	22 days	12
15	Establish Access Controls	15 days	9
16	Implement Traffic Controls	707 days	9
17	Construct Support Facilities	44 days	14SS+10 days,8
18	Establish Construction Water	20 days	12SS
19	Air Monitoring	719 days	12SS+10 days
20	Dust Control	719 days	19SS
21	**Mine Site Excavation (Section 3)**	**547 days**	**12**
22	Site Preparation and Construction Access Development	22 days	44
23	**Mine Waste Excavation**	**506 days**	
24	Phase 1 (45K CY; Excavate and Haul PTW)	17 days	44,17,56SS+10 days,22,66
25	Phase 2 (218K CY; Excavate and Haul)	81 days	24FS+5 days
26	Phase 3 (558K CY; Excavate and Haul)	298 days	25FS+5 days
27	Phase 4 (55K CY; Excavate and Haul)	21 days	26FS+5 days
28	Phase 5 (43K CY; Excavate and Haul)	16 days	27FS+5 days
29	Phase 6 (35K CY; Excavate and Haul)	13 days	28FS+5 days
30	Haul Road Verification Surveys and Clean Up	22 days	32
31	Former Mill Site Yard Verification Surveys and Clean Up	12 days	30
32	Verification Surveys	442 days	24SS+10 days
33	**Principal Threat Waste Removal**	**206 days**	
34	Stockpiling	15 days	24SS
35	Loadout and Haul to Disposal Facility	90 days	10,34
36	**Final Grading and Seeding**	**373 days**	**24FS+10 days**
37	Phase 2	5 days	25
38	Phase 3	5 days	26
39	Phase 4	5 days	27
40	Phase 5	5 days	28
41	Phase 6	5 days	29
42	**Haul Roads (Section 4)**	**65 days**	**12**
43	Construct Access Roads	15 days	12SS+15 days,8
44	Construct Mine Waste Haul Road	28 days	43
45	Construct Borrow Haul Roads	22 days	44
46	**Construction Stormwater Management (Section 5)**	**758 days**	**12**
47	Implement Construction Stormwater Controls	758 days	14SS+15 days
48	**Mine Site Permanent Stormwater Controls (Section 6)**	**55 days**	**12**
49	Cutoff Wall	5 days	26FF
50	Outlet Channel	15 days	49
51	Box Culvert and Outlet Apron	20 days	50
52	Outlet Channel Downdrain	15 days	51
53	**Repository (Section 7)**	**591 days**	**12**
54	Cover Stripping. Screening, Stockpiling	22 days	17
55	Stormwater Containment Berm Construction	10 days	54
56	Radon Barrier Conditioning	471 days	54
57	Mine Waste Placement	471 days	24SS
58	Cover Construction (Haul and Place Cover Layers)	471 days	57SS+30 days
59	West Apron and Southwest Regrade	15 days	58FS+10 days
60	Seeding	5 days	59
61	**Borrow Areas (Section 8)**	**577 days**	**12**
62	Borrow Area Development	535 days	44
63	Borrow Area Reclamation and Seeding	66 days	62FS-44 days
64	**Mill Site Stormwater Controls (Section 9)**	**631 days**	**12**
65	Dilco Hill Channels	15 days	17
66	East Repository Channel	25 days	17,65
67	Alluvial Flood Plain Improvements	15 days	59
68	North Cell Drainage Channel	15 days	67
69	North Diversion Channel Improvements	15 days	68
70	**Demobilization/Revegetation (Section 10)**	**75 days**	
71	Reclaim Haul Roads	15 days	69
72	Reclaim Repository Yard and Access Roads	15 days	69
73	Reclaim Former Millsite Yard	15 days	72
74	Seeding of Remaining Areas	10 days	73SF+60 days
75	**ROCK JETTY REPLACEMENT (Section 9)**	**390 days**	**12**
76	Riprap Development (Off-site Pit) & Stockpile	260 days	78SF
77	Excavation	130 days	78SF
78	Riprap Placement	130 days	58FF

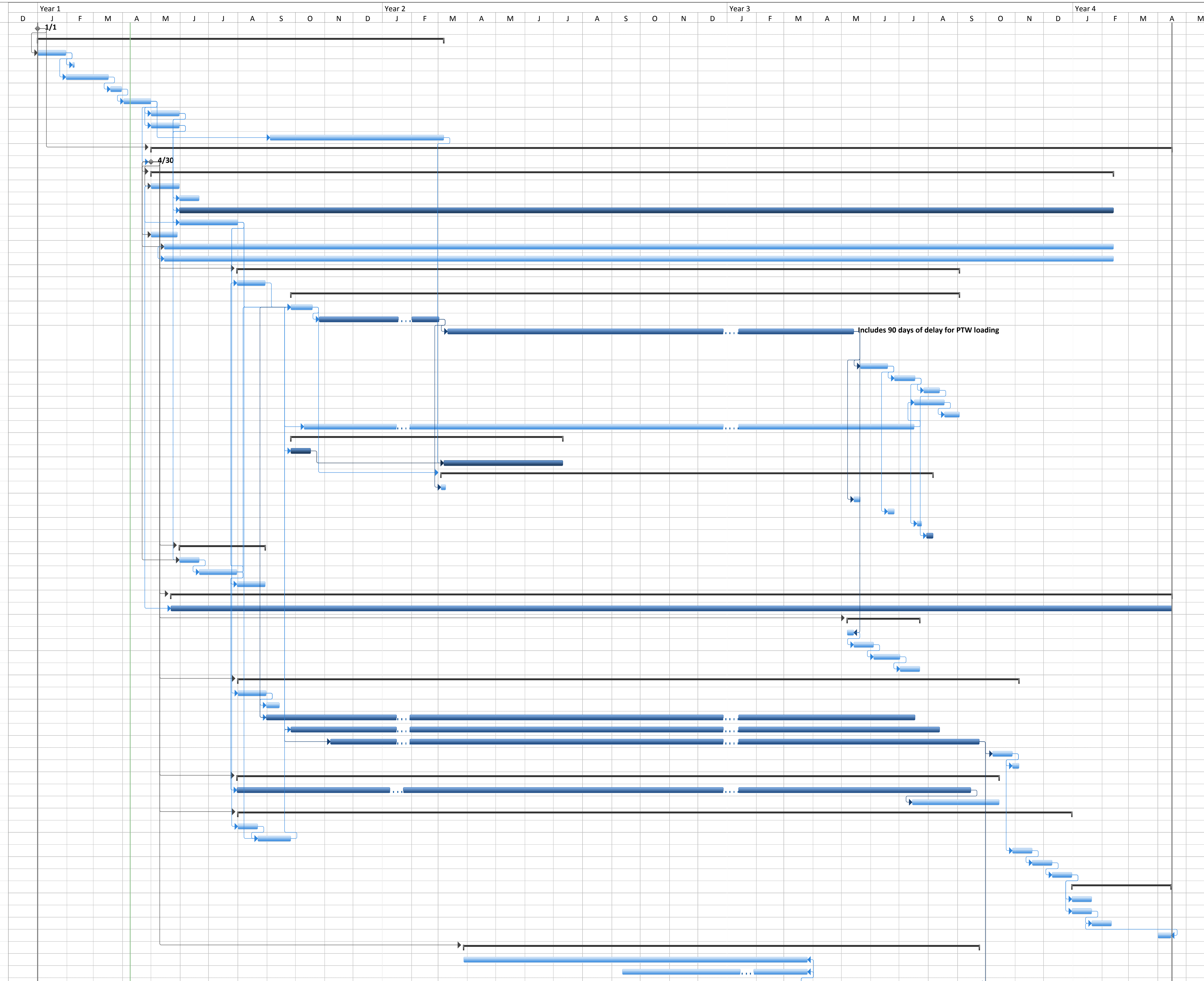


FIGURE K.1-1 PRELIMINARY REMOVAL ACTION SCHEDULE

Northeast Church Rock

95% Design Report

Appendix L:

Health and Safety Plan

This page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS

ALARA	As Low as Reasonably Achievable
ANSI	American National Standards Institute
AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
APR	Air Purifying Respirator
ASTM	American Society for Testing and Materials
CC	Construction Contractor
CFR	Code of Federal Regulations
COC	chemicals of concern
CPR	Cardiopulmonary Resuscitation
CQAO	Construction Quality Assurance Official
CS	Construction Superintendent
CSC	Construction Supervising Contractor
CSHP	Contractor Safety and Health Plan
dBA	Decibels on the 'A' Weighted Scale
DEET	N,N-Dimethyl-m-toluamide
GE/UNC	General Electric / United Nuclear Corporation
H&S	Health and Safety
HAZCOM	Hazard Communication
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HASP	Health and Safety Plan
JSA	Job Safety Analysis
MSDS	Material Safety Data Sheet
MSHA	Mining Safety and Health Administration
NECR	Northeast Church Rock
NIOSH	National Institute for Occupational Safety and Health
NMAC	New Mexico Administrative Code
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
PSO	Project Safety Officer
PVC	polyvinyl chloride
RA	Removal Action

RAO	Remedial Action Objective or Remove Action Objective
RPP	Radiation Projection Plan
RSO	Radiation Safety Officer
RST	Radiation Safety Technician
SDS	Safety Data Sheets
SM	Site Manager
SOP	Standard Operating Procedure
SSO	Site Safety Officer
USEPA	United States Environmental Protection Agency

CHANGE SUMMARY PAGE

Procedure/Plan No: NECR Mine Site Removal Action HASP

Change No.	Date	Affected Page(s)	Change Summary

L.1 INTRODUCTION

This Health and Safety Plan (HASP) describes the minimum health, safety and emergency response requirements for performing Removal Action (RA) activities at the Northeast Church Rock (NECR) Site and construction at the UNC Mill Site.

This HASP has been prepared on behalf of General Electric and United Nuclear Corporation (GE/UNC), and is applicable to all GE/UNC employees, contractors, and subcontractors involved with the RA. It establishes general safety requirements, and procedures for the protection of personnel and to prevent and minimize personal injuries, illnesses and physical damage to equipment, supplies, and property.

The work covered by this HASP will be conducted by GE/UNC, its contractors and their subcontractors. GE/UNC personnel, contractors, subcontractors, suppliers, visitors, and all personnel engaged in work at the Site shall comply with all provisions of this HASP. This HASP shall not be modified without written approval of GE/UNC.

GE/UNC cannot anticipate all the hazards inherent to all contractor and subcontractor work activities. Therefore, each contractor and subcontractor will be required to read and evaluate this HASP to ensure that it adequately addresses the hazards presented to their employees. The Construction Contractor (CC) will then be required to prepare their own Contractor Safety and Health Plan (CSHP), which will be specific to the project and that at a minimum is compliant with this HASP. Addenda may be attached to this HASP to ensure that additional potential risks are controlled for the RA activities.

This HASP was prepared using the Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (USDHHS, 1985). This site-specific HASP presents safety and health procedures designed to minimize potential risks of harm to personnel working on the Mill and Mine Sites. These procedures were developed in accordance with the list of regulatory guidelines, presented below, as applicable and appropriate. Individual contractor activity may be regulated under the Occupational Safety and Health Administration (OSHA) General Industry Standard, Construction Standard, US Nuclear Regulatory Commission (NRC), and/or other standards listed below to ensure consistent and conservative risk management. Specific hazards in this HASP may specify the more stringent or prescriptive requirements of the standards. The majority of operations conducted during the RA are primarily regulated by OSHA and/or the NRC. Since this is an inactive mine site formerly regulated by MSHA, GE/UNC and its contractors/subcontractors may utilize applicable MSHA best practices for managing specific mine related operations. These operations include but are not limited to:

- Ground Control for Berms (30 CFR Part 56 Subpart B)
- Loading, Hauling, Dumping & Traffic Safety (30 CFR Part 56 Subpart H)
- Machinery (30 CFR Part 56 Subpart M)

This HASP was developed with the intent that regardless of the activity, all activities are compliant with the following regulatory and consensus standards (herein referred to as “applicable H&S codes”):

- Occupational Safety and Health Administration (OSHA) Title 29 Code of Federal Regulations (CFR), Part 1910 (General Industry Standards)
- Occupational Safety and Health Administration (OSHA) Title 29 Code of Federal Regulations (CFR), Part 1926 (Construction Standards)
- NRC Standards for Protection against Radiation included in 10 CFR 20
- American National Standards Institute (ANSI), N14.1 Nuclear Materials - Uranium Hexafluoride - Packaging for Transport and N14.5 Radioactive Materials - Leakage Tests on Packages for Shipment
- Applicable section of New Mexico Administrative Code (NMAC) Titles 19 and 20

L.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical RA at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the RA 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 L.2-1 presents performance standards related to the health and safety plan and explains how the design accomplishes these standards.

Table L.2-1: Task Specific Performance Standards

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
30	2013 ROD, Section 2.9.5 – Perimeter Air Monitoring Stations	Air Monitoring	Perimeter air monitoring stations will be positioned and operated to monitor emissions during site preparation construction, stockpiling, loading of bulk-carriers, stockpile management, consolidation, cover construction and restoration. Dust suppression controls will be implemented to maintain a safe working environment and to protect human health and the environment.	Air monitoring is discussed in Appendix Q.
`82	2011 Action Memo, Table A-1; 10 CFR 61.23(d) and 43	Health and Safety	10 CFR 20 Standards for Protection Against Radiation. Refer to www.ecfr.gov.	Protection against radiation is addressed in Attachment L-1 – Radiation Protection Plan
98	10 CFR 61.51(a)(2)	Health and Safety	10 CFR 61.43 Protection of Individuals During Operations. Refer to www.ecfr.gov.	Protection against radiation is addressed in Attachment L-1 – Radiation Protection Plan
77	2013 ROD, Table 1 and Sections 2.9.2 and 2.9.5	Health and Safety	40 CFR 192.41 Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended. Refer to www.ecfr.gov.	Protection against radiation is addressed in Attachment L-1 – Radiation Protection Plan
78	2013 ROD, Table 1 and Sections 2.9.2 and 2.9.5	Health and Safety	40 CFR 192.43 Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended. Refer to www.ecfr.gov.	Protection against radiation is addressed in Attachment L-1 – Radiation Protection Plan

*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)

L.3 HASP ORGANIZATION

L.3.1 Purpose of the Health and Safety Plan

The purpose of the HASP, which includes a Radiation Protection Plan (RPP; Attachment L-1), is to provide information to all contractors working on site so that they can complete the project objectives in a safe and healthful manner. The evaluation of hazards, levels of protection and procedures specified in this HASP are based on the best information available during the writing of this plan. It is recognized that every feasible safety or health hazard faced on site may not be contained in this document and that site conditions change. Therefore, it is part of every employee's job to continuously assess site conditions in relation to his/her own knowledge of how to do a task safely. If at any time an employee lacks clarity in how to do a job safely or is unsure of the potential for adverse exposure to a contaminant, that employee shall bring this to the attention of the Site Safety Officer (SSO) or his/her direct supervisor. No employee is expected to do work that he/she does not know how to do properly and safely. All employees are empowered with Stop Work Authority for imminent hazards affecting life, property or the environment (See Section 5.3.)

L.3.2 Site Location and Description

The NECR Mine Site is located approximately 16 miles northeast of Gallup, New Mexico and is accessed via State Highway 566. The mine is located in Sections 34 and 35, Township 17 North, Range 16 West and Section 3, Township 16 North, Range 16 West in McKinley County, New Mexico. Uranium ore was processed at the site and tailings were generated from 1977 to 1982. Closure of the NECR Mine was performed between 1986 and 1993 and included removal of equipment and buildings, sealing of the mine shafts and vent holes, removal and disposal of some mine waste materials, trash and debris, and removal of other waste materials in areas regulated by the NRC. The remaining surface features on the Site are limited to the mine pad areas, several small buildings, concrete foundations, a waste rock dump, power lines, and primary and secondary mine roads.

L.3.3 Contractor Safety and Health Plan

Prior to the start of any work, the CC shall prepare a CSHP, which shall be specific to the project and that at a minimum is compliant with this HASP. The CSHP shall include:

1) A job safety analysis (JSA) for each work site activity and job classification required in the activity area that present any health or safety risks. Each JSA will detail the task, identify the task-specific hazards and the measures to eliminate or control those hazards.
2) Direction as to whether elimination, substitution, engineering controls, administrative controls, personal protection measures, or a combination thereof, shall be implemented to address the hazards identified above. Measures shall include but are not limited to access control, site layout, traffic control, fall protection, hearing protection, respiratory protection, confined space protection, excavation protection, and measures to address any other work area activities.
3) Provisions for regular informal safety meetings. The Contractor Project Safety Officer shall conduct safety meetings with the CC's employees at the frequency specified in the CSHP, once per week at a minimum, but preferably at the start of each shift. The CC shall require participation by all personnel working at the project Site. For tasks/projects involving multiple contractors, combined safety meetings are required. Participants at these meetings shall discuss specific work activities for that shift, safe work practices, results from recent experience or altered conditions, safety inspections, required personal protective equipment (PPE), and all other necessary safety precautions.
4) Provisions for more formal safety meetings to discuss accidents, incidents, safety goals, emphasis items, and results of safety inspections. The CC shall notify the Construction Supervising Contractor (CSC) and GE/UNC personnel of the time, date, and location of these meetings, and shall encourage participation by all persons working at the project site.
5) A documented process for assuring compliance by their subcontractors, suppliers, and authorized visitors to the project. In addition, the CSHP shall specify the measures taken to discourage unauthorized personnel from entering the site.

6) An effective drug and alcohol prevention program.

7) Provisions for regular safety inspections. The CC shall conduct regular safety inspections at the frequency specified in the CSHP. The subcontractor shall provide documentation to the Construction Quality Assurance Official (CQAO) of the date of these inspections, the findings, and the measures taken to address the findings.

8) The disciplinary measures that shall be taken to correct violations of the CSHP.

9) The notification, investigation, and implementation procedures that the CC shall implement in the case of an accident or incident including near miss occurrences.

The CC shall submit the CSHP to the CSC and GE/UNC for the project records and shall provide updates to the CSHP should conditions change. An up-to-date copy of the CSHP shall be at the project site in the CC's possession at all times.

L.3.4 Differing Opinions

When a dispute or difference of opinion occurs between the CSC or GE/UNC and CC personnel concerning any interpretation of the safety practices as found in this plan or the CC's CSHP, the most stringent plan shall be the controlling plan. The subcontractor shall not start or continue with work until the safety practices and procedures in dispute are resolved to the satisfaction of all applicable senior management personnel.

L.3.5 Modifying the Health and Safety Plan

This HASP must be modified should significant processes or conditions change, new hazards are identified, the scope of work is revised, or the provisions specified in the HASP are not adequate to protect the health and safety of all personnel. All HASP modifications shall be documented on the form included at the beginning of this document (HASP Change Summary Page). The form must have referenced verbal concurrence, or the signature from the SSO. All changes to the HASP shall be documented with the appropriate revision number.

L.4 HASP ROLES AND RESPONSIBILITIES

The key health and safety personnel are listed in Table L.4-1. The authorities, responsibilities and qualifications for key personnel are discussed below. Contractors are required to provide a Project Safety Officer responsible for the health and safety of their personnel, subcontractors, vendors, and visitors.

Table L.4-1 – Key Personnel

Personnel	Name	Affiliation	Phone (Work)	Phone (Other)
Site Manager	TBD			
Site Safety Officer	TBD			
Radiation Safety Officer	TBD			
Project Safety Officer	TBD			

L.4.1 GE/UNC Site Manager

The GE/UNC Site Manager (SM) has overall responsibility for worker safety and to assure that RA work activities comply with the health and safety requirements and guidelines of this HASP. The SM is responsible for ensuring the necessary resources (qualified personnel, equipment, supplies, etc.) are being provided to the project. The SM also is responsible for procuring contractors/subcontractors that are qualified to perform in accordance with this HASP. The SM or his/her delegate directs the SSO and Radiation Safety Officer (described below).

L.4.2 Site Safety Officer

The SSO reports to the SM and has responsibility for implementation of this HASP and conformance with all applicable worker safety regulations, as appropriate. The SSO is the primary contact for matters relating to health and safety. The SSO must approve any changes to the HASP or changes to the JSAs that could impact health and safety. The SSO is responsible for resolving any health and safety issues that arise out of the work. The SSO coordinates with the Radiation Safety Officer (described below) to ensure that both this HASP and the RPP included in Attachment L-1 are effectively implemented. The SSO coordinates with the Contractor Project Safety Officer (described below) to ensure the CSHP is being effectively implemented, and that tasks/projects involving multiple contractors/subcontractors are coordinated. The responsibilities of the SSO are:

- Direct health and safety related activities, such as coordinating combined safety meetings among multiple contractors/subcontractors.
- Report all safety related incidents or accidents immediately to the SM and the Construction Superintendent (CS; defined in project Construction Quality Assurance Plan [CQAP]).
- Assist in all aspects of implementing the HASP.
- Conduct air monitoring/sampling and interpreting results.
- Maintain health and safety equipment.
- Implement emergency procedures as required.
- Evaluate the effectiveness of the HASP and reporting deficiencies as needed.
- Enforce the buddy system so that workers are observed by at least one other worker in the work group. The purpose of the buddy system is to maintain communication between workers and provide rapid assistance in the event of an emergency.
- Maintain records of HASP compliance agreements for all staff and contractors.

- Conduct safety meetings as required.
- Define limited access areas (based on potential hazards) on a task by task basis.
- Monitor personnel for signs of stress, such as cold exposure, heat stress, and fatigue.
- Implement radiation protection procedures as directed by the Radiation Safety Officer (RSO), SM or his designee.
- Act as Emergency Coordinator in the event of an emergency.

The SSO has authority to:

- Suspend work or otherwise limit exposure to personnel if health and safety conditions appear to be unsuitable or inadequate
- Upgrade and downgrade levels of protection based on air monitoring data

L.4.3 Radiation Safety Officer and Radiation Safety Technician

The RSO reports to the SM and is the individual responsible for oversight of the activities related to radiation safety. The RSO coordinates with the SSO (described above) to ensure that both this HASP and the RPP (Attachment L-1) are effectively implemented. The RSO may be supported by a Radiation Safety Technician (RST). The responsibilities for the RSO/RST are described in the RPP (Attachment L-1).

L.4.4 Contractor Project Safety Officer

The CC is required to provide a Project Safety Officer (PSO) responsible for the health and safety of their personnel, subcontractors, vendors and visitors. The PSO reports to the CS and the CQAO (defined in the CQAP).

- The PSO is responsible for:
- Providing JSAs that list requirements for specific tasks and types of equipment for each activity
- Conducting regular safety meetings
- Performing regular safety inspections at the frequency specified in the CSHP
- Coordinating changes to the HASP with the SSO relating to specific work activities
- Correcting work practices or conditions that may result in injury or exposure to hazardous substances
- Coordinating with the CQAO, CS, SM, SSO, and RSO/RST on health and safety matters

The PSO has authority to:

- Suspend field activities if the health and safety of personnel become endangered
- Suspend personnel or subcontractors from field activities for infractions of the health and safety plan, pending an evaluation by the CQAO

L.4.5 Contractor and Subcontractor Responsibilities

Any RA contractor (including subcontractors) shall ensure compliance with all applicable Health and Safety (H&S) codes. The CC shall provide all safeguards, safety devices, and protective equipment, and shall take any other actions necessary to protect the life, safety and health of persons working at or visiting the project Site, the public, and the property in connection with the performance of the work. The CC shall take every reasonable precaution to minimize any dangers or hazards to their employees. In the case of conflicting requirements, the more stringent of the requirements shall apply. The CC will be held accountable for the safety performance of its employees including lower tier subcontractors.

L.4.5.1 Competent Person

Prior to start of work, the CC shall designate at least one competent person for each of the operations being completed. The appropriate competent person(s) shall be present on the project Site at all times during removal and remediation related activities. A competent person is an individual who, by way of training, experience, or combination thereof, is knowledgeable of applicable standards, is capable of identifying existing and predictable workplace hazards relating to the specific operation, is designated by the employer, and has authority to take appropriate actions.

L.4.5.2 Unsafe Conditions

The CC shall immediately correct any unsafe conditions that are brought to its attention. When unsafe conditions are not corrected to the satisfaction of GE/UNC, the Construction Supervising Contractor or CC management personnel, or the CC fails to correct the unsafe conditions and/or repeatedly fails to comply with applicable H&S codes, specific work activities will stop. All GE/UNC, Contractor, or Subcontractor personnel have the authority and responsibility to stop work associated with unsafe or unhealthy workplace conditions or acts. The work stoppage will be in place until the corrective steps to eliminate the unsafe conditions or acts are taken.

L.4.6 Field Personnel Responsibilities

Management of safety by the personnel listed above does not relieve any employee of his or her responsibility to perform work according to safe work practices. The employee must be familiar with the Health and Safety Policy, know who to contact for safety related questions and concerns, know where the Work Plans are located, how to respond to site emergencies including how to respond to first aid, and the names, locations and telephone numbers of emergency response services. All written and oral safety rules must be observed recognizing particular job-associated hazards. The employee is responsible for observing the following general safe work practices:

1) Review, understand, and acknowledge the CSHP and applicable task-specific JSAs.
2) A job shall not be started until proper instructions have been received and understood.
3) Any hazardous conditions, unsafe equipment, or unsafe working practice shall be reported to the supervisor immediately.
4) All injuries or accidents shall be reported immediately to the supervisor, regardless of severity.
5) Moving equipment shall not be operated unless the operator has been instructed and properly trained in its use and the equipment was inspected prior to use.
6) Speed limits, traffic signs, “clean/dirty” road designations and parking regulations must be observed within the Site and in travel to and from the Site on public roads.
7) Safety devices and safety guards must be in place before operating any equipment.
8) Hand tools and special tools must be kept clean and maintained in good repair.
9) The correct tool must be used for the particular job in the proper manner.
10) Proper protective equipment must be used for particular job conditions.
11) Loose clothing must not be worn as it may be caught in moving equipment causing injury. Long hair must be bound to prevent entanglement with equipment.
12) Good housekeeping must be practiced at all times.
13) The rules of personal hygiene shall be observed to avoid infection and contamination with toxic chemicals and radioactive material.
14) Practical jokes, rowdiness, and “horseplay” are strictly forbidden.

15) Reporting to the work site under the influence of alcohol or drugs, or bringing them on the premises, is forbidden.
16) Under no circumstances shall safety be sacrificed.
17) No job shall be considered finished until the safety of the next person to use the equipment has been assured.
18) All site radiation safety procedures and work rules must be followed.
19) Failure to adhere to safety and health procedures and rules can result in removal from the site.

L.4.7 Site Visitors

Personnel visiting the site who are invitees (visitors), employees, or subcontractors will be permitted to enter work areas only with prior approval by the SM or designee. The SM or SSO must adequately inform the visitors of the current hazards and controls including the protective equipment required. The SM or the SSO will escort the visitors or provide the visitors with an escort for their visit.

Visitors wishing to enter the site exclusion or contamination reduction area must provide verification to the SSO that he/she has been medically approved and trained per the Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard. Unless prior arrangements are made, PPE other than hard hat, safety glasses and high visibility vests will not be provided to visitors. Standard requirements for PPE are Level D; should that change, under no conditions will field staff provide respiratory protection to site visitors. Prior to entry, this HASP must be reviewed, and a Personal Acknowledgement form signed.

L.5 STANDARD OPERATING GUIDELINES

All RA contractors will implement and enforce the requirements of the HASP in this document and comply with applicable H&S codes.

L.5.1 General

The following practices are expressly forbidden during on-site work:

- Smoking, eating, drinking, chewing tobacco, or applying cosmetics while in the exclusion area, contamination control area, decontamination area, or any potentially contaminated area.
- Ignition of flammable materials in the work area (equipment needed to work around flammable materials will be bonded and grounded, spark proof and explosion resistant, as appropriate).
- Performance of tasks in the exclusion area without a “buddy” or specified system accounting for a buddy.

Personnel must keep the following guidelines in mind when on site conducting field activities:

- Hazard assessment is a continual process; personnel must be aware of their surroundings and constantly be aware of the chemical/physical hazards that are present.
- The number of personnel in the exclusion area will be the minimum number necessary to perform work tasks in a safe and efficient manner.
- Team members will be familiar with the physical characteristics of each site including wind direction, site access, and location of communication devices and safety equipment.
- The location of overhead power lines and underground utilities must be established prior to approach or ground disturbance.

Where feasible, engineering controls will be selected to reduce exposure of site personnel to health or safety hazards. Engineering controls that may be feasible include: design of site layout, designated traffic patterns, use of pressurized cabs or control booths on equipment, use of remotely operated material handling equipment, dust suppression techniques (such as wetting down a surface with a water spray), noise insulation barriers, and use of shoring devices for trench or excavation entry.

When engineering controls are not feasible, administrative controls in the form of training, policies and procedures, and safe work practices will be implemented to minimize risk to personnel from site hazards. Work practices that may be instituted include removing all non-essential personnel from the exclusion area and locating employees upwind of the hot area. Work rotation will be used to control exposures to extreme thermal stresses; however, work rotation for the purpose of limiting exposure to site personnel from airborne chemical hazards is unacceptable.

PPE will always be considered as a control method of last resort.

L.5.2 Recordkeeping

Documentation is one of the methods of ensuring that the site safety program is implemented properly. The Project shall establish reporting and recordkeeping requirements in accordance with Federal and/or State law. It is the SSO’s responsibility to maintain and update these documents. Listed below are the minimum project health and safety compliance documentation requirements:

- A copy of this HASP must be on site
- OSHA Job Safety and Health Protection poster posted at the site

- OSHA Injury and Illness Recordkeeping Form 300, and 301 or equivalent which is maintained at the removal and remediation site. The Summary of Occupational Injuries and Illnesses from the previous year, OSHA Form 300a shall be posted at the site from February 1 through April 30.
- Calibration records for health hazard assessment monitoring equipment
- Record of health hazard assessment monitoring results (a field log book or daily report sheet is acceptable
- Incident reports, including near misses, for the project
- Inspections (daily visual inspections recorded in a field log book or daily report sheet)
- Personal acknowledgement forms signed by all site workers
- Daily tailgate safety meeting forms
- Visitor sign-in sheet
- Respirator fit test and equipment inspection documentation for Level C or higher jobs
- Contractor Competent Person designations and associated documentation
- Permits, if required, for the job:
    - Permit Required Confined Space
    - Hot Work
    - Lockout / Tagout
    - Excavation entry
- Training and medical surveillance certifications:
    - Initial 40-hour, or 24-hour, HAZWOPER training
    - 8-hour refresher HAZWOPER training
    - OSHA 30-hour or 10-hour construction training
    - SSO's 8-hour supervisory HAZWOPER training
    - On-the-job site-specific and radiation worker training
    - First Aid / CPR
    - Medical clearance for working on hazardous waste sites and wearing respiratory protection

L.5.3 Guidelines for Observed or Identified Hazards

If a condition is identified that could immediately result in an accident causing severe injury or death:

- Take appropriate measures to ensure your own safety and the safety of others by immediately removing yourself/them from the immediate danger of the hazard area.
- Advise others in the area of your potential concern. This would include notifying the client representative. Do not advise how to correct the immediate hazard, only that one appears to exist.
- If the potential concern is not addressed, personnel should notify the CS, Construction Supervising Contractor and the SM or his/her designee.

If a condition is identified that may not be an immediate danger, but could result in an accident involving less serious or minor injury, damage to equipment, or environmental release:

- Take appropriate measures to ensure your own safety and the safety of others by immediately removing yourself/them from the immediate hazard area.
- Advise others in the area of your concern. This would include notifying the client representative. Do not advise how to correct the deficiency; only that it appears that one exists.

In either case, notify the SSO.

L.5.4 Enforcement of Safe Work Practices in a Multi-Employer Job Setting

Under OSHA, each employer is required to provide a safe and healthy working environment for employees. When several employers are working simultaneously on the project, the activities of one employer could expose personnel of another company to a hazard.

Where an employer creates unsafe conditions, the exposing employer shall be responsible for exercising reasonable diligence to discover the condition, and for taking steps to protect their personnel. When the exposing employer has authority to correct the hazard, it shall do so. Where the exposing employer lacks the authority to correct the hazard, the employer shall ask the creating and/or controlling employer to correct the hazard; inform its personnel of the hazard; and take reasonable alternative protective measures. In extreme circumstances (e.g., imminent danger situations), the exposing employer shall remove their personnel from the area to avoid the hazard.

Each Contractor will be held accountable for compliance with applicable H&S codes. All contractors/subcontractors must protect their employees from hazards, regardless of who created them.

L.5.5 Injury Prevention and Response

The SSO shall ensure that, when necessary, an ample supply of the following is available for all site personnel:

- Insect repellent, with active ingredient N,N-diethyl-m-toluamide (DEET) at approximately 30 percent
- Sunscreen with sun protection factor of at least 30
- Electrolyte replacing fluids

At least one field team member will be certified to render both first aid and CPR with an AED. An AED must be kept on site during the project. A first aid kit, including necessary protection against bloodborne pathogens, will be available at each site for use by trained personnel. The following is a list of first aid supplies that should be available for use during field work:

- Antiseptic wipes
- Antibacterial ointment (e.g., bacitracin)
- Compound tincture of benzoin (bandage adhesive)
- Assorted adhesive bandages
- Butterfly bandages / adhesive wound-closure strips
- Gauze pads (various sizes)
- Nonstick sterile pads
- Medical adhesive tape
- Blister treatment
- Ibuprofen / other pain-relief medication

- Insect sting relief treatment
- Antihistamine to treat allergic reactions
- Splinter (fine-point) tweezers
- Safety pins
- Elastic wrap
- Triangular cravat bandage
- Finger splint(s)
- SAM splint(s)
- Rolled gauze
- Rolled, stretch-to-conform bandages
- Hydrogel-based pads
- First-aid cleansing pads with topical anesthetic
- Hemostatic (blood-stopping) gauze
- Tourniquet
- Non-latex gloves
- Medical shears/scissors
- An adequate supply of fresh potable water for emergency eye wash purposes or portable emergency eyewash also will be available at each site. All injuries, illnesses, and near misses must be reported using a form compliant with OSHA requirements.

L.5.6 Fire Protection Plan

Field activities associated with hazardous waste operations potentially could result in a fire at a site. Cigarette smoking is expressly forbidden in work areas. At least one Class ABC dry chemical fire extinguisher, 10-pound minimum, will be available for use at each site.

All electrical wiring, including cord sets, will be free from damaged insulation, frayed ends and sections, damaged receptacles, and all hook-ups will be checked for loose fittings. Portable power tools will be connected to a ground fault circuit interrupter and care will be taken to ensure that electrical connections do not exceed the maximum current load capacity for any single circuit.

L.5.6.1 Wildfires

Areas (particularly the southwestern United States) with wide open spaces of natural brush present the danger of wildfires when dry grasses and brush catch fire. As warranted, the SSO will check regularly with the local fire department during the most common wildfire months (July through November). Should a wildfire threaten a work site, the SSO will watch for changing conditions and evacuate and secure each active site, in accordance with local fire department instructions.

L.5.6.1.1 Fire or Explosion Response Action

The actions listed below are in a general chronological sequence. Conditions and common sense may dictate changes in the sequence of actions and the addition, elimination, or modification of specific steps. Due to the remoteness of the site, site workers need to consider the response time for emergency personnel.

1) Upon detecting a fire/explosion, personnel will immediately notify the fire department and SSO.
2) A determination will be made as to whether or not the fire is small enough to extinguish readily with immediately available portable extinguishers or water, or if other fire-fighting methods are necessary.
3) Non-essential personnel will be directed away from the area of the fire.
4) Someone will be directed to greet the fire crew and show them the way to the site over non-contaminated ground if possible. Once the fire department arrives, the senior fire official is now in charge of the site.
5) If it is judged that a fire is small enough to fight with available extinguishing media, employees will attempt to extinguish the fire provided that:
   - A clear path of escape is maintained at all times
   - They are able to approach the fire from the upwind side, or opposite to the direction of the fire's progress.
   - The correct extinguisher is readily available or a water source or heavy equipment operator that can put soil on the fire is available.
   - No known complicating factors are present, such as likelihood of rapid spread, imminent risk of explosion, or gross contamination.
6) The SSO or designee will perform a head count for that work area.
7) The SSO will assist the fire crew in performing any necessary decontamination of the fire equipment.

L.5.6.1.2 Fire Extinguisher Information

Four classes of fire, along with their constituents, which may be anticipated at the site are as follows:

- Class A - Wood, cloth, paper, rubber, many plastics, and ordinary combustible materials. Extinguish with water or ABC dry chemical extinguisher or other A-rated extinguishing media.
- Class B - Flammable liquids, gases, and greases. Extinguish with ABC dry chemical, Purple K, carbon dioxide or other B-rated media.
- Class C - Energized electrical equipment. Extinguish with ABC dry chemical, carbon dioxide or other C-rated media.
- Class D - Combustible metals such as magnesium, titanium, sodium, and potassium. Extinguish with Metal-X Dry Chemical.

The SSO shall conduct an inspection of the all fire extinguisher(s) initially prior to placement and on a monthly basis to ensure that the unit is adequately charged with extinguishing media, the pin is intact, and the extinguisher is stored properly. Do not store a fire extinguisher on its side. All personnel who may use a fire extinguisher are required to be trained. To use the extinguisher, follow the acronym PASS for instructions listed below:

1) Pull the pin on the top of the unit.
2) Aim at the base of the fire.
3) Squeeze the handle on the top of the unit.
4) Sweep the extinguishing media along the base of the fire until the fire is out. Ensure that the fire is fully cooled before assuming it is completely extinguished.

L.5.7 Earthquake and Disaster Preparedness

If an earthquake or other disaster occurs during working hours and the magnitude is such that site personnel may be in danger, the SSO will initiate the site evacuation procedure. This action is to be taken only if in the judgment of project personnel and/or

SSO that the earthquake is large enough to have potentially caused damage to any of the structures or equipment being used on the site.

If the earthquake or disaster occurs during non-working hours, the SSO will determine whether safe entry into the work areas can be made, or if an inspection is needed first. If at any time, the inspection team feels that they need the assistance of the fire department, the inspection shall cease until the fire department is able to assist.

L.5.8 Sanitation

Work breaks, eating, drinking, and conducting paperwork tasks will be performed in the field vehicle or other suitable location outside of the exclusion and controlled areas (refer to Section L.8.7). Field personnel will wash their hands prior to eating or drinking.

Project site toilet facilities will be available to site workers. Due to the remoteness of the site, portable toilet facilities will be rented and brought to the project site. One toilet will be rented if the anticipated size of the field crew is less than 20. All rented toilets will be equipped with a door that is lockable from the inside. Rental toilets will include, at a minimum, a weekly cleaning service. A visual search for spiders (particularly black widow spiders) should be conducted prior to using any portable toilet.

Potable water will be available in the support area for all field team members. The SSO is responsible for ensuring that an adequate supply of water is available at the site. During times of heavy labor and hot temperatures, it is recommended that approximately 1 liter of water per hour be ingested. Electrolyte replacement beverages also may be provided for site personnel. Non-potable water outlets must be clearly identified. When decontamination procedures are prohibitive for the purpose of ingesting water during work, field team members may drink water without prior personnel decontamination under the following stipulations:

- Water is dispensed from a cooler with a pull-lever or top push pouring spout. Push-button pouring spouts are unacceptable as dirty fingers can easily contaminate the pouring spout.
- Disposable drinking cups must be used and discarded after each use.
- Drinking cups must be dispensed out of a plastic or metal dispenser attached to the cooler allowing the bottom of the cup to be grabbed without touching the rim of the top.

If a support area for food handling activities is used, it must comply with local requirements governing the use of barbecues and vending. Remember to store food at above 140 degrees F or below 40 degrees F to kill or retard food-borne pathogenic microorganisms.

L.5.9 Housekeeping

One of the best ways to keep a safe site is to keep a clean and orderly site. The SSO shall remind all site workers that it is their responsibility to ensure that housekeeping is kept up and that the sites, staging areas and parking areas are free from trash, debris and cluttered walkways. This includes the following:

- The SSO will designate trash receptacles.
- The SSO will designate appropriate storage for flammable materials (e.g., decontamination solvents). This may include a flammables cabinet.
- The SSO will designate “Smoking Areas” that are acceptable for site conditions (e.g., no smoking near dry grass).
- All materials shall be stored such that it is stacked, braced, racked, blocked, interlocked, or otherwise secured to prevent sliding, rolling, falling or collapse.
- Any protruding materials (e.g., nails) will be kept clear from walkways and positioned such that someone will not accidentally lean on them.

- Dangerous depressions in the ground shall be avoided by setting up work so that people are not required to walk over them. If that cannot be done, the depression should be temporarily covered or otherwise made safe.
- Any combustible scrap (e.g., cardboard boxes) shall be removed at regular intervals.
- Hoses and cords shall be run the minimum distance necessary and if they must pass over walkways, they must be secured or passed overhead.

L.5.10 Emergency Response Plan

The objective of this HASP is to minimize the potential for chemical, biological, and physical hazards, and operational incidents. As part of this program, emergency response planning provides procedures for responding to emergencies that may occur during the project. *It is not the intention of this program to include professional emergency response activities as part of the field operations. Thus, all site personnel are instructed to assess emergencies in terms of whether the problem can be solved safely with the personnel and equipment at the site. If it is determined that site personnel are able to contain the emergency safely, they should do so. If it is determined that the emergency is beyond the abilities of site personnel, evacuation and notification must take place immediately.* This section provides general information for responding to emergency situations the CC and CSC should develop and emergency response plan prior to the beginning of construction.

Emergency Medical Assistance Network. Section L.11 provides this site-specific information. Emergency telephone numbers and a map showing the locations of the hospital(s) or emergency clinic(s) capable of providing emergency service for hazardous waste site workers are provided. Telephone numbers for the Poison Control Center, local Police and/or Sheriff's Department, local Fire Department, Office of Emergency Services, utility service or "one call" system number, management, workers' compensation reporting and project emergency contacts also are included. This information must be reviewed periodically by the SSO to ensure that it is current.

Standby Vehicles. Vehicles that can be used to transport injured personnel, if an ambulance is not necessary, from work sites will be available during working hours.

Communication System. If cellular phones or two-way radios cannot be used at the site or are ineffective due to terrain, an alternate communication system must be preplanned and communicated. This information will be inserted in Section L.11 or posted at the site.

Emergency Response Leader. The SSO assumes overall lead of the situation for personnel on site, and will coordinate all activities with the CC. Each subcontractor's "competent person" will work with the SSO to control the emergency. These people will take time during the beginning of the project to establish or confirm the following:

- Best route to the specified medical facility.
- Assembly area, in the event of an emergency (preferably upwind, uphill at least 100 feet from the support area).
- Number of people on site at any given time (a count must be made at assembly area during emergencies).
- Alarms and communication methods (phones, horn, verbal, etc.).
- First aid supplies available and in clean condition; identification of at least two field team members with current training certificates.
- Evacuation routes clear and posted (as necessary, such as inside buildings).

Emergency Reporting. All accidents, safety related incidents, and safety related near misses will be documented and reported to the SSO who will make the subsequent necessary notifications.

L.6 HEALTH AND SAFETY TRAINING REQUIREMENTS

L.6.1 Required Courses and Meetings

Employees engaged in field activities within the Exclusion Area or Decontamination Areas must have successfully completed OSHA HAZWOPER initial training in compliance with 29 CFR 1910.120. Annual 8-hour HAZWOPER refresher training shall be completed by each employee. Annual refresher training will be completed within 365 days of the last completed refresher training course. Site managers and supervisors shall successfully complete an 8-hour supervisor's course in addition to other training received. Attendance at the initial Site Safety Meeting and other as-needed Site Safety Meetings shall also be required of all personnel working on Site. Additional training such as radiation safety, excavation safety, confined space entry, work from heights, etc. will be required for specific persons or activities as may be required by JSAs.

L.6.2 Worker Right to Know

As part of the training required under 29 CFR 1910.120 and the Hazard Communication (HAZCOM) standard in 29 CFR 1910.1200, workers shall be familiarized with MSDSs/SDSs and instructed on the terms and concepts that relate to MSDSs/SDSs. Contractors and subcontractors will provide the SSO with a written HAZCOM plan together with all the MSDSs/SDSs for the hazardous products they are using. These plans will meet or exceed the requirements outlined in Company Right to Know Plan. As part of the Site Safety Meetings, the SSO shall review hazardous materials that will be used and the precautions that will be taken when working with these materials. MSDSs/SDSs shall be kept in a binder at the Site for reference by workers.

L.6.3 Emergency Recognition

During the initial Site Orientation Meeting, all employees will be trained to recognize and respond to on-Site emergencies, and to anticipate and avoid hazards discussed in this HASP. Site Action Levels will be discussed during the Site Orientation Meeting so that personnel will understand air monitoring results and the level of hazards they represent.

L.6.4 Physical Hazards

Possible physical hazards will be identified and discussed at the Site Orientation Meeting by the SSO or authorized Company representative. Potential hazards are discussed further in Section L8.3.

L.6.5 Radiation Training

The radiation training requirements are described in Section 2.4 of the RPP (Attachment L-1).

L.6.6 Respiratory Protection

Respiratory protection training is included in the initial 40-hour and 8-hour update training specified in Section L.6.1. The regulations governing respiratory protection can be found in Federal OSHA 29 CFR 1910.134. Site-specific training will be provided for the use of air purifying respirators issued for contaminants of concern, and any supplied air respirators issued for emergency response and/or egress.

L.6.7 Hearing Conservation

Hearing conservation is included in the initial 40-hour and 8-hour refresher training classes required for the hazardous waste operations and emergency response regulation. The regulations governing hearing conservation can be found in 29 CFR 1910.95. To the extent possible, engineering controls will be used to dampen excessive noise. When necessary, personnel will be issued hearing protection to control noise exposure.

L.6.8 Confined Space Entry

Entry into confined spaces is not anticipated for this project. Excavations will not be entered. However, if confined space entry becomes necessary it will be completed using the following guidelines to conduct a confined space entry. General awareness of confined space entry training is provided in the 40-hour initial and 8-hour refresher training programs. However, a detailed confined space entry training program, in accordance with 29 CFR 1910.146 would be required prior to entries into confined spaces. Under no circumstance will employees not specifically trained in confined space safety be permitted to enter a confined space.

L.6.9 Emergency Response Procedures

Each project site will require unique emergency response procedures. All employees will be made aware of the project emergency assistance network and the most probable route of evacuation from a site in the event of an emergency. A minimum of one annual rehearsal of the Emergency Response Procedures will be conducted for each year of site operations.

L.6.10 Documentation of Training

Documentation of training requirements is the responsibility of each employer. Written documentation verifying compliance with the training requirements of this section must be submitted to the SSO prior to entering work areas. Documentation of each worker's current training credentials will be kept in the field office and submitted to regulatory compliance personnel upon request.

L.7 REQUIRED MEETINGS

All site personnel are required to attend a project safety orientation, as well as periodic safety meetings. Safety topics discussed are to be documented accompanied with an attendance signature sheet. Meetings to be conducted are as follows:

Meeting Type	Purpose	Length	Frequency
Project Orientation	To acquaint employees RA scope of work and activities.	Approximately one to four hours.	At time of first assignment to the Project.
Daily Tailgate Meetings	To discuss relevant topics for the day's work.	Approximately 5-10 minutes.	Daily, each work day
Monthly Safety Meeting or Pre-Task review of field work.	To cover specific safety topics; or to review hazards and safety practices, as required	Approximately 10-30 minutes.	Monthly or at the beginning of new field activities, as required

The SSO or designee at each active work site will hold a Tailgate Safety Meeting (also called Toolbox Safety Talks) prior to starting work in the morning or later in the day if conditions change. Safety topics discussed are to be documented accompanied with an attendance signature sheet. The contents of the daily meeting shall include:

- Discussion of work to be done that day or portion of the day
- Anticipated chemical, physical, radiological, ergonomic and biological hazards and controls
- Method(s) of communication and emergency reporting
- Review of materials covered in the orientation as they apply to daily activities
- Employee issues or concerns
- Any site, process and/or task modification or change effecting employee safety and health or the environment

L.8 PROJECT/SITE HAZARDS AND THEIR CONTROL

L.8.1 Site Hazards

Field personnel may be subject to the hazards posed by various activities taking place. This section of the HASP is meant to provide a brief description of the controls that should be taken to prevent injury to employees observing or participating in such tasks. The following types of activities are anticipated on the project:

- Chemical and Radiological Hazards
- Physical Hazards
- Extreme Temperature and Adverse Weather
- Biological Hazards

L.8.2 Chemical and Radiological Hazards

L.8.2.1 Site-Related Chemicals

The primary constituents-of-concern (COCs) identified in site soil include (included in background): arsenic, silica, and uranium and its decay products. Diesel fuel (TPH) impacted soil and bedrock is also present near the surface in the Area North of NECR-1. In addition, respirable dust that may contain these constituents is also included. Table L.8-1 was created from the list of COCs to provide occupational exposure limits, some physical and chemical properties, routes of exposure and signs and symptoms of exposure.

Table L.8-1. Occupational Health Exposure and Toxicological Properties for Contaminants of Occupational Health Concern

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Vapor Pressure (mmHg)	Route of Exposure	Additional Information
ARSENIC (CAS 7440-38-2)	0.005 mg/m^3	0.002 mg/m^3	0.01 mg/m^3	NA	NA	NA	NA	INH, ING, CON, ABS	Ulceration of nasal septum, dermatitis, gastro-intestinal disturbances, peripheral neuropathy, respiratory irritant, hyperpigmentation of the skin, CARCINOGEN.
DUST, TOTAL	15 mg/m^3	NA	NA	NA	NA	Depends on compound	Depends on compound	INH, CON	Nuisance, may cause sneezing or itchy eyes.
DUST, RESPIRABLE	5 mg/m^3	NA	NA	NA	NA	Depends on compound	Depends on compound	INH, CON	Nuisance, may cause sneezing, coughing, or itchy eyes.
DIESEL FUEL	n/a	n/a	100 mg/m^3 or 11 ppm	n/a	n/a	n/a	5	INH, ING, CON, ABS	Irritant to eyes, skin, nose and throat; burning sensation in chest. Headache, nausea, weakness, restlessness, incoherence, confusion, drowsiness, vomiting, diarrhea, dermatitis and chemical pneumonia upon aspiration of the liquid. Representing diesel range organic hits at sites listed.
NAPHTHALENE	10 ppm	10 ppm	10 ppm	15 ppm	250 ppm	8.12	0.08	INH, ING, CON, ABS	Eye irritant; headache; confusion; excitement, malaise, nausea, vomiting, abdominal pain, irritated bladder; profuse sweating; jaundice; renal shutdown; dermatitis.
TOTAL PETROLEUM HYDROCARBONS	300	No REL	300	500	ND	n/a	38-300	INH, CON ING, ABS	Irritant to eyes, mucus membrane, headache, narcosis; dermatitis. Represents the various oils and heavier fuels used that may have impacted the sites.
URANIUM (CAS 7440-61-1)	0.05 mg/m^3	0.05 mg/m^3	0.2 mg/m^3	0.6 mg/m^3	10 mg/m^3	NA	0	INH, ING, CON	Dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]

Table L.8-1 Occupational Health Exposure and Toxicological Properties for Contaminants of Occupational Health Concern

Contaminant	NRC Oral Ingestion ALI (uCi)	NRC Inhalation ALI (uCi)	NRC Inhalation DAC (uCi/ml)	NRC Air Effluent Concentration (uCi/ml)	NRC Water Effluent Concentration (uCi/ml)	Route of Exposure	Additional Information
RADIUM-226	2E+0 (Bone Surface) 5E+0	6E-1	3E-10	9E-13	6E-8	INH, ING, CON	CARCINOGEN
THORIUM-230	4E+0 (Bone Surface) 9E+0	2E-2	6E-12	2E-14	1E-7	INH, ING, CON	CARCINOGEN
URANIUM-238	1E+1 (Bone Surface) 2E+1	1E+0 (Bone Surface) 2E+0	6E-10	3E-12	3E-7	INH, ING, CON	CARCINOGEN
RADON PROGENY	NA	With daughters removed 1E+4 With daughter present 1E+2 (or 4 working level months)	With daughters removed 4E-6 With daughter present 3E-8 (or 0.33 working level)	With daughters removed 1E-8 With daughter present 1E-10	NA	INH	CARCINOGEN

Key:

A1 – ACGIH notation for a confirmed human carcinogen.
ABS – Absorption
ACGIH – American Conference of Governmental Industrial Hygienists
ALI – Annual Limits on Intake
Ca – Carcinogen
Con – Contact
DAC – Derived Air Concentration
IDLH – Immediately Dangerous to Life and Health.
Ing – Ingestion
Inh – Inhalation
LFT – Lowest Feasible Concentration
MG/M3 – Milligrams per Cubic Meter
NIOSH – National Institute for Occupational Safety and Health
NL – Not Listed
NRC – Nuclear Regulatory Commission
OSHA – Occupational Safety and Health Administration
PEL – Permissible Exposure Limit (8-hour TWA)
PPM – Parts per Million
REL – Recommended Exposure Limit
ST- Designated Stel Preceding the Value
STEL- Short-term Exposure Limit (15-minute TWA)
TLV – Threshold Limit Value
TWA – Time-Weighed Average

L.8.2.2 Chemicals Brought to Support Work

During the course of construction, contractors will bring certain chemicals to the site. These may include:

- Fuels: Gasoline, Diesel
- Lubricants and Greases
- Coolants and Anti-freeze
- Dust Control Chemicals
- Alconox®
- Solvents

Safety Data Sheets (SDSs) for these chemicals and any other chemicals used in the course of the work will be kept at the jobsite. All containers must be labeled with the identity of the contents as well as a hazard warning and emergency notices.

L.8.2.3 Radiation Hazards

Since there is a potential for exposure to radiation above background levels, the RPP, describes radiation hazards, safety requirements, training and policies, and the requirement that radiation doses be kept as low as is reasonably achievable (ALARA). Specific radiation safety procedures applicable to the RA are covered in the RPP.

Although unlikely, during the process of removing rock from the Repository cover layer and swales, there is a potential that earthwork on the cover could expose existing tailings. These materials have the potential to be higher in activity levels than material being moved from the Mine Site. In general, tailing can be identified by a light gray color and differs in appearance from the soil cover. If anyone suspects that tailings are exposed during the work process, ALARA principles should be followed and work must stop so the RSO may scan the ground surface in the work area. Material that is confirmed to be tailing must be returned to beneath the existing radon barrier. The work area must then be confirmed by scans that the tailing material has been removed from the surface.

L.8.3 Physical Hazards

L.8.3.1 Vehicle and Earthmoving Equipment

Equipment working in RA area will follow MSHA vehicle general rules. These rules include:

- Use the honking system for moving vehicles and equipment
  - 1 honk – starting engine
  - 2 honks – moving forward
  - 3 honks – moving reverse
- Chock wheels at all times that the vehicle is unattended
- Use of high visibility flags on all motor vehicles

Activities will include the use of earthmoving equipment (equipment). Personnel operating equipment will be trained in accordance with 29 CFR 1926 Subparts H, O, and W. As work plans are developed, JSAs will be completed for all activities involving equipment and job-specific protective measures will be established. Certification records and Competency designations will be maintained for all site operators.

In general:

- Daily and routine equipment inspections must be performed by a competent, trained personnel prior to use. Inspections must be done in accordance with the manufacturer's recommendations.
- Operators must use all manufacturers designated ladders, steps, handholds and access ways to mount and dismount equipment. Three points of contact/control must be maintained, and the equipment should be faced even during dismount.
- Dirt buildup on access supports, ice and foul weather can hamper equipment access. Clear all obstacles during the inspection process.
- No one shall approach a piece of heavy or mobile equipment without first obtaining eye contact, communicating intentions, and receiving a positive signal to approach from the operator.
- Adhere to all designated travel routes and posted traffic signs.
- Ground personnel shall wear a highly visible safety vest (Class 2 or 3) or equivalent type of attire and stay out of the swing radius, footprint, or travel of the moving equipment. Ask operator about blind spots, if unsure.
- Never stand beneath an elevated or suspended load.
- Backup alarms must be functional, whenever activated confirm no one is the backing path of the equipment.

L.8.3.2 Excavating and Trenching

Construction and RA activities will include excavation, which at times may be extensive. All personnel will keep back at least 6 feet from excavation/trench edge greater than 3 feet deep and will avoid movement between the excavation/trench and any equipment or spoils positioned within 10 feet of the excavation/trench.

If work, or entry, in an excavation/trench greater than 4 feet in depth becomes necessary, entry will not be allowed until a relevant JSA is developed and affected employees are trained on safe work practices, egress methods, and emergency procedures by an excavation competent person. The excavation must be inspected by a competent person each shift prior to entry, or after any event that could affect safe entry.

All work involving excavations/trenches will be conducted in accordance with 29 CFR 1926 Subpart P and an excavation plan or JSA will be developed and followed that includes, but is not limited to:

- Designation of a competent person able to classify soils, identify hazards and develop soil stabilization methods and personal protective measures.
- Spoils maintained three feet, or greater, from the edge.
- Utility clearance (both overhead and underground). Hand digging is required within 2 feet of the utility. Manual means must be used to avoid disturbance and/or damage to the utility. All underground and overhead utilities are considered as "live."
- Atmospheric assessment and any necessary protective measures.
- Trench inspection prior to entry by a competent person.
- Vehicle management/safety.
- Highwall/sidewall stabilization method clearly identified.
- Equipment and spoils management.
- Means and method of egress including a ramp, stair, or ladder system with total travel distance limited to 25 feet or less. All ladders must be secured.

- Elevated work requiring fall protection.

L.8.3.3 Elevated Work

Some work activities may involve work on elevated surfaces. All work, where a walking/working surface (horizontal and vertical surface) with an unprotected side or edge which is 6 feet (1.8 m) or more above a lower level, shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems. Workers will be informed on the existing systems as part of site orientation, and systems in place for specific areas/activities will be included in the relevant JSA(s). Any contractor or subcontractor who creates an elevated walking/working surface shall prepare a site specific fall protection plan, prevent exposure to the fall hazard for all other site personnel and protect their workers from fall as specified in 29 CFR 1926 Subpart M.

The fall protection plan for elevated work must include control measures to protect personnel below from falling objects such as barricading, tool tethering, closed tool bag, debris netting, etc.

Workers in mechanical lifts, including scissor lifts, boom trucks, suspended or supported personnel baskets, articulating lifts, and other similar devices must use personal fall arrest at all times.

L.8.3.4 Confined Space

If work or entry into a confined space becomes necessary entry will not be allowed until a confined space entry program is in place, a relevant JSA is developed and affected employees are trained on safe work practices, egress methods, and emergency procedures by a competent person. Work involving confined spaces will be conducted in accordance with 29 CFR 1910.146 and the final entry permit issued by GE/UNC.

L.8.3.5 Ladders and Scaffolding

All ladders employed on site and their use will comply with 29 CFR 1926 Subpart X. JSAs for activities using portable ladders will include the requirement to inspect the ladder(s) prior to use. Contractors and subcontractors using scaffolds will have an SOP detailing their proper erection, use, inspection, and disassembly. The competent person for scaffold erection, pre-shift inspection, and dismantling shall be designated in writing. JSAs for activities using scaffolds shall detail the safe work practices specific to the scaffold type and include the requirement for pre-shift/pre-use inspection.

L.8.3.6 Power and Hand Tools

All hand and power tools and similar equipment shall be inspected prior to use and maintained in a safe condition. When power tools are designed with guards, they will be maintained with guards in place. Any electrical cord or pneumatic hose damaged during operation will be replaced as specified by the manufacturer, damaged tools will be removed from service and tagged out for further use until all necessary repairs are made. Wherever power or hand tools are used, their safe use, care, and limitations will be addressed in relevant JSAs. All contractors using power and hand tools will integrate procedures and policies compliant with 29 CFR 1926 Subpart I into their CSHP and JSAs.

All hand-held power tools must be equipped with a constant pressure switches that will automatically shut off the power when the trigger is released. Hand-held power tools with on/off or lock-on switches are not to be used.

Air hoses must be secured at the couplings by means of a pin, clip or other hose whip prevention device.

Powder actuated tools require certified operators, area signage, the affected area cleared of personnel, and proper disposal of un-exploded charges.

L.8.3.7 Electrical Hazards

All equipment used at NECR and methods of use, as well as all electrical wiring will comply with 29 CFR 1926 Subpart K. Only qualified personnel will access electrical switchboards and panelboards. Contractors and subcontractors using temporary switchboards and/or panelboards will provide methods for compliance with 29 CFR 1926.404 and 29 CFR 1926.405 as part of their HASP and include provisions for routine inspections of the systems. All electrical service installations shall be assessed and appropriately managed for possible arc flash hazards.

L.8.3.8 Underground Utilities or Buried Materials

Ground disturbance (digging, drilling, excavation, etc.) outside the mine waste disturbance requires underground utilities and buried materials clearance. Clearance processes must be included in both the work plan and the JSA, including the process to confirm completion prior to work start.

L.8.3.9 Overhead Power Lines

Overhead power lines are present at NECR. Additionally, as work progresses the existence and locations of overhead power lines may change. For any work with vehicle/equipment over 8 feet in height and for any construction, the work plan and all supporting JSAs must include provisions for the identification, demarcation, and clearance of power lines as prescribed in 26 CFR 1926 Subparts L, N, and V.

L.8.3.10 Steep Slopes and Tripping Hazards

The Site is situated in mountainous and wooded terrain. Proper footwear and clothing will protect against minor abrasions (Level D PPE is required on site), but will not protect against slips, trips, or falls. Walking routes should be selected to avoid steep slopes. Work in remote and/or rugged terrain should not be conducted alone.

L.8.3.11 Slips, Trips, and Falls

Slips, trips and falls cause a high percentage of injuries and recordable accidents at construction and reclamation sites. Rocky, uneven, steep, and often wet terrain may be encountered during the removal project.

The risks of such accidents can be minimized by wearing proper footwear for the task and being aware of the physical conditions at the site. When walking from one location to another at a removal site, the worker must check the footing, muddy or slick conditions, steep slopes, uneven surfaces, and other potential hazards.

L.8.4 Extreme Temperatures and Adverse Weather Conditions

L.8.4.1 Cold Stress

This section describes situations where cold stress is likely to occur and discusses procedures for the prevention and treatment of cold-related injuries and illnesses. Cold conditions may present health risks to employees during field activities. The three primary factors that influence the risk potential for cold stress are moisture, temperature and wind velocity. Other factors that increase susceptibility to cold stress, include age (very young or old), smoking, alcohol consumption, fatigue, and wet clothing. Hypothermia can occur at temperatures above freezing if the individual has on wet or damp clothing or is immersed in cold water. The combined effect of temperature and wind can be evaluated using a wind chill index as shown in Table L.8-2.

Bare flesh and body extremities that have high surface area-to-volume ratios such as fingers, toes and ears are most susceptible to wind chill or extremely low ambient temperatures. Because cold stress can create the potential for serious injury or death, employees must be familiar with the signs and symptoms and various treatments for each form of cold stress. Table L.8-3 provides information on frostbite and hypothermia, the two most common forms of cold-related injuries.

Table L.8-2 – Cooling Power of Wind on Exposed Flesh Expressed as an Equivalent Temperature

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Chill Temperature (°F)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(Wind speeds greater than 40 mph have little additional effect).	LITTLE DANGER in less than 1 hour with dry skin; maximum danger from false sense of security				INCREASING DANGER from freezing of exposed flesh within 1 minute			GREAT DANGER that flesh may freeze within 30 seconds				

Source: Modified from American Conference of Governmental Industrial Hygienists. 1997. "Threshold Limit Values for Chemical Substances and Physical Agents."

Table L.8-3 – Cold Stress Conditions

Condition	Causes	Signs and Symptoms	Treatment
Frostbite	Freezing of body tissue, usually the nose, ears, chin, cheeks, fingers, or toes	Pain in affected area that later goes away Area feels cold and numb Incipient frostbite (frostnip) – skin is blanched or whitened and feels hard on the surface Moderate frostbite – large blisters Deep frostbite – tissues are cold, pale and hard	Move affected worker to a warm area Immerse affected body part in warm (100 to 105 °F) water – not hot! Handle affected area gently; do not rub After warming, bandage loosely and seek immediate medical treatment
Hypothermia	Exposure to freezing or rapidly dropping temperatures	Shivering, dizziness, numbness, weakness, impaired judgment, and impaired vision Apathy, listlessness, or sleepiness Loss of consciousness Decreased pulse and breathing rates	Immediately move affected person to warm area Remove all wet clothing and redress with loose, dry clothes Provide warm, sweet drinks or soup (only if conscious) Seek immediate medical treatment

When working in cold environments, specific steps should be taken to lessen the chances of cold-related injuries. These include the following:

- Protecting exposed skin surfaces with appropriate clothing (such as face masks, hand wear, and footwear) that insulates, stays dry, and blocks wind.
- Shielding the work area with windbreaks to reduce the cooling effects of the wind.

- Providing equipment for keeping workers' hands warm by including warm air jets and radiant heaters in addition to insulated gloves.
- Using adequate insulating clothing to maintain a body core temperature of above 36 °C/96.8 °F.
- Providing extra insulating clothing on site.
- Reducing the duration of exposure to cold.
- Changing wet or damp clothing as soon as possible.

L.8.4.2 Heat Stress

This section describes situations where heat stress is likely to occur and provides procedures for the prevention and treatment of heat-related injuries and illnesses. Wearing PPE, especially during warm weather, puts employees at considerable risk of developing heat-related illness. Health effects from heat stress may range from transient heat fatigue or rashes to serious illness or death.

Many factors contribute to heat stress, including PPE, ambient temperature and humidity, workload, and the physical condition of the employee, as well as predisposing medical conditions. However, the primary factors are elevated ambient temperatures in combination with fluid loss. Because heat stress is one of the more common health concerns that may be encountered during field activities, employees must be familiar with the signs, symptoms, and various treatment methods of each form of heat stress. Heat stroke is the most serious heat-related illness – it is a threat to life and has a 20 percent mortality rate. Direct exposure to sun, poor air circulation, poor physical condition, and advanced age directly affect the tendency to heat stroke. Table L.8-4 lists the most serious heat conditions, their causes, signs and symptoms, and treatment.

Table L.8-4 – Heat Stress Conditions

Condition	Causes	Signs and Symptoms	Treatment
Heat cramps	Fluid loss and electrolyte imbalance from dehydration	Painful muscle cramps, especially in legs and abdomen Faintness Profuse perspiration	Move affected worker to a cool location Provide sips of liquid such as Gatorade® Stretch cramped muscles Transport affected worker to hospital if condition worsens
Heat Exhaustion	Blood transport to skin to dissipate excessive body heat, resulting in blood pooling in the skin with inadequate return to the heart	Weak pulse Rapid and shallow breathing General weakness Pale, clammy skin Profuse perspiration Dizziness Unconsciousness	Move affected worker to cool area Remove as much clothing as possible Provide sips of liquid such as Gatorade® (only if conscious) Fan the person but do not overcool or chill Treat for shock Transport to hospital if condition worsens
Heat Stroke	Life threatening condition from profound disturbance of body's heat-regulating mechanism	Dry, hot and flushed skin Constricted pupils Early loss of consciousness Rapid pulse Deep breathing at first, and then shallow breathing Muscle twitching leading to convulsions Body temperature reaching 105 or 106 °F or higher	Immediately transport victim to medical plant Move victim to cool area Remove as much clothing as possible Reduce body heat promptly by dousing with water or wrapping in wet cloth Place ice packs under arms, around neck, at ankles, and wherever blood vessels are close to skin surface Protect patient during convulsions

When working in hot environments, specific steps should be taken to lessen the chances of heat-related illnesses. These include the following:

- Ensuring that all employees drink plenty of fluids (Gatorade® or its equivalent) – note eating and drinking should only occur in designated areas as (see Section L5.7)
- Ensuring that frequent breaks are scheduled so overheating does not occur
- Revising work schedules, when necessary, to take advantage of the cooler parts of the day

L.8.4.3 Adverse Weather Conditions

The primary concern with regard to adverse weather is electrical storms. Outdoor work must be halted during electrical storms and workers will seek shelter either in vehicles or NECR buildings as appropriate. Individuals working outdoors must be aware of changing weather conditions. Electrical storms may occur suddenly and without much warning. A significant concern with adverse weather is flash flooding, especially associated with the Pipeline Arroyo, haul road crossing, and borrow area excavation and construction. Work in these areas should be halted in the event of a possible flood, and workers should move to higher ground.

L.8.5 Biological Hazards

Biological hazards are likely to be encountered during environmental sampling activities and occasionally during routine Site operations. Biological hazards include:

- Animals (rodents, coyotes, deer, etc.)
- Insects
- Reptiles (snakes and gila monsters)
- Poisonous plants
- Bacteria and viruses

L.8.5.1 Animals

Workers will be instructed to avoid approaching wild animals or unfamiliar domestic animals. Small mammals may carry rabies and other viruses. Animal bites must be reported to the SSO or PSO immediately. Workers should seek shelter in a nearby vehicle or building when potentially dangerous wildlife is observed (e.g., bear, mountain lion) and remain in a safe location until the wildlife have left the area.

L.8.5.2 Insects, Spiders and Scorpions

Workers will wear insect repellant while in areas where insects are likely to be a problem. Any worker with a particular allergy to bee stings or other insect bites will be required to obtain instructions and proper medication from his or her personal physician and must make that condition known to the Site SSO.

Black widow spiders are prevalent at the Site. Workers need to be especially careful in turning over rocks. Black widow spiders tend to get into clothing, as a result the unwary person could be bitten. Workers should carefully check clothing and shoes before donning them and frequently during the work period to be sure there are no unwanted creatures clinging to them. All spider bites will be reported to the SSO or PSO immediately and documented accordingly.

Scorpions may be present at the Site. As with spiders, workers should be careful when turning over rocks. Workers should check shoes and clothes before putting them on, as scorpions tend to be small and can get into clothing. Most scorpion stings do not require treatment; however, all scorpion stings will be reported to the SSO or PSO immediately and documented accordingly.

L.8.5.3 Reptiles: Snakes and Gila Monsters

Snake bites can occur when snakes are inadvertently disturbed when stepping on or near them or when turning over rocks. Workers will be instructed to look before placing their hands in an area where snakes may be present, e.g., rock crevices, and to be aware when walking through vegetated areas. Snake bites must be reported to the SSO or PSO immediately and medical evaluation obtained. In the event that the snake is suspected to be venomous, call 911 immediately. While awaiting medical assistance, move the person away from the snake and have them lie down with the bite site below their heart. Keep the person calm and still, while covering the wound with a loose, sterile bandage.

Gila monsters are large venomous lizards that are distinguished from the non-venomous Mexican beaded lizard by coral-like patterns on their skin. While typically reserved, they will attack if provoked. Workers should keep a safe distance away if a Gila monster is encountered. In the event of an attack, Gila monsters are known to clamp down on the victim which can last several minutes and is extremely painful. Removal of the lizard is first priority and should be done by prying the jaw open with a strong stick while making sure the lizard is on solid ground. Gila monster bites are almost never fatal, however medical assistance should be sought in order to clean the wound and inspect for broken teeth. Poisonous Plants

Workers shall be aware of poisonous plants (e.g., poison ivy) that may be indigenous to the area where environmental sampling will take place. Long-sleeved shirts and long pants should be worn when sampling in areas where such plants have been observed or are known to be present. Ivy-wipes or similar products should be on-hand for on-site exposures.

L.8.5.4 Bacteria and Viruses

Proper personal hygiene will prevent most work-related infections. Care should be taken in structures where rodents may be or have been present. Rodent feces and urine may contain the hanta virus. If such structures are to be entered and dust generated, the areas should be sprayed with a 10 percent Clorox® solution prior to work being performed.

Bubonic plague is extremely rare; however, several cases have been documented in western states in the last few years. The plague can be contracted from a flea bite or fluids from animals (squirrels, chipmunks, other rodents) that are infected with the disease. In order to reduce the risk of the plague, workers should never feed rodents, avoid close proximity to rodent burrows and excrement, wear long pants, and use insect repellent.

L.8.6 The Buddy System

The “buddy” system will be used at all times when employees are within an exclusion or contamination reduction area. The “buddy” system is a method of organizing work groups so that there is someone that is always available to:

- Provide his or her partner with assistance in an emergency
- Observe his or her partner for signs of chemical or physical exposure
- Periodically check the integrity of his or her partner’s PPE
- Notify the emergency response personnel when an emergency situation occurs

The “buddy” system usually requires that two or more people work within visual range from one another. However, the “buddy” system can include radio contact if site conditions are such that a person could otherwise work alone. In order to deviate from the “buddy” system, an explanation of the specific task to be completed is required, along with a procedure for assuring that single person work parties are safe. Any deviations from the “buddy” system as it is described here will be presented.

L.8.7 Site Work Areas

During execution of the RA, the Mine and Mill sites will be organized into work areas using the following terms and definitions:

- Support: Area(s) free of contamination.
- Controlled: Area(s) with potential contamination.
- Exclusion: Area(s) with contamination subject to the RA (Mine Site and Repository).
- Decontamination Area: The transition area between the Controlled area and the Support Area. This is where personnel enter and exit the Controlled Area and where most decontamination activities take place.

These areas and the facilities they contain are discussed in Appendix B of the 95% Design Report and shown on the Section 2 Drawings.

L.8.7.1 Exclusion Area and Controlled Area

The Exclusion Area and the Controlled Area are work areas where contamination or potential contamination exists. Because this area has the potential for workers to be exposed to contaminants, all field staff entering this area will wear the appropriate PPE and adhere to the training and medical surveillance requirements presented in this document.

L.8.7.2 Decontamination Area

Initially, the decontamination area will be considered to be an unimpacted area. As operations proceed, the area around the decontamination station may become contaminated, but to a much lesser degree than the exclusion area. Personnel assisting with decontamination will wear a level of PPE at or one below that used by personnel in the exclusion area.

Decontamination procedures are discussed in Appendix M of the 95% Design Report.

L.8.7.3 Emergency Decontamination

Emergency decontamination of site personnel may be necessary for medical reasons or in the event of major contamination by contact with contaminated material. Emergency procedures will include:

- Assistance by on-site personnel for removal of contaminated protective clothing.
- If the employee is injured and cannot be moved, attempts will be made to cut away any contaminated clothing for removal.
- If the situation is life-threatening, decontamination or removal of protective clothing must still be considered. Many hospital emergency rooms and ambulance services will not risk putting the facility out of service due to decontamination issues. Thus, in order to minimize the spread of contaminants, contaminated personnel will be wrapped in blankets and/or plastic sheeting (maintaining an open airway) during transport to the emergency treatment facility. Emergency personnel will be notified of the nature of the contaminated material so that necessary protective measures can be taken by emergency personnel.
- If the employee can walk or be moved without injury, all affected skin areas should be washed thoroughly with soapy water and rinsed.
- Equipment will be disposed in appropriate collection containers.

L.8.7.4 Support Area

The support area, the outermost part of the regulated area, is free from recognized site hazards. Support equipment such as a command post, site vehicles, and paperwork stations will be located in this area. Since normal work attire is appropriate within this area, potentially contaminated personal protective clothing, equipment and un-containerized samples will not be permitted.

L.8.7.5 Traffic Control and Site Security

Traffic control and site security are discussed in Appendix M of the 95% Design Report.

L.8.7.6 Communication Systems

Two general types of communications systems should be available for all workers assigned to field projects. One system will ensure adequate communication between site personnel, and the other will ensure the ability to contact personnel and emergency assistance off the site. On-site communications are generally audible and/or visual. Off-site or communications among several sites at one project location or property is usually accomplished with electronic devices, such as radios or cell phones. Any deviations from these standard modes of communication must be pre-arranged.

Common types of internal communications include conversation, noisemakers (horns, bells) or hand signals. The common hand signals are provided below:

Signal	Interpretation
Hand gripping throat	Respiration problems, can't breathe
Grip team member's wrist or place both hands around waist	Leave site immediately; no debate!
Thumbs up	OK, I'm all right; I understand
Thumbs down	No, negative
Hands on face	Put on respirator

L.9 PERSONAL PROTECTIVE EQUIPMENT

Work conducted as part of a HAZWOPER program must meet a minimum level of personal protection. OSHA and the USEPA have identified standard levels of PPE; a description of USEPA Levels A, B, C and D are provided in the following sections. This section indicates the specific PPE ensembles for work at the site.

The proper selection, fit-testing, use, maintenance, disposal and limitations of each piece of PPE shall be reviewed during the training programs described in Section 4. These training topics should be reviewed periodically during tailgate safety meetings. All respiratory protective equipment, APR or supplied air respirators shall be National Institute for Occupational Safety and Health (NIOSH) approved. All footwear, hard hats and safety glasses/goggles shall be ANSI approved. There is no longer an OSHA prohibition for the use of contact lenses with respiratory protective devices. Individuals who feel that the contact lens provides them superior vision and comfort may use them on-site and with respirators.

All of the work conducted at the site is anticipated to be completed in Level D PPE. Level C PPE information is provided herein in the event that site conditions warrant upgrade. It is anticipated that Level C could be required if radiation protection monitoring reveals that engineering and administrative controls are not adequate in reducing exposures to radiological hazards (e.g., airborne radiological particulate).

The standard PPE ensemble for work is Level D as specified below. Tasks with a deviation from the standard are listed in the table, with only the changed information. If a sign posted by the SSO indicates that a piece of PPE is needed, obey the posted sign regardless of what the task is, or the table below indicates.

L.9.1 Standard Level D PPE

The following items must be available for use during all field programs. Individual items may not be necessary if the hazard is not present (e.g., no overhead machinery or hazards means no hard hat required, unless posted signs state the area as hard hat required, or moving heavy equipment is present). It is acceptable when exposures above occupational exposure limits are not anticipated, immersion or engulfment is not expected, and the atmosphere contains between 19.5 and 22 percent oxygen. The standard Level D PPE ensemble includes:

Item	Description
Boots	Safety-toed work boots (meeting ASTM F2413 specifications or equivalent)
Clothing	Work clothing includes long pants, long sleeve shirts, or coverall. Can be cotton, poly-cotton blend or Tyvek. A high visibility safety vest must also be worn.
Gloves	Gloves appropriate for the hazard present shall be worn at all times while working in the field. Gloves will be selected based on the hazards present. Thin nitrile gloves (e.g., N-Dex) might be appropriate when handling potentially contaminated soil, water, debris, equipment or articles while heavy work or cut resistant gloves would be more appropriate for handling sharp objects or when using a sharp cutting tool.
Safety glasses	ANSI Z87.1 compliant with rigid side shields (plain or sun glass tint depending on brightness). Safety goggles may be worn over non-safety prescription eyewear. Face shields must be worn in addition to safety glasses where chemical splash or flying material or debris hazards exist.
Hard hat	When overhead hazards exist or working around heavy equipment (ANSI Z89.1).
Safety vest	High-visibility reflective safety apparel/vest when working in roadways or around moving heavy equipment. (ANSI/ISEA 107 Class 2 or equivalent)
Hearing protection	When working in areas where noise levels exceed 85 decibels on the “A” weighted scale (dBA). If unsure, have the task or area tested. A rule of thumb is having to shout to be heard at a distance of 3 feet. Double hearing protection required at 105 dBA.

The only recognized modified Level D PPE ensemble is a standard Level D ensemble changed to accommodate radiological hazards.

L.9.2 Standard Level C PPE

In the event that air monitoring indicates the need to upgrade into Level C PPE, additions shall be made to the existing standard Level D PPE ensemble. An air purifying respirator (APR), either half-face or full-face, with either a dust filter (any N, R, or P series filter) or high efficiency particulate air (HEPA) filter, now referred to as P100, will be worn. The P100 cartridges shall be pink or magenta and shall be changed at the end of every shift. Double gloves with thin Nitrile under thick Nitrile will be worn and taped to the sleeves of a disposable coverall. Either boot covers, with substantial tread, or PVC or rubber steel-toed boots will be worn, taped to a disposal coverall. Tyvek coveralls, or equivalent, will be worn.

Item	Description
Boots	Steel-toed work boots or steel toed rubber or polyvinyl chloride (PVC) boots meeting ANSI or ASTM specifications.
Clothing	Chemical resistant coveralls as specified in Section 7.5. Cuffs duct-taped to hand and foot protection.
Gloves	Inner and outer chemical resistant gloves as specified in Section 7.5 to be used with work gloves and cut resistant gloves.
Safety glasses	Safety glasses with side shields or goggles (ANSI Z87.1). Faceshield over safety glasses or goggles, when saw cutting, working with pressure devices or when splash is likely. If corrective lenses are needed when wearing a full-face APR, brand-specific inserts must be purchased in advance.
Hard hat	When overhead hazard or working around heavy equipment (ANSI Z89.1).
Safety vest	Brightly colored traffic-type safety vest when working in roadways or around moving heavy equipment.
Hearing protection	When working in areas where noise levels exceed 85 decibels on the “A” weighted scale (dBA). If unsure, have the task or area tested. A rule of thumb is having to shout to be heard at a distance of 3 feet.

Individual items may not be necessary if the hazard is not present (e.g., no overhead machinery or hazards means no hard hat required, unless posted signs state the area as hard hat required, or moving heavy equipment is present). It is acceptable when exposures above occupational exposure limits are not anticipated, immersion or engulfment is not expected, and the atmosphere contains between 19.5 and 22 percent oxygen.

L.9.3 Standard Level B PPE

Level B is not permitted under this HASP. Should Level B conditions arise, work shall stop and an amendment to this HASP will be developed to adequately address the increased hazards, protective gear and site personnel.

L.9.4 Standard Level A PPE

Level A is not permitted under this HASP. Should Level A conditions arise, work shall stop and an amendment to this HASP will be developed to adequately address the increased hazards, protective gear and site personnel.

L.10 MEDICAL SURVEILLANCE

All personnel entering the Exclusion Area as defined in this HASP must be actively participating in a medical surveillance program tailored to hazardous waste operations, respiratory protection, hearing conservation and any site-specific substance-specific standards (e.g., radiation). The medical surveillance program includes the following types of examinations:

- Initial, prior to hazardous waste site activities
- Periodic, usually annually, bi-annually for people in the field less than 30 days per year
- Upon termination
- Following exposure or injury
- Additionally, as necessary, on a case-specific basis

Prior to work start-up, an emergency medical assistance network will be established. The Fire Department, ambulance service, and clinic or hospital emergency room are identified in Section 10 of this HASP. A vehicle shall be available on site during all work activities to transport injured personnel to the identified emergency medical facility if an ambulance is clearly not needed.

Medical surveillance specific to radiation (e.g. thermoluminescent dosimeters) is described in the RPP (Attachment L-1).

L.11 EMERGENCY CONTACT INFORMATION

L.11.1 Always Provide Your Exact Location to a 911 Operator

The SM, or designee, will be responsible for taking necessary action and contacting the appropriate emergency contacts in the event of an emergency. The following are contacts for emergencies that may occur during fieldwork activities at NECR.

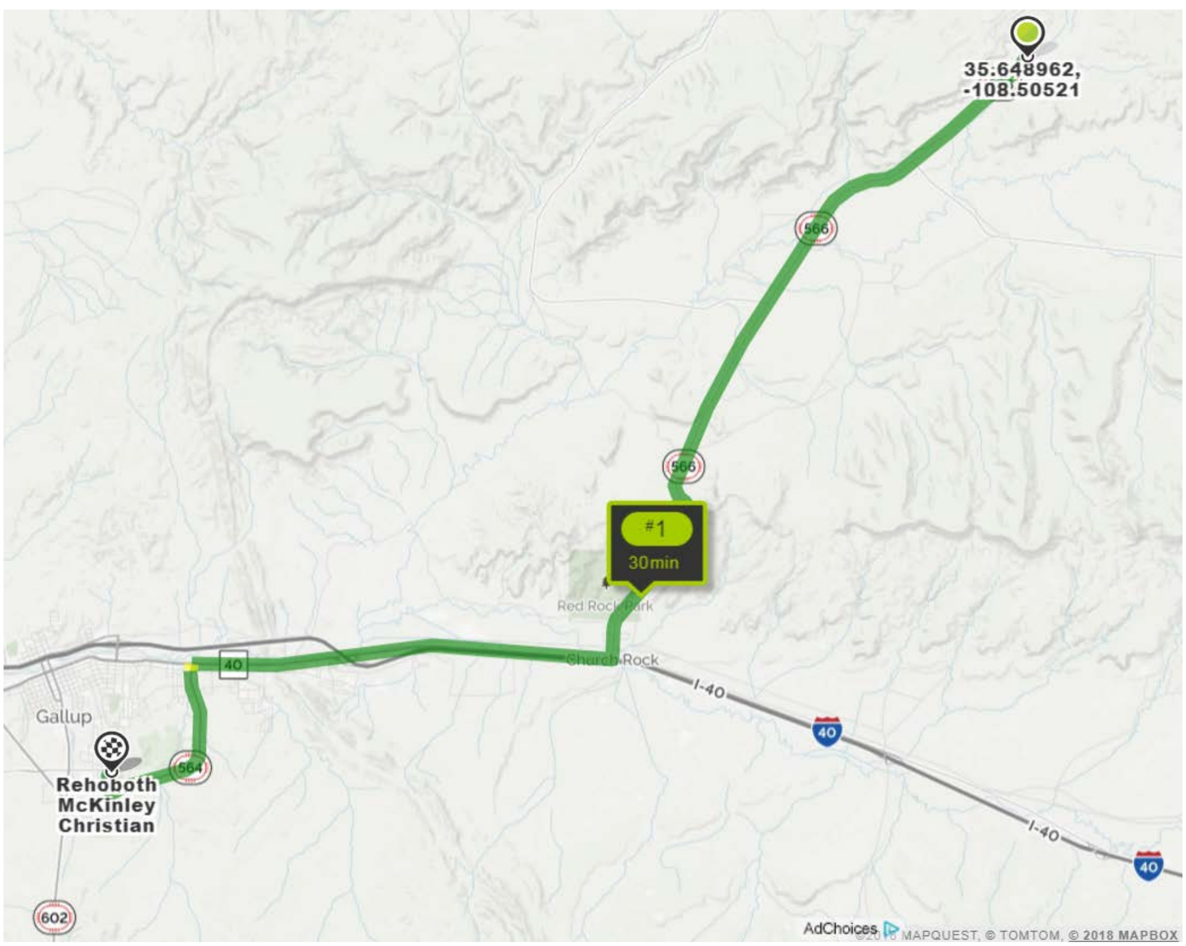
L.11.2 Site-Specific Information

Site Location
Northeast Church Rock Mine Site
McKinley County, New Mexico
State HWY 566, 16 miles NE of Gallup, NM, End of State Hwy 566 and Red Water Pond Road

L.11.3 24-Hour Emergency Hospital

Rehoboth – McKinley Christian Hospital
1901 Red Rock Dr.
Gallup, NM 87301
Phone: (505) 863-7000

Directions: Drive southwest on State Highway 566 and turn RIGHT onto NM-118/ROUTE 66. Continue to follow NM-118, turn LEFT onto S BOARDMAN AVE/NM-564, turn RIGHT onto COLLEGE DR, turn RIGHT onto HOSPITAL DR, and turn RIGHT onto REDROCK DR



Contractor Personnel Contact List

Position	Name	Phone Number(s)
GE/UNC Project Manager	TBD	
Site Manager	TBD	
CSC On-site Representative	TBD	
Construction Superintendent (CS)	TBD	
Site Safety Officer (SSO)	TBD	
Project Safety Officer (PSO)	TBD	
Radiation Safety Officer (RSO)	TBD	
UNC Local Representative		
UNC Project Manager		

L.11.4 24-Hour Emergency

Emergency Contact Numbers	
Ambulance	911
Fire Department	911
Police Department	911
Poison Control	(800) 222-1222
National Response Center	(800) 424-8802
Utilities Underground Service Alert	(800) 321-2537 or (505) 260-1990
OSHA Regional Center	(800) 321-6742
MWHA Workers' Compensation Insurance, Auto Accident, or Incident Reporting Information	(866) 469-4456 / 24-hour number

L.12 REFERENCES

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

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

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

U.S. Department of Health and Human Services (USDHHS), NIOSH, OSHA, and USCG, 1985. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.* 1985.

ATTACHMENT L-1

RADIATION PROTECTION PLAN

Northeast Church Rock Mine Site Removal Action

Attachment L-1

Radiation Protection Plan

This page intentionally left blank

TABLE OF CONTENTS

ATTACHMENTS

LIST OF ACRONYMS

ALARA	As Low As Reasonably Achievable
ALI	Annual Limits on Intake
CC	Construction Contractor
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
cm	centimeters
cpm	counts per minute
DAC	Derived Air Concentration
DDE	Deep Dose Equivalent
dpm	disintegrations per minute
EDE	Effective Dose Equivalent
gm	gram
HASP	Health and Safety Plan
hr	hour
ICRP	International Committee on Radiation Protection
LLD	Lower Limits of Detection
lpm	liters per minute
MDA	minimum detectable activity
MDC	Minimum Detectable Concentration
ml	milliliter
mm	millimeter
mrem	millirem
Mill Site	Northeast Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NECR	Northeast Church Rock
NIST	National Institute of Standards and Technology
NMAC	New Mexico Administrative Code
NRC	U.S. Nuclear Regulatory Commission
NMED	New Mexico Environmental Department
OSHA	Occupational Safety and Health Administration
pCi	picocuries

PPE	personal protective equipment
RA	Removal Action
RPP	Radiation Protection Program
RSO	Radiation Safety Officer
SOP	Standard Operating Procedure
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminscent Dosimeter
µCi	microcuries per milliliter
µR	micro Roentgen

1.0 INTRODUCTION

This section describes the Radiation Protection Program (RPP) that will be implemented to provide radiation protection to workers, the general public, and the environment during the Removal Action (RA) associated with removing and transporting uranium ore impacted soil at the Northeast Church Rock Mine Site (Mine Site) to the repository at the Church Rock Mill Site (Mill Site). Although the mine waste from the Mine Site will be disposed of in the Repository on top of the Tailings Impoundment, the disposal activities will not involve handling any byproduct material (tailings) during the RA. The Repository will be above the existing tailings radon barrier cover; that radon barrier cover will be scarified and compacted during the RA activities. This RPP complies with the Occupational Safety and Health Administration (OSHA) requirements 29 CFR 1910.1096 for exposure to ionizing radiation, which is based on US Nuclear Regulatory Commission's (NRC's) regulations of 10 CFR 20 (*Standards for Protection Against Radiation*) and New Mexico Administrative Code (NMAC) 20.3.4 (*Standards for Protection Against Radiation*). The RPP includes necessary radiation safety training, organization and responsibilities; occupational health physics monitoring for internal and external exposure assessment; and administrative and engineering exposure control measures and protection.

1.1 Radiation Safety Organization

The RPP will be implemented under the guidance of a radiation safety officer (RSO) for the Northeast Church Rock (NECR) and UNC Mill Sites. The RSO, or his site designee, will implement this plan and have the authority to stop work should radiation safety concerns arise. All employees, contractors, and visitors to the NECR Site will adhere to the RPP. All individuals involved with the construction work or other related activities onsite have responsibility for radiation safety. The RSO or his designee will have the primary responsibility for overseeing and implementing the RPP.

Supervisory personnel for GE/UNC: The Site Manager (SM), the Construction Supervising Contractor (CSC), and the Construction Contractor (CC), and any subcontractors used for the work have an important role in the radiation protection of their subordinates or other personnel working on site. The supervisory personnel will be responsible for ensuring that their subordinates and other personnel working for the CC are supplied with required radiation training and personal protective equipment. They shall ensure that the personnel under their supervision follow the rules and regulations of the RPP. Supervisors are also responsible for knowing the radiation hazard conditions and the need for radiation personal protective equipment (PPE) through necessary communications with the radiological staff. All individuals, including supervisors, working in the Exclusion or Controlled areas will be trained for radiation hazards and radiation safety. The CC's supervisors will immediately notify the RSO of any radiation hazardous condition observed by or reported to the contractors.

1.2 Worker Training

All workers in potentially impacted areas will attend a radiation safety training program. Emphasis will be placed on site-specific activities and radiological safety practices, including personal decontamination. The RSO will retain documentation of the training. The radiation safety training will include:

- General History and Site Overview
- Regulatory Overview
- Fundamentals of Radiological Protection
- Biological Effects
- Radiation Limits
- As Low As Reasonably Achievable (ALARA)
- Personnel Monitoring Program
- Radioactive Contamination Control

- Radiological Postings and Site Control
- Emergency Procedures

Site safety personnel also will conduct brief daily tailgate safety meetings (see Section L.7.1 of the Health and Safety Plan [HASP]) to discuss any safety issues that may concern onsite workers or the Radiation Safety Officer (RSO).

1.3 Standard Operating Procedures

Standard operating procedures (SOPs) for performing all major tasks associated with this plan have been developed and are attached to this plan. Major tasks include radiation surveys, airborne radioactivity measurements, respiratory protection, contamination control, equipment decontamination, access/egress control. The SOPs will be maintained onsite during the construction activities and revised as necessary.

1.4 As Low as Reasonably Achievable Policy

The project team is committed to keeping individual and collective radiation doses to ALARA levels and supports an administrative organization for radiation safety. The RPP will utilize, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are ALARA. The Site RSO will assess the radiation protection plan monthly. The RSO will review operating and maintenance procedures and equipment and facilities to reduce exposures to ALARA. In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals will also be maintained at the lowest practicable level.

2.0 RADIATION DOSE LIMITS

The radiological hazard from uranium ore dust is from uranium and its decay products. The uranium ore presents a potential for exposure due to internal radiation hazards from alpha emitting radionuclides (U-nat, Ra-226, Th-230, and Rn-222 progeny) and external radiation hazards from gamma emitting radionuclides (primarily Pb-214 and Bi-214).

2.1 Occupational Dose Limits

The dose limits from occupational exposure to radiation at the Site are listed below.

a. The annual limit is the more limiting of:
    1. The total effective dose equivalent equal to 5 rems; or
    2. The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems.
b. The annual limits to the lens of the eye and to the skin are:
    1. An eye dose equivalent of 15 rems; and
    2. A shallow-dose equivalent of 50 rems to the skin or to any extremity.

2.2 Dose Limit to an Embryo/Fetus

The radiation dose limit to an embryo/fetus during entire pregnancy, due to occupational exposure of a declared pregnant woman, will be 0.5 rem (500 mrem). All female workers will be required to notify the RSO, in writing, of their pregnancy immediately upon knowledge or suspicion of such pregnancy. The RSO will review work assignments of any declared pregnant woman to assure that the embryo/fetus dose does not exceed the 0.5 rem limit and is maintained ALARA. If the dose equivalent to the embryo/fetus is found to have exceeded 0.5 rem (500 mrem) or is within 0.05 rem (50 mrem) of this dose, by the time the woman declares the pregnancy, the dose will be deemed to be in compliance with paragraph (a) of this section if the additional dose equivalent to the embryo/fetus does not exceed 0.05 rem (50 mrem) during the remainder of the pregnancy.

2.3 Planned Special Exposures

Due to low levels of radioactivity associated with the uranium ore, planned special exposures will not be authorized at the Site.

2.4 Summation of External and Internal Doses

Summation of external and internal doses as specified in 10 CFR 20 and NMAC 20.3.4.406 is not likely to be required at the Site, because the doses from either the external or internal radiation exposures are not likely to exceed 10 percent of the limit. The construction activities at the Site involve excavation or disturbance of uranium ore impacted soil and material. Based on the site data from previous investigations and RA activities, it is very unlikely, with appropriate administrative and engineering controls, that during the construction activities any individual will receive an external radiation dose in excess of 10 percent of the limits, or an intake of radionuclides in excess of 10 percent of Annual Limits on Intake (ALIs) for uranium and its daughters. However, if surveys indicate that both the internal and external doses are likely to exceed 10 percent of the limit, one of the two methods will be used to demonstrate compliance with the limits:

- Summation of Internal and External Doses - If it is determined that both the internal radiation dose from air sampling measurements, and the external radiation dose from personal dosimeters, is likely to exceed 10 percent of the limit, the Committed Effective Dose Equivalent (CEDE) and Deep Dose Equivalent (DDE) will be summed. This will demonstrate compliance with Total Effective Dose Equivalent (TEDE). The internal radiation dose will be calculated as described in Section 5.0, and the external radiation dose will be assessed as described in Section 6.0.
- Summation of External Dose and DAC Hours - If routine air sampling and thermoluminescent dosimeter (TLD)

results indicate that the dose from either internal or external radiation exposure could exceed 10 percent of the limit, the summation requirements of internal and external radiation doses will be met. Compliance with this summation will be met if the sum of the DDE (mrem, as determined by personal dosimeters) divided by 5000 (mrem, TEDE) and the total number of Derived Air Concentration (DAC) hours for all radionuclides (as determined in Section 6.1) divided by 2000 does not exceed one. Based on average Ra-226 soil concentrations and average external radiation exposure rates, exposures are expected to be less than 10 percent of the limit for both external and internal exposures with adequate dust control during construction activities.

2.5 Determination of Prior Occupational Dose

If any individual at the NECR Site is likely to receive, in one year, an occupational dose in excess of 10 percent of the limit in Section 5.0, the RSO will determine the individual's prior occupational dose as follows:

- A determination will be made based on information on the nature and the amount of prior occupational dose disclosed in a signed statement from the individual, or from the individual's most recent employer, for work involving radiation exposure for the current year.
- An attempt will be made to obtain the records of life-time cumulative occupational radiation.

2.6 Radiation Dose Limits for Individual Members of the Public

The dose limits for individual members of the public will be consistent with NMAC 20.3.4.413 as follows:

- Total effective dose equivalent of 0.1 rem (100 mrem) per year to individual members of the public, exclusive of the dose contributions from background radiation; and
- Maximum dose rate of 0.002 rem/hour and 0.05 rem per/year in the unrestricted area from external radiation sources.

If any member of the public enters any controlled area, which is located outside the Exclusion Area, the above dose limits will apply.

3.0 SITE CONTROL

Site control is necessary to prevent unauthorized, untrained, or unprotected personnel from entering the site. Areas where construction activities associated with uranium ore impacted soils and material are conducted will be designated as the Exclusion and Controlled areas for the purpose of radiation protection. Access to these areas will be controlled for radiation protection. This measure will be taken to limit the spread of impacted materials and to reduce the radiation exposures to ALARA levels.

3.1 Designated Controlled Areas

Each area of the Mine Site within the Exclusion Area may present a different type and extent of radiation hazard. Some areas will be designated as separate controlled areas within the Exclusion Area depending on the degree of potential for, and nature of, any exposure to radiation. Controlled areas are established to limit radiation exposures to visitors and the general public. The designation of an area and associated barriers, and necessary precautions will be established, changed, or removed. A Controlled Area may be established outside the Exclusion Area if a radiation hazard exists. Access will also be managed in any controlled area outside the Exclusion Area, and the occupational dose limit in this area will be the same as the limit for members of the public.

The NECR Mine Site RA presents an added component to the radiation protection to members of the public. The mine waste from the Mine Site will be hauled and consolidated into the Repository at the Tailings Impoundment. The mine waste haul road from the Mine Site to the Repository crosses public NM highway 566. The highway crossing will be controlled during haul operation. A traffic control signal system, as discussed in Appendix M, and other control measures and radiological surveys of the highway crossing will be implemented for radiation protection of members of the public during the haul operation. The highway crossing traffic signal system will stop public traffic while haul trucks are crossing and regularly reopen, stopping haul traffic and allowing public traffic to proceed. Control measures will include mud grates at each end of the haul road when leaving the Mine Site and the Repository. Once past the mud grates, the trucks would stop for a radiologic frisking and any loose contamination above the field screening level would be brushed or scraped from the trucks until they are determined by frisking to be below the screening level prior to leaving the exclusion areas. Mud grates will also be located at the highway crossing. At the end of each haul work day, the highway crossing surface would be checked for any contamination. Any identified contamination in the crossing will be collected and moved to the repository for disposal. Accumulation of mud and dirt on the paved section of the crossing will be prevented. Any uncontaminated sediment or soils would be swept to the shoulder. Temporary gates will be installed to restrict haul road access when the crossing is not in use.

3.2 Radiation Areas

Based on the exposure rate levels at the NECR Site, a Radiation Area, where an individual could receive a whole body radiation dose of 5 mrem per hour or 100 mrem during five consecutive work days, is not expected at the Site.

3.3 Airborne Radioactivity Areas

Any area where the airborne uranium ore dust (uranium and its decay products) exists in concentrations:

1. in excess of the 5 $x10^{-11}$µCi/ml; or
2. to such a degree that an individual present in the area without respiratory protective equipment could exceed, during a 40-hour work week, an intake of 0.6 percent of ALI or 12 total DAC hours (airborne concentration of 30 percent of DAC averaged over a 40-hour work week),

will be designated and posted as an "Airborne Radioactivity Area".

Based on radionuclide levels, the work areas being outdoors, and with appropriate controls (dust control), airborne radioactivity areas are not expected during construction activities. However, if an area is designated as airborne radioactivity area, respiratory protective equipment will be provided for individuals in this area. Additional reasonable control measures will be implemented to lower airborne concentrations, since the respirator use should be the last resort for radiation protection. Time spent in these areas by each individual will be logged for exposure assessment.

3.4 Clean Areas

Any area where the radioactivity level is not high enough to require radiation protection may be designated as a "Clean Area". The Clean Area will not exceed the surface radionuclide levels of 5,000 dpm/100 cm^2 averaged over one square meter, with a maximum level of 15,000 dpm/100 cm^2, not to exceed 100 cm^2 area for total alpha, and 1,000 dpm/100 cm^2 of removable alpha contamination. If any location, within the exclusion area, meets the Clean Area criteria, that area may be designated as a Clean Area. Areas such as work break activities (eating, drinking, smoking, etc.) within the project Support Area will be maintained as Clean Areas. Each worker will be informed of Clean Areas during radiation safety training.

4.0 RADIOLOGICAL MONITORING

The RSO will conduct general work area monitoring to assess potential radiation exposures to workers and for planning purposes to verify that radiation exposures are ALARA. The two principal radiation exposure pathways are inhalation of long-lived airborne particulate radionuclides and direct gamma radiation from impacted soil and material. Airborne radon and the short-lived particulate radon progeny should not present a significant hazard because of the low levels of radionuclides in soil and because all activities will be performed outdoors.

Radiation monitoring instruments such as alpha scintillometers, gamma scintillometers, gamma radiation exposure rate meters and Geiger-Mueller detectors will be function-checked prior to use each day using appropriate check sources. The Site RSO will calibrate radiation monitoring equipment, including air samplers, annually unless damaged, in which case it will be sent for repair and replaced with another calibrated meter. Radiological field and laboratory analysis equipment will be calibrated using National Institute of Standards and Technology (NIST) traceable standards. Frequency of calibration will be on an annual basis by qualified personnel and using approved procedures. A background and function check will be made on each radiological instrument for each day of use.

All procedures used for radiation surveys and health physics monitoring will meet appropriate Lower Limits of Detection (LLDs) requirements and quality assurance program as defined in the NRC Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities," and Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring".

5.0 INTERNAL RADIATION DOSE ASSESSMENT

Internal radiation dose is received from intake of radioactive material, primarily alpha radiation emitters. The radionuclides of significance in the uranium decay series of the uranium ore at the Site which would result in committed dose equivalent are U-nat, Ra-226, Th-230, and Rn-222 progeny. If required, the internal radiation dose will be assessed in accordance with Section 5.1.

5.1 Internal Radiation Exposure from Inhalation

The internal radiation exposure in terms of DAC hours for radionuclide will be calculated as follows:

DAC hrs = (C/DAC) x h

Where:
C = area airborne concentration of radionuclide, microcuries per milliliter (µCi/ml)
DAC = DAC of radionuclide, µCi/ml
h = hours worked in the area

The DAC hours for all radionuclides will be summed to obtain total DAC hours. The DAC applicable to limiting exposure to airborne uranium ore dust in restricted areas is given in paragraph 3 of the Note to 10 CFR 20, Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage". For gross alpha counting of the air sample, the DAC value is 6 x 10^{-11} microcuries (µCi) of alpha activity per milliliter (ml) of air. This concentration applies to the alpha emissions of U-238, U-234, Th-230, and Ra-226. The uranium ore dust concentration is applicable to areas where only uranium ore, prior to chemical separation of the uranium from the ore, is handled. Therefore, the DAC hours calculated for gross alpha activity of uranium ore dust DAC for the Site will include all alpha emitting radionuclides (U-238, U-234, Th-230, and Ra-226).

5.2 Internal Radiation Dose from Inhalation

The Committed Dose Equivalent (CDE) to any organ (bone surface and lungs) and CEDE will be calculated using the following equation if the exposure averaged over a week exceeds 12 DAC hours:

CDE, mrem = C x h x IR x f

Where:
C = area airborne concentration, µCi/ml
h = hours worked in the area
IR = inhalation rate, 1.2E+06 m^3/hour
f = exposure to dose conversion factor, mrem/µCi

The radionuclide exposure to dose conversion factor (f) from Table 2.1 of the International Committee on Radiation Protection (ICRP), Publication 30 (ICRP 30) will be used. The most restrictive (conservative) factor (f) of the lung clearance class (D, W, or Y) will be used for dose calculations.

Following are the factors (f) listed in ICRP 30 for CEDE for stochastic effect that will be used for calculations:

Ra-226 (W): 8.58E+03 mrem/µCi
Th-230 (Y): 3.26E+05 mrem/µCi
U-nat (Y): 1.25E+05 mrem/µCi

There is no conversion factor listed in ICRP 30 for Rn-222 progeny. The CEDE will be calculated on the basis that the intake of one ALI (100 µCi) is equal to 5,000 mrem CEDE. The CEDE from all of the above radionuclides will be summed as total CEDE.

The most highly exposed organ from intake of insoluble uranium and Ra-226 are the lungs and the bone surface from intake of Th-230. The CDE to the bone surface from the inhalation of uranium and Ra-226, according to ICRP 30 is insignificant. The CDE to the bone surface from the inhalation of insoluble uranium is less than the CEDE. The factors (f) listed in ICRP 30 that will be used for the calculation of CDE, non-stochastic dose, to the bone surface and lungs are as follow:

Ra-226 (W) = 5.96E+05 mrem/µCi
Th-230 (Y) = 1.99E+06 mrem/µCi
U-nat (Y) = 1.04E+06 mrem/µCi

The CDE from Ra-226 and U-Nat for the lungs will be summed to demonstrate compliance with the organ limit.

5.3 Oral Ingestion and Skin Absorption

Intake of uranium and its daughters, through oral ingestion and skin absorption could be received during break activities (eating, drinking, smoking, chewing, etc.) and from contact with uranium ore dust by individuals. During any construction activity, if potential exists for oral ingestion and skin contact of uranium ore dust, appropriate PPE (such as coveralls and gloves) must be used.

All individuals will be provided with Clean Areas for break activities. All Clean Areas will be equipped with a water supply where all individuals will wash their hands prior to any break activity. These Support Area facilities will be maintained to assure that they meet the radionuclide level criteria for Clean Areas.

All personnel will be frisked for radiological contamination prior to leaving the controlled area or contacting potentially impacted soil at the Site. A portable alpha radiation detector or a beta/gamma detector will be used for personnel contamination monitoring. Construction personnel will remove contaminated PPE (such as gloves, boot covers, and coveralls). Disposable PPE will be placed in a designated radioactive waste container for disposal as radioactive waste. Non-disposal PPE or work clothing will be removed prior to entry into the decontamination area for later reuse. The contamination limit for skin and clothing shall be 1,000 dpm of gross alpha radiation activity per 100 cm^2.

Personnel will clean any skin with a contamination reading above the 250 dpm/10 cm^2 exposure control and ALARA limit by washing the affected area. The RSO will re-survey the affected area following washing to confirm no contamination remains. Skin contamination is easily removed by washing with soap and water.

5.4 Surveys and Monitoring for Internal Radiation Exposure

As discussed previously, the internal radiation dose is not likely to exceed 10 percent of the limit. However, area air sampling will be performed for airborne gross alpha activity from uranium and its daughters (U-nat, Ra-226 and Th-230). The frequency of air sampling will be established in SOPs based on soil radionuclide levels and any previous airborne concentrations during comparable activities.

Individual DACs for uranium and its alpha emitter daughters, as specified in Table 1, of Appendix B, 10 CFR 20 are listed below:

U-nat	2.0E-11 µCi/ml
U-238	2.0E-11 µCi/ml
U-234	2.0E-11 µCi/ml
Th-230	6.0E-12 µCi/ml
Ra-226	3.0E-10 µCi/ml

The long lived gross alpha activity in the uranium decay chain is made up primarily of U-nat (U-234 and U-238), Th-230 and, Ra-226. A conservative approach for radiation protection is that all of the airborne gross alpha activity from construction activities associated with uranium ore is from U-234 and U-238, Th-230 and Ra-226. Since RA activities at the NECR Site will be associated with handling only the uranium ore impacted material, the DAC for gross alpha activity of uranium ore will address all alpha emitters.

If needed, individual airborne concentrations for U-nat, Ra-226, and Th-230 will be determined. It is not practical in the field to perform isotopic analyses for U-238, U-234, Ra-226, and Th-230 on the routine occupational airborne particulate sample filters. The airborne concentration of U-nat, Ra-226, and Th-230 can be determined from their activity fraction of the gross alpha activity of uranium ore dust material which has the potential for becoming airborne. Since these radionuclides (U-234, U-238, Ra-226, and Th-230) are in secular equilibrium in uranium ore dust, their airborne concentrations will be determined by multiplying the airborne gross alpha activity by 0.25. Secular equilibrium of U-238, U-234, Ra-226, and Th-230 in uranium ore waste at the NECR is supported by analysis of U-nat and Ra-226 analytical results for 375 surface and subsurface soil samples collected during the RSE activities and performed by vendor laboratory. The soil sample results, and U-238, U-234, Ra-226, and Th-230 fraction calculations are discussed in Attachment 5 to this plan.

Based on the assumption that U-238 is in secular equilibrium with its decay product in uranium ore, an airborne gross alpha activity limit of 2.4E-11 µCi/ml would assure that the Th-230 DAC of 6.0E-12 µCi/ml, lowest of the four radionuclides, is not exceeded. For a mixture of radionuclides, the sum of the fractions of the concentrations divided by the respective DACs need be equal to or less than unity. Since the mixture of radionuclides U-234, U-238, Th-230 and Ra-226 in uranium ore being in equilibrium, activities of all four radionuclides will be equal. Therefore, if the airborne gross alpha activity from uranium ore is equal to or less than 1.48E-11 µCi/ml, the sum of the fractions of the radionuclide concentrations divided by their respective DACs will be equal to or less than unity. Therefore, airborne gross alpha activity of 1.48E-11 µCi/ml will be used as action level at the NECR Site for radiation protection for activities associated with mine site material.

5.4.1 Work Area Air Sampling Using RAS Sampler

The RSO or the Radiation Safety Technician (RST) will collect work-area airborne particulate samples using an appropriate intermediate volume air sampler with a flow rate of approximately 50 liters per minute (lpm). Samples will be collected on 47-mm glass fiber filters installed in the air samplers. The sampling station will be located at a point as near to the workers as practical and will be changed as the work tasks and other factors change. Considerations for locating the sampler include the prevailing wind direction, site activities, and soil radionuclide level. Air samples will be collected at a height of 1 to 1.5 m above ground level in locations free from unusual micrometeorological or other conditions that could result in artificially high or low concentrations. General work-area air monitoring will be performed during intrusive work or when the site activities can create airborne radioactivity.

A short sampling period would be required to measure radionuclides in air at DAC-levels, because the flow rate of these samplers is approximately 50 lpm. Based on a flow rate of about 50 lpm, along with counting sample filters for 30 minutes using an alpha counter with a background counting rate of 20 counts per hour and an efficiency of about 30 percent would provide Minimum Detectable Concentration (MDC) of below 5.0×10^{-12} µCi/ml, less than 10 percent of the gross alpha DAC. The filters will be counted for gross alpha activity using the alpha tray counter after the filters have been aged sufficiently, at least 72 hours for radon progeny decay. An initial count may be performed after the sample filter has been aged for 24 hours for information and exposure control.

5.4.2 Work Area Air Sampling Using Lapel Sampler

If the RSO determines that there is a potential for airborne gross alpha activity to exceed 10 percent of the DAC for gross alpha activity, an individual of the group having the potential for the greatest exposure in the work area will be equipped with a personal air sampler. Airborne concentration measurements from the personal air sample will be used to determine the exposure of individuals in that area.

A lapel sampler (MSA Air Sampler or equivalent) with a flow rate of approximately 1.5 to 2 lpm and a 37-millimeter (mm) filter cassette with a Type A/E glass fiber filter will be used. The RSO will analyze the effectiveness of the lapel samplers as follows. The samplers are assumed to be operating for an 8-hour day, resulting in 960 liters of air being pulled through the filter. The sample will be removed and counted 12 or more hours later, after the radon-222 progeny have decayed. A final count will be made after four days when most of the radon-222 progeny has decayed. Gross alpha emissions will be counted on Ludlum Model 2929/Ludlum Model 43-10-1 tray counters. These counters have an alpha background count rate of less than 10 counts per hour and an efficiency of approximately 0.4 counts per minute (cpm) per dpm for thorium-230. This corresponds to a minimum detectable activity (MDA) of 0.5 dpm or an MDC of 1.0×10^{-12} µCi/ml, less than 10 percent of the gross alpha DAC for the lapel sampler under the assumed conditions.

Work area air sampling will be performed on three days for the first week (1st, 3rd, and 5th day) of RA activities associated with handling of mine waste. Air sampling will also be conducted at the background (upwind) location. If the work area net airborne concentrations are less than 10 percent of DAC for gross alpha activity, the work area air sampling will be continued at a rate of once per week. If the work area airborne concentrations are greater than 10 percent of DAC, personal air sampling will be conducted (an individual of the group having the greatest potential for exposure in the work area will be equipped with a personal air sampler). The personal air sampling frequency will remain at three days per week as long as the net airborne concentrations are greater than 10 percent and less than 30 percent of the DAC. When the airborne concentrations decline below 10 percent of the DAC as a result of implementation of necessary control measures, the air sampling frequency will be reduced to once per week.

5.4.3 Work Area Radon Monitoring

It is not anticipated that the radon or radon progeny concentrations will be significant because of the low levels of Ra-226 in soil and because the work is being conducted outdoors. The winds should disperse the radon and progeny to levels much below concern for worker protection. If needed, track etch radon monitors will be utilized for airborne radon and radon progeny concentrations.

5.4.4 Bioassays

As discussed previously, internal exposures from airborne ore impacted soil are expected to be less than 10 percent of the intake limit from the construction activities associated with low levels of radionuclides in soil (average of about 35 pCi/gm Ra-226) and adequate dust control. In addition, uranium in ore is not sufficiently soluble for Bioassay (urinalysis) to be an effective monitoring method. Bioassay (urinalysis) sampling is not planned for the current work. However, bioassay will be performed for uranium analysis for intake assessment for any individual exposed to an airborne uranium concentration of 30 percent of DAC averaged over a 40-hour work week. Since entrance bioassays are not performed, the baseline uranium level will be considered zero.

5.5 Exposure Control

All individuals will be instructed in procedures necessary to minimize the intake of uranium and its daughters. Clean Areas will be designated within the work areas during break activities such as eating, drinking, smoking, or chewing.

Exposure controls will be achieved through personal monitoring, evaluation of radiological hazards, and PPE. Exposures will also be controlled by using engineering control measures to minimize airborne particulate concentrations. Some of the control measures that may be used when needed include:

- Applying water to areas to be excavated
- Spraying water during excavation and material handling operations
- Modifying or stopping work during windy conditions (presence of visible dust)
- Controlling locations of work stations relative to wind direction

- Conducting intrusive work during low wind conditions (normally in the morning)

5.6 Respiratory Protection

As discussed above, airborne exposures through inhalation will be controlled by using engineering control measures, such as keeping the ore impacted soil moist by spraying water to minimize airborne particulate concentrations. Respiratory protection will not be used during routine construction activities. Respiratory protection will only be used during corrective actions for lowering airborne concentrations. Construction personnel working where airborne concentrations of uranium ore dust in the work area exceed that defined as an “airborne radioactivity area will wear air-purifying respirators. The respiratory protection program will comply with 10 CFR 20. Other acceptable methods meeting the requirements include limiting exposure times and controlling access.

5.7 Administrative Control Limits

To prevent any inadvertent overexposure, the administrative control limit for airborne radioactive material is established at 25 percent of the DACs. This control limit will be used as an action level to implement any necessary control measures.

5.8 Compliance with Dose Limits for Individual Members of the Public

As discussed previously, due to low levels of radionuclides and adequate control measures any significant offsite airborne release of impacted dust is unlikely. Airborne particulate radionuclides will be monitored at the downwind boundary to assess dose for individual members of the public as described in the Dust Control and Air Monitoring Plan (Appendix Q of the 95% Design Report). The airborne concentration of U-nat, Ra-226, and Th-230 will be determined from their activity fraction of the gross alpha activity of uranium ore, which has the potential for becoming airborne. Since these radionuclides (U-234, U-238, Ra-226, and Th-230) are in secular equilibrium in uranium ore dust, their airborne concentrations will be determined by multiplying the airborne gross alpha activity by 0.25. Eberline RAS-2 air samplers or an equivalent air sampler, with 47-mm Type A/E glass fiber filters will be used to evaluate airborne concentrations. Air filters will be counted onsite for gross alpha activity, which will be compared to the limits.

Compliance with dose limits for individual members of the public will be demonstrated. The following are the applicable effluent concentration limits:

U-nat:	9.0E-14 µCi/ml
Ra-226:	9.0E-13 µCi/ml
Th-230:	3.0E-14 µCi/ml
Rn-222:	1.0E-08 µCi/ml (for the class “with daughters removed”, used because the track etch radon monitor is equipped with a filter that removes the daughters prior to the measurement)

6.0 EXTERNAL RADIATION DOSE ASSESSMENT

Uranium ores pose a potential for a deep dose from exposure to external radiation sources from gamma emitting radionuclides of the uranium decay chain, primarily Bi-214 and Pb-214. The shallow dose (skin dose) from exposure to beta radiation from uranium ore and tailings material is insignificant because of low concentrations of beta emitting radionuclides, and self-absorption of beta radiation in the uranium ore matrix.

6.1 Monitoring for Occupational External Exposure

All individuals, including workers, vendors, and visitors in the work areas will be monitored for exposure to external radiation. The RSO will take exposure rate measurements in the work areas using a Ludlum Model 19 µR meter or equivalent. RSO will produce site exposure-rate maps to guide construction activities toward minimizing radiation exposure.

The RSO will issue personal dosimeters, such as Luxel+ OSL dosimeter, to all construction personnel to monitor their external exposure. Construction personnel will wear the dosimeter under protective clothing to prevent possible impacts of the dosimeter from dirt or airborne dust. All dosimeters, as well as controls, will be placed in the Support Area when not in use. Personal dosimeters will be provided and read quarterly.

6.2 Monitoring for External Exposure to General Public

Direct gamma radiation exposure rate measurements will be used at the NECR Site perimeter upwind and downwind boundary to determine external radiation exposure to the public. In addition, periodic direct gamma radiation exposure rate measurements will be performed at the mine waste haul road and the NM highway 566 crossing for radiation protection to the public.

6.3 Exposure Control

Based on the average gamma radiation exposure rates, the external radiation doses during construction activities are expected to be less than 10 percent of the limit. To control external radiation exposures, access to the Exclusion and Controlled areas will be restricted. Personal monitoring, area radiological hazard evaluations and PPE will be used to control exposures. The administrative control limit for external exposure is set at 25 percent of the limit.

There is no area or source at the NECR Site where the exposure rate is high enough that an individual will receive a dose equivalent to 0.1 rem (100 mrem) in one hour. Therefore, there is no “high” or “very high” radiation areas at the NECR Site.

7.0 RELEASE OF EQUIPMENT AND MATERIAL

Materials and equipment used for excavation and handling of impacted soil will be monitored for contamination prior to release to the unrestricted area. An alpha scintillation detector, coupled to a ratemeter, will be used to scan or make static counts on potentially impacted items. Removable contamination monitoring will also be performed for equipment and material when the total contamination levels are measured above the removable contamination level. The RSO will wipe an area of 100 cm^2 with a dry filter or soft absorbent paper while moderate pressure is applied. At least one wipe sample will be collected from each item. The RSO will collect wipe samples for removable contamination from all one square meter areas in large items where direct readings indicate that the removable limit may be exceeded. The wipe samples will be counted for gross alpha using the Ludlum Model 2929/Ludlum Model 43-10-1 alpha-beta tray counter or equivalent. The counting time will be adjusted to produce an MDA of 50 percent of the applicable limit.

Any equipment or material with contamination level above the limits specified in the NRC Regulatory Guide 8.30 (as listed in the table below) will be decontaminated. There also is a requirement to reduce surface contamination to ALARA levels below the limits. Items that cannot be decontaminated to ALARA levels below these limits will be considered radioactive waste and disposed of accordingly.

Nuclide	Acceptable Surface Contamination Limits		
	Total Average	Total Maximum	Removable
Natural uranium, uranium-235, uranium-238, and associated decay products	5,000 dpm alpha / 100 cm^2	15,000 dpm alpha / 100cm^2	1,000 dpm alpha / 100 cm^2

If decontamination is required, the following procedures will be implemented:

- Equipment or material will be decontaminated in the designated area
- The method of decontamination shall be based on the type and extent of contamination of the equipment or material
- Decontamination shall be achieved by wet methods, such as high pressure water, steam cleaning, or wet scrubbing of elevated areas, to minimize airborne radioactive materials

All decontaminated equipment or material will be allowed to dry prior to the surface contamination survey. Equipment or material will be released only after it has been surveyed for contamination.

All expendable material (such as disposable coveralls, gloves, towels) generated during construction activities has the potential to be impacted from uranium ore dust. These materials will be disposed in designated disposal areas at the NECR Site.

8.0 INCIDENTS, NOTIFICATION REQUIREMENTS AND RECORDS

The Site RSO will thoroughly document all incidents. Incidents will be reported as required by 10 CFR 20.

Before the project starts, the RSO, SM, SSO, CC and CSC will coordinate with the applicable response organizations to properly treat potentially contaminated victims in the event of an accident. McKinley Christian Hospital in Gallup, NM is equipped to accept radiologically contaminated victims and will be the designated hospital for medical treatment. Industrial accident victims will be monitored and decontaminated, if necessary, prior to leaving the site only if their injuries are not life threatening and decontamination will not affect the injury. A RST, the Site RSO, or the SM will accompany the victim for treatment to facilitate communication with medical response personnel.

Any events that require reporting will be reported by the RSO or his designee through the CSC, and the appropriate regulatory agencies. In non-emergencies, federal or state agencies will not be contacted. Immediate reporting is required when a loss of control of radioactive material that presents a real or potential hazard to off-installation populations, such as:

- Loss of control of radioactive material that presents a threat to life or health.
- Any event, such as fire, explosion, or toxic gas release, involving radioactive material that prevents taking the immediate protective actions needed to avoid exposures to radiation or radioactive material, or to avoid releases of licensed or permitted material, above regulatory limits.
- Any unexpected event involving radioactive material or radiation exposure deemed serious enough to warrant the interest or action of officials or agencies. This includes:
  - Events that may cause inquiries by the public or press
  - Events requiring immediate OSHA, NRC, and/or New Mexico Environmental Department (NMED) notification

Any event that causes a significant reduction in the effectiveness of any authorized shipping package during use. The Site RSO will detail the defects and their safety significance, explain how the defects were repaired and detail the plan to prevent their recurrence.

Although highly unlikely at the NECR Site, immediate notification to the Assistant Secretary of Labor or their duly authorized representative, for employees not protected by the NRC by means of 10 CFR part 20; or State of New Mexico Regulations NMAC 20.3; is required by telephone (1-800-321-6742) or online at www.osha.gov is required for incidents involving radioactive material that can or has caused the following exposures:

- 25 rem TEDE
- 75 rem effective dose equivalent (EDE)
- 250 rem SDE
- Potential intakes of 5 times the ALI in 24 hours

Likewise, unlikely at the NECR Site, twenty-four-hour notification is required for incidents involving radioactive material that can or has caused the following exposures:

- 5 rem TEDE
- 15 rem EDE
- 50 rem SDE
- Potential intakes exceeding the ALI in 24 hours

Written notifications will be submitted within 30 days to the Assistant Secretary of Labor or their duly authorized representative, for employees not protected by the NRC by means of 10 CFR part 20 or State of New Mexico Regulations, for the following:

- Doses exceeding occupational limits for adults
- Doses exceeding occupational limits for an embryo/fetus
- Doses exceeding license limits
- Levels of radiation or concentrations of radioactive material in the exclusion area exceeding applicable license limits
- Levels of radiation or concentrations of radioactive material in unrestricted areas exceeding 10 times applicable license limits

Records of the RPP implemented during construction activities will be maintained by the RSO. The records shall include surveys and calibrations, individual monitoring results, prior occupational doses, special exposures, dose to public, notifications of incidents, reports to individuals and any planned special exposures.

ATTACHMENTS 1 TO 4

STANDARD OPERATING PROCEDURES

(TO BE UPDATED BY CONTRACTOR PRIOR TO BEGINING OF CONSTRUCTION)

RPP SOP-1
Gamma Radiation Exposure Rate Survey
UNC NECR RA Radiation Protection Program

1.0 SCOPE

This procedure will be used to measure gamma radiation exposure rate for radiation protection and may be used during characterization and remedial action at uranium mine and mill tailing sites.

2.0 EQUIPMENT AND MATERIALS

2.1 A vendor calibrated Micro-R-Meter (Ludlum Model 12S, Ludlum Model 19 or Eberline PRM-7.

2.2 Map of survey areas, ink pen and appropriate field survey Forms to record survey readings and notes.

3.0 INSTRUMENT CONFIGURATION & OPERATIONS

The gamma exposure rate survey will be performed using Micro-R-meter (µR meter) for radiation protection and exposure rate characterization at uranium mine and mill tailings mill sites. The µR meters are totally configurated (consisting of 1x1 NaI detector and ratemeter) exposure rate measurement equipment. Micro-R-Meter, such as Ludlum model 12S. Ludlum Model 19 or Eberline PRM-7 contain a 1x1 NaI detector. Prior to any instrument function check or the operation, the technician will read the Technical Manual for the instrument operations.

3.1 Instrument Function Check

An operational function check will be performed on the µR meters each day prior to any field surveys. Calibration date for the instruments must be within one year. If not, the instrument must be calibrated with a certificate in file. The function check will be performed in field office. The following function check procedures will be used and the pertinent information recorded on the Function Check Form (Attachment A or equivalent).

3.1.1 Visual Inspection

Perform a visual inspection of the instrument, checking for signs of any damage.

3.1.2 Calibration Due

Verify calibration validity of instruments. Calibration date for the instruments must be within one year.

3.1.3 Battery Charge

Assure that the meter battery is functional. The meter indicator should be within “Battery OK” position.

3.1.4 Background Exposure Rate

The background exposure rate measurement will be performed at the designated location in the field office. A location will be designated in the field office for obtaining the required daily function check. Keep all beta/gamma radiation sources away from the detector while performing the background check. The background function check exposure rate readings must be within 20% of the background counts obtained following calibration at same location.

3.1.5 Source Function Exposure Rate

Obtain the gamma radiation source, (1% U_3O_8 ore standard sealed in a red can marked Function Check Source" or Cs-137 check source). The function check source was used to determine the acceptable count range for the µR meters immediately following calibration. Place the source at the same location on the µR meter (circle drawn on front of the meter) to obtain the source function check reading following calibration. Select appropriate scale and wait about 10 seconds for reading to stabilize. The source function check reading must be within 20% of the source reading following calibration.

3.1.6 Technician

After completing the function check, initial in the column marked TECH of the Function Check Form (Attachment A).

4.0 FIELD GAMMA RADIATION SURVEYS

The gamma radiation exposure rate survey will be conducted as either scan survey (walkthrough) or static survey (stationary) measurements.

4.1 Scan Exposure Rate Survey

Scan exposure rate surveys (walkthrough surveys) will be performed by walking with the µR meter/detector at waist high from the ground surface with the meter response in “FAST” Mode and audio speaker ON to determine exposure rate range and identify and locate any hot spots within an area.

4.2 Static Radiation Survey

Static exposure rate surveys will be performed at any point or location of interest. The µR meter/detector will be held at about waist high from the ground surface with the µR meter response in “SLOW” Mode, and allowing at least 10 seconds to stabilize and taking a reading for that point or location.

Record the exposure rate survey data in the Exposure Rate Survey Field Form (Attachment B)

5.0 ATTACHMENTS

Attachment A	µR meter Function Check Form
Attachment B	Exposure Rate Survey Field Form

Attachment A

AVM Environmental Services, Inc.
Micro R Meter Function Check Form

Micro R Meter: ____________________

Function Check Source ID: _________________

Function Check @ Calibration ____________________________
Acceptable Function Check Reading (uR/hr) Range (20%) ___________________ to ____________________

Date	Physical Check	Cal Date	Battery[1] Volts or OK	BKG Reading uR/hr	Source Reading [2] uR/hr	Within Acceptable Range Y or N	Cal Due	Tec h

Note: (1) Battery Voltage must be within BAT TEST Range (2) Function Check Source must be placed in the circle on the front side of the meter

Attachment B
AVM Environmental Services, Inc.
Exposure Rate Survey Field Form

Instrumentation :____
Instrument Calibration Date: ___________________, Instrument Daily Function Check Performed: __________

Survey Area/Unit Description
____

Survey Date/Time	Survey Area/Location ID/Description	Exposure Rate (uR/hr)	Comments/Notes

RPP SOP-2
OCCUPATIONAL AIRBORNE RADIOACTIVE PARTICULATE MONITORING
UNC NECR RA Radiation Protection Program

1.0 SCOPE

1.1 Purpose

This procedure describes two techniques for determining the concentration of airborne radioactive particulate. The techniques differ only in sample collection; the analytical technique for determining the concentration from the filter media is the same for either sample collection method. The procedure is intended to:

1.1.1 Demonstrate compliance with the intake limits for workers specified in the Radiation Protection Program.

1.1.2 Meet the posting requirements for airborne radioactivity areas specified in the Radiation Protection Program.

1.1.3 Determine whether precautionary measures such as process or engineering controls, increased surveillance, limitation on working times, provision of respiratory protective equipment, or other precautions should be considered to meet the Radiation Protection Program.

1.1.4 Determine whether exposures to radioactive materials are being maintained As Low As Reasonably Achievable (ALARA) as stated in the Radiation Protection Program.

1.2 Applicability

This procedure applies to all personnel under Radiation Safety Officer (RSO) supervision performing airborne particulate monitoring at uranium mine and mill tailings sites.

2.0 REFERENCES

2.2 Portable Instrument/Survey Record Procedure for Field Projects.

2.3 10 CFR 20, "Standards for Radiation Protection"

2.4 NRC Regulatory Guide 8.30, Health Physics Surveys in Uranium Mills

2.5 NRC Regulatory Guide 8.25, Calibration and Error Limits of Air Sampling Instruments for Total Volume of Air Sampled.

3.0 EQUIPMENT AND MATERIALS

3.1 Air Sampler: Either Area, Breathing Zone, or High Volume

3.2 Particulate Filters GF A/E (37mm or 47mm, to fit air sampler), Envelopes for Filter Storage or Petri dishes.

3.3 Alpha radiation Counting Instrument (Ludlum 2929)

3.4 Air Particulate Sampling Survey Report/Form (Appendix A or equivalent).

4.0 AIR SAMPLE COLLECTION INSTRUCTIONS

4.1 Area Air Samples

4.1.1 Select a calibrated Regulated Air Sampler (RAS-1). Install a 47mm diameter filter in the filter head.

4.1.2 Select a suitable location for sampling. The location chosen is based upon an evaluation of the operation being performed. The ideal location would approximate the breathing zone of a worker and would be between the source of the potential airborne material and the location of the worker(s).

4.1.3 Determine the time and flow rate necessary to sample a volume sufficient to ensure that a required Lower Limit of Detection (LLD) will be met.

4.1.4 Turn on the air sampling unit, adjust the flow rate to a calibrated value, and record the starting time, flow rate, vacuum and initials of the technician.

4.1.5 Record the exact location of the air sampling unit and the nature of the work being performed. Record any other pertinent comments.

4.1.6 Periodically check air sampler unit for proper operation.

4.1.7 After the minimum collection time to meet the LLD requirement in Step 4.1.3, record ending flow rate, vacuum and time, and turn off the air sampling unit. Remove the air filter and place in sample envelope or Petri dish and label it.

4.2. Lapel (Personal) Samples

4.2.1 Select a calibrated lapel air sampler and install a 25mm diameter filter in the filter cassette head. Install the cassette into the cyclone.

4.2.2 Determine the time and flow rate necessary to sample a volume sufficient to ensure that an adequate LLD is obtained. Due to the low flow rate of lapel air sampling pumps, it is usually necessary to operate the pump for a longer period of time then the RAS-1 pumps. A two (2) to eight (8) hour sample, if possible, is preferable.

4.2.3 Select a worker of a ground with a highest potential for exposure to airborne materials. Instruct the worker regarding the wearing of the lapel sampler. Ensure the filter head is positioned in the breathing zone.

4.2.4 Record the name of the worker and the nature of the work being performed. Record any other pertinent information.

4.2.5 Turn on the air sampling pump, adjust the flow rate to a calibrated value, and record the start time, start flow rate, and initials of the issuing technician.

4.2.6 Periodically, check the work area and air sampling unit for proper monitoring and operation.

4.2.7 Record the ending flow rate and ending time, and turn off the air sampling unit. Remove the air filter and place it in the sample envelope or Petri dish.

NOTE: Any period of time which the sampler is left running outside work area (e.g. during lunch break) shall be deducted from the total run time used in calculating airborne concentrations.

5.0 COUNTING INSTRUCTIONS

5.1 An initial 24 hour decayed count may be performed for informational purposes. Allow a minimum of 72 hours from the end of sample collection before counting sample (to allow for decay of interfering short-lived radon daughters) as appropriate. The MDC/LLD should be less than 10% of 6.0E-11 µCi/ml DAC for gross alpha for the final counting of the sample.

5.2 Count the samples per Reference 2.1

5.3 Record the results per Reference 2.1

6.0 RECORDS

All forms generated as a result of this procedure shall be maintained throughout the duration of the project and then retained in the permanent project file.

UNC NECR RA Radiation Protection Program
AIR PARTICULATE SAMPLING FIELD DATA SHEETS

Sample #/Dish #____________________ Date:____________________________

SOP:______________________________ Field Tech:________________________

Area/Location/Assigned to:____

____

Sampler Used:______________________ Filter Used:______________________
Sampler Serial #:____________________ Vac./Roto. Rdg(start)_______________
Sampling Rate(SR):________________LPM Vac./Roto. Rdg(stop)_______________

Time Start:____________Stop:____________ Elapsed(E):_____________(min)
Volume of Air Sampled____(ml)
(SR x E x 1000)

Initial Count

Alpha Counter_________________________, Efficiency__________________ Bkg.__________________

Count Date and Time_____________________________
Alpha Counts_____________________________, Count Time____________________________________
Bkg. Counts______________________________, Count Time____________________________________
Gross Alpha______________________________ µCi/mL MDC______________________________µCi/mL
% DAC__________________________________

Final Count

Alpha Counter_________________________, Efficiency__________________ Bkg.__________________

Count Date and Time_____________________________
Alpha Counts_____________________________, Count Time____________________________________
Bkg. Counts______________________________, Count Time____________________________________
Gross Alpha______________________________ µCi/mL MDC______________________________µCi/mL
% DAC__________________________________

$$\text{Gross Alpha Activity, µCi/ml} = \frac{\text{(Gross cpm – Bkg cpm)}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$$

$$\text{Estimated Error (uncertainty 95\%), µCi/ml} = \frac{\text{1.96 x } \sqrt{\{\text{(Gross cpm/t min,Gorss)+(Bkg cpm/t, min Bkg)}\}}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$$

$$\text{MDC, µCi/ml} = \frac{\text{(3+4.66) x (}\sqrt{\text{(Bkg cpm)}}\text{)/t min, Bkg}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$$

RPP SOP-3
SURFACE CONTAMINATION SURVEYS
UNC NECR RA Radiation Protection Program

1.0 SCOPE

1.1 Purpose

This procedure describes general methods and techniques to be used when performing surface contamination surveys. Contamination surveys are performed and documented to demonstrate compliance with regulatory surface contamination limits and to determine:

- Protective clothing and respiratory protection requirements;
- Contamination levels for release of material and equipment from the restricted area;
- The effectiveness of contamination control and decontamination methods; and
- Personnel contamination survey.

1.2 Applicability

This procedure applies to personnel under RSM supervision performing contamination surveys at uranium mine and mill tailings sites.

2.0 REFERENCES

2.1 US NRC Regulatory Guide 8.30, Health Physics Surveys in Uranium Mills".

3.0 EQUIPMENT AND MATERIALS

3.1 Survey Maps (plan view of area, items or equipment to be surveyed)

3.2 Smear papers and envelopes, Plastic Bags, Petri dishes, or equivalent for holding individual smears

3.4 Gloves, appropriate anti-contamination clothing

3.5 Portable Radiation Survey Instruments: Alpha detector (such as Ludlum 43-5 or Eberline AC-3) and beta/gamma detector (such as Eberline HP-210); and scaler/rate meter (such as Ludlum Model 12 or 2224-1).

3.6 Laboratory Alpha and Beta Counters (such as Ludlum Model 2929)

3.7 Contamination/Radiation Survey Report Form (Appendix A or equivalent)

4.0 PROCEDURE

4.1 Survey Locations

4.1.1 Smear and direct contamination surveys should be taken on floors, walls, and on representative items contacted by personnel to the contamination area, such as table tops where break activities are conducted..

4.1.2 Smears should be taken where total direct contamination level exceeds the removable contamination limit (1000 dpm/100 cm^2).

4.1.3 Smears and/or direct contamination readings shall be taken on all equipment removed from the restricted area.

4.1.4 Direct contamination scan shall be performed on personnel hands, clothing, and bottom of shoes or boots.

NOTE: All alpha radiation surveys shall be taken on dry surfaces.

4.2 Direct Surface Contamination Surveys

4.2.1 Select a portable survey instrument(s) for making an alpha or beta-gamma survey, or both, and determine that the instrument(s) is calibrated and operating properly by performing function check.

4.2.2 Pass the detector slowly over the surface to be surveyed holding the detector as close as possible (no more than 1 cm) to the surface without actually touching the surface. Locate area of maximum count rate by using the audible response of the instrument. Record measurement(s) at this position and take a smear if applicable (see paragraph 4.2.2).

4.2.3 Record the direct surface contamination readings on Contamination/Radiation Survey Form in the appropriate columns for gross alpha, open-window (OW) beta-gamma, or closed-window (CW) gamma results.

4.2.4 Calculate the alpha dpm/probe by subtracting the background cpm from the gross cpm and multiplying the net cpm by the instrument's calibration factor. Record in the dpm/probe column.

4.2.5 Conversion of dpm per probe area to dpm per 100 cm^2 should be done for all direct contamination measurements.

4.2.6 Calculate the beta net count rate by the background cpm. Determine the gamma disintegration rate using the detector efficiency and detector active area.

NOTE: DO NOT USE AN INSTRUMENT WHICH DOES NOT HAVE A POSTED CALIBRATION FACTOR, OR ONE WHICH IS OUT OF CALIBRATION.

4.2.7 For surveys of equipment, if necessary, make sketches and recorded readings on sketches and/or recorded readings on Contamination/Radiation Survey Form using descriptions of survey locations adequate to re-locate the area surveyed again.

4.3 Removable Contamination Surveys

4.3.1 Wipe smear paper over an area of approximately 100 cm_2 (wipe a square area 4 inches by 4 inches or an "S" pattern 16 inches long).

NOTE: SMEAR LOCATION SHOULD BE IDENTIFIED BY MARKING ENVELOPES OR SMEARS WITH NUMBERS WHICH CORRESPOND TO THOSE OS THE SURVEY MAP.

4.3.2 Protect smears from cross contamination by immediately placing them in their individual envelopes or bags.

4.3.3 Complete survey and counting information on heading of Contamination/Radiation Survey Form using current calibration and background determinations.

4.3.4 Enter minimum detectable activity (MDA) for counter used. (Background Count time should equal sample count time.)

4.3.5 Count each smear for at least 5 minutes and enter data on Contamination/Radiation Survey Form.

NOTE: COUNT RATES LESS THAN MDA WILL BE SO NOTED BUT ALL SPECIFIC NUMERICAL VALUES SHALL BE RECORDED EVEN IF THEY ARE NEGATIVE NUMBERS.

Attachment A

UNC NECR RA Radiation Protection Program
Surface Contamination/Radiation Survey Form
Pre-Design Sampling

Instrument ____________________ ____________________ ____________________
Instrument SR# ____________________ ____________________ ____________________
Function Check ____________________ ____________________ ____________________
Detector **Efficiency** ____________________ ____________________ ____________________
Detector **Area/Factor** ____________________ ____________________ ____________________

Equipment or Location : ____

Area	Total Alpha		Removable Alpha		Total Beta-Gamma		Location/Comment
	cpm	dpm/100cm^2	cpm	dpm/100cm^2	cpm	dpm/100cm^2	

Notes: ____
____

Technician: ________________________________ Date: ____________________________

Attachment

Acces Control Log Form
NECR RA Radiation Protection Program

Personnel Contamination Limit CPM:

Date	Worker Name	Personal Dosimeter ID	Work ID	Hours in Work Area						Time Out	Vehicle Frisked for Contamination	Personnel Frisked for Contamination	Comments
				Time In	Area	Area	Area	Area					

ATTACHMENT 5

NECR MINE SITE URANIUM ORE DUST ISOTOPIC ANALYSIS

AVM Environmental Services, Inc.

NECR Mine Site Uranium Ore Dust Isotopic Analysis

The NECR mine site is a uranium mine site impacted by uranium ore, in which uranium and its decay products (primarily U-238, U-234, Th-230 and Ra-226) prior to chemical separation are naturally at or near secular equilibrium. This analysis is performed to support that U-238, U-234, Th-230 and Ra-226 in uranium ore at NECR are at or near secular equilibrium. U-nat and Ra-226 were analyzed on a total of 375 surface and subsurface soil samples as a part of the Removal Site Evaluation during 2006-2007. Th-230 was not analyzed on the samples. Based on a conservative assumption that gross alpha activity from uranium ore dust sample would be from the four long lived radionuclides (U-238, U-234, Th-230 and Ra-226), Th-230 fraction was calculated using U-nat and Ra-226 results (see US Nuclear Regulatory Commission 10 CFR 20, Standards for Protection Against Radiation, Appendix B, Footnote 3). The soil sample analytical results are presented in Table 3.15 and Table 3.16 of the October 2007 Final RSE Report for the NECR and are summarized in the attached table.

As shown in the table, the uranium (U-nat) mass concentration results mg/Kg for average of samples from each area were converted to activity concentrations in pCi/g using conversion factor of 1 mg/kg = 0.677 pCi/g (see https://www.nrc.gov/docs/ML1627/ML16271A362.pdf). The U-234 and U-238 activity concentrations from U-nat (U-238, U-234 and U-235) activity were calculated using their fraction of 0.4889 of U-nat (see www.lm.doe.gov/fernald/2010aser_unitsconversns.pdf). The Th-230 concentration in pCi/g were calculated using U-234, U-238 and Ra-226 concentrations and assuming that gross alpha activity in soil samples would be from U-238, U-234, Th-230 and Ra-226. An average of 375 samples calculated to be 25.7 pCi/g, 25.7 pCi/g, 30.7 pCi/g and 27.4 pCi/g for U-238, U-234, Ra-226 and Th-230, respectively. Based on the average results, the isotopic activity percentage calculated to be 23.5%, 23.5%, 28.0% and 25.0% for U-238, U-234, Ra-226 and Th-230, respectively, as shown in the table, which shows that these radionuclides are near the equilibrium? Therefore, 0.25 fraction for Th-230 is appropriate to determine its activity from uranium ore dust air sampling gross alpha activity results.

AVM Environmental Services, Inc.
NECR Mine Site Uranium Ore Dust Isotopic Analysis Table

Soil Sample Type	Area	Number of Samples	U-nat (U-234, U-235 and U-238)		Mean U-234 pCi/g [2]	Mean U-238 pCi/g [2]	Mean Ra-226 pCi/g	Estimated Mean Th-230 pCi/g [3]
			Mean, mg/Kg	Mean pCi/g [1]				
Surface Soil	NECR-1	31	116.2	78.7	38.5	38.5	39.3	38.7
	NECR-1 Step Out	16	14.4	9.7	4.8	4.8	9.7	6.4
	NECR-2	15	50.3	34.1	16.6	16.6	27.7	20.3
	NECR-2 Step Out	4	2.7	1.8	0.9	0.9	5.7	2.5
	Sandfill 1	15	8.8	6.0	2.9	2.9	10.2	5.3
	Sandfill 1 Boundary	3	2.7	1.8	0.9	0.9	4.5	2.1
	Sandfill 2	13	51.4	34.8	17.0	17.0	27.7	20.6
	Sandfill 3	13	65.8	44.5	21.8	21.8	28.7	24.1
	Sandfill 3 Boundary	2	2.9	2.0	1.0	1.0	1.4	1.1
	Ponds 1 and 2	19	125.3	84.8	41.5	41.5	105.9	62.9
	Ponds 1 and 2 Boundary	4	1.7	1.2	0.6	0.6	1.5	0.9
	Pond 3/3a	15	437.1	295.9	144.7	144.7	102.1	130.5
	Sediment Pad	14	195.7	132.5	64.8	64.8	60.5	63.4
	NEMSA	5	2.7	1.8	0.9	0.9	1.5	1.1
	Boneyard	5	4.6	3.1	1.5	1.5	10.4	4.5
	Venthole 3/8	5	77.2	52.3	25.6	25.6	31.5	27.5
	Trailer Park	5	42.8	29.0	14.2	14.2	16.6	15.0
	Homesites	45	4.5	3.0	1.5	1.5	3.9	2.3
Subsurface Soil	NECR-1 Soil Boring	28	99.9	67.6	33.1	33.1	21.4	29.2
	NEFCR-2 Test Pit	6	33	22.3	10.9	10.9	5.9	9.2
	Sandfill1 Test Pit	9	38	25.7	12.6	12.6	39.4	21.5
	Sandfill 2 Test Pit	5	10.1	6.8	3.3	3.3	2.2	3.0
	Sandfill 3 Test Pit	7	162.6	110.1	53.8	53.8	27.8	45.1
	Pond 1 and 2 Soil Boring and Test Pit	14	116.7	79.0	38.6	38.6	71.2	49.5
	Poind 3/3a Soil boring and Test Pit	14	23	15.6	7.6	7.6	3.4	6.2
	Sediment Pad soil boring and test pit	9	161	109.0	53.3	53.3	70	58.9
	NEMSA Test Pit	13	121.4	82.2	40.2	40.2	45	41.8
	Boneyard Test Pit	11	46.2	31.3	15.3	15.3	11	13.9
	Arroyo Soil Boring	30	27.2	18.4	9.0	9.0	16.4	11.5
				Sample (N = 375) average	25.7	25.7	30.7	27.4
				Radionuclide Activity Percentage of Gross Alpha Activity	23.5%	23.5%	28.0%	25.0%

Data Source: Table 3.15 and Table 3.16, NECR Final RSE Report, October 2007

Notes: (1) U-nat activity calculated using 1 mg = 677 pCi conversion factor; (2) U-234 and U-238 activities calculated based on each at 48.89% of U-nat activity

(3) Th-230 activity calculated based on assumption that Gross Alpha activity is from U-234, U-238, Th-230 and Ra-226.

Northeast Church Rock

95% Design Report

Appendix Q:

Dust Control and Air Monitoring Plan

MWH® now part of Stantec

This page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

AMP	Air Monitoring Plan
AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
ARAR	Applicable or Relevant and Appropriate Requirements
CC	Construction Contractor
CFR	Code of Federal Regulations
DQO	Data Quality Objective
GPM	gallons per minute
HASP	Health and Safety Plan
LLD	Lower Limit of Detection
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
mrem	millirem
NMAC	New Mexico Administrative Code
NRC	US Nuclear Regulatory Commission
PTW	principal threat waste
QA	quality assurance
RA	Removal Action
RAO	Remedial Action Objective
RPP	Radiation Protection Program
ROD	Record of Decision
RSO	Radiation Safety Officer
SOP	standard operating procedure
TLD	thermoluminescent dosimeter
TWA	time weighted average
USEPA	US Environmental Protection Agency
µCi/ml	microcuries per milliliter
µR	microroentgen

Q.1 INTRODUCTION

This appendix to the Northeast Church Rock 95% Design Report presents requirements and protocols for dust control and air monitoring at the Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site).

This appendix:

- Demonstrates that the design will attain the applicable standards identified in the Record of Decision (ROD; USEPA, 2013)
- Explains performance requirements for dust control during construction
- Presents methods and protocols for air monitoring during construction, including radiation and dust monitoring

Q.2 PERFORMANCE STANDARDS

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

Table Q.2-1: Performance Standards Applicable to the Dust Control Air Monitoring Plan

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
44	2013 ROD, Section 2.9.5, Transportation	Transportation	Transportation of all mine waste will be transported in such a manner to mitigate the production of dust, including the use of covers and/or dust suppression actions. A transportation plan will be used to identify the routes of travel, times of operation, and traffic rules. Emergency spill containment and cleanup contingencies will also be included in the transportation plan to address mine waste spills.	Dust suppression controls are addressed in this appendix. The transportation plan is included as Appendix M.
30	2013 ROD, Section 2.9.5, Perimeter Air Monitoring	Air Monitoring	Perimeter air monitoring stations will be positioned and operated to monitor emissions during site preparation construction, stockpiling, loading of bulk-carriers, stockpile management, consolidation, cover construction and restoration. Dust suppression controls will be implemented to maintain a safe working environment and to protect human health and the environment.	Air monitoring and dust suppression controls are addressed in this appendix. The transportation plan is included as Appendix M.
9	2015 AOC SOW, Paragraph 24 – Air Monitoring	Air Monitoring	In the Design, Respondents shall include detailed plans and specifications for air monitoring stations to be installed around the perimeter of the SA Site during the response action. Respondents' detailed plans and specifications shall ensure that perimeter air monitoring stations will be positioned and operated to monitor emissions during dust-or emission-generating activities, including site preparation, construction activities, excavation and backfill, stockpiling (staging), loading of bulk-carriers, stockpile management, consolidation, cap construction and regrading. Respondents shall ensure that their detailed plans and specifications also include dust prevention and dust suppression controls that will be implemented to maintain a safe working environment and to protect human health and the environment.	Air monitoring and dust suppression controls are addressed in this appendix.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
49	2013 ROD Table 1	Environmental Monitoring	10 CFR 61.53(c), Environmental Monitoring. Refer to www.ecfr.gov.	Air monitoring to detect the release of radionuclides during construction is addressed in this appendix.

*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)

Q.3 DUST CONTROL PLAN

Dust will be controlled during the Removal Action (RA) using water, dust suppressants, gravel surfacing, and operational controls, as applicable. The Construction Contractor (CC) will be required to prepare and implement a dust control plan tailored to its specific operations prior to any earthwork activities at the Mine and Mill Sites (including borrow areas).

The CC's dust control measures must comply with the maximum nuisance dust levels discussed in Section Q.4. Perimeter air monitoring will be conducted to evaluate dust levels during construction and the CC will be notified if dust levels exceed acceptable limits. The CC will be required to stop work if dust levels are not kept below the levels outlined in Section Q.4. The CC shall use daily field reports to document dust control measures that were implemented and their effectiveness, as well as the details of water usage, storage, and withdrawal.

Q.3.1 Specific Dust Control Measures

The following sections describe dust suppression measures that will be employed for specific construction activities, including:

- Excavation, placement, and grading
- Hauling
- Speed limits
- Screening (separating soil and rock)
- Stockpiles

Q.3.1.1 Excavation, Placement and Grading

Methods and equipment to minimize/control dust generation during earthwork operations will include some or all of the following measures:

- Application of water or other approved dust suppressants to reduce visible dust during execution of work
- Avoidance of excavation or placement of overly dry or fine soils during high wind conditions to the extent practical
- Application of water or other approved dust suppressants to areas where wind can generate dust, including disturbed areas that are not being actively worked
- Use of windrows or other wind break methods
- Maintenance and protection of native vegetation where possible, through minimization of site disturbance
- Stabilization of inactive, disturbed work areas by longer term methods such as matting, tack and mulch, or crusting agents
- Implementation of permanent stabilization on a regular basis when sufficient area exists for application

Q.3.1.2 Hauling

The methods and equipment to minimize/control dust generation during earthwork operations will include some or all of the following measures:

- Application of water or other approved dust suppressants to haul roads to minimize visible dust during hauling
- Application of water during loading
- Wetting or covering loads during hauling

- Street sweeping and/or cleaning as necessary
- Implementing haul road speed limits (see below)
- Limiting access and haul road development to the minimum necessary to execute work

In addition, wet washing or dry brushing of equipment will be conducted as needed to control tracking of impacted material or mud onto roadways. Operators will secure and cover loads on haul vehicles carrying removal materials from the Mine Site.

Q.3.1.2.1 Speed Limits

A speed limit of 20 miles per hour will be implemented on haul and access roads. Speed limit and no-idle zone signs will be posted on on-site roads and haul roads. Lower speed limits may be necessary to control dust depending on actual day-to-day site conditions. Site supervisory personnel will enforce speed limits. Appropriate corrective actions will be implemented if equipment operators are observed to be operating equipment at excessive speeds.

Q.3.1.3 Screening

Material screening operations can be major sources of airborne dust due to the inherent nature of the size reduction and segregation processes. Dust from screening operations will be controlled using water trucks, water sprays, and/or manned water hoses.

Q.3.1.4 Stockpiles

Temporary stockpiles may be required for borrow and imported materials. During active stockpile construction, water will be applied directly to the stockpiles by spraying with hoses and water truck sprays.

Principal threat waste (PTW) stockpiles will require more robust dust control than water or chemical agents. Active stockpile areas can be effectively managed for dust control during placement using water and small tracked equipment for moderate compaction. Water is also effective for dust control during excavation and loading. Inactive PTW stockpiles will require a membrane cover. There are many effective alternatives for this application and the CC will be required to submit for approval the cover materials and system it will use to manage the PTW stockpiles. The CC will be required to demonstrate that its proposed cover system will be stable during reasonably anticipated high wind events.

Q.3.2 Water Management

The CC will have a minimum of two water trucks on-site to spray haul roads, excavation areas, placement areas, and borrow areas for dust control. Due to the potential for dry and windy conditions, work areas will likely need to be wetted regularly for dust control. Allowing a contractor to move water trucks between the Exclusion Areas and Support Areas for daily dust control operations would require decontamination and could result in insufficient dust control in either or both areas. Therefore, dedicated water trucks will be required for work conducted in contaminated and non-contaminated areas. The CC will employ the appropriate number of water trucks to suit its operations.

The Mill Site well will supply water for dust control as well as for decontamination and sanitary uses. Well details and location information are presented in Appendix B.

A typical haul road can be expected to require 25 to 50 gallons per 1,000 square feet per hour for dust control during summertime conditions, such as can be expected at the Mine and Mill Sites (Tannant and Regensburg, 2001). Additional dust control or construction suppression water will be required for excavation, placement, compaction, and stockpiling activities. Decontamination and domestic water demands are also considered. Table Q.3-1 provides estimates of daily dust control water demand during construction and the required storage capacity to meet this demand without the use of supplemental dust control measures. Table Q.3-2 provides estimates of daily dust control water demand during construction and the required storage capacity to meet this demand with the use of supplemental dust control measures to reduce water consumption. The calculation brief for dust control water demand is presented in Attachment Q.1.

Table Q.3-1: 95% Design Estimate of Dust Control Water Demand and Required Storage Without Supplemental Dust Control Measures

Dust Control Area Construction Water Demand	Estimated Hourly Demand (gal/hr)	Required Storage and Well Production	
		40-Hour Week*	50-Hour Week**
All Areas	22,773 (380 GPM)	231,000 gallon storage (11) 21,000 gallon tanks 79 GPM well yield	295,000 gallon storage (15) 21,000 gallon tanks 102 GPM well yield
Dust Control Water		*40-hour week is (5) 8-hour shifts **50-hour week is (5) 10-hour shifts Well Pump Requirements: Max TDH: 529 Feet Required Pump HP: 16 - 21 4- to 6-inch discharge pipe diameter	
Mine Waste Haul Roads	10,809		
Borrow Haul Roads	2,498		
Yards	275		
Excavation/Placement/ Inactive Areas	1,200		
Operational Water			
Compaction Control	6,825		
Decontamination and Domestic Water	166		
Evaporation Pond Wetting	1,000		

GPM – gallons per minute

Table Q.3-2: 95% Design Estimate of Dust Control Water Demand and Required Storage with Supplemental Dust Control Measures

Dust Control Area	Estimated Hourly Demand (gal/hr)	Required Storage and Well Production	
		40-Hour Week*	50-Hour Week**
All Areas	18,417 (307 GPM)	187,000 gallon storage (9) 21,000 gallon tanks 64 GPM well yield	240,000 gallon storage (12) 21,000 gallon tanks 82 GPM well yield
Dust Control Areas		*40-hour week is (5) 8-hour shifts **50-hour week is (5) 10-hour shifts Well Pump Requirements: TDH: 550 Feet Required Pump HP:13-17 4- to 6-inch discharge pipe diameter	
Mine Waste Haul Roads	7,154		
Borrow Haul Roads	1,796		
Yards	275		
Excavation/Placement/ Inactive Areas	1,200		
Operational Water			
Compaction Control	6,825		
Decontamination and Domestic Water	166		
Evaporation Pond Wetting	1000		

GPM – gallons per minute

The on-site well currently yields between 45 and 67 GPM depending on operating conditions. As discussed in Appendix B, mechanical upgrades will be included in an early phase of the RA to increase yield to meet construction demand. Construction operations are likely to be constrained by water production and storage capacity as indicated in Tables Q.3-1 and Q.3-2. Alternative methods of dust suppression (e.g., use of road salts, resin modified emulsions, and/or biodegradable oils) on haul roads may be proposed by the CC to reduce water use or to increase working hours. The RA schedule in Appendix K is based on a 40-hour work week to account for the water production constraints indicated in Tables Q.3-1 and Table Q.3-2.

This 95% design assumes that 21,000-gallon closed-top portable water tanks, or similar, will be placed in the former Mill Site Yard and connected to the well with temporary piping. Sufficient space is indicated on the Drawings to accommodate each of the storage scenarios indicated above. Piping and layout configurations will be determined by the CC. Closed-top tanks are preferable to a water management pond because they offer scalability and eliminate water losses from evaporation. Well testing to confirm production capacity and determine necessary mechanical upgrades prior to commencement of the RA will be required. Water storage capacity and the RA schedule will be revised accordingly based on the outcome of this well testing and production evaluation.

Q.4 AIR MONITORING PLAN

The Air Monitoring Plan (AMP) establishes air monitoring, sampling and analysis protocol during construction activities to demonstrate protection of individual members of the public that meets the dose limits defined in 10 CFR 20, Appendix B, Table 2. To achieve this, air monitoring will be conducted at upwind and downwind locations for internal and external radiation. The proposed locations are shown on Figure Q.4-1. Based on the most recently available (2012) annual wind rose from the weather station at the Gallup, NM Municipal airport, as shown in Figure Q.4-1, the predominant wind direction in the region is from the southwest. The air monitoring stations will be placed as described below:

- Two Mine Site downwind air monitoring stations will be placed to account for occasional shifts in the wind direction throughout the day (one near each residence downwind of the Mine Site, which are located generally northeast of the excavation areas)
- One downwind air monitoring station will be placed northeast of the Repository at the Mill Site tailings impoundment
- One downwind air monitoring station for dust monitoring will be placed northeast of the borrow area
- One upwind (background) air monitoring station will be placed south of the Mine and Mill Sites

Occupational air monitoring for site workers is addressed in the RA Health and Safety Plan (HASP – Appendix L).

The methods that will be used to monitor internal and external radiation exposure are described in the Standard Operating Procedure for Perimeter Airborne Particulate Monitoring, which is included as Attachment Q.2 and is discussed below.

The AMP will also include monitoring for respirable dust according to U.S, Environmental Protection Agency's (USEPA's) Primary National Ambient Air Quality Standard. Respirable dust will be monitored during construction to determine the effectiveness of dust control measures. Records of air monitoring implemented during the RA at the Mine and Mill Sites will be provided with the RA Final Construction Report.

Q.4.1 Radiation Monitoring

Perimeter air monitoring for internal and external radiation exposure to individual members of the public will be conducted using the methods described here, and as summarized on Table Q.4-1. To evaluate the potential internal radiation exposure to the public, air particulates will be collected on a 47-mm Type A/E glass fiber air filters using air samplers (e.g., RAS-2 or equivalent), as specified in Attachment Q.2. The loaded filter will be counted on-site for gross alpha activity after allowing at least 72 hours for decaying of the alpha emitting radon progeny collected on filters from ambient air. Individual airborne concentrations will be determined for U-234, U-238, Ra-226, and Th-230 from their activity fraction of the gross alpha activity of dust material, which has the potential for becoming airborne. Since these radionuclides are in secular equilibrium in uranium ore dust, the individual radionuclide airborne concentration will be determined by multiplying the airborne gross alpha activity by 0.25. The net airborne concentrations (downwind concentrations minus the background concentrations) will be compared to the air concentration values specified in Table 2 of Appendix B to 10 CFR Part 20. These calculations can be conducted following counting of the air sample filter, as needed for assessing effectiveness of control measures. An initial 24-hour decayed count of the loaded filters may be performed for informational purposes only to facilitate any operational adjustments needed at the beginning of the removal action. Final analysis will be performed after 72 hours. For the purpose of demonstrating compliance with the airborne effluent concentration limits, net concentrations will be averaged quarterly, but not for longer than a yearly period. The effluent concentration limits for assessment and control of dose to the public are based on annual dose limit as specified in 10 CFR 20, Appendix B, Table 2, thus the compliance with the limit could be demonstrated by yearly average of the concentrations. The quarterly average is used for the exposure control measure, which would be a conservative approach.

To evaluate potential internal airborne radon and radon progeny concentrations, track etch radon monitors will be continuously exposed at the perimeter air monitoring stations and submitted for laboratory analysis on a quarterly basis. The track etch monitors will be analyzed by the manufacturer quarterly or at the end of the project, whichever is shorter.

To evaluate potential external radiation exposure, environmental thermoluminescent dosimeters (TLDs) will be exposed continuously at the perimeter air monitoring stations and will be submitted for laboratory analysis on a quarterly basis. Until the TLD results have been received from the laboratory, external exposure from gamma radiation will be estimated based on area exposure rate field measurements using a calibrated micro-R-meter. This will be done weekly, or less frequently, based on changes in the gamma radiation source as determined by the Radiation Safety Officer (RSO).

The results and measurements will be compared against the limits presented in Section Q.4.1.2. If exceedances of the limits are observed, construction will stop, USEPA will be notified, and construction will not resume until the cause(s) for the exceedances were identified and rectified. The results of these monitoring activities will be transmitted to the USEPA with the monthly status reports.

Table Q.4-1: Summary of Perimeter Air Monitoring Plan

Type	Instrumentation	Location[1]	Frequency	Action Level	Analysis
Radiation Monitoring					
Internal Radiation	RAS-2 Sampling pump with 47-mm Type A/E glass fiber filter	1 upwind and 3 downwind	5 days/week the week for the first week, thereafter 3 days or less per week based on monitoring results.	U-234, U-238, Ra-226, and Th-230, air concentration values as specified in 10 CFR 20, Appendix B, Table 2 (annual total effective dose equivalent of 0.05 rem)	Analyzed by RSO using an Alpha Radiation Counting Instrument, such as L2929/43-10-1
Internal Radiation	Landauer Radtrak Alpha-track detector	1 upwind and 3 downwind	As above, then continuously during construction.	Rn-222 dose limits as specified in 10 CFR 20, Appendix B, Table 2	Analyzed by manufacturer quarterly or at end of project
External Radiation	Landauer InLight Dosimeter	1 upwind and 3 downwind	Continuously for duration of project.	Dose limits as specified in 10 CFR 20.1302(b)	Analyzed by manufacturer on a quarterly basis
External Radiation	Ludlum Model 19 Micro R Meter	1 upwind and 3 downwind	Estimate exposure rate weekly	Dose limits as specified in 10 CFR 20.1302(b)	Estimated by RSO
Airborne Dust Monitoring					
Airborne Dust	Model 8520 Dustrack Aerosol Monitor	1 upwind and 4 downwind	Starting 2 days prior to construction, 24 hrs/day for the first 3 days of significant earthmoving activities, then continuously during working hours thereafter.	24-hr TWAs for PM10 = 150 $\mu g/m^3$ & PM 2.5 = 35 $\mu g/m^3$ (40 CFR 50)	Direct read

Notes:

1. The downwind perimeter air monitoring location may be adjusted based on wind conditions and daily activities. The radtrak and dosimeter will be placed at fixed locations for the duration of construction.

2. TWA = time weighted average

Q.4.1.1 Background Monitoring

Mobilization for construction is expected to take approximately two to four weeks, with minimal earth moving activities occurring the first week. Mobilization activities will include fence removal, installation of erosion and sediment control measures, and vegetation removal. Baseline perimeter monitoring will be conducted the week prior to the start of earthwork, including the following:

- Airborne dust monitoring will be conducted for a minimum of two days prior to beginning earthwork
- Dust monitoring will be conducted 24 hours/day for the first 3 days of significant earthmoving activities (e.g., excavation/hauling) and then during working hours for the remainder of construction

Background airborne radionuclide concentrations for internal radiation exposure monitoring will simultaneously be conducted with downwind monitoring at the frequency specified in Section 4.1.4.1. Results of initial monitoring will be reviewed to evaluate whether adjustments need to be made to construction methods to ensure public and worker safety.

Q.4.1.2 Radiation Criteria

The individual airborne concentrations obtained from the gross alpha activity counts and estimates from the track etch monitors will be reviewed to assess compliance with the following airborne effluent concentration limits for Y lung classification averaged over a year. These airborne effluent concentrations, if inhaled continuously over the course of a year, will produce a total effective dose equivalent of 0.05 rem. This total dose equivalent coincides with the annual internal radiation dose limits for individual members of the public as specified in 10 CFR § 20.1302(b) Appendix B, and New Mexico Administration Code (NMAC) 20.3.4.414.

- U-234, Y: 5.0E-14 µCi/ml
- U-238, Y: 6.0E-14 µCi/ml
- Ra-226, W: 9.0E-13 µCi/ml
- Th-230, Y: 3.0E-14 µCi/ml
- Rn-222 w/decay products 1.0E-08 µCi/ml

The airborne gross alpha activity at the Mine Site is expected to be from uranium ore dust. Thorium compounds in the uranium ore dust are likely to be insoluble oxides, which would fall under yearly lung classification as noted for thorium in the radionuclide table of Appendix B of 10 CFR Part 20. Therefore, 3.0E-14 µCi/ml airborne effluent concentration limit for Y Class is appropriate. In order not to exceed the effluent concentration limit of 3.0E-14 uCi/ml, the gross alpha activity would have to be less than 1.2E-13 µCi/ml, since Th-230 would represent 25 percent of the gross alpha activity. The 1.2E-13 µCi/ml gross alpha activity limit will assure that none of the above radionuclide effluent limit is exceeded. The Rn-222 limit for the class “with daughters removed” is used because the track etch radon monitor is equipped with a filter that removes the daughters prior to the measurement.

Q.4.1.3 External Radiation Criteria

Quarterly TLD laboratory results and weekly field gamma results will be reviewed by the RSO to assess compliance with the following external radiation dose limits for individual members of the public as specified in 10 CFR 20.1301 and NMAC 20.3.4.413 (see Table Q.4-1):

- Total effective dose equivalent of 0.1 rem (100 mrem) per year to individual members of the public
- Maximum dose rate of 0.002 rem/hour and 0.05 rem per/year in the unrestricted area from external radiation sources

If a member of the public enters a controlled area outside the restricted area, the above dose limits will apply.

Q.4.1.4 Monitoring Methods

Q.4.1.4.1 Internal Radiation

In order to demonstrate compliance with the dose limits, monitoring will be conducted for:

- Airborne gross alpha activity from air particulate inhalation
- Airborne radon and radon progeny inhalation

Airborne gross alpha activity will be monitored by collecting grab air particulate samples, approximately 8-hour (the potential maximum time of exposure based on the construction activities) at the monitoring stations shown on Figure Q.4-1 for field analysis at locations both downwind and upwind of the construction activities using air sampler, such as an Eberline RAS-2 (see Table Q.4-1). The air sampling flow rate, sampling time, and sample counting time will be determined to meet required Lower Limit of Detection (LLD) for the most restrictive effluent limit. Consistent with the prior Interim Removal Actions, air samples will be collected 5 days/week during the first week of excavation activities. After the first five days, sampling frequency will be reduced to three days/week if the monitoring results show airborne concentrations less than 0.25 times the most restrictive effluent limit. If the airborne concentrations are sustained at less than 0.25 times the most restrictive effluent limit, air sampling frequency will be reduced to a frequency of once per week. If sampling data indicate that gross alpha activity is greater than 0.25 times the most restrictive effluent limit, air sampling will be increased as necessary. The monitoring results will be reviewed to evaluate effectiveness of control measures and whether any adjustments need to be made to construction methods to ensure public and worker safety. The increased air sampling will be maintained until the airborne concentrations decline back to less than 0.25 of the limits. Gross alpha activity measurements will be measured at one location upwind of the construction activities to establish background and four downwind locations (See Figure Q.4-1). Two locations are downwind of the Mine Site, one is downwind of the proposed Repository at the tailings disposal area to monitor soil placement activities, and one is downwind of the borrow areas located north of the TDA.

To evaluate potential internal radiation exposure, the RAS-2 air filters will be counted on-site for gross alpha activity from uranium, Ra-226 and Th-230 after radon progeny from the particulate sample has decayed, generally 72 hours, using an Alpha Radiation Counting Instrument such as Ludlum 2929/43-10-1.

Airborne radon and radon progeny concentrations will be monitored continuously at the monitoring stations for the duration of excavation and soil placement activities with track etch radon monitors at one upwind and two downwind locations: one at the edge of NECR-1 and a second downwind of the Tailings Disposal Area; these locations will be fixed for the duration of construction activities. Track etch monitors will be replaced quarterly or at the end of the RA, and analyzed by the manufacturer (Landauer, Inc.).

Q.4.1.4.2 External Radiation

To evaluate external radiation exposure, both TLDs and direct gamma radiation exposure rate field measurements will be used. Exposure rate measurements will be made at approximately three feet from the ground surface, waist level, using a microroentgen (μR) gamma survey meter. Exposure rate measurements will be performed weekly at the location of the environmental TLDs and at additional perimeter locations based on construction activities and environmental conditions.

Environmental TLDs will be used continuously at monitoring stations for the duration of excavation and soil placement activities at upwind and downwind locations, as shown on Figure Q.4-1. Locations will be fixed for the duration of construction activities. The TLDs will be analyzed by the manufacturer on a quarterly basis.

Q.4.2 Nuisance Dust Monitoring

The perimeter AMP will include monitoring for respirable dust (PM10 and PM2.5), as per USEPA's Primary National Ambient Air Quality Standard (40 CFR 50) during this project, especially during the beginning stages of construction to determine any long-term measures that may be needed to protect employee health. Monitoring will be conducted at an upwind location and at four downwind locations (see locations on Figure Q.4-1). Dust monitoring will be conducted using a Model 8520 Dustrack Aerosol Monitor and will be conducted continuously during working hours (see Table Q.4-1).

The results of the dust monitoring will be reviewed by the RSO and assessed to determine potential health hazards or risks. Respirable dust standards shall be USEPA's Primary National Ambient Air Quality Standards at 24 hour Time Weighted Average (TWA) of:

- PM10: 150 micrograms/cubic meter ($\mu g/m^3$)
- PM2.5: 35 $\mu g/m^3$

Personal air space monitoring necessary for General Electric/United Nuclear Corporation employees and the CC's employees will be performed in accordance with their respective HASPs.

Q.5 QUALITY ASSURANCE QUALITY CONTROL

Quality assurance aspects, including Data Quality Objectives (DQOs) specified in Appendix T-3 Quality Assurance Project Plan, applicable to the air monitoring program will be implemented to ensure that it is reasonably valid and of defined quality. The quality assurance (QA) program for airborne effluent monitoring during the Mine Site RA will be consistent with the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 4.15, Quality Assurance for Radiologic Programs - Effluent Streams and Environment (NRC, 2007). The Regulatory Guide is applicable to effluent monitoring performed for assessing compliance with dose limits for individual members of the public in accordance with 10 CFR 20, Appendix B, as specified in Section Q.4.1. The following presents specific QA elements that will be developed and implemented to ensure the quality of data/results for airborne radiological effluent monitoring program:

Q.5.1 Organization

The organization as it relates to the management and operation of the air monitoring program, including QA policy and functions, is defined in the Radiation Protection Program (RPP), which is included in the HASP for the Mine Site RA. The RSO will be responsible for the review and approval of written procedures and the preparation, review and evaluation of monitoring data and reports. The RSO and his/her staff performing QA functions will have the authority and organizational freedom to identify quality problems; to initiate, recommend, or provide solutions; and to verify implementation of solutions. Reporting will be at a management level that is independent of activity performance, costs, and schedule. Qualification of the RSO and his staff will be consistent with U.S. NRC Regulatory Guide 8.31.

Q.5.2 Operating Procedures

The air sampling and data generation, dose calculation/assessment, sample management, sample (filter) counting, reporting and filter storage/disposal procedures are described in Attachment Q.2, Standard Operating Procedure (SOP) for Airborne Particulate Monitoring, and in the RPP.

Q.5.3 Quality Control in Air Sampling and Analysis

The SOP in Attachment Q.2 specifies the measurement of sampling flow rates, volume, and calibration of air samplers with rotometers and the use of the rotometers to perform daily flow rate checks. The use of glass fiber filter papers will be used to efficiently collect air particulates. Air sampler with adequate airflow to collect sufficient air volume to meet minimum detectable concentration will be used.

The loaded air particulate filter paper will be counted using an alpha counting system calibrated using a certified source annually. Daily efficiency and operational function checks will be performed as specified in the SOP. A replicate count of 10 percent of the sample loaded filter paper will be performed.

Q.5.4 Verification and Validation

The RSO will review air sampling and counting data to validate the results. As indicated in Section Q.4, compliance with dose limits for individual members of the public will be demonstrated by comparing the airborne effluent concentrations with applicable effluent concentration limits. The RSO will perform periodic audits of the air sampling and filter counting system to verify that the air monitoring program is implemented properly. Any deficiency found will be corrected and documented.

Q.5.5 Records

All records, including forms generated as a result of this procedure, shall be maintained throughout the duration of the project and then retained in the permanent project file.

Q.6 GREEN AND SUSTAINABLE REMEDIATION CONSIDERATIONS

USEPA's Superfund Green Remediation Strategy Policy (USEPA, 2010) requires incorporation of BMPs for green remediation as listed in ASTM-E2893-16 (ASTM International, 2016). 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 Borrow Areas 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).

GSR considerations as applicable to dust control focus on preservation of water as on-site water resources are restricted to a single well and importation of water from off-site sources would not be in-line with the GSR core elements, specifically: minimizing total energy use, air pollution, greenhouse gas emissions, water use and impact to water resources (ASTM 2893-13). Within the context of dust suppression, water conservation will be achieved by the following methods as described in Sections Q.3.1 & Q.3.2:

- Utilization of approved dust suppressants, such as magnesium chloride
- Enforcing maximum speed limit of 20 MPH
- Maintenance and protection of native vegetation where possible, through minimization of site disturbance
- Stabilization of inactive, disturbed work areas by longer term methods, such as matting, tack and mulch, or crusting agents
- Implementation of permanent stabilization on a regular basis when sufficient area exists for application.

Through these methods it is anticipated that no off-site water will be utilized and therefore no additional greenhouse emissions or fuel will be required to achieve dust suppression goals.

Q.7 REFERENCES

ASTM International, 2016. ASTM Standard E2893-16, “Standard Guide for Greener Cleanups,” ASTM International, West Conshohocken, PA, 2016, DOI: 10.1520/E2893-16E01, www.astm.org.

Tannant, D.D. and B. Regensburg, 2001. Guidelines for Mine Haul Road Design.

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

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

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

U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research, 2007. Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs - Effluent Streams and Environment. Revision 2. July.

FIGURE

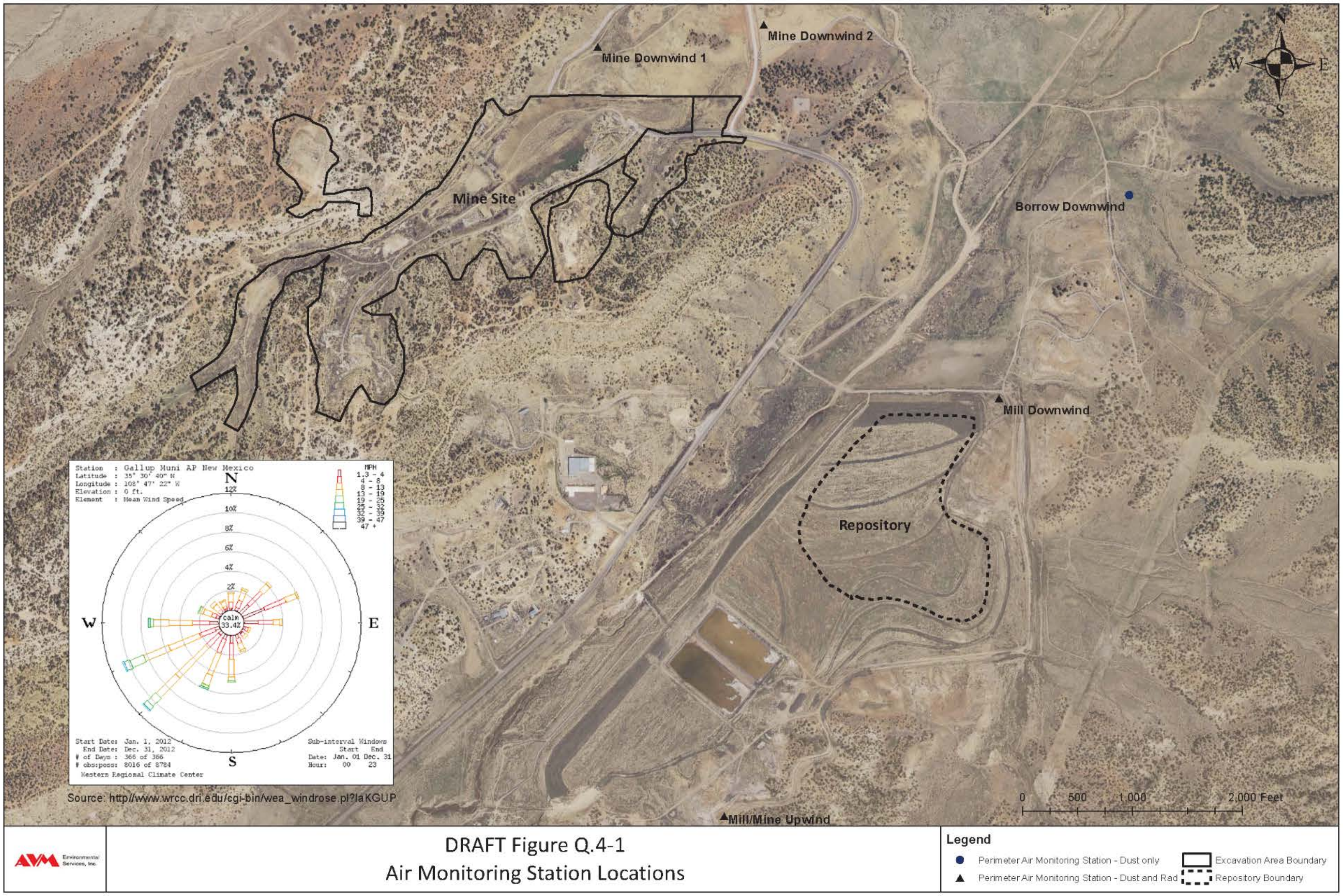


Figure Q.4-1: Air Monitoring Station Locations

ATTACHMENT Q.1
Calculation Brief - Dust Control Water Balance

MWH now part of Stantec

CALCULATIONS

Client:	General Electric/United Nuclear	**Sheet:**	1 of 3
Project:	NECR 95% Design	**Date:**	10/24/17
Description:	Dust Control Water Balance	**Job No:**	10508639

ATTACHMENT Q.1: DUST CONTROL WATER BALANCE

Revisioning					
Rev.	**Date**	**Description**	**By**	**Checked**	**Date**
0	06/06/16	Preliminary (30%) Design	J. Coleman	J. Cumbers	06/08/16
1	07/01/16	Preliminary (30%) Design	J. Coleman	J. Cumbers	07/08/16
2	10/24/17	95% Design	J. Coleman	J. Cumbers	10/24/17

Revisions

Issue Date	Description
7/1/16	Recalculated including water demand for compaction of mine waste and cover material.
10/24/17	Recalculated with additional demand per EPA comments on 30% design and additional well information.

Location and Format

Electronic copies of these calculations are located on the project teamsite.

The following calculations were generated using the following software:

Microsoft Excel 2013

Table of Contents

Client:	General Electric/United Nuclear	**Sheet:**	2 of 3
Project:	NECR 95% Design	**Date:**	10/24/17
Description:	Dust Control Water Balance	**Job No:**	10508639

Objective

The objective of these calculations is to estimate daily water needs for dust control and verify the well yield and storage capacity required to provide adequate dust control water for the project.

Background

The onsite well was drilled in 1976 to 1,580 feet below ground surface (bgs) and the bottom of the well casing is set at 1,490 feet bgs; however, a pipe and pump became lodged in the well years ago and they are blocking the deeper part of the well. The well is constructed with an 8-inch diameter steel casing and is screened in a 20- and a 40-foot interval between 1,390 and 1,475 feet bgs. The existing well pump has a 2-inch discharge pipe, is 20HP, 3-Phase 480V, and is located about 700 feet bgs. The static water level is approximately 410 feet bgs. When pumping between 45 and 67 gallons per minute (gpm) the water level drops to about 525 feet bgs. Site personnel have reported the on-site well is capable of producing a constant flow (pumped 24/7 for weeks) of about 47 gpm when pumping water to the evaporation ponds over 1,000 feet away.

Calculations indicate that 100 gpm would be achieved with a 20HP pump and either a 4- or 6-inch discharge pipe.

Applicable Codes and Standards

The estimated dust control requirements for haul roads are taken from “Guideline for Mine Haul Road Construction” by D.D. Tannant and B. Regensburg, 2001. Excerpts attached.

Methods

Simple spreadsheet daily water balance.

Assumptions

The following assumptions were used:

Compaction water required at a rate of about 3 percent by mass of placed material based on sampling and analysis of mine and borrow materials.

Hourly Haul Road Dust Control Water Application: 25 Gal/KSF (LOW); 50 Gal/KSF (HIGH). See reference (KSF = 1000 SF).

Assume a high application rate is needed for the Mine Waste Haul Road as this will be a high visibility road that crosses a public highway. Low application rate used in mine area assuming lower speeds, distributed traffic, opportunity for other dust control measures (vegetated roads). Assumes low water use for borrow roads to control nuisance dust only. Additional assumptions listed in calculation tables.

Water balance calculations assume pumping 7 days per week to maintain storage.

Calculations

See Attachments A and B for water demand and storage.
See Attachment C for compaction water calculation.
See Attachment D for Total Discharge Head (TDH) calculation.

Max TDH = 529 Feet. Water Horsepower = Q(gpm) x H(ft)/3,960. Q=102 gpm; H =529; WHP = 13.62 HP.

Pump HP Required = WHP/pump efficiency (75%)/motor efficiency (90%) = 13.62 / 0.75 / 0.9 = 20.2 HP

Results

If no additional dust suppressants are used, a 40-hour work week would require an estimated well production of 79 gpm and a 50-hour work week would require 102 gpm. These scenarios would require eleven and fourteen 21,000-gallon tanks for storage respectively, or 220,000 and 282,000 gallons of storage.

If additional dust suppressant additives are incorporated, the required well productions would be reduced to 64 gpm for a 40-hour week and 82 gpm for a 50-hour work week. Storage capacity of between 186,000 gallons and 240,000 gallons is required for these scenarios; which corresponds to nine and twelve 21,000-gallon tanks, respectively.

There is sufficient space in the Mill Yard for the required water storage scenarios.

A 20HP pump with 4-inch or 6-inch discharge piping is capable of producing 102 gpm.

Conclusions

The construction schedule is based on a 40 hour per week operation. The Construction Contractor can reduce water needs with the use of alternate dust suppression techniques (i.e. additives). A higher discharge pump and larger discharge piping will produce adequate water supply.

Import of water is not a viable option.

Attachments

Attachment A – Water balance for water only (no supplemental dust control)
Attachment B – Water balance with supplement dust control
Attachment C – Water for Compaction
Attachment D – Total Discharge Head Calculations
Attachment E – Typical water storage tank
Attachment F – Excerpt from *Guidelines for Mine Haul Road Design* (2001).

References

Tannant, D.D. and B. Regensburg, 2001. *Guidelines for Mine Haul Road Design*.

ATTACHMENT Q.2
SOP – Airborne Particulate Monitoring

Attachment Q.2
STANDARD OPERATING PROCEDURE
AIRBORNE PARTICULATE MONITORING
AVM Environmental Services, Inc.

1.0 SCOPE

1.1 Purpose

This procedure describes the method for determining the concentration of airborne radioactive particulate at the upwind and downwind boundary areas during the Removal Action at the North East Church Rock site activities. The procedure is intended to:

1.1.1 Demonstrate compliance with the intake limits for the general public specified in the Radiation Protection Program.

1.1.2 Determine whether exposures to radioactive materials are being maintained As Low As Reasonably Achievable (ALARA) as stated in the Radiation Protection Program.

1.2 Applicability

This procedure applies to all personnel under Radiation Safety Officer (RSO) supervision performing airborne particulate monitoring during the RA at NECR.

2.0 REFERENCES

2.1 10 CFR 20, "Standards for Radiation Protection"

2.2 NRC Regulatory Guide 8.30, Health Physics Surveys in Uranium Mills

2.3 NRC Regulatory Guide 8.25, Calibration and Error Limits of Air Sampling Instruments for Total Volume of Air Sampled

3.0 EQUIPMENT AND MATERIALS

3.1 Air Sampler: Eberline RAS-II Low Volume Air Sampler (40 – 60 liters per minute) or similar equipped with rotometer.

3.2 0.45 micron particulate GF 47 mm filter media. Envelopes for Filter Storage or Petri dishes.

3.3 Alpha radiation Counting Instrument (Ludlum 2929 with 43-10-1 detector or similar)

3.4 Certified Th-230 1.85 inch disc source

3.5 Air Particulate Sampling Field Data Form (Attached or equivalent).

3.6 Alpha-Beta Counting System Function Check Form (Attached or equivalent)

4.0 AIR SAMPLE COLLECTION INSTRUCTIONS

4.1 Select a suitable upwind or downwind location for sampling. The filter head should be situated at approximately five feet from the ground surface.

4.2 Select a calibrated regulated air sampler (RAS-II). Install a 0.45 micron glass fiber filter in the filter head. The sampling pump roto meter should be cross calibrated at least annually or when repaired.

4.3 Determine the time and flow rate necessary with consideration of counting instrument background count rate, efficiency and sample counting time to sample a volume sufficient to ensure that a required lower limit of detection (LLD) will be met.

4.4 Turn on the air sampling unit, adjust the flow rate to the desired calibrated flow rate, and record the starting time, flow rate, vacuum, totalizer flow meter reading, and initials of the technician on a field data sheet. Record any other pertinent comments.

4.5 Periodically check air sampler unit for proper operation.

4.6 After the minimum collection time to meet the LLD requirement in Step 4.3, record ending flow rate, vacuum and time, and turn off the air sampling unit. Remove the air filter and place in a sample envelope or Petri dish and label it. Record sampling data in the attached Air Particulate Sampling Field Data /Form

5.0 FILTER COUNTING INSTRUCTIONS

The counting efficiency for alpha radiation emitters are energy dependent. The alpha radiation energies of these radionuclides (U-234 @4.72 & 4.77 MeV, U-238 @4.15 & 4.20 MeV, Th-230 @4.62 & 4.69 MeV and Ra-226 4.60 and 4.78) MeV are within a tight range indicating they essentially have similar counting efficiencies. The Ludlum Measurements, Inc (LMI), the instrument manufacturer measured and reported 4π efficiencies of 36% for U-nat (U-238, U-234 and U-235), 38% for Th-230 and 39% for PU-239 (5.2 MeV) using certified sources. Ra-226 has alpha radiation energy of 4.60 & 4.78 MeV, similar to Th-230 @ 4.62 and 4.69, thus the Ra-226 alpha radiation would have similar counting efficiency as Th-230. The efficiencies for U-238, U-234, and Ra-226 alpha radiations are essentially the same as Th-230 alpha radiation. Therefore, using Th-230 efficiency would be appropriate to determine gross alpha activity from these radionuclides.

An initial 24-hour or 48-hour decayed count may be performed for informational purposes only. The only way to obtain true gross alpha activity for U-234, U-238, Th-230 and Ra-226 for any exposure assessment is to allow alpha activity from radon progeny to decay, for at least 72 hours prior to counting the air filters. Please note that any alpha activity from the 24 hour count will be significantly overestimated, specifically depending on ambient radon progeny concentrations.

5.1 The alpha radiation counting system should at least annually with operational function check parameters (HV, threshold, efficiency, background counts, etc) established following the calibration.

5.2 The alpha radiation counting system should be calibrated at least annually with operational function check parameters (HV, threshold, efficiency, background counts, etc) established following the calibration. Perform and record function check of the counting system each day prior to use.

5.3 Allow a minimum of 72 hours from the end of sample collection before counting sample for decaying off the alpha emitting radon progeny collected on filters from ambient air. The LLD for gross alpha activity should be <1.2 x 10^{-13} µCi/ml, 10% of gross alpha activity limit of1.2 x 10^{-14} µCi/ml for the final counting based on the most restrictive effluent concentration limit 3.0 x 10-14 μCi/ml (Y) of Th-230, which would be 25% of the gross alpha activity.

5.4 Count the air sample filter and background filter (unexposed blank filter paper) for at least 60 minutes, or the necessary time period based on the volume of the air sample to meet required LLD for alpha activity counts using the Ludlum 2929 scaler/43-10-1 detector.

5.5 Record the background and air sample filter counts and the counting data in attached Air Particulate Sampling Survey Report/Form. Calculate the airborne gross alpha activity, uncertainty and Lower Limit of Detection as shown in the Air Particulate Sampling Survey Report/Form. After counting, store all loaded filters in appropriately labeled containers.

Calculate the individual radionuclide (U-234, U-238, Th-230 and Ra-226) concentrations from gross alpha activity based on the site specific activity fraction ratio, if available. For airborne gross alpha activity from uranium ore dust, use 0.25 fractions for U-234, U-238, Th-230 and Ra-226 individual radionuclide airborne concentration calculation.

6.0 RECORDS

All forms generated as a result of this procedure shall be maintained throughout the duration of the project and then retained in the permanent project file.

AIR PARTICULATE SAMPLING FIELD DATA FORM

Sample #/Dish #________________________ Date:________________________________

SOP:_________________________________ Field Tech:___________________________

Area/Location/Assigned to:____

____

Sampler Used:___________________________ Filter Used:___________________________
Sampler Serial #:_________________________ Vac./Roto. Rdg(start)___________________

Sampling Rate(SR):___________________LPM Vac./Roto. Rdg(stop)___________________

Time Start:______________Stop:_____________Break Time:_____________Elapsed(E):________________(min)
Volume of Air Sampled____(ml)
(SR x E x 1000)

Initial Count

Alpha Counter_____________________________ Efficiency______________________Bkg._____________________

Count Date and Time_________________________________
Gross Alpha Counts__________________________ Count Time____
Bkg. Counts_________________________________ Count Time____
Gross Alpha _________________________________ µCi/mL
LLD_________________________________µCi/mL
% Effluent Concentration Limit__________________

Final Count (at least after 72 hours)

Alpha Counter_____________________________ Efficiency______________________Background_______________
Count Date and Time_________________________________
Gross Alpha Counts__________________________ Count Time____
Bkg. Counts_________________________________ Count Time____
Gross Alpha_________________________________ µCi/mL
LLD_________________________________µCi/mL
%Effluent Concentration Limit____________________

Gross Alpha Activity, µCi/ml = $\dfrac{\text{(Gross cpm–Background cpm)(FA*)}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$

Estimated Error (uncertainty 95%), µCi/ml = $\dfrac{\text{1.96 x (FA*) x [(Gross cpm/t min,Gorss)+(Bkg cpm/t, min Bkg)]}^{0.5}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$

LLD, uCi/ml= $\dfrac{\text{4.66 x (FA*) x [(Bkg counts)}^{0.5}\text{]/t min, Bkg count time}}{\text{2.22E+6 (dpm/µCi) x Eff (cpm/dpm) x Sample Volume (ml)}}$

*Filter Absorption (FA) = 1.25 for glass fiber filters; 1.0 for Cellulose nitrate filters

Ludlum 2929 Scaler/43-10-1 Alpha-Beta Counting System Function Check Form

L2929 /43-10-1

Function Check Source ID: :_________________________________

Acceptable background Count (cp10m) Range (20%) _____________________ to ___________________

Acceptable Source Count (cp10m) Range (20%) _____________________ to ______________________

Date	Physical Check	Cal date	HV Volts	Alpha BKG Counts (CP10M)	Alpha Source Counts (CP10M)	Beta BKG Counts (CP10M)	Beta Source Counts (CP10M)	Within Acceptable Range Y or N	Comments	Tech

Note: (1) Calibration HV set @1000 V

Northeast Church Rock

95% Design Report

Appendix R:

Release Contingency and Prevention Plan

This page intentionally left blank

TABLE OF CONTENTS

TABLES

LIST OF ACRONYMS / ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
CC	Construction Contractor
CFR	Code of Federal Regulations
CS	Construction Superintendent
CSC	Construction Supervising Contractor
FSL	Field Screening Level
GE/UNC	General Electric/United Nuclear Corporation
mg/kg	milligrams per kilogram
Mine Site	Northeast Church Rock Mine Site
NECR	Northeast Church Rock
NRC	Nuclear Regulatory Commission
pCi/g	picocuries per gram
PPE	Personal Protective Equipment
PSO	Project Safety Officer
PTW	Principal Threat Waste
Ra-226	Radium-226
RAO	Remedial Action Objective or Removal Action Objective
ROD	Record of Decision
RSO	Radiation Safety Officer
SOP	Standard Operating Procedure
SPCCP	Spill Prevention Control and Countermeasures Plan
SSO	Site Safety Officer
TC	Transportation Contractor
TBD	to be determined
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency

R.1 INTRODUCTION

This appendix to the Northeast Church Rock 95% Design Report addresses the plan to control and prevent release of mine waste to the environment during handling and transportation. Materials to be disposed of have been classified in the Technical Specifications as defined below and these classifications are used in this appendix:

Principal Threat Waste (PTW): Soils and debris with Ra-226 values greater than 200 pCi/g and/or greater than 500 milligrams per kilogram (mg/kg) of total uranium.

Unclassified Waste: Soils and debris with Ra-226 concentrations above the field screening level (FSL) of 2.24 pCi/g and below 200 pCi/g. Unclassified waste includes surface mine debris and structures, and cleared vegetation from areas subject to excavation of contaminated soils and sediments.

Spill prevention and control on release of hazardous materials related to construction activity will be addressed by the Construction Contractor's (CC's) Spill Prevention Control and Countermeasures Plan (SPCCP) required by the Technical Specifications (Appendix J), or the Transportation Contractor's (TC's) similar plan.

Control of release of sediments in stormwater during the Removal Action is addressed in Appendix E - Stormwater Management Plan.

R.2 PERFORMANCE STANDARDS

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

Table R.2-1: Performance Standards Applicable to the Release Prevention and Contingency Plan

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
44	2013 ROD, Section 2.9.5,	Transportation	Transportation of all mine waste will be transported in such a manner to mitigate the production of dust, including the use of covers and/or dust suppression actions. A transportation plan will be used to identify the routes of travel, times of operation, and traffic rules. Emergency spill containment and cleanup contingencies will also be included in the transportation plan to address mine waste spills.	Dust suppression controls are addressed in Appendix Q. Traffic controls for on-site transport of mine waste from the Northeast Church Rock Mine Site to the Church Rock Mill Site are included in Appendix M.

*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)

R.3 RELEASE PREVENTION

R.3.1 Unclassified Mine Waste Handling and Transport

Unclassified mine waste is to be handled and transported in a manner that prevents release. The following general handling requirements are to be followed:

- Haul trucks will be loaded within the contaminated area of the Northeast Church Rock Mine Site (Mine Site) using loading methods that minimize the need for truck or container decontamination.
- Truck beds on trucks hauling mine waste will be covered when leaving the Mine Site.
- A contamination control point will be employed at both ends of the mine waste haul road to frisk haul trucks and remove any loose material to minimize contamination of the haul road (trucks moving from the Exclusion Areas to the Controlled Area).
- A contamination control system will be used at the haul road crossing of New Mexico Highway 566 (NM 566) as discussed in Appendix M.
- Dedicated trucks will be used for transport of unclassified mine waste. Trucks may not leave the controlled areas of the site without decontamination (refer to Appendix M – Traffic Safety and Security).
- The requirement for the use of respirators during mine waste handling will be determined based on occupational air monitoring and sampling results.

R.3.2 PTW Handling and Transport

PTW is to be handled and transported in a manner that prevents release. The following general handling requirements are to be followed:

- PTW material shall be loaded at the PTW staging area into covered trucks or sealed intermodal shipping containers. The CC shall use loading methods that minimize the need for truck or container decontamination. The CC shall be required to adjust loading methods if, at the discretion of the Construction Supervising Contractor (CSC), excessive contamination of trucks or containers is occurring.
- Any loose material that drops onto the cab, bumpers, running boards, or other exterior surfaces will be removed and placed back on the PTW stockpile. The truck tailgate will be closed and a tarpaulin (or other suitable cover) will be placed over the entire load and adequately secured so that mine waste cannot be released to the environment during transport.
- PTW loading shall not be conducted when conditions are too rainy or muddy to adequately control runoff or contamination within the loading area.
- Loaded trucks or intermodal containers will be inspected by the CC for external contamination prior to staging for transfer to highway vehicles.
- Highway vehicles shall not be allowed to enter the mine Exclusion Areas or the Controlled Area of the Mine Haul Road.
- Speed limits will be established and enforced.
- The requirement for the use of respirators during PTW handling will be determined based on occupational air monitoring and sampling results.

The contract carrier will be responsible for compliance with all applicable laws and adhering to the following procedures and protocols, during transport of PTW from the Mine Site to the disposal or receiving facility. The following general requirements are to be followed:

- 49 CFR 170 through 173 apply to transportation and off-site disposal of the PTW. Highway trucks will be placarded for transportation of low-specific activity radioactive materials in accordance with 49 CFR 172 and manifests will be completed to document contents of each shipment.
- The trailer or container must be kept closed at all times, when containing PTW and when empty, by use of a tarpaulin or other suitable cover. The carrier must ensure that there is no leakage or spillage from the truck trailer. The trailer must remain placarded when it is empty.
- The carrier will inform appropriate Mine Site and receiving facility personnel of the route to be taken from the Mine Site to the disposal or receiving facility.
- Shipments of PTW will be transported without unnecessary delay from the Mine Site to the receiving facility. The carrier may designate suitable locations for temporary storage of vehicles along the route from the Mine Site to the receiving facility if it is necessary to coordinate delivery times at the receiving facility. These “safe havens” are subject to approval by the Mine Site and the disposal or receiving facility.
- Maintaining exclusive use of the transport vehicle for PTW shipment. An unrestricted use release survey will have to be conducted by the receiving facility before the vehicle can be used for other purposes.
- Unloading the PTW shipment at the receiving facility in accordance with the procedures stipulated by the receiving facility.
- Carrying and adhering to an Emergency Response Plan (see Section R.4)
- Verifying that all drivers are properly trained (see Section R.3.3).

R.3.3 Training

Mine site safety personnel will provide training to CC personnel including: basic radiation concepts, dust and contamination control, vehicle scanning requirements, exclusive use transport provisions, and emergency response contact and response information. The training record will be documented and maintained on site. Additional detail regarding on-site safety training is include in Appendix L - Health and Safety Plan.

The PTW TC will be required to provide training to its drivers including job functions to be performed by the employee, emergency response procedures, self-protection measures, and accident prevention methods. A record of current training, inclusive of the preceding three years, will be kept for every employee of the transportation contractor.

Each truck driver and any other carrier personnel involved in the loading or unloading of PTW onto and from the transport vehicle must be trained in the applicable requirements of 49 CFR Parts 390 through 397 and the procedures necessary for the safe operation of the vehicle. Driver training must include the following subjects:

- Pre-trip safety inspection
- Use of vehicle controls and equipment, including operation of emergency equipment
- Operation of vehicle, including turning, backing, braking, parking, handling, and vehicle characteristics including those that affect vehicle stability, such as effects of braking and curves, effects of speed on vehicle control, dangers associated with maneuvering through curves and steep grades, and dangers associated with weather or road conditions that a driver may experience (e.g., storms, high winds)
- Procedures for crossing through tunnels, bridges, and railroad crossings

- Requirements pertaining to attendance of vehicles, parking, smoking, routing, incident reporting, and loading and unloading of materials

The above training is the responsibility of the TC and may be satisfied by compliance with the current requirements of a Commercial Driver's License with a hazardous materials endorsement.

R.4 EMERGENCY RESPONSE (CONTINGENCY)

The Emergency Response Plan provides guidance for dealing with emergencies and shall be implemented immediately whenever there is a release or spill of mine waste material that occurs during the transport of the material. The Emergency Response Plan shall be reviewed and immediately amended whenever:

- The plan fails in an emergency
- Procedures or other circumstances pertaining to the transport of mine waste change in such a way that increases the potential for release of mine waste
- The list of emergency contacts change
- The list of emergency equipment changes

R.4.1 Emergency Contact Information

Emergency Contact Numbers
Ambulance 911
Fire Department 911
Police Department..911
National Response Center .... (800) 424-8802

Table R.4-1: Removal Action Personnel Contact List

Position	Name	Phone Number(s)
GE/UNC Project Manager	TBD	
Site Manager	TBD	
CSC On-site Representative	TBD	
Construction Superintendent (CS)	TBD	
Site Safety Officer (SSO)	TBD	
Contractor Project Safety Officer (PSO)	TBD	
Radiation Safety Officer (RSO)	TBD	
UNC Local Representative	TBD	
UNC Project Manager	TBD	
Transportation Contractor Representatives	TBD	

R.4.2 Scene Assessment and Notifications

Prior to performing any action at an accident, the scene will be assessed for potential hazards including injuries, fires, fuel spills, downed power lines, traffic hazards, and proximity to streams or rivers. Identified hazards are to be avoided and, if possible, abated as soon as possible.

<u>On-Site Incidents:</u>

- Notify the Construction Superintendent (CS) and Site Safety Officer (SSO) immediately.

<u>Off-Site Incidents:</u>

- It is recommended that the driver carry a copy of USDOT's current Emergency Response Guidebook and be trained in its use so that he/she can better identify potential hazards and the appropriate response procedures.
- Notify emergency services immediately.

- Notify TC safety/response personnel.
- Notify the SSO.
- Notify the receiving facility's safety personnel.

R.4.3 Exposure

A cleanup action of low specific activity material such as the PTW will not result in a worker becoming overexposed to radiation, even if the action extends over several work days. Cleanup personnel would adhere to the applicable Radiation Protection Plan for either the Northeast Church Rock (NECR) Site (included in Appendix L) or the receiving site, depending on which personnel respond.

R.4.4 Required Personal Protection Equipment

Level "D" personal protective equipment (PPE) consisting of work pants, sleeved work shirt, and sturdy work boots or shoes is required. Gloves, hard hats, safety glasses, dust masks, and steel-toed safety shoes/boots may be also required as needed.

R.4.5 Response Actions

In the event of a mine waste spill or release, immediately take the following measures to keep the spill from spreading, entering sewer or storm drains, or affecting human health. In all cases caution and common sense must be maintained with the primary goal being to prevent and/or limit personal injury.

The driver, if capable, is responsible for the accident site and related area on public roads or highways until the arrival of the fire department or law enforcement personnel. Initially, reflective triangles, flares, and volunteer flaggers can be used to control traffic until emergency responders arrive. Once the site has been secured and the preliminary investigation is complete, the assigned supervisor of the contracted Emergency Response Team shall be in charge of traffic control and cleanup activities. Professional traffic control measures will be needed for any subsequent clean-up actions.

R.4.5.1 Facility Response

Personnel and clean up equipment from the NECR Site and/or personnel from the receiving facility shall respond as determined during selection of the receiving facility. Response may include, but not be limited to:

- Equipment and personnel dispatched from NECR to cleanup spilled materials and return them to NECR.
- Equipment and personnel sent from the receiving facility to cleanup spilled materials and transport them to the receiving facility.
- Verification survey personnel dispatched from NECR to verify cleanup.

R.4.5.2 Spill Cleanup and Disposal

Because of its potential to cause a fire or contaminate nearby water courses, containment and cleanup of any fuel spills is normally the first priority. Many fire department vehicles carry adsorbents and booms to contain and clean up these types of spills. Response to these type incidents will be as required by the CC's SPCCP required by the Technical Specifications (Appendix J), or the TC's similar plan.

Clean up procedures for spilled mine waste is similar for on-site and off-site incidents. Spilled mine waste, depending on the size of the spill, can be cleaned up with a loader, hand shovels, rakes, and shop brooms. If the spill is large, the material should be transferred directly to another vehicle approved for mine waste haulage. Smaller spills can be placed in barrels or other suitable containers. If windy conditions exist, dust can be controlled with light water sprays; however, large volumes of water that may result in runoff should not be used. If the spill occurs near or within a stream or river, efforts should be made to limit the quantity of mine waste released to the water course.

After visible spilled has been removed, a gamma radiation survey will be conducted to identify residual contamination on ground surfaces. After residual contamination is removed, the area should be rechecked with a gamma radiation survey to verify that the area is at or near background radiation levels. This is normally readily achievable on hard surfaces such as concrete or asphalt. Some over-excavation of underlying soils may be necessary in gravel or grassy areas. If there is a concern regarding the cleanup levels achieved, soil samples may be taken of the contaminated area and a nearby uncontaminated area to establish background levels.

Recovered materials that have been loaded for transport can be released by the assigned cleanup supervisor to be transported to the receiving facility or back to the NECR Site as appropriate. Any materials contaminated with oil or fuel will be containerized and transported to a suitable holding area for later characterization and appropriate disposal.

R.5 REFERENCES

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

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

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

Northeast Church Rock

95% Design Report

Appendix T:

Cleanup Verification Plan

MWH® now part of Stantec

This page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
ARAR	Applicable or Relevant and Appropriate Requirement
EME	EPA Metadata Editor
EDD	Electronic Data Deliverable
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
Mill Site	Northeast Church Rock Mine Site
Mine Site	Northeast Church Rock Mine Site
NRC	US Nuclear Regulatory Commission
QAPP	Quality Assurance Project Plan
RAO	Remedial Action Objective or Removal Action Objective
ROD	Record of Decision
SOW	Statement of Work
USEPA	US Environmental Protection Agency

T.1 INTRODUCTION

This appendix presents the Cleanup Verification Plan for the Northeast Church Rock Mine Site (Mine Site). This plan consists of the Excavation Control Plan and the Final Status Survey Plan prepared by AVM Environmental Services, Inc., a subcontractor to Stantec. It also includes the Quality Assurance Project Plan (QAPP) prepared by Stantec. The Final Status Survey Plan is attached as T.2 and, the QAPP is attached as T.3. Standard operating procedures are referenced in attachments T.2 and T.3 and included in T.4.

T.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC. These standards 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 T.2-1 presents Performance Standards related to the Cleanup Verification Plan for the Mine Site and explains how the design accomplishes these standards.

Table T-2.1: Performance Standards Applicable to the Cleanup Verification Plan

<table>
<tr><th>Identifying Number*</th><th>Location of Performance Standard Requirement</th><th>Topic</th><th>Performance Standard</th><th>Comments</th></tr>
<tr><td>83</td><td>2011 Action Memo, Table 4.1 – Field Screening Levels</td><td>Field Screening Levels</td><td>Table 4.1 Selected Field Screening Levels
<table>
<tr><th>Contaminant of Potential Concern</th><th>Field Screening Level</th></tr>
<tr><td>Ra-226</td><td>2.24 pCi/g</td></tr>
<tr><td>Arsenic</td><td>3.7 mg/kg</td></tr>
<tr><td>Molybdenum</td><td>390 mg/kg</td></tr>
<tr><td>Selenium</td><td>390 mg/kg</td></tr>
<tr><td>Uranium</td><td>200 mg/kg</td></tr>
<tr><td>Vanadium</td><td>390 mg/kg</td></tr>
</table></td><td>Mine waste identified with field screening level values for Ra-226 greater than 2.24 pCi/g and not classified as principal threat waste would be excavated and hauled to the Repository.</td></tr>
<tr><td>88</td><td>2011 Action Memo, V.A.1, Bullet 7 – Confirmation Sampling</td><td>Confirmation Sampling</td><td>Confirmation Sampling. Conduct confirmation scanning, sampling and analysis to ensure that the Action Levels have been met in excavated areas.</td><td>Procedures for confirmation scanning, sampling, and analysis is described in the Final Status Survey Plan (Attachment T.2).</td></tr>
<tr><td>15</td><td>2015 AOC SOW, Paragraph 30 – Data Submission</td><td>Data Submission</td><td>Respondents shall submit data under this SOW, according to the following technical specifications for those submissions:

Respondents shall submit sampling and monitoring data in the standard EPA regional Electronic Data Deliverable (EDD) format that EPA identifies. EPA may change this EDD format upon written notice to the Respondents. EPA may allow Respondents to use other non-EDD Format data delivery methods upon Respondents' showing that the EDD Format presents a significant burden to Respondents or upon Respondents showing that technological improvements make the EDD Format outdated.</td><td>Respondents will submit cleanup and sampling data for the Mine Site in the standard USEPA regional Electronic Data Deliverable (EDD) format that USEPA identifies.</td></tr>
</table>

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
			Respondents shall submit spatial data, including spatially-referenced data and geospatial data, in the ESRI File Geodatabase, and as unprojected geographic coordinates in decimal degree format using North American Datum 1983 (NAD83) or World Geodetic System 1984 (WGS84) as the datum. If applicable as determined by EPA, Respondents shall include descriptions of their data collection methods in their data submissions. At EPA's discretion, Respondents shall include projected coordinates with documentation. Respondents shall include metadata with all spatial data submissions. Respondents shall ensure that all metadata that they submit is compliant with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata and its EPA profile, and the EPA Geospatial Metadata Technical Specification. An add-on metadata editor for ESRI software, the EPA Metadata Editor (EME), complies with these FGDC and EPA metadata requirements and is available at https://edg.epa.gov/EME/. Respondents shall ensure that each data file that Respondents submit includes an attribute name for each SA Site unit, including the NECR and UNC Sites for which data is submitted. Respondents shall consult and use the information published by EPA at http://www.epa.gov/geospatial/policies.html, as Respondents identify and name data attributes. Respondents understand and agree that spatial data submitted by Respondents will not, and is not intended to, define the boundaries of the SA Site.	
20	2015 AOC SOW, Paragraph 43 – Pre-Final NECR Mine Cleanup Verification and Revegetation Plan	Pre-Final NECR Mine Cleanup Verification and Revegetation Plan	Respondents shall submit a Pre-Final NECR Mine Cleanup Verification and Revegetation Plan for the NECR Site that shall be a continuation and expansion of the Preliminary NECR Mine Cleanup Verification and Revegetation Plan, and any Intermediate Design.	The Cleanup Verification Plan is presented here with the 95% Design, rather than as a separate submittal. The Revegetation plan for the Mine Site is included as Appendix U.

*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)

T.3 REFERENCES

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

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

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

ATTACHMENT T.1
Excavation Control Plan
(excluded from LAR submittal)

ATTACHMENT T.2
Final Status Survey Plan

95% Design

Final Status Survey Plan

Northeast Church Rock Mine Site Removal Action

Prepared by

AVM Environmental Services, Inc.
Grants, New Mexico

July 2018

Table of Contents

Table of Contents (Continued)

TABLES

FIGURES

ATTACHMENTS

ACRONYMNS

BMP	Best Management Practice
CPM	counts per minute
CL	Confidence Level
cy	cubic yards
DCGL	Derived Concentration Guideline Level
DCGLemc	Elevated Measurement Comparison for DCGL
DCGLw	DCGL for Nonparametric Statistical Test
DGPS	Differential Global Positioning System
DQA	data quality assessment
DQO	Data Quality Objective
EDRA	East Drainage Removal Action
emc	elevated measurement comparison
FOV	field of view
FSS	Final Status Survey
g	gram
Ha	alternative hypothesis
Ho	null hypothesis
HASP	Health and Safety Plan
IRA	Interim Removal Action
keV	Kiloelectronvolt
kg	kilogram
L	liter
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
mg	milligram
NaI	Sodium Iodide
NCR	Non Conformance Report
NIST	National Institute of Standards and Technology
NECR	Northeast Church Rock
NRC	U.S. Nuclear Regulatory Commission
NUREG	U.S. Nuclear Regulatory Commission Regulation
PARCC	Precision, Accuracy, Representatives, Comparability, and Completeness
pCi	picocuries
PDS	Pre-design Studies
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
QC	quality control
Ra-226	radium 226
RA	Removal Action
RAL	Removal Action Level
RALemc	Elevated Measurement Comparison for RAL
ROD	Record of Decision

ACRONYMNS (Continued)

RSE	Removal Site Evaluation
RSO	Radiation Safety Officer
Site	Northeast Church Rock Mine Site
SOP	standard operating procedure
USEPA	U.S. Environmental Protection Agency
UTL	upper tolerance level
WRS	Wilcoxon Rank Sum

1.0 INTRODUCTION

This document provides a framework for performing a Final Status Survey (FSS) of the excavated areas following completion of the Removal Action (RA) at the Northeast Church Rock Mine Site (Site) near Gallup, New Mexico. The objective of the FSS is to demonstrate that the residual radium 226 (Ra-226) and total uranium concentrations in the excavated areas following the RA meet the release criterion for the Site. The Removal Site Evaluations (RSEs) (MWH 2007 and 2011) and Pre-Design Studies (PDS) (MWH 2014a and 2014b) identified approximately 1,000,000 cubic yards (cy) of mine spoils from 17 areas of mining activities. These areas total approximately 125 acres, as shown in Figure 1. This FSS Plan is based on available information from the RSEs, Interim Removal Action (IRA) in the Home Site (NECR-1 Step-out 1) Area (MWH 2009), RA in the East Drainage Area (NECR-1 Step-out 2) (EDRA) (MWH 2013) and the PDS. A summary of the nature and extent of contamination is provided in the 2011 Action Memorandum (“2011 Action Memo”, USEPA, 2011) and the Record of Decision (ROD) (USEPA, 2013).

The remedy selected in the ROD addresses removal of surface and subsurface soil exceeding the Ra-226 and total uranium Removal Action Levels (RALs). The 2011 Action Memorandum specifies RAL of 2.24 pCi/g for Ra-226 for removal of mine waste at the Site. The Ra-226 RAL is based on the USEPA pre-determined DCGLw at 1.24 pCi/g, plus the 1.0 pCi/g background reference area concentration since Ra-226 is present in background at the Site. The Action Memorandum specifies 230 mg/kg RAL for total uranium. Upon successful completion of this soil RA a FSS will be performed to confirm compliance with the pre-determined RALs for release for appropriate use. The guidance found in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USEPA 2000) will be used to demonstrate compliance with the RALs. This FSS Plan includes a means to statistically evaluate for residual Ra-226 activity using the MARSSIM process and outlines the contents of the FSS report for each survey area within the Site.

2.0 SITE DESCRIPTION

The Site is located approximately 16 miles northeast of Gallup, in McKinley County, New Mexico. The primary ore mineral mined at the Site was coffinite, which was placed in small temporary stockpiles before transport to the Church Rock Mill Site. Active mining operations at the Site occurred between 1968 and 1982 at which time the mine was placed on stand-by status. Seventeen areas where surface and subsurface soils impacted by uranium ore were identified by the RSEs and PDS conducted between 2006 and 2013. The RSE and PDS determined that Ra-226 in surface soils ranged from background to 875 pCi/g, and background to 438 pCi/g in subsurface soils to an approximate depth of up to 20 feet. Additional Site descriptions can be found in the RSEs (MWH 2007 and 2011) and PDS Reports (MWH 2014a and 2014b).

3.0 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQOs) for the FSS are provided below to establish a systematic procedure for defining criteria that must be met for the data collection design to be satisfied. The DQO process includes a description of when to collect samples, where to collect samples, the tolerable level of decision errors for the study, and how many samples to collect. The DQO process consists of the seven steps listed below (USEPA 2006):

1. State the problem.
2. Identify the goals of the study.
3. Identify information inputs.
4. Define the boundaries of the study.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

The DQO process is described in the following sections as it applies to the Site FSS.

3.1 State the Problem

The soils at the Site exceed the 2.24 pCi/g Ra-226 RAL, which consists of the 1.24 pCi/g Derived Concentration Guideline Level (DCGL) plus the 1.0 pCi/g mean background concentration, and also exceed the total uranium RAL specified in the 2011 Action Memo (USEPA 2011). The selected remedy for the Site requires excavation and removal of surface and subsurface soil exceeding the RALs. The problem is that it is uncertain if the residual contamination in the survey unit surface soils after the RA meets the Site release criterion.

This FSS Plan will be used to determine whether residual Ra-226 and total uranium concentrations in soils at the Site comply with the RALs. The MARSSIM provides guidance for planning, conducting, evaluating and documenting final status surveys for demonstrating compliance with dose/risk-based regulations or standards and is geared towards structures, such as buildings, and relatively small land areas. It is not as useful for sites with large land area sites such as NECR, which consists of nearly 230 acres. Therefore, this document includes minor adjustments to the approach (e.g., survey unit size) to facilitate an efficient final status survey design but is still consistent with the MARSSIM guidance.

MARSSIM uses two activity concentration cleanup requirements known as DCGLs. First, the DCGLw for the Site refers to a wide area average that must be met for survey areas. Second, the DCGLemc refers to an elevated measurement comparison that addresses more localized elevated areas that may exceed the DCGLw at specific locations but not when averaged over a survey unit. The DCGLs are developed so that post-RA residual activity concentrations achieve the acceptable risk for the Site.

Since the contaminant, Ra-226, is present in the background at the Site, the FSS data collected in the field will be inclusive of the background level, similar to the RAL (DCGLw at 1.24 pCi/g, plus the 1.0 pCi/g background reference area concentration) as mentioned previously. The MARSSIM process considers that the FSS data from survey units are inclusive of the background concentration during any comparison, statistical evaluation, which includes the WRS test (see Section 8.4 of the MARSSIM). Thus, MARSSIM process is related to RAL since it is the release criterion for the Site consists of DCGLs and background level. Therefore, the RAL terminology, RAL indicating DCGLw plus the background level and RALemc indicating DCGLemc plus the background level will be used in this document to be consistent with the 2011 Action Memo release criterion and the MARSSIM process.

3.2 Identify the Goals of the Study

The goal of this FSS plan, and the associated FSS data collection, is to confirm that removal of mine spoils meets pre-determined Ra-226 and total uranium RALs specified in the 2013 ROD and 2011 Action Memo. The FSS data will be used to evaluate whether post-RA soils contain Ra-226 and total uranium concentrations above the 2.24 pCi/g Ra-226 RAL, and 230 mg/kg total uranium RAL specified in the ROD.

Compliance with the RALs will be demonstrated by using guidance found in the MARSSIM. Specifically, compliance will be demonstrated using data collected by performing gamma surface scans and static surveys associated with grids, and collecting systematic confirmatory soil samples (i.e., samples associated with a grid), and additional samples if deemed necessary based on professional judgment (i.e., samples targeting specific areas of concern) consistent with the MARSSIM guidance.

The principal study question is whether Ra-226 and total uranium concentrations exceed the RALs in soils following the RA. The possible alternative actions are the release of the survey areas or additional remediation to meet alternative actions. The decision statement is:

- If the Ra-226 and total uranium concentration in soils are below the RALs, the areas meet the release criterion
- If the Ra-226 and total uranium concentrations in soils are above the RALs, the areas do not meet the release criterion and require additional RA

3.3 Identify Input Information

The following information is needed to resolve the decision statement:

- This is a new data collection effort by gamma radiation surveys and soil samples collected from RA excavated areas. Residual concentrations of Ra-226 will be measured in excavated areas.

- Historical information pertaining to the area-specific nature and extent of contamination from the RSEs, PDS and IRAs, which may include gamma static and scan survey data, and surface and subsurface soil sampling data, to guide excavation during the RA and to confirm the appropriate FSS area classification designation for specific areas of interest.

- Information from excavation control surveying, also known as remedial action support surveying, for those areas where excavation and removal of soils takes place for the RA activities. Excavation control survey data collection will include gamma scan surveys and any soil sampling result.

- A Ra-226 DCGL for Wilcoxon Rank Sum (WRS) Test (DCGLw) of 1.24 pCi/g for the soil has already been established by U.S. Environmental Protection Agency (USEPA) based on acceptable risk in the 2011 Action Memorandum for the Site. An elevated measurement Comparison (DCGLemc) for the FSS Class areas will be calculated consistent with MARSSIM guidance as discussed in Section 4.5, based on the area bounded by sampling points. The elevated measurement comparison (emc) for the RAL is established at DCGLemc plus background level. The RAL for total uranium of 230 mg/kg, is based on its chemical toxicity, and is not based on its radioactivity.

- FSS data collection, which will include scan and gamma static surveys of excavated surfaces and confirmatory soil sampling for static surveys, combined with appropriate analytical methods.

- The site-specific regression equations to convert field gamma radiation survey measurements in counts per minute (CPM) to the soil Ra-226 concentrations.

In addition to this quantitative information, visual observations will also be used to determine if there is an indication of contamination or buried waste during the excavation.

Guidance provided in the MARSSIM is the basis for this FSS Plan. The MARSSIM guidance was developed for use in designing, implementing, and evaluating final status radiological surveys. This guidance emphasizes the use of the DQO and data quality assessment (DQA) processes, along with a sound program of quality assurance/quality control (QA/QC).

FSS data will be used to address FSS decision-making. The excavation control survey data may also be used for FSS decision-making if the excavation control data are collected in a manner consistent with FSS protocols and the DQOs.

3.4 Define the Boundaries of the Study

The FSS Plan actions will address the Site areas undergoing RA activities. The selected remedy includes excavation and removal of surface and subsurface soils exceeding the RALs. The Site remediation boundary was developed based on the RSEs, PDS and IRA data, and consists of 17 separate areas, as shown in Figure 1. The areas will be classified based on known or potential contamination exceeding the RALs consistent with the MARSSIM guidance (see Section 4.1).

The footprint of the soil excavation at the Site has been based on the results of the RSEs, PDS and IRA data as shown in Figure 2. Definitive FSS Class 1 area footprints will be established prior to the initiation of the FSS data collection based on the excavation control survey of the footprint of the excavated area. Areas within the Site soil excavation and removal footprint will be included in the FSS.

IRAs were previously completed, and a post IRA Status Survey was performed in the IRA areas (NECR-1 Step-out 1 and Step-out 2, which includes the Home Site Area and the East Drainage Area). The FSS Plan will also address these two areas, shown in Figure 2 as Class 1 areas. Boundaries of these Class 1 areas are associated with the footprints of soil excavation during the 2009 IRA and 2012 EDRA, which included interim status surveys, and demonstrated attainment of the RAL (MWH 2013).

Boundaries of Class 3 areas will be associated with the areas around the Class 1 areas to verify that no contamination migrated outside the Class 1 areas during the RA, as shown in Figure 2.

3.5 Develop the Analytic Approach

Implementing the steps for FSS data analytic approach for decision rule is as follows:

- **Statistical parameter of interest**: The FSS data statistical parameter of interest for decision rule for the Site is the mean (average) concentration of Ra-226 and total uranium since a single average value is used for dose/risk assessment to develop the RAL for the Site.

- **Site RAL**: The 2011 Action Memorandum specifies RAL of 2.24 pCi/g for Ra-226 for removal of mine waste at the Site. The Ra-226 RAL is based on the USEPA pre-determined DCGLw at 1.24 pCi/g, plus the 1.0 pCi/g background reference area concentration since Ra-226 is present in background at the Site. The Action Memorandum specifies 230 mg/kg RAL for total uranium.

The Decision Rule for release of survey units is described in Section 7.0 and includes confirming survey area classification, demonstrating compliance with DCGLemc and DCGLw, and WRS statistical testing.

3.6 Specify Performance or Acceptance Criteria

The FSS data evaluation and the null hypothesis (Ho) for the WRS test for demonstrating compliance with cleanup goals are stated in Section 7.3. A conclusion will be drawn from the FSS data evaluation or the WRS test, if needed. Since the contaminant, Ra-226, is present in the background at the Site, the WRS test will be performed for the Ho, which is that the median residual contamination exceeds the acceptance criterion (DCGLw plus the background level.). If the Ho is rejected, the alternative hypothesis (Ha) must be accepted and the finding of the evaluation is that the site satisfies the cleanup requirement. The WRS test will be used, as described in the MARSSIM, to test the Ho for DCGLw compliance. For the DCGLemc requirements, gamma scan and static surveys, and any soil sample results will be compared against a DCGLemc equivalent detector CPM, and sample results will be compared directly to DCGLemc requirements.

To enable testing of data relative to the cleanup criteria, there are two types of fundamental decision errors. A type I (alpha) error is the incorrect rejection of a true null hypothesis (a "false positive"), while a type II error (beta) is incorrectly retaining a false null hypothesis (a "false negative"). A type I decision error of 0.05 and Type II decision error of 0.10 will be used for the FSS, which includes the calculation of the minimum number of sample required for each survey unit for the WRS test to demonstrate compliance with the DCGLw release criteria. A type I error rate of 0.05 will be used for a tolerance level calculation of the background data set for establishing investigation levels for a measurement, and for confidence interval calculation for evaluation of the data sets. A 0.05 type I error rate will also be used for p-value associated with the gamma radiation to Ra-226 correlations. The acceptable probability of a Type II error will be used to determine if additional samples are necessary for controlling Type II errors during a DCGLw evaluation. Type II errors do not adversely impact public safety and health; however, they can impact the schedule and budget. Data quality indicators for precision, accuracy, representativeness, comparability, and completeness (PARCC) have been established:

- Precision will be determined by a comparison of replicate values from field measurements and from a sample analysis; the objective will be a relative difference of 30 percent or less of the RAL or DCGLemc values.

- Accuracy is the degree of agreement with the true or known; the objective for this parameter will be ±30 percent of the RAL or DCGLemc values.

- Representativeness and comparability will be ensured through the selection and proper implementation of systematic sampling and measurement techniques. Representativeness is a qualitative expression of the degree to which sample data accurately and precisely represent a characteristic of a population, a sampling point, or an environmental condition. Representativeness is maximized by ensuring that, for a given task, the number and location of sampling points and the sample collection and analysis techniques are appropriate for the specific investigation, and that the sampling and analysis program provides information that reflects "true" site conditions.

- Completeness refers to the portion of the data that meets acceptance criteria and is therefore usable for statistical testing. The objective is a 95 percent completeness goal. The number of data points calculated for the WRS test will be increased by 20 percent to account for possible lost or unusable data. Therefore, the completeness goal will be attained for this FSS by assuring that a minimum of 80 percent of the total number of data point measurements planned are useable.

The generic PARCC criteria that focus on activity concentration results and analytical performance around the DCGL requirements may not be meaningful if very low contamination is encountered, which is expected to be the case during FSS work. Other factors should be considered when evaluating the quality and usability of the produced data sets.

3.7 Develop the Plan for Obtaining Data

Field screening techniques, gamma surveys, soil sampling, soil sample analysis, and the DQA process will be used, as appropriate, throughout the FSS. As data are collected and analyzed from initial survey units the assumptions in this plan will be reviewed for accuracy.

4.0 FSS DATA COLLECTION PLAN

This section describes the general FSS data collection activities that will take place to satisfy the DQO described in Section 3. Section 5 provides details about field implementation of this plan.

4.1 Classification of Survey Areas

For the FSS, the survey areas will be classified consistent with the MARSSIM. The MARSSIM defines three types of FSS classes. Class 1 units include areas that required remediation and areas where historical data indicate DCGLw exceedances likely existed prior to remediation. Class 2 area includes impacted areas that have been remediated and are not expected to require additional remediation (i.e., no historical evidence that contamination exceeds DCGLw activity concentrations). Class 3 area includes areas where there is no historical evidence of significant impacts.

Class 1 Areas

The RSEs and PDS determined that 17 areas exceeded the RAL (Table 1 and Figure 2). These areas will be undergoing RA. The 17 areas are grouped into three separate Class 1 FSS Areas based on their proximity and vertical extent of contamination (i.e., surface versus subsurface). Area 1, the Venthole 3/8 area which contains surface contamination at a depth of less than one foot and is isolated from the other mine areas is designated as FSS Area 1. Fourteen cleanup areas (Area No. 2a, 2b, 3a, 3b, 3c, 4, 5, 6, 7, 8, 9, 10, 11 and 12) that contain surface and subsurface contamination are grouped and designated as FSS Area 2. The other two adjacent areas, the Trailer Park Area and Sediment Collection Area, which contain surface contamination at a depth of less than one foot, are grouped and designated as FSS Area 3. In addition, the Decontamination Area at the Construction Support Yard at the Mill Site, as shown on Figure 2, will be included as a Class 1 FSS area (Area 4) since it will be used for equipment decontamination, and may undergo necessary cleanup and FSS if residual levels are above the Mill Site baseline levels.

The IRA was completed in the Home Site Area (NECR-1 Step-out 1) in 2009 and a RA was completed in the East Drainage Area (NECR-1 Step-out 2) at the Site in 2013. Post-IRA interim status surveys were conducted in these areas, which indicated that the areas met the RAL according to the MARSSIM evaluation (MWH 2009 and 2013). Nevertheless, these areas are included as Class 1 areas for the FSS. The Home Site Area (NECR-1 Step-Out 1) is designated as FSS Area 5 and the East Drainage Area (NECR-1 Step-Out 2) as FSS Area 6.

Class 2 Areas

The Haul Road, which is the road from the Mine Site to the Repository, and the road to Construction Support Yard, will be classified as a Class 2 FSS area and is designated as FSS Area 7. The Haul Road is classified as a Class 2 area because the road will be in an area known to not exceed the RAL. The footprint of the storm water collection ponds along the haul road will be incorporated into the haul road for the FSS. The Equipment Yard will be used for maintenance and parking and is within the Construction Support Yard at the Mill Site and has also been classified as Class 2 area (FSS Area 8) because it will be located in an area which was previously remediated and verified under the U.S.NRC requirements of 10 CFR Part 40, Appendix A, Criterion 6, and it was released for unrestricted use by the USNRC. Also, control measures, such as securing waste in haul trucks, frisking haul trucks and vehicles, and if necessary removing any loose removable contaminated soil from wheels and wheel wells will be implemented during hauling to avoid cross contamination of the Haul Road and the Equipment Yard. The Haul Road and the Equipment Yard will be scanned periodically to verify that the implemented control measures are effective.

Class 3 Areas

Areas adjacent to the Class 1 areas will be considered Class 3 areas. Although control measures will be implemented during the RA, there may be a potential for contaminant migration into adjacent areas during the RA activities. Therefore, these adjacent areas will be classified as Class 3 areas and included in the FSS to verify that contamination has not migrated from Class 1 areas during RA activities. The Class 3 areas will be located along the outer boundaries of the Class 1 areas. The width of the Class 3 areas along the upwind and up gradient boundaries will be approximately 50 feet, and 100 feet wide for the adjacent areas along the downwind and down gradient boundaries. The predominant wind direction in the region is from the southwest, as indicated by the most recently available 2012 wind rose from the weather station at the Gallup, NM Municipal airport (http://www.wrcc.dri.edu/cgi-bin/wea_windrose.pl?laKGUP). Most of the Site sits in a valley and the down gradient direction is fairly similar to the wind direction. The width of some of the Class 3 areas may be physically limited due to rock outcrops, cliffs and steep arroyo banks adjacent to Class 1 areas and Class 2 FSS area boundaries. A Class 3 area is not included around the Class 2 Area Haul Road since it is not expected to contain residual contamination above the RAL and control measures will be implemented to mitigate cross contamination. Also, a Class 3 area around the Construction Support Yard at the Mill Site is not included for the FSS because the cross contamination of surrounding areas will be mitigated by administrative and engineering control measures as discussed above. The Equipment Yard and the Decontamination Area of the Construction Support Yard will be segregated and fenced with access gates. Egress from both areas to the unrestricted support zone will be controlled. Personnel and vehicles will be monitored for contamination, and will be decontaminated if necessary. The Construction Support Yard will be protected from storm water run offs by using engineering controls.

4.2 Background Reference Area

An appropriate Ra-226 background value and associated variance in soils for statistical purpose for the Site was obtained during the 2006 RSE (MWH 2006a). Background sampling consisted of 25 samples at nodes of triangular grid from a reference area of approximately 4 acres. The background sampling location was selected from an area un-impacted by mining activities and upwind and upslope from the Site. Background sampling results showed an average Ra-226 concentration in soil of 1.0 pCi/g with a standard deviation of 0.18 pCi/g. The background study results were reported in the Technical Memorandum for Results of Background and Ra-226 Correlation Sampling at the Site (MWH 2006b).

4.3. Sample Number Calculations

The DCGL is defined in the MARSSIM as the radionuclide-specific activity concentration within a survey area corresponding to the release criterion. Site compliance with the DCGLw is demonstrated by using discrete samples and a nonparametric statistical test. By using appropriate equations, one can determine the sample numbers required per survey area to achieve desired Type I and Type II error rates for a particular statistical test.

The number of samples for survey units for a WRS test consistent with the MARSSIM guidance Section 5.5.2.2 was determined. A nonparametric WRS test was selected because Ra-226 is present in background soil. MARSSIM specifies using sample standard deviation from the background area data set for calculating the minimum number of required samples. The DQA in the MARSSIM Section 8.2 also recommends verifying the underlying assumptions made during the design, which includes sample standard deviation.

The 149 sample data set from the most recent EDRA interim status survey indicated a standard deviation of 0.46, significantly higher than the 0.18 standard deviation determined from the background data set. The standard deviation of the background reference area data set is low and likely lower than the standard deviation of the survey unit FSS data sets, thus requiring recalculation of the number of samples needed during the DQA and resurvey for WRS test. Therefore, standard deviation of 0.46 from the EDRA interim status survey will be used for the required number of sample calculation. The statistical parameters used and the calculation to determine the data points needed to apply the nonparametric WRS test for the Site is shown in Table 2.

The statistical parameters shown in Table 2 were selected to achieve low error rates, as specified for the DQOs. The relative shift is based on the DCGLw, lower bound of the gray region and the standard deviation. As shown in Table 2, the minimum number of data points needed to apply the nonparametric WRS test for the Site calculates to 40 data points per survey unit. The number of data points determined using the WRS test was increased by 20 percent to account for possible lost or unusable data. This statistical test, plus 20 percent resulted in 48 data points being collected for each survey unit with the Ra-226 DCGLw of 1.24 pCi/g, which applies to all Mine Site FSS areas, including the Haul Road. The results from a minimum of 40 usable data points from gamma static survey locations in each survey unit will be used for the FSS statistical tests and evaluation. The Construction Support Yard consisting of the Class 1 Equipment Decontamination Area and the Class 2 Equipment Yard is located at the Mill Site yard. The Mill Site yard was previously remediated at the Ra-226 cleanup criteria of 5.0 pCi/g plus the background level of 1.0 pCi/g under the USNRC requirements of 10 CFR Part 40 (UNC 1993). Therefore, the DCGLw parameter value of 5.0 pCi/g is used for the calculation of the number of data points for FSS survey units within the Construction Support Yard at the Mill Site as shown in Table 2. Prospective power curves for Class 1 and Class 2 FSS designs show that the assumptions of the FSS design, including survey unit size and expected standard deviation, validate the specified DQOs, as shown in Attachment 1.

4.4 Sampling Grid and Transect Spacing

There are 48 samples (data points) required per survey unit in the Mine Site areas and seven data points required per survey unit in the Construction Support Yard located at the Mill Site, as discussed in Section 4.3. Class 1 survey unit size for the RA has been modified from the MARSSIM suggested 0.5 acres to 2.5 acres. This will help facilitate an efficient and practical FSS, as well as allow acceptable statistical evaluation of the FSS data used for demonstrating compliance with the release criterion for this large of a site. The MARSSIM suggested survey unit size of about 0.5 acre would results in about 350 survey units for the approximately 175-acre Class 1 areas, with uniform type of contamination/media. Thus, using a 0.5-acre survey unit size would require complex management of survey units and inefficiently complex and onerous FSS and statistical evaluation over a relatively large homogeneous areas. The 2.5-acre Class 1 survey unit size will conform to any risk assessment assumption for establishing the release criterion.

The Ra-226 DCGLw for the Site is based on risk from a residential land use exposure scenario. The RESRAD code for risk assessment uses an average concentration value for a default contamination zone of 10,000 m^2, or 2.5 acres, which is the survey unit size proposed for the Site. Generally, an area or site may be divided into smaller survey units to facilitate considerations for different types of contamination/media, such as drywall areas, ceiling material areas, floor material areas, outdoor paved yards and outdoor unpaved yards for an overall risk/dose assessment. At the Site, there is but one media (soil) and one form of contamination (mine spoils at the RA areas. Thus, the contamination type/media would be the same in a 0.5 acre or a 2.5-acre survey unit and would not impact the overall dose/risk.

Each FSS Class area is divided into survey units based on the specified size of 2.5 acres for Class 1 and 5.0 acres for Class 2 survey units and are rounded to the nearest whole number of survey units for the FSS areas. The size of each Class 1 survey unit will be about the specified survey unit size of 2.5 acres. The only exception is the Decontamination Area survey unit which is in total an area of 0.92 acre and is the only survey unit in its FSS Area. The size of each Class 2 survey unit will be about the specified survey unit size of 5.0 acres or smaller. The number of survey units may change depending on the actual excavation footprint following the RA. MARSSIM specifies no size limit for Class 3 survey units. The conceptual boundaries and ID numbers of the Class 1 survey units are shown on Figure 3 and Figure 4, and of the Class 2 survey units on Figure 5. The conceptual boundaries and ID numbers of the Class 3 survey units are shown on Figure 3 and Figure 4. The Red Water Pond Road will tentatively be included as a Class 3 area and may be included in the FSS depending on the timing and nature of any removal actions or other activities undertaken at the Quivira Mine that have the potential to re-contaminate the road.

A triangular grid system has been selected for the FSS. The grid length calculation parameters are included in Table 3. The length of the triangular grid is determined based on the number of samples per survey unit and the typical size of a survey unit at the Mine Site, 2.5-acre for Class 1 areas and 5.0-acre for Class 2 areas. The calculation results in a triangular grid length of 51 feet for Class 1 and 72 feet for Class 2 survey units for the Mine Site areas. The Mine Site area and NECR-1 Step-Out area Class 1 survey unit grid length is rounded down from the calculated 51 feet to 50 feet, which will provide an additional margin of safety for the number of samples in survey units slightly smaller than 2.5 acres. Each survey unit will be sampled at a rate of 48 samples per survey unit. Because the survey unit numbers are rounded to whole numbers and the size of survey units may slightly vary from the specified survey unit size. The number of sampling data points will be maintained at a rate of 48 per survey unit. In no case, the number of obtained useable data points will be less than 40 per survey unit, as discussed in Sections 3.6 and 4.3. If a survey unit has less than 40 useable data points, random data points will be added to make up the difference. Interim status surveys with an 80-feeet triangular grid length previously performed in FSS Area 5 and FSS Area 6, resulted in approximately 20 sample locations per 2.5 acre. Results of the Interim Status Survey will be included in the FSS. Approximately 28 additional data points will be located in these two areas during the FSS to attain the minimum number of data points per survey unit. A 72 feet triangular grid within the Class 2 Haul Road survey unit is not practical due to its narrow shape with a width of less than the grid length. For the Haul Road Class 2 survey unit, 48 data points will be placed approximately every 105 linear feet along the haul road survey unit as shown in Figure 5. The total area of the Haul Road, which includes the road from the fork going to Equipment Yard at Mill Site, is approximately 4.43 acres. This placement will result into a conservative area of approximately 4020 square feet bounded by a data point, which is less than the 4489 square feet area bounded by a Class survey unit 72 feet triangular grid node.

As per MARSSIM, data points in Class 3 survey units are located randomly. A total of 48 data points will be located randomly in Class 3 survey units as shown in Figure 3 and Figure 4. The final boundaries of Class 3 survey units may change depending on the final boundaries of adjacent Class 1 Areas. Therefore, the random data point locations may need revision based on the exact final boundaries of Class 3 survey units.

The Construction Support Yard survey units are much smaller than the typical Mine Site area survey units. Therefore, the smallest survey unit size in each Class is used to calculate grid length to place at least the calculated required number of data points in each survey unit. The calculation results in a triangular grid length of 81 feet for Class 1 and 137 feet for Class 2 survey units for the Construction Support Yard areas at the Mill Site yard. The Class 1 survey unit grid length is rounded down from the calculated 81 feet to 80 feet, and Class 2 survey unit grid length is rounded down from the calculated 137 feet to 135. Each survey unit will be sampled at a rate of at least seven data points per survey unit. The grid length calculation parameters are included in Table 3.

A one-minute gamma static survey will be conducted at each node of the triangular grid in each Class 1 and Class 2 FSS survey unit. A one-minute gamma static survey will be conducted at about 48 randomly placed points in each Class 3 survey units. A total of approximately 3,523 grid nodes are estimated for Class 1 survey units, about 62 grid nodes for Class 2 survey units, and about 240 points in Class 3 survey units for the FSS, are shown in Table 1. The conceptual grid nodes for the FSS gamma static survey are based on the excavation footprint determined by the RSE (MWH 2007 and 2011) and the PDS (MWH 2014a and 2014b). The actual number of grid nodes may change depending on the actual excavation footprint following the RA.

Transect spacing for the FSS systematic gamma scan surveys will be calculated using the detector field of view (FOV) for gamma radiations from Ra-226 sources (transect spacing = FOV/% scan coverage). For example, using a conservative FOV of at least 6.0 feet for 2x2 NaI detectors for Ra-226 gamma radiations, a 100 percent scan coverage requires a transect spacing of 6.0 feet and 25 percent scan coverage will require 24 feet transect spacing. If a different FOV is used, it will be verified by conducting a FOV test. The FOV test will be conducted by using a uranium ore source and a 2x2 NaI detector. The detector baseline (background) counts will be obtained with the detector at 12 inches above the ground surface and without exposing the detector to the source. The detection range limit will be verified by obtaining gamma counts for the source under the detector, and moving the source at an increment of one foot away from the detector on the ground and obtaining counts until the counts are not significantly (95 percent confidence level [CL]) above the baseline counts.

4.5 Small Areas of Elevated Activity

Elevated areas of concern are assumed to be primarily associated with the Class 1 areas (i.e., excavation floors). At the Site, small, isolated, and elevated areas may be encountered in the soils from the floors of the excavation. MARSSIM and this FSS Plan address these areas through the definition of the DCGLemc requirement. The RSE characterization data suggest that locations with elevated Ra-226 concentrations pose the most concern from the perspective of the DCGLemc. Locations with elevated Ra-226 concentrations are in the Class 1 areas and are expected to be excavated before FSS work begins. It is expected that these types of areas will be initially identified by the scan results as being above the RAL and that this finding will be confirmed based on soil sample results.

When a measurement at a discrete location and scan exceeds the RALemc (DCGLemc plus the background level), the first action is to confirm the DCGLemc exceedance and to assure the instrumentation is functioning properly. A DCGLemc exceedance is not conclusive of exceeding the release criterion but may require further investigation. This may involve making further measurements to determine that the level of the elevated residual contamination in the area is such that the resulting dose meets the release criterion, which may require re-survey. If the investigation indicates that the elevated residual contamination in the area will result in the dose exceeding the release criterion, the location or area may require further remediation.

The MARSSIM requires verifying that the systematic sampling densities in Class 1 areas are sufficient to also address DCGLemc concerns, given the expected scan Minimum Detectable Concentration (MDC) values. The DCGLemc was calculated consistent with MARSSIM Section 5.5.2.4. The area factor needed for DCGLemc calculation was determined using RESRAD 7.2. The RESRAD 7.2 run outputs are included in Attachment 1. All exposure pathways were calculated assuming a unity concentration of one pCi/g of Ra-226 and the 10,000 m^2 default area of contamination in RESRAD 7.2. Other than changing the Class 1 survey unit area, 201 m^2 bounded by the 50-foot triangular grid node for the Mine Site and 515 m^2 area bounded by the 80-foot triangular grid node for the Decontamination Area at the Mill Site, the RESRAD default values were not changed. The area factor was computed by taking the ratio of the dose per unit concentration generated by RESRAD for the default 10,000 m^2 to that generated for the 201 m^2 and 515 m^2 bounded by the triangular grid nodes. If the DCGL for residual radioactivity distributed over 10,000 m^2 is multiplied by this value, the resulting concentration distributed over the specified smaller area results in the same calculated dose. As shown in Table 4, A Ra-226 DCGLemc of 3.09 pCi/g was calculated for the Mine Site 50-foot triangular grid Class 1 survey units with Ra-226 DCGLw of 1.24 pCi/g, and 8.06 pCi/g for the Decontamination

Area 80-foot triangular grid Class 1 survey units with a Ra-226 DCGLw of 5.00 pCi/g. This results in RALemc of 4.09 pCi/g (3.09 DCGLemc plus 1.0 pCi/g background) for Mine Site 50-foot triangular grid Class 1 survey units and 9.06 pCi/g (8.06 DCGLemc plus 1.0 pCi/g background) for the Decontamination Area 80-foot triangular grid Class 1 survey units. Gamma survey techniques (i.e., surficial surveys) with a 2x2 NaI scintillation detector and soil sample analysis using USEPA Method 901.1 modified (gamma spectroscopy) will be adequate to detect any DCGLemc exceedances.

4.6 Gamma Radiation Surveys

Direct gamma radiation surveys will be used to detect Ra-226 in soils for the FSS. Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 keV at about 4 percent intensity. Field measurement of alpha radiation from soils using radiation detection is an inadequate technique. Due to the low energy of its gamma radiation emission, field determination of Ra-226 is not practical. However, Ra-226 in soil can be determined by measuring gamma radiation levels of its decay products (Pb-214 and Bi-214), which emit high energy gamma radiation at higher intensities and are easily detected and quantified by a sodium iodide (NaI) scintillation detector. This is a surrogate method consistent with MARSSIM guidance (Section 4.3.2).

The DCGLs (DCGLw and DCGLemc) are presented in terms of mass activity concentration based on acceptable risk for release of the areas. When applied to soil, these DCGLs are expressed in units of activity per unit mass of soil, pCi/g. The direct gamma radiation measurements, using a Sodium Iodide (NaI) scintillation detector, provide radiation levels in counts per unit time. The counts per unit time for a given radioactivity depend on the efficiency of the detector. Pb-214 and Bi-214 are decay products of Ra-226 through radon-222, a gaseous form, some of which emanates from soil. This process results in activity disequilibrium between Ra-226 and Bi-214 in the soil. The Rn-222 gas emanation fraction from the soil varies with different geometric characteristics of a particular soil type. Therefore, a site-specific calibration is necessary. Typically, about 20 percent of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant percentage (about 80 percent) of this will decay into Pb-214 and Bi-214 in the soil matrix. If the soil geometry and other parameters such as moisture, radon emanation fraction, contamination distribution profile, gamma ray shine from nearby sources, and land topography are consistent, the ratio of Pb-214/Bi-214 to Ra-226 is consistent. This results in a direct correlation between Pb-214/Bi-214 gross gamma radiation levels and Ra-226 concentrations in the soil. Therefore, a site-specific correlation between direct gamma radiation levels and Ra-226 soil concentrations in pCi/g will be used to convert the CPM measurement to equivalent Ra-226 in soil.

The soils at the Site are impacted by uranium ore, and no processed waste (11e.(2) material), which would indicate the uranium decay series is out of secular equilibrium, is located on the Site. Therefore uranium (U-234 and U-238) would be in secular equilibrium with Ra-226. The 230 mg/kg total uranium (U-nat) RAL is equivalent to about 76 pCi/g of

Ra-226. Therefore, removal of soils exceeding the 2.24 pCi/g Ra-226 RAL also assures that uranium ore impacted soils with about 7 mg/kg total uranium, far below the 230 mg/kg total uranium RAL, are removed. Therefore, Ra-226 results by gamma survey will be used to detect and estimate total uranium content in soil. This is similar to a surrogate method consistent with MARSSIM guidance (Section 4.3.2). In addition, the total uranium analytical results of the soil samples by the off-site vendor laboratory will be used to confirm compliance with the total uranium RAL.

4.6.1 Gamma Survey Instrumentation

Similar to the instrumentation used for the RSEs, IRAs and PDS, the instrumentation configuration for direct gamma radiation level measurement during this survey consists of a 2x2 NaI scintillation detector (such as Eberline SPA-3 and Ludlum 44-10) for detection of gamma radiation, connected to a scaler/rate meter (such as Ludlum 2221 or Ludlum 2241) for processing and counting the detected gamma radiation. This instrument configuration has been used widely for this type of application and is recommended by the MARSSIM. The SPA-3 and L44-10 scintillation detectors are rugged with the highest sensitivity gamma radiation detection for field application and this type of field survey. For radiation surveys where significant shine interference is present from nearby areas, such as areas with deep excavation and areas within close proximity of waste piles, the 2x2 NaI scintillation detector will be installed in a 0.5-inch-thick lead collimator to reduce gamma shine interference. During the surveys, the detector will be held approximately 12 inches above ground level, which should focus on and be most sensitive to approximately 36-inch diameter area under the detector. The Scaler/Rate meter will be interfaced with a sub-meter accurate Differential Global Positioning system (DGPS) and a data logger controller for electronically recording the gamma radiation levels to corresponding location coordinates for systematic gamma scan surveys. The instrumentation will be calibrated consistent with Standard Operating Procedure (SOP)-1, provided in Attachment T.4.

Direct gamma radiation measurements using a NaI scintillation detector provide radiation levels in counts per unit time. The gamma survey results in counts per unit time have no intrinsic meaning to Ra-226 RAL in pCi/g. The counts per unit time for a given radioactivity depend on the efficiency of the detector. The direct gamma radiation level in detector CPM for the collimated and bare detectors, below which there is an acceptable level of assurance that the established RAL is attained, will be based on the site-specific correlations between gamma radiation count rates and surface soil Ra-226 activity. Final gamma radiation level to surface soil Ra-226 Correlations for 2x2 NaI bare and 0.5-inch lead collimated detectors are developed as described in Attachment 1 to Appendix T-1 from data collected for previous correlations during the Site RSEs and IRAs.

The previous correlations were developed for surface soils at the Site with no recent rain or temperatures below freezing with snow cover or frozen ground surface. Gamma radiation surveys will not be conducted if the ground surface is covered with snow or is frozen. Also, the survey will not be conducted prior to at least two hours following a rain storm and the ground surface will be inspected to verify that there is no excessive moisture.

MDCs for both the static and gamma scan radiation survey will be calculated as discussed in SOP-1. Based on data collected with this instrumentation during the RSE, PDS and IRAs surveys, the instrument MDC is expected to be below 1.12 pCi/g (50 percent of 2.24 pCi/g, the DCGLw plus 1.0 pCi/g background level) for static surveys. The instrument scan MDC is expected to be below 1.12 pCi/g, which will be less than 50 percent of the 4.09 pCi/g limit (the DCGLemc 3.09 pCi/gm plus 1.0 pCi/g mean background concentration) for scan surveys in Class 1 survey units, and less than 50% of the 2.24 pCi/g limit for scan surveys in Class 2 and 3 survey units.

4.6.2 Gamma Scan Surveys

Gamma scan survey data will be collected from excavated soil surfaces as part of the FSS data collection process. As part of the FSS process, gamma scan surveys serve three primary roles:

1. Establish that an area is ready for FSS gamma static surveys and soil sampling (i.e., no significant evidence of elevated gross activity that may indicate DCGL exceedances).
2. Identify Ra-226 activity anomalies that might be indicative of DCGLemc exceedances within FSS areas.
3. Identify spatial trends in Ra-226 activity within or across FSS survey areas that will assist in interpreting systematic static soil sampling results if there are DCGLw exceedances in systematic sampling results.

Gamma radiation scan surveys performed during the excavation control survey may be used for the FSS gamma scan surveys if the instrumentation and the survey techniques meet the FSS DQOs. Systematic gamma scan surveys will be conducted primarily by using bare 2x2 NaI detectors.

Prior to gamma static surveys and confirmatory soil sampling, gamma scan surveys will be conducted for 100 percent coverage in each Class 1 area. The systematic gamma scan survey density in all survey units of FSS Area 7 and FSS Area 8 are planned at 50 percent coverage.

The Class 3 areas adjacent and around the outer boundaries of Class 1 and Class 2 areas are included in the FSS to verify that contamination has not migrated from Class 1 and Class 2 areas during the lengthy RA activity periods. Control measures will be implemented during RA activities to minimize the potential of any contamination migration. The Class 3 areas may be impacted but are not expected to contain residual levels of contamination significantly above the background level. MARSSIM Section 5.5.3 specifies a judgment based gamma scan for Class 3 Areas. Therefore, a gamma scan based on professional judgment along a serpentine transect at approximate a 25 percent coverage rate will be conducted in Class 3 areas. If an erosion channel with measurements above the appropriate investigation level identified coming out of Class 1 or Class 2 areas into a Class 3 area, a scan will be performed along the channel until the scan results drop below the investigation level.

The FSS gamma scans will be digitally recorded, including date, time, location and count rate. An electronic file of the scan data will be provided following QA/QC review within five working days of data collection from a survey area.

4.6.3 Gamma Static Surveys

Following gamma scan surveys for the FSS, a one-minute gamma static survey will be conducted at each triangular grid node class 1 and Class 2 survey units as a part of the FSS systematic sampling as discussed above. The estimated 3,523 data points for gamma static survey for the 71 Class 1 survey units listed in Table 1 are shown on Figure 3 and Figure 4. Approximately 62 data points for an estimated 3 Class 2 survey units listed in Table 1 are shown on Figure 5. Gamma static survey will be conducted at approximately 240 random locations in the estimated five Class 3 survey units shown on Figure 3 and Figure 4. The FSS systematic static surveys will be used to evaluate compliance with DCGLw requirements and to confirm that the elevated measurement comparison (emc) exceedances are not an issue for the survey units each systematic sample represents.

4.6.4 Investigation Levels

Investigation levels established for all three area classifications for use during the FSS are consistent with MARSSIM Section 5.5.2.6. Since Ra-226 is present in the background at the Site, the Ra-226 background level will be included with appropriate DCGL values to establish the investigation levels for each area classification for any further investigations. An emc for Class 1 areas or a 95-95 Upper Tolerance Level (UTL) of the appropriate background dataset for Class 2 and Class 3 areas is used for establishing investigation levels. The investigation may involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the resulting dose or risk meets the release criteria. The investigation may also require survey unit reclassification, remediation, and/or resurvey depending on the results of investigation. The NECR RA FSS investigation levels are determined as discussed below and are presented in Table 5.

Measurements above the DCGLw in Class 1 areas are not necessarily unexpected. Class 1 area measurements are subject to the emc. The Site DCGLemc will be used as an investigation level for Class 1 Areas. Consistent with MARSSIM guidance, any static measurement at a discrete location or scan measurements in a discrete area above the Ra-226 RALemc of 4.09 pCi/g (DCGLemc plus mean background level) will be flagged for further investigation, except for the Class 1 Decontamination Area. For the Class 1 Decontamination Area, any static measurement at a discrete location or scan in a discrete area which are above 9.06 pCi/g Ra-226 (the 8.06 pCi/g Mill Site DCGLemc plus 1.0 pCi/g mean background level) as shown in Table 4, will be flagged for further investigation. However, as a precautionary measure, any direct measurement in Class 1 Areas exceeding the midpoint between the RAL (DCGLw plus background) and RALemc (DCGLemc plus background), which would be 3.17 pCi/g for Mine Site Class 1 Areas and 7.53 pCi/g Mill Site Decontamination Class 1 Area, may be flagged for further investigation.

In Class 2 areas, neither measurements above the RAL nor RALemc are expected. Any static measurement at a location or scan in a discrete area in the Mine Site Class 2 area (FSS Area 7 which is above the 2.24 pCi/g Ra-226 investigation level will be flagged for further investigation. For the Construction Support Yard Class 2 Area at the Mill Site (FSS Area 8), any static measurement at a discrete location or scan measurements in a discrete area that is above the investigation level of 6.45 pCi/g Ra-226 will be flagged for further investigation. The investigation level for Class 2 Equipment Yard Area at the Mill Site is based on the 5.0 pCi/g Mill Site DCGLw, as discussed in Section 4.3 above, plus 1.45 pCi/g, which is the 95-95 UTL of the background area dataset discussed in the next paragraph.

The Class 3 areas may be impacted but are not expected to contain residual levels of contamination significantly above the background level. The Ra-226 distribution in mine site background area varies with a standard deviation of 0.182 based on 25 samples (MWH 2006b), which is expected throughout the Site, including Class 3 areas. A 95-95 UTL of 1.45 pCi/g was calculated from the Mine Site background area dataset, as shown in Attachment 3. Therefore, the investigation level for the Class 3 areas is established at 1.76 pCi/g (1.45 pCi/g 95-95 UTL plus 25 percent of the 1.24 pCi/g DCGLw). Any static measurement at a discrete location that is above 1.76 pCi/g of Ra-226, and for scanning measurement in a discrete area above 2.24 pCi/g (DCGLw plus background level), consistent with Section 5.5.2.6 of MARSSIM, will be flagged for further investigation.

4.7 Soil Samples

Systematic confirmatory and judgment-based surface soil samples will be collected from the excavated areas as a part of the FSS. The surface soil sample results will be used for confirmation of gamma survey results for DCGLw and DCGLemc requirements and will also be used for updating the gamma radiation level to surface soil Ra-226 concentration correlation.

4.7.1 Judgment Based Soil Samples

Surface soil samples will be collected based on professional judgment to target specific locations where there are concerns about potential DCGLemc exceedances from the scan and gamma static surveys within FSS areas. Judgment based sampling locations may be selected as necessary, based on a variety of factors, such as an elevated gamma scan survey result (either collected as part of excavation control surveys or FSS), visual evidence of contamination, or the presence of physical infrastructure that still exists within the FSS area footprint. Soil sample for the FSS will be analyzed by field ex-situ soil screening using SOP-4 provided in Attachment T.4. If the ex-situ soil screening result show that the DCGLemc is not exceeded, it will be confirmed by vendor laboratory analysis. Soil samples collected during excavation control surveys will be collected consistent with the FSS requirements so that the soil sampling data obtained can be used for FSS purposes where appropriate.

4.7.2 Systematic Soil Samples

Systematic surface samples will be collected for vendor laboratory analysis as confirmation samples for the FSS systematic gamma static surveys to evaluate compliance with DCGLw requirements. Confirmatory surface soil samples will be collected at five percent of the gamma static survey locations from each Class 1, Class 2 and Class 3 FSS areas. A surface soil sample will be collected every 20th gamma static survey location.

5.0 FIELD ACTIVITIES

The FSS field activities follow the same general approach in each survey area and include:

1. Initially collecting gamma scan survey data
2. Verifying that the gamma scan survey data do not identify any gamma activity levels of potential concern from a FSS perspective
3. Performing judgment-based sampling as necessary with evaluation of the samples by on-site ex-situ soil gamma screening to determine if elevated area concerns (i.e., DCGLemc) exist that require additional excavation and removal
4. Systematic one-minute gamma static surveys at the nodes of triangular grids (50 feet grid length for Class 1 survey units and 72 feet grid length for Class 2 survey units) to support DCGLw evaluations
5. Confirmatory soil sampling with off-site laboratory analyses for systematic gamma static surveys

A description of field activities is provided in the subsections below.

5.1 Gamma Scan Surveys

When excavation in an area is complete, systematic gamma scan surveys of the excavated areas will be conducted. Gamma scan surveys will be performed in a manner that provides 100 percent coverage of excavated soil surfaces by walking along transects with the bare detector at 12 inches above the ground surface (see SOP-3, to be provided in Attachment

T.4 to the 95 Percent Design Report). Initially, a 6-foot transect spacing is determined based on a conservative detector FOV of 6.0 feet. If a different FOV is used, it will be verified by a FOV test. A scan rate of near three feet per second will be maintained depending on terrain but will not exceed six feet per second. Procedures are provided in the MARSSIM for calculating scan MDCs for particular survey instruments. More detail on signal detection theory and instrument response is provided in NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions (NRC 1998). Based on the scan rate, detector background counting rate, detector response factor, detector FOV (at least six feet diameter for the Pb-214 and Bi-214 high energy gamma radiations) and the desired sensitivity index, the selected instrumentation will meet the scan MDC at less than 50 percent of appropriate scan MDC limit for the Site at a scan rate of up to six feet per second.

A typical/example scan MDC calculation consistent with MARSSIM Section 6.7.2, scan MDC for Land Areas, based on site-specific survey and instrumentation parameters is described in SOP-1. The actual scan MDC will be calculated using actual FSS instrumentation and survey parameters to demonstrate that it does not exceed the DCGLs. It will generally be below 50 percent of the 4.09 pCi/g RALemc (the DCGLemc plus the background level) for Class 1 survey units and will be below 50% of 2.24 pCi/g RAL (the DCGLw plus the background level) for Class 2 and Class 3 survey units. Based on operational and function check data, and survey parameters for this instrumentation during previous surveys at the Site, a scan MDC for a 2x2 NaI bare detector is estimated at less than 0.6 pCi/g, and less than 1.0 pCi/g for collimated 2x2 NaI detector, below 50 percent of the 4.09 pCi/g RALemc.

The gamma scan survey measurements will be electronically logged with a suitable sub-meter DGPS which provides a real-time corrected location coordinates. If elevated activities above the applicable investigation level are encountered, one-minute static readings will be collected over the location of interest. In addition, for each location where a soil sample is collected, a one-minute gamma static measurement will be collected above each soil sampling location.

Gamma scan results will be compared to the RAL discussed above and locations where the data indicate an anomaly will be flagged (defined as a contamination level that exceeds the RALemc). Judgment based Soil samples will be collected at these locations and compared to the RALemc, and/or the soils in that location will be excavated and removed.

Gamma scan survey data that satisfy quality control (QC) requirements will be archived electronically in a readily retrievable format along with appropriate meta data (e.g., date collected, detector identification, technician identification, purpose of survey, and any necessary explanatory notes).

5.2 Gamma Static Surveys

Following completion of the FSS gamma scan surveys in an area, a one-minute gamma static measurement will be conducted at each data point, node of the 50-foot triangular grid, in each Class 1 survey unit and at data point at every node of the 72-foot triangular grid in each Class 2 survey unit as a part of the FSS systematic sampling, as shown in Figure 3, Figure 4 and Figure 5, respectively. The numbers of the estimated static survey locations for each FSS area are shown in Table 1. The gamma static surveys will be conducted using the same instrumentation as used for the excavation control survey and the FSS gamma scan surveys. The FSS gamma static surveys will be conducted with the detector fitted with 0.5-inch lead collimator. The gamma static surveys will be conducted for a one-minute counting time with the detector at 12 inches above the ground surface (see SOP-3, to be provided in Attachment T.4 to the 95 Percent Design Report).

A detailed, typical example of a static measurement MDC calculation based on site-specific survey and instrumentation parameters is described in SOP-1, which was calculated in accordance with MARSSIM Section 6.7.1. Based on operational and function check data, and survey parameters for this instrumentation during previous surveys at the Site, the static gamma measurement MDC for a 2x2 NaI detector is estimated at less than 0.6 pCi/g for the bare and collimated detector, below 50 percent of the 2.24 RAL for the Site. The gamma static surveys will be electronically logged with a suitable sub-meter accuracy DGPS which provides real time corrected location coordinate data.

The gamma static survey results in CPM will be converted to equivalent Ra-226 concentration in surface soil by using the linear regression analysis equation from the site-specific correlation for Ra-226 concentration in soil. Gamma static survey data that satisfy QC requirements will be archived electronically in a readily retrievable format along with appropriate metadata (e.g., date collected, detector identification, technician identification, purpose of survey, and any necessary explanatory notes).

5.3 Field Gamma Radiation Ex-Situ Soil Screening

FSS soil samples may be screened by on-site soil screening to verify the absence of significant contamination issues. Ex-situ field soil screening by single channel analysis for Ra-226 content will be performed (see SOP-4) specifically on the soil samples collected based on professional judgment. This screening allows corrective actions (e.g., expedited confirmation, additional excavation and re-sampling) to be taken immediately before committing resources to off-site laboratory analyses. Data from on-site soil screening will not be used to demonstrate DCGL compliance.

For an expedited estimate of Ra-226 in soil, a reference soil with a known Ra-226 concentration (similar to 2.2 pCi/g RAL) will be used. This method, which is more reliable than the scan or the gamma static surveys, was successfully implemented during the Site RSEs, PDS, and IRAs for expedited estimates of Ra-226 in soil. A single channel analyzer, Ludlum L2221 integrated with Ludlum 44-20 3x3 NaI scintillation detector will be used to measure 609 KeV radiation of the Ra-226 decay product Bi-214. The sample will be placed in a plastic liner around the detector in a heavily lead shielded counting chamber. The heavily shielded counting chamber lowers the system background noise thus improves the MDC. The 609 KeV gamma radiation counts are obtained and compared to the reference soil and sample soil for field screening. Based on operational and function check data during the previous soil screening during the IRAs and PDS, the Ra-226 MDC for this screening system is estimated at 0.5 pCi/g.

5.4 Judgment Based Soil Samples

In the event that elevated activities are encountered during the FSS gamma scan surveys, one-minute gamma static survey readings will be collected over the location of interest to confirm the elevated reading. If the one-minute reading is above the RALemc value, a soil sample based on professional judgment will be collected from that location. A one-minute static reading from a height of 12 inches will be collected above each soil sampling location. Field samples will be collected using a stainless-steel scoop or spoon and will be homogenized in a stainless-steel bowl and placed in a sample bag (see SOP-5, to be provided in Attachment T.4 of the 95 Percent Design Report). The soil sample will initially be field screened for expedited Ra-226 content by on-site soil screening as discussed above. If the field screening of the soil sample shows Ra-226 content below the RALemc, the sample will be sent to a vendor laboratory for confirmation Ra-226 analysis.

5.5 Systematic Soil Samples

Systematic surface soil samples will be collected as confirmation samples for the FSS systematic gamma static survey measurements, which will be used to evaluate compliance with DCGLw requirements. Confirmation surface soil samples will be collected at five percent of the gamma static survey locations in all FSS classified areas, as shown on Figure 3 Figure 4 and Figure 5. The estimated numbers of systematic confirmatory soil samples for each FSS area are listed in Table 1. Field samples will be collected by using a stainless-steel scoop or spoon and will be homogenized in a stainless steel bowl and placed in a sample bag (see SOP-5 in Attachment T.4 of the Design Report). The systematic soil samples will be sent to an off-site vendor laboratory for analysis of the Constituents of Concern Ra-226 and total uranium analysis, as well as the Constituents of Concern arsenic, molybdenum, selenium and vanadium, specified in the 2011 Action Memo.

5.6 Laboratory Analysis

FSS systematic confirmatory surface soil samples will be shipped to an off-site contract laboratory for analysis Ra-226 (Reporting Limit of 0.5 pCi/g) analysis using USEPA method 901.1 modified for soil media, and total uranium (Reporting limit of 0.2 mg/kg) by USEPA Method 6020. Laboratory methods, instruments, and sensitivities will be in accordance with

USEPA protocols for environmental analysis. Any laboratory used for environmental sample analysis will have appropriate Environmental Laboratory Approval Program certification or equivalent. Laboratory instrumentation will be calibrated by using National Institute of Standards and Technology (NIST) traceable standards.

5.7 Instrument Calibration and Function Checks

Instruments and equipment used during the FSS will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations. Instruments will be calibrated annually. Daily operational and functional checks will be performed for radiological instruments before first use. Equipment that fails calibration or becomes otherwise inoperable during the FSS will be removed from service and segregated to prevent inadvertent use. Such equipment will be tagged to indicate that it should not be used until the problem can be corrected. Equipment requiring repair or recalibration must be approved for use by the Radiation Safety Officer (RSO) or designee before being placed back into service. Equipment that cannot be repaired or recalibrated will be replaced. Potentially affected data acquired on such equipment will be identified and evaluated for usability and potential impact on data quality

5.8 Corrective Actions

Corrective actions will be initiated if problems related to analytical/equipment errors or noncompliance with approved criteria are identified. Corrective actions will be documented through a formal corrective action program at the time the problem is identified.

Nonconformance with the established procedures presented in the FSS Plan or in the Quality Assurance Project Plan (QAPP; Appendix T-3 of the Design Report), will be identified and corrected. The Project Manager will issue a nonconformance report (NCR) for each nonconforming condition. In addition, corrective actions will be implemented and documented in the appropriate field logbook.

Procedures for corrective actions related to sample collection/field measurements and laboratory analyses are explained in the QAPP.

5.9 Sample Chain of Custody and Documentation

Documentation of pertinent field activities, such as instrument calibrations/function check data, field measurements will be recorded in the field forms and field logbooks as necessary. The field sampling and analysis documentation procedures, including labeling, chain of custody, photographs, etc. are described in the Field Sampling Plan.

5.10 Correction to Documentation

Original information and data in field forms and logbooks, on sample labels, on chain of custody forms, and any other project-related documentation will be recorded in black waterproof ink in a completely legible manner. Errors made on any accountable document will be corrected by crossing out the error and entering the correct information or data. Any error discovered on a document will be corrected by the individual responsible for the entry. Erroneous information or data will be corrected in a manner that will not obliterate the original entry, and corrections will be initialed and dated by the individual responsible for the entry.

5.11 Sample Packaging and Shipping

Sample containers will be packaged in thermally insulated rigid-body coolers. Sample packaging and shipping will be conducted in accordance with procedures that are described in the QAPP and applicable U.S. Department of Transportation specifications. A checklist provided in the QAPP will be used by the individual responsible for packaging environmental samples to verify completeness of sample shipment preparations. In addition, the laboratory will document the condition of the environmental samples upon receipt. This documentation will be accomplished by using the cooler receipt checklist provided in the project QAPP. All samples collected during the project will be shipped within the sample holding time specified by the analytical method. Samples will be stored in a secure area between sample collection and shipment to the laboratory.

5.12 Field Decontamination

Field sampling equipment used during soil sampling will be decontaminated between samples. Equipment to be decontaminated includes stainless steel scoops, bowls, spoons, core barrels, and hand auger barrels. Other equipment used during sampling activities that does not directly contact sample materials (down-hole rods, shovels, etc.) will be cleaned by a pressurized cleaner to remove visible soil contamination. One rinsate sample for each piece of sampling equipment for the project will be collected to verify adequacy of the decontamination method.

Field decontamination will be conducted in an area near the field equipment staging area or in an area approved by the RSO. Decontamination activities will be conducted so that solid and liquid wastes generated can be containerized and disposed of appropriately.

5.13 Radiation Protection

Radiation protection for workers and the public during the FSS is addressed and included in the Site RA Health and Safety Plan (HASP).

6.0 DATA QUALITY ASSESSMENT

The interpretation of survey results and decisions will follow the DQA process as outlined in the MARSSIM. There are five steps in the DQA process:

1. Review the DQOs and survey design.

2. Conduct a preliminary data review.
3. Select a statistical test.
4. Verify the assumptions of the statistical test.
5. Draw conclusions about the data.

The primary purpose of the DQOs and review of the FSS design is to ascertain, after data collection, that the original assumptions built into the DQO process that generated the data collection strategy are still valid. Deviations from original assumptions will require revisiting the DQO process, adjusting for realities uncovered by field work, and determining whether the data collected still meet the original objectives of the data collection, and, if not, the corrective steps required. Any corrective actions will be implemented following USEPA review and approval.

The preliminary data review will include a review of QA reports to ensure that the data produced are of the quality assumed by the DQO process and a review of the data sets themselves to identify trends and properties that may be pertinent to the decisions that must be made on the basis of the data. This effort will include basic data statistical analysis techniques, such as creating posting maps and histograms, determining the data set means, standard deviations and median for each FSS area.

7.0 DECISION LOGIC

Through the course of the FSS design, implementation, and data collection process there are a number of generic key decision points that include:

- Identifying appropriate FSS area designation (i.e., Class 1 or Class 2) and layout of individual FSS survey units.

- Demonstrating there are no DCGLemc exceedances for Class 1 Areas through a combination of gamma scan surveys, soil sampling (as necessary) based on professional judgment, and systematic gamma static surveys and soil sampling.

- Demonstrating compliance with DCGLw requirements using systematic gamma static surveys and confirmatory soil samples from FSS areas and WRS statistical tests.

7.1 Confirming Survey Area Classification

FSS data sets (gamma scan and gamma static surveys and soil sampling results) will be reviewed to determine if there are anomalous results that are inconsistent with the original survey area classification for the area from which the data were collected. An example of an anomalous result might be a systematic sample result near or above the DCGL values for a Class 2 Area. Anomalous results do not necessarily indicate noncompliance with the DCGLs, but may indicate that the underlying information used as a basis for the FSS area classification was incorrect. In these instances, further investigation may take place to ensure that the anomalous result is not indicative of unexpected residual contamination that warrants attention or reclassification of a Class 2 Area.

7.2 Demonstrating DCGLemc Compliance

Compliance with the DCGLemc is demonstrated through a combination of gamma scan surveys and sampling. Since the FSS gamma scan survey is sensitive enough to detect if DCGLemc exceedances exists and will be implemented for 100 percent of a survey area surface, DCGLemc compliance may be demonstrated with gamma scan surveys alone. In the course of DCGLw compliance, sufficient systematic static surveys and samples will be collected to demonstrate DCGLemc compliance (or vice versa). For the DCGLemc requirements, scan and gamma static surveys and soil sample results will be compared against the RALemc.

The generic process for demonstrating DCGLemc compliance is for Class 1 Areas. Logged, spatially complete gamma survey data will be collected for each FSS area. These data will be compared to the DCGLw. If the result is above the DCGLw, the individual systematic survey result will be compared to the DCGLemc. If the result exceeds the DCGLemc, further data may be collected to better define the excavated area, and remediation may take place before the FSS process continues. Locations flagged as potential anomalies by the gamma walkover data or for any other reason (e.g., visual evidence of contamination, historical information, etc.) will be sampled based on professional judgment.

7.3 Demonstrating Compliance with DCGLw

Each survey unit will have systematic gamma static surveys and confirmatory soil samples collected to allow for a DCGLw compliance evaluation. The statistical tests will be applied to FSS systematic gamma static survey results collected at the nodes of 50-feet triangular grid in each Class 1 survey unit. When the data clearly show that a survey unit meets or exceeds DCGLw compliance, the result may be obvious without performing a formal statistical analysis. If the systematic gamma static survey measurements are at or below the RAL, the survey unit meets the DCGLw compliance. Examples of circumstances leading to specific conclusions based on a simple examination of the data for this FSS are summarized in Table 6.

Since Ra-226 is present in background, the non-parametric WRS test will be used, if needed, for this FSS consistent with MARSSIM guidance to evaluate whether the mean concentration in an FSS area is statistically different than the mean of the reference area. The WRS test will be used with the following parameters:

The hypothesis tested by the WRS test is

Null Hypothesis

H_o: The median concentration in the survey area exceeds that in the reference area by more than the DCGLw

versus

Alternative Hypothesis

H_a: The median concentration in the survey area exceeds that in the reference area by less than the DCGLw

The Ho to be tested is that residual contamination exceeds the release criterion. If the Ho is rejected, the alternative hypothesis will be accepted, and the finding of the evaluation is that the FSS area satisfies the release criterion requirement.

If the survey area does not pass the WRS test, the reason will be investigated, and appropriate action will be taken. If additional excavation and removal is required within a FSS area, the affected area will be reclassified as a Class 1 Area (if not already), and the FSS data collection process will be repeated.

7.4 Demonstrating Compliance with the Total Uranium RAL

The 2011 Action Memo and the ROD specify a total uranium RAL of 230 mg/kg for removal of soils at the Site. Since the soils at the Site are impacted by uranium ore, uranium will be in secular equilibrium with its associated decay products. The 2.24 pCi/g Ra-226 will be in secular equilibrium with approximately 6.8 mg/kg of total uranium. Therefore, removal of soils exceeding the 2.24 pCi/g Ra-226 RAL also assures that soils at levels far below the total uranium RAL of 230 mg/kg are removed. Gamma static survey results for Ra-226 and total uranium analytical results of the systematic confirmatory soil samples will be used to demonstrate compliance with the total uranium RAL.

7.5 Final Verification Process

A final verification survey will be performed following the final status survey, regrading, and revegetation so that no recontamination of mine RA areas occurs. These final verification surveys will likely occur over several different construction seasons, as the preferred time for seeding is in the fall. To limit erosion, revegetation is not proposed to occur in one season.

The final verification survey will consist of gamma scan surveys at 25 percent coverage in the closed-out survey units at the end of the RA construction. The action level for this verification process will be same as the investigation levels specified for appropriate class areas as specified in Section 4.6.4. Scan measurements in a discrete area that are above the action level will be flagged for further investigation and undergo appropriate corrective action, which may include remediation. If the area is remediated, the area within the survey unit or the entire survey unit may require resurvey for close out.

8.0 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

QA/QC measures will be employed throughout the FSS process to ensure that decisions are made using data of acceptable quality. The QAPP covers project QA/QC requirements and activities. Part of the QA/QC process is data validation, which will take place as described in the QAPP included as Appendix T-3.

A QA/QC program will be conducted during surveys that, in accordance with established procedures, will specify and measure the performance of measurement methods through the collection of an appropriate number or frequency of QC samples. Such samples could include field and laboratory blanks, field duplicates, laboratory replicates, and spiked samples. Field instruments will be calibrated on NIST traceable standards at a frequency prescribed in the QAPP. A daily function check will be performed for all field instruments before use. Corrective actions will be conducted if performance falls outside expected ranges.

All surveys and sample collection for this FSS will be performed in accordance with established QC requirements. Replicate surveys, sample recounts, instrument performance checks, chain of custody, control of field survey data and databases, and QC investigations provide sufficient level of confidence in the data collected to support the survey outcome. The radiologic survey instrument QA/QC frequencies, such as calibration and function checks, are described in the appropriate SOPs. The field QA/QC replicate survey and sampling include the following:

- Duplicate measurement at five percent of gamma static survey locations.
- Replicate gamma scan at five percent of scanned area.
- Confirmatory soil sample for gamma static survey at five % of gamma static measurement locations.
- Field QA/QC duplicate soil samples for offsite vendor laboratory analysis at a frequency of five percent of the soil samples collected.
- Replicate recounting of onsite ex-situ gamma soil screening at a frequency of ten percent of the total number of samples screened with a minimum of one per day.

In addition, QA/QC measures will ensure that trained personnel conduct surveys with approved procedures and properly calibrated instruments. Procedures will cover sample documentation, chain of custody, field and laboratory QC measurements, and data management.

9.0 REPORT OF FSS FINDINGS

Survey procedures and sampling results will be documented in a FSS report following the general guidance for FSS reports in MARSSIM. This FSS report will become an integral part of the RA report. This FSS report will contain, at a minimum, the following information:

1. A site map that shows scan data, locations of elevated direct radiation levels, and sampling locations from each survey area

2. Tables of radionuclide concentrations in each sample from each survey unit, including, but not limited to, the results in pCi/g, measurement errors, detection limits, and sample depths

3. Summary statistics for analytical data, surface scan data, and gamma logging data from each survey area

4. A graphical display of individual sample concentrations in the form of posting plots and/or histograms for each survey unit and visual identification of trends

5. Results of the WRS test

The last step of the DQA process will be documenting results and drawing conclusions.

10.0 REFERENCES

MWH, 2006a. Removal Site Evaluation Work Plan, Northeast Church Rock Mine Site, Prepared for United Nuclear Corporation. August.

MWH, 2006b. Technical Memorandum, Results of Background and Radium-226 Correlation Sampling, Northeast Church Rock Mine Site, Prepared for United Nuclear Corporation. October.

MWH, 2007. Final Removal Site Evaluation Report, Northeast Church Rock Mine Site, Prepared for United Nuclear Corporation. October.

MWH, 2009. Interim Removal Action Work Plan Northeast Church Rock Mine Site. Prepared for United Nuclear Corporation. July 24.

MWH, 2011. Northeast Church Rock Mine Site, Supplemental Removal Site Evaluation Report, Eastern Drainage Area, Prepared for United Nuclear Corporation and GE Corporate Environmental Program. September.

MWH, 2013. Northeast Church Rock Mine, Eastern Drainage Removal Action, Construction Completion Report, Prepared for United Nuclear Corporation. March.

MWH, 2014a. Pre-Design Studies, Northeast Church Rock Mine Site Removal Action, Northeast Church Rock Mine Site. Prepared for United Nuclear Corporation and General Electric Corporation. October 31.

MWH, 2014b. Pre-Design Studies, Northeast Church Rock Mine Site Removal Action, Church Rock Mill Site. Prepared for United Nuclear Corporation and General Electric Corporation. October 31.

UNC, 1993. United Nuclear Corporation, Church Rock, Mill Decommissioning Report, License No. SUA-1475, Docket No. 40-8907, April.

USEPA, 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016.

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, EPA/240/B-06/001, Office of Environmental Information, Washington, D.C., February

USEPA 2011. Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site, McKinley County, New Mexico, Pinedale Chapter of the Navajo Nation. September 29

USEPA 2013. Region 6, 2013. Record of Decision, United Nuclear Corporation Site, McKinley County, New Mexico. March 29.

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

Tables

Table 1: NECR Mine Site FSS Areas

FSS Area Class	FSS Area ID	Area Description/contamination Type	Area Approximate Size, Ft^2	Area Approximate Size, Acres	Estimated No. of Survey Units (1)	Estimated Survey Unit size, Acres	Estimated No. of Data (Static Survey) Points (2)	Estimated Confirmatory Soil Samples @5% of SS Points
FSS Class 1 Areas	1	Vent Hole Area (, Surface, <1.0 ft deep contamination; Excavation Area 1)	398,487	9.1	4	2.3	190	10
	2	Mine Areas (Surface plus subsurface >1.0 feet deep Contamination; Excavation Areas 2,3,4,6,7,8,9,10,11 and 12)	4,154,927	95.4	39	2.4	2010	101
	3	Trailer Park & Sediment Collection Area (Surface, <1.0 ft deep contamination; Excavation Area 13 &14)	563,100	12.9	5	2.6	260	13
	4	Equipment Decontamination Area at Mill Site	39,988	0.9	1	0.9	7	1
	5	Home Site (NECR-1 Step-out) IRA Area	1,667,570	38.3	15	2.6	720	36
	6	East Drainage RA Area	710,464	16.3	7	2.3	336	17
	Class 1 Area Total		**7,534,536**	**173.0**	**71**		**3523**	**178**
FSS Class 2 Areas	7	Haul Road (including storm water collection ponds)	215,621	4.9	1	4.9	48	2
	8	Equipment Yard at Mill Site	278,160	6.4	2	3.2	14	2
	Class 2 Area Total		**493,781**	**11.3**	**3**		**62**	**4**
FSS Class 3 Areas	9	Buffer Zone Around Class 1 FSS Area 1	284,312	6.5	1	6.5	48	2
	10	Buffer Zone Around Class 1 FSS Area 2 and 3	1,103,583	25.3	2	12.7	96	5
	11	Buffer Zone Around Class 1 FSS Area 5 and 6	559,985	12.9	2	6.4	96	5
	Class 3 Area Total		**1,947,879**	**44.7**	**5**		**240**	**12**
TOTAL			**9,976,196**	**229.0**	**79**		**3825**	**194**

Notes: (1) Typical Class 1 Survey Unit Size 2.5 Acres & Class 2 Survey Unit Size 5.0 Acres; (2) Total estimated data points in FSS Area 5 and 6 includes data points from the Interim Status Survey

Table 2: Parameters for Number of Data Point Calculation for WRS Test

Parameter	Column 1[1] Value	Column 2[1] Value
Type I Error (alpha, α)	0.05	0.05
$Z_{1-\alpha}$, percentile for α = 0.05 (MARSSIM Table 5.2)	1.645	1.645
Type II Error (beta, β)	0.10	0.10
$Z_{1-\beta}$, percentile for β = 0.10 (MARSSIM Table 5.2)	1.282	1.282
DCGLw	1.24	5.00
Standard Deviation, σ (From 2013 EDRA 149 sample Interim Status Survey Dataset)	0.46	0.46
LBGR @ 95%, 1.96σ	0.90	0.90
Shift Δ (DCGLw-LBGR)	0.34	4.10
Relative Shift Δ/σ	0.736	8.910
Pr, probability for relative shift Δ/σ (MARSSIM Table 5.1)	0.689665	1.000
Number of data points from reference area/ survey unit pair, MARSSIM Equation 5.1 $N = (Z_{1-\alpha} + Z_{1-\beta})^2 / 3(Pr - 0.5)^2$	79.39	11.42
Adding additional 20% and rounded up to next even number	96	14
Number of data points from BRA	48	7
Number of data points from SU	48	7

Note (1): Column 1 is for the mine site 1.24 pCi/g DGCLw & Column 2 is for the mill site 5.00 pCi/g DCGLw

Table 3: Grid Length Calculation Parameters

Parameter	Class 1 Survey Unit Values		Class 2 Survey Unit Values	
	Mine Site Removal Action Areas	Decontamination Area at Mill Site Yard	Mine Site Removal Action Areas	Equipment Yard at Mill Site Yard
Survey Unit Area, square Feet, A	108,900	39988	217,800	114300
Survey Unit Area, square meters, A	10117	3715	20234	10619
Number of data points required per survey unit, n	48	7	48	7
Calculated Length (L) of Triangular grid, $L = \sqrt{(A/0.866n)}$, Feet	51	81	72	137
Length (L) of Triangular grid, Rounded down	**50**	**80**	**72**	**135**

Table 4: DCGLemc Calculation Parameters

Parameter	Mine Site RA Class 1 Survey Units 50-foot TRG	Mill Site Decontamination Area Class 1 Survey Unit 80-foot TRG
Area Bounded by grid nodes (TRG grid node for Class 1), m^2, Contamination zone area	201	515
Dose, mrem/yr, RESRAD 7.2 (Ra-226 concentration @ unity (1 pCi/g) and all default pathways and parameters, including default contamination zone area @ 10,000 m^2)	17.4	17.4
Annual dose, mrem/yr, RESRAD 7.2 (Ra-226 concentration @ unity (1 pCi/g) and all default pathways and parameters, except contamination zone area)	6.99	10.80
Area Factor	2.49	1.61
Site Ra-226 DCGLw, pCi/g	1.24	5.00
Site Ra-226 DCGLemc, pCi/g	**3.09**	**8.06**
Site RALemc (DCGLemc+Background) pCi/g	**4.09**	**9.06**

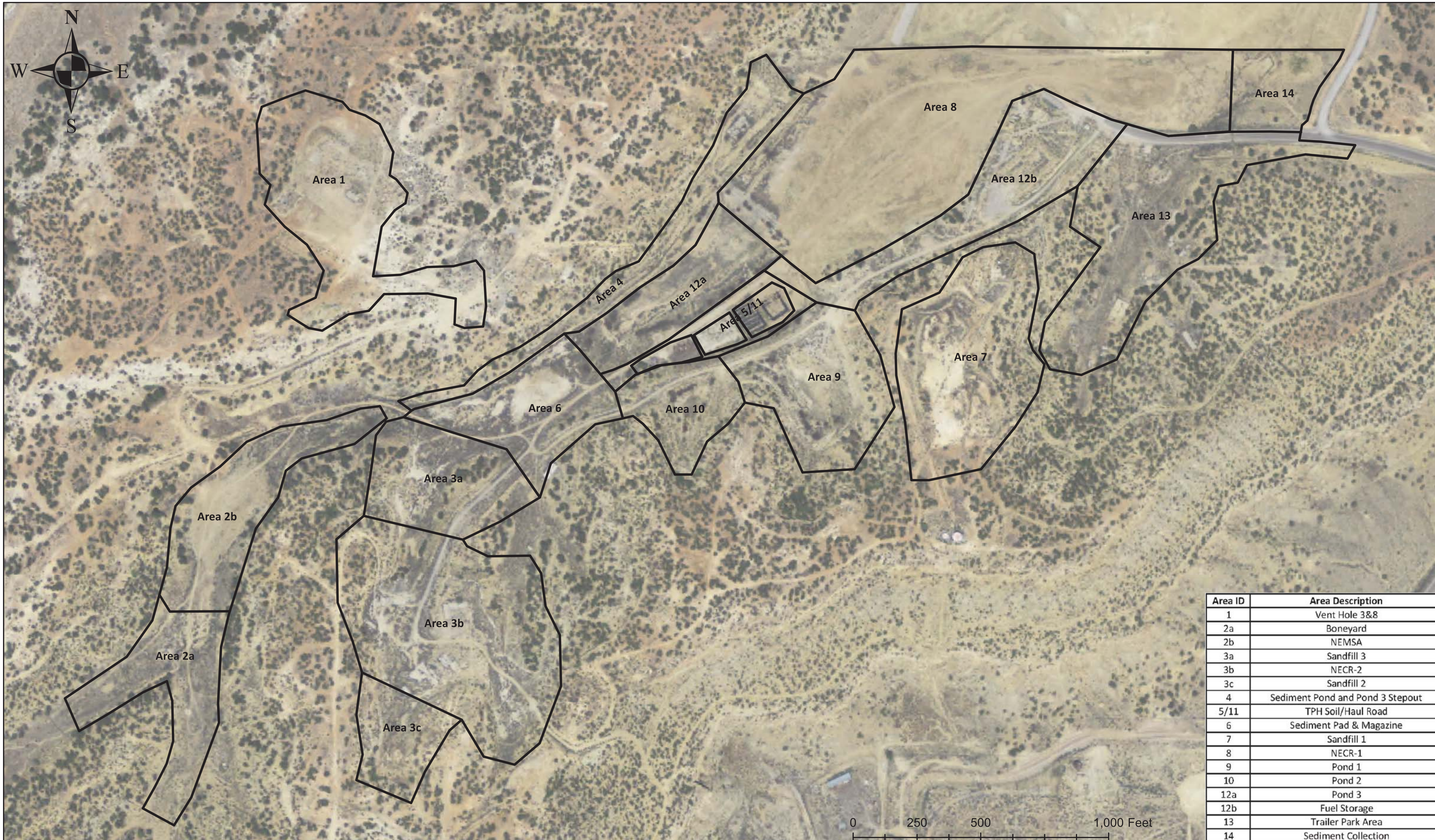
Table 5: NECR RA Final Status Survey Investigation Levels

Survey Unit Classification	Investigation Level for Ra-226 Direct Measurement or Soil Sample Result	Investigation Level for Scan Result
Mine Site Class 1	4.09 pCi/g	4.09 pCi/g
Mill Site Class 1	9.06 pCi/g	9.06 pCi/g
Mine Site Class 2	2.24 pCi/g	2.24 pCi/g
Mill Site Class 2	6.45 pCi/g	6.45 pCi/g
Class 3	1.76 pCi/g	2.24 pCi/g

Table 6: Summary of Statistical Test

Survey Result	Conclusion
Difference between largest survey unit measurement and smallest reference area measurement is less than $DCGL_W$	Survey unit meets release criterion (RAL)
Difference of survey unit average and reference area average is greater than $DCGL_W$	Survey unit does not meet the release criterion (RAL)
Difference between any survey unit measurement and the reference area measurement greater than $DCGL_w$ and the difference of survey unit average and reference area average is less than $DCGL_w$	Conduct WRS test and elevated measurement comparison

Figures



Area ID	Area Description
1	Vent Hole 3&8
2a	Boneyard
2b	NEMSA
3a	Sandfill 3
3b	NECR-2
3c	Sandfill 2
4	Sediment Pond and Pond 3 Stepout
5/11	TPH Soil/Haul Road
6	Sediment Pad & Magazine
7	Sandfill 1
8	NECR-1
9	Pond 1
10	Pond 2
12a	Pond 3
12b	Fuel Storage
13	Trailer Park Area
14	Sediment Collection

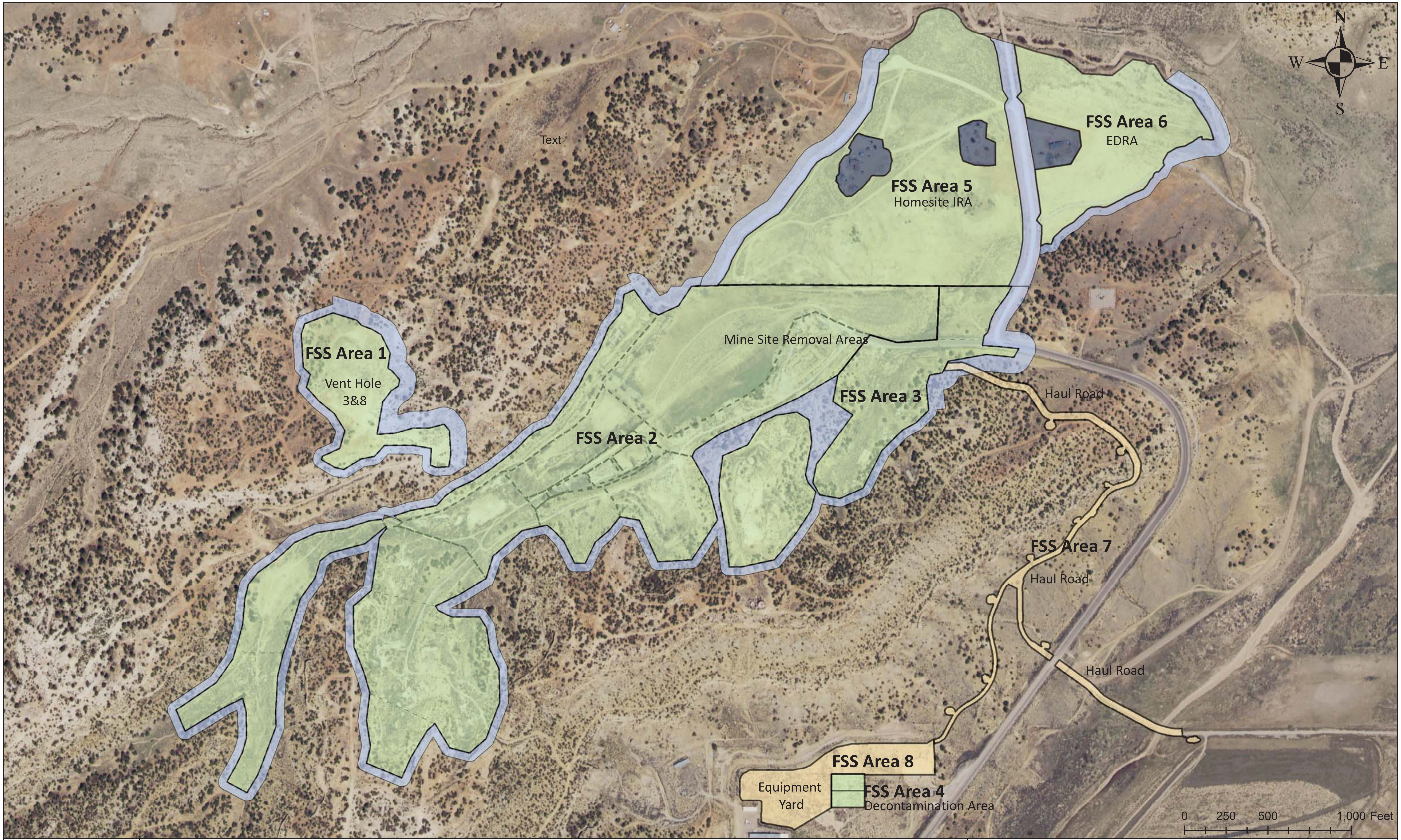
AVM Environmental Services, Inc.

Figure 1
95% Design Final Status Survey Plan
NECR RA Soil Excavation and Removal Areas

March 2018

Legend

Excavation Area Boundaries



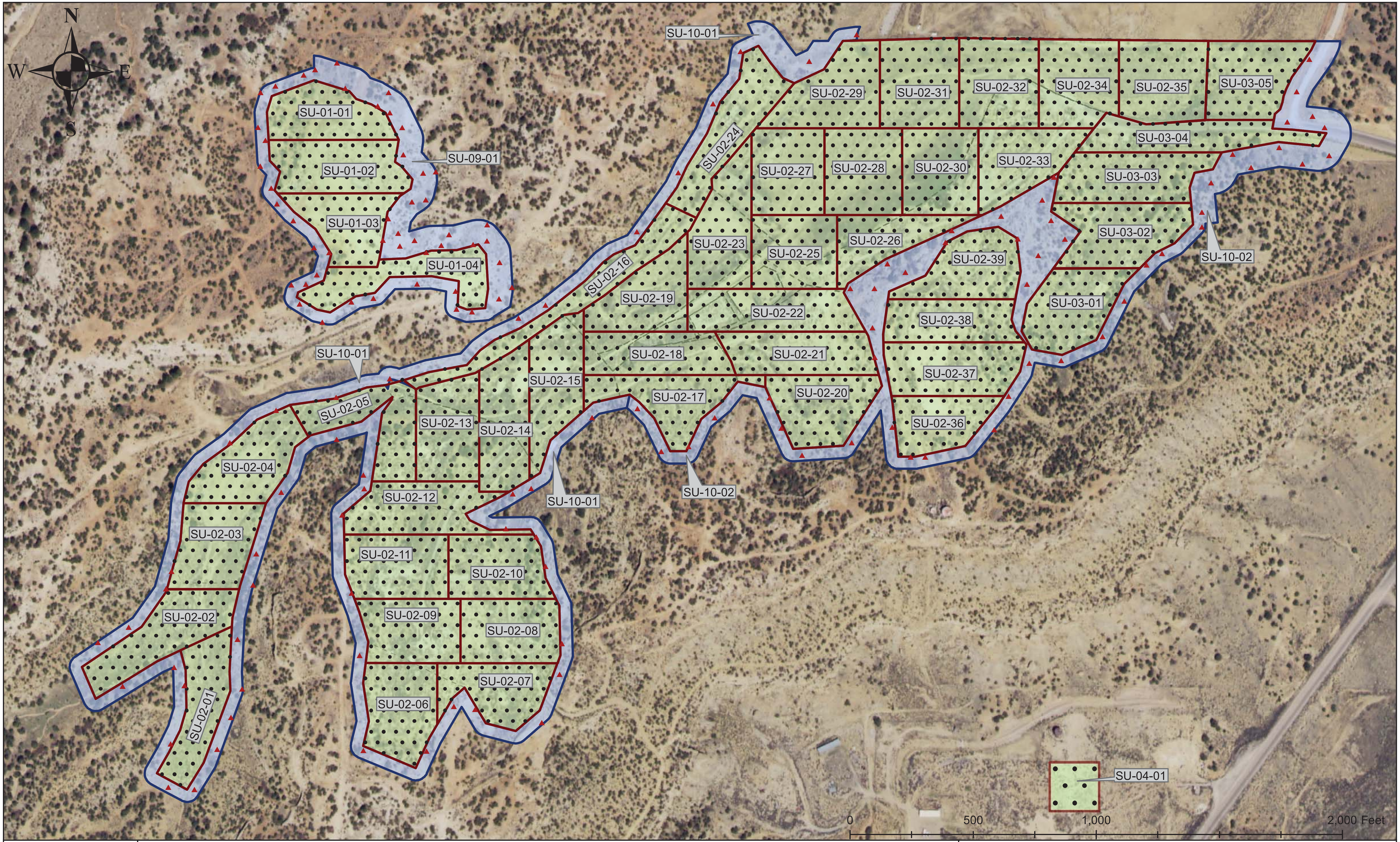
AVM Environmental Services, Inc.

Figure 2
95% Design Final Status Survey Plan
NECR RA FSS Areas

March 2018

Legend

- FSS Class 1 Area
- FSS Class 2 Area
- FSS Class 3 Area
- EPA Homesites



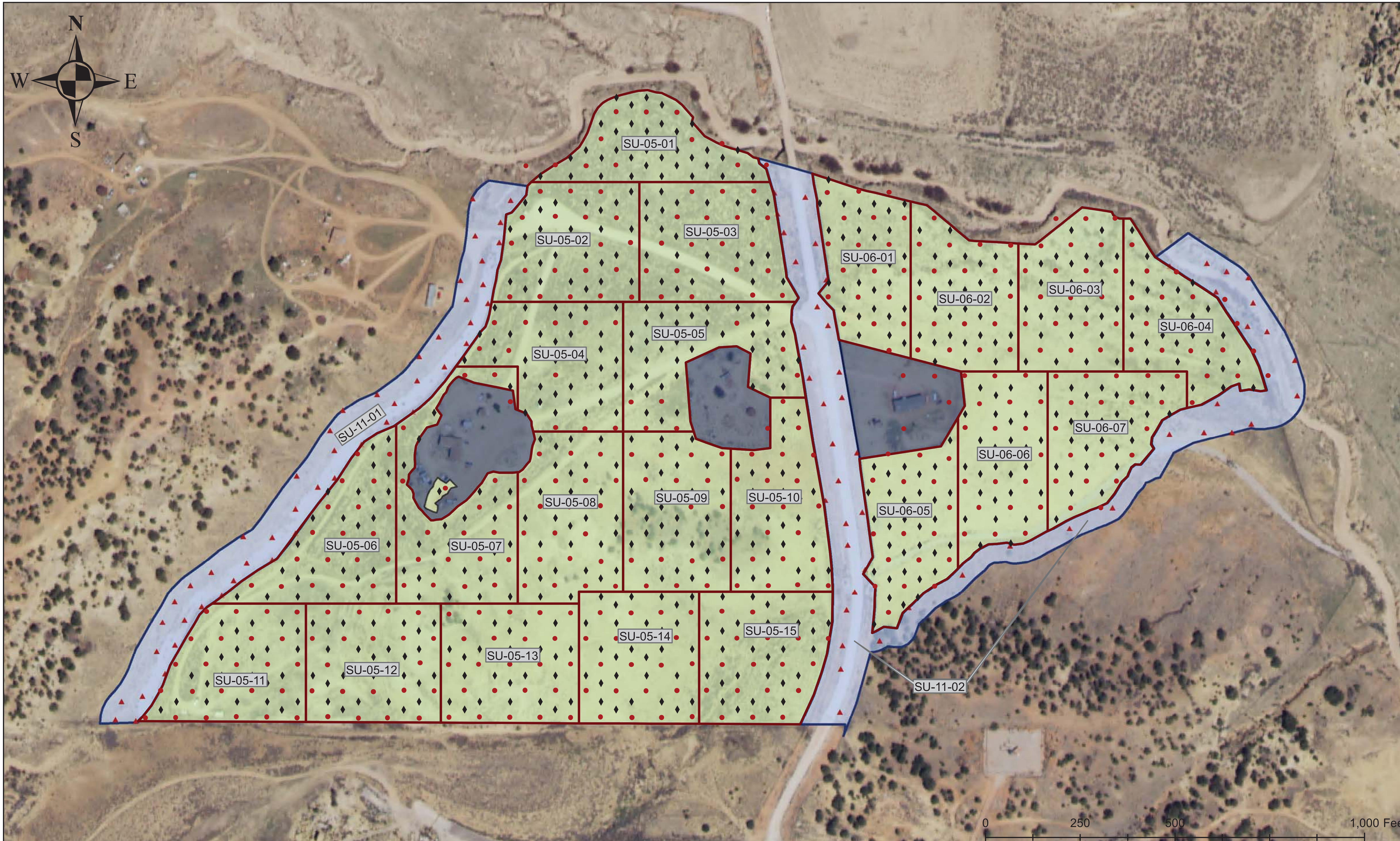
AVM Environmental Services, Inc.

Figure 3
95% Design Final Status Survey Plan
NECR Mine Site RA FSS Class 1 and Class 3 Survey Units and Data Points

March 2018

Legend

- Class 3 Random Point
- Class 1 50ft TRG Data Point
- Class 1 Survey Unit Boundary
- Class 3 Survey Unit Boundary
- FSS Class 1 Area
- FSS Class 3 Area



AVM Environmental Services, Inc.

Figure 4
95% Design Final Status Survey Plan
NECR Step Out Area RA Class 1 & Class 3 Survey Units with Data Points

March 2018

Legend

- Interim Status Survey Data Point
- Add-In Status Survey Data Point
- Class 3 Random Data Point
- Survey Unit Boundary
- Class 3 Survey Unit Boundary
- EPA Homesite
- FSS Class 1 Area

Figure 5
95% Design Final Status Survey Plan
NECR RA Class 2 Survey Units with Data Points

AVM Environmental Services, Inc.

March 2018

Legend
- Class 2 FSS Data Point
- Class 2 Survey Unit Boundary
- FSS Class 2 Area

Attachment 1

Final Status Survey Plan Prospective Power Curve

SURFACE SOIL SURVEY PLAN

Survey Plan Summary

Site Name:	NECR Mine Site
Planner(s):	AVM
Survey Unit Name:	NECR Class 1
Comments:	N/A

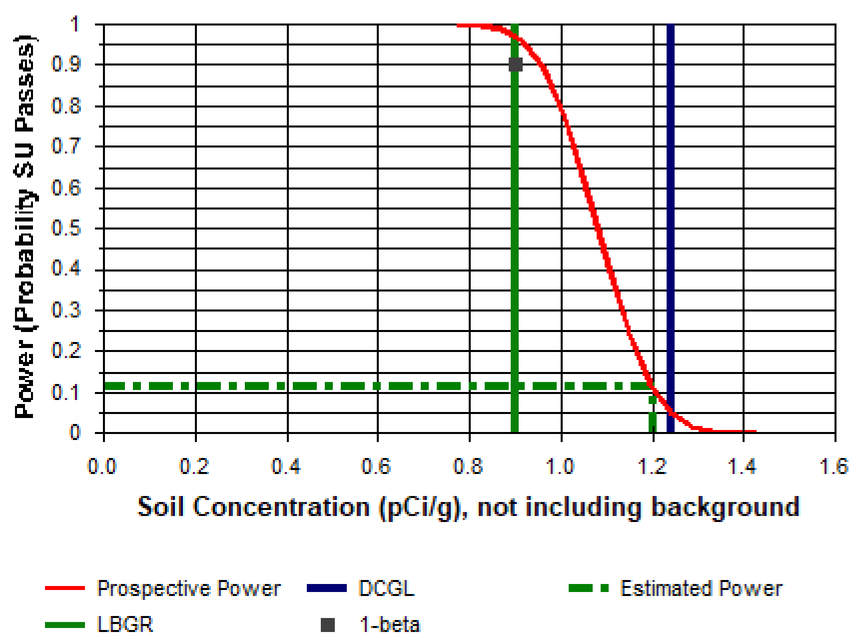
Statistical Design Details

Area (m²):	201	Classification:	1
Selected Test:	WRS	Estimated Sigma (pCi/g):	0.46
DCGL (pCi/g):	1.24	Sample Size (N/2):	48
LBGR (pCi/g):	0.90	Average Area Bounded by Samples (m²):	4.2
Alpha:	0.050	Estimated Conc. (pCi/g):	1.2
Beta:	0.100	Estimated Power:	0.11

Elevated Measurement Comparison Summary

Scanning Instrumentation:	2x2 NaI Detector
Post-EMC Sample Size N/2:	48

Prospective Power Curve



Measured Contaminant Details

Contaminant	DCGLw (pCi/g)	Modified DCGLw (pCi/g)	Survey Unit Estimate (Mean ± 1-Sigma) (pCi/g)	Reference Area Estimate (Mean ± 1-Sigma) (pCi/g)
Ra-226+C	1.24	N/A	2.2 ± 0.46	1.0 ± 0.18

Elevated Measurement Comparison Details

Contaminant	DCGL (pCi/g)	Actual Scan MDC	Area Factor	Required Scan MDC	New Area Factor	Area (m^2)	Post-EMC N/2	Comment
Ra-226+C	1.24	1.1	N/A	N/A	N/A	N/A	48	Actual Scan MDC <= DCGL

Selected Area Factor Table Interpolation Method: Linear

Report Created 08/07/2017 0836 (*COMPASS v1.1.0*)

SURFACE SOIL SURVEY PLAN

Survey Plan Summary

Site Name:	NECR Construction Support Yard
Planner(s):	AVM
Survey Unit Name:	Class 1 Decon Area at Mill Site
Comments:	N/A

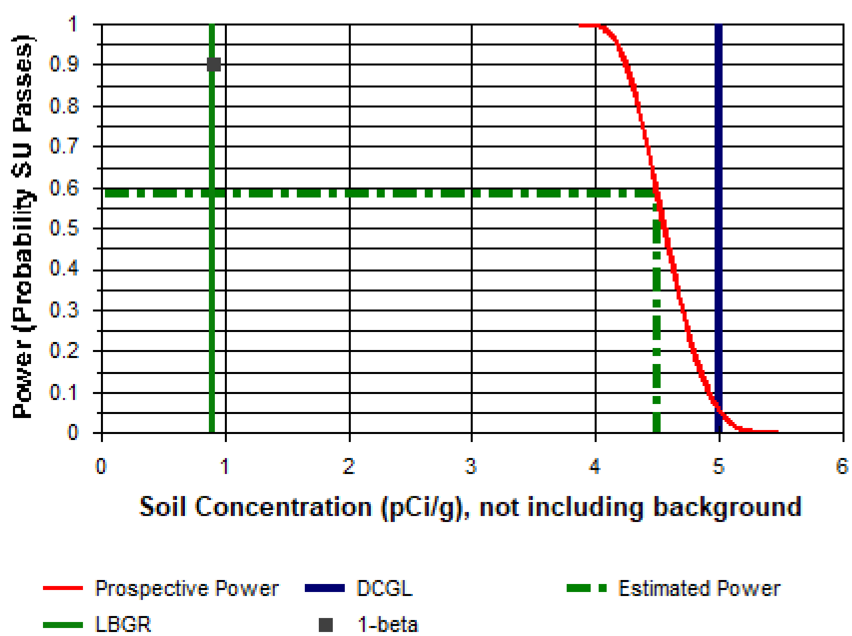
Statistical Design Details

Area (m²):	3,716	Classification:	1
Selected Test:	WRS	Estimated Sigma (pCi/g):	0.46
DCGL (pCi/g):	5.0	Sample Size (N/2):	7
LBGR (pCi/g):	0.90	Average Area Bounded by Samples (m²):	531
Alpha:	0.050	Estimated Conc. (pCi/g):	4.5
Beta:	0.100	Estimated Power:	0.58

Elevated Measurement Comparison Summary

Scanning Instrumentation:	2x2 NaI Detector
Post-EMC Sample Size N/2:	7

Prospective Power Curve



Measured Contaminant Details

Contaminant	DCGLw (pCi/g)	Modified DCGLw (pCi/g)	Survey Unit Estimate (Mean ± 1-Sigma) (pCi/g)	Reference Area Estimate (Mean ± 1-Sigma) (pCi/g)
Ra-226+C	5.0	N/A	5.5 ± 0.46	1.0 ± 0.18

Elevated Measurement Comparison Details

Contaminant	DCGL (pCi/g)	Actual Scan MDC	Area Factor	Required Scan MDC	New Area Factor	Area (m^2)	Post-EMC N/2	Comment
Ra-226+C	5.0	1.1	N/A	N/A	N/A	N/A	7	Actual Scan MDC <= DCGL

Selected Area Factor Table Interpolation Method: Linear

Report Created 09/22/2017 1021 (*COMPASS v1.1.0*)

Attachment 2

RESRAD 7.2 Run Outputs

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	Ra-226	1.000E+00
Thickness:	2.00 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	1.232E+01	1.258E+01	1.307E+01	1.448E+01	1.672E+01	1.640E+01	9.562E+00	1.267E+01
M(t):	4.929E-01	5.033E-01	5.227E-01	5.791E-01	6.690E-01	6.558E-01	3.825E-01	5.069E-01

Maximum TDOSE(t): 1.740E+01 mrem/yr at t = 54.9 ± 0.1 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.487E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	5.050E+00	0.2902	3.947E-03	0.0002	0.000E+00	0.0000	1.145E+01	0.6581	3.684E-01	0.0212	2.864E-01	0.0165	2.416E-01	0.0139
Total	5.050E+00	0.2902	3.947E-03	0.0002	0.000E+00	0.0000	1.145E+01	0.6581	3.684E-01	0.0212	2.864E-01	0.0165	2.416E-01	0.0139

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.487E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.740E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.740E+01	1.0000

*Sum of all water independent and dependent pathways.

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	201.00 square meters	Ra-226	1.000E+00
Thickness:	2.00 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	6.472E+00	6.511E+00	6.581E+00	6.775E+00	6.991E+00	6.256E+00	3.609E+00	2.175E+00
M(t):	2.589E-01	2.604E-01	2.633E-01	2.710E-01	2.796E-01	2.502E-01	1.444E-01	8.702E-02

Maximum TDOSE(t): 6.993E+00 mrem/yr at t = 32.59 ± 0.07 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.259E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	4.791E+00	0.6852	2.502E-03	0.0004	0.000E+00	0.0000	2.144E+00	0.3067	6.835E-03	0.0010	5.617E-03	0.0008	4.206E-02	0.0060
Total	4.791E+00	0.6852	2.502E-03	0.0004	0.000E+00	0.0000	2.144E+00	0.3067	6.835E-03	0.0010	5.617E-03	0.0008	4.206E-02	0.0060

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.259E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.993E+00	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.993E+00	1.0000

*Sum of all water independent and dependent pathways.

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	515.00 square meters	Ra-226	1.000E+00
Thickness:	2.00 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	8.631E+00	8.753E+00	8.977E+00	9.624E+00	1.060E+01	1.002E+01	5.817E+00	5.197E+00
M(t):	3.452E-01	3.501E-01	3.591E-01	3.850E-01	4.239E-01	4.007E-01	2.327E-01	2.079E-01

Maximum TDOSE(t): 1.080E+01 mrem/yr at t = 47.89 ± 0.10 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.789E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	4.808E+00	0.4453	2.881E-03	0.0003	0.000E+00	0.0000	5.831E+00	0.5401	1.872E-02	0.0017	1.473E-02	0.0014	1.211E-01	0.0112
Total	4.808E+00	0.4453	2.881E-03	0.0003	0.000E+00	0.0000	5.831E+00	0.5401	1.872E-02	0.0017	1.473E-02	0.0014	1.211E-01	0.0112

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.789E+01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.080E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.080E+01	1.0000

*Sum of all water independent and dependent pathways.

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	417.00 square meters	Ra-226	1.000E+00
Thickness:	2.00 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	7.972E+00	8.069E+00	8.245E+00	8.750E+00	9.486E+00	8.855E+00	5.135E+00	4.242E+00
M(t):	3.189E-01	3.227E-01	3.298E-01	3.500E-01	3.794E-01	3.542E-01	2.054E-01	1.697E-01

Maximum TDOSE(t): 9.607E+00 mrem/yr at t = 45.02 ± 0.09 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.502E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	4.792E+00	0.4988	2.804E-03	0.0003	0.000E+00	0.0000	4.688E+00	0.4880	1.503E-02	0.0016	1.191E-02	0.0012	9.660E-02	0.0101
Total	4.792E+00	0.4988	2.804E-03	0.0003	0.000E+00	0.0000	4.688E+00	0.4880	1.503E-02	0.0016	1.191E-02	0.0012	9.660E-02	0.0101

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 4.502E+01 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.607E+00	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.607E+00	1.0000

*Sum of all water independent and dependent pathways.

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	1466.00 square meters	Ra-226	1.000E+00
Thickness:	2.00 meters		
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	1.174E+01	1.199E+01	1.246E+01	1.381E+01	1.597E+01	1.567E+01	9.141E+00	1.232E+01
M(t):	4.696E-01	4.797E-01	4.983E-01	5.525E-01	6.389E-01	6.269E-01	3.656E-01	4.928E-01

Maximum TDOSE(t): 1.663E+01 mrem/yr at t = 55.0 ± 0.1 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.502E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	4.835E+00	0.2907	3.236E-03	0.0002	0.000E+00	0.0000	1.146E+01	0.6888	5.401E-02	0.0032	4.198E-02	0.0025	2.417E-01	0.0145
Total	4.835E+00	0.2907	3.236E-03	0.0002	0.000E+00	0.0000	1.146E+01	0.6888	5.401E-02	0.0032	4.198E-02	0.0025	2.417E-01	0.0145

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.502E+01 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.663E+01	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.663E+01	1.0000

*Sum of all water independent and dependent pathways.

Attachment 3

Background UTL Calculation for NECR FSS Investigation Levels

Attachment 3
NECR Background UTL Calculation for NECR FSS Investigation Levels

NECR Background Aresa Data Set

Location ID	Date Collected	Radium 226, pCi/g
NECRBKG-01	8/17/2006	0.8
NECRBKG-02	8/17/2006	1.3
NECRBKG-03	8/17/2006	1.1
NECRBKG-04	8/17/2006	1.3
NECRBKG-05	8/17/2006	1.1
NECRBKG-06	8/17/2006	1.0
NECRBKG-07	8/17/2006	1.1
NECRBKG-08	8/17/2006	1.2
NECRBKG-09	8/17/2006	1.2
NECRBKG-10	8/17/2006	0.9
NECRBKG-11	8/17/2006	1.0
NECRBKG-12	8/17/2006	1.2
NECRBKG-13	8/17/2006	1.0
NECRBKG-14	8/17/2006	1.0
NECRBKG-15	8/17/2006	1.2
NECRBKG-16	8/17/2006	0.7
NECRBKG-17	8/17/2006	1.1
NECRBKG-18	8/17/2006	0.6
NECRBKG-19	8/17/2006	1.1
NECRBKG-20	8/17/2006	1.0
NECRBKG-21	8/17/2006	1.0
NECRBKG-22	8/17/2006	0.8
NECRBKG-23	8/17/2006	0.9
NECRBKG-24	8/17/2006	1.0
NECRBKG-25	8/17/2006	1.3
# of samples		25
Mean		1.0
Sd		0.182

Tolerance Intervals for the Normal Distribution

	25	Number of samples			
	1.0	Mean			
	0.182	Standard deviation			
at	**95%**	certainty (Confidence Level)			
for	**95%**	of Population			
The tolerance Interval Range will be contained within	0.56	to	1.52	(a Two-sided Tolerance Interval)	
95 95 UTL	**1.45**	**(an Upper One-sided Tolerance Interval)**			
95 95 LTL	0.62	(a Lower One-sided Tolerance Interval)			

Intermediate quantities used in the calculation:

z(1-p):	1.64485	
z(1-g):	1.64485	
a:	0.94363	
b:	2.59732	
k1:	2.27785	
df:	24	1.95996
z((1-p)/2):	1.95996	
Excel's ChiSq(g,n-1):	13.8484	
Robust ChiSq(g,n-1):	13.8484	
k2:	2.6313	

Reference:
NIST/Sematech Handbook, Section 7.2.6.3
http://www.itl.nist.gov/div898/handbook/prc/section2/prc263.htm

ATTACHMENT T.3
Quality Assurance Project Plan

Northeast Church Rock

95% Design Report

Attachment T.3

Quality Assurance Project Plan

This page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

%D	percent difference
%R	percent recovery
CLP	Contract Laboratory Program
C-O-C	chain-of-custody
°C	degrees Celsius
CSC	Construction Supervising Contractor
CVS	calibration verification standard
DQO	data quality objective
EDD	electronic data deliverable
GC/MS	gas chromatography/mass spectroscopy
GE/UNC	General Electric/United Nuclear Corporation
ICAL	initial calibration standard
ICB/CCB	initial calibration blank/continuing calibration blank
ICP	inductively coupled plasma
ICS	interference check sample
LCS	laboratory control sample
LIMS	laboratory information management system
LQAP	laboratory quality assurance plan
MD	matrix duplicate
MDA	minimum detectable activity
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NECR	Northeast Church Rock
NIST	National Institute of Standards and Technology
PARCC	precision, accuracy, representativeness, completeness, comparability
PM	Project Manager
QAPP	Quality Assurance Project Plan
QA	quality assurance
QAM	quality assurance manager
QC	quality control
RA	Removal Action
RCA	recommendations for corrective action

RER	replicate error ratio
RL	reporting limit
RPD	relative percent difference
SM	site manager
SOP	standard operating procedure
SSL	soil screening level
SW	solid waste
USEPA	United States Environmental Protection Agency

1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) is part of the Northeast Church Rock 95% Design Report (Design Report) and covers activities related to cleanup verification as part of the Northeast Church Rock (NECR) Mine Removal Action (RA). This QAPP has been prepared by Stantec on behalf of General Electric Company and United Nuclear Corporation (GE/UNC). This QAPP describes the project requirements for field sampling activities, sample analysis, and data assessment activities associated with this project.

This QAPP presents the policies, organization, functions, and quality assurance/quality control (QA/QC) requirements to meet the project-specific data quality objectives associated (DQOs) with soil sample collection and analysis. The DQOs are described in Attachments T.1 and T.2.

1.1 QAPP Objectives

The objective of this QAPP is to provide the guidance to be followed for chemical and radiological analysis of soil samples collected during cleanup verification activities to verify that the data are of sufficient quality to support the project DQOs and the data end uses. This QAPP also presents the project organization and QA/QC procedures to be followed by the Contract Laboratory for sample analysis.

The procedures detailed in this QAPP are in accordance with applicable professional technical standards and the following guidance:

- USEPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, EPA QA/R-5 (USEPA, 2001).
- Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4 (EPA/240/B-06/001, USEPA, 2006).
- USEPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846; USEPA Third Edition, Final Update III, December 1996).
- Prescribed Procedures for Measurement of Radioactivity in Drinking Water (USEPA/600/4-80-032, August 1980)
- Quality Assurance for Regulatory Monitoring Programs – Effluent Streams and the Environment (Nuclear Regulatory Commission, Regulatory Guide 4.15, July 2007)

The target parameters for soils included in this QAPP are radium 226 (Ra-226) and total uranium, which were selected to meet the DQOs for the cleanup verification activities.

This QAPP is required reading for Construction Supervising Contractor (CSC) staff participating in the work effort. The QAPP will be in the possession of the field team during sample collection and in possession of the Contract Laboratory providing analytical services. The CSC and analytical Contract Laboratory personnel working on this project must comply with the procedures documented in this QAPP to maintain comparability and representativeness of the resulting data.

1.2 Document Organization

The remainder of this QAPP is organized as follows:

Section 2.0 **Project Organization.** This section describes the organization for this project.

Section 3.0 **Quality Assurance Objectives for Measurement Data.** This section presents the field and Contract Laboratory analytical procedures to be followed to confirm that measurement data collected during this project meet the project quality assurance objectives. This section also includes the procedures for instrument calibration for all anticipated analyses performed by the Contract Laboratory. Detailed field equipment calibration procedures are described in Attachments T.1 and T.2 of the Design Report.

Section 4.0 **Sampling Procedures.** This section references back to Attachments T.1 and T.2.

Section 5.0 **Sample Custody.** This section presents the Contract Laboratory chain-of-custody (C-O-C) procedures. Field C-O-C procedures are defined in Attachments T.1 and T.2.

Section 6.0 **Analytical Procedures.** The analytical procedures to be used by the Contract Laboratory are presented in this section.

Section 7.0 **Internal Quality Control Checks.** CSC and Contract Laboratory internal QC checks are presented in this section.

Section 8.0 **Data Reduction, Reporting, Verification, and Validation.** Procedures for reducing, reporting, verifying, and validating field and chemical data are defined in this section.

Section 9.0 **Performance and Systems Audits.** CSC and Contract Laboratory procedures for performance and systems audits are presented in this section.

Section 10.0 **Preventative Maintenance Procedures.** Preventative maintenance procedures that will be followed by the Contract Laboratory are detailed in this section. General procedures for field-related tasks are presented in this section; specific details are included in Attachments T.1 and T.2.

Section 11.0 **Corrective Actions.** This section defines the corrective actions that will be implemented in the event of field or Contract Laboratory non-conformances.

Section 12.0 **Quality Assurance Reports to Management.** The quality assurance reporting requirements for this project are presented in this section.

Attachment 1 **Quality Control Procedures**, Frequency of QC Sample Analysis and Acceptance Criteria, and Laboratory Corrective Action Procedures, and Reporting Limit Criteria. This attachment includes the following information for methods in Section 6.1.1:

- Control limits that will be used for matrix spike (MS), matrix spike duplicate (MSD), and laboratory control sample (LCS), standard assessment.
- Method specific calibration requirements, QC sample analysis frequency, and corrective action procedures.
- Method specific reporting limit (RL) requirements.

The specific criteria that will be used for data assessment are as follows:

Control Limits. The control limits for this project are based on the referenced analytical method or current industry standards.

Calibration Requirements, **QC Sample Analysis Frequency, and Corrective Action Procedures.** The analytical methods listed in Section 6.1.1 were used for establishing instrument calibration, QC sample analysis frequency, and corrective action requirements for this project.

Reporting Limits. The analyte RLs listed in Attachment 1 of this QAPP are for reference only. The RLs for this project will reflect the RLs established by the Contract Laboratory. RLs will be compared to the USEPA Regional Soil Screening Levels (SSLs) established in May 2013 for radionuclides (as applicable). If the RL exceeds the SSL the sample results will be reported to the method detection limit (MDL) or an alternate method of analysis will be used.

2 ORGANIZATION

At the direction of GE/UNC or their appointed representative, the CSC will have the overall responsibility for the implementation of this project. The CSC's responsibilities include preparing the project plans and conducting the field activities. Descriptions of the responsibilities and authorities for the key positions as they relate to project QA and QC are provided below. In addition, the following paragraphs describe the Contract Laboratory organization and training requirements.

2.1 General Electric/United Nuclear Corporation

The GE/UNC Representative and Site Manager (SM) have overall responsibility for the successful completion of the sampling program and are responsible for:

- Developing or overseeing the scopes of work (i.e., cleanup verification activities)
- Defining project objectives and schedules
- Reviewing and analyzing overall task performance with respect to planned requirements and authorizations
- Interfacing with the federal and state regulatory agencies
- Approving reports (deliverables) before their submission to the federal and state regulatory agencies

2.2 Construction Supervising Contractor Organization

2.2.1 Construction Supervising Contractor Project Manager

The CSC Project Manager (PM) is responsible for implementing the project and will have the authority to commit the resources necessary to meet project objectives and requirements. In addition, the CSC PM will be responsible for:

- Acquiring and applying resources as needed to perform the project within budget and schedule constraints
- Defining project objectives and developing the project schedules
- Establishing project policy and procedures to address the specific needs of the project as a whole, as well as the objectives of each task
- Orientation of all project staff regarding project-specific considerations
- Developing and meeting ongoing project and/or task staffing requirements, including mechanisms to review and evaluate each task product
- Reviewing the work performed on each task to ensure quality, responsiveness, and timeliness
- Reviewing and analyzing overall task performance with respect to planned requirements and authorizations
- Reporting significant conditions adverse to quality and obtaining concurrence by the Project QA Manager on proposed resolutions
- Reviewing quality assurance audit reports and any resulting corrective action disposition
- Approving reports (deliverables) before their submission to GE/UNC

2.2.2 Construction Supervising Contractor Technical Leader

The CSC Technical Leader for the project will have overall responsibility for the technical aspects associated with the project and will also be responsible for:

- Implementation of QC for technical data provided by the field staff including field measurement data
- Adherence to work schedules provided by the PM
- Generation, review, and approval of text and graphics required for field team efforts
- Identification of problems at the field-team level and discussion of resolutions with the PM
- Day-to-day coordination with the PM on technical issues
- Development and implementation of field-related work plans
- Coordination and management of field staff
- Report preparation

2.2.3 Construction Supervising Contractor Field Team Leader

The field team leader will have overall responsibility for verifying that work performed in the field meets the quality standards defined in this QAPP. The Field Team Leader will report directly to the CSC PM.

2.2.4 Construction Supervising Contractor Field Team

Under the direction of the CSC Field Team Leader, field staff are responsible for the planning, coordinating, performing, and reporting specific technical tasks. Field staff will have the responsibility of applying the QAPP and the other parts of the Cleanup Verification Plan to their assigned activities. Their specific responsibilities include:

- Develop and maintain technical activity files
- Implement technical procedures applicable to tasks

2.2.5 Quality Assurance Manager

The Construction Supervising Contractor QA Manager (QAM) for this project will remain independent of direct job involvement and day-to-day operations and will have direct access to GE/UNC staff as necessary, to resolve QA disputes. The QA Manager is responsible for auditing the implementation of the QA program in reference to project-specific requirements, and report any findings to the CSC PM. Specific functions and duties will include:

- Conducting QA audits on various phases of the field operations (as necessary)
- Reviewing and approving of QA plans and procedures
- Providing QA technical assistance to project staff on chemistry and field sampling
- Reporting on the adequacy, status, and effectiveness of the QA program on a regular basis to appropriate staff

The QAM will prepare quarterly reports that describe QA activities and findings, corrective actions, or recommendations that will be provided to the USEPA. The QAM may also provide technical assistance on field sampling to the field team, in consultation with the project chemist.

2.2.6 Construction Supervising Contractor Project Chemist

The CSC Project Chemist like the QA Manager, reports to an individual outside the project team and is responsible for interfacing with the project team and the Contract Laboratory and will provide direction and support for all sampling activities, including sample collection, handling, storage, preservation, and shipment. Other responsibilities will include:

- Interfacing with the Contract Laboratory PM on matters concerning chemical sampling and analysis, laboratory readiness, sampling schedules, sample containers, laboratory reports, data verification, and the resolution of nonconforming activities or data
- Reviewing analytical data to confirm conformance with quality assurance testing and standards
- Identifying, reporting, and recommending solutions for nonconforming sampling or analytical activities or data
- Serving as the main point of contact for issues related to sample analysis

2.3 Contract Laboratories Organization

The primary laboratory performing analytical work for this project will conduct all radionuclide and other chemical analyses. The laboratory will perform the standard methods of analysis required for this project, meet the criteria specified in this QAPP, and hold applicable certifications, and will generally be organized as described in the following paragraphs. The specific organizational structures of the contract laboratory will be described in its Laboratory Quality Assurance Plan (LQAP), which is included in Attachment 2.

2.3.1 Laboratories Project Manager

The laboratories will assign a specific individual to assume Project Management responsibilities for activities relating to the analysis program for this project. This individual will be the primary contact for the CSC and will be responsible for verifying that the project requirements as they relate to the Contract Laboratory are met. This individual will be responsible for the following:

- Scheduling sample analysis and confirming that data are generated in accordance with the specifications presented in this QAPP
- Monitoring the progress and timeliness of the work
- Reviewing work orders and the laboratory reports
- Processing changes in the scope of work

This individual will also be responsible for verifying that project-specific corrective action is taken when necessary to address problems identified by the QC sample results or QA audit results and for approving final analytical reports prior to submission to the CSC.

2.3.2 Laboratories Quality Assurance Officer

The laboratories' quality assurance officer (Quality Assurance Officer) will be responsible for confirming that the laboratory QA/QC activities are performed in accordance with the requirements specified in both this QAPP and the laboratory's internal QAPP. Responsibilities will include preparing QA documents that define QA/QC procedures, reviewing and approving laboratory QC procedures, and oversight of inter-laboratory testing programs and laboratory certifications. This individual will also be responsible for monitoring method operation through periodic data reviews and technical system audits. Unacceptable findings will be reported to the appropriate individuals for corrective action.

2.3.3 Laboratory Sample Custodian

The laboratory sample custodian will report directly to the Laboratory Manager and will be responsible for:

- Receiving and inspecting samples
- Recording information regarding sample condition on and signing the appropriate forms
- Verifying the C-O-C and documenting any discrepancies
- Notifying the Laboratory PM or other appropriate laboratory personnel of sample receipt and inspection
- Assigning a unique identification number and customer number to each sample and logging it into the sample receiving log book and laboratory management information system (LIMS)
- Transferring samples to the appropriate laboratory sections
- Controlling and monitoring access and storage of samples and extracts

2.3.4 Laboratory Staff

Laboratory staff involved with sample preparation and analysis will consist of experienced professionals who possess the degree of specialization and technical competence to perform the required work in an effective and efficient manner.

2.4 Laboratory Training Requirements

Laboratory staff associated with the project will have sufficient training to safely, effectively, and efficiently perform their assigned tasks.

3 OBJECTIVES FOR MEASUREMENT DATA

Data quality refers to the level of reliability associated with a particular data set or data point. The data quality associated with environmental measurement data is a function of the sampling plan rationale, the sample collection procedures, and the analytical methods and instrumentation used in making the measurements. The overall QA objective is to develop and implement procedures for field sampling, C-O-C, Contract Laboratory analysis, and data reporting that will provide data that meet task-specific DQOs and that are legally defensible. Data quality objectives are qualitative and quantitative statements that specify the field and Contract Laboratory data quality necessary to support specific decisions or regulatory actions. The DQOs describe which data are needed, why the data are needed, and how the data are to be used to meet the needs of this sampling program. DQOs also establish numeric limits for the data to allow the data user (or reviewers) to determine whether the data collected are of sufficient quality for their intended use.

The DQOs for this project are included in Attachments T.1 and T.2. The DQOs were developed in accordance with the *Guidance for the Data Quality Objectives Process, EPA QA/G*-4 (USEPA, 2006). The remainder of this section defines how the data will be assessed to meet the task-specific DQOs and the criteria that will be used to define acceptable limits of uncertainty.

3.1 Data Types

The data types required for this project are based on the task-specific DQOs, the end-use of the analytical data, and the level of documentation. Both screening and definitive data will be collected. The specific type of data that will be collected for each sampling task are defined in Attachments T.1 and T.2. Whether data are considered screening or definitive is based on the method of sample collection, preparation, and analysis. Definitive data include data that are collected using standard sampling methods and analytical methods of known precision and accuracy. Screening data include data that are collected using non-standard sampling methods or collected using rapid, less precise methods of analysis with less rigorous sample preparation or quality control as compared to analytical methods from which definitive data are generated. For this project all data from the Contract Laboratory are considered definitive.

3.2 Data Quality Definition and Measurement

To determine the overall quality of definitive data, the results of QC sample analysis will be evaluated in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) DQOs established in this QAPP. The QC samples that will be used to assess the quality of both the field and Contract Laboratory data (prepared both in the laboratory and in the field) are described later in this section. A summary of the chemical data quality control evaluation program in terms of the DQOs is presented in Table 3-1. Method specific quality control procedures, frequency of QC sample analysis and acceptance criteria, and laboratory corrective action summaries that will be used as guidance for this project are included in Attachment 1.

3.2.1 Precision

Precision is the reproducibility of measurements under a given set of conditions. For large data sets, precision is expressed as the variability of a group of measurements compared to their average value (i.e., standard deviation). For duplicate measurements, precision is expressed as the relative percent difference (RPD) of a data pair and is calculated using the following equation:

$$\mathrm{RPD} = \frac{|\mathrm{A - B}|}{\frac{(\mathrm{A + B})}{2}} \times 100$$

Where: A and B are the reported concentrations for duplicate sample analyses

For radionuclide methods precision can also be expressed using the replicate error ratio (RER). The RER is used when the sample concentration is less than five times the minimum detectable activity (MDA). The RER is determined as follows:

$$RER = \frac{(S-R)}{\left[\left(\sqrt{0.15*S}\right)^2 + E^2\right] + \left(\sqrt{0.15*R)^2 + ER^2}\right)},$$

Where:

RER = replicate error ratio

S = sample value

E_S = sample counting error (at 2 standard deviations)

R = replicate value

E_R = replicate counting error (at two standard deviations)

Contract Laboratory Precision. Contract laboratory precision will be assessed using the calculated relative percent difference (RPD) between the following sample data:

- MS/MSD sample data
- Parent and associated field replicate sample data
- Parent and matrix duplicate (MD) sample data (as applicable)

In addition, precision will be evaluated using the response factors for calibration standards (three or more replicated analyses) by calculating the relative standard deviation as follows:

$$(S/\overline{X}) \times 100$$

Contract laboratory precision will also be assessed for metals using the calculated percent difference (%D) for serial dilutions. The %D will be calculated using the following equation:

$$\%D = \left(\frac{C_C - E_C}{E_C}\right) x\,100$$

Where:

Cc = Calculated concentration

Ec = Expected Concentration

3.2.2 Accuracy

Accuracy is the degree of agreement of a measurement or an average of measurements with an accepted reference or "true" value, and is a measure of bias in the system. The accuracy of a measurement system is affected by errors introduced through the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analytical techniques. Accuracy will be evaluated using the percent recovery (%R) calculated using the following equation:

$$\%R = \frac{\left|X_s - X_u\right|}{K} \times 100\%$$

Where:

X_s is the measured value from the spiked sample

X_u measured value of the unspiked sample

K is the known amount of the spike in the sample

The background level (X_u) is set to zero when percent recovery is calculated for the laboratory control sample or other standard reference materials.

Contract Laboratory Accuracy. Contract Laboratory accuracy will be assessed quantitatively through the analysis of MS/MSD samples LCS, interference check samples (metals analysis only), post digestion spikes, and response factors for calibration standards, and internal standard recoveries.

3.2.3 Representativeness

Representativeness is a qualitative expression of the degree to which sample data accurately and precisely represent a characteristic of a population, a sampling point, or an environmental condition. Representativeness is maximized by ensuring that, for a given task, the number and location of sampling points and the sample collection and analysis techniques are appropriate for the specific investigation, and that the sampling and analysis program provides information that reflects "true" site conditions.

Contract Laboratory Data. Contract Laboratory data will be evaluated for representativeness by assessing whether the laboratory followed the specified analytical criteria in this QAPP and their standard operating procedures (SOPs). In addition, representativeness will be evaluated by assessing compliance with sample preservation and holding time criteria, and the results of method and instrument blank sample results, initial calibration blank/continuing calibration blank (ICB/CCB) results (metals analysis only), and field replicate sample analyses.

3.2.4 Comparability

Comparability is a qualitative parameter that expresses the confidence with which one data set may be compared to another. Comparability is dependent on similar QA objectives and is achieved through the use of standardized methods for sample collection and analysis, the use of standardized units of measure, normalizing results to standard conditions, and the use of standard and comprehensive reporting formats as defined by this QAPP.

Contract Laboratory Data. Laboratory data comparability depends on the use of similar sampling and analytical methods and standard units of measure between different tasks at a specific site. For this project, chemical data will be collected using standard sampling and analyses procedures. Data comparability will also be assessed by comparing investigative sample data to QA or QC sample data.

3.2.5 Completeness

Completeness is the measure of the amount of valid data obtained from a measurement system relative to the amount of data scheduled for collection under correct, normal conditions. Completeness measures the effectiveness of the overall investigation in collecting the required samples, completing the required analyses, and producing valid results. Completeness will be calculated on a per analyte basis using the following equation:

$$\% \text{ completeness} = \frac{\text{number of valid results}}{\text{number of possible results}}$$

Where: The number of valid data points is the total number of valid analytical measurements based on the precision, accuracy, and holding time evaluation.

Contract Laboratory Data. Contract Laboratory data completeness is a quantitative measure of the percentage of valid data for all analytical data as determined by the precision, accuracy, and holding time criteria evaluation. Completeness will be calculated using the completeness equation by dividing the total number of valid data points by the total number of data points. The Contract Laboratory completeness goal for data collected under this QAPP is 95 percent.

If the 95 percent completeness goal is not met for field or laboratory data, the GE/UNC SM will be immediately notified. The determination regarding the need for corrective action will be based upon how critical the data are to the project DQOs and will be made by the CSC and the GE/UNC Project Managers in conjunction with federal and state regulatory agencies Project Manager.

3.3 Method Detection Limits, Reporting Limits, and Instrumentation Calibration Requirements

3.3.1 Method Detection Limits

The MDL is an empirically-derived value used to estimate the lowest concentration a method can detect in a matrix-free environment. The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero.

The Contract Laboratory will, at a minimum, perform MDL studies during initial method setup, annually, or whenever the basic chemistry of a procedure is changed. The MDLs will be method specific and include any cleanup method used. The MDLs will be established for all target analytes in an interference-free matrix using the procedures in 40 Code of Federal Regulations, Part 136, Appendix B, or an equivalent statistical approach. To confirm that the valid MDL values are determined, the laboratory will analyze an MDL check sample by spiking an interference-free matrix with all target analytes at approximately two times the calculated MDL. The MDL check sample will be taken through all the preparatory and determinative steps used to establish the calculated MDL values to verify a response is detected. If any of the target analytes are not detected, then the concentration will be increased in another MDL check sample, and the analysis repeated until the failed target analytes are detectable. The detectable target analyte concentrations will be used in lieu of the calculated MDL values to establish the lowest detected concentration for samples taken through all appropriate method procedures. The laboratory may demonstrate continued method detection capability by analyzing the check sample on a quarterly basis, in lieu of the annual MDL study. When multiple instruments or confirmation columns are used for the same method, separate MDL studies may be replaced by the analysis of an MDL check sample on all instruments/columns. The MDL check sample will be analyzed after major instrument maintenance or changes in instrumentation or instrumental conditions to verify the current sensitivity of the method.

3.3.2 Reporting Limits

The RL is the lowest concentration that can be reliably achieved within limits of precision and accuracy during routine operating conditions and is based on the MDL for each analyte. The RL is established at a factor of five to ten times the MDL, but no lower than three times the MDL for any target analyte. Example RLs for the analytical methods included in this QAPP are presented in Attachment 1. The laboratory-specific RLs for each method included in this QAPP will be back checked against the project objectives to ensure that data usability goals are met. Data reporting requirements are described in Sections 7.0 and 9.0.

3.4 Instrument Calibration

This section describes procedures to be used for instrument calibration by the Contract Laboratory. The procedures that will be followed for field meter or instrument calibration are detailed in Attachments T.1 and T.2. Analytical quality control requirements, evaluation criteria, acceptance criteria, preventative maintenance, and corrective actions are discussed later in this QAPP.

Instrument calibration is necessary to confirm that the analytical system is operating correctly and functioning at the proper sensitivity to meet the required RLs. Calibration establishes the dynamic range of an instrument, establishes response factors to be used for quantitation, and demonstrates instrument sensitivity. Criteria for calibration are specific to the instrument and the analytical method. The following paragraphs describe procedures that will be followed by the Contract Laboratory for instrument calibration.

Standard/Reagent Preparation. Instruments will be calibrated in accordance with the Contract Laboratory's SOPs. To verify the highest quality standard, primary reference standards will be used by the Contract Laboratory and will be obtained from the National Institute of Standards and Technology (NIST), USEPA Cooperative Research and Development Agreement vendors, American Association of Laboratory Accreditation vendors, or other reliable commercial sources. When standards are received at the Contract Laboratory, the date received, supplier, lot number, purity, concentration, and expiration date will be recorded in a standards logbook. Vendor certifications for the standards will be retained in the files and made available on request.

Standards will be obtained in their pure form or in a stock or working standard. Dilutions will be made from the vendor standards. All records regarding standards will unambiguously trace their preparation, use in calibration, expiration dates, and quantitation of sample results. Standards will be given a standard identification number, and the following information recorded in the appropriate file (standards logbook): source of standard, the initial concentration of the standard, the final concentration of the standard, the volume of the standard that was diluted, the solvent and the source and lot number of the solvent used for standard preparation, the expiration date of the standard, and the preparer's initials. All standards will be verified prior to use.

After preparation and before routine use, the identity and concentration of the standards will be verified. Verification procedures include verification of the standard's concentration by comparing its response to a standard of the same analyte prepared or obtained from a different source. Reagent purity will be assessed by analyzing an aliquot of the reagent lot using the analytical method in which it will be used; for example, every lot of laboratory grade water is analyzed for undesirable contaminants prior to use in the laboratory. Standards will be routinely checked for signs of deterioration (e.g., discoloration, formation of precipitates, and changes in concentration), and will be discarded if deterioration is suspected or the expiration date has passed. Expiration dates will be taken from the vendor recommendation, the analytical methods, or from internal research.

Instrument Calibration. Criteria for calibration are specific to the instrument and the analytical method. Each instrument will be calibrated according to the analytical methods following manufacturer's guidelines and using standard solutions appropriate to the type of instrument and the linear range established for the method. Reported analytes will be present in both initial and continuing calibrations, which must meet the acceptance criteria specified in the analytical method and are summarized in Attachment 1. The instrument calibration will be from lowest to the highest calibration standard and the lowest calibration standard concentration will be at the RL for each target analyte.

Multipoint calibrations will contain the minimum number of calibration points specified in the method with all points used for the calibration being contiguous. If more than the minimum number of standards is analyzed for the initial calibration, the standards analyzed will be included in the initial calibration. The only exception is the dropping of a standard from the calibration that has been statistically determined as an outlier, providing that the requirement for the minimum number and RL standard criteria are met.

Instrument calibration information will be documented, and at a minimum include the equipment to be calibrated, the reference standards used for calibration, the calibration techniques, actions, acceptable performance tolerances, frequency of calibration, and calibration documentation format. The Contract Laboratory will maintain records of standard preparation and instrument calibration. Calibration records will include daily checks using standards prepared independently of the calibration standards, and instrument response will be evaluated against established criteria. The analysis logbook, maintained for each analytical instrument, will include, at a minimum, the date and time of calibration, the initials of the person performing instrument calibration, and the calibrator reference number and concentration. Calibration procedures for the methods included in this QAPP are presented in Attachment 1 and are from the following:

- USEPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846; USEPA Third Edition, Final Update III, December 1996).
- Prescribed Procedures for Measurement of Radioactivity in Drinking Water (USEPA/600/4-80-032, August 1980)

A summary of calibration procedures, corrective actions, and QC acceptance limits are provided in Attachment 1.

3.5 Contract Laboratory Batch Quality Control Logic

The frequency of instrument calibration and QC sample analysis for the analytical methods are batch controlled. Sample data for this project will be associated with sample batch QC samples that were extracted or prepared concurrently with the site samples and analyzed in the same analytical batch (analyzed on the same instrument relative to the primary sample results). The identity of each preparation or analytical batch will be unambiguously reported with the analyses so that a reviewer can identify the QC samples and the associated environmental samples. The following paragraphs define sample and instrument batches.

Sample Batch. For this project, a sample batch is a group of twenty or less environmental samples of the same matrix which are extracted or prepared within the same time period (concurrently) or in limited continuous sequential time periods with the same lot of reagents. Keeping batches "open" for more than two hours will not be accepted; samples and their associated QC samples (method blank, LCS, MD, and MS/MSD) will be prepared in a continuous process. The sample batch will be analyzed sequentially on a single instrument (as practicable).

Analytical Batch. The analytical batch is a group of 20 or less environmental samples that are analyzed together within the same analytical run sequence as defined by the method calibration criteria or in continuous sequential time periods. Samples in each batch will be of similar matrix, will be treated in a similar manner, and will use the same reagents.

3.6 Elements of Quality Control

The quality control parameters and samples that will be used to evaluate analytical data in terms of the PARCC criteria are described in this section. These include QC samples prepared both in the field and by the Contract Laboratory. A summary of QC sample evaluation in relation to the PARCC parameters is presented in Table 3-1. Method specific quality control procedures, frequency of QC sample analysis, acceptance criteria (control limits), and corrective action procedures are included in Attachment 1.

3.6.1 Field Elements of Quality Control

For field sampling, quality control samples are used to assess sample collection techniques and to assess environmental conditions during sample collection and transport. For this project, field QC samples will include field replicate samples (samples that are submitted blind to the laboratory).

Temperature Blanks and Cooler Temperature. Temperature blanks will be used to evaluate the internal temperature of the cooler and assess whether the sample temperature criterion of 4°C ± 2 degrees Celsius (°C) was met during sample shipment, as applicable. The temperature of the blank is measured at the time the samples are received by the Contract Laboratory and recorded on the C-O-C. Temperatures that exceed the temperature criterion indicate that the samples may not have been handled or transported properly.

Field Replicate Samples. Field replicate samples are soil samples that are submitted blind to the Contract Laboratory to assess variability in the sample media and to assess sampling and analytical precision. A field replicate sample is a single grab sample that is replicated into two samples during collection. For each field replicate sample pair, one of the samples is labeled with the correct sample identification and the other is labeled with fictitious sample identification. This replicate sample pair is then submitted to the same Contract Laboratory as two separate samples. Precision will be evaluated by calculating the RPD between the field replicate sample pairs for all analytes detected at or above the RL. RPD calculations will not be performed when either one or both of the sample results for the field replicate sample pairs are reported as less than the RL.

Although the RPD will be calculated between field replicate samples, the results will not be used as a basis for qualifying data or accepting or rejecting data. The RPD and actual results will be evaluated qualitatively to assess precision of field sample collection procedures. An RPD within ± 30 percent will be used as an indication of good agreement between the parent and replicate sample results and that good field procedures were followed.

Performance evaluation samples requested by USEPA will be included in a site sample batch during the Removal Action construction, as appropriate. Performance evaluation samples will require coordination with the QAM prior to the start of sampling.

3.6.2 Contract Laboratory Elements of Quality Control

The Contract Laboratory will, as a minimum, analyze internal QC samples at the frequency specified by the analytical method and in this QAPP. Method-specific quality control procedures, frequency of QC sample analysis, acceptance criteria (control limits), and corrective actions are provided in Attachment 1. The following paragraphs discuss holding time and the QC samples that will be used to assess laboratory data quality.

Sample Holding Time. Sample holding time reflects the length of time that a sample or sample extract remains representative of environmental conditions. For methods that do not require sample extraction one holding time will be evaluated, the length of time from sample collection to analysis. For methods that require sample extraction prior to analysis two holding times will be evaluated; the length of time from sample collection until sample extraction, and the length of time from sample extraction to sample analysis. These holding times will be compared to the holding times specified by the respective analytical method. The holding times for each analytical method included in this QAPP are listed in Table 3-2. Samples will not be analyzed outside of the specified method holding times without approval by the CSC Project Chemist.

Method Blanks. Method blanks will be used to monitor the Contract Laboratory preparation and analytical systems for interferences and contamination from glassware, reagents, sample manipulations, and the general laboratory environment. The method blank is an analyte-free matrix (e.g., laboratory grade sand) to which all reagents will be added in the same volumes or proportions as used in sample processing. Method blanks will be taken through the entire sample preparation/extraction and analytical process. Method blanks will be prepared and analyzed with each analytical or preparation batch of environmental samples up to a maximum of 20 samples of a similar matrix. No analytical data will be corrected for the presence of analytes in blanks.

Internal Standards. Internal standards are compounds that behave similarly to the target analytes during analysis and will be used to assess accuracy for gas chromatography/mass spectroscopy (GC/MS) analysis. Internal standards will be prepared and added to the initial calibration standard (ICAL), the continuing calibration verification standard (CVS), and all samples (field and QC) prior to analysis. Internal standard data will be reviewed for compliance with the analytical method acceptance criteria presented in Attachment 1.

Surrogate Spikes. Surrogate spikes will be used to evaluate the accuracy of analytical instrument performance for organic analysis. Surrogate spikes will be added to each sample for organic compound analysis, including QC samples, prior to extraction as specified in the laboratory's SOP. The percent recovery of each surrogate spike will be calculated and compared to the project acceptance criteria (Attachment 1).

Initial and Continuing Calibration Blanks. ICB/CCB samples are analyzed with each sample batch using the inductively coupled plasma (ICP) method SW-846 6020 to determine whether metals are introduced into samples during preparation by the laboratory.

Laboratory Control Samples. Laboratory control samples will be used to measure laboratory accuracy in the absence of matrix interference. LCSs are prepared in the laboratory and consist of samples of a known matrix (laboratory grade sand) spiked with a known quantity of specific target analytes at a level less than or equal to the midpoint of the calibration curve for each analyte. The midpoint is defined as the median point in the curve, not the middle of the range. These samples are taken through the entire sample preparation and analytical process. LCSs will be prepared and analyzed with each analytical or preparation batch of environmental samples up to a maximum of 20 samples of a similar matrix. If more than one LCS is analyzed in an analytical batch, results from all LCSs analyzed will be reported.

Matrix Spikes and Matrix Spike Duplicates. Matrix spikes measure matrix-specific method performance and will be used to assess accuracy and precision. Unlike LCSs, MS/MSD samples will be used to assess the influence of the sample media (media interference) on sample analysis. Samples for MS/MSD analysis will be collected from each sampling location. A minimum of one MS/MSD sample pair will be analyzed with every batch of GE/UNC samples in a sample delivery group of up to 20 field samples. Each MS/MSD sample will be spiked with the compounds specified by this QAPP prior to sample extraction or analysis at a concentration less than or equal to the midpoint of the calibration curve for each analyte. The sampled scheduled for MS/MSD analyses will be designated on the C-O-C form.

Matrix Duplicate Samples. Matrix duplicate samples are identical to field replicates, except that the duplicate sample does not have a false identification. Precision will be evaluated by calculating the RPD between the MD and parent sample pairs for all analytes detected at or above the RL. RPD calculations will not be performed when either one or both results is less than the RL.

Interference Check Sample. The interference check sample (ICS), used in ICP analyses only, contains both interfering and analyte elements of known concentrations and is analyzed at the beginning and end of each run sequence. The ICS is used to verify background and inter-element correction factors.

Serial Dilution. Serial dilutions are conducted for metals analysis to assess positive or negative interferences when the concentration of a metal detected in a sample is ten times greater than the instrument detection limit (after sample dilution). A five-fold dilution of the sample is analyzed and compared to the results of the original analysis. If the difference between the original and diluted sample results is greater than 10 percent, a chemical or physical interference is suspected.

Field Replicates. As discussed previously, field replicates will be used to assess both sampling and analytical precision. The purpose of submitting "blind" samples to the Contract Laboratory is to assess the consistency or precision of the laboratory's analytical system. Precision will be evaluated by calculating the RPD between the parent and field replicate samples.

As discussed previously, although the RPD will be calculated between field replicate samples, the results will not be used as a basis for qualifying data or accepting or rejecting data. The RPD and actual results will be evaluated qualitatively as additional evidence to support data comparability and quality. An RPD within ± 30 will be used as an indication of agreement between the parent and duplicate sample results and that laboratory procedures were followed.

4 SAMPLING PROCEDURES

4.1 Sample Collection Procedures

Sample collection procedures are defined in Attachments T.1 and T.2.

5 SAMPLE CUSTODY AND SHIPPING

To confirm that samples are identified correctly and remain representative of the environment, the sample documentation and custody procedures outlined in this section will be used during the sampling program to maintain and document sample integrity during collection, transportation, storage, and analysis. Field sampling personnel will be responsible for verifying that proper documentation and custody procedures are initiated at the time of sample collection, and that individual samples can be tracked from the time of sample collection until custody of the samples is transferred to the Contract Laboratory. The Contract Laboratory will be responsible for maintaining sample custody and documentation from the time the laboratory receives the samples until final sample disposition.

To minimize common problems such as labeling errors, chain of custody errors, transcription errors, preservation failures, etc., detailed procedures for properly recording sample information and analytical requests on C-O-C records, for preserving samples as appropriate, and for sample packaging and shipment are described in Attachments T.1 and T.2. The remainder of this section focuses on Contract Laboratory C-O-C procedures.

5.1 Chain-of-Custody

C-O-C procedures provide a written record of the possession of each sample from collection through laboratory analysis. A sample is considered in custody if one of the following applies:

- It is in an authorized person's immediate possession
- It is in view of an authorized person after being in physical possession
- It is in a secure area after having been in an authorized person's physical possession
- It is in a designated secure area, restricted to authorized personnel only

5.1.1 Contract Laboratory Chain-of-Custody Procedures

Upon receipt by the Contract Laboratory, the integrity of the shipping container will be checked by verifying that the custody seal is not broken. The cooler will be opened and examined for evidence of proper cooling, and the presence of temperature blanks. The individual sample containers will be checked for breakage, damage, or leakage. The contents of the shipping container will then be verified against the C-O-C. If problems are found, they will be documented on the sample custody form(s) and the CSC Project Chemist will be notified immediately. The shipping receipts will be placed with the C-O-C records and stored in the project files.

If the samples and documentation are acceptable, each sample container will be assigned a unique laboratory identification number and entered into the laboratory's sample tracking system. Sample tracking will be documented in the LIMS, or other appropriate tracking system. Other information that will be recorded includes date and time of sampling, sample description, due dates, and required analytical tests.

When sample log-in is completed, the samples will be transferred to limited-access temperature controlled storage areas. The sample storage areas (coolers, refrigerators) will be kept at $4^{o}C \pm 2^{o}C$, if applicable, and their temperatures will be recorded daily with thermometers calibrated against NIST thermometers.

The Contract Laboratory will follow its SOPs for sample log-in, storage, tracking, and control (Attachment 2). Sample custody will be maintained within the laboratory's secure facility until the samples are disposed. The Contract Laboratory will be responsible for sample disposal, which will be conducted in accordance with all applicable local, state, and federal regulations. Sample disposals will be documented, and the records maintained by the Contract Laboratory in the project file.

5.2 Sample Packaging and Shipping Procedures

Samples will be shipped in accordance with applicable State and Federal Department of Transportation requirements. The following paragraphs describe general sample packaging requirements.

Samples will be packaged and shipped to laboratory the same day of sample collection via a commercial carrier using the following procedures:

- Sample labels will be completed and attached to sample containers as described in Attachments T.1 and T.2.
- The samples will be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler with the exception of the air/vapor samples. Air/vapor samples will be placed in the boxes in which the sample containers were received.
- When required, wet ice in double re-sealable bags (to prevent leakage) will be placed around, among, and on top of the sample bottles. Enough ice will be used so that the samples will be chilled and maintained at 4°C ± 2°C during transport to the laboratory. Ice will not be used on the air/vapor samples.
- To prevent the sample containers from shifting inside the cooler, the remaining space in cooler will be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed C-O-C Form will be placed in a waterproof plastic bag and taped to the inside of the cooler lid.
- The lid will be secured by wrapping strapping tape completely around the cooler in two locations.
- “This Side Up” labels will be placed on two sides of the cooler.
- Custody seals will be placed in two locations (the front right and back left of the cooler) across the cooler closure to ensure that any tampering is detected. The date and initials of the sampler will be written on the custody seal.
- A copy of the C-O-C record and the signed air bill will be retained for the project files.

Environmental samples will be shipped priority (next day arrival by 10:00AM) to the Contract Laboratory, as prescribed in Attachments T.1 and T.2.

5.3 Final Project Files Custody Procedures

The final project files will be maintained by CSC and will be under the custody of the PM in a secured area. At a minimum, the project file will contain all relevant records including:

- Field logbooks
- Field data and data deliverables
- Photographs
- Original field logs
- Clean container certifications from laboratory
- Contract Laboratory data deliverables
- Data verification reports
- Data assessment reports
- Progress reports, QA reports, interim study reports, etc.

- Custody documentation (tags, forms, airbills, etc.)

6 ANALYTICAL PROCEDURES

This section describes the analytical procedures to be used for the acquisition of chemical data and includes the relevant aspects of field and Contract Laboratory procedures (sample preparation and extraction procedures, and instrumentation). Analytical quality control requirements, evaluation criteria, acceptance criteria, calibration procedures, preventative maintenance, and corrective actions are discussed in following sections.

6.1 Contract Laboratory Analytical Procedures

6.1.1 Analytical Methods

The analytical methods covered under this QAPP include Ra-226 by USEPA Method 901.1 modified and total uranium by USEPA Method 200.8 (SW6020). These analytical methods are from the following:

- USEPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846; USEPA Third Edition, Final Update III, December 1996).
- Prescribed Procedures for Measurement of Radioactivity in Drinking Water (USEPA/600/4-80-032, August 1980)

The analytical methods are briefly described in Table 6-1. Method 901.1 was designed for analysis of water samples and is modified by the laboratory for analysis of soils. Samples will be prepared and analyzed in accordance with this QAPP, the referenced analytical method, and the Contract Laboratory's SOPs.

6.1.2 Data Reporting Requirements

The following criteria for reporting data will apply for all samples: MDLs and sample results will be reported to one decimal place more than the corresponding RL, unless the appropriate number of significant figures for the measurement dictates otherwise.

Target compound non-detections will be reported (at a minimum) as less than the RL.

- If the USEPA SSL of a specific compound is greater than the RL, the sample data will be reported to the MDL
- If target analytes are detected between the MDL and RL, they will be reported as quantified and qualified with a "T" flag to indicate the data are estimated
- If target analytes are detected at or above the RL, they will be reported as quantified

Additional Reporting Requirements for Definitive Data. The Project Chemist will be notified immediately regarding the failure of sample data to meet the RL to assess potential corrective action. The decision to implement corrective action will be based on whether there are any analytical alternatives or clean up steps that would improve the reporting limit and whether the elevated reporting limits will adversely affect data use. Data that do not meet the MDLs or RLs due to sample dilution will be included in the case narrative and the supporting documentation will be included in the data packages.

7 INTERNAL QUALITY CONTROL CHECKS

Internal quality control checks are used to evaluate whether field measurements, sampling procedures, and laboratory analytical method performance are within acceptable limits of precision and accuracy. The following sections describe the internal QC that will be followed for both field and Contract Laboratory activities.

7.1 Sample Collection

The accuracy and precision of the field sampling procedures will be assessed as described in Section 3.0 of this QAPP. Sample representativeness will be assessed by the analysis of field replicate samples. These samples are described in Section 3.0.

7.2 Contract Laboratory Analysis

The general objectives of the internal Contract Laboratory QC program are to:

- Confirm that procedures are documented, including any changes in administrative and/or technical procedures
- Verify that analytical procedures are validated and conducted according to method guidelines and laboratory SOPs
- Monitor the performance of the laboratory using a systematic inspection program
- Confirm that data are properly reported and archived

The Contract Laboratory will conduct internal quality control checks for analytical methods in accordance with its SOPs, the individual method requirements, and this QAPP. The Contract Laboratory will notify the Project Chemist in writing before making significant changes resulting from corrective actions to this QAPP or analytical methods. The CSC PM and the GE/UNC Project Managers will be notified if the data impacts the task-specific DQOs.

Contract Laboratory quality control consists of two distinct components, a laboratory component and a matrix component. The laboratory component measures the performance of the laboratory analytical process during sample analyses, while the matrix component measures the effects of a specific media on the method performance. The QC samples that will be used to assess the laboratory component and the media component of analysis are described Section 3.0. The criteria against which the QC data will be evaluated are listed in Attachment 1. Corrective actions for instrument calibrations or QC sample data out of compliance are listed in the corrective action summary tables included in Attachment 1.

8 DATA REDUCTION, REVIEW, REPORTING, VERIFICATION, VALIDATION, AND RECORDKEEPING

The data reduction, review, reporting, verification, and validation procedures are described in this section to affirm that: (1) complete documentation is maintained, (2) transcription and data reduction errors are minimized, (3) the data are reviewed and documented, and (4) the reported results are qualified if necessary. Laboratory data reduction and verification procedures are required to confirm the overall objectives of analysis and reporting meet method and project specifications.

8.1 Data Reduction

8.1.1 Contract Laboratory Data Reduction

The Contract Laboratory will reduce all analytical data (both screening and definitive) in accordance with the analytical methods and the guidance presented in Sections 3.0. Section 3.0 contains equations that will be used by the Contract Laboratory to assess precision and accuracy, and Section 3.0 and Attachment 1 provide information regarding instrument calibration and target analyte quantitation.

8.2 Data Review

8.2.1 Contract Laboratory Data Review

Prior to the release of data to the CSC, the Contract Laboratory will perform in-house data review under the direction of the Contract Laboratory PM and/or the laboratory QA Officer and will prepare and retain full analytical and QC documentation. In general, the Contract Laboratory data review will be conducted as described in the following paragraphs.

The bench analyst will conduct the initial data review based on established protocols specified in laboratory SOPs and analytical method and this QAPP. At a minimum this review will include the following:

- An assessment of sample preparation procedures and documentation for accuracy and completeness
- An assessment of sample analysis procedures and documentation for accuracy and completeness
- Assessments of whether the appropriate SOPs were followed
- An assessment analytical results for accuracy and completeness
- An assessment of whether QC samples are within established control limits and method blank data are acceptable
- An assessment of whether documentation is complete (e.g., anomalies in the preparation and analysis have been documented, out-of-control forms, if required, are complete, holding times are documented, etc.)

The calculations that will be used to evaluate precision and accuracy are defined in Section 3.0. The acceptance criteria for calibration, precision, and accuracy assessment and the corrective action summaries are provided in Attachment 1.

When an analysis of a QC sample (blank, spike, or similar sample) indicates that the analysis of that batch of samples is not in control, the analyst will immediately bring the matter to the attention of the appropriate designated Contract Laboratory QC staff (Quality Assurance Officer, Project Manager, Section Leader, etc.). This individual will determine whether the analysis can proceed, or if selected samples should be rerun, or specific corrective action must occur before analyzing additional samples. Out-of-control analyses and information justifying accuracy or precision outside acceptance criteria will be documented. A Nonconformance Report will be prepared for Contract Laboratory analysis out of control events that require documentation. The

CSC Project Chemist will be notified as soon as feasibly possible to determine the appropriate corrective action for out-of-control events resulting in unacceptable data.

After this review is complete, the analyst will sign the applicable control documentation associated with the analytical batch and forward to the appropriate reviewer. This reviewer (department manager, Quality Assurance Officer, etc.) will be responsible for review and approval of the analytical control documentation associated with each analytical batch, as well as corrective action explanations provided by the analyst. This individual will also be responsible for determining whether the analytical data meet quality control criteria established by the analytical methods and by this QAPP and for identifying QC problems that require further resolution. A permanent record of any corrective actions will be maintained in the Contract Laboratory files.

The Contract Laboratory PM will provide the final review and approval of the analytical data that have been approved by the analyst and other designated reviewer. The Contract Laboratory PM will also be responsible for reviewing all final data reports for proper format and reporting consistency prior to release of the reports to the CSC. This review will include the following as a minimum:

- Contract Laboratory name and address
- Sample information (includes unique sample identification, sample collection date and time, date of sample receipt, and date(s) of sample preparation and analysis)
- Analytical results reported with an appropriate number of significant figures
- Reporting limits reflecting dilutions, interferences, and corrections for dry weight as applicable
- Method references
- Appropriate QC results and correlations for sample batch traceability and documentation
- Data qualifiers with appropriate references and narrative on the quality of results
- Confirmation that QAPP requirements have been met

The Contract Laboratory PM and/or QA Officer will also be responsible for qualifying any data that may be unreliable. Data qualifications will be based on the analytical method, and this QAPP. The flags that will be used by the Contract Laboratory for data qualification are listed in Table 8-1.

8.3 Data Reporting

8.3.1 Contract Laboratory Data

The hard-copy analytical data will be reported in a format organized to facilitate data verification using Contract Laboratory Program (CLP)-like forms. The information that will be included in the Contract Laboratory data packages is listed in Table 8-2.

The Contract Laboratory will provide an electronic deliverable report in a format as specified by the CSC. The Contract Laboratory will provide the electronic deliverable via ASCII files in via electronic mail or compact disk.

8.4 Data Verification

As described in Section 3.0, the field and analytical data will be evaluated using the DQOs, which are quantitative and qualitative statements that describe data quality. To determine whether the DQOs of for this project have been met, the QC sample results and standard procedures will be compared to the acceptance criteria established in this QAPP. The CSC Project Chemist will conduct a Level III verification as described in Section 8.4.1 for all definitive project data and Level IV verification for 10 percent of the data. Both Level III and IV performance evaluation samples provided by EPA will be included in any site sample batch with prior coordination, Level IV data packages will be provided to EPA upon request.

8.4.1 Level III Data Verification

The CSC Project Chemist will perform a Level III data verification for all metal, organic, and radionuclide data. Because there are no DQOs attached to the agronomic data, it will not be verified. The objective of the data verification is to provide a data review that verifies the laboratory QC results. The verification will be based on guidance outlined in this QAPP. The verification will be structured to assess whether the acceptance criteria for instrument calibration and QC sample analysis (Attachment 1) have been met. The calculations that will be used to assess data quality are presented in Section 3.0 and the criteria that will be used to assess data quality are described in Attachment 1.

Level III data verification techniques include accepting, rejecting, or qualifying the data on the basis of acceptance criteria defined in Attachment 1. The flags that will be used to qualify data are listed on Table 8-1 and the qualification procedures that will be followed are described in Table 8-3.

The Level III data verification will be documented on a Data Verification Form that will include the signature of the reviewer and the date of the verification. The Data Verification Form lists the parameters that must be verified to constitute Level III data verification. Data will not be released for use prior to completion of the data verification.

8.4.2 Level IV Data Verification

Level IV verification will be conducted for 10 percent of the data. In addition to the QC parameters reviewed during the Level III verification process, a review of raw data from the instrument (e.g., quantitation reports), a back check of all calculations, and a review of sample preparation and analytical logs will occur.

8.5 Data Validation

The objective of the data validation is to assess whether the field and chemical data are of sufficient quality to support the task-specific DQOs (i.e. end use). The data will be qualitatively and quantitatively assessed on a project-wide, task-specific, matrix-specific, parameter-specific, and unit-specific basis. Factors that will be considered during this evaluation will include, but not be limited to the following:

- Were samples collected using the methods included in this QAPP and Attachments T.1 and T.2?
- Were proposed analyses performed in accordance with this QAPP and the Contract Laboratory’s SOPs?
- Were the RLs elevated and what impact if any to data usability occurred?
- Were samples obtained from all proposed sampling locations and depths?
- Do any data exhibit elevated detection limits due to matrix interference or contaminants present at high concentrations?
- Were field and laboratory data verified in accordance with the verification protocols, including the project-specific QC objectives specified in this QAPP?
- Which data sets were found to be unusable (“R” qualified) based on the data verification results?
- Which data sets were found to be usable for limited purposes (“UJ” qualified) based on the data verification?
- What affect do qualified data have on the ability to implement the project decision rules?
- Can valid conclusions be drawn for all matrices for each specific task?

- Were issues requiring corrective action fully resolved?
- Do the data collected support the correlations between field gamma count rates and laboratory Ra-226 concentrations?

8.6 Data Management

The individuals responsible for data management for this project include all personnel responsible for identifying, reporting, and documenting activities affecting data quality. In general, the qualifications of the individuals associated with data management activities will be commensurate with the level of expertise necessary to ensure the intended level of evaluation. A detailed description of the data management methods and procedures is included in Attachment 3, Data Management Plan.

Project files will provide a traceable record for data management activities. The Contract Laboratory will maintain a project file that includes the following; formulas used for data reduction, computer programs, which data transfers are electronic or manual, data review protocol, and raw data files. Data acquired electronically will be transferred and manipulated electronically to reduce errors inherent in manual data manipulation. Data entered, transferred or calculated by hand will be spot checked for accuracy by someone who did not perform the original entries or calculations.

The Contract Laboratory will preserve electronic and hardcopy records sufficient to recreate each analytical event conducted pursuant to this project. The minimum records the Contract Laboratory will keep include the following:

- C-O-C forms
- Initial and continuing calibration records including standards preparation traceable to the original material and lot number
- Instrument tuning records (as applicable)
- Method blank results
- Spike and spike duplicate records and results
- Laboratory records
- Raw data, including instrument printouts
- Bench work sheets with compound identification and quantitation reports
- Corrective action reports
- Other method and project required QC samples and results
- Laboratory-specific written SOPs for each analytical method
- QA/QC function in place at the time of analysis of project samples

Computer acquired data will also be stored on magnetic tape, disks, or other media, that can be accessed using industry-standard hardware and software for data processing, retrieval, or reporting. The laboratory will maintain data collected for this project sampling for a minimum of seven years following submission of the data reports.

Laboratory analytical data and applicable field data will be provided as electronic data deliverables (EDDs) in a format that is compatible with the USEPA Scribe database. The process for generating the EDDs is described in Attachment 3, Data Management Plan.

9 PERFORMANCE AND SYSTEM AUDITS

Technical systems and performance audits will be performed as independent assessments of sample collection and analysis procedures. Audit results will be used to evaluate the ability of the Contract Laboratory to (1) produce data that fulfill the objectives established for this project, (2) comply with the QC criteria presented in this QAPP, and (3) identify any areas requiring corrective action. The systems audit is a qualitative review of the overall sampling or measurement system, while the performance audit is a quantitative assessment of a measurement system, and includes both internal and external audits. The CSC personnel will conduct internal audits. External audits are the responsibility of federal and state regulatory agencies. Definitive data verification and validation is also a quantitative check of the analytical process, where documentation and calculations are evaluated and verified. Data verification is discussed in Section 8.0.

9.1 Laboratory Performance and System Audits

In-house and regulatory agency audits of laboratory systems and performance will be a regular part of the laboratory's QA program. Internal audits will be conducted by the laboratory's Quality Assurance Officer or designee, and consist of a review of the entire laboratory system and at a minimum include: examination of sample receiving, log-in, storage, and C-O-C documentation procedures; sample preparation and analysis; and instrumentation procedures.

An internal audit of the laboratory may be performed by the CSC, at the discretion of the GE/UNC SM, within six months of field investigation start up and will include a review of the following items:

- Sample custody procedures
- Calibration procedures and documentation
- Completeness of data forms, notebooks, and other reporting requirements
- Data review and verification procedures
- Data storage, filing, and record keeping procedures
- QC procedures, tolerances, and documentation
- Operating conditions of facilities and equipment
- Documentation of training and maintenance activities
- Systems and operations overview
- Security of laboratory automated systems

Magnetic tape audits involve the examination of the electronic media used by the Contract Laboratory to collect, analyze, report, and store data. These audits are used to assess the authenticity of the data generated, and assess the implementation of good automated laboratory practices. The CSC Project Chemist may perform magnetic tape audits of the Contract Laboratory if warranted by on-site audit results.

The CSC will forward audit results to appropriate management and the GE/UNC SM. Deficiencies and corrective action procedures will be clearly documented in the audit report.

External field audits are the responsibility of the federal and state regulatory agencies. Field audits will be conducted at any time during the field operations and will be based upon the information presented in Attachments T.1 and T.2 and this QAPP. The audits may or may not be announced, at the discretion of the auditing agency.

10 PREVENTIVE MAINTENANCE PROCEDURES

A preventive maintenance program will be in place to promote the timely and effective completion of a measurement effort. The preventive maintenance program is designed to minimize the downtime of crucial sampling and/or analytical equipment due to unexpected component failure. In implementing this program, efforts will be focused in three primary areas: (1) establishment of maintenance responsibilities, (2) establishment of maintenance schedules for major and/or critical instrumentation and apparatus, and (3) establishment of an adequate inventory of critical spare parts and equipment.

10.1 Contract Laboratory Equipment

Preventive maintenance of laboratory equipment and instruments is essential to ensure the quality of the analytical data produced. The objective of preventive maintenance is to ensure instrument operation is appropriate for both task-specific and method DQOs. The Contract Laboratory has a routine preventive maintenance program to minimize the occurrence of instrument failure and other system malfunctions and will have designated individuals who perform routine scheduled maintenance for each instrument system and required support activity. The following paragraphs focus on maintenance responsibilities, maintenance schedules, record keeping, and inventory of spare parts and equipment.

Maintenance Responsibilities. Maintenance responsibilities for Contract Laboratory equipment will be assigned to designated personnel. These individuals establish maintenance procedures and schedules for each major equipment item. The instrument manufacturer service engineers will perform instrument maintenance and repair, as scheduled/needed. The analysts will perform other routine preventive maintenance tasks. Only qualified individuals will perform any maintenance activities.

Maintenance Schedules. Maintenance schedules are based on the manufacturers' recommendations and/or sample load. Maintenance activities for each instrument will be documented in a maintenance logbook, as described below.

Record Keeping. Instrument maintenance will be documented in instrument-specific bound logbooks, which are kept with the instrument. The date, initials of the individual performing the maintenance and the type of maintenance will be recorded in this logbook. Receipts from routine maintenance performed by the manufacturer's representative will be filed in the appropriate laboratory department (e.g., ion chromatograph maintenance receipts are stored in the organic section). This logbook will serve as a permanent record that documents any routine preventive maintenance performed, as well as any service performed by external individuals such as manufacturers' service representatives. In addition, receipts from routine maintenance performed by manufacturers' representatives will be maintained in the laboratory's file. These records will be made available upon request during external audits.

Spare Parts. An adequate inventory of spare parts is maintained to minimize equipment down time. This inventory will include those parts (and supplies) which are subject to frequent failure, have limited useful lifetimes, or cannot be obtained in a timely manner.

Contingency Plan. In the event of instrument failure, every effort will be made to analyze samples by an equivalent alternate means within holding times. If the redundancy in equivalent instrumentation is insufficient to handle the affected samples, the CSC will be immediately notified and the corrective action to be taken will be determined by the CSC Project Chemist and PM and GE/UNC SM (as applicable).

11 CORRECTIVE ACTIONS

11.1 Corrective Action Requirements

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out of control performance that may affect data quality. Proposed and implemented corrective action will be documented in the regular quality assurance reports to the appropriate project management as defined in Section 2.0. The CSC PM or designee will implement corrective action only after approval. If immediate corrective action is required, approvals secured by telephone from the GE/UNC SM will be documented in an additional memorandum.

For each incidence of noncompliance, a formal corrective action program will be established and implemented at the time the problem is identified. The individual who identifies the problem will be responsible for notifying the CSC PM, who in turn will notify other applicable personnel. Implementation of corrective action will be confirmed in writing as described previously.

Nonconformance with the established QC procedures specified in Attachments T.1 and T.2 or this QAPP will be identified and corrected in accordance with the QAPP. Corrective actions will be implemented and documented in the field logbook. No staff member will initiate corrective action without prior communication of findings through the proper channels.

11.1.1 Contract Laboratory Corrective Action

Corrective actions are required whenever unreliable analytical results prevent the quality control criteria from being met, as specified by the analytical method; the Contract Laboratory's SOPs, or this QAPP. The corrective action taken depends on the analysis and the nonconformance. A summary of corrective actions that will be undertaken for problems associated with specific laboratory analyses is provided in Attachment 1 of this QAPP.

Corrective action will be undertaken if one of the following occurs:

- Blanks consistently contain target analytes above acceptance levels
- Undesirable trends are detected in spike recoveries, spike recoveries are outside the QC limits, or RPDs between duplicate analyses are consistently outside QC limits
- There are unusual changes in RLs
- Deficiencies are detected during QA audits
- Inquiries concerning data quality are received from the CSC Project Chemist

The analyst who reviews the sample preparation or extraction procedures and performs the instrument calibration and analysis will handle corrective actions at the bench level (primarily). If the problem persists or its cause cannot be identified, the matter will be referred to the department supervisor or QA department for further investigation. Once resolved, full documentation of the corrective action procedure will be filed with the appropriate Contract Laboratory QA department. A summary of the corrective actions will be included in the data reports.

11.1.2 Data Verification Corrective Actions

Corrective action may be initiated during data verification or data assessment. Potential types of corrective action include resampling by the field team or reanalysis of samples by the Contract Laboratory.

Corrective actions that will be taken depend on the ability to mobilize the field team, how critical the data are to the task-specific DQOs, and whether the samples are still within holding time criteria. When a corrective action situation is identified by the CSC

Project Chemist, the CSC PM will have responsibility for authorizing the implementation of the corrective action, including resampling and documenting the corrective action and notifying the GE/UNC SM for authorization.

11.2 Corrective Action System

A system for issuing, tracking, and documenting completion of formal Recommendations for Corrective Action (RCA) exists for addressing significant and systematic problems. Recommendations for corrective actions are issued only by a member of the QA group, or a designee in a specific QA role. Each RCA addresses a specific problem or deficiency, usually identified during QA audits of Contract Laboratory or project operations. An RCA requires a written response from the party to whom the RCA was issued. A summary of unresolved RCAs is included in the monthly QA report to management. The report lists all RCAs that have been issued, the manager responsible for the work area, and the current status of each RCA. An RCA requires verification by the QA group that the corrective action has been implemented before the RCA is considered to be resolved. In the event there is no response to an RCA within 30 days, or if the proposed corrective action is disputed, the recommendation and/or conflict are pursued to successively higher management levels until the issue is resolved.

12 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Deliverables associated with this project will contain separate QA sections in which data quality information collected during specific tasks is summarized. Deliverables include reports that summarize the sampling program findings. Submission of these reports is the responsibility of the CSC PM. Quality assurance sections will identify all QA samples collected and the corresponding primary samples and will report accuracy, precision, and completeness of the data as well as the results of the performance and system audits, and any corrective action needed or taken during the project. Quarterly reports describing QA activities and findings, corrective actions, or recommendations will be submitted to the USEPA during construction.

13 REFERENCES

US Environmental Protection Agency (USEPA), 1980. Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA/600/4-80-032.

US Environmental Protection Agency (USEPA), 1996. *EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods*. SW-846 Third Edition, Final Update III, December.

US Environmental Protection Agency (USEPA), 2001. EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, EPA QA/R-5.

US Environmental Protection Agency (USEPA), 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA* QA/G-4. EPA/240/B-06/001.

US Nuclear Regulatory Commission, 2007. *Quality Assurance for Regulatory Monitoring Programs – Effluent Streams and the Environment*, Regulatory Guide 4.15, July.

TABLES

Table 3-1. Quality Control Sample Data Evaluation in Terms of Data Quality Indicators

Parameter	Quality Control Program	Evaluation Criteria
Precision	Field Duplicate Sample Pairs	Relative Percent Difference
	Field Duplicate Sample Pairs	Replicate Error Ratio
	Matrix Spike/Matrix Spike Duplicate Sample Pairs	Relative Percent Difference
	Matrix Duplicate Sample Pairs	Relative Percent Difference
	Serial Dilution	Percent Difference
Accuracy	Matrix Spike	Percent Recovery
	Matrix Spike Duplicate	Percent Recovery
	Laboratory Control Samples	Percent Recovery
	Interference Check Samples	Percent Recovery
	Initial Calibration Standards	Relative Standard Deviation
	Initial Calibration Verification	Percent Difference
	Calibration Verification Standards	Percent Difference
	Internal standards	Percent Recovery
	Post digestion spike	Percent Recovery
Representativeness	Sample Preservation and Holding Time	Qualitative, Degree of Confidence
	Method Blanks	Qualitative, Degree of Confidence
	Equipment Rinsate Blank Samples	Qualitative, Degree of Confidence
	Initial Calibration and Continuing Calibration Blanks	Qualitative, Degree of Confidence
	Field Duplicates	Quantitative/Qualitative, Degree of Confidence
Comparability	Standard Field Procedures	Qualitative, Degree of Confidence
	Standard Analytical Methods	Qualitative, Degree of Confidence
	Standard Units of Measure	Qualitative, Degree of Confidence
Completeness	Valid Data	Percent Acceptable Data

Table 3-2. Laboratory Analytical Methods, Sample Containers, Preservatives, Units of Measure, and Holding Time Criteria

Laboratory Analysis (Method) Soil Samples	Sample Container	Preservative	Unit of Measure	Holding Time
Metals (SW-846 6010/6020/EPA200.8)	8-oz glass wide-mouth with Teflon™ lined cap	NA	mg/kg	180 days from sample collection to analysis
Radium 226 (901.1 modified)	Gallon Ziploc™ Bag	NA	pCi/g	180 days from sample collection to analysis

Notes:

1. USEPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (U.S. EPA Third edition, Final Update III, December 1996)
2. Prescribed Procedures for Measurement of Radioactivity in Drinking Water (USEPA/600/4-80-032, August 1980)

mg/kg milligrams per kilogram

pCi/g picocuries per gram

Table 6-1. Analytical Method Summary

Method	Analytical Procedure
EPA 901.1 modified Radium-226 by Gamma Spectrometry	A homogeneous aliquot of sample is put into a standard geometry for gamma counting and set aside for 21 day in-growth period. Samples are counted long enough to meet the required sensitivity of measurement.
SW-846 6010B Metals by Inductively Coupled Plasma (ICP)	The ICP method measures element-emitted light by optical spectrometry. Samples are nebulized, and the resulting aerosol is transported to the plasma torch. Element-specific atomic-line emission spectra are produced by a radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer and the intensities of the emission lines are monitored by photo-sensitive devices.
SW-846 6020 Metals by ICP/Mass Spectrometer	Metals in solution is analyzed using ICP/Mass Spectrometer.

EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), (U.S. EPA Third Edition, September 1986; Final Update III, December 1996).

Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA/600/4-80-032, August, 1980)

Table 8-1. Data Qualifiers

Qualifier	Description
J	The analyte was positively identified, the quantitation is an estimation.
U	The analyte was analyzed for, but not detected. The associated numerical value is at or below the MDL.
T	The analyte was positively identified but the associated numerical value is below the RL.
R	The data are rejected and may not be usable due to QC deficiencies.
B	The analyte was found in an associated blank, as well as in the sample.
M	A matrix effect was present.
S	To be applied to all field screening data.

MDL Method detection limit

RL Reporting limit

QC Quality control

Table 8-2. Data Reporting Requirements

Data Type	Analysis Type	Data Reporting Requirement	Report Format
Metals and radionuclide data	Level III data package for standard methods of analysis	Case narrative (including samples not meeting QC criteria, out of control conditions, corrective actions, and matrix effects with justification) Completed C-O-C and sample receipt and log in forms	—Hard copy of data report —Hard copy of data report
		Target compound results for all samples, including field QC samples and dilution factors, reanalysis, batching information, and bracketing information Method blank results MS/MSD results (spike concentration, actual values, and percent recovery) Matrix duplicate data LCS results (spike concentration, actual values, and percent recovery)	—Hard and electronic copy of data report —Hard and electronic copy of data report —Hard and electronic copy of data report —Hard and electronic copy of data report —Hard and electronic copy of data report
		Surrogate results, organic analysis (spike concentration, actual values, and percent recovery) Initial calibration summary form Continuing calibration summary form Internal standard area and retention time summary (if applicable) Injection logs Raw data for all samples where matrix interference is invoked as the reason for MS/MSD, surrogate spike, or internal standard failure ICP interference check sample data Post digestions spike sample data Method of standard addition data (if required) Holding time summary Manually integrated data	—Hard and electronic copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report —Hard copy of data report
	Level IV data package for standard methods of analysis	Level III data package plus raw data for all samples and associated quality control samples	—Hard copy of data report

1. USEPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846; U.S. EPA Third Edition, Final Update III, December 1996).
2. Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA/600/4-80-032, August, 1980).
3. Analytical results will also be provided in an electronic data deliverable that is compatible with USEPA SCRIBE.

Table 8-3. General Flagging Conventions

QC Requirement	Criteria	Flag	Flag Applied To
Holding Time[a]	Time exceeded for extraction or analysis	J- for the positive results UJ for the non-detects	All analytes in the sample
LCS[a]	% R > Upper Control Limit (UCL) %R < Lower Control Limit (LCL)	J+ if high bias for the positive results None if high bias for non-detects J- if low bias for the positive results UJ if low bias for non-detects	The specific analyte(s) in all samples in the associated analytical batch
Method Blank	Analyte(s) detected ≥ Reporting Limit (RL)	B	The specific analyte(s) in all samples in the associated analytical batch with results above the RL
Matrix duplicates	Matrix duplicates > RLs and relative percent difference (RPD) outside CL	J for the positive results	The specific analyte(s) in all samples collected on the same sampling date
Matrix spike or Matrix Spike Duplicate (MS/MSD)	MS or MSD % recovery (R) > UCL or MS or MSD % R < LCL or MS/MSD RPD > CL	J+ if high bias for the positive results None if high bias for non-detects J- if low bias for the positive results UJ if low bias for non-detects J for the positive results	The specific analyte(s) in the parent sample. If parent sample concentration greater than 4 times the spiking concentration, no data will be qualified.
Sample Preservation/ Collection[a]	Preservation/collection requirements not met	J- for the positive results UJ for the non-detects	All analytes in the sample
Sample Storage[a]	< 2 Degrees Celsius (°C) or > 6°C or as required	J- for the positive results UJ for the non-detects	All analytes in the sample

a) Data will be rejected if a gross exceedance occurs.

ATTACHMENT 1

Quality Control Procedures, Frequency of QC Sample Analysis and Acceptance Criteria, and Laboratory Corrective Action Procedures, and Reporting Limit Criteria

TABLE 1-1a

RADIUM-226 BY GAMMA SPECTROMETRY – EPA 901.1
REPORTING LIMITS

Analysis	Analytical Method[(a)]	Analyte	Water MDC (pCi/l)	Water MDL (pCi/l)	Soil MDC (pCi/g)	Soil MDL (pCi/g)
Ra-226	EPA 901.1	Radium-226	Sample specific	NA	Sample specific	NA

(a) Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA/600/4-80-032, August, 1980)

MDC minimum detectable concentration

MDL method detection limit

NA not applicable

pCi/l picocuries per liter

pCi/g picocuries per gram

TABLE 1-1b

RADIUM-226 BY GAMMA SPECTROMETRY – EPA 901.1
QUALITY CONTROL ACCEPTANCE CRITERIA

Analytical Method[(a)]	Spiking Compounds	Accuracy Percent Recovery (%)	Precision RPD/(RER)[b]
EPA 901.1			
	Radium-226 (soil)	80-120	20
	Radium-226 (water)	80-120	20

[(a)]Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA/600/4-80-032, August, 1980)

[(b)]RPD/RER – relative percent difference/replicate error ratio (calculated between parent sample and duplicate)

TABLE 1-1c

RADIUM-226 BY GAMMA SPECTROMETRY – EPA 901.1
CALIBRATION SPECIFICATION AND CORRECTIVE ACTION SUMMARY

Analytical Method[a]	QC Element	Frequency	Acceptance Criteria	Corrective Action
EPA 901.1	Energy Calibration	Recommended Annually or After maintenance or when needed due to peak shifts or QC failures	Minimum of 10,000 Counts and Energy vs. Channel fit is ±1% Energy vs. FWHM fit is ≤2%	1) Purchase new standard 2) Recount 3) Perform instrument maintenance
	Energy calibration	Recommended Annually or After maintenance or when needed due to peak shifts or QC failures.	Efficiency number between 0 and 1	1) Purchase new standard 2) Recount 3) Perform instrument maintenance
	1000 Minute Background	Monthly	Within established instrument control limits (3σ)	1) Confirm chamber is empty 2) Recount 3) Perform instrument Maintenance
	30 Minute Background	Prior to daily analysis or Weekly, if no daily analysis occurs.	Within established instrument control limits (3σ)	1) Confirm chamber is empty 2) Recount 3) Perform instrument maintenance
	10 Minute Performance Check	Prior to daily analysis OR Weekly, if no daily analysis occurs.	Within established instrument control limits (3σ)	1) Recount 2) Perform instrument maintenance 3) Purchase new standard
	Method blank (MBLK)	1/preparation batch	<Lowest reporting limit	1) Re-analyze samples from batch, Or 2) Qualify sample data
	Laboratory Control Sample (LCS)	1/preparation batch	%Rec = 80-120	1) Repeat analyses once 2) Correct problem 3) Re-analyze all samples associated with failing LCS
	Duplicate Sample (DUP)	1/preparation batch	% RPD ≤ 20 OR If RPD > 20% and response < 5 * LLD, then RER ≤ 2.0	1) Rerun sample pair, evaluate for sample homogeneity 2) Report with qualifiers***

TABLE 1-1c

RADIUM-226 BY GAMMA SPECTROMETRY – EPA 901.1
CALIBRATION SPECIFICATION AND CORRECTIVE ACTION SUMMARY
(Page 2 of 2)

Analytical Method(a)	QC Element	Frequency	Acceptance Criteria	Corrective Action
	Control Charting and Proof of Competency	Annual statistical review of method.	Data statistically within control limits.	1) Trend Analysis/ Method Review 2) Correct method/instrument problem. 3) Replace analyst
	Batch Definition	Batch not to exceed number of samples analyzed in a 24 hour period after completion of performance check.	Samples analyzed within 24 hours of performance check. Must pass all method QC criteria	1) Re-analyze samples

***DUP Qualifier (Canned Comment) for use when values are low and the % RPD criteria does not apply. Since the difference between the analytical result for the sample and its duplicate is less than the reporting limit, the RPD variance is not considered significant.

(a) Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA/600/4-80-032, August, 1980)

LCS laboratory control sample

MDA minimum detectable activity

DER duplicate error ratio

RPD relative percent difference

TABLE 1-2a

METALS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY
SW-846 6020 (SOIL) AND EPA 200.8 (WATER)
REPORTING LIMITS

Analysis	Analytical Method[(a)]	Analyte	Soil RL (mg/kg)	Soil MDL (gg/kg)	Water RL (mg/l)	Water MDL (mg/l)
Metals	SW-846 6020 (soil) and EPA 200.8 (water)	Uranium	1	0.021	0.0003	0.000023

(a) EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), (U.S. EPA Third Edition, September 1986; Final Update III, December 1996).

USEPA Methods for the Determination of Inorganic Substances in Environmental Samples (EPA 100-400 Series) (EPA/600R-93/100, August 1993)

mg/l milligrams per liter

mg/kg milligrams per kilogram

TABLE 1-2b

METALS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY
SW-846 6020 (SOIL) AND EPA 200.8 (WATER)
QUALITY CONTROL ACCEPTANCE CRITERIA

Method[a]	Analyte	Accuracy Soil (% R)	Precision Soil (% RPD)	Accuracy Water (% R)	Precision Water (% RPD)
SW-846 6020 (soil) and EPA 200.8 (water)	Uranium	75-125	20%	70-130	10%

(a) EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), (U.S. EPA Third Edition, September 1986; Final Update III, December 1996).

USEPA Methods for the Determination of Inorganic Substances in Environmental Samples (EPA 100-400 Series) (EPA/600R-93/100, August 1993)

%R – percent recovery

RPD – relative percent difference

TABLE 1-2c

METALS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY – SW-846 6020 (SOIL)
CALIBRATION SPECIFICATION AND CORRECTIVE ACTION SUMMARY

Method	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
SW-846 6020 (soil)	Tuning mass calibration	Daily. Must pass to proceed.	0.9-1.1 amu Doubly charged m/z <2.5% Singly charged m/z <1.5% RSDs < 7%	Check sample introduction Re-prepare tune solution Adjust tuning parameters
	Tune check	Daily. Must pass to proceed.	Instrument generated report states PASS for 5 replicates of mass ranges <5% RSD and within 0.1 amu.	Check sample introduction Re-prepare tune solution Adjust tuning parameters
	Instrument calibration	Daily, or when needed. 4-point calibration and blank.	Correlation coefficient of 0.998 or better is required.	Recalibrate and reanalyze. Prepare fresh IC standards until successful.
	Initial calibration verification (ICV)	Immediately follows calibration. Second source standard used.	6020 R% = 90-110 Immediately after IC when new standards are prepared.	Re-calibrate and rerun. Prepare fresh standards and/or ICV. Run cannot continue until passes.
	Low level ICV (LL-ICV)	Immediately follows ICV. Calibration source standard used.	70-130%	Determine cause. Re-calibrate.
	Initial calibration blank (ICB)	Run at beginning of run.	Larger of ±1* lowest reporting limit or 2.2 X MDL	Re-pour blanks, re-calibrate, and re-run. Prepare fresh blank.
	Internal standard (IS)	Run inline for all items analyzed throughout the run.	Recovery > 70% is acceptable value.	Dilute fivefold and re-run. Continue to dilute until adequate recovery is attained.
	Interference check solutions (ICS-A and ICS-AB)	Run at beginning of run and every 12 hours.	70-130% set in-house.	Re-prepare and re-run. Check for source of interference.
	Continuing Calibration verification (CCV)/ instrument performance check (IPC)	Run at beginning of run, every 10 samples, and at end of run.	R% - 90-110 as continuing calibration check.	Re-calibrate and re-run samples since last valid CCV. Check for sample matrix problem.
	Low level CCV	Run at beginning of run, every 10 samples, and at end of run.	70-130%	Determine cause for failure. Re-analyze. Re-calibration or clean.
	Continuing calibration blank (CCB)	Run before every CCV.	+ 1 to -1 * PQL	Check for high concentration sample carryover. Re-analyze CCB. Re-analyze affected samples. Re-calibrate.

TABLE 1-2c

METALS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY – SW-846 6020 (SOIL)
CALIBRATION SPECIFICATION AND CORRECTIVE ACTION SUMMARY
(Page 2 of 2)

Method	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Analytical spike sample (MS4)	Minimum 1 per 10 samples.	6020: R% = 75-125	Evaluate LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	Analytical spike duplicate (MS4), or analytical duplicate sample	Minimum 1 per 10 samples.	Larger of 3 * PQL or 20% RPD %R see MS	See LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	Method blank (MBLK) / laboratory reagent blank (LRB)	One per analytical run for direct samples, or one per digestion batch.	Larger of ± 1 * lowest reporting limit or 2.2 X MDL.	Re-analyze LRB/MBLK. Re-digest samples from batch which fail acceptance criteria or flag and report data.
	Laboratory fortified blank (LFB)	One per analytical run for direct samples, or one per digestion batch.	R% = 85-115	Re-analyze LFB Re-digest sample batch or flag data.
	Laboratory control sample (LCS)	One per water digestion batch	80-120%	Re-analyze LFB. Re-digest sample batch or flag data.
	SRM (Standard Reference Materials) = LCS	One per solid digestion batch	Within acceptance ranges established by control chart	Re-analyze LCS. Re-digest sample batch or flag data.
	Pre-digestion spike / laboratory fortified sample matrix (MS3)	Minimum one per 20 or one per digestion batch.	R% = Water: 75-125 Waste: 75-125	See LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	Matrix spike duplicate (MSD3) or digestion duplicate sample	Minimum one per 20 or one per digestion batch.	Larger of 3 * PQL or 20% RPD	See LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	MDL study	Annually, or whenever method changes might affect sensitivity	Prior studies	Repeat if obvious problem occurs. Adjust reporting limit to MDL.
	LOD	Follows MDL study at one to four times MDL result	Positive result above zero	Rerun LOD Rerun MDL, then LOD Consult QA
	LLQC	Follows MDL study at same concentration as LL-ICV, taken through prep	70-130%	Re-run LLQC Re-run MDL, then LLQC Re-calibrate
	IDL study	Quarterly, changes in operator or whenever changes might affect sensitivity.		
	DOC	Annually per analyst and prior to reporting samples from a new analyst	85-115%	Four sequential LCS analyses

[a]All corrective actions shall be documented, and all records shall be maintained by the laboratory.

TABLE 1-2d

METALS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY – EPA 200.8 (WATER)
CALIBRATION SPECIFICATION AND CORRECTIVE ACTION SUMMARY
(Page 1 of 2)

Method	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
EPA 200.8 (water)	Instrument calibration	Daily, or when needed. 4-point calibration and blank.	Correlation coefficient of 0.995 or better is required.	Recalibrate and reanalyze. Prepare fresh IC standards until successful.
	Initial calibration verification (ICV)	Immediately follows calibration. Second source standard used.	200.8 R% = 90-110 Immediately after IC when new standards are prepared.	Re-calibrate and rerun. Prepare fresh standards and/or ICV.
	Initial calibration blank (ICB)	Run at beginning of run.	Larger of ±1* lowest reporting limit or 2.2 X MDL	Re-pour blanks, re-calibrate, and re-run. Prepare fresh blank.
	Continuing Calibration verification (CCV)/ instrument performance check (IPC)	Run at beginning of run, every 10 samples, and at end of run.	R% - 90-110 as continuing calibration check.	Re-calibrate and re-run samples since last valid CCV. Check for sample matrix problem.
	Continuing calibration blank (CCB)	Run after every CCV.	+ 1 to -1 * PQL	Check for high concentration sample. Re-analyze CCB. Re-analyze affected samples.
	Analytical spike sample (MS4)	Minimum 1 per 10 samples.	200.8: R% = 70-130	Evaluate LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	Analytical spike duplicate (MSD2), or analytical duplicate sample	Minimum 1 per 10 samples.	Larger of 3 * PQL or 20% RPD %R see MS	See LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	Method blank (MBLK) / laboratory reagent blank (LRB)	One per analytical run for direct samples, or one per digestion batch.	Larger of ± 1 * lowest reporting limit or 2.2 X MDL.	Re-analyze LRB/MBLK. Re-digest samples from batch which fail acceptance criteria or flag and report data.
	Laboratory fortified blank (LFB)	One per analytical run for direct samples, or one per digestion batch.	R% = 85-115	Re-analyze LFB Re-digest sample batch or flag data.

TABLE 1-2d

METALS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROSCOPY – EPA 200.8 (WATER)
CALIBRATION SPECIFICATION AND CORRECTIVE ACTION SUMMARY
(Page 2 of 2)

Method	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action[a]
	Laboratory control sample (LCS)	One per digestion batch	80-120%	Re-analyze LFB. Re-digest sample batch or flag data.
	SRM (Standard Reference Materials) = LCS	One per solid digestion batch	Within established acceptance ranges	Re-analyze LCS. Re-digest sample batch or flag data.
	Pre-digestion spike / laboratory fortified sample matrix (MS3)	Minimum one per 20 or one per digestion batch.	R% = Water: 70-130 Waste: 75-125	See LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	Matrix spike duplicate (MSD3) or digestion duplicate sample	Minimum one per 20 or one per digestion batch.	Larger of 3 * PQL or 20% RPD	See LCS performance. Report spike as analyzed if LCS/LFB is acceptable.
	MDL study	Annually, or whenever method changes might affect sensitivity	Prior studies	Repeat if obvious problem occurs. Adjust reporting limit to MDL.

[a]All corrective actions shall be documented, and all records shall be maintained by the laboratory.

ATTACHMENT 2
Contract Laboratory Quality Assurance Plans

ACZ Laboratories, Inc.

2773 Downhill Drive
Steamboat Springs, CO 80487
www.acz.com
970.879.6590

Quality Assurance Plan v.23

Document ID: SOPAD018.02.17.23
Effective Date: February 14, 2017
Last Review: February, 2017 by Matt Sowards

Approval Authority[1]:

Matt Sowards, Executive Vice President/QA Officer
Reserve Technical Director – Radiochemistry

Brett Dalke, Executive Vice President/Lab Director
Technical Director – Geochemistry

Technical Directors & Signatories

Scott Habermehl, Project Manager Supervisor

Max Janicek, Project Manager

Sue Webber, Project Manager

Steve Pulford, Technical Director – Metals

Alyssa Dybala, Technical Director – WetChemistry

Brian Uhrig, Technical Director – WetChemistry

Brett Dalke, Technical Director – Geochemistry

Mark McNeal, Technical Director – Radiochemistry

Gus Torde, Technical Director – Organics

[1] Emails & read receipt constitute approval signatures.

Table of Contents

1 INTRODUCTION

ACZ Laboratories, Inc. is an environmental testing laboratory that provides data to clients primarily for regulatory purposes. Samples are analyzed for compliance with federal programs including the Resource Conservation Recovery Act (RCRA), Safe Drinking Water Act (SDWA), and Clean Water Act (CWA). Environmental compliance and management decisions are based on the analytical data provided, which are critical to the expenditure of large amounts of money; are important to public health safety; are important in evaluating, monitoring, and protecting the environment; and may be essential in litigation. ACZ's data must be of known and documented quality to support sound decisions and withstand adversarial inquiry.

An effective Quality Management System is the cornerstone of the generation of reliable analytical data. ACZ's Quality Assurance Plan (QAP) outlines the quality assurance and quality control objectives, policies, and procedures determined to be necessary to meet the requirements of the EPA, federal government entities, state agencies, other regulatory authorities, and our clients. This document provides the framework to ensure all ACZ employees have sufficient knowledge and training to perform their job responsibilities in a manner that assures all data reported to ACZ's clients is accurate, reliable, technically sound, legally defensible, and impartial.

For data to be useful, it must be of known and documented quality. The word "quality" has many different meanings, but for the purposes of environmental testing activities can be stated simply as "conformance to requirements." Conforming to requirements allows objective measurements to be applied, rather than subjective opinions, to determine when work is of good quality. *Quality control* refers to all activities that measure conformance (i.e. good quality) of the data. It requires action(s) to be taken and is typically included as part of the procedure. *Quality assurance* provides the records of the results obtained from the required action(s) and refers to the ability of the laboratory to demonstrate or prove to an outside party that the quality of the data is what the laboratory states it is. Quality assurance relies heavily on documentation, and to be effective, the documentation must: (1) assure the quality control procedures are being implemented as required; (2) assure the reported data reflect the sample as it was received, meaning sample mix-up was avoided, the sample was properly preserved prior to analysis, etc.; (3) facilitate traceability of an analytical result; and (4) be subjected to reasonable precautions to protect data from loss, damage, theft, and internal or external tampering.

Quality Policy Statement: To maintain an effective QA program, continually improve the quality of our environmental testing services, and consistently provide clients with technically sound and legally defensible data in a timely manner, the management of ACZ recognizes the importance of its commitment to:

- Ensuring good professional practice by well-trained and qualified employees with the necessary experience and skills to carry out their organizational functions and to meet or exceed ACZ's standards for the quality and reliability of its testing services.
- Ensuring the data provided to our clients is of known and documented quality, and is accurate and impartial.
- Ensuring that all quality assurance and quality control policies and procedures are communicated to and understood by all employees, and that they are implemented by all employees in their work.
- Ensuring that all aspects of the business operations are conducted in a manner that adheres to the TNI Standards and all of ACZ's policies and procedures documented in the QAP, SOPs, emails, memos, etc.
- Upholding the spirit and intent of ACZ's Data Integrity Program and implementing the requirements of the program.

2 QUALITY SYSTEM OBJECTIVES & COMPONENTS

ACZ's QAP provides a framework that guides all technical staff and administrative personnel. The information presented is necessary to ensure all employees perform their duties in a manner that allows the company to achieve its objectives, thereby ensuring the precision, accuracy, completeness, and consistency of the analytical data reported to our clients. This framework is referred to as the Quality System. The Quality System encompasses every documented quality assurance (QA) and quality control (QC) policy and procedure and guides all business functions and laboratory operations by specifying standardized protocols to control both the short-term and long-term activities that influence the quality and defensibility of our testing services.

The Quality System is designed to be appropriate to the type, range, and volume of the environmental testing undertaken. The Quality System is not a static entity and must function in a manner that allows for continuous evolution of all aspects of ACZ's business when improvements have been identified and have been determined to be necessary or beneficial. ACZ management recognizes that the staff is comprised of people who possess varied experience and knowledge and can contribute valuable insight and suggestions regarding these improvements. All employees are encouraged to be involved in this process. The following six (6) key elements form the foundation of ACZ's Quality System:

- Documents & Records
- SOPs
- Training
- Audits
- Corrective Actions
- Management Review of the Quality System

2.1 Documents & Records

The entire history of any sample must be readily understood through the associated documentation. To this extent, a formal and systematic control of documents and records is necessary for accurately reconstructing all events pertaining to any sample and for guaranteeing the quality and defensibility of the data. All information relating to the laboratory facility's equipment, analytical test methods, and related laboratory activities (such as sample receipt, sample preparation, data verification and data reporting) must be documented, and all records, including those pertaining to calibration and test equipment, certificates and reports, must be maintained. Documents and records must be safely stored (protected against fire, theft, loss, deterioration, and vermin), and must be held secure and in confidence to the client for a minimum of 10 years. Refer to §10 for details regarding the storage and control of ACZ's documents and records.

2.1.1 Documents

All official documents are reviewed for accuracy, approved for release by authorized personnel, and distributed through ACZ's LabWeb intranet. LabWeb is a computerized document control system based in HTML that can be accessed from any network computer within the facility. For printed documents to be considered controlled, the header must be in sync with the header on LabWeb. Obsolete or invalid SOPs retained for knowledge preservation or other reasons must be clearly marked to identify their purpose.

All documents are categorized by department and are assigned a unique document ID that is displayed in either the header or footer section. The ID nomenclature starts with either SOP (procedure) or FRM (form), followed by the 2-letter department code, the unique document number, the month and year of issue, and the revision. The effective date for any SOP or other document is included on the title page and header section of each subsequent page and indicates the implementation date.

The QA Officer has full responsibility of the Document Control System. Only employees with the appropriate computer access (IT and QA staff) can upload documents to LabWeb. A new or revised document is reviewed, and following approval, the document control number is updated and the SOP or form is uploaded to Labweb. When a new version of an SOP is added to Labweb, the previous version is removed from the active list, date-stamped and electronically archived in a designated location on the network. This automatic process guarantees that ACZ can retrieve the version that was in effect at any given time.

2.1.2 Records

A record is any information or data on a particular subject that is collected and preserved. Records are produced on a daily basis and contain original, factual information from an activity or study. For ACZ's purpose, this information may be recorded by the following means: LIMS database, logbooks, raw instrument data, worksheets, and notes (or exact copies thereof) that are necessary for the reconstruction and evaluation of the report of the activity or study. The record management system provides control of records for data reduction, validation, reporting and storage, and also provides control of all laboratory notebooks and logbooks. The system must allow for historical reconstruction of all laboratory activities that produced analytical data, must document the identity of personnel involved in sample receipt, preparation, calibration, and testing; and must facilitate the retrieval of all working files and archived records for inspection and verification purposes. At a minimum, the following criteria for records must be met:

1) Instrument logbooks must be kept up-to-date on a daily basis. Document all relevant activities when the event occurs or as soon as practical thereafter.
2) Dilution factors and observations must be recorded at the time they are made, and notes regarding samples or analyses must be identifiable to the specific task.
3) A detailed description of any departure from a documented procedure, and the reason for the departure, must be provided at the time it is performed.
4) All generated data must be recorded either by an automated data collection system or must be recorded directly, promptly and legibly in permanent ink (blue or black is preferred).
5) Erroneous entries (hard copy or electronic) cannot be destroyed by methods such as erasures, overwritten files or markings. Refer to §16 for ACZ's error correction protocol.
6) Any changes to hard copy records must be clearly initialed and dated by the responsible staff. Changes to electronic records must also be traceable to the individual who made the change, and the reason for the change must be provided.
7) Records generated by computers must have hard copy or write-protected backup copies.

2.2 Standard Operating Procedures

A documented procedure is required for all phases of ACZ's business operations, from sample log-in through sample disposal. A Standard Operating Procedure (SOP) is a written document that details the manner in which an operation, analysis, or action is performed and thoroughly prescribes the techniques and procedures, which are the accepted process for performing certain routine or repetitive tasks. Analytical SOPs must be written with adequate detail to allow someone similarly qualified, other than the analysts who routinely performs the procedure, to reproduce the procedure used to generate the test result. To the extent possible, administrative SOPs [non-technical] must include specific requirements pertaining to the process; however, the procedure itself may be a more general description so as to lend a degree of necessary flexibility to account for client requests and other circumstances which may be outside of ACZ's control.

Proposed revisions to any test SOP shall be submitted by the pertinent department supervisor (exceptions may be granted on a case by case basis) and be reviewed and approved by QA prior to implementation. Changes to provide additional clarification, correct typographical errors, etc. do not require formal approval and/or training. Analytical SOPs must be reviewed annually using the SOP Review Form (FRMQA035), and Administrative SOPs must be reviewed regularly and revised if necessary to ensure the information is accurate and reflects current practice. Documenting changes in the controlled copy of any SOP is prohibited. Refer to §10.5.1 for additional information on SOPs.

SOPs are proprietary documents and ACZ does not distribute them freely. Any copy sent electronically or otherwise to an outside party is considered uncontrolled, and the recipient understands that additional changes can be made without prior notification. Excluding method development, the use of uncontrolled copies of SOPs is not permitted.

Unless the reference method is followed exactly and contains sufficient detail to ensure consistent application, an SOP must be developed before a new procedure, application, or instrument can be implemented. The introduction of a new method must be a planned activity directed by the Production Manager, assigned to the appropriate technical director(s), and overseen by QA staff. Exceptions may be made when the client provides specific procedural instructions. In this event, the client's instructions must be followed exactly and appended to ACZ's test report package. Exceptions are primarily related to the preparation of solid materials for analytical testing (refer to SOPAD043 for additional details). An SOP template (SOPAD025) may be obtained from QA. If a client requests a procedure for which there is no published method or existing SOP, ACZ will utilize the process described in the SOP *Client Service Policies and Procedures* (SOPAD043). Analytical SOPs are written in accordance with the TNI Standards and must include or reference the following items, where applicable:

1) identification of the test method
2) summary, scope & application of the test method, including matrices & parameters to be analyzed
3) references, including documents provided by instrument / equipment manufacturer
4) sample collection, preservation, & storage
5) equipment & supplies
6) reagents & standards, including storage conditions & shelf-life for each
7) safety
8) interferences
9) complete procedure, including details and acceptance criteria for initial & continuing calibration
10) data review & assessment, including protocols for handling out-of-control or unacceptable data
11) quality control, including acceptance criteria & corrective action for handling failed quality control
12) calculation equations (dilution factors, RPD, % recovery, etc.) & calibration formulas
13) method detection limit & quantitation limit
14) method performance, including Demonstration of Capability and Method Detection Limit procedures
15) pollution prevention & waste management
16) definitions
17) tables, diagrams, flowcharts

2.3 Training

It is the responsibility of ACZ's management to ensure the competence of all employees who perform environmental tests and other specific duties, operate equipment or instrumentation, give opinions and interpretations, evaluate results, and sign test reports. Additionally, ACZ management is responsible for formulating the goals and policies with respect to the necessary education, training, and skills of all personnel and for providing training that is relevant to the company's present and anticipated tasks.

Employees must possess the appropriate combination of education, experience, and skills to adequately demonstrate a specific knowledge of their particular functions and to carry out those functions in a manner that meets ACZ's standards and expectations. Additionally, each staff member must demonstrate an understanding of laboratory operations, test methods, related quality assurance and quality control procedures, and management of records and documents to the extent necessary to successfully perform their job duties.

All full-time and part-time personnel must complete a formal training process for Safety, Ethics, Quality Assurance / Quality Control, Quarantined Materials, and Sexual Harassment on the first day of hire and are subsequently responsible for complying with all requirements that pertain to their job duties. For all technical staff, training for analytical procedures must be completed prior to independent generation of client data. In general, any staff member who is undergoing training must be provided with appropriate supervision. It is the responsibility of each supervisor or manager to ensure personnel within his or her department are supervised, competent, and working in accordance with ACZ's Quality System.

2.3.1 Safety Training

Safety training is scheduled with ACZ's Chemical Hygiene Officer (CHO) and includes viewing a video of general laboratory safety, a complete review of ACZ's Chemical Hygiene Plan, and a building tour to identify the location of Safety Data Sheets, emergency showers, eye wash stations, and emergency exits. Following completion of the training, the employee takes an exam, which allows the CHO to evaluate their understanding of the material covered.

2.3.2 Data Integrity Training

ACZ is committed to fostering and enforcing an ethically sound work environment that encourages the conscientious production of accurate, technically sound, and legally defensible data. Data integrity training is required for all full-time and part-time employees (permanent or temporary) as described in ACZ's SOP *Data Integrity Principles & Policies* (SOPAD039). Initial training provides an orientation of ACZ's Ethics program, ACZ's Code of Conduct, Code of Ethics, and zero-tolerance policy. Each new employee is introduced to the company's Ombudsman. Data integrity training is provided for all current employees on an annual basis. At a minimum, employees must review ACZ's Data Integrity Principles & Policies (SOPAD039) and provide documented testimony indicating they have read, understood, & agree to adhere to them.

2.3.3 QA Training

All full-time and part-time employees attend an initial orientation session which is based on the most current version of ACZ's Quality Assurance Plan [QAP] and focuses on the relationship between quality control, quality assurance, environmental testing, and environmental monitoring.

2.3.4 Sexual Harassment Training

Sexual Harassment training is required for each new employee and includes viewing a video that demonstrates the identification, reporting, and remediation of harassment issues in the work place. Any complaints of sexual harassment must be brought to the attention of ACZ's EVPs as soon as possible.

2.3.5 Technical personnel must be thoroughly trained in the analytical techniques and operating principles for all pertinent method procedures. Under no circumstances may any analyst independently generate or review client data for a test procedure before completing the required training and receiving the explicit approval of the technical director overseeing the analysis. §5 provides details of ACZ's technical training program.

2.3.6 Employees may be authorized to perform AREV or SREV for a procedure by the pertinent department supervisor or the QAO. Authorization indicates the employee has been trained on applicable QC requirements, corrective actions, and data qualification. AREV & SREV shall be performed in accordance with effective version of the associated test SOP. Authorization is tracked in an excel spreadsheet located on a network drive. Computer permissions are configured so that all employees may view the spreadsheet but only QA staff may edit it.

2.3.7 Training is required for all employees whose activities are affected by any procedural change(s) to an SOP and is considered to be complete once each employee has submitted documentation attesting they have read, understand, and agree to follow the revised policy.

2.3.8 ACZ recognizes the benefit of continuing education and encourages employee participation in advanced training courses, seminars, and professional organizations and meetings.

2.4 Audits

The purpose of an audit is to verify conformance to documented Quality Assurance and Quality Control policies and procedures, and to identify discrepancies when they exist. In the latter case, any problems shall be addressed and resolved in an appropriate manner to assure the Quality System is continuously improved on all levels.

2.4.1 External Audits

External audits are conducted to ascertain compliance with rules, regulations, and additional criteria for certification, and will have a higher degree of formality than internal audits. Where records are required, compliance will be critically evaluated. Issues of non-compliance identified in previous audits are usually reviewed to verify the laboratory has remediated them effectively. The ease with which important records and information can be retrieved is a criterion for judgment of the management practices of a laboratory and may dictate the depth of the audit. Individual state agencies, laboratory Accrediting Bodies, and current and potential clients routinely audit ACZ.

The on-site assessment is generally a two to four day process during which the regulating agency conducts an entrance interview and tours the facility before performing an in-depth review of documents, workgroups, reports, electronic data files, etc. A critical aspect of the on-site assessment is review and verification of bench-level documentation and analyst interviews to determine actual laboratory practices. ACZ's policy is to always have QA personnel present during an interview. If necessary, the EVP, may attend the interview. An exit interview is conducted upon completion of all on-site assessments, during which observations and findings are reviewed. The agency will submit a final report to ACZ, generally within 30 days, detailing all pertinent findings and recommendations.

Upon receipt and review of the agency's report, the QA department will meet with department managers to develop a corrective action plan, which must be submitted to the agency by the date indicated in their report. Each finding or group of similar findings is addressed as a major corrective action as described in §2.5.2. Employees shall not make changes to any laboratory or other practice based on comments or opinions expressed by the regulating agency during an interview or any other stage of the on-site assessment without first obtaining approval from QA. ACZ will revise policies and procedures as necessary as part of the major corrective action process.

2.4.2 Internal Audits

ACZ is responsible for the quality of its data and must take reasonable efforts to assure itself and all interested parties confidence can be placed in it. ACZ shall conduct internal audits of its activities to verify compliance with the Quality System. It is the responsibility of the QA Officer (QAO) to plan, direct, and organize internal audits; however, a trained and qualified individual, independent from the area or system being audited, may be designated by the QAO to conduct an internal audit. The area of activity audited, the audit findings, and subsequent corrective actions shall be documented.

The internal audit program shall address all elements of the management system. At least one test method shall be audited annually for each analytical laboratory division. Method audits encompass both qualitative evaluation of the operational details of the QA program and quantitative evaluation of the accuracy of data generated by the laboratory staff. Test method audits include step by step witnessing of the procedure. Laboratory Divisions:

- Wet Chemistry (Prep and Analytical)
- Metals (Instrument & Prep)
- Soils
- Radiochemistry (Prep and Analytical)
- Organics (Prep and Analytical)

When audit findings cast doubt on the effectiveness of the operations or on the correctness or validity of the laboratory's test or calibration results, the laboratory shall take timely corrective action, and shall notify
customers in writing if investigations show that the laboratory results may have been meaningfully affected. Client contact should be initiated within two months of discovering the error(s). If data impact assessment cannot be completed in this timeframe management shall set a deadline commensurate to the demands of the assessment.

More frequent internal audits may be scheduled depending on the following criteria:

- Number and type of corrective actions filed for a method or activity
- Client complaints
- Continued failure to achieve acceptable results for a Proficiency Testing sample
- Findings from an external audit
- Request from management

All findings from internal audits are directed through ACZ's corrective action system. Each finding is assigned a corrective action number (similar findings may be combined). A general description of the process is as follows:

1) Findings and observations are summarized in a report.

2) The report is distributed to the department supervisor, Production Manager, and EVPs.

3) The supervisor reviews the report and composes a plan of corrective action (POC) and projected completion dates for each finding. The POC should be proportional to the finding and the projected completion date commensurate with the demands of the tasks required for the corrective action.

4) The supervisor submits the plan of corrective action to the QAO or designee for review and approval.

5) The QAO or designee reviews the plan of corrective action for each internal audit finding. Once the plan of corrective action is accepted, a major corrective action number is assigned to each planned corrective action or group of similar corrective actions.

6) The supervisor negotiates the corrective action and submits a Corrective Action Report (FRMQA001) for each major corrective action number to the QA department for final review.

7) Once all corrective actions associated with the internal audit have been completed and approved, the internal audit process is complete.

An in-depth review will be conducted if there is any evidence of inappropriate actions or vulnerabilities related to data integrity. This review shall be handled in a confidential manner until a follow up evaluation, full investigation, or other appropriate actions have been completed and the issue(s) clarified. Refer to ACZ's SOP *Data Integrity Policies & Procedures* (SOPAD039).

2.4.3 Proficiency Testing (PT) Program

ACZ is required to participate in a formal Proficiency Testing Program at the frequency stipulated by regulating agencies. These "performance evaluations" are facilitated through the introduction of blind samples, purchased from approved vendors. ACZ analyzes PT samples for most accredited parameters twice in a calendar year, with each study being approximately six (6) months apart. These tests are matrix, technology, and analyte specific, and provide useful information regarding the accuracy of the analytical data being produced. At a minimum, ACZ participates in the Water Supply (WS) study for SDWA, the Water Pollution (WP) study for CWA, a Soil study for RCRA, and a Radiochemistry PT study for Drinking Water. Refer to SOPAD011 for additional details.

2.5 Corrective Action

Corrective action shall be performed when any aspect of ACZ's testing and/or calibration work, or the results of this work, do not conform to established procedures or the agreed requirements of the customer. Corrective actions are a fundamental element of ACZ's QA Program, as a successful Quality System requires the identification of deficiencies and depends on the development, implementation, and documentation of effective contingency plans and resolutions to effectively remediate the deficiencies. Corrective actions are classified as minor, major, or technical.

2.5.1 Minor Corrective Action

Minor corrective actions address problems or issues isolated to a specific data set or group of data sets that do not meaningfully impact reports *already* issued to clients. The minor corrective action report (FRMQA001) allows for complete documentation of any temporary deviation from the SOP or other protocol. The employee who initiates the corrective action will complete Section 1 of the report. Documentation must be accurate and must provide a complete detailed explanation of the situation for future reference. The need to qualify data shall be critically assessed and appropriately addressed. The department supervisor should always be informed of the need for a minor corrective action and may provide additional information in the appropriate section. The project manager may also provide additional information in the appropriate section if necessary. QA does not need to close a minor corrective action; however, the employee may review the report with QA personnel and request their signature in the appropriate section. Minor corrective actions do not require follow-up.

Complete documentation may be provided either on the workgroup bench sheet or on the data review checklist in lieu of using FRMQA001. Use FRMQA001 if the deviation applies to many workgroups and attach a copy of the completed form to each workgroup before the workgroup is scanned. If the report is generated after the workgroups have been scanned, then the workgroup must be retrieved and rescanned with the report included as part of the data package. In this case, a note is made on the front page of the workgroup package indicating the reason the workgroup was rescanned (i.e. “CAR attached, WG rescanned”).

2.5.2 Major Corrective Action

Major corrective actions address problems which are systematic or meaningfully impact reports which have been issued to clients. It is the responsibility of the QAO to notify laboratory management in writing of departures from the Quality System, and it is the responsibility of the laboratory management to ensure remediation is completed by the assigned due date or to negotiate an extended deadline.

A major corrective action is initiated whenever a system failure has been identified or whenever an audit finding or other circumstance casts doubt on the correctness or validity of the analytical results. The client must be notified in writing if their work is significantly affected. The QA department will work with the Project Manager to determine if a revised report must be issued to the client. See ACZ’s SOP *Client Service Policies and Procedure* (SOPAD043) for details. A major corrective action may also be initiated when the need for preventive action has been identified (refer to §2.5.4).

Only QA department personnel may open and close a major corrective action. When opened, the corrective action shall be assigned a unique tracking number (referred to as the CAR number) to ensure that ACZ maintains a complete and accessible record of all Quality System deviations or failures, root cause determinations and subsequent resolutions, and preventive actions. A remediation deadline shall be assigned for all major corrective actions.

Examples of circumstances requiring a major corrective action include, but are not limited to:

- Contamination trends as indicated by blanks routinely above acceptable levels
- Spikes, surrogates and lab control samples continually outside acceptance limits
-
- “Not Acceptable” Proficiency Testing results
- Findings from internal or external audits
- Discrepancies between what was reported to clients and what should have been reported to clients due to equation errors or incorrect LIMS configuration.
- Hold times or deadlines routinely missed
- Evidence of insufficient or inadequate training

Following initiation, the procedure for a major corrective action proceeds to an investigation by the assigned individual to determine the root cause of the problem and identify possible resolutions to rectify the problem. The action(s) most likely to eliminate the problem and prevent recurrence of the problem must be selected, documented and implemented, and pertinent staff members must be trained, if necessary. Changes resulting from the corrective action will be monitored, if necessary, to ensure the resolution(s) are effective. A general outline of the procedure is as follows:

1) Initiation: Any employee may initiate a corrective action by notifying QA. The department manager should be notified first so that they can assess the need for a major corrective action. If determined to be necessary, QA personnel will open a corrective action, assign a unique tracking number, and a deadline for remediation. Deadlines shall be assigned based on the anticipated demands of remediation and potential threat posed to data integrity.

2) Assignment: QA assigns the corrective action to the person(s) responsible for problem characterization, Root Cause Analysis (RCA), Data Impact Assessment (DIA), corrective (including preventive) actions. Sections 1 and 2 of FRMQA001 shall be completed by the assignee(s).

3) Immediate action shall be taken to eliminate propagation of errors. Stopgap measures may be employed, including but not limited to: subcontracting analyses, imposing a moratorium on data reporting, manual data transformation. Immediate action shall be to a degree commensurate with the magnitude and risk of the problem.

4) Investigation and Action: Must be completed by the assigned deadline. Deadline extensions shall be negotiated with the QA department.

    a. The assigned individual(s) launch an investigation of the problem. There are three major components of the investigation
        1) Characterization of the problem: A thorough, but succinct, description of the problem must be composed. Whenever possible, this includes determination of the exact timeframe during which the error was present and what workgroups and samples were affected.
        2) Root Cause Analysis (RCA): Focuses on establishing the sequence of events or causal chain leading up to the problem, identifying contributing factors and elucidating relationships between them, and determining where intervention could be reasonably implemented to change performance and prevent an undesirable outcome. The depth of the RCA shall be commensurate with the risk and magnitude of the problem.
        3) Data Impact Assessment (DIA): Once the problem has been fully characterized, it shall be evaluated to determine whether client data may have been significantly impacted by the error. The DIA shall be commensurate with the risk and magnitude of the problem.

    b. A resolution to correct the problem and prevent its recurrence must be determined & implemented. Resolution may be done solely by the person(s) who investigated the root cause or it may require input from one or more additional departments.

        1) Conduct additional training if necessary. Training must be documented using the appropriate form and must include a description provided by the person who conducts the training. All trainees are required to sign and date the form to acknowledge he/she has received training, understands the change(s) and agrees to adhere to any change(s) in a policy or procedure.
        2) Revise SOP(s) as necessary. Proposed revisions must be approved by QA prior to implementation.
        3) Configure or enhance automated systems (e.g. LIMS) to correct problems or support preventive measures.
        4) Correct data in ACZ's LIMS as deemed necessary by Technical Directors, QA Staff, & Project Managers.
        5) Perform additional measures (e.g. instrument or support equipment purchase, etc.) as necessary.

6) Document implementation dates for each corrective action.
7) Attach or reference all supporting documentation in the corrective action report.

5) Project Manager Review: If necessary, the PM will determine whether affected data will be accepted or rejected, contact the client, and issue revised reports accordingly. Project Manager review may not be required for every major corrective action.

6) QA reviews the corrective action. If satisfactory, the corrective action is approved and closed.

7) If deemed necessary, QA conducts follow-up. Follow-up is scheduled after sufficient time has elapsed to observe the efficacy of the corrective action and may need to be done multiple times. If the corrective action is determined to be ineffective, a new major corrective action will be initiated and the process repeated. QA follow-up may be documented on the corrective action report or the CAR spreadsheet located on ACZ's network.

2.5.3 Technical Corrective Actions

Technical corrective actions apply to departures or deviations from the quality control parameters stated in individual test SOPs. Each test SOP must include all required quality control that applies to the procedure (as stipulated by the method and other regulatory agencies) as well as the performance frequency, acceptance criteria and corrective action for handling failed quality control measurements. Each SOP must describe the procedures to be followed for reviewing and assessing data, including corrective action for handling out-of-control or unacceptable data. The required protocol for technical corrective actions is summarized below.

1) Identify the individual responsible for assessing each nonconformance and initiating or recommending corrective action [analyst who performs AREV]

2) Define how the analyst must treat data if associated quality control measurements are unacceptable [section 12 of SOP]

3) Specify how non-conformance and subsequent corrective actions are to be documented [data review checklist]

4) Specify how management reviews the corrective actions [reviewed during SREV]

To the extent possible, samples shall be reported only if all quality control measures are acceptable. If a quality control measure is found to be out of control then the corrective action described in the SOP must be performed. Alternatively, report data with the appropriate qualifier if reprocessing and reanalysis is not possible. The qualifier must be assigned to any sample associated with the failed quality control measure. A current list of all extended qualifiers is available in the LIMS database and may be accessed by all employees.

2.5.4 Preventive Action

Preventive action is a pro-active process to identify opportunities for improvement rather than reacting to the identification of problems or complaints. Needed improvements and *potential* source(s) of any nonconformance, either technical or concerning the Quality System, must be identified and addressed. Examples of preventive action include but are not limited to: maintaining a cross-trained staff; maintaining a supply of spare consumable parts; monitoring the performance of support equipment; performing routine maintenance on instruments; maintaining an adequate supply of standards/reagents; ordering supplies before running out; completing log-in review in a timely manner; ensuring ACZ can perform work before samples are accepted; correcting quotes before samples are logged in; and analyzing samples by the appropriate method.

2.6 Management Review of the Quality System

At least once per calendar year, ACZ's management conducts a review of its Quality System and all activities related to its environmental testing services to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements. At a minimum, the review must take the following into account:

- Suitability of policies and procedures.
- Manager and supervisor reports
- Review of internal audits
- Status, review, and discussion of major corrective actions
- Review of recent external audits
- Results of recent PT studies and corrective actions initiated / completed
- Changes in the volume and type of work undertaken
- Customer feedback
- Complaints
- Recommendations for improvement
- Status of state certifications
- Ethics and Data Integrity
- Other pertinent issues
- Resources and training.

2.6.1 Department Reports

Each department manager completes a Department Report (FRMQA041 or FRMQA042) prior to the Management Review meeting. Each item on the report is to be evaluated as it pertains to the individual department.

2.6.2 Management Review Report

The completed department reports are submitted to ACZ's EVPs. At a time specified by the EVPs management meets as a group to discuss the reports. All reviews shall be appropriately documented.

2.6.3 Customer Feedback

ACZ solicits customer feedback on an annual basis through the use of a client survey distributed and received via email. The survey asks for feedback regarding customer service, data quality, staff, value, timeliness, and laboratory standing compared to other labs. Feedback is compiled by the CEO and discussed during management review of the quality system.

2.6.4 When a finding is identified through the management review process ACZ's corrective action protocol shall be initiated.

3 ETHICAL AND LEGAL RESPONSIBILITY

All ACZ employees have an ethical and legal responsibility to produce data that is accurate, reliable, and legally defensible. ACZ's proactive program for the prevention and detection of improper, unethical, or illegal actions includes an Ombudsman who acts as a neutral party and serves as a confidential liaison between ACZ employees and management regarding questions, problems, complaints, suggestions, or ethical dilemmas.

Initial employee orientation includes ACZ's Code of Conduct, Code of Ethics, and zero-tolerance policy. Employees are informed of the processes in place to ensure employees are free from undue internal or external commercial, financial, or other pressures that may adversely affect the quality of an employee's work, endanger the trust in the independence of ACZ's judgment, or compromise the integrity of ACZ's environmental testing activities. A more detailed description of all aspects of the ethics program is provided in ACZ's SOP *Data Integrity Principles & Policies* (SOPAD039).

ACZ will not tolerate unethical or improper activities or behavior. Violation of company policies may lead to repercussions ranging from a warning to termination and possible criminal prosecution if warranted by the situation. ACZ has access to many resources that may be utilized at any time to help clarify any situation determined to be a "gray area." Employees are strongly encouraged to seek further guidance from a supervisor, ACZ's Ombudsman, EVPs, or QA staff whenever doubt is raised. Activities that will not be tolerated include, but are not limited to:

- **Misrepresentation of a procedure or documentation** – Intentionally performing a job duty in a manner that does not comply with a documented procedure, including but not limited to a test SOP or method used for sample analysis; providing inaccurate and misleading documentation associated with a data package or failing to provide the necessary documentation as part of a data package.

- **Falsifying Records** – Providing false information on personal credentials, resumes or educational transcripts, logbooks, raw data and client reports, or creating data without performing the procedure (also known as dry labbing).

- **Improper peak integration** – Intentionally performing improper integration of data chromatograms so quality control samples meet acceptance criteria. This is also known as peak shaving or peak enhancing.

- **Improper clock setting** – Readjusting the computer clock so that it appears samples were analyzed within hold times. Also referred to as time traveling.

- **Improper representation of Quality Control samples** – Failing to treat batch quality control samples in the same manner as client samples (including Proficiency Testing samples) or misrepresenting any type of quality control sample associated with the preparation batch and/or analytical batch.

- **Improper calibration** – Intentionally performing improper manipulation of calibration data or forging tune data so that it meets acceptance criteria.

- **File Substitution** – Replacing invalid data with valid data from a different time so the analysis appears to be successful.

4 PERSONNEL AND RESPONSIBILITIES

ACZ Laboratories, Inc. is an S corporation with two owners.

Refer to FRMAD072 for ACZ's current organizational chart.

It is the responsibility of management to document company policies, objectives, systems, programs, procedures, and instructions to the extent necessary to assure the quality and defensibility of all data.

ACZ's Executive Vice Presidents (EVP) are responsible for the overall management of the laboratory. On an operational level, one EVP is the appointed Lab Director with a focus on Production, Sales, & Marketing. The other EVP is the appointed Quality Assurance Officer with a focus on Quality, Compliance, Information Technology, and Project Management. On a tactical level, the focus on these divisions is less acute, and on a strategic level the EVPs focus on all divisions. Finance shares equal focus across all levels. The President/Owner is the ultimate authority at ACZ but has no formal responsibilities beyond those required by law.

It is the responsibility of all managers to ensure that all documented ACZ policies and procedures, including those in the QAP and associated SOPs, are communicated to, understood by, made available to, and implemented by ACZ personnel.

ACZ only uses personnel who are employed by or under contract to the laboratory.

4.1 Executive Vice President (EVP)

The EVP is ultimately responsible for all analytical and operational activities of the laboratory and must ensure that 1) the laboratory carries out all environmental activities in such a way as to meet the requirements of the TNI Standards and 2) the laboratory satisfies the needs of the client and the regulatory authorities. General duties involve budgeting for all departments, making decisions on capital equipment and automation; developing company policies and benefits; addressing personnel issues such as hiring, firing, and promotions; and working with clients on various matters. Day-to-day responsibilities include providing direction to all laboratory departments including laboratory operations, accounting, marketing, QA, and client services. Additional responsibilities are as follows:

- Work directly with ACZ's Ombudsman to provide and maintain a mechanism for confidential reporting of ethical/data integrity issues as well as issues that may directly affect current ACZ policies.
- Define the minimal level of qualification, experience, and skills necessary for all laboratory positions.
- Provide the QA department with defined responsibility and authority for ensuring the successful development, implementation, and management of ACZ's Quality System.
- Provide the Production with defined responsibility and authority for ensuring the technical operations and provision of resources needed to maintain the required quality of laboratory operations.
- Provide adequate supervision of environmental staff by persons familiar with methods and procedures, purpose of each test, and assessment of the test results.
- Ensure all technical staff has demonstrated capability in the activities for which they are responsible and ensure that the training of each member of the technical staff is kept up-to-date.
- Ensure the QA department has access to the highest level of management at which decisions are made on laboratory policy or resources.
- Provide managerial staff the authority and resources needed to discharge their duties.
- Provide technical personnel the resources needed to discharge their duties.
- Specify and document the responsibility, authority, and interrelationship of all personnel who manage, perform or verify work affecting the quality of calibrations and tests.
- Implement appropriate and current guidelines for all lab methods and procedures to ensure data quality and efficiency of analyses. Ensure all method protocols utilized by ACZ meet the QC requirements as established by EPA or other governing agency.
- Document all policies and procedures related to the analytical and operational activities of the laboratory.
- Provide support to technical staff to ensure timely completion of all laboratory work, and develop contingency plans to ensure workflow progresses as planned.
- Meet quarterly (or more often) with department leaders reporting directly to the EVPs.

4.2 QA Officer (QAO)

The QA Officer reports directly to the President; however, the QA department is considered a separate entity from operations in order to ensure data is evaluated objectively. The QAO has direct access to the President, and is therefore able to discuss and/or resolve all concerns, policies, etc. related to quality assurance or quality control. The primary responsibility of the QAO is to develop, implement, and manage all aspects of ACZ's Quality System, and he/she may take any action necessary to ensure all ACZ employees adhere to all policies, procedures, and objectives documented in ACZ's QAP, SOPs, memorandums, emails, etc. If warranted, the QAO has the authority to halt the performance of a single method or the production of a department, and if necessary, the operations of the entire laboratory, and will grant permission to resume when satisfied that the issue(s) have been resolved. Additional responsibilities include but are not limited to those stated in FRMAD060 and the following:

- Review and revise ACZ's QAP and provide training for all employees following approval of a new version.
- Provide QA orientation to new employees.
- Meet quarterly (or more often) with EVP/Lab Director and Laboratory Department Supervisors.
- Work with department managers to develop and improve training protocols.
- Conduct department training sessions as needed to address specific problems and questions.
- Arrange for or conduct internal audits; notify management of deficiencies; and track corrective actions.
- Organize all external audits; notify management of deficiencies; and assign and track corrective actions.
- Review and approve SOPs.
- Meet at least quarterly with Laboratory department supervisors to provide information, respond to questions, etc.
- Manage Proficiency Testing (PT) program.
- Coordinate and maintain all regulatory and client certification programs.
- Review and validate a determined percentage of all data packages from Log-in to Reporting.
- Work with marketing/client service representatives on QA aspects of proposals.
- Work with Project Managers and the Production Manager to resolve client feedback regarding data quality.
- Review and maintain records and documentation for audits, certifications and all other QA issues.

  Qualifications:

  - General knowledge of the analytical test methods
  - Documented training and/or experience in QA procedures
  - Knowledge of the Quality System as defined under TNI

4.3 QA Coordinator

The QA Coordinator reports directly to the QAO and assists with the development, implementation, and management of the Quality System. Primary job responsibilities are as follows:

- Review and maintain records/documentation for employee training including DOCs, MDLs, etc.
- Provide initial QA orientation to new employees.
- Coordinate annual data integrity training.
- Schedule analyses and compile and report data for Proficiency Testing (PT) program, including DMRQA.
- Initiate and track corrective actions related to PT samples and manage all documentation associated with analyses.
- Review and approve SOPs.
- Conduct internal audits, notify management of deficiencies; and track corrective actions.
- Conduct department training sessions as needed to address specific problems and questions.
- Update control chart-generated QC limits in the LIMS database as needed.
- Monitor control & calibration of support equipment
- Assist QAO with management of certifications.
- Manage ACZ's resume compilation.
- Update ACZ organizational chart as necessary.

Qualifications:

- General knowledge of the analytical test methods
- Documented training and/or experience in QA procedures
- Knowledge of the Quality System as defined under TNI

4.5 Laboratory Department Supervisor

Each Laboratory Department Supervisor is a full-time employee who reports to the EVP/Lab Director and exercises day-to-day oversight of laboratory operations for their specific area(s) of expertise. Each supervisor must be familiar with the test methods and related theory and instrumentation, as well as the assessment of results. In addition to monitoring the standards of performance, validity of all analyses, conformance to documented requirements, and quality of all data generated in their respective department(s), each supervisor is also responsible for ensuring that a new analyst has successfully completed all training requirements and is adequately prepared to commence work on client samples. Additional responsibilities are described in FRMAD060. If any supervisor is absent for more than 15 consecutive calendar days then another full-time staff member meeting the required qualifications will be assigned to perform the supervisor's duties.

Required Qualifications for a Laboratory Department Supervisor:

1) Chemical analyses (Organics & Metals): BS or BA in chemical, environmental, biological sciences, physical sciences or engineering, with a minimum of 24 college semester credit hours in chemistry and at least two (2) years of experience in the environmental analysis of representative inorganic and organic analytes for which the laboratory seeks or maintains accreditation. A masters or doctoral degree in one of the above disciplines may be substituted for one (1) year of experience.

2) Inorganic Chemical analyses (other than Metals): At least an earned associate's degree in the chemical, physical, or environmental sciences, or two (2) years of equivalent and successful college education, with a minimum of 16 college semester credit hours in chemistry and at least two (2) years of experience performing such analyses.

3) Radiological analyses: BS or BA in chemistry, environmental, biological sciences, physical sciences, or engineering, with at least 24 college semester credit hours in chemistry and at least two (2) years of experience in the radiological analyses of environmental samples. A masters or doctoral degree may be substituted for one (1) year of experience.

   The minimum requirements may be relaxed if the Laboratory Department Supervisor is not the appointed technical director of the laboratory division.

4.6 Business Development Manager

ACZ's Business Development Manager reports directly to the EVP/Lab Director and supervises all Client Service Representatives, each of who conducts marketing and sales efforts on behalf of ACZ with potential, new and existing clientele, and develops and maintains long-term relationships with customers by working with Project Managers when necessary. Additional responsibilities of the Business Development Manager are described in FRMAD060. ACZ's Client Service staff is authorized to review all contractual agreements with clients, review all proposals and develop price quotations for routine and non-routine analytical projects.

4.7 Project Manager Supervisor

The Project Manager Supervisor reports directly to the EVP/QAO and is responsible for overseeing the PM department. Additional responsibilities of the Project Manager Supervisor are described in FRMAD060. Each Project Manager serves as the primary laboratory contact for each ACZ client, handles all client service requests, and investigates and resolves any problem brought to ACZ's attention by the customer. In order to provide consistency, each PM is assigned a list of clients, and it is the primary responsibility of each PM to ensure all of their client project needs are managed on a day-to-day basis and met in a timely manner and that all data submitted to the client is of high quality. All PMs work directly with the Laboratory Department Supervisors regarding client data issues (due dates, hold times, retests, data quality, etc.), with Document Control regarding client reports, and with the QA department regarding data quality questions or concerns. The Project Manager Supervisor directly oversees Reporting and the Front Office.

4.8 Instrument Operator

Instrument operators report directly to the respective Laboratory Department Supervisor. The position involves the analysis of various matrices for trace level contaminants using specialized and technical instrumentation. Each operator must be capable of performing all job duties in an accurate and proficient manner. Education will be verified by providing a copy of a college transcript or diploma, which is maintained in the employee's personnel file. Experience is verified by ACZ's CFO prior to completing the hiring process (verbal or documented verification provided by each reference listed on a resume or application is acceptable). The operator must demonstrate understanding of related theory, mathematics, analytical instrumentation, and data interpretation. This work is predominantly intellectual and involves the continuous use of professional and sound judgment. The employee must meet or exceed all requirements for generation of litigation-quality data and must also continue to demonstrate increased proficiency regarding the interpretation of the data as well as the operation and troubleshooting of the assigned instrument(s). These improvements should be attainable through ongoing efforts in-house as well as through specialized instruction at off-site locations. Exceptions pertaining to experience or education will be made on a case-by-case basis.

Qualifications:

- BA or BS in Chemistry or related science or a minimum of 3 years of relevant experience in lieu of degree
- Prior laboratory experience is preferred but is not required.
- Successful completion of training by supervisor or proficient instrument operator

4.9 Laboratory Analyst [Technician]

The laboratory technician reports directly to the respective Laboratory Department Supervisor. The position involves analysis of various matrices using appropriate analytical techniques and support equipment as well as preparation of samples for instrument analyses. Each technician must be capable of performing all job duties in an accurate and proficient manner. Education will be verified by providing a copy of a college transcript or diploma, which is maintained in the employee's personnel file. Experience is verified by ACZ's CFO prior to completing the hiring process (verbal or documented verification provided by each reference listed on a resume or application is acceptable). The technician must demonstrate understanding of related principles and mathematics, must possess common sense and mechanical skills, and must seek professional judgment from the supervisor as necessary. The employee must meet or exceed all requirements for generation of litigation-quality data as well as sample preparation tasks and routine analyses, and must also continue to demonstrate continuous improvements. These improvements should be attainable through ongoing training efforts in-house as well as through training opportunities at off-site locations. Exceptions pertaining to experience or education will be made on a case-by-case basis.

Qualifications:

- BA or BS in Chemistry or related science is preferred but is not required
- Prior laboratory experience is preferred but is not required
- Successful completion of training period by supervisor or proficient technician

4.10 Information Technology (IT) Manager

The Information Technology Manager reports directly to the EVP/QAO and is responsible for the oversight of the IT department regarding the installation and maintenance of ACZ's computer network and all hardware and software and related equipment deployed on the premise. Additional responsibilities are described in FRMAD060. The department is also responsible for developing, maintaining, and improving custom written applications for laboratory automation and efficiency as well as for ACZ's LIMS, Intranet (Labweb), Internet and electronic data deliverables (EDDs).

4.11 Chemical Hygiene Officer (CHO)

The Chemical Hygiene Officer is responsible for oversight of ACZ's documented Chemical Hygiene Plan, conducting initial and refresher safety training for all employees, monitoring exposures, and maintaining records for Safety Data Sheets, injury reports, chemical exposure reports, etc. Additional responsibilities include working with management to develop and implement policies to improve the program. The person designated as CHO must have completed at least one basic laboratory safety course and have one year of experience performing laboratory work, preferably with responsibility for at least one area of laboratory safety.

4.12 Hazardous Waste Officer (HWO)

The HWO is responsible for managing and, with the collaboration of management, enforcing all aspects of ACZ's Hazardous Waste Management Plan (SOPAD007). The HWO must insure the HWP is compliant with relevant requirements in the US Code of Federal Regulations as well as any additional state regulations. Additional duties include bulking and labeling hazardous materials, filling out required documentation, and arranging for disposal; these activities may be delegated to qualified individuals under the supervision of the HWO. The HWO must know and understand the specific waste streams that ACZ uses and be able to determine how to dispose of unknown chemicals. This is best done by attending a training course on "Laboratory Waste Management." The individual responsible for hazardous waste disposal and signing the waste manifest must maintain HAZWOPER and DOT hazmat certification.

4.13 Radiation Safety Officer (RSO)

ACZ's Radioactive Materials License (RML) requires the laboratory have an RSO. The EVP/QAO appoints a Radiation Safety Officer to act as his/her representative in implementing the Radiation Safety Program. The RSO's responsibilities include developing radiation safety guidelines in accordance with Nuclear Regulatory Commission (NRC) and Colorado state rules and regulations, and for assuring compliance with those guidelines by ACZ personnel. The RSO will work with ACZ's administration to implement policies and seek ways to improve the safety program. The person designated as RSO must have completed a Radiation Safety Course or have at least 3 years of experience prior to being officially designated as the RSO. The RSO reports directly to the EVP/QAO of ACZ.

4.14 Chief Financial Officer (CFO)

ACZ's Chief Financial Officer is primarily responsible for all financial matters including payroll, accounts receivable, accounts payable and financial statements; monthly and annual balance and profit and loss statements; and assisting with annual budget preparation. In addition, the CFO maintains and monitors the security system and electronic time clock; invoices client projects from the database; updates customer account information; acts as the administrator for 401k/Profit Sharing Plan; maintains and executes the Employee Benefits Manual; and assists in hiring process by posting job openings, scheduling qualified candidates for interviews, checking references, and ensuring a new employee provides proof of education.

5 TECHNICAL TRAINING

Prior to the independent generation or review of data for client samples (including PT samples), all analysts must undergo a formal, documented training process. Technical personnel must be thoroughly trained in the analytical techniques and operating principles and procedures for the methods utilized by ACZ. This process includes but is not limited to: reading the associated published method, reading all related SOPs, improving laboratory skills, learning troubleshooting, maintenance, calibration and operating procedures for pertinent equipment and instruments, and creating workgroups and reviewing data through the LIMS database.

It is the responsibility of the department supervisor to determine that a new analyst is properly trained, has successfully completed all initial training requirements and is prepared to commence work on client samples. Under no circumstances may an analyst independently generate client data before receiving the explicit approval of the technical director overseeing the analysis.

5.1 The effective version of the test SOP provides the training framework for all sample preparation and analysis. The SOP is typically based on published approved methodologies (EPA or other) and incorporates any necessary activities and protocols not included in the published method(s) as well as requirements stipulated by other regulatory agencies.

5.2 Training for data AREV or SREV only must be documented as specified in §2.3.6. For analysts, approval to perform a procedure includes approval to perform AREV for the procedure. For supervisors and technical directors, approval to perform a procedure includes both AREV and SREV approval. SREV-specific authorization is required for analysts.

5.3 Each employee must be trained either by the department supervisor or by an analyst within the department who is proficient in the area of testing and has been designated by the supervisor. Whenever possible, anyone performing training must meet the following requirements:

1) Documentation of training on the effective version of the test SOP.
2) Documented approval for the analysis.
3) A current IDOC or CDOC.

Exceptions may be granted on a case-by-case basis as approved by the QAO.

5.4 Initial training is documented using the Initial Method Training form (FRMQA004). The General Lab Practice Training Form (FRMQA047) is also required for an analyst's first procedure. Once training has been completed, the trainee and the instructor fill out the form together to ensure all pertinent information has been addressed and to ensure the trainee comprehends the material and is provided an opportunity to ask questions or request additional training. The trainee's signature is an attestation that he/she has read, understands, and agrees to follow the effective version of the SOP.

5.5 To demonstrate an aptitude for the procedure, the analyst must perform a successful Initial Demonstration of Capability (IDOC) prior to independent preparation and/or analysis of client samples. Performance is documented using FRMAD023. The data is reviewed initially by the trainee (AREV). SREV is performed by the pertinent technical director or designee. A new IDOC is required if an analyst does not perform the method within 12 months.

5.6 Prior to performing an IDOC, a new analyst should be provided sufficient opportunity to practice the procedure. This confirms the analyst understands the procedure and feels comfortable performing the procedure independently. Data associated with any practice is not submitted to QA.

5.7 It is not necessary for the first IDOC attempt to pass; however, the supervisor needs to review the analyst's techniques if multiple attempts do not pass.

5.8 A thorough review of the raw data is performed as part of initial method training and should include particular attention to details not presented in LIMS or on the final report, such as generating final sample concentration from the instrument response provided in the raw data (if applicable), verifying correct standard and reagent traceability.

5.9 Where specified by the method or a regulating entity, and as stated in the test SOP, successful demonstration of performance such as Linear Calibration Range determination (LCR) or Method Detection Limit (MDL) study must be completed prior to independent analysis of client samples.

5.10 All initial training documentation must be submitted to the QA department as a complete package. At a minimum, the package must include:

1) Initial Method Training form (FRMQA004), signed by the trainee and instructor (or department supervisor).

2) IDOC documentation:
   ✓ Completed and signed certification statement (FRMAD023)
   ✓ Workgroup bench sheet, raw data, and all supporting documentation

3) If applicable, an MDL study. Complete FRMAD031 and attach all related raw data and supporting documentation.

4) If applicable, calibration range study. Complete FRMQA029 and attach all related raw data and supporting documentation.

5) For all determinative methods utilizing a calibration curve or average response factor, the Method Calibration Form (FRMQA050).

   NOTE: For those test methods for which no spiking solution is available only an Initial Method Training form (FRMQA004) is required.

5.11 Following review of all pertinent training documentation, the pertinent technical director will issue procedure-specific clearance for the trainee to independently generate and review data for client samples. This permission is tracked and may be viewed on a designated location on the public network drive.

1) Approval for preparation procedures is granted after the instrument data has been reviewed and approved.

2) An unapproved analyst who is "shadowing" the trainer (observing, learning the organization of the lab, reagent room, etc.) may not assist with the procedure, and the workgroup documentation must bear only the initials of the trainer, who is fully responsible for the data.

3) If the analyst has successfully completed training for a procedure and generates client data or reviews client data prior to the technical director's approval, then any workgroups or data review checklist must also bear the initials of a proficient analyst, with current approval for the method, who oversees the analyst's work for the procedure and assumes full responsibility for the data. The primary analyst must always be aware that he/she is responsible for the workgroup. The use of another employee's initials without their explicit approval is expressly prohibited.

5.12 The supervisor is responsible for ensuring the training of each analyst is kept up-to-date. Each analyst must read, understand, and agree to follow the effective version of the SOP and continued proficiency must be demonstrated and documented annually for each analyst. A one month grace period is allowed for submitting CDOC documentation. Thereafter, the analyst is prohibited from performing the procedure until a successful CDOC or IDOC is submitted to QA.

5.13 Each Laboratory Department Supervisor routinely conducts department meetings to discuss procedures, work schedules, resources, questions and concerns, problems, QA, etc.

6 SAMPLE COLLECTION AND HOLDING TIMES

Sample collection procedures are well documented by the EPA and other agencies. ACZ's clients are instructed to provide representative samples whenever possible. ACZ supplies its clients with the containers and other materials necessary to maintain sample integrity (to the extent possible) from the time of collection through analysis. Although ACZ does not perform sample collection activities, each project manager or client service representative will assist a client with specific sampling requirements as needed. When necessary, they will direct a client to other resources. The following sections include general information on sample containers, preservatives. and holding times. These are essential components in preserving the chemical and physical properties possessed by the sample at the time of collection.

6.1 Sampling Containers and Preservatives

The EPA outlines the requirements for sample container types, sample volume, and preservation. ACZ's inventory includes various sizes of plastic and glass containers that range from pre-sterilized to certified-clean by the supplier. Amber bottles are used when specified by the method. Glass containers are obtained from vendors that specialize in the sales of environmental sample containers, and all non-certified bottles are purchased from reputable lab/industry vendors. Refer to FRMAD045 and FRMAD046 for bottles types and preservation techniques for specific analyses. Refer to the pertinent test method SOP for specific information regarding EPA requirements for container types, chemical, and thermal preservation.

All sample containers shipped to our clients are new, contain the appropriate preservative(s), and are color-coded to identify preservation and storage. Out-going containers are packed in clean coolers with a copy of ACZ's Sample Acceptance Policy, general directions for sample collection, bottle labels, ice packs, sampling information, blank chain of custody, return shipping labels, and custody seals. Trip blanks and rinsette water are included when requested by the client or when mandated by a specific analytical method. After samples have been collected they are cooled to a temperature ≥ 0 °C and ≤ 6.0 °C. Samples that require thermal preservation must be maintained within this temperature range until all analyses have been completed.

6.2 Holding Times

The EPA has conducted lengthy studies of sample degradation versus time to establish a maximum holding time for each parameter, and the results of these studies are compiled into holding-time tables to provide guidelines for litigation purposes. Data for a sample prepared / analyzed outside of the established holding time may be rejected by regulators as unusable. Holding times will vary slightly from regulation to regulation, thus further emphasizing the need for a client to consult with their Project Manager prior to sample collection. The holding time typically begins at the time or date of collection in the field. Holding times observed by ACZ are specified in the laboratory's test method SOPs.

If ACZ Laboratories, Inc. receives samples past holding times or near the expiration of the holding time, sample analysis will proceed unless the client has indicated on the CCOC that an attempt to contact the client must first be made. Analyses performed outside of holding time will be appropriately qualified on the final report. Holding times ≤ 72 hours are calculated based on the hour of the sample date/time. Holding times > 72 hours are calculated based on the day of the sample date/time.

In general, and unless otherwise noted in the test SOP, sample preparation and analysis must be completed within the stated holding time. For analyses that extend beyond the intended scope of the method for an analyte or matrix, the hold time stated in the SOP must be met or the samples must be appropriately qualified.

7 SAMPLE CUSTODY & SAMPLE HANDLING

Sample custody begins with receipt of sample containers from the client and continues beyond preparation and analysis to the proper disposal of primary and secondary sub-samples. Complete and accurate documentation must be provided at all stages of custody. There are many key elements to sample custody including laboratory security, chain of custody records, sample storage, internal custody logs, sample tracking within the laboratory, control of subcontracted work, and sample disposal. Unless otherwise specified, ACZ is contractually committed to retain samples for a minimum of 30 days after the invoice of a project[2].

7.1 Sample Receipt and Log-in

Refer to SOPAD045, *Sample Receipt & Log-In Procedure / Maintenance of Sample Integrity,* for the details of ACZ's sample receipt and log-in procedures. Upon delivery of samples to ACZ, Log-In personnel evaluate the condition of the cooler and custody seals. The custody seals are then broken to retrieve the Chain of Custody (COC), which must be signed by the sample custodian to document transfer of sample possession to ACZ.

Sample conditions are evaluated and any problems, such as expired hold times, lack of preservative or improper cooler temperature, are noted. Clients are notified of problems as soon as possible so that a contingency plan can be initiated if necessary. Samples are logged-in and are delivered to the assigned storage areas. Samples (including subsamples, extracts, etc.) must be stored away from standards, reagents, food, and other potential contaminants. Following log-in, every project is reviewed by the assigned PM. Upon completion of the review, the client receives an electronic summary that details the project information. This summary allows the client an opportunity to make changes to the project before samples are analyzed. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

7.2 Internal Custody Logs

Some clients may specify additional custody tracking of the samples once they have been logged in. Internal custody may require that samples are stored in a manner that ensures limited access. The internal custody log (FRMQA015) shall accompany the samples from log-in through completed analysis. The person responsible for the work signs and dates each entry and/or page in the logbook. When all data from a sample set is compiled, copies of all logbook entries shall be included in the final report package. For projects requiring internal custody, ACZ will adhere to the procedure described in the SOP *Client Service Policies and Procedures* (SOPAD043).

7.3 Sample Tracking

Sample flow through the laboratory is facilitated by the use of an Oracle-based LIMS database (Laboratory Information Management System). Every product (requested analysis) logged into the LIMS for a sample has a specific, pre-determined department path. All products have default paths of at least Login Review and Reporting. Between these two departments, a product may go through, for example, Soil Prep and Metal Analysis or Soil Prep, Organic Prep and GC Analysis. At each department step in a product's path, the status can be updated and viewed at any time. Analytical product statuses are defined below. Additional information regarding sample tracking is available in the SOP *Client Service Policies and Procedures* (SOPAD043).

NEED	Prep or Analysis has not been started
WIP	Prep or Analysis has been started (Work In Progress)
PREP	Sample preparation is complete and sample is ready for analysis
UPLD	Analytical data has been uploaded into LIMS
AREV	Analyst has reviewed and accepted analytical data
SREV	Supervisor has reviewed and accepted analytical data
DONE	Analysis or task has been completed
REDO	Sample requires reanalysis
REDX	Sample requires re-digestion/extraction

[2] Currently, samples scheduled for any radiochemistry parameters are held for a minimum of 90 days to facilitate radioactive material inventory monitoring. This policy is subject to change at any time in harmony with ACZ's Radiation Safety Plan.

CANT	Sample preparation or analysis cannot be performed
NREV	Project requires PM review before work can begin
HOLD	Prep or analysis postponed
SENT	A final report has been issued to the client

8 PROCUREMENT, INVENTORY AND TRACEABILITY OF SUPPLIES

8.1 Procurement / Inventory

All consumable supplies are purchased from reputable vendors that have been evaluated for service, quality, and price. To the extent possible, materials traceable to national or international standards of measurement are purchased for use in technical operations. Supplies are purchased using ACZ's purchase order (PO), remote inventory management system (RIMS), and the Aestiva ordering system. The Purchasing Agent is not permitted to make a substitution for any material specifically requested unless the Laboratory Department Supervisor approves the substitution. Upon receipt, reagents, chemicals, standards, and other laboratory consumables are stored in the Chemical & Supply Room, which has limited access, or are delivered to the laboratory. Refer to ACZ's SOP *Purchase, Receipt, and Storage of Consumable Materials for Technical Operations* (SOPAD037) for additional information.

8.2 Glassware

ACZ uses only laboratory grade glassware. Prior to use, glassware is cleaned to meet the sensitivity of the method. Refer to individual test SOPs for detailed cleaning procedures.

8.3 Other Supplies

Routine consumables (centrifuge tubes, autosampler tubes, pipette tips, etc.) are purchased through an automatic system managed by Fisher (RIMS). All other supplies are purchased on an as-needed basis through ACZ's Purchase Order and the Aestiva ordering system. Refer to SOPAD037 for additional information.

8.4 Traceability of Standards and Reagents

To provide complete traceability, each data package must reference every standard and reagent used for sample preparation or analysis, including but not limited to acids, bases, preservatives, color reagents, pH indicators, buffers, and instrument reagents. Each PCN and/or SCN must be documented either on the workgroup bench sheet, data review checklist, or a current standard/reagent form. The open date for all original containers is not tracked in LIMS; however, good laboratory practice dictates the open date be noted on the sample container.

8.4.1 Primary Control Number (PCN)

Upon receipt, all stock chemicals, standards, and reagents are assigned a unique PCN in LIMS for tracking and traceability purposes. A label with the PCN and the expiration date is affixed to the container and the Certificate of Analysis is scanned or downloaded and saved in the public drive (if applicable). The data for each PCN is entered using the certified value(s) supplied by the vendor, as indicated on the Certificate of Analysis. Because the certified value is entered, the final concentrations for prepared standards may vary slightly from the theoretical value indicated in the test SOP. Certified values shall be used for standards when available. If certified values are not available, informational values may be used. If the certified reference values for any PCN are changed after the PCN has been used in the laboratory, then complete documentation must be provided as a major corrective action (FRMQA001).

8.4.2 Secondary Control Number (SCN)

To ensure complete traceability, a unique SCN must be created when any intermediate or working standard is prepared from one or more stock solutions, stock chemicals, or intermediate solutions. A standardized format is used for creating the SCN: a two-letter code indicates the lab section and is followed by the prep date and then by a daily sequential number. For example, the SCN **II051128-2** denotes the second standard prepared on November 28, 2005 in the Inorganic Instrument lab. An acceptable alternative is to let LIMS assign a unique number when prompted.

An SCN for any working standard subjected to a LIMS calculation must be created electronically in LIMS. The initial volume and concentration of each constituent and the final volume of the prepared solution are entered in the SCN Wizard program to calculate the final concentration of each analyte using the formula $C_1V_1 = C_2V_2$. The preparation date, expiration date, and preparer's initials are included as part of this electronic record. A hard copy of the SCN report may be affixed to the standard/reagent logbook, depending on individual department practice; however, it is not required.

Prepared reagents do not require an SCN be created electronically in LIMS; however, preparation must be recorded in the department's designated logbook. At a minimum, the logbook entry must clearly identify what reagent was prepared, its subcomponents, the preparer's initials, the preparation date, and the expiration date. This information is sufficient for color reagents, buffer solutions, instrument reagents, etc. because details of the preparation are stated in the test SOP.

8.5 Preparation and Expiration of Standards and Reagents

8.5.1 Preparation of Standards and Reagents

Refer to individual test SOPs for detailed information regarding standard and reagent preparation. In general, either Class A pipettes or mechanical pipettes are used to measure and dispense aliquots of any solution used to prepare a standard or reagent. Accurate delivery of mechanical pipettes must first be verified as described in ACZ's SOP *Control, Calibration, and Maintenance of Measuring and Test Equipment* (SOPAD013).

All containers of prepared reagents and standards stored for more than one day must be properly labeled with the SCN (or other unique identifier), name/description, preparation date, and expiration date. Preparation of reagents and standards must be documented as described in §8.4.2.

8.5.2 Expiration of Purchased Standards and Chemicals (PCNs)

When provided, the manufacturer's expiration date will be assigned. If the manufacturer does not provide an expiration date, an expiration date of 5 years from receipt is assigned unless the laboratory has knowledge indicating a longer or shorter shelf life is appropriate.

An expired stock material may continue to be used if its reliability can be verified. For the purpose of ensuring transparency, the rationale for extending the expiration date must be documented on FRMQA051 and submitted to the QA department or pertinent technical director for approval. If the extension is granted, FRMQA051 is saved on a network drive. Unusable materials should be replaced and the standard or reagent remade as soon as possible. Remove the container from the lab or the supply room and dispose of properly. Contact ACZ's HWO for assistance.

8.5.3 Expiration of Prepared Standards

Storage conditions and shelf life for prepared standards are provided in the individual test SOPs. The following guidelines may be used to determine the shelf life for a prepared standard if the method does not prescribe a shelf life:

1) A standard that has been prepared in-house may continue to be used after its assigned expiration date for as long as its reliability can been verified. Whenever possible, reliability should be verified by comparison to another, unexpired standard containing the same constituents. For applicable procedures, instrument response may be considered when determining whether or not a solution is still reliable.

    - In cases where reliability has been verified, the expiration date of the SCN must be updated in LIMS and/or the standard/reagent logbook. The rationale for extending the expiration must be documented on FRMQA051 and submitted to the QA department for approval.

    - In the event the solution was used prior to updating the SCN then documentation must be provided as part of the workgroup to indicate the solution was used past the shelf life stated in the SOP (a minor corrective action or FRMQA051 may be used if more than one workgroup is affected). The expired standard must be remade as soon as its reliability becomes questionable – it is the responsibility of the analyst to use their best judgment.

2) The shelf life of any prepared standard with any analyte concentration < 10 mg/L is 90 days from the preparation date. This is a general guideline – if any constituent does not remain in solution for 90 days, then the standard must be prepared more often. If the manufacturer's expiration date for any stock standard is sooner, then the expiration date of the SCN is the manufacturer's expiration date for a single analyte solution or the earliest manufacturer's expiration date for a multiple analyte solution.

3) The shelf life of a prepared standard with analyte concentration $\geq$ 10 mg/L is one year from the preparation date. This is a general guideline – if any constituent does not remain in solution for one year, then the standard must be prepared more often. If the manufacturer's expiration date for any stock standard is sooner, then the expiration date of the SCN is the manufacturer's expiration date for a single analyte solution or the earliest manufacturer's expiration date for a multiple analyte solution.

4) In general, prepared Radiochemistry standards expire one year from the preparation date. The solution may be re-evaluated using control charts, efficiency checks, or other criteria and the expiration date extended by year intervals if the solution is still deemed usable. Refer to the specific test SOP for details.

8.5.4 Expiration of Reagents

In general, a reagent is a solution, which does not contain the target analyte(s). Storage conditions and shelf life are stated in the individual test SOPs. The expiration date can be extended for a prepared reagent provided its reliability can be verified. LCS/LFB performance (QC criteria met) may be used to verify reagent stability if the control standard is a valid indication of the reagent's continued functionality/stability. Reagents used to treat samples for interference may not be verified this way. Reagents used to dissociate complexed target analytes may not be verified this way unless the LCS is an appropriate complex. FRMQA051 must be submitted to QA or the pertinent technical director for approval whenever an expiration extension is requested.

9 MAINTENANCE AND CALIBRATION OF INSTRUMENTATION & EQUIPMENT

9.1 Maintenance of Instruments and Support Equipment

The best protocol for producing quality work is to prevent errors and non-conformances rather than react to and correct problems after they occur. An essential part of this protocol is ensuring that all laboratory instrumentation and equipment used for the generation of data have been optimized and are functioning properly before commencing work on client samples. Performing routine maintenance and optimizing instrument-operating conditions prior to sample analysis minimizes instrument downtime, thereby improving productivity and ensuring quality of the data. It is the responsibility of the designated analyst(s) to perform and properly document daily and routine maintenance, instrument optimization, troubleshooting, instrument service or repair, and repair or replacement of parts.

All manufacturer-prescribed inspection and maintenance shall be performed according to the schedule indicated in the operator's manual (or similar) provided by the manufacturer and must be documented in the instrument logbook, a separate maintenance logbook, or on the instrument maintenance checklist (available in LabWeb). ACZ management recognizes that performing all maintenance procedures at the frequency indicated by the manufacturer may not be necessary to sustain instrument optimization. Therefore, at a minimum, instrument part(s) and optimization shall be inspected according to the schedule. The analyst must use their professional judgment to determine if maintenance or replacement is necessary at that time. Decisions to deviate from the manufacturer's schedule shall be documented.

All support equipment (any device that may not be the actual test instrument, but is necessary to support laboratory operations) must be monitored regularly to confirm proper functioning. The temperature of all drying ovens, refrigerators, freezers, and incubators must be checked each day the equipment is in use and each check recorded on the associated Temperature Logsheet. Refer to SOPAD013 for more detail.

Equipment that does not meet performance specifications must be taken out of service and FRMAD029 attached to indicate the instrument or equipment is waiting for repair and cannot be used. During this downtime the department supervisor, Production Manager, and Project Manager may collectively determine it is necessary to sub-contract samples until correct performance of the repaired instrument or equipment has been demonstrated by a successful calibration or other suitable test. Document all contact with the manufacturer, as well as all repairs and other services, in the instrument or maintenance logbook to be used as a reference for solving future instrument problems. Transport and storage of measuring equipment shall be done in accordance with manufacturer recommendations. Additionally, when instrumentation or equipment goes outside of the direct control of the laboratory, the functioning and calibration status must be checked and shown to be satisfactory before it is returned to service. Refer to SOPAD013 for additional information.

To minimize downtime and prevent analytical delays, each laboratory should maintain an adequate inventory of reagents, stock standards, glassware, etc. and should keep a sufficient supply of extra "critical" parts in-house. Instrument redundancy should be established for all analyses and Instrument Qualification (IQ) should be maintained on backup instruments.

9.2 Instrument Calibration

The accuracy of all instrument-generated data relies on proper calibration. In general, calibration or standardization involves defining the relationship between instrument response and the amount or concentration of analyte introduced into the instrument. The graphical depiction of this relationship is referred to as the calibration curve.

Calibration frequency must be performed in accordance with the manufacturer's guidelines, test method or other regulatory requirements, or client contract stipulations, whichever is most stringent. Every calibration or standardization must meet the acceptance criteria stated in the SOP and shall be subsequently verified by analyzing an initial calibration verification standard (ICV) or other control standard (if specified in the SOP) that contains all target analytes and has been prepared or obtained from a different source than the one used to prepare the calibration standards.[3] Calibration standards and the second-source verification standard should be prepared on different days. If they are prepared concurrently, then another qualified analyst should prepare the second-source verification standard. This minimizes the risk of both solutions being prepared consistently incorrectly.

A continuing calibration verification standard (CCV) containing all analytes of interest must be analyzed at the frequency stated in the test SOP to ensure the stability of the initial calibration curve has not varied over time due to any change in the analytical instrument and its detection system, such as instability of standards, instrument cleanliness, column performance, matrix effects, flow changes, and changes within the laboratory environment.

For applicable methods, all initial and continuing calibration steps must be clearly detailed in the test SOP. Additionally, each test SOP must specify the frequency and acceptance limits for the calibration and subsequent verification (ICV and CCV). In general, acceptance criteria are method-specific; however, the SOP may also include requirements of other regulatory agencies. Prior to resuming sample analysis, immediate corrective action must be taken if the calibration, ICV, or CCV is outside of the acceptance criteria. Technical corrective actions are described in the individual test SOPs. Refer also to §11.2 for additional information.

General calibration guidelines are listed below. Additional information is provided in the individual test SOP's and ACZ's SOP *Control of Measuring & Test Equipment* (SOPAD013).

- Understand the method requirements for calibration (minimum number of standards, etc.)
- Use the correct calibration model (linear, second-order, etc.)
- Include all target analytes in the calibration standards and second-source standard
- Analyze a calibration standard with a concentration less than or equal to the quantitation limit.
- Do not remove points from the middle of the calibration (only high or low standards may be dropped).
- Calibration is a single-event process. A retest of a calibration standard must be performed immediately.
- Documentation and resolution of calibration abnormalities is critical

[3] If a second source standard is not available calibration shall be verified using a standard from a different lot. If a different lot is not available, an analyst who did not prepare the calibration standards may prepare the calibration verification standard. For some standards, it is important to consider whether manufacturers have obtained their material from the same lot.

10 CONTROL AND STORAGE OF RECORDS AND DOCUMENTS

A formal and systematic control of records and documents is necessary to accurately reconstruct the entire history of any sample and guarantee the quality and defensibility of the data. All information pertaining to instrumentation and equipment, analytical test methods, and related laboratory activities, such as sample receipt, sample preparation, data verification, audits, corrective actions, method validation, and data reporting must be documented, must identify all personnel involved, and must be readily understood. All records, including those pertaining to calibration and test equipment, certificates and reports, must be maintained, and the management system must facilitate the retrieval of all working files and archived records for inspection and validation purposes. Documents and records must be safely stored (protected against fire, theft, loss, environmental deterioration, and vermin) and must be held secure and in confidence to the client for a minimum of 10 years. The hard copy of all records and documents must be maintained in a designated storage area with limited access. To the extent possible, hard copies for the most recent two (2) years are stored on-site, and if necessary, may be moved to off-site storage after two years. Off-site storage conditions must meet the same criteria that apply to on-site storage.

10.1 Workgroups

10.1.1 Changes made to any workgroup record (hardcopy or electronic) must be documented.

1) If a workgroup is "dissolved" or its data deleted from LIMS, the analyst is prompted in LIMS to provide an explanation of why he/she is performing the task.

2) Changes to upload files must be documented on the hard copy of the workgroup.

10.1.2 Workgroup data that is re-uploaded *for any reason* must first be deleted. If any of the data changes, the Run Approval report shall be corrected. The workgroup shall be rescanned if necessary.

10.1.3 Document Control or other administrative personnel use a multi-page scanner with its own PDF scanning software to scan all hardcopy portions of workgroups.

1) Before the workgroup is scanned, the top page is reviewed to make sure it has both the AREV and SREV initials and dates.

2) The person scanning the workgroup must initial in the lower right hand corner of the front page of the workgroup. This provides an indication the document has been scanned.

3) The workgroup is scanned to the designated network directory and is then moved through an automated process to the appropriate read-only LabWeb directory. This directory is accessible to all employees. When a workgroup is rescanned, the previous file is maintained. A copy will be automatically created so as not to overwrite any files and will have a letter appended; starting with "A" the first time the workgroup is rescanned. <u>The most current file will not have a letter appended</u>.

10.1.4 The hard copy is filed by workgroup number in a file cabinet in the supply room by the front office. When capacity is reached, the workgroups are boxed and prepared for long-term storage. The front of the full storage box is labeled with the year and the workgroups contained in the box. The first box of each new calendar year is "1." Full boxes are consecutively numbered, transferred to a designated location and stored in numerical order. The storage room is locked at all times and access is limited to authorized staff.

10.1.5

10.2 Electronic File Retention & Storage

All electronic records, stored either on instrument computers or on the network, are systematically backed up to both fixed and removable media. These records include Oracle data, instrument raw data, workgroups, client reports, instrument upload files, SOPs and other controlled documents, and department data.

10.2.1 Critical system data is protected by Microsoft's Data Protection Manager. The Data Protection Manager is configured to maintain data for a period of 10 years.

10.2.2 All archived data is moved to a secondary machine on a weekly basis. From there, it is backed up to removable media to provide additional data redundancy.

10.2.3 The removable media from the first week of the month is pulled from service and moved to ACZ's safe deposit box at a local bank. The most recent 6 months of tapes are kept in the bank safe deposit box. Months 7 through 12 are placed in a secure, data rated, 4-hour fireproof safe. Note that this removable media only contains data from December 1st of the previous year to the present date.

10.2.4 At the conclusion of the calendar year, a master copy is made that comprises all of the data from December 1st of the previous year through January 31st of the following (current) year. This 14-month span of data is then moved to ACZ's safe deposit box at a local bank. At that time, the removable media that has aged 10 years is removed from the safe deposit box and its contents are destroyed. All data on the secondary machine from prior to December 1st of the previous year is removed from the system so that it is no longer included on the weekly backup.

10.2.5 Data that has aged 5 years is deleted from the Oracle Database on a monthly basis.

10.3 Instrument Data Files

Instrument raw data files are backed up by ACZ's Instrument Data Backup Application (IDBA). IDBA is a program that accesses local directories from instrument computers. Each morning the program retrieves and backs up individual data files from the specified directory on each instrument computer. Refer to ACZ's SOP *Backup and Archive of Instrument Data Files* (SOPAD044) for details.

10.4 Client Reports

10.4.1 Client reports are generated and signed electronically and are automatically stored as a PDF at a designated location on the network that has limited access. If a copy of any report exists on the network, and a new report is generated, then the existing copy will be renamed so that it is not overwritten. This way ACZ maintains a copy of all reports generated for a client.

10.4.2 Hardcopy documentation associated with a client project (CCOC, invoice, Login Review Form, etc) is filed by project number and stored in the document storage location.

10.4.3 Electronic Data Deliverables (EDD) are stored on the network at a designated location.

10.4.4 Once a project has been invoiced, the working directory is moved to the designated storage network location as a read-only PDF. If a project is un-invoiced, the project folder is copied back to the working directory where changes may take place. If an invoice is altered, a revised invoice is included with the project hardcopy.

10.4.5 In general, changes are not allowed to projects (including compilation) if the project has been invoiced. If a change needs to be made, the project must first be un-invoiced. At the time of un-invoicing, the user must provide a reason in LIMS to explain why the project was un-invoiced. This information is then stored in the Oracle database.

10.4.6 If a test report requires amendment after it has been issued to the client, the entire report shall be re-issued with the amendment. The amended report shall include a case narrative describing change(s) from the original report. Amended reports shall be uniquely identified and contain a reference to the original report. Typically, the laboratory number assigned to the project serves as the link to the original report. Amendments shall meet all the requirements of ACZ's quality system.

10.5 Documents

10.5.1 Standard Operating Procedures

10.5.1.1 Refer to §2.2 or SOPAD049 for additional information pertaining to SOPs.

10.5.1.2 The original master copy of each SOP is stored as a PDF in a secured public directory. The cover page indicates approval authorities. Approval is documented through emails. Whenever an SOP or SOP revision is approved, QA emails all staff whose job activities intersect the SOP or SOP revision with training instructions and a request for read receipt. The pertinent technical director or supervisor shall be included in the email distribution list. This email constitutes QA's signature of approval. Read receipts constitute training signatures and the technical director's or supervisor's signature of approval. Emails requesting read receipts for training documentation purposes shall contain a statement that by sending read receipt the sender attests they have read, understand, and agree to follow the identified policy. MS Outlook's read receipt is mimicked for this process. To send read receipt, trainees and approval authorities reply to the sender and replace "Re" with "Read" at the beginning of the subject field. Emails documenting training and/or approval shall be saved in a public outlook email folder or converted to PDF's and stored in the same directory as the SOP master copy or a subdirectory therein.

SOP master copies pre-dating the above paperless policy are located in the document control office.

10.5.1.3 A printed controlled copy of any SOP may be obtained from ACZ's LabWeb.

1) To ensure outdated information is not inadvertently used as a reference, Invalid or obsolete SOPs must be promptly removed from all points of use or clearly marked to indicate the purpose of retention

10.5.1.4 SOP Revisions: Any revision to a procedure must be approved by QA before changes may be implemented.

10.5.2 When documents are found to contain conflicting policies or procedures, the most recent document will be followed unless the conflict is prescribed as an exception to general protocol by a document more specific to the application.

10.5.3 Forms containing procedures or equations shall be controlled. Equations shall be validated and protected from inadvertent alteration.

10.5.4 All controlled forms must be printed from LabWeb and may not be stored on a separate network drive. If photocopies are used then any unused copies of the expired version must be disposed of as soon as a new version is uploaded to LabWeb. This ensures that the effective version of any controlled form is in use at all times. Exceptions may be granted by the QAO on a case by case basis.

10.5.5 The original certificate of analysis for any stock material, if provided, is stored in electronic format on ACZ's network.

10.5.6 Accreditation certificates are stored as PDF files to a designated network location. Original copies are maintained by QA. Certificates are also posted to ACZ's website.

10.5.7 Original calibration certificates and related documentation for support equipment (including but not limited to pipettes, thermometers, and glass micro liter syringes) are maintained by the QA Department.

10.5.8 LIMS and other problems pertaining to IT are documented and managed by the electronic system called Help Desk. If an employee encounters a problem that requires attention, that employee will submit a request through Help Desk. The request requires a priority be assigned. This system allows ACZ to track all changes made to computer systems.

10.6 Records

10.6.1 Records include, but are not limited to: all logbooks; phone logs; raw data, derived data, and calibration data; training documentation (training forms, MDL studies, DOCs, etc.); proficiency testing results; calibration and certification records; internal audit reports; external audit reports; corrective action reports; management reports; and regulatory correspondence.

10.6.2 Records related to sample log-in are maintained as described in SOPAD045.

10.6.3 Records related to support equipment calibration and calibration verification are maintained as described in SOPAD013.

10.6.4 Certificates of cleanliness and volumetric accuracy received with consumable supplies (e.g. sample containers, centrifuge tubes) shall be submitted to and maintained by QA. Any other type of certificate that does not have a defined storage location shall be submitted to QA.

10.6.5 Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, dictated observations, and recorded data from automated instruments.

10.6.6 Original copies of records, except those pertaining to analytical data, are maintained by the QA department or Document Control, and access is limited.

10.6.7 Relevant qualifications, training skills, and experience of technical personnel are maintained in the employee's training file.

10.6.8 Records such as transcripts, applications for employment, performance evaluations, etc. are maintained in the personnel files, which are stored in the secured office of the CFO.

10.6.9 The DOC certification statement (FRMAD023), initial method training form (FRMQA004), General Lab Practice Training Form (FRMQA047), and Method Calibration Training Form (FRMQA050) are filed with the workgroup if the DOC was logged-in; otherwise, the DOC package is filed in the method files. An analyst training spreadsheet referencing training dates and documentation locations is maintained on a public drive.

10.6.10 Each employee's legal name, legal signature, and initials are documented on the New Employee Checklist (FRMAD043). The form is maintained in the employee's personnel file, which is stored in the CFO's office. Additionally, employee names, signatures, and initials are documented in a logbook maintained by ACZ's CFO. In the event an employee legally changes their name, the CFO is responsible for garnering new signatures and initials in the logbook; FRMAD043 is not updated in this event.

10.6.11 Each Organic Instrument ICAL data package is scanned to the designated network directory as a PDF and the hard copy stored in labeled boxes. Alternatively, a PDF may be generated directly from the instrument files. ICAL information that needs to be attached to any subsequent workgroup(s) must be printed from the PDF.

10.6.12 Logbooks shall be maintained and controlled as described in SOPAD013.

10.6.13 Project Managers are responsible for maintaining all emails pertaining to a client and/or project. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043).

10.6.14 Changes to electronic records must be traceable to the individual who made the correction, and the reason for the change must be provided. Erroneous entries cannot be destroyed by methods such as overwritten files.

10.6.15 Record Storage and Retention

10.6.15.1 The minimum record retention period of 10 years may be increased dependent upon client request, regulatory requirement, or civil action order.

10.6.15.2 Records stored by a computer must have hard copy or software backup copies.

10.6.15.3 Records stored only on electronic media must be supported by the hardware and software necessary for their retrieval and utilization in the proper format.

10.6.15.4 Records stored on electronic media must be stored in a way to provide protection from electronic or magnetic sources.

10.6.15.5 If there is a change in ownership and/or a change in location, all records and documents will be made available to clients for 10 years. Under no circumstances shall any records or documents be destroyed – all records and analyses performed that pertain to TNI accreditation are subject to inspection by the TNI accrediting authorities for a 5 year period. (The 10 year record retention policy is client driven, TNI standards require records be retained for a minimum of 5 years.) A new owner of ACZ will assume possession of all records and documents.

10.6.15.6 If ACZ goes out of business, all records and documents will be stored and maintained according to protocol in a location to be determined at the time of closure.

10.6.16 Access to Archived Records

10.6.16.1 Access to archived information must be documented with an access log. A log is kept in each storage location, and any person entering a storage location must provide the required information in the log.

10.6.16.2 Hard copy records are stored in a locked environment with limited access. When a record is removed from its location, a "checkout card" must be filled out to indicate who removed the record, the date the record was taken, and a description of the record. The card marks the place in the storage box, and when the record is returned the card is pulled from the box.

10.6.16.3 Any changes to be made to archived electronic data will require assistance from IT to do so.

10.6.16.4 Electronic data that has been archived to removable media is stored in a bank safety deposit box. Access is limited to ACZ's EVPs, IT staff, and CFO and recorded in a logbook maintained by the IT Manager.

10.6.17 Record Disposal

10.6.17.1 Records are disposed of in a manner that ensures client confidentiality.

10.6.17.2 Stored records will be reviewed to determine which ones can be destroyed in compliance with ACZ's record retention policies.

10.7 Computer Data and Records

10.7.1 Network File Server

Computer files pertaining to all aspects of ACZ's business are stored on a series of file servers. To gain access, an employee logs on to the "LAB" domain. Each employee has a unique network user name so that security rules may be enforced. No "guest" logon is permitted. Every employee belongs to a specific "group" and directory security is enforced through privileges granted to these groups. An employee is granted access to files that pertain to their job functions. Other files will be granted read-only or no access as appropriate to the employee's position.

Data generated and reported by ACZ is extremely confidential and the company may be liable for the consequences of the release of this data to any unauthorized person. The implementation of password security is not arbitrary and ensures data is protected and cannot be disclosed to outside parties. Weak passwords that are not changed frequently make this scenario more likely.

In general, the network will prompt employees to change their password every 30 days. The password must be at least five (5) characters. Numeric characters are optional. Passwords may not be shared with other employees, unless necessary for work purposes. The use of another employee's password without permission from ACZ's EVPs, or IT Manager (with the exception of common passwords for shared computers) is grounds for disciplinary action.

10.7.2 LIMS Server

a. Information stored in LIMS consists of all sample and client information needed for day-to-day production activities. The information is stored in an Oracle database. Access is controlled through membership in "groups." Employees may update and change database records according to their job responsibilities. Otherwise, information is restricted to read-only access or no access.

b. No modifications to data can be made through applications not authorized by ACZ's IT department unless a CAR or Help Desk ticket is submitted or documentation is provided on the hardcopy of the workgroup. Unauthorized applications include any form of direct database manipulation.

c. Tracked changes will be audited on a regular basis by the QA department or its designee to ensure sufficient information is being supplied as to why changes occur. The explanations must be both professional and specific.

10.7.3 Docs Server

For general users, access to the docs server is read-only and is permitted through Internet Information Services (IIS) authentication and is logged in IIS log files. Direct access is limited to authorized users or groups who need to bypass the IIS to perform their job duties. The server is updated on a regular basis by automated scripts.

11 ELEMENTS OF QUALITY CONTROL

A critical focus of ACZ's quality control policies and protocols involves monitoring sample preparation and measurement processes to determine matrix effects and to evaluate laboratory performance. Quality control samples are typically analyzed with every batch of environmental samples. Each test SOP provides detailed information regarding quality control sample types, acceptance criteria, and corrective actions, if applicable to the procedure, and reflects the requirements of the method and/or other regulatory authorities.

Performance control samples demonstrate precision or accuracy and expose out-of-control events. Matrix-specific control samples indicate possible effects of the matrix on method performance and may also identify data as in-control or out-of-control. Data that is out-of-control dictates corrective action ranging from re-preparation and re-analysis to reporting data with qualifiers. The corrective action specified in the SOP shall be performed if any quality control sample does not meet the acceptance criteria.

To the extent possible, client samples are reported only if all quality control measures are acceptable. If any measure is outside of the acceptance criteria, and the data will be accepted and reported to the client, then the appropriate data qualifier(s) must be assigned to all associated samples. The list of current extended qualifiers is maintained in the LIMS database.

11.1 Method Performance

11.1.1 Negative Control – Prep Blank (Method Blank)

A prep blank or method blank shall be analyzed at a minimum of one per batch. The blank shall be processed along with and under the same conditions as the associated samples. Method blanks are not applicable for certain analyses, such as pH, Conductivity, Flash Point, and Temperature.

The prep blank is used to assess possible contamination introduced during sample processing steps. A prep blank is prepared using Type I water or other similar matrix that is free of the target analyte(s) and contains all reagents in the same volumes used to prepare the client samples. Unless specified in the test SOP, sample concentration may not be corrected for the prep blank value.

While the goal is to have no detectable contaminants, each prep blank must be carefully evaluated as to the nature of the interference and the effect on the analysis of each sample in the batch. Contamination in the prep blank results from four principle sources: the environment the analysis is performed in; the reagents used; the supplies and apparatus used; and the analyst performing the analysis. Contamination sources vary and the test SOP must be referenced to determine appropriate corrective action.

When method blanks fail acceptance criteria, potential sources shall be investigated and measures taken to correct, minimize or eliminate the problem, and associated client samples must be reprocessed and reanalyzed. Alternatively, data may be reported with the appropriate qualifier if reprocessing and reanalysis is not possible or if one of the following criteria is met:

1) The concentration of a target analyte in the blank is at or above the acceptance limit and the measured concentration of the analyte in an associated sample is greater than 10 times the measured concentration of analyte in the blank.
2) The concentration of the target analyte in the associated sample is less than the MDL.
3) Corrective actions could not be performed or are ineffective. Thoroughly document any corrective action taken and the outcome.

11.1.2 Positive Control (however named)

Laboratory Fortified Blank (LFB), Laboratory Fortified Blank Duplicate (LFBD), Laboratory Control Sample Water (LCSW), Laboratory Control Sample Water Duplicate (LCSWD), Laboratory Control Sample Solid (LCSS), Laboratory Control Sample Solid Duplicate (LCSSD).

1) The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps.

2) The LCS is a quality system matrix, known to be free of the analytes of interest, spiked with known concentrations of analytes. Alternatively, an appropriate Certified Reference Material (CRM) containing the analytes of interest may be used.

3) If no separate preparation method is used (e.g. dissolved metals), an ICV or CCV may double as the LCS. If different acceptance criteria are specified, the most stringent criteria shall be observed.

4) Each test SOP must define the positive control to be used for the procedure, the required frequency, acceptance criteria, and contingencies for corrective action.

5) Unless the reference method specifies a different frequency, the LCS shall be analyzed at a minimum of one per batch, not to exceed 20 environmental samples.

6) Any affected samples associated with a failing LCS shall be re-processed for analysis or the results reported with appropriate data qualification. A failing LCS may be re-tested once to confirm the failure. Additional re-tests must be accompanied by documented corrective action taken between tests. For example, the instrument did not sample from the correct tray position in the first two tests; alignment was corrected for the third test.

   Note: In general, qualification of data for LCS failures is only permitted if there is insufficient sample for re-analysis, the data is extremely time sensitive, or the LCS failed high but the analyte was not detected above the reporting limit in the sample.

7) The components to be included in the LCS shall be as specified by the method, regulation, or as requested by the client. **<u>In the absence of such specifications, the following rules shall be observed (Radiochemistry excluded)</u>** :

   a) For those components that interfere with an accurate assessment, such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported.

   b) For those methods that have extremely long lists of analytes, a representative number may be chosen. The analytes selected shall be representative of all analytes reported. The following criteria shall be used for determining the minimum number of analytes to be spiked. **<u>However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period</u>**:

      i. For methods that include one (1) to ten (10) targets, spike all components.

      ii. For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.

      iii. For methods with more than twenty (20) targets, spike at least sixteen (16) components.

8) An LCSW duplicate may be prepared and analyzed with the batch, typically in lieu of a matrix duplicate or spike duplicate. Data is acceptable if the LCSW and/or LCSWD is within the acceptance limits and the RPD passes. Associated samples must be re-prepped and reanalyzed if either of the following occurs:

   a) LCSW/D RPD fails the acceptance criteria specified in the SOP.

   b) % R of both the LCSW and LCSWD is outside the acceptance limits.

9) For a solid or semi-solid matrix, an LCSS and LCSSD are often prepared and analyzed.[4] The data is acceptable if the LCSS and/or LCSSD are within the acceptance limits and the RPD passes. Associated samples must be re-prepped and reanalyzed if any of the following occurs:

   a) LCSS/D RPD fails the acceptance criteria specified in the SOP.

   b) % R of both the LCSS and LCSSD is outside the acceptance limits.

[4] Corrective action for Recommendation #5 cited in the 2002 ADHS audit report.

10) When the acceptance criteria for the LCS are exceeded [i.e. high bias] then any associated client sample with a measured concentration less than the reporting limit (MDL or PQL) may be accepted and reported with the appropriate qualifier.

11) Refer to §11.1.3.3 for additional information regarding data assessment for solid-matrix workgroups prepared with both LCSS/LCSSD and MS/MSD.

12) An LCS is not required for those analytes for which no spiking solution is available.

13) The following apply to radiochemistry only:

    a) The activity of the LCS shall be at least 10 times the Lower Limit of Detection (LLD) or Minimum Detectable Activity (MDA). Note: this requirement does not apply to DOCs.

    b) Whenever possible, the standards used to prepare the laboratory control sample shall be from a source independent of the standards used for instrument calibration.

    c) Where a radiochemical method, other than gamma-ray spectroscopy, has more than one reportable analyte isotope (e.g. plutonium, 238Pu and 239Pu, using alpha-particle spectrometry), only one of the analyte isotopes needs to be included in the laboratory control sample at the indicated activity level. However, where more than one analyte is detectable, each shall be assessed against the specified acceptance criteria.

    d) Where gamma-ray spectrometry is used to identify and quantify more than one analyte, the laboratory control sample shall contain gamma-emitting radionuclides that represent the low (e.g., Am^{241}), medium (e.g., Cs^{137}) and high (e.g., Co^{60}) energy range of the analyzed gamma-ray spectra. As indicated by these examples, the nuclides need not exactly bracket the calibrated energy range or the range over which nuclides are identified and quantified.

    e) The laboratory control sample shall be prepared with similar aliquot size to that of the routine samples for analyses.

11.1.3 Sample Specific Controls

The effect of different sample matrices on the performance of any method can be profound; therefore, matrix spikes, duplicates, and surrogate compounds are analyzed to evaluate matrix effects on data quality. Each SOP includes specific information regarding the usage and evaluation of matrix-specific QC samples and also states the required corrective action to take if any matrix QC fails.

ACZ provides analytical services to numerous and varied clients. Therefore, the possibility of routinely favoring one client or sample is highly unlikely, and over time the samples from all routine sources should be fortified. ACZ recommends that analysts, to the extent possible, select samples to spike or duplicate that are representative of the workgroup. Analysts are not to associate QC with a client sample known to be or believed to be any type of blank or Proficiency Testing sample. Several exceptions exist for selecting samples for spiking or duplicating:

1 A sample is not spiked or duplicated if the volume is inadequate and the client sample and QC sample(s) would require dilution; however, if no other option is available then the client sample and Duplicates should be prepared and analyzed on the same dilution whenever possible. Matrix spikes will not be accepted on different dilutions (minor d.f. variations in soils samples are acceptable) unless no other alternative exists. The data must be qualified in this event.

2 Use the same weights (as close as possible) to prepare duplicates of solid matrix samples.

3 A client may require that one or more of their samples be spiked or duplicated. A “RUN QC” comment is added when the sample is logged in to notify the analyst that QC must be performed for a specific sample or project. Alternatively, the Special Instructions function in ACZ’s LIMS may be used to communicate the request. If a client requests that their sample(s) be spiked or duplicated, ACZ will accommodate the client for a fee.

4 A reactive sample is unpredictable and is a poor choice for spiking or duplicating.

5 A PT sample is not a real-world sample and is a poor choice for spiking or duplicating, because the data does not provide any useful information about possible matrix effects. When selecting samples for batch QC such as spikes or duplicates, PT samples should be avoided. If insufficient volume exists to spike or duplicate any other samples in the batch, it is appropriate to select a PT sample. It is better to use the PT sample for a duplicate than a spike if this choice is presented. If a batch consists solely of a PT sample, QC designed to assess matrix effects is not required (e.g. spike, SDL); an assessment of precision is still required and may be accomplished by duplicating the PT sample, or preferably, running a duplicate of the positive control.

11.1.3.1 Surrogates

Surrogates are organic compounds that are similar to the target analyte(s) in chemical composition and behavior in the analytical process, but are not normally found in environmental samples. Surrogates are included in the scope of Organic methods and are used to evaluate accuracy, method performance and extraction efficiency and are added to environmental samples, controls, and blanks, in accordance with the method requirements.

When surrogate recoveries fail acceptance limits, corrective action stated in the test SOP shall be performed. If corrective action cannot be performed or is ineffective, reported data must be appropriately qualified.

11.1.3.2 Matrix Spike Samples

A matrix spike sample (however named) is used to determine the level of bias (accuracy) associated with a particular matrix. For the purposes of this document, “MS” designates a matrix spike, and “MSD” designates a matrix spike duplicate. Spikes are prepared by adding a known and appropriate quantity of each target analyte to a replicate aliquot of client sample.

The required analytical frequency is specified by the method or other regulating entity and is indicated in the test SOP. Each result is evaluated against the acceptance criteria, and matrix effects are determined and reported to the client. The following evaluation criteria apply to spikes that are subjected to processing steps and post-digestion spikes (analytical spikes).

- Percent Recovery (%R) is considered for all spikes.
- %R is evaluated only if the theoretical concentration in the spiked aliquot is greater than or equal to the PQL; otherwise, each associated client sample must be reported with the appropriate qualifier, regardless of %R, unless a representative number of analytes as described in §11.1.3.2.1 are evaluated for %R.
- If %R for the MS and/or the MSD is outside of the acceptance limits, the RPD passes, and all other pertinent prep and instrument QC passes, each associated client sample may be accepted and reported with appropriate qualification.

11.1.3.2.1 The components to be included in the MS & MSD shall be as specified by the method, regulation, or as requested by the client. **In the absence of such specifications, the following rules shall be observed (Radiochemistry excluded)**:

1) For those components that interfere with an accurate assessment, such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported.
2) For those methods that have extremely long lists of analytes, a representative number may be chosen. The analytes selected shall be representative of all analytes reported. The following criteria shall be used for determining the minimum number of analytes to be spiked. **However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period**:

a) For methods that include one (1) to ten (10) targets, spike all components.

b) For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.

c) For methods with more than twenty (20) targets, spike at least sixteen (16) components.

11.1.3.3 Matrix Duplicates and Matrix Spike Duplicates

The matrix-specific precision associated with an analysis is determined through the use of a matrix duplicate (DUP) or spike duplicate (MSD), which are performed at a frequency specified by the method or other regulating entity (refer to the specific test SOP). If the method does not prescribe a frequency, a duplicate shall be included in each workgroup, not to exceed 20 samples. The results are evaluated, and the matrix affect on precision are determined and reported to the client.

- Relative Percent Difference (RPD) is used to evaluate precision, unless the test SOP specifies a different technique (§12.4.6).

- RPD for a spike duplicate is evaluated only if the observed concentration is greater than or equal to the PQL; otherwise each associated client sample must be reported with the appropriate qualifier.

- RPD for a matrix duplicate is evaluated only if the observed concentration is greater than 10 times the MDL or 2 times the PQL if an MDL has not been established; otherwise each associated client sample must be reported with the appropriate qualifier, regardless of RPD.

- In the absence of other contributing factors, a DUP failure for a solid or semi-solid matrix is attributed to non-homogeneity of the sample, and each associated client sample may be reported with the appropriate qualifier.

- For an aqueous matrix, if the DUP fails then all associated samples must be retested. If permitted by the instrument software the sample and DUP can be reanalyzed at the end of the analysis in lieu of retesting all associated samples.

- For an aqueous matrix, if the MS/MSD RPD fails then the associated samples must be reanalyzed. If permitted by the instrument software the sample and MS/MSD can be reanalyzed at the end of the analysis in lieu of retesting all associated samples.

- If applicable, evaluate the LCS/LCSD if the RPD fails for a matrix duplicate or spike duplicate. Each associated client sample may be reported with the appropriate qualifier if the LCS/LCSD meets the criteria stated in §11.1.3.2.

- For a solid or semi-solid matrix, if both the LCSS and LCSSD recoveries pass but the RPD fails, then acceptable precision may be demonstrated by a passing RPD for the MS/MSD, and each associated client sample may be reported with the appropriate qualifier.

- A sample and duplicate may only be re-analyzed once before additional corrective action is required. If more than one re-analysis is performed, the workgroup documentation must include justification.

11.2 Instrument Specific Controls

All data must be associated with a passing instrument calibration and initial calibration verification. To the extent possible, all data must be associated with passing continuing calibration verification. If the initial calibration verification results (ICV/ICB) are outside of the acceptance criteria, then the source of the failure must be identified, necessary corrective action performed, and the instrument recalibrated if necessary before proceeding with sample analysis.

If the continuing calibration verification results (CCV/CCB) do not meet the acceptance criteria, then the source of the failure must be identified and corrective action performed, including recalibration if necessary, before continuing with sample analysis. If reanalysis of any sample associated with failing calibration verification is not possible and results will be reported, the data shall be appropriately qualified.

For instruments that permit the analysis of subsequent workgroups using the most recent calibration, two (2) consecutive attempts of the opening CCV/CCB are allowed. If both attempts fail to produce acceptable results then the sources of failure must be identified and corrective action performed, including recalibration if necessary, before commencing sample analysis.

If a CCV or ICV *retest* fails and the instrument is not recalibrated, 2 consecutive passing CCVs or ICVs are required before continuing with analysis.

Unless stated otherwise by the test SOP, passing calibration verification must bracket all batch quality control samples, and results for additional instrument check standards, if applicable, must be within the acceptance criteria stated in the SOP. However, when the acceptance criteria for a CCV or CCB are exceeded (i.e. high bias) any associated client sample with a measured concentration less than the MDL may be accepted and reported with the appropriate qualification. This exception is not allowed if the workgroup contains a batch LCS (however named) which fails low.

11.3 Other Control Indicators

11.3.3 Internal Standards

Internal Standards (IS) are measured amounts of certain compounds added after preparation or extraction of a sample to be analyzed. The IS is an analyte not likely to be found in the environment and is used in a calibration method to correct sample results affected by column injection losses, purging losses or viscosity effects. The IS is added to client samples, controls and blanks in accordance with the method requirements. When the results are outside of the acceptance limits for applicable quality control samples, corrective actions shall be performed. Once system control has been reestablished, all samples analyzed while the system was malfunctioning shall be reanalyzed. If corrective actions could not be performed or are ineffective and associated sample results will be reported, the data must be appropriately qualified.

11.3.2 Trip Blank

The trip blank is a sample container filled in the laboratory with Type I water that is shipped to the collection site in the sample cooler, returned to the laboratory, logged-in, and analyzed in the same manner as the client samples. With the exception of Hg-1631, trip blanks are not opened in the field.

11.3.3 Instrument Blank

The instrument blank is an aliquot of Type I water processed only through the instrument steps of sample analysis and is used to determine presence of instrument contamination. For Organic instrument methods, neither surrogate nor IS standards are added.

11.3.4 Equipment Blank

An equipment blank is provided by the client and is used to assess the effectiveness of equipment decontamination procedures. Type I water is poured into (or over) or pumped through the sampling device, collected in a sample container and transported to the lab to be analyzed for all parameters requested for the environmental samples collected at the site.

11.3.5 Ambient Blank

The ambient blank consists of Type I water poured into a VOA vial at the sampling site (in the same vicinity as the associated samples). It is handled like an environmental sample and transported to the laboratory for analysis. Ambient blanks are prepared when samples are to be analyzed for VOA analytes and are used to assess the potential introduction of contaminants from ambient sources (e.g. active runways, engine test cells, gasoline motors in operation) to the samples during sample collection. The frequency of collection for ambient blanks is specified in the client's field-sampling plan. Ambient blanks are not required for all projects.

11.3.6 Radiological Tracers & Carriers

Radiological tracers and carriers are used for radiological analyses. The control reacts in the same manner as the target isotope and is used to assess analyte recovery. The tracer is added to client samples and QC in accordance with the requirements stipulated in the test SOP. Because the tracer recovery has a direct impact on the LLD, the recovery must be high enough to yield LLDs that are within the scope of the project or meet ACZ's acceptance criteria. Refer to the test SOP for evaluation criteria and corrective action(s) for out-of-control tracer recovery.

11.4 Titrants – Where applicable, test SOPs shall include procedures for verifying the concentration of titrants prepared by the laboratory. Verification is not required for purchased titrants with certified values. If a purchased titrant is diluted, verification is required.

12 EVALUATING QUALITY CONTROL SAMPLES

In general, acceptance criteria for quality control samples are method-specific; however, compliance with the requirements of clients and regulatory or other accrediting agencies must also be demonstrated. Immediate corrective action must be taken if any quality control is outside of the acceptance criteria. Appropriate corrective actions are described in the test SOP. To the extent possible, client samples are reported only if all quality control measurements are acceptable. If a quality control measure is outside of acceptance criteria, and the data will be reported, then all samples associated with the failed QC must be appropriately qualified. Clients will occasionally request limits different from those in a published method. Deviations from ACZ's policies pursuant to client request must be explicitly noted on client reports. ACZ will not be held liable in the event such deviations do not meet client regulatory needs.

Unless otherwise stated, for the purpose of determining conformance to specifications, ACZ employs the rounding method described in ASTM E29. When using this method, observed values are rounded to the same decimal place limits are expressed before assessing conformance. For example, if the calculated percent recovery for an LCS is 89.5% and the QC limits are 90 to 110%, the percent recovery would be rounded to 90% and evaluated as passing. (Note: double rounding is NOT permitted, e.g. 89.48 rounds to 89.5 rounds to 90.) Conversely, if limits were expressed as 90.0 to 110.0%, the same LCS would be evaluated as failing acceptance criteria. Analysts must consider whether the QC limits expressed in the test method cohere in a technically sound manner with the rounding method. If they do not, the SOP must express the limits to a technically sound numerical place value, or the absolute method must be employed. The absolute method takes a limit of 6˚C, 6.0˚C, and 6.000˚C all to mean the same thing, exactly 6 degrees Celsius.

For methods that permit the use of control charts or do not specify acceptance criteria for quality control measurement, limits may be generated by plotting historical data obtained from analytical processes considered in control. Whenever practical, a minimum of 20 data points is used. The process of rejecting data points relies heavily on the statistician's judgment and control chart activities are therefore restricted to supervisors and experienced analysts. All points must be associated with passing calibrations and calibration verification(s). Data points with known anomalies must be rejected. Data points should not be rejected solely because they fail acceptance criteria. Control chart documentation must clearly indicate rejected data points. ACZ's LIMS has a utility for querying and retrieving historical data for control chart applications. Control chart limits are typically set at ± 3σ. All control chart limits are reviewed and approved by the QA department prior to implementation. When possible, a comparison to previous limits is included in the review and may form the basis for rejecting new limits and requiring an investigation of the analytical system's condition. Previous limits are archived in a network folder. Default acceptance criteria established by the Arizona Department of Health Services (ADHS) may be used in lieu of generating a control chart to establish limits; however the SOP must specify which limits are in use.[5] **NOTE:** For all data evaluation, final results ending with 1 – 4 are rounded down and results ending with 5 – 9 are rounded up.

12.1 Accuracy

Accuracy is defined as "The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations". Control samples (LCS or LFB) and spiked samples are analyzed with every batch of samples or as stipulated by the specific test SOP to assess accuracy and matrix effects.

- Percent Recovery (%R) for a control sample is calculated as follows:

$$\%R = \frac{M}{S_p} \times 100$$

Where: M = Measured concentration of the control sample

S_p = True value of the control sample

[5] Arizona Administrative Code (A.A.C.), Title 9, Ch. 14, Table 6.4 (September, 2016)

- Percent Recovery (%R) for a spike is calculated as follows:

$$\%R = \frac{M - S}{S_p} \times 100$$

Where: M = Measured concentration of the spiked sample
S = Measured concentration of the sample aliquot
S_p = True value of the spike concentration

12.2 Precision

Precision is defined as "The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms." Matrix duplicates and spike duplicates are analyzed with every batch of samples or as stipulated by the test SOP to determine the precision associated with the analysis. If any method does not specify acceptance criteria for the RPD, then default criteria of RPD $\leq$ 20 is used (a value that rounds to 20 is acceptable). [6] The Relative Percent Difference (RPD) as an absolute value is calculated as follows:

$$|RPD| = \frac{(S - D)}{[(S + D) / 2]} \times 100$$

Where: S = Sample Value
D = Duplicate Value

12.3 Other Calculations

- Solids Dilution Factor:

$$\text{Dilution Factor} = \frac{V}{(W)(\%\ \text{solid})}$$

Where: V = Final digestate volume, in mL
W = Sample weight used, in g
%solid = %solid of the sample as a fraction

- Sample Concentration for Solids:

  - wet weight [biota tissue, fruit or vegetable matter, etc.]: $\text{mg/Kg} = \frac{DF * C * V}{W}$

  - dry weight [plant matter, grasses, soil, sludge, etc.]: mg/Kg = SF * C * DF

  Where: DF = instrument dilution factor
  C = raw data value, in mg/L
  V = Final volume of digestate, in L
  W = sample (as received) weight used, in Kg
  SF = soil dilution factor

- Percent Difference for Serial Dilution (SDL):

$$|\%D| = \frac{[I - (s * 5)]}{I} \times 100$$

Where: I = initial sample result
s = serial dilution result (raw data value)

For SDL calculations in LIMS, "s" is multiplied by 5 and the resulting "reg value" is compared to the "found value" to calculate %D.

[6] ADHS Information Update #87 (July 7, 2005)

12.4 Radiochemistry Calculations: (**NOTE**: Specifications in the individual test SOPs supercede the information detailed below.)

12.4.3 Activity

The results of radioactivity are typically reported in terms of activity per unit volume or mass. Units are normally expressed in picocuries (pCi), which equal 2.22 disintegrations per minute (dpm). Specific formulas to determine activity are in the SOP for each method. The general formula is as follows:

$$C = \frac{R_{net}}{(e)(y)(i)(v)(u)}$$

Where: C = activity per unit volume (pCi/L)
R_{net} = net counts per minute
e = counting efficiency, cpm/dpm
y = chemical yield
i = ingrowth correction factor
v = volume or mass being counted (L)
u = units correction factor, 2.22 for cpm to pCi

12.4.4 Counting Error

Radiochemical data are considered incomplete without reporting associated random and systematic errors. For this reason all radiochemical results should be accompanied by a counting error at the 95% confidence level (1.96*standard deviation). The general counting error formula is as follows:

$$E = \frac{1.96\,(R_o / t_1 + B / t_2)^{1/2}}{(e)(y)(i)(v)(u)}$$

Where: E = counting error
R_o = gross sample, cpm
t_1 = sample count duration, min
B = background, cpm
t_2 = background count duration, min
e, y, i, v, and *u* are as previously defined.

12.4.5 Lower Limit of Detection (LLD)

LLD (also referred to as Minimum Detectable Activity or MDA) is considered the smallest quantity of sample radioactivity that will yield a net count for which there is a pre-determined level of confidence that radioactivity is present. At the 95% confidence level, the following equation calculates the LLD for any single nuclide. The calculation uses the standard deviation for the background counting rate, assuming the sample and background counting rates should be very similar at the LLD. A formula for determining LLD is as follows:

$$\mathrm{LLD}_{95} = \frac{4.66\,S_b}{(e)(y)(i)(v)(u)}$$

Where : LLD_{95} = Lower limit of detection at the 95% confidence interval
S_b = Standard deviation of the instrument background counting rate, cpm
e, y, i, v, and *u* are as previously defined

12.4.6 Precision

The normalized absolute difference, or Replicate Error Ratio (RER), between the sample and the laboratory duplicate, given by the following equation shall be used to determine that results do not differ significantly when compared to their respective 2* sigma uncertainty.

$$RER = \frac{|Sx - Dup|}{\sqrt{(Sx_{error})^2 + (Dup_{error})^2}} \leq 2.0$$

Where: Sx = sample concentration in pCi/L
Sx_{error} = sample counting error (in pCi/L) at the 95% confidence level.
Dup = duplicate concentration in pCi/L
Dup_{error} = duplicate counting error (in pCi/L) at the 95% confidence level.

NOTE: For Radchem samples, both RPD and RER may be used to evaluate precision. RPD is the default assessment for Drinking Water samples; RER is the default assessment for non-Drinking Water samples. Data for both RER and RPD are uploaded to LIMS for all analyses. Use the following guidelines to correctly assess precision. Further details are provided in ACZ's Wiki and should be consulted to ensure data for each workgroup is correctly evaluated. Go to LabWeb \ Wiki \ Analytical Departments \ Radio Chemistry.

Drinking Water:

RPD ≤ 20, RER < 2.0 – Precision is judged to be in control
RPD ≤ 20, RER > 2.0 – Precision is judged to be in control;
RPD > 20, [sx] < 5x [LLD], RER < 2.0 – Precision is judged to be in control; qualify data.
RPD > 20, [sx] > 5x [LLD], RER> 2.0 – Precision of the prep batch is questionable.
RPD > 20, [sx] > 5x [LLD], RER < 2.0 – Precision of the prep batch is questionable.

Non-Drinking Water:

RER < 2.0, RPD ≤ 20 – Precision is judged to be in control.
RER < 2.0, RPD > 20 – Precision is judged to be in control;
RER > 2.0, RPD ≤ 20 – Precision of the sample prep batch is questionable.
RER > 2.0, RPD > 20 – Precision of the sample prep batch is questionable.
RER > 2.0, [sx] > 5x [LLD], RPD ≤ 20 – Precision is judged to be in control; qualify data.

13 VALIDATION AND REVIEW OF ANALYTICAL DATA

ACZ has a responsibility to provide the best data possible to ensure our clients can make sound and cost-effective decisions regarding public health and the environment. In order to generate and report reliable data, the analytical systems used need to be properly functioning, and the review process must be conducted in a manner that is logical and reasonable and would be defensible if subjected to legal scrutiny. Decisions regarding data quality must be backed by good science and sound professional judgments.

The entire validation and review process encompasses more than solely evaluating the final results for client and quality control samples. To this extent, the necessary steps must also be performed *prior* to sample preparation or analysis to ensure the quality of the data. Following sample analysis, data is uploaded to the LIMS database and then submitted to a variety of process chains such as calculations, rounding, application of qualifiers, etc. A multi-level data review process is utilized to verify the uploaded analytical data meets all documented ACZ requirements as well as any client-specific quality objectives. At a minimum, the validation process must include the following steps, as applicable:

- Monitor the expiration dates for all stock, intermediate, and working standards, reagents, and chemicals.

- Prior to analysis, determine that holding times have not been exceeded. Unless otherwise specified by the test SOP, sample preparation and analysis must be completed within the holding time.

- Prior to analyzing samples, verify the correct set-up and operation of the instrument or equipment. Perform calibration, maintenance, and optimization as necessary to ensure proper functioning.

- QC Association
  1) In general, for QC frequency of 1 per10 or less client samples, the first set of QC is associated with samples 1 – 10. If there are fewer than 20 samples in the workgroup, then the remaining client samples are associated with the second set of QC.
  2) If sample characteristics or amount dictate that 2 of the first 10 samples be spiked or dup'd, then the first spike or DUP is associated with samples 1 through 11 excluding the 2nd sample spiked or dup'd, and the 2nd spike or dup is associated with itself and samples 12-20. For example, if samples 3 & 5 are spiked in a 20 sample batch, sample 3 is associated with 1-4 & 6-11, and sample 5 is associated with 5 and 12-20. The same principle applies if both spiked or dup'd samples reside in the 2nd set of ten within the workgroup sequence.
  3) Variations to the QC association rules noted above are permitted but must be documented with the WG. The documentation must define the altered QC association and provide a compelling, technically sound reason for the deviation. QC association may **not** be changed after data has been acquired.
  4) QC association must be properly defined in LIMS.

- Before completing workgroup creation, verify the correct PCNs and/or SCNs have been entered. Percent recovery for control samples and spikes is calculated using the information in LIMS for each.

- Verify the proper sub-sample (green dot, yellow dot, etc.) is being used for preparation or analysis.

  - Notify the supervisor or Production Manager as soon as possible if a sample cannot be located.
  - Document on the bench sheet if a sub-sample other than the type indicated in the SOP is used.

- Clearly label tubes, beakers, autosampler cups, etc. to identify the sample (and dilution factor, if applicable).

- Manage sample volume to ensure all analyses from a bottle type can be completed.

- Document all dilution factors at the time the dilution is performed.

- Record complete and accurate observations when an analysis, sample preparation, or sample matrix is unusual or problematic.

- Ensure transcription errors do not occur. Verify all data manually entered into LIMS is correct before completing the upload process.

- The calibration workgroup must be associated with all subsequent workgroups. Record the calibration workgroup number (or calibration file name) on the data review checklist.

- Provide complete traceability for all standards and reagents used for sample preparation and analysis.

- Batch quality control samples must be treated in the same manner as client sample, including preparation.

- If it is necessary to perform a calculation manually, use the values in the raw data [do not truncate] and then round the final result to the appropriate numerical place value. If the final result passes the acceptance criteria then pass the QC in LIMS and note on the data review checklist that it passes.

- LIMS performs several additional QC calculations on the approved data including cation/anion balance (CAB) checks, calculated TDS versus actual TDS ratios, and Total versus Dissolved ratios. The Project Manager may update the status of pertinent samples to REDO if one of these calculations indicates a discrepancy with the associated data.

- If two attempts fail to produce acceptable data then notify the supervisor or Production Manager before taking further action. It may be necessary to first determine if a larger problem is interfering with the analysis. Investigate the problem before qualifying the associated data.

- If there is an indication the analytical system is out of control, the issue must be investigated. Notify the supervisor immediately. Conduct troubleshooting in a systematic, organized manner.

- All data must be reviewed initially in LIMS [AREV] by the analyst who performed the analysis or another individual authorized to perform or AREV the procedure. The department supervisor or another individual authorized for SREV performs the secondary review [SREV]. The following are data review guidelines:

    1 A data review checklist must be completed during the review process. Verify all items listed and note any errors, problems or non-compliances and the corrective action(s) taken.

    2 If applicable, review the raw data to verify the analytical system was in control and to ensure no anomalies exist. Check for notes on the bench sheet regarding the preparation or analysis.

    3 For client samples and quality control samples, ensure all results are within the measurement range and are bracketed by a passing calibration and passing calibration verification [ICV/ICB or CCV/CCB]. Sample values outside of the measurement range must be appropriately qualified if reanalysis is not possible.

    4 The corrective action specified in the SOP must be performed if any quality control sample does not meet the acceptance criteria.

    5 Data generated after the hold time has elapsed may not be usable for the client. If reprep or reanalysis will be conducted outside of the holding time, check first with the supervisor.

    6 Confirm all dilutions are appropriate. A reasonable explanation must be provided on the bench sheet if a sample was diluted and the value is less than the quantitation limit (refer also to §15).

    7 If a spike fails, determine if the sample concentration is disproportionate to the spike added. If the analyte concentration in the sample is more than **4 times** the spike concentration, note the failure on the checklist and appropriately qualify the associated samples.

8 If a spike recovery suggests the sample was not spiked, matrix interference must be confirmed prior to qualifying samples. If matrix interference cannot be confirmed, then re-prep and/or re-test all associated samples.

9 Each associated client sample must be appropriately qualified if the matrix spike, matrix duplicate, or spike duplicate data cannot be used for validation purposes.

10 Confirm failed QC by verifying the correct PCN or SCN was entered. Make corrections if necessary before proceeding with data review.

11 Verify all assigned qualifiers are appropriate. Does use of a particular qualifier make sense? Could data be defended using the qualifier assigned to the scenario or problem?

12 If a case narrative is necessary, the reason for accepting and reporting the data must be sound and logical. Provide sufficient and accurate verbiage to ensure the data is legally defensible.

13 If a sample was retested in the same workgroup, verify the correct data will be reported. All other data for the sample must be failed; LIMS cannot report multiple datum for the same sample-product-analyte combination.

14 Confirm all samples have the correct status (PASS, FAIL, REDO, REDX) before completing the review process. For multi-parameter workgroups, all analytes must have the correct status.

15 Refer also to §11 for data evaluation criteria.

14 DETECTION LEVELS

Current practice identifies several detection levels, each of which has a defined purpose: Instrument Detection Limit (IDL), Method Detection Limit (MDL), Reporting Limit (RL), and Practical Quantitation Limit (PQL). The MDL and PQL are stated in each test SOP and are adjusted accordingly in LIMS when data is uploaded to reflect the use of smaller sample volume (dilution) or larger sample volume (concentration).

14.1 Instrument Detection Limit (IDL)

The concentration equivalent to the analyte signal which is equal to three times the standard deviation of a series of 10
replicate measurements of the calibration blank signal at the selected analytical mass. (EPA Method 200.8 definition.)

14.2 Method Detection Limit (MDL)

The EPA defines the MDL as the "minimum concentration of substance that can be measured by a specific testing protocol and reported with 99% confidence that the analyte concentration is greater than zero…" This confidence interval means that any substance detected at a concentration equal to the MDL is 99% likely to be present, but it also means there is a 1% chance that the substance will be considered falsely present (false positive). The MDL procedure is designed so that the probabilities of both false positive and false negative errors are acceptably small; however, the procedure has limitations. Data users must understand the limitations when evaluating low level data and must proceed with caution when interpreting data reported between the MDL and PQL in order to minimize the risk of making poor environmental decisions.

MDLs are dependent on variables (temperature, instrument conditions, analysts, matrix, etc.) and are typically determined by processing, preferably over the course of several days, at least seven individual replicates of a fortified blank sample through the method's preparation and analytical schemes. MDLs determined for the same method / matrix / technology must be compared to ensure they are in agreement.

ACZ maintains a current MDL for each applicable method. A qualitative verification of the MDL must be performed annually for each applicable method, analyte, instrument, and matrix and before a new instrument or method is utilized for client samples. Refer to ACZ's SOP *Demonstration of Capability & Method Detection Limit Studies* (SOPAD001) for additional information.

14.3 Practical Quantitation Limit (PQL)

The PQL represents the lowest quantitative level that can be reported with a specified degree of confidence. Data reported at or above the PQL is considered reproducible, allowing for comparison of analytical results over a relatively long period of time, which is important to the monitoring of environmental data. ACZ *typically* defines the PQL as a value 2 – 10 times the MDL with an accuracy of 70 to 130% in a matrix free of interferents. The low calibration standard shall be at or below the PQL. Reported values less than the PQL are qualified as estimated. The region between the MDL and PQL is a continuum of uncertainty, lacking distinct cutoff points, and the error below the PQL is increased to the extent that the statistical validity of the result is questionable.

15 SAMPLE DILUTIONS

Sample dilution may be necessary for one or more of the following reasons: (1) sample concentration exceeds the established measurement range of the procedure/method; (2) sample volume or material is limited; (3) matrix interference is indicated or suspected; (4) sample matrix is reactive; (5) aqueous sample contains high sediment; (6) color, odor or other physical characteristics are present; (7) For ICP and ICPMS, TDS is greater than 2000 mg/L. In all cases, the analyst must use good professional judgment when determining the most appropriate dilution. Whenever possible, prepare and analyze client samples and any complimentary duplicates or spikes on the same dilution.

For samples that contain high concentration of analyte(s), the analyst will use their knowledge of the measurement range of the procedure to determine an optimal dilution that yields quantifiable data with minimal error propagation. In general, prepare the dilution so the final concentration is near the mid-point of the measurement range. A sample must be retested on a smaller dilution if analyte concentration is less than the reporting limit; exceptions must be explained on the bench sheet. For multi-parameter analyses, it may not be practical to report all analytes within the desired range, and the analyst must use their best judgment when determining a reasonable dilution factor.

The following requirements pertain to all dilutions:

- Document all dilution factors when the dilution is performed.
- Assign the appropriate “D” qualifier if data for the diluted sample is less than the quantitation limit
- Retest sample on smaller dilution if the result is less than the quantitation limit (or document justification for accepting the data on the bench sheet or data review checklist)
- Document the reason for any dilution on the bench sheet [not required for sample values that exceed the measurement range of the procedure]

16 ERROR CORRECTION PROTOCOL

When an error occurs in any type of record it must be crossed out with a **single line**. The error must not be erased, deleted, overwritten, obliterated, or made illegible. Alterations to make data legible are considered error corrections. The correct value must be entered alongside. All changes to hard copy records must be initialed and dated by the person making the correction. [7]Under no circumstances may White-Out® or any other substance be used to conceal data. Concealing or improperly altering data is fraudulent and may be grounds for termination from ACZ. Equivalent measures must be taken to avoid loss or change of original data in the case of records stored electronically. Refer to §10 for details of corrections made to electronic records. The following is an example of proper error correction:

fleece BWC 10-20-06
Mary had a little lamb, it's ~~feet~~ as white as snow. And everywhere that ~~Lary~~ went, the lamb was sure to go.
Mary BWC 10-20-06

[7] There is one exception to this rule. Client identification may be obliterated from a record if it’s presence compromises client confidentiality (e.g. client ID is mistakenly entered in a logbook). In this event, the rationale for obliteration must be clearly stated and initialed and dated by the person making the correction.

17 COMPUTER / AUTOMATED PROCESSES

ACZ employs its proprietary LIMS (Laboratory Information Management System) to acquire, record, process, store, and archive data. LIMS is the primary application for all employees and encompasses the combination of hardware and software throughout the entire facility. Tasks performed with LIMS include but are not limited to creating workgroups, reviewing data, and generating client reports. ACZ implements the defined standards of Good Automated Laboratory Practices (GALP) to establish a uniform set of procedures to assure that all LIMS data used by our clients is reliable, credible, and legally defensible.

17.1 Software

The software used to achieve GALP goals is a combination of industry standard commercial off the shelf (COTS) software and internally developed applications. COTS software is purchased through professional and well-developed companies such as Oracle, Microsoft, and Lab Vantage Systems that complete sufficient testing and quality control to assure their products function properly. Internal applications undergo testing before being implemented and distributed throughout the laboratory.

Electronic records are protected, backed up, and archived to prevent unauthorized access or amendment. Refer to §10 of this document and ACZ's SOP *Backup and Archive of Instrument Data Files* (SOPAD044) for details.

17.2 Hardware

ACZ deploys many servers using industry standard architecture. All servers run standard enterprise operating systems such as Microsoft Windows Server and SuSE Linux. All data residing on network servers is routinely backed up.

To the extent possible, instrument PCs comply with at least the minimum recommendations of the instrument manufacturer and they are connected to ACZ's network. This allows transparent backup and access to computers by system administrators.

17.3 Security

GALP security is controlled through a set of passwords. A log-in name and password are required to access ACZ's network. User passwords must be at least five characters and must be changed when the user is prompted. Each user has a given set of network rights and is restricted to software necessary to complete their job functions as well as his/her own documents. Refer also to §10.7.1 for additional information.

A firewall protects the network from internet traffic. The only traffic permitted access to the internal network is protocols approved by ACZ such as IMAP, SMTP and HTTP. Incoming and outgoing E-mails are scanned for viruses and content. Email that fails this automated scan is quarantined for further review. Web traffic that is potentially harmful or inappropriate is automatically blocked by ACZ's proxy server.

17.4 Electronic Signatures

ACZ permits the use of electronic signatures to approve documentation produced by the laboratory and to enter contractual agreements. Electronic signatures meeting the following criteria are considered equivalent to a handwritten signature:

(1) Each electronic signature shall be unique to one individual and shall not be reused by, or reassigned to, anyone else.
(2) Signing shall be password protected.
(3) Signatures shall be embedded with a timestamp.
(4) Faxed handwritten signatures are considered equivalent to a wet signature unless proven unreliable.
(5) E-documents that contain contractual commitments must be signed by an officer of the company.

18 CLIENT SERVICES

18.1 Contracting Services

ACZ's sales representatives and project managers are responsible for reviewing requests, preparing quotes, and entering contractual commitments with clients. Prior to accepting new work, it must be verified that the laboratory has appropriate facilities and resources to meet client needs. To the extent possible and pragmatic, ACZ shall use the latest valid edition of a standard. This is dictated largely by what ACZ's accrediting authorities will issue certification for. Where an older standard is universally recognized by ACZ's accrediting authorities but the latest is not, ACZ will typically use the older standard. As necessary, sales representatives and project managers must collaborate with ACZ's Production Manager, QAO, and/or technical directors to evaluate laboratory capacity, capability, and resources. Refer to SOPAD043 for additional details.

18.2 Subcontracting

ACZ utilizes subcontract labs to perform analyses for various reasons. A subcontracted lab must meet the clients DQOs and laboratory certification requirements for the subcontracted analysis. When applicable, ACZ advises its clients in writing of its intentions to subcontract any portion of the testing to another party. Any non-accredited tests shall be clearly identified as such to the client. ACZ scans this report as an attachment to be included as part of ACZ's final report. A comment is added to ACZ's final report indicating which subcontracted laboratory performed the analyses, if the name is not indicated on the attachment. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

18.3 Data Reporting

Once all analyses and the entire review process have been completed, a client report is generated and submitted for final validation by the Project Manager. If necessary, a case narrative is written describing the details of the project and any non-conformances or other relevant issues. The PM electronically signs the report, and the Document Control department sends the report to the client in an electronic format. At a minimum, the following information appears on an ACZ analytical report:

Client Name	Sample Matrix
Client Address	Parameter/Analyte
Client Contact	Method Reference
Lab Sample ID	Result
Client Sample ID	Units
Client Project ID	LIMS Qualifier (U, B, J, H)
ACZ Report ID	MDL or LLD
Date/Time Sampled	PQL
Date/Time Received	Analyst's Initials
Date/Time Analyzed	Extended Qualifiers (as separate page)

A complete electronic data package contains the analytical reports, the external chain of custody records, sample shipping documentation, and any other relevant project information. Department Reference Sheets explaining acronyms, qualifiers, and method references are also included. All of these documents are an integral part of the final data package and must always be viewed as a whole. To prevent the separation of reports, each page identifies the project number, the sequential page number, and the total number of pages in the data package. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for more detail.

If requested by a client, custom and standard Electronic data deliverables (EDDs) are generated by the Document Control department. These deliverables, containing data in client specified format, are sent by e-mail with the client report. EDDs and analytical reports access data from the same Oracle tables, thus eliminating the possibility of inconsistent results. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for more detail.

Results may be reported in a simplified manner for internal customers or in accordance to a written agreement with a customer.

18.3.1 ACZ Report Packages

ACZ provides different levels of data packages based on client request. ACZ defines the different levels as follows:

Level 2: Standard analytical reports

Level 3: Standard analytical reports; Electronic Data Deliverable (EDD); Standard QC summary

Level 4A: Standard analytical reports, Extended QC Summary (standard QC plus calibration verification checks, interference checks and serial dilutions) EDD, raw data and run logs. This package can be provided either on a disk or in a full paginated data package with the raw data

Level 4B: "CLP like" data package: CLP like forms 1-12; Run Logs and raw data incorporated into the full paginated data package.

NOTE: Surcharges apply for non-standard reports.

18.4 Data Confidentiality

ACZ has an obligation to each client to maintain custody of samples, data, and reports and to keep all data or other information confidential. To uphold this responsibility, ACZ retains custody of the information at all times – data or other client information obtained by ACZ is not allowed to leave the premises. This includes but is not limited to Chains of Custody, raw data, workgroups, run logs, logbooks, reports, QC summaries, data packages and other media containing data. Client data cannot be released to anyone except the client (as directed on the Chain of Custody) or the client's designated representative, and project data, including any client information, is not to be discussed with anyone other than ACZ employees and/or the client without first receiving written permission from the client. Additionally, client-specific information is not to be documented on raw data, workgroups, logbooks, or other records that may be provided to any client as part of an extended data package. All information must be referenced using only the ACZ log-In number. Refer to ACZ's SOP *Data Integrity Principles and Policies* (SOPAD039) for additional details of policies pertaining to confidentiality.

External access to the ACZ network is limited to employees that may need to access information remotely. Employees requiring such access use ACZ's Virtual Private Network (VPN). The VPN client is setup on the employee's computer so that it adheres to ACZ security standards. These standards include (1) a unique user name (2) a password with at least 12 characters, and (3) 128 bit encryption of data to and from the client from the ACZ servers. After the VPN server has authenticated the employee, the employee must logon to the ACZ domain through normal domain security in order to access any ACZ network resources. Most employees initiate a "Remote Desktop" connection to their office PCs, thus ensuring that ACZ data is never accessible from the client PC hard drive.

18.5 Client Feedback

Handling client feedback is a joint effort between QA, Project Managers, Laboratory Department Supervisors, and Client Service representatives. If a client has a concern or complaint, either a Project Manager or Client Service Representative takes the call and initiates the feedback procedure by documenting the complaint or problem and requesting the assistance of the Laboratory Department Supervisor and/or QA Officer. If the issue cannot be easily resolved, then it must be documented using FRMAD024, which is routed from the initiator to other appropriate parties, including the QAO if necessary. All client feedback is submitted to management as part of the Management Review of the Quality System. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

19 FACILITIES

ACZ Laboratories, Inc. inhabits a modern 31,000 square foot laboratory facility architecturally designed and specifically organized to ensure efficient operation and meet the needs of a large capacity analytical laboratory. Complete lists of instrumentation, balances, thermometers, & weight sets are maintained on a network drive. Incompatible activities are effectively separated. Refer to FRMQA066 for ACZ's floor plan.

19.1 Accommodation of Environmental Test Conditions

19.1.1 Temperature and room pressure are controlled by an HVAC system which maintains 19 independent zones. The clean room, metals lab, and organic instrument lab are kept under positive pressure to prevent contaminant infiltration. The radiochemistry and organic prep labs are kept under negative pressure to prevent the migration of fire, smoke, and chemical releases from the laboratory space. All other zones are maintained at a neutral pressure.

19.1.2 In humid environments, a sudden rise in temperature can result in condensation on microcircuitry leading to problems such as reduced life cycle, inaccurate readings, corrosion, etc. Due to the laboratory's location at 6730 feet above sea level, these concerns are irrelevant and humidity monitoring is only required for desiccators and the clean room.

19.1.3 Servers have a 20 minute backup power supply. If there is an interruption in power, the IT Manager receives a text. This provides sufficient time to ramp down the servers.

19.2 Security

A secure facility is essential to maintaining sample and data integrity and to providing safety to employees and visitors. ACZ has an electronic security system, which controls and limits access to only authorized personnel. The following steps have been taken to ensure this security:

- All entryways are secured. ACZ has three entries equipped with proximity readers which allow access to an employee only after he/she presents their access card. Access to the front visitor entry is controlled by an interior push button monitored by ACZ staff.
- All employees are required to use their access cards to enter and exit the building.
- If any employee does not have their access card, they must sign in at the front desk. This ensures a record is maintained of which personnel were in the building at any time. A temporary access card will then be activated and issued to the employee for the day. These access cards are identified by the word "Temporary" written on a scenic background.
- During normal business hours, public access into the building can be made at the front entrance and the west shipping entrance. Both doors are equipped with a buzzer.
- Visitors must enter and exit through the main entrance and must sign the register at the front desk upon arrival and before departure. A visitor pass is issued at sign in and collected at sign out. There are two types of visitor passes. A red pass identified by the word "Visitor", will not function as an access card and symbolizes the visitor requires an escort. The other visitor pass is identified by the word "Visitor Pass" written on a scenic background and will not function as an access card. This visitor does not require an escort. The determination of which pass the visitor gets is made first, by the visitor's trust level and, second, by the visitors access needs. Visitor passes must be collected when the visitor leaves for the day.
- Companies or individuals under contract to perform recurring or extensive work for ACZ are assigned an access card similar to employees. Contractor passes function as an access card for a defined period of time commensurate with the contract work.
- Emergency Exit doors are to be used only for emergency purposes. If a door is opened, an alarm will sound.
- Loaning or transferring access cards to anyone, including other ACZ employees, is prohibited.

20 RADIOCHEMISTRY

20.1 DATA TRANSFORMATION

ACZ's radiochemistry department utilizes excel spreadsheets to transform instrument response into final results. Spreadsheet equations are locked and password protected in order to reduce the likelihood of inadvertent modifications. Additionally, spreadsheet equations are validated by the radiochemistry supervisor or a sufficiently experienced analyst on an annual basis. Initial validation must be performed by hand calculating results. Annual validation may be performed by populating the current template with data that has been hand calculated in a previous validation and comparing the calculated results from the current template to the hand calculated results from the previous validation. Documented secondary review is required for all updates to spreadsheet templates (e.g. incorporating new mass attenuation coefficients).

20.2 INSTRUMENTATION

Radioanalytical instrumentation is located adjacent to the radiochemistry prep lab. In order to maintain appropriate temperature control in the instrument lab, separation must be maintained. The door between the two lab areas must be kept closed when not in use. Except as noted, instrument checks and other determinations must be performed and documented annually, or more often if necessary.

NOTE: To eliminate potential contamination, planchets must be stored in a covered container or in a drawer.

20.2.1 Gas-Flow Proportional Counter

20.2.1.1 Instrument Reliability Test (Voltage Plateau Determination) – The proper voltage plateau for alpha and beta is where the counting rate is consistent (should not exceed > 5% over a 150 volt change in anode voltage).

20.2.1.2 Cross Talk (Carryover) Check - Cross talk is defined as the percentage of alpha counts represented on the beta plateau. Once the amount of cross talk is determined, the cross talk settings are adjusted on the instrument to eliminate cross talk.

20.2.1.3 Detector Efficiency Curve (Self Absorption) - Efficiency curves are graphs plotting counts versus sample residue density and determine the efficiency of the alpha and beta counter as a function of sample residue density. This factor is part of the overall determination of sample activity.

20.2.1.4 Background Determination - Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. The background is determined weekly by counting an empty planchet for 12 hours. On each day of use the instrument is checked for background drift by counting an empty planchet for 90 minutes. Background counts must fall within established control chart limits or corrective action must be taken before analyzing samples. Although most radiation measurement systems are noteworthy for their stability, sudden changes can occur due to instrument component failure, loss of gas pressure, vacuum, or contamination of a detector or sample chamber from a high activity sample. Subsequently, instrument drift in detector efficiency and background must be checked both before and after measuring samples used for drinking water compliance monitoring. Refer to individual test SOPs for additional details.

20.2.1.5 Instrument-Response Check (Performance Check) – This continuing calibration check verifies the instrument response and stability and is performed daily for each detector. For a performance check measurement, the same calibration sources must be used as for the calibration measurement in order to verify the current measuring results still match the results of the calibration measurement stored last. At the end of the check the count rates and the relative deviations from older calibration measurements are displayed. The system signals

"OK" if the deviations do not exceed the maximum deviation defined by the user. Samples used for drinking water compliance monitoring must be bracketed by passing performance checks. Refer to individual test SOPs for additional detail.

20.2.2 Liquid Scintillation Counter

20.2.2.1 *Optimal Window* - When determining radionuclides by liquid scintillation, it is necessary to select the optimal window by counting a standard for five minutes and generating a sample spectrum. For better clarity, a log scale for the channel number axis should be used. On the graph, the region of interest is determined by the energy of the peak one is trying to quantitate. The optimal window is formed by extending this region by 10% on each side of the alpha peaks.

20.2.2.2 *Efficiency Quench Curve* – The liquid scintillation instrument, a Beckman LS 6000TA, automatically corrects for quenching by the H - Method. Refer to SOPRC010 for details.

20.2.2.3 *Background Check* - Three background blanks are run with every batch. The first two are run immediately after calibration. The third, the CCB, is employed as a measurement of instrument drift and is run immediately before the final LCS. For both checks, the counting duration must be equivalent to the longest sample counting duration.

20.2.2.4 *Instrument-Response Check Source* - This continuing calibration check verifies instrument response and stability and must be performed daily. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the source rate is outside the ±2 sigma-warning limit then the variability should be further investigated. If the source check is outside the ±3 sigma out of control limits, then no further samples should be analyzed until the problem is resolved. Resolution might include a new efficiency curve, background checks, and/or instrument maintenance. If insufficient data exists for control charts, ±10% of the initial source value is considered acceptable. The source for this check is a Tritium standard.

20.2.3 Alpha Spectrometer

20.2.3.1 *Energy vs. Channel Calibration* - Each alpha spectrometer has a set number of channels associated with it. To associate these channels to a specific alpha particle, the channels must be calibrated. One known calibrated solid source is placed into the detector and analyzed for five minutes to determine its associated channel to its calibrated energy peak. Since the energy is linear across the channels, all of the channels now have an associated energy. This determination is performed on an annual basis, or whenever maintenance is performed that could potentially affect the calibration.

20.2.3.2 *Background Checks* - Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. Placing an empty sample tray in the counting chamber and counting it for as long as the longest sample-counting duration can determine the background rate (or a background check can be completed overnight). An overnight background determination must be completed at least quarterly.

20.2.3.3 *Instrument-Response Check Source* - This continuing calibration check verifies the instrument response and stability and is performed daily. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the source rate is outside the ±2 sigma-warning limit, then the variability should be further investigated. If the source check is outside the ±3 sigma out of control limits, then no further samples should be analyzed until the problem is resolved. Resolution might include a background check, and/or instrument maintenance. If insufficient data exists for control charts then ±10% of the true value is considered acceptable.

20.2.4 Gamma Spectrometer

20.2.4.1 *Background Checks* –Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. A cave background must be measured monthly and the background gross activity recorded. The cave background is determined by counting the empty cave for a period of time at least as long as the longest sample-counting duration. When drinking water samples are present in the batch, and additional background check is measured at the end of the batch to monitor instrument drift.

20.2.4.2 *Instrument-Response Check (Performance Check)*- The total activity of a calibration or check source will check the efficiency calibration currently in use and the general operating parameters of the system, including source positioning, contamination, library values, and energy calibration. This activity calculation uses the general analysis program to ensure that the total system is checked. This check is performed for every workgroup. If the performance check is within the defined acceptance limits, instrument reliability and stability is established. If the performance check does not meet acceptance criteria, then no further samples should be analyzed until the problem is resolved. Samples used for drinking water compliance monitoring must be bracketed by acceptable performance checks. Resolution might include a background check, and/or instrument maintenance. Refer to SOPRC016 for additional information.

21 CERTIFICATIONS

ACZ has primary or secondary (reciprocal) certification with numerous states and EPA regions. Current certificates can be viewed at http://acz.com/certifications/. Each certificate contains a scope of accreditation listing each method the laboratory is accredited for by the issuing authority.

APPENDIX A REFERENCES UTILIZED BY ACZ

- “TNI Standards,” National Environmental Laboratory Accreditation Conference, (current version).
- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act," USEPA, Federal Register Vol. 67, No. 205, October 23, 2002.
- "Manual for the Certification of Laboratories Analyzing Drinking Water," USEPA, (current version).
- "Methods for the Chemical Analysis of Water and Wastes," USEPA, EPA-600/4-79-020, March 1983.
- "Test Methods for Evaluating Solid Waste," USEPA, SW-846 Third Edition, Update IV, January 2008.
- “Guidelines in Establishing Test Procedures for the Analysis of Wastewater Pollutants,” Code of Federal Regulations 40, Parts 136, 141, 143.
- "Quality Assurance of Chemical Measurements,” Taylor, J., Lewis Publishers, Michigan, 1987
- "Annual Book of Standards, Water Analysis," ASTM, 1989.
- "Quality Control in Analytical Chemistry," Kateman, G., Vol. 60, 1985.
- "Principles of Environmental Analysis, Analytical Chemistry," Keith, L.H., et al., Vol. 55, 1983.
- "Handbook for Analytical Quality Control in Water and Wastewater Laboratories," USEPA, 1979.
- “Guidance for the Data Quality Assessment: Practical Methods for Data Analysis,” USEPA, EPA 600/R-96-084, July 2000.
- “Methods for the Determination of Metals in Environmental Samples,” USEPA, EPA 600/4-91-010, June 1991.
- “Methods for the Determination of Metals in Environmental Samples,” Supplement I [to EPA 600/4-91-010], USEPA, EPA 600/R-94-111, May 1994.
- “Methods for the Determination of Inorganic Substances in Environmental Samples,” USEPA, EPA 600/R-93-100, August 1993.
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," USEPA, EPA 821/B-96-005, December 1996.
- "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," USEPA, EPA 600/4-80-032. August 1980.
- “Determination of Lead-210, Thorium, Plutonium and Polonium-210 in Drinking Water: Methods 909, 910, 911, 912,” 01A0004860 (Region 1 Library), March 1982.
- “Good Automated Laboratory Practices - Principles and Guidance to Regulations for Ensuring Data Integrity in Automated Laboratory Operations” USEPA, 2185, 1995.
- “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications”, ASTM E29-08

APPENDIX B DEFINITIONS OF TERMS

Acceptance Criteria: specified limits places on characteristics of an item, process, or service defined in requirement documents.

Accreditation: verification by a competent, disinterested, third party that a laboratory possesses the capability to produce accurate test data, and that it can be relied upon in its day-to-day operations to maintain high standards of performance.

Accrediting Body: The Territorial, State, or Federal agency having responsibility and accountability for environmental laboratory accreditation and which grants accreditation.

Accreditation body: Authoritative body that performs accreditation.

Accuracy: the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator.

Aliquot: A discrete, measured, representative portion of a sample taken for analysis.

Analyte: The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family, and which are analyzed together. (EPA Risk Assessment Guide for Superfund; OSHA Glossary)

Analytical Spike (AS): an aliquot of client sample to which a known amount of target analyte is added and that demonstrates the absence or presence of interference in the matrix. The AS is prepared exactly the same way as the LFB, only spiking into sample instead of reagent blank, and is not prepped (digested) prior to analysis. The AS may also be referred to as a post-digestion spike.

Analytical Spike Duplicate (ASD): a second replicate analytical spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

Analytical System: the combination of events, techniques, and procedures used to generate analytical results.

Analyst Review (AREV): See Primary Review.

Atomization: A process in which a sample is converted to free atoms.

Audit: a systematic evaluation to determine the conformance to quantitative and qualitative specifications of some operational function or activity.

Batch: environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same matrix, meeting the above criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of 20 or less prepared environmental samples (extracts, digestates or concentrates) that are analyzed together as a group. QC samples (e.g. LCS, MS, MSD) do not count towards the maximum of 20.

All required QC samples must be prepared and/or analyzed with each batch at the frequency required by the method, even if there are less than 20 client samples in the batch. If the workgroup has more than 20 samples, then sufficient batch QC must be analyzed for additional samples. Every batch of environmental samples is assigned a unique (i.e. traceable) six-digit numerical identifier called the LIMS Workgroup number.

Blank: a sample that has not been exposed to the analyzed sample stream utilized to monitor contamination during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. See also Equipment Blank, Field Blank, Instrument Blank, Method Blank, Reagent Blank. Refer to §11.3 for types of blanks.

Blind Sample: a sub-sample for analysis with a composition known to the submitter. The analyst or laboratory may know the identity of the sample but not its composition. It is used to test the analyst or laboratory's proficiency in the execution of the measurement process.

Calibration: to determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter, instrument, or other device. The levels of applied calibration standard should bracket the range of planned or expected sample measurements.

Calibration Curve: the graphical relationship between the known values, such as concentrations, or a series of calibration standards and their instrument responses.

Calibration Range: The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.

Case Narrative: Additional documentation provided in the client report that describes any abnormalities and deviations that may affect the analytical results and summarizes any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data.

Certified Reference Material (CRM): A reference material one or more of whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate or other documentation which is issued by a certifying body.

Chain of Custody Form: a legal record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; the collector; time of collection; preservation; and requested analyses.

Client: Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations. (ANSI/ASQ E4-2004)

Confirmation: Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to:

- Second column confirmation;
- Alternate wavelength;
- Derivatization;
- Mass spectral interpretation;
- Alternative detectors; or
- Additional cleanup procedures. (TNI)

Conformance: An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements. (ANSI/ ASQC E4-1994)

Congener: A member of a class of related chemical compounds (e.g., PCBs, PCDDs)

Continuing Calibration Blank (CCB): the same solution as the calibration blank, it detects baseline drift in the calibration of the instrument. When specified by the method, analyze a CCB immediately after each CCV, including the final CCV.

Continuing Calibration Verification (CCV): a solution of method analytes of known concentrations used to confirm the continued calibration of the instrument. The CCV is analyzed at the frequency indicated in the test SOP.

Corrective Action: the action taken to eliminate the causes of an existing nonconformity, defect, or other undesirable situation in order to prevent recurrence.

Data Audit: a qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e. the data meet specified acceptance criteria)

Data Reduction: the process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more useable form.

Definitive Data: Analytical data of known quality, concentration, and level of uncertainty. The levels of quality and uncertainty of the analytical data are consistent with the requirements for the decision to be made. Suitable for final decision-making. (UFP-QAPP)

Demonstration of Capability (DOC): a procedure to establish the ability of the analyst to generate acceptable accuracy [and precision, if applicable].

Detection Limit: the lowest concentration or amount of target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive value (see Method Detection Limit).

Digestion: A process in which a sample is treated (usually in conjunction with heat) to convert the sample to a more easily measured form.

Document Control: the act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly, and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

Eluent: A solvent used to carry the components of a mixture though a stationary phase. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Elute: To extract; specifically, to remove (adsorbed material) from an adsorbent by means of a solvent. (Merriam-Webster's Collegiate Dictionary, 2000)

Elution: A process in which solutes are washed though a stationary phase by the movement of a mobile phase. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Equipment Blank: a sample of analyte-free media that has been used to rinse common sampling equipment to check the effectiveness of decontamination procedures.

False Positive (Type I or alpha error): concluding that a substance is present when it truly is not.

False Negative (Type II or beta error): concluding that a substance is not present when it truly is.

Field Blank: a blank prepared in the field by filling a clean container with Type I water and appropriate preservative, if any, for the specific sampling activity being undertaken.

Holding Time (Maximum Allowable Holding Time): the maximum time that samples may be held prior to analysis and still be considered valid or not compromised.

Homologue: One in a series of organic compounds in which each successive member has one more chemical group in its molecule than the next preceding member. For instance, CH3OH (methanol), C2H5OH (ethanol), C3H7OH (propanol), C4H9OH (butanol), etc., form a homologous series. (*The Condensed Chemical Dictionary* G.G. Hawley, ed. 1981)

Initial Calibration Blank (ICB): a solution identical to the calibration blank and confirms the absence of background contamination in the calibration blank. When specified by the method, an ICB is analyzed immediately after the ICV.

Initial Calibration Verification (ICV): a solution of method analytes of known concentrations intended to determine the validity of the instrument calibration. The ICV must be analyzed immediately after each calibration and must be prepared from a source independent of the calibration standards, preferably purchased from a different manufacturer.

Instrument Blank: an aliquot of Type I water or solvent processed through the instrument steps of the measurement process; used to determine presence of instrument contamination.

Interference, spectral: Occurs when particulate matter from the atomization scatters the incident radiation from the source or when the absorption or emission of an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Interference, chemical: Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Internal Standard (IS): a known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

Isomer: One of two or more compounds, radicals, or ions that contain the same number of atoms of the same elements but differ in structural arrangement and properties. For example, hexane (C_6H_{14}) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane. (Websters)

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample): a sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.

Laboratory Fortified Blank (LFB): a reagent blank spiked with a known concentration of analyte. The LFB is analyzed exactly like a sample and determines whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

Legal Chain of Custody Protocols: procedures employed to record the possession of samples from the time of sampling until analysis and are performed at the special request of the client. These protocols include the use of a Chain of Custody form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.

Linear Dynamic Range (LDR): concentration range over which the instrument response to analyte is linear.

Matrix Duplicate (DUP): a second aliquot of a client sample that is prepared and analyzed in the same manner as all other samples in the same workgroup. The DUP demonstrates the precision of the method.

Matrix Spike (spiked sample or fortified sample): a sample prepared by adding a known amount of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes (MS or LFM) are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

Matrix Spike Duplicate: a second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

Maximum Contamination Limit (MCL): the numerical value expressing the maximum permissible level of contaminant in water that is delivered to any user of a public water system.

May: denotes permitted action, but not required action.

Measurement Quality Objectives (MQOs): The desired sensitivity, range, precision, and bias of a measurement.

Measurement System: A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s).

Method Blank: a sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as client samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for the sample analyses.

Method Detection Limit: the minimum concentration of an analyte, in a given fortified matrix, that can be measured and reported with 99% confidence that the concentration is greater than zero.

Method of Standard Additions: A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration. (This process is often called spiking the sample.) (Modified Skoog, Holler, and Nieman. Principles of Instrumental Analysis. 1998)

Must: denotes a requirement.

Negative Control: Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.

Nonconformance: An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also the state of failing to meet the requirements.

Outlier (Statistical): an observation or data point that deviates markedly from other members of the population.

Performance Audit: the routine comparison of independently obtained qualitative and quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory.

Positive Control: Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.

Precision: the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

Preservation: refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical and/or biological integrity of the sample.

Primary Review (AREV): The first level of data review conducted after data has been generated and uploaded to LIMS. Primary review is typically conducted by the analyst who generated the data but may be performed by another authorized individual. Quality control and corrective actions are evaluated as part of this review. Where acceptance criteria fails, samples are scheduled for re-preparation and/or re-analysis or data is appropriately qualified.

Proficiency Testing: A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.

Proficiency Testing Program: The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories. (TNI)

Proficiency Testing Study Provider: Any person, private party, or government entity that meets stringent criteria to produce and distribute TNI PT samples, evaluate study results against published performance criteria and report the results to the laboratories, primary accrediting authorities, PTOB/PTPA, and TNI.

Proficiency Test Sample (PT): A sample, the composition of which is unknown to the analyst and is provided to test whether the analyst/laboratory can produce analytical results within specified acceptance criteria. (QAMS)

Protocol: a detailed written procedure [SOP] for laboratory operation that must be strictly followed.

Quality Assurance: an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality.

Quality Control: the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.

Quality Manual [QAP]: a document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.

Quality System: a structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products, and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control.

Quantitation Limit [Limit of Quantitation, Practical Quantitation Limit]: level, concentration, or quantity of a target variable (i.e. target analyte) below which data is reported as estimated. The quantitation limit may or may not be statistically determined, or may be an estimate that is based upon analyst experience or judgment.

Quantity Sufficient (QS): Refers to the addition of appropriate diluent to the solution to achieve the final volume.

Raw Data: any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for reconstructing and evaluating the report of the activity or study.

Reagent Blank (method reagent blank): a sample consisting only of Type I water and reagent(s) without the target analyte(s) or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.

Reference Method: a method of known and documented accuracy and precision issued by an organization recognized as competent to do so (EPA, etc.). The reference method is included on the client report.

Reporting Limit (RL): The lowest analyte level (concentration or mass) the laboratory will report as a detected result. ACZ's default reporting limit is the MDL; however the RL may be defined as the PQL or another level dependent on project needs.

Retention Time: The time between sample injection and the appearance of a solute peak at the detector. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Sample: Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis

Sample Tracking: procedures employed to record the possession of the samples from the time of sampling until analysis, reporting, and archiving. These procedures include the use of a Chain of Custody form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.

Secondary Review (SREV): The second level of data review conducted after primary review (AREV) has been completed. Secondary review is typically conducted by the pertinent department supervisor but may be performed by another authorized individual. Quality control and corrective actions are evaluated as part of this review. Data qualifiers and sample statuses assigned at AREV are evaluated and corrected if necessary.

Selectivity: (Analytical chemistry) The capability of a test method or instrument to respond to a target substance or constituent in the presence of non-target substances. (EPA-QAD)

Sensitivity: the capability of a method or instrument to discriminate between measurement responses representing different levels (i.e. concentrations) of a variable of interest.

Shall: denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there is no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification so long as the requirement is fulfilled.

Should: denotes a guideline of recommendation whenever noncompliance with the specification is permissible.

Signal to Noise Ratio (S/N): a dimensionless measure of the relative strength of an analytical signal (S) to the average strength of the background instrumental noise (N) for a particular sample.

Spike: a known amount of target analyte added to a blank sample or client sub-sample; used to determine the recovery efficiency or for other quality control purposes.

Standard Deviation: the measure of the degree of agreement (precision) among replicate analyses of a sample. The population standard deviation (n degrees of freedom) should only be used for more than 25 data points; otherwise, when referenced, standard deviation implies sample standard deviation (n-1 degrees of freedom).

Standard Operating Procedure (SOP): a written document which details the manner in which an operation, analysis, or action is performed. The techniques and procedures are thoroughly prescribed in the SOP and are the accepted process for performing certain routine or repetitive tasks.

Supervisor [however named]: the individual designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training, and experience to perform the required analyses.

Surrogate (SURR): a substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them for quality control purposes.

Test Method: adoptions of a scientific technique for a specific measurement problem, as documented in a laboratory SOP or published by a recognized authority.

The NELAC Institute (TNI): a voluntary organization of state and federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories.

Traceability: the property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

Tuning: A check and/or adjustment of instrument performance for mass spectrometry as required by the method.

Validation: The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Verification: Confirmation by examination and provision of evidence that specified requirements have been met.

APPENDIX C TECHNICAL DIRECTORS

Name	Department	Degree
Steve Pulford	Metals	BS, Chemical Engineering, Minor in Biochemistry
Gus Torde	Organics	BS, Chemistry
Alyssa Dybala	Wet Chemistry	BS, Pharmaceutical Marketing
Matt Sowards	Radiochemistry (reserve)	BA, Neuroscience
Brian Uhrig	Wet Chemistry	BS, Biological Sciences
Brett Dalke	Geochemistry	BA, Geology & English
Mark McNeal	Radiochemistry	BS, Biology
If a technical director is absent for a period exceeding fifteen calendar days, another qualified full time employee shall be assigned to temporarily fulfill the duties of technical director. Defined reserve technical directors shall assume these duties by default. Where reserves are not yet defined, management shall appoint a qualified individual as necessary. If a technical director is absent for more than 34 days, it is the QAO's (or delegee's) responsibility to notify accrediting bodies in writing.		

ENERGY LABORATORIES-CASPER, WY QUALITY ASSURANCE MANUAL

Revision July 27, 2017

Energy Laboratories, Inc.

2393 Salt Creek Hwy.
PO Box 247
Casper, Wyoming 82602

Toll Free (888) 235-0515
Local: (307) 235-0515
Fax: (307) 234-1639
E-mail: casper@energylab.com

____
Laboratory Manager
Chrystal Sheaff, Ph.D.

____
Technical Director
Steven E. Carlston

____
Quality Assurance Officer
Donny Juarez

____

TABLE OF CONTENTS

ELI COMMITMENT

Energy Laboratories, Inc. Strives Toward:

1. Being highly skilled in the field of analytical chemistry.
2. Delivering quality and service with integrity.
3. Encouraging the professional development of our staff.
4. Offering our employees a safe and positive work environment.
5. Being profitable and using resources wisely for a sustainable future.

INTRODUCTION

Energy Laboratories, Inc. provides chemical, industrial hygiene, and environmental analytical services to private industry, agricultural industry, engineering consultants, government agencies, and private individuals. Analytical services include: analysis of waters and soils for inorganic and organic constituents, aquatic toxicity testing, hazardous waste analysis, radiochemistry, industrial hygiene, microbiology, soils and water physical parameters, and petroleum analysis.

Founded in 1952, Energy Laboratories currently incorporates four separate testing laboratories. The corporate headquarters are located in Billings, MT, with laboratories located in Casper, WY; Gillette, WY; and Helena, MT.

ELI, as a coordinated company of four participating laboratories, has developed a QA program that takes into account the various method types and EPA programs, while also considering sample matrices, to develop a single comprehensive set of QA guidance. We have used scientific approaches, Good Laboratory Practices, EPA Methods and Guidance documents, and accreditation audit guidance to develop our overall QA Program.

The Quality Assurance Program establishes acceptable performance criteria for all routine analytical procedures being performed by laboratory personnel. The Quality Assurance Assessment Program provides a formal system for evaluating the quality of data being generated and reported. This, in addition to the experience and expertise of our analysts, provide a comprehensive Quality Assurance Program. Energy Laboratories, Inc., in Casper, Wyoming, is certified under the Safe Drinking Water Act by Region (SDWA) VIII EPA. Individual state approval for SDWA is managed through reciprocal certifications when required by a specific state. ELI-Casper also holds accreditation for Clean Water Act, Safe Drinking Water Act and Resource Conservation Recovery Act (RCRA) parameters through the National Environmental Laboratory Accreditation Program (NELAP), which is supported by the EPA. The NELAP certification is maintained through the state of Florida. Individual state approval for CWA (NPDES), SDWA, and RCRA is managed through the Federal/State DMRQA program or through reciprocal certifications when required by a specific state. To perform radon testing, ELI Billings is certified under the National Radon Proficiency Program administered by the National Environmental Health Association. ELI-Casper also maintains a United States Nuclear Regulatory Commission (USNRC) Materials License and therefore conducts all radiological effluent and environmental monitoring of licensed facility's samples in accordance with the guidelines set forth in *REGULATORY GUIDE 4.15 - QUALITY ASSURANCE FOR RADIOLOGICAL MONITORING PROGRAMS (INCEPTION THROUGH NORMAL*

OPERATIONS TO LICENSE TERMINATION) EFFLUENT STREAMS AND THE ENVIRONMENT. This Quality Assurance Manual contains the above guidance document's QA program elements that ensure the quality of the data for radiological effluent and environmental monitoring programs. Copies of ELI's certificates and licensing for all laboratories are maintained on ELI's website: www.energylab.com.

The ELI Quality Assurance Manual and the ELI Professional Services Guide together are used to outline the ELI Quality Assurance/Quality Control Program. This Quality Assurance Manual is appropriate to all departments of Energy Laboratories-Casper. The procedures discussed or referenced in this manual describe our day-to-day laboratory practices and adhere to USEPA Safe Drinking Water Act, and TNI (The NELAC Institute) requirements as well as Good Laboratory Practices (GLPs). Information on ELI-Casper's, and all other ELI laboratories', applicable accreditations and certifications are maintained on the ELI website at www.energylab.com. Where possible, ELI uses EPA, AOAC, ASTM, APHA, NIOSH, OSHA, or published analytical methods and follows the procedures with strict adherence to described protocol and recommended QA/QC parameters. The analytical methods approved and in use are described in Standard Operating Procedures, and are available for review at the laboratory. Vital parts of our Quality Assurance Program, Quality Control and Quality Assessment programs are outlined in Chapters One and Two of this manual.

To generate data that will meet project-specific requirements, it is necessary to define the type of decisions that will be made and identify the intended use of the data. Data Quality Objectives (DQOs) are an integrated set of specifications that define data quality requirements and the intended use of the data. Project-specific DQOs will be established as needed for both field and lab operations. Through the DQO process, appropriate reporting limits, extraction/digestion methods, clean-up methods, analytical methods, target analytes, method quality control samples, sample security requirements, quality control acceptance ranges, corrective action procedures, reporting formats and reporting limits can be specified. Professional laboratory project managers are available to assist clients in specifying appropriate laboratory analyses and reporting procedures necessary to meet project requirements.

Client-specific DQOs can be coordinated with the laboratory through our Project Managers via quotations or contracts, or with relevant documentation provided to the laboratory prior to (or at time of) sample receipt. Client-specific requirements are communicated to analysts and final report validators through the laboratory LIMS system. By default, our methods, analytes, and QC parameters are set up to meet the DQOs specified in the referenced method and/or federal/state regulations. ELI encourages clients to provide ELI documentation of any client-specific, regulatory or project monitoring requirements.

Certain types of requests may not be suitable to standardized analytical methods. These custom requests are handled individually with laboratory management and staff scientists. Project-specific methods and reporting packages are available. Attention to documentation of the analytical procedure and use of suitable QC parameters is maintained according to good scientific discipline and Good Laboratory Practice guidelines.

The ELI-Casper Laboratory Manager, or their designee, will evaluate all new contracts to determine that the laboratory is capable of performing the requested work. This process includes ensuring that the laboratory maintains the required accreditation, equipment and resources. In the event that sample analysis is not performed at our Casper location, clients are notified, on the laboratory analytical report, if the work is subcontracted to a qualified ELI laboratory or an outside laboratory (See Subcontracting Policy – Chapter 6 in this QA Manual).

This Quality Manual and related quality documentation meet requirements of the National Environmental Laboratory Accreditation Program (NELAP), which is an EPA approved accreditation program.

CHAPTER 1 – QUALITY CONTROL PROGRAM

Quality Policy Statement

Energy Laboratories, Inc. is committed to producing laboratory data of known and documented quality that is scientifically valid, meets method specifications, satisfies regulatory requirements, and accomplishes the data quality objectives of the client and project. Management ensures that the laboratory maintains current certifications and is in compliance with accreditations through USEPA, State Agencies, and NELAP. Those method, regulatory, and client requirements (as well as the policies, procedures, and all referenced documents) are incorporated into our Quality Assurance Program; which is outlined within this Quality Assurance Manual. Our Quality Systems are designed to comply with the standards as defined by the most current version of the NELAC accreditation standard and ISO 17025 standards. To ensure compliance with these standards, all laboratory personnel are required to be familiar with quality documentation and implement those policies and procedures in their work. ELI is dedicated to the continual improvement of the management system's effectiveness by providing appropriate corporate resources to set objectives, offering training opportunities, and monitoring the quality performance of our staff. ELI also provides facilities and equipment adequate and appropriate to these objectives.

Quality Assurance Program

The purpose of the Quality Assurance Program is to ensure that the analytical services provided by Energy Laboratories are of high quality, data is within established accuracy and precision limits (required by the referenced method or Standard Operating Procedure), and each analytical result produced meets or exceeds our accreditation requirements. Management ensures that the integrity of the management system is maintained. The Technical Directors, or their designees, ensure that changes to the management systems are planned, implemented and documented.

Management establishes and maintains data integrity by providing the following to ELI's data integrity system:

1) Data Integrity Training (Including the highest standards of ethical behavior)
2) Periodic review of data integrity procedural documentation
3) Annual review of data integrity procedures with updates as needed
4) Periodic, in-depth monitoring of data integrity
5) Maintenance of signed data integrity documentation for all laboratory employees

All employees are expected to implement and follow the policies contained within the Quality Assurance Program.

The quality systems in the program consist of the policies and procedures, and all referenced documents, described in this Quality Assurance Manual. The Quality Control Program also functions to maintain the laboratory's compliance with accreditations through USEPA, State Agencies, and NELAP.

The Quality Control Program requires that the following points be met for each applicable analytical method:

- Performance of any analytical method requires that the proper equipment and instrumentation are available. A list of major equipment is listed in Appendix D. The procedure for operation of an analytical instrument is described in the equipment manufacturer's operating manual, and may also be supplemented with a specific Standard Operating Procedure (SOP) for the instrument and/or the method.

- Specific SOPs cover operation of the instrument including the sequence of operations involved in instrument start-up, calibration, analysis, and shut down. Chapter 13 of this manual includes recommended preventative maintenance, and/or a list of parameters used to identify other types of maintenance. SOPs outline any special safety precautions for operation of the instrumentation.

- SOPs of detailed Standard Methods, EPA, ASTM, NIOSH, APHA, OSHA, or other published procedures include, as appropriate, a list of any method-specific items or variances, a list of QC parameters and their recommended method performance ranges, recommended or example analytical sequences, specific or unique safety information, method references, and a signed signature page. SOPs details, and format of method SOPs, follow NELAP requirements. Detailed SOPs may be prepared for those procedures that do not have published methods. Further details of SOP format and information required in method SOPs can be found in the ELI SOP, *Preparation, Numbering, Use, and Revision of Standard Operating Procedures.* Written Standard Operating Procedures referenced within this manual are available at the laboratory for review. (ELI SOPs are considered confidential proprietary information).

- For radiochemical analysis performed at ELI-Casper and other ELI's laboratories, each method undergoes Method Validation as outlined in EPA's specific method and/or the Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP), Chapter 6.

- The required detection level (RDL) for radiochemical analysis of drinking water samples is calculated based on the requirements in 40 CFR 141.25(c), which is a sample specific determination. The equation is specific for each method and noted in the method-specific SOP where appropriate.

- The initial test method evaluation for chemical analysis involves Method Detection Limit (MDL) studies, (refer to ELI SOP, *Determination of Method Detection Limits (MDL) and Quantitation Limits*), confirmation of the Limit of Detection (LOD) and/or Practical Quantitation Limit (PQL), also known as the Limit of Quantitation (LOQ), an evaluation of method performance (using four or more replicates of quality control samples), evaluation of the selectivity of the method, and any additional method-specific requirements.

  ELI demonstrates that laboratory staff members are qualified and capable of performing the method. Analysts are assigned duties based on their skills and experience. Training records are maintained for all analysts. Curricula vitae of key management and supervisory personnel are described in Appendix C.

- It is the responsibility of the analyst to become thoroughly familiar with the methodology and instrument operation before performing the analysis. It is the responsibility of the person providing training to monitor all laboratory results generated for a reasonable time. The amount of time necessary may vary depending on the method and the experience of the analyst. At a minimum, the analyst's performance is to be monitored until the analyst demonstrates the ability to generate results of acceptable accuracy and precision according to the method.

- All analysts are required to demonstrate and maintain a record of proof of competency by routinely analyzing quality control samples appropriate to the analytical procedures they perform. Competency in analyzing these control samples is documented in analysts' training files per NELAP requirements (for more information, see ELI SOP, *Personnel Training and Training Records*). For those analyses where external proficiency testing (PT) samples are not routinely analyzed, competency is documented by including the results of routine analysis of method-specific quality control samples (prepared by laboratory staff) and/or a verifying statement of procedural review by a supervisor or trained analyst.

- Each analytical method is subjected to quality control monitoring. The purpose is to demonstrate that results generated meet acceptable accuracy and precision criteria for the method. Precision and bias are determined for standard and non-standard methods. Precision and bias are determined for standard methods through control charting of data from quality control samples. Precision and bias using non-standard, modified standard or laboratory-developed methods are compared to the criteria established by the client (when requested), the method, or the laboratory.

- Quality control requirements are outlined in the methods and ELI, at a minimum, follows the guidelines specified in the methods used. Additional QC requirements are also added as appropriate. Performance is periodically evaluated against method requirements using control charts.

- Quality control monitoring to measure accuracy for each method generally requires that five to ten percent of all samples analyzed be fortified (spiked) with a known concentration of target analytes tested by the method. The percent recovery is then calculated. This provides a means for monitoring method accuracy and evaluating sample matrix effects. Where appropriate, surrogates are included in the method to monitor method performance on each individual sample. Blank spike samples replace matrix spike samples for certain methods, or when there is insufficient sample for a matrix spike analysis. Historical, routine batch QC sample performance can be used to estimate the precision and accuracy of the method.

- Quality control monitoring to measure precision for each method requires replicate samples be prepared and analyzed when appropriate. Actual requirements are outlined in the specific SOP. When replicate samples or matrix spike duplicates are analyzed, relative percent difference is calculated and used to monitor precision of the method. In instances where there are no specific method requirements, it is the policy of this laboratory to analyze five to ten percent of all samples in duplicate. Duplicate test results must be within the control limits established for each analysis type or data is qualified. Acceptance limits generally follow specifications listed in the method. Matrix spike duplicates replace sample duplicates for most methods.

- When not defined in the method, method blanks and/or instrument blanks are analyzed one in every 20 samples at a minimum. Method blanks are used to verify that contamination from laboratory reagents and glassware is not present in the analytical sample process. Generally, the method blank should be less than the reporting limit, or 10 times less than the concentration amount in the sample, for the analytical parameter being tested, whichever is greater.

- When method spike frequency is not defined in the method, method spikes (blank spikes) are analyzed one in every 20 samples at a minimum. Excluding methods with no method spike requirements.

- Calibration standards are analyzed and calibration curves are developed for all applicable methods. For additional information on instrument calibration, see Chapter 7 of this QA manual.

- The initial calibration is continuously monitored by analyzing a continuing calibration standard every 10 to 20 samples, or within a specified time frequency, and at the end of each analytical sequence; depending on the method and instrumentation. Results must be within an established range as described by the method SOP. Initial calibrations are verified against a standard from a second source.

- Proficiency testing samples and further quality control check samples may be required for various methods. Refer to Chapter 2 of this QA manual for further details.

Estimation of Uncertainty

The estimation of uncertainty consists of the sum of the uncertainties of the individual steps or processes of an analytical procedure. The variability of the sampling plan, sample heterogeneity, extraction procedure, instrument calibration, instrument drift, systematic bias, and many other factors all contribute to the uncertainty of a measurement or result.

ELI estimates uncertainty utilizing Confidence Intervals defined as $\pm 2\sigma$ (95%) and $\pm 3\sigma$ (99%) where σ is the standard deviation of the recovery of quality control samples. The confidence intervals calculated from these QC samples are based on the spike level concentrations for each method. Uncertainty at low concentrations may be one to three times the quantitation limit. Real world samples, depending on matrix interferences, may have a greater amount of uncertainty associated. Due to limitations in assessing the uncertainty for each matrix type, the confidence intervals calculated from method QC samples provides an estimate of uncertainty.

Energy Laboratories, Inc. uses the procedures outlined in ELI SOP, *Control Chart Generation and Maintenance*, for the purpose of evaluating estimation of uncertainty for chemical analyses and uses the determination of uncertainty on a sample-specific basis for all radiochemistry measurements. These estimates of uncertainty have formulas documented in the individual SOP.

Maintenance of Performance Records

All quality control monitoring is recorded and documented. Quality control data is recorded in laboratory notebooks, electronic summary files, and/or analysis sheets. Generally, review of QC data and trends is managed within the Laboratory LIMS system. QC data management and control chart generation, maintenance, and usage are described in ELI SOP, *Control Chart Generation and Maintenance*. It is the responsibility of the analyst to see that all results are recorded in a timely manner.

All quality control data is filed and available for inspection and assessment by analysts, supervisors, management, and quality control personnel.

Method Quality Control Specifications

A general summary of Quality Assurance/Quality Control specifications are outlined in Appendix A. Exact details of method QC can be found in the applicable method SOPs. These types of QA parameter tables are available upon approved request for our clients to use in the preparation of Quality Assurance Project Plans (QAPPs).

CHAPTER 2 – QUALITY ASSESSMENT PROGRAM

The function of the Quality Assessment Program is to provide formal evaluation of the quality of data being generated and reported by the laboratory. External and internal quality control measures are used in this assessment. These measures include proficiency testing samples, laboratory quality control check samples, and routine internal and external audits on methodology and documentation procedures.

Proficiency Testing (PT) Samples

PT samples are supplied by an outside entity and contain known amounts of constituents. The laboratory does not have access to known values of the samples. Only the PT provider has knowledge of constituent levels prior to the formal publishing of the test results.

PT samples are received on a minimum bi-annual basis, with results sent to the providing entity for evaluation. Proficiency Testing (PT) samples for USEPA, NELAP and various State certifications are Water Pollution Study samples (WP or DMRQA), Water Supply Study samples (WS), and LPTP Soil PT samples provided by either Sigma-Aldrich and/or Environmental Resource Associates (ERA); both being NELAP approved PT providers. Routine participation in LPTP, WS and WP PT sample studies is used to maintain certifications for Safe Drinking Water Act (SDWA), Clean Water Act (CWA), National Pollutant Discharge Elimination System (NPDES), Discharge Monitoring Report Quality Assurance (DMRQA), permit monitoring analyses, Resource Conservation and Recovery Act (RCRA) analyses, as well as other states and projects requiring method accredited parameter analyses. The samples are analyzed in the same manner as any routine sample in the laboratory. Acceptable results are those that fall within a defined range as determined by the vendor/EPA/NELAP; based on multi-laboratory study results. The provider sends results to USEPA and other certifying agencies as requested by ELI-Casper. PT study results are posted on the ELI website www.energylab.com.

A copy of the certificate for our primary certifications to perform drinking water analyses issued by the Environmental Protection Agency (USEPA) and the NELAP certificate from Florida Department of Health are maintained on the ELI website at www.energylab.com. The EPA certification includes a list of parameters/methods for which drinking water certification has been granted. The NELAP certificate also includes RCRA methods used for hazardous waste characterizations and CWA parameters/methods which are used for NPDES monitoring permits. ELI also participates in the Federal/State DMRQA programs for clients which require/request this with their NPDES permits. Reciprocal accreditation in other states is based on either of these, or both, depending on specific state certification requirements/parameters. A list of current certifications is maintained on the ELI website at www.energylab.com.

Blind Quality Control Check Samples are samples submitted as regular lab samples and are processed through the system in the same manner as any other routine environmental sample. The analysts do not know the true values of these samples when performing the analyses. Method performance reports are returned to the analysts. Clients occasionally submit these types of samples for their QAPP.

Inter-Laboratory comparison samples are samples containing known or unknown quantities of analytes that are split and analyzed by more than one laboratory.

Quality Control Check Samples

Quality Control Check Samples are performance evaluation samples used for routine method performance monitoring. As appropriate, analytical procedures include the analysis of a quality control sample with every sample batch analyzed. The materials are obtained from a commercial source when available, or they may be prepared in-house. Acceptable results are within a defined range based on certified ranges, or against statistically determined control limits, method-defined criteria or client defined Data Quality Objectives. Routinely used methods not subjected to PT sample monitoring are evaluated with Quality Control Check Samples, as appropriate.

QC samples are processed through the system in the same manner as any other sample, except the analyst is aware of the source, concentration, and acceptance ranges of target analytes and calculates analyte recoveries to evaluate method performance in real time.

Quality Assurance Audits

Quality Assurance Audits consist of internal and external laboratory inspections designed to monitor adherence to Quality Systems and quality control requirements. These audits check general laboratory operations, overall Quality Systems, adherence to QA program requirements, sample tracking procedures, sample holding times, storage requirements, adherence to procedures during analysis, calculations, completion of required quality control samples within the group surrounding the sample, and proper record-keeping.

Internal quality control audits are conducted or coordinated by the Quality Assurance Officer of the laboratory. See ELI SOP, *Internal Quality Assurance Audits*, for further information. ELI conducts internal inspections on a regular basis to monitor adherence to quality control requirements. Results of formal audits are given to management with possible recommendations for corrective action in the event any discrepancies are found. As necessary, a follow-up review is conducted to determine that identified problems have been addressed. Annually, the overall quality systems of the laboratory are reviewed and a summary report is prepared.

Per NELAP/ISO 17025-2005 requirements, the management of the laboratory will conduct an annual review of the Quality System, including policies, procedures and environmental testing activities. This is done to ensure the continuing suitability and effectiveness of the QA systems, as well as provide the opportunity to introduce necessary changes or improvements. The review shall take into account, at a minimum, the following:

- The suitability of policies and procedures
- Reports from managerial and supervisory personnel
- The outcome of recent internal audits
- Corrective and preventative actions
- Assessments by external bodies
- The results of inter-laboratory comparisons or proficiency tests
- Changes in the volume and type of work
- Client feedback
- Complaints

- Recommendations for improvement
- Other relevant factors, such as quality control activities, resources and staff training

The findings from management reviews and the corrective actions that arise from these findings shall be recorded. The management shall ensure that any corrective actions are carried out within an appropriate, pre-determined time frame.

ELI welcomes external Quality Assurance Audits, by qualified outside auditors, for review and comment on the overall QA program. To maintain certifications, accrediting authorities from the USEPA and NELAP conduct periodic comprehensive external audits. External audits to meet Quality Assurance Project Plans (QAPPs), as applicable to environmental remediation projects, or for major industries, are conducted as requested. For more information, see ELI SOP, *External Quality Assurance Audits*.

CHAPTER 3 – LABORATORY FACILITIES

The Energy Laboratories, Inc. – Casper, WY facilities consists of three buildings located at 2393 Salt Creek Highway, Casper, WY 82601.

The phone number for Casper's Energy Laboratories, Inc. is (307) 235-0515, the fax number is (307) 234-1639, the toll free number is 888-235-0515, the email address is casper@energylab.com, and the website is www.energylab.com.

Laboratory space includes adequate bench top and floor space to accommodate periods of peak work load. Working space includes sufficient bench top area for processing samples; storage space for reagents, chemicals, glassware, bench and portable equipment items; floor space for stationary equipment; and adequate associated area for cleaning glassware. Laboratory departments are organized and the facilities are designed for specific laboratory operations in order to protect the safety of analysts and to minimize potential sources of contamination between and within department areas (for more information, see ELI SOP, *Facility Description, Access, and Security*).

The laboratory is appropriately ventilated and illuminated, and is not subject to excessive temperature changes. Specific laboratory areas are temperature and humidity controlled as required. Ample cabinets, drawers and shelves are available for storage and protection of glassware. Exhaust fume hoods are available as needed for use during preparation, extraction, and analysis of samples. Employee exposure monitoring is conducted to provide a safe working environment.

To maintain security, all visitors must enter their name on the ELI sign-in log at the front desk and wear a visitor's badge.

The laboratory has provisions for the disposal of chemical, radiochemical and microbiological wastes. These provisions are described in Standard Operating Procedures. For more information, see ELI SOPs, *General Laboratory Waste Disposal*, and *Radiochemistry Waste Disposal*.

CHAPTER 4 – PERSONNEL REQUIREMENTS AND LABORATORY ORGANIZATION

Relationship between Management, Technical Operations, Support Services and the Quality System

Laboratory Organization

The corporate organization of the four ELI laboratories located in Montana (2) and Wyoming (2) is provided in Appendix B. The Billings laboratory is the center for all corporate functions. Each laboratory is managed and operated individually under the supervision of a Laboratory Manager. All ELI laboratories have fiscal and QA/QC responsibilities to the corporate office, as well as general operating policies and goals. Quality Assurance Manuals are prepared individually for each laboratory and follow the QA/QC program outlined in the ELI-Billings QA manual.

The ELI-Casper Organizational Chart is also included in Appendix B with curricula vitae of key ELI-Casper laboratory personnel maintained in Appendix C of this manual. Job descriptions are maintained by the Human Resources Department.

Quality Assurance receives direct support from senior management. Laboratory Quality Assurance Officers report directly to the Corporate Quality Assurance Officer as well as the Laboratory Manager. Quality Assurance Officers provide independent oversight of Quality Systems within the overall Energy Laboratories structure. When Quality Assurance Officers fill more than one role within the organization, they operate independently of direct environmental data generation while fulfilling quality assurance responsibilities. Quality Assurance Officers facilitate development of and maintain the Quality Assurance Manual, provide assistance to personnel on quality assurance / quality control issues, maintain a quality assurance training program, and review quality documentation including SOPs.

Management ensures the development and implementation of programs and policies to continuously improve the effectiveness of ELI's QA Program and Management Systems. Management performs an annual review of the laboratory's Quality System (policies, procedures, work instructions) to assure their continuing suitability and effectiveness (See ELI SOP: *Management Reviews*, for detailed procedures). As appropriate, management identifies and implements any necessary changes or improvements. Corrective and preventive actions are detailed in a Corrective Action Report and filed with the QA Department. (Refer to ELI SOP: *Nonconformance Procedures and Corrective/Preventive Action Reports,* for detailed procedures.) In addition, management performs meetings with supervisory and key staff members throughout the year. Supervisors and QA personnel provide input on their specific areas of responsibility and evaluate the following:

1) Client-Related Items
2) Internal and External Audit Reports
3) Proficiency Testing Results
4) Review of Performance by Department
5) Corrective and Preventive Actions
6) Personnel Training Needs
7) Quality System Policies and Procedures

8) Resources including Personnel, Equipment and Facilities

Laboratory Management Review findings are compiled into a summary report. The report includes deficiencies identified and areas for improvement. The QA department ensures items from the Management Review are tracked, including actions that must be addressed, assignment of parties responsible for the actions to be taken, and recommendations on improvements to the Quality System. The Technical Director, Laboratory Manager, Quality Assurance Officer or designee, shall assign specific persons to address management review findings and establish deadlines for their completion. The Technical Director, Laboratory Manager, Quality Assurance Officer or designee, reviews and approves all documents issued to personnel in the laboratory as part of the management system. The Technical Director, or designee, has overall responsibility for the technical operations of the laboratory. Any procedural deviations to SOPs that are client or project-specific must receive approval either from the Technical Director, Laboratory Manager, or Quality Assurance Officer. Work is stopped when identification of any of the following is made: unapproved departures from the management system, unauthorized deviations from the procedures for performing tests and/or calibrations, and data quality or data integrity issues. The Technical Director, Laboratory Manager, Quality Assurance Officer, or designee, is responsible for providing authorization for the work to resume once the identified issue has been addressed.

Personnel Requirements

ELI maintains experienced staff and management. Below is a summary of the primary roles, responsibilities and qualifications for the designated positions. Laboratory experience can be substituted for academic requirements. At ELI's smaller laboratory operations, the technical director may serve multiple roles. Detailed job descriptions are maintained by the Human Resources Department. Specific titles of employees are at the discretion of the Laboratory Manager.

Laboratory Manager

The Laboratory Manager is required to have education equivalent to a Bachelor of Science degree in Chemistry or a related science. Five years of relevant laboratory experience is required.

The Laboratory Manager is responsible for all operations, client management, analysis scheduling, equipment acquisition, as well as compliance with all employment, safety, environmental and NELAP/ISO 17025 regulations. The Laboratory Manager may delegate daily activities of these work aspects to appropriate personnel. The Laboratory Manager reports directly to the Corporate Operations Manager. All Laboratory Managers have both technical and management responsibilities.

Quality Assurance Officer

The Quality Assurance Officer is required to have an education or experience equivalent to a Bachelor's of Science degree in Chemistry or a related science. Five years of relevant laboratory experience is preferred.

The Quality Assurance Officer is responsible for quality systems development, implementation, and management. The Quality Assurance Officer is also responsible for maintaining and improving compliance with all applicable state and federal regulations as well as maintaining compliance with NELAP/ISO 17025 regulations regarding Quality Systems. The Quality Assurance Officer or his/her designee with the help of the Laboratory Manager and Marketing Department manages the laboratory's certification programs to meet government regulatory and specific client requirements. The QA program is implemented in cooperation with all levels of management and staff. Quality Assurance Officers report directly to the Corporate Quality Assurance Officer. The Laboratory Manager will direct daily laboratory-specific QA/QC requirements.

Technical Director

The Technical Director is required to have a Bachelor of Science degree in Chemistry or a related science. Five years of relevant laboratory experience is required.

The Technical Director is responsible for ensuring compliance with all laboratory policies and that the analyses conducted under their supervision are compliant with all state, EPA, and NELAC/ISO17025 standards. The Technical Director reports directly to the Laboratory Manager.

The Technical Director may serve multiple roles. The Laboratory Manager can also serve as one of the laboratory technical directors.

Laboratory Supervisor

A Laboratory Supervisor is required to have education or experience equivalent to a Bachelor of Science degree in Chemistry or related science. Two years of relevant laboratory experience is required.

ELI's Laboratory Supervisors are responsible for the day-to-day operation of the laboratories: scheduling testing, assigning work, and completing the technical review of laboratory data. Supervisors are responsible for ensuring compliance with all laboratory policies and ensure that the analyses conducted under their supervision are compliant with all state, EPA, and NELAC/ISO17025 standards. They report directly to the Laboratory Manager.

Analysts

Laboratory Analysts are required to have an education equivalent to a Bachelor of Science degree in Chemistry (or related science), or a High School diploma with experience as an analyst in training. New analysts require on-the-job training under direct supervision of a qualified analyst. The training shall be relevant to the present and anticipated tasks required and the effectiveness of the training is evaluated (for more information, see ELI SOP, *Personnel Training and Training Records)*. After the initial training period, and on a continuing basis thereafter, the analyst must demonstrate acceptable skills through the successful participation in the analysis of applicable performance evaluation and quality control samples.

Laboratory Analysts perform the following duties: Preparation of samples and reagents, analysis and preliminary data input, as well as various other tasks assigned by the supervisor. Laboratory Analysts are responsible for complying with all laboratory policies and procedures.

Laboratory Technicians

Laboratory Technicians are required to have a High School Diploma or equivalent. Laboratory Technicians work under the supervision of the primary analyst performing general laboratory tests.

Under the supervision of a primary analyst, Laboratory Technicians perform the following duties: preparation of samples and reagents, analysis, and preliminary data input, as well as various other tasks assigned by the supervisor.

Laboratory Technicians are responsible for complying with all laboratory policies and procedures.

Approved Signatories

Signatures for policies are based on appropriate individuals, roles and responsibilities as determined by the policy being reviewed and approved. A list of significant signatories is included below. Additional signatures may be required for specific procedures.

- Laboratory Manager
- Technical Director
- Quality Assurance Officer
- Radiation Safety Officer (RSO)
- Corporate Officer- Board of Directors

A master list including signatures and initials for all employees is maintained for reference and signature verification.

CHAPTER 5 – SAMPLING PROCEDURES

Private individuals or companies, who are responsible for using proper collection procedures, collect most of the samples processed in this laboratory. Members of the staff are acquainted with proper sample collection and handling procedures and advise those who need help in this area. Instructions and forms for initiating Chain-of-Custody are available from ELI. Laboratory procedures for logging in samples for analysis and maintaining Chain-of-Custody are described in ELI SOP, *Sample Receipt, Login, and Labeling*.

When the laboratory has been assigned the responsibility of sample collection, there is strict adherence to correct sampling protocols, initiation of chain-of-custody, sampling documentation, complete sample identification, and prompt transfer of sample(s) to the laboratory. Procedures are described in ELI SOP, *Field Sampling*.

This laboratory provides proper sample containers and preservatives as specified for the procedure. Certified sample bottles may be ordered upon request. Sample containers, preservatives, coolers for shipping, re-sealable plastic bags for ice containment, trip blanks for monitoring contamination during shipping, temperature blanks for accurately monitoring sample receiving temperatures, Chain-of-Custody forms, Chain-of-Custody seals, sample bottle labels, instructions for sampling, sample labeling, sample preservation, and sample packaging/shipping are provided upon request. Sample container type, sample volume, preservation requirements, and maximum holding times, are detailed for each analyte/method in the ELI Professional Services Guide. See the ELI website, www.energylab.com for the current pricing.

Energy Laboratories maintains a strict Sample Acceptance Policy. The client is notified (as appropriate) upon sample receipt, or as soon as possible, if there is any doubt concerning the sample's suitability for testing, including but not limited to, when:

- Samples are out of temperature compliance;
- Samples are received in unacceptable containers;
- Samples have not been properly preserved;
- Samples have labels or chain-of-custody procedures that are incomplete;
- Samples cannot be analyzed within method recommended holding time; or
- The custody seal has been broken.

Notification of sample receipt condition is available through the final report, Energy Source, Email, telephone and/or voice message.

Samples not collected or documented properly can be rejected for any regulatory-based analysis with re-sampling recommended. If re-sampling is not possible, or the client cannot be contacted, the sample may be analyzed, and if analyzed, the sample will be clearly qualified on the analytical report.

The Laboratory will attempt to preserve any sample that has been determined to be improperly preserved. Procedures are described in ELI SOP, *Bench Level pH Preservation Verification, Documentation and Communication*. Aqueous samples for volatile analysis are checked for preservation at the time of analysis. Samples for microbiological analysis are collected in pre-sterilized 120 mL plastic bottles containing sodium thiosulfate.

Sample preservation should be performed immediately upon sample collection. For composite samples, each aliquot should be preserved at collection. Refer to ELI Professional Services Guide for detailed information on sample preservation requirements per applicable method and regulatory requirements.

The sample condition report is hand-written on the Chain-of-Custody form and contains Chain-of-Custody procedures, carrier used for sample shipment, sample receipt temperature, and general comments concerning sample condition. In addition, the samples may be screened for potential radioactivity. The sample condition report is provided with the analytical data report package. For more information, see ELI SOP, *Sample Receipt, Login, and Labeling*.

When any sample is shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements as described in the ELI Professional Services Guide, the Office of Hazardous Materials, Material Transportation Bureau, and Department of Transportation have determined the Federal Hazardous Materials Regulations do not apply to the following:

A) Hydrochloric Acid - (HCl) in water solutions of 0.04 % by weight or less (pH of 1.96 or greater).
B) Nitric Acid - (HNO_3) in water solutions of 0.15 % by weight or less (pH of 1.62 or greater).
C) Sulfuric Acid - (H_2SO_4) in water solutions of 0.35% by weight or less (pH of 1.15 or greater).
D) Sodium Hydroxide - (NaOH) in water solutions of 0.080% by weight or less (pH of 12.30 or less).

For regulatory compliance monitoring, it is required that all samples be analyzed within the prescribed holding times. Holding times are the maximum times allowed between sampling and analysis for results to still be considered valid. Samples should be delivered to the laboratory as soon as possible following collection to assure that holding times can be met. Samples are analyzed as soon as possible after sample receipt. When maximum holding times cannot be met, re-sampling is requested. If samples are analyzed out of hold, data is appropriately qualified.

To ensure that drinking water analysis requirements for radiochemistry are met, the requirements for sample handling, preservation, and instrumentation for radiochemical analysis are included in ELI SOP *Sample Receipt, Log-In and Labeling*. (For additional information, refer to “Manual for the Certification of Laboratories Analyzing Drinking Water”, Table VI-2: Sample Handling, Preservation, and Instrumentation, EPA 5th Edition, January 2005).

CHAPTER 6 – SAMPLE HANDLING

The ELI laboratory utilizes a sample tracking policy that includes client-initiated chain of custody. Upon receipt, the security of the samples is maintained by the implementation of the laboratory access and security policies. See ELI SOP, *Facility Description, Access and Security*.

Sample Receipt

All samples arriving at the laboratory are logged in the Laboratory Information Management System (LIMS). Each sample container is given a unique laboratory sample number. The sample receipt checklist evaluates Chain-of-Custody procedures; carrier used for sample shipment, sample temperature, and provides general comments concerning sample condition. The completed checklist is provided with the analytical report package. Chain-of-Custody forms are checked for pertinent information. If necessary information has been omitted, the collector is notified, if possible, and the missing information is requested.

Sample preservation is verified in accordance with procedures documented in the ELI SOP, *Bench Level pH Preservation Verification, Documentation and Communication*. If requested by the client, ELI staff will preserve or filter samples as appropriate. If samples are improperly preserved, or the maximum holding times are exceeded upon arrival at the laboratory, the client is notified and re-sampling is encouraged.

Samples are stored per method specifications, or as method/parameter storage requirements are updated per later EPA guidance in Federal Regulations posted in 40CFR (Method Update Rules).

During sample login, all sample information such as sample description, client name and address, analyses requested, special requirements, etc. are entered into the computer database of the Laboratory Information Management System (LIMS). Requested analysis parameters and special requirements are communicated to the analysts via their LIMS work lists. Project-specific requirements are maintained in the LIMS for any samples received from a special project. This process ensures that individual requirements are maintained.

Chain-of-Custody

Evidence level internal chain-of-custody (COC) procedures are available on a project-specific basis. For these procedures, internal COC sample custody is maintained down to the individual analyst level. When transferring the possession of the samples, the transferee must sign and record the date and time on the chain-of-custody record. Every person who takes custody must fill in the appropriate section of the chain-of-custody record. When received by ELI, sample identification information on the sample containers is compared to the custody report form. The sample is inspected and information regarding the condition of the sample and seal (if used) is recorded on a report form; the method of shipping is also documented on the report form. A copy of the report form is kept with the sample data file and a copy is sent to the client with the analysis report. Internal chain-of-custody forms are used, when appropriate, to document the progress of the sample through the laboratory. ELI's routine COC policy is maintained at the laboratory level through our laboratory access and security policies. See ELI SOP, *Facility Description, Access, and Security*.

Sample Tracking

Samples are tracked through the analytical process by the LIMS. Completed analyses, which have been approved by the appropriate reviewer as valid data, are reported in the LIMS. When all analyses are complete, the data is reviewed as a whole to ensure results pass data quality checks. The completed report is signed by an approved signatory. The signed report is sent to the client via requested delivery format. Generation of the invoice automatically completes the work order in the LIMS and removes the samples from the status report. For more information, see ELI SOP, *Document and Record Management, Control and Archiving*.

Sample Disposal

It is preferred that remaining hazardous sample material be returned to the originator (client) for disposal. When this is not possible or reasonable, ELI will dispose of remaining hazardous sample materials with a waste disposal surcharge added to the cost of the analysis.

The disposal of laboratory wastes will be performed in accordance with local, state, and federal regulations which apply to such activities. Each method SOP addresses waste minimization and management specific to the method procedure. See ELI SOPs, *General Laboratory Waste Disposal,* and *Radiochemistry Waste Disposal* for more information.

Subcontracting Policy

The ELI Casper laboratory utilizes the expanded laboratory capability and expertise to provide comprehensive analytical services. This occurs when the laboratory is requested to perform an analysis outside of the laboratory's capabilities (If sample overload is experienced; if equipment is out of service; or when the laboratory is not accredited for the particular analysis). Upon completion of the analyses, the subcontracted laboratories report the sample results, and their quality control package, to the primary laboratory. The results are reviewed before being reported.

ELI laboratories are certified to perform drinking water analysis in their state and in neighboring states. Samples are forwarded to our branch laboratories only if the laboratory is certified in the state from which the sample originated. Individual laboratory Quality Assurance Programs are consistent with the Corporate Quality Assurance Program and are monitored through internal laboratory audits.

To support Energy Laboratories, Inc. Casper analytical services, ELI laboratories (which maintain specific instrumentation for specialized analysis) are utilized to provide complete analytical services. All ELI laboratory certificates are available on the Energy Laboratories website at www.energylab.com.

In the event that ELI is dependent on the service of an outside laboratory for analyses not available through our facility or our branch laboratories, the client is notified that their samples are subcontracted to an outside laboratory. The outside laboratory reports the results to ELI and these results become part of the final report. Any external or internal subcontracted analyses that require accredited analyses will be performed by a laboratory accredited for those parameters in the State from which the sample originated. All final reports indicate where the analyses were performed.

CHAPTER 7 – INSTRUMENT OPERATION AND CALIBRATION

Laboratory instruments and equipment are operated and calibrated according to the manufacturer's instructions and according to the requirements of the method being used. Exact calibration procedures are outlined in the appropriate SOP. For most instruments, a calibration curve composed of three to five standards covering the concentration range of the samples is prepared. The acceptance criteria for the calibration curves are listed in the individual methods. Unless otherwise specified in the method, at least one of the standards is at or below the practical quantitation limit (PQL) of the method. Routine PQLs for each method are given in the ELI Professional Services Guide. Calibration standards are routinely compared to second source calibration standards to verify accuracy. These second source standard results must fall within an established range, as described by the SOP, to be considered acceptable. Whenever possible, the laboratory uses calibration standards prepared from certified stock standards. Initial instrument calibration curves are verified and routinely monitored by analyzing a continuing calibration standard every 10 to 20 samples (or within a specified time frequency) and at the end of every analytical sequence, depending on the analysis method and instrumentation. When applicable to the method, high-level samples, which produce an analytical response outside the calibrated range of the instrument, are diluted (or reduced in mass) and re-analyzed until a response within the calibrated range is obtained and/or the result is appropriately qualified.

System cleanliness is verified through the analysis of reagent/instrument blanks prior to analysis, between highly contaminated samples, and at regular intervals during the analysis.

Use of measuring equipment and reagents (glassware, water, chemical reagents, and industrial gases) conform to Good Laboratory Practice guidelines. Good Laboratory Practices (GLPs) are laboratory guidelines which were established by the Food and Drug Administration and published in the Federal Register (21 CFR, part 58). The GLP guidelines were adopted by the Environmental Protection Agency. SOPs are developed in accordance with GLP and NELAP guidelines. Laboratory volumetric glassware conforms to National Institute of Standards and Technology (NIST), American Society for Testing and Materials (ASTM) Class A or B standards. All mechanical pipettes are calibrated at least quarterly. Laboratory balances are serviced and calibrated by certified technicians annually. Calibration checks of balances are performed each day of use, using ASTM Class 1 weights. Laboratory thermometers are calibrated annually against a NIST traceable thermometer. Laboratory drying ovens, incubators, freezers, refrigerators, and water bath temperatures are monitored and recorded each working day, or at frequencies as described in the specific SOP. Laboratory pure water is generated by commercial water purification systems and is monitored and documented each working day in accordance with specifications needed for applicable methods. The routine analysis of laboratory blanks is used to verify laboratory water quality and the suitability of sampling containers. Chemical reagents and gases meet or exceed purity requirements for their intended uses. Laboratory stock and working standards are derived from ISO 17025 and/or 9001 (or equivalent-certified) commercially available primary standards whenever possible. Standard preparation notebooks document the reagent/standard type, source, purity, content, concentrations, preparation date, and analyst. All calibration standards are documented in the analytical records such that they are uniquely identified and traceable to stock standards and their source.

Standard Operating Procedures (SOPs) detail the sequence of operations involved in instrument start-up, calibration, analysis, shut-down, and routine maintenance. Suggestions for corrective action are included with the SOPs and parameters are identified which dictate certain types of maintenance. Instrument and method detection limit studies are performed at the method required frequency or whenever there is a significant change in instrumentation. Method Detection Limits are determined according to EPA guidelines found in 40 CFR, part 136, Appendix B (except for the few methods that are not amenable to MDLs). Refer to ELI's Professional Services Guide for practical quantitation limits (method reporting limits). Acceptable instrument response/performance criteria are based upon the manufacturer or the analytical method specifications. SOPs exist for all major pieces of analytical equipment/methods.

Instrument logbooks and/or electronic logbooks are used to document instrument maintenance and repairs. Instruments that are no longer being utilized are documented in the applicable instrument logbook as "out-of-service" with the date the instrument was taken out of use noted. All out-of-service instruments are labeled with an out-of-service tag that identifies the effective date the instrument was taken out of use.

Laboratory analysts record and document all instrumental runs in Laboratory Instrument Logbooks or computer files. Instrument Logbooks and/or dated computer files record instrument performance data, analytical sequences, instrument maintenance, calibration standards data, and any other additional information pertinent to operation of the instrument.

CHAPTER 8 – RECORDS AND REPORTING

Document Management

Energy Laboratories Inc. QA manages three types of documents: 1) controlled, 2) approved, and 3) obsolete.

A CONTROLLED document is one that is uniquely identified, issued, tracked, and kept current as part of the Quality System. Controlled documents may be internal documents or external documents. Controlled documents are considered to be all documents issued to personnel in the laboratory as part of the management system such as regulations, standards, other normative documents, test and/or calibration methods, as well as drawings, software, specifications, instructions and manuals. All internal ELI controlled documents are written and reviewed by personnel technically competent to perform that procedure and approved for use by the Laboratory Manager as well as the Quality Assurance Officer.

An APPROVED document is one that has been reviewed and approved for use by authorized personnel prior to issue. Approval of these documents is indicated by the inclusion in the controlled document list.

An OBSOLETE document is one that has been superseded by more recent versions. Obsolete documents are retained for legal use or historical knowledge preservation. Old or archived SOPs are available for review using the laboratory's electronic document system. ELI's OBSOLETE document records are maintained for at least ten years.

Documents are reviewed on an annual basis to ensure their contents are suitable and in compliance with the current quality systems requirements, and accurately describe current operations. SOPs include a Record of Review/Revision page, which details revisions or reviews. The Quality Assurance Officer maintains a master list of controlled documents (which include title, author, and date of issue).

Procedures for identification, collection, access, filing, storage, and disposal of records are found in ELI SOP, *Document and Record Management Control and Archiving*.

Laboratory Notebooks

Several different types of Laboratory Notebooks are maintained at the ELI Laboratory. These include, but are not limited to, the following:

Method/Parameter Notebooks
Project Notebooks
Instrument/Equipment Use and Maintenance Notebooks
Standard Preparation Logbooks
Balance Calibration Logbooks
Pipet Calibration Logbooks
General Logbooks

The general purpose of maintaining each of these Laboratory Notebooks is to record the details that may be important in repeating a procedure, interpreting data, or documenting certain operations. Entries in the notebook may include data such as standard and sample weights, pH measurements, instrument operating parameters, preparation of calibration curves, analytical run sequences, calculations, recording of instrument operating parameters, sample condition, etc. The analyst's notebook is particularly important in documenting analyses that deviate in any way from routine or standard practices. It can also be an important training record. All pertinent data is to be recorded directly in the notebook. Some notebooks or data records are maintained in electronic format (LIMS, spreadsheets, or databases). Electronic data records are duplicated using hardcopy and/or alternate electronic backup techniques.

It is the responsibility of each analyst to maintain a laboratory notebook according to Good Laboratory Practices (GLP) Guidelines. All physical laboratory notebooks are assigned a unique logbook control number and are assigned to an analyst and/or supervisor. These notebooks remain the responsibility of the ELI staff member's supervisor to whom they are assigned until they are formally transferred to another staff member, until they are completely filled and returned to the ELI QA Department for archiving. ELI staff members, other than the individual to whom the laboratory notebook is issued to, may make entries in the notebook as long as those entries are consistent with the intended use of the notebook and such entries are initialed and dated. Procedures for use and maintenance of laboratory notebooks are detailed in ELI SOP, *Laboratory Notebooks*.

Records

The laboratory maintains records of all chemical analyses, including all quality control records, for a minimum of ten years. In the event that Energy Laboratories, Inc., or any individual laboratory transfers ownership or goes out of business, the records will be transferred to the new owners. If an ELI laboratory is closed, records will be maintained by Energy Laboratories Corporate office in Billings, Montana. Energy Laboratories, Inc. reserves the right to offer the records to the clients in the event of complete closure. Details are described in ELI SOP, *Document and Record Management, Control and Archiving*.

Data Reduction

Data reduction refers to the process of converting raw data to reportable units. The reporting units used and analytical methods performed are described in the ELI Professional Services Guide.

Wherever possible, the instrument is calibrated to read out directly in the units reported. In this case, the value is recorded directly into a laboratory notebook, logbook, bench sheet, or electronic file and presented for review.

In cases such as titration, gravimetric measurements, or other techniques that require calculation prior to reporting, raw data is recorded in the appropriate laboratory notebook or electronic file, or on the appropriate laboratory form. The calculations specified in the methods are used to determine the reported value. That value is also entered into the laboratory notebook or bench sheet. Most calculations are automated to reduce the chance of arithmetic or transcription errors.

Wherever possible, electronic data results are transmitted throughout the laboratory via the LIMS computer network. This process is intended to minimize manual data transcriptions within the laboratory. Additional advantages include the opportunity for rapid comprehensive data validation by supervisors, and more rapid data reporting.

Validation

Data validation includes the procedures used to ensure that the reported values are consistent with the raw data, calculated values, sample type, sample history, and other analysis parameters requested.

The data recorded is validated with several review steps. The analyst who submits the analytical results checks all the values reported for omissions and accuracy. Elements of this review also evaluate all instrument and method QC results. Automated data management programs are designed with an interactive step allowing data review by the analyst. Results to be reported are approved by the analyst.

The report is reviewed for the suitability of the data according to project and method performance specifications. Analytical results for each requested parameter may be evaluated against other requested parameters, project specifications, other samples within the set, historical files associated with the project/client, and/or any other information provided with the sample.

The reports are generated, proofread, and reviewed by designated reporting staff.

The Laboratory Manager, project managers, supervisors, Quality Assurance Officer or their designees, may also examine the data included in the final report.

Internal and external laboratory audits review selected sets of data to ensure that the analytical results are correct and accurate, analytical methods are appropriate, documentation and record keeping procedures are complete, and that there is compliance to the overall objectives of the Quality Assurance Program. Data integrity is monitored on an on-going basis.

All controlled automated programs used to process and report data are initially verified using manually calculated results. Whenever a modification is performed to a program, re-verification of overall software function is performed.

One step of the Quality Control process involves data outlier detection; data that falls outside of established limits. If an outlier is observed, corrective action is taken as appropriate, to investigate and/or correct the cause. Actions to correct these causes may include, but are not limited to, inspection of the instrumentation, checking calibrations, checking sample numbers or dilutions, re-analyzing samples or calibrations.

Reporting

One copy of the report is distributed to the client, via requested delivery format, after the report is validated and signed. A standardized report format is used unless otherwise specified. Client-specified report formats are available upon request. Results can be sent via physical media, email, EDD, website FTP and/or FAX when requested by the client. Energy Laboratories, Inc. offers its clients access to electronic records through our Energy Source Portal.

Various levels of data reporting are available. All analytical results, regardless of the level of reporting used, have record keeping procedures which allow an appropriate "data validation package" to be produced. Note that a comprehensive "data validation package" is most easily generated at the time of sample analysis. Example data packages are available upon request.

Safe Drinking Water Act (SDWA) compliance monitoring samples for microbiological and chemistry samples that exceed the SDWA maximum contaminant level (MCL) may require notification to the appropriate state agencies. Generally, notification to the client, and to the state, of any SDWA MCL exceedance must be within 24 hours of completion of analysis/review, or by noon the next business day. If requested by the client, additional copies of the report will be sent to a specified address or person.

The final copy of a completed report is maintained in an electronic format. An electronic copy of this file is available upon request. Energy Source is a client resource of ELI that provides secure online access for clients to view their data and documents. Clients are able to access their electronic files through ELI's secure website at https://energysource.energylab.com/. For more information, see ELI SOP, *Document and Record Management, Control and Archiving*.

In addition to traditional ink signatures, Energy Laboratories has approved the use of electronic signatures within our company-produced PDF documents. These signatures comply with Title 15 of the US Code Section 101 regarding legal requirements of a digital signature.

Electronic signatures verify that the document has not changed after it was produced. Upon opening the document, notifications automatically display to inform the recipient of the validity of the sender's electronic signature and all included certificates. Should any changes be detected, an alert message is automatically displayed, noting that the signatures cannot be validated due to changes made to the document. Detailed instruction on how to view/validate ELI's electronic signatures is available.

CHAPTER 9 – GENERAL LABORATORY PRACTICES

Chemicals and Reagents

When available and appropriate, chemicals used in the laboratory are analytical reagent grade (AR) chemicals purchased from reliable suppliers. Reagents are prepared, standardized, and made fresh as mandated by the method, their stability, and according to Good Laboratory Practices. Procedures for purchasing of materials may be found in ELI SOP, *Property Procurement, Inventory, and Control*.

Normalized standards are checked regularly against independently prepared reference materials.

All standards and reagents are dated when received, opened, or prepared, and each is labeled with an expiration date when applicable. Standards and reagents are checked for discoloration or signs of degradation and are discarded if these are observed.

Certified primary standards are obtained from ISO accredited commercial sources when available. Standards used for calibration are verified against second source standards. Secondary and working standards are accurately prepared with volumetric flasks, or other calibrated glassware, from primary standards and stored in appropriate containers.

ELI has determined five years to be a reasonable expiration date for stable salts where the manufacturer does not supply such information. Titrants, standards, and other solutions used for analytical purposes are frequently standardized upon preparation with certified or traceable standards. Method SOPs specify if standardization is necessary. The date and analyst's initials must be recorded on the container whenever re-standardized and these records are maintained in a laboratory notebook or in the LIMS.

Individual SOPs may also provide additional details for reagent requirements.

Reagent Interference

To determine the extent of reagent interference, method blanks are analyzed prior to sample analysis whenever appropriate.

If any interference cannot be eliminated, the magnitude of the interference is considered when calculating the concentration of the specific constituent in the sample, but only when permitted within the applicable method.

If reagents, materials, or solvents contain substances that interfere with a particular determination, they are replaced.

Individual method SOPs may also provide additional requirements for handling reagent interferences.

Glassware Preparation

All glassware used for inorganic and radiochemical analysis is washed in warm detergent solution and thoroughly rinsed in tap water. Glassware is then rinsed well three times with laboratory-purified water. This cleaning procedure is sufficient for many analytical needs, but individual SOPs detail additional procedures when necessary. Glassware washing procedures for various analyses are described in ELI SOPs, *Cleaning of Glassware Used in Inorganic Analyte Sample Preparation and Analysis*, *Cleaning of Glassware Used in Volatile and Semivolatile Analyte Sample Preparation and Analysis*, and *Cleaning of Glassware Used in Radiochemical Sample Preparation and Analysis.*

All glassware used for organic analysis is washed in warm synthetic detergent solution and thoroughly rinsed in tap water. The glassware is then rinsed well with laboratory-purified water, followed by rinses with acetone to remove any residual organics. Prior to use, the glassware is rinsed three times with the organic solvent to be used with the glassware.

All glassware used for microbiological analysis is washed in warm detergent solution. The detergent must be proven to contain no bacteriostatic or inhibiting substances. The glassware is rinsed thoroughly with laboratory-purified water. Specific details are described in method specific SOPs.

Disposable, glassware/plasticware is preferred for many procedures in the laboratory. The cleanliness and suitability of disposable glassware/plasticware is continuously evaluated for each test with the routine analysis of method blanks.

All volumetric glassware used in precise measurements of volume is Class A or laboratory calibrated.

Laboratory Pure Water

Laboratory-purified water is used in the laboratory for dilution, preparation of reagent solutions and final rinsing of glassware. For organic analysis, organic-free water is prepared and used. Energy Laboratories, Inc. uses water purification systems that are designed to produce deionized water that meets the requirements of the methods. Use and maintenance of laboratory reagent water systems are described in ELI SOP, *Use and Maintenance of the Laboratory Purified Water System.*

Water quality is monitored for acceptability in the procedure in which it is used. Specific details are listed in the appropriate SOPs.

Employee Training

All new ELI employees and contract personnel are given an initial general orientation and tour of the laboratory facilities. Personnel are shown the locations of safety equipment such as safety showers, eye wash fountains, fire extinguishers, and first aid supplies. Personal protective equipment such as lab coats, disposable gloves, and safety glasses (if applicable) are issued at this time.

Safety considerations are a vital part of the training process. All hazards associated with the performance of a procedure or with the operation of an instrument are to be understood by the trainee before training can be considered complete. General laboratory safety procedures are a part of the new and current employee training. Specific safety procedures are outlined in SOPs and in instrument Operator's Manuals. Training in use of protective clothing, eye protection, ventilation, and general safety are provided to each employee.

All new and existing employees must demonstrate capability prior to performing an analytical procedure independently (see Chapter 1). Method performance on Quality Control Samples is used to document employee training and work quality. Employees are required to read the Quality Assurance Manual and all appropriate SOPs. Employees also are required to sign, for all applicable Manuals and SOPs, a Record of Acknowledgement Form that states they have read, understood, and agree to abide by the Manual/SOP.

Employees also receive training on general laboratory policies including ethics and conflict of interest. All employees are required to read, understand and comply with the Corporate Compliance & Ethics Manual. Data integrity training is provided for all employees initially upon hire and annually thereafter. In addition to the *Corporate Compliance & Ethics Manual*, the ELI Quality Assurance department maintains an *Assessment of Data Integrity* SOP, which supplements the corporate manual and provides specific training on data integrity. All employees are required to read, understand and comply with the ELI *Assessment of Data Integrity* SOP. An annual Ethics training course is given to all laboratory employees. Attendance is required and is recorded with a signature attendance sheet or other form of documentation that demonstrates all staff members have participated and understand their obligations related to data integrity and ethics policies. For details pertaining to ethics training and additional ethical procedures and policies refer to ELI SOP, *Personnel Training and Training Records*.

ELI encourages attendance at courses, workshops and other forms of continuing education available from on-site seminars, private institutions, local schools, and State and Federal regulatory agencies. Staff and department meetings are held routinely to communicate company policies and procedures. All training on procedures and policies is documented, per NELAP guidelines, in employee training files. For more information see ELI SOP, *Personnel Training and Training Records*.

Data Integrity

In order to provide for the integrity of ELI and client data, the laboratory has multiple controls on the network, LIMS and applications used. These controls limit access to and the ability to change data as well as provide for redundancy in case of loss.

These include but are not limited to:

- Users connecting to ELI computer systems are authenticated through a user name and password combination.
- Passwords are required to be changed on a regular basis.
- Permissions within ELI applications are role based with different roles having various levels of access and control. Users (analysts, supervisors, and managers) are assigned to these roles.
- In the LIMS, analytical data locks after a period of time and cannot be modified without special handling.

- Certain information has been identified for additional tracking and logging. Changes to this information is not only tracked in an audit log but also reported to select personnel.
- Information on ELI servers including the ELI LIMS system is backed up and recoverable.

Standard Operating Procedures

Laboratory operations and procedures are documented in Standard Operating Procedures (SOPs). SOPs provide information regarding the consistent and safe operation of the laboratory. SOPs provide details that may not be specified in the published analytical method(s). For routine procedures other than analytical methods, SOPs define the steps required in accomplishing a given task. All SOPs are reviewed and updated periodically to reflect any changes in laboratory operations. Method SOPs follow NELAP requirements. For more information on generation and distribution of SOPs, see ELI SOP, *Preparation, Numbering, Use, and Revision of Standard Operating Procedures*.

Client Confidentiality

Each employee has the responsibility to maintain confidentiality in all matters pertaining to our clients, samples submitted, and Energy Laboratories, Inc. Information obtained during employment with this laboratory, regarding the specific business of this laboratory, or its clients shall at no time be revealed to any outside sources without permission from the owner of the data.

Sample submittal, analysis and the report contents are considered confidential information of the client. When requested to provide results (either in person, via telephone or email), the employees shall verify that the requestor is either the person associated with the project, on the COC, or on a list provided by the client who are authorized to receive data. If a person who is not associated with the project personnel (or is not on the approved list), the base client will be contacted to inquire about authorization to release data. These contacts are documented and associated with the work order in the LIMS system to provide archival proof of authorization to release data. If the client does not authorize a release of data, the requestor will be contacted and informed of this decision.

Client confidentially is maintained electronically through the use of password-protected logins on all laboratory computer systems. Additionally, the laboratory maintains network security such as anti-virus programs and firewalls that prevent any unauthorized outside access. All copies of the original report are stored on the laboratory's document archival system, which is also protected from unauthorized use by the network security systems. Raw data, reports, and LIMS records are kept in a secure location of the laboratory or off-site. All client confidential paper waste, including printouts, is shredded.

CHAPTER 10 – QUALITY CONTROL MONITORING

Routine Monitoring

Temperatures of incubators, water baths, refrigerators, and ovens are checked and recorded according to a prescribed schedule using an automated monitoring system. In the event that the automated monitoring system is inoperable for more than twelve hours the appropriate temperatures will be recorded manually on instrument specific forms.

Conductivity of the laboratory-purified water is continuously monitored using an automated monitoring system and as method blanks in routine analytical runs. In the event that the automated monitoring system is inoperable for more than twelve hours the recorded method blanks will serve as the required monitoring.

Reagents are dated and initialed at the time of receipt. Expiration dates are assigned as a fundamental component of their receipt and/or preparation. Reagents are not used after manufacturer's expiration date is exceeded.

Balances are checked daily, or as required, against ASTM Class 1 NIST traceable weights and are calibrated and serviced by certified technicians annually.

SOPs are reviewed annually for accuracy.

Laboratory Notebooks are reviewed periodically for correctness and accuracy by supervisors.

Proficiency Testing (PT) Samples are analyzed as required (See Chapter 2 of this QA Manual).

Quality Control Check Samples are analyzed with each analytical batch.

Internal and external audits are performed as specified or requested (See Chapter 2 of this QA Manual for additional discussion).

Additional monitoring requirements may also be specified in individual SOPs.

The Laboratory maintains an active fraud protection program that is implemented through the laboratory ethics policy. Additionally, the potential of fraud is monitored through analyst supervision, management supervision, regular internal audits, PT study participation, and an active quality assurance program.

Instruments/Methods

Calibration is performed as outlined in Chapter 7 of this QA Manual.

Generally, and depending on method requirements, the standard curve is verified with a known second source reference sample. The reference sample results must fall within the appropriate target range for the calibration to be considered acceptable.

In most cases, the calibration stability is checked by analyzing a continuing calibration standard every 10 to 20 samples, depending on the analysis and instrumentation. The verification standard results must fall within an established range as described by the SOP.

All laboratory instruments are subjected to preventive maintenance schedules. Preventive maintenance schedules are specified in instrument maintenance logbooks.

As appropriate, instrument and/or method detection limits are determined annually, or more frequently if changes in instrument performance are noted or per method requirements. Procedures for the determination of instrument detection and method detection limits are described in ELI SOP, *Determination of Method Detection Limits (MDL) and Quantitation Limits*.

Precision and accuracy requirements for each method are specified in the SOPs. General guidelines are given below.

- Each analytical batch will contain QC samples to measure the accuracy of the method. Each QC sample result is monitored to be within QC specifications of the method. Results of blank spiked sample analysis must be within the established control limits. Quality Control Limits are specified in the SOPs and meet recommended QC limits as described in the referenced method.

- Each analytical batch will contain QC samples to measure the precision of the method. (See Chapter 1 for discussion on duplicate sample analysis.) Criteria for duplicate sample acceptance are found in the SOP and are generally taken from the referenced method.

- Each analytical batch will contain QC samples to measure the performance of the method on the sample matrix. These are typically identified as a matrix spike analysis and may be performed in duplicate to assess method precision. Typically the sample is fortified with a known amount of target analyte and spike recoveries are calculated. Results outside of method QC guidance are flagged. Quality control limits and appropriate corrective actions steps are specified in the method SOP.

- Several methods are considered to be concurrent methods in that they are either nearly identical or are identical to a method with a different citation. Even if two methodologies are identical in procedure, slight differences in the QC requirements might be the only difference between the two methodologies. These types of methods may also be considered "concurrent" if the procedures are identical and the more stringent of the two method criteria are used. During data reduction and reporting, the referenced method specifications and criteria will always take priority.

As appropriate, the performance trends of QC sample results are evaluated with Quality Control Charts. Suitability of existing QC limits is evaluated and possibly adjusted, but not to exceed method specification.

CHAPTER 11 – CORRECTIVE ACTION

When the quality control checks indicate that an analysis is not within the established control limits, corrective action is needed. This section gives general guidelines for corrective action. Corrective actions for each method or instrument are detailed in individual SOPs. Records are maintained of non-conformances requiring corrective action to show that the root cause(s) was investigated, and includes the results of the investigation. The Quality Assurance Officer will monitor implementation and documentation of the corrective action to assure that the corrective actions were effective.

Method QC samples that fail to fall within QC control limits may be analyzed again to verify if a problem exists. However, matrix spike or matrix spike duplicate QC samples are not required to be re-analyzed if the performance can be attributed to matrix effects; data results are then reported and flagged.

If the repeat analysis is not within control limits, the particular instrument or procedure is checked according to the specific protocols outlined in the method or according to the instrument manufacturer's guidelines. Proper control must be established before the instrument can continue analysis. Analysis of all samples that were analyzed while the procedure was considered to be out of control must be repeated. In the case of radiochemical analysis, the term “analyze again” means to recount the final sample on the same (or different) detector.

If the analyst is unable to achieve acceptable results after following the corrective action guidelines detailed in the SOP, a supervisor and/or the Technical Director is consulted. If necessary, the appropriate service personnel are contacted if the problem is determined to be due to instrument error, and cannot be resolved. It is also possible that the result is due to statistical variation of the results based on the tolerable error rate that has been determined for the analysis (usually 0.05). In certain cases, where control limits are exceeded, it is possible that problems cannot be corrected to satisfy QC criteria. This could be due to problems such as matrix interference, instrument problems, lack of sufficient sample, missed holding times, high blank contamination, etc. If all possible solutions available to correct the problem are examined and the sample results are still considered valid, qualifying comments are attached to the sample report describing the non-compliance and probable cause.

In the case of a single radiochemistry detector being returned to service, this refers only to the samples counted on that detector. For example, an individual gas proportional counter instrument may have up to 16 detectors; if only one does not pass the QC check the others are still valid and sample analyses performed on the others do not need to be repeated.

In the event that a QC audit or other informational review shows an analysis report to be incorrect, incomplete, or adversely compromised, a revised report and explanation is submitted to the client within ten business days unless otherwise communicated to the client with another time period. The report will clearly be identified as a revised report. As appropriate, an explanation submitted to the client should give a detailed review of the problem and document any unapproved deviations from the regulations, standard operating procedures, or project-specific scope of work that may have caused it. The explanation to the client may include, but not be limited to, the following components:

1) What actions have been taken regarding the affected data set(s),

2) Identification of the cause, and
3) Corrective action(s) taken to prevent future occurrence.

In the event that a QC check fails, the analyst will follow the procedures outlined in the QA/QC summary of the SOP.

Quality Control Checks for each method or instrument may vary. Energy Laboratories Inc. follows the QC checks set by each governing method. Due to the wide variations between methods, specifics are listed within each SOP for the given method. Please reference the SOP for specific QC checks for the given method. The QC checks may include: ICV, MB, CCV, CCB, LCS, LCSD, LOD, MS, MSD or others specific to that method.

A general summary of Quality Assurance/Quality Control specifications is outlined in Appendix A. Exact details of method QC can be found in the applicable method SOPs.

Procedure for Dealing with Complaints

DEFINITIONS

Complaint: For the purposes of this procedure, a complaint comes from a client, a user of our data, or employee. The complaint might cover issues about the quality of our data, sample turnaround time, method used, pricing, or other expectations.

Client: The client is a person or company that ordered and paid for the services.

Procedure: The staff person receiving the complaint exercises judgment in deciding the severity and disposition of every complaint. The judgment must be used to decide whom if anyone is alerted to the complaint and what actions are appropriate. The complaint issued should be handled with a high degree of discretion and tact by the supervisor or manager involved. The individual handling the complaint is instructed to follow ELI's guidelines provided in this section on how to handle the complaint. This involves listening to the client and getting adequate information so the complaint can be investigated and resolved. The appropriate laboratory staff is notified and a solution to the problem, as well as a timeline for action, is given.

After the complaint is investigated or resolved, as necessary, the client is made aware of the results and determination is made as to what further actions are needed. Complaints and investigations may result in the need to submit a revised report or invoice. Complaints that are straightforward and can be resolved using the resources available to the person handling the complaint should be resolved there. These include such things as minor revisions of reports or invoices. If other decisions need to be made, the appropriate person should be contacted.

It may be appropriate to initiate or prepare a non-compliance report. This report should be completed with the intention of informing the affected staff about the problem from which everyone may learn, change our procedures, and improve our service. A procedure to document non-compliance reports is documented in ELI SOP, *Nonconformance Procedures and Corrective/Preventive Action Reports.*

If an employee sees an issue, they are encouraged to report concerns regarding Quality Systems, unethical behavior, and/or financial mismanagement. This issue should initially be brought to the attention of their supervisor. The supervisor will take appropriate action to resolve the concern. If the employee is uncomfortable with approaching their supervisor or feels that the issue was not properly dealt with, they may approach higher levels of management with their issue.

Energy Laboratories, Inc. has also implemented a program to facilitate confidential reporting to upper management. This tool allows employees to report situations or behaviors that they consider to be unethical, immoral, or improper. It also allows the reporting of suggestions or comments. The program has been implemented at ELI so that anyone reporting a situation can be assured that there will not be retaliation for reporting. It is meant to encourage parties to communicate with upper management when there appears to be no alternative for resolving the types of issues already described. Access to the program is available on the ELI internal and external websites as well as through a 24-hour telephone hotline number (877-874-8416).

Penalty for Improper, Unethical or Illegal Actions

Energy Laboratories, Inc. employees are expected to work in an ethical, proper, and legal manner. They are expected to perform laboratory analyses according to the cited method(s) and in conjunction with the SOP and the Quality Assurance Plan. Employees are expected and required to report any violations of this policy. All employees are mandated to participate in an ethics-training program as part of their orientation upon hire.

Improper, unethical, or illegal actions by an employee will be addressed on a case-by-case basis as determined by the seriousness of the offense. Corrective actions may include disciplinary action up to and including discharge.

CHAPTER 12 – MANAGEMENT OF CHANGE

Management of change is the process used to review and manage proposed changes to materials, technology, equipment, procedures, personnel and facility operations. These changes may be permanent or temporary depending on circumstances. Change is managed, communicated, and documented as appropriate to the level of change, by the Laboratory Manager and the Supervisors of each department. Significant revisions to controlled documents may require employees to sign a record of acknowledgement.

- New Equipment Validation – Documented in the Instrument Maintenance Module. Supporting studies are documented in the LIMS.
- Implementation of new test methods and method updates – Documented in the method SOP and Instrument Maintenance Module. Supporting studies are documented in the LIMS.
- The QA Manual and SOPs – Documented in the Record of Revision and stored in the Document Control Software.
- Work order changes are documented in the work order report and stored in the LIMS or Document Control Software.
- LIMS changes - documented in a version control repository.
- Personnel Changes – documented in the Employee Training Records or Personnel Records.

CHAPTER 13 – MAJOR EQUIPMENT AND METHODS

A summarized listing of major instrumentation and the corresponding certified methodology is included in Appendix D. Refer to the ELI Professional Services Guide, located on the ELI website at www.energylab.com, for a list of all methods and analyte parameters that Energy Laboratories, Inc. performs corporately.

CHAPTER 14 – PREVENTIVE MAINTENANCE

Preventive maintenance is performed on laboratory equipment according to the manufacturer's guidelines and laboratory operational experience. Repairs and maintenance are accomplished in-house by experienced laboratory personnel whenever possible. Other than consumable equipment items, an inventory of spare parts is not maintained. Spare parts are available from outside vendors on an as needed basis. (To ensure method capability, some methods have more than one instrument available). An example of maintenance performed:

Instrument	Maintenance	Frequency – Note that Daily is based on use.
Balances	Check with Class 1 weights	Daily
	Independent Service	Annually
Pipettes	Check volume	Quarterly/Daily
IC	Change Bed supports	Weekly
	Change Guard Column	As Needed
	Change Analytical Column	As Needed
	Calibrate	After maintenance or as needed
	Clean Stator Plate	Annually
	Change tubing	As needed
	Calibrate Conductivity Cell	Every 6 months
	Backup Data	Monthly
ICP-Atomic Emission	Check Pump Tubing	Daily
	Check Coolant Levels	Monthly
	Lubricate Autosampler	As needed
	Air Filter	Quarterly
	Optics Servicing	As needed
ICP-Mass Spectrometry	Check Pump Tubing	Daily
	Check Coolant Levels	Monthly
	Check Electron Multiplier	Daily
	Lubricate Autosampler	As needed
	Air Filter	Quarterly
Gas Chromatograph	Change Septum	As needed
	Check Injection Liner	Daily
	Clean Detector	As needed
	Change Gas Cylinders	At 200 psi
	Change Column	As needed
Auto Analyzers	Check For Leaks	Daily
	Change Tubing	When wear is visible
	Lubricate Pumps	Annually
	Lubricate Sampler	Annually
Man-tech Auto-titrator	Visually inspect all probes/ stirrer/ thermometer and fill probes	Daily/As needed
	Flush pH probe/ Fluoride probe	Every 15 days
	Calibrate sample dosing pump	Quarterly
	Replace Tubing	Annually/ As needed
	Clean out titration vessel and rinse station	Quarterly/ As needed
	Clean buret	Quarterly
	Calibrate buret	Monthly
	Replace pH/ Fluoride probe	As needed
	Replace Tubing	As needed
	Change Lip seals gland washers on dosing pump	As needed
	Visually inspect all probes/ stirrer/ thermometer and fill probes	Daily/As needed

Instrument	**Maintenance**	**Frequency – Note that Daily is based on use.**
Metrohm-automated pH, conductivity, ion electrode analyzer	Visually inspect all probes/ stirrer/ thermometer and fill probes	Daily/As needed
	Flush pH probe/ change storage solution	Monthly/ As needed
	Replace Tubing	As needed
	Calibrate buret	Monthly
	Replace pH probe	As needed
Mass Spectrometers	Monitor Vacuum Pressures	Daily
	Monitor Background Levels	Daily
	Monitor Electron Multiplier	Daily
	Change Pump Oil	As Needed
Microbiology	Monitor Room Temperature	Twice daily
	Monitor Incubator Temperature	Twice daily
	Autoclave Maintenance	Annually
	Monitor Water Bath Temperature	Twice daily
Radiochemistry Detection Equipment	Check Background	Daily
	Check Efficiency	Daily
	Clean Window	As needed
	Change Gas Cylinders	At 200 psi
Liquid Chromatograph	Flush System	Daily
	Change Filters	As needed
	Replace Seals	As needed
Continuous Monitoring System	Check Temperatures	Daily, calibrated annually
Reagent Water Systems	Change/Check Cartridges	Quarterly, or as needed
Compressed Gases (general)	Change Gas Cylinders	At 50 psi, monitor daily

CHAPTER 15 - REFERENCES

ANSI N42.23-1996, American National Standard Measurement and Associated Instrument, Quality Assurance for Radioassay Laboratories.

ANSI N13.30-2011, American National Standard Measurement and Associated Instrument, Performance Criteria for Radiobioassay

ASTM Annual Book of Standards, Part 31 (water), American Society for Testing and Materials.

ASTM D 7282-06 Standard Practices for Set-up, Calibration, and Quality Control of Instruments Used for Radioactive Measurements.

Handbook for Analytical Quality Control in Water and Wastewater Laboratories, Environmental Protection Agency. EPA 600/4-79-019

ELI Professional Services Guide, Current Revision, Energy Laboratories, Inc.

Manual for the Certification of Laboratories Analyzing Drinking Water, 5th Ed., EPA 815-R-05-004, 2005.

Manual for the Certification of Laboratories Analyzing Drinking Water, Supplement to 5th Ed., EPA 815-F-08-006, June 2008.

Methods for Chemical Analysis of Water and Wastes Environmental Protection Agency, 600/4-79-020.

Methods for the Determination of Metals in Environmental Samples – Supplement I, EPA/600/R-94-111, May 1994.

Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93-100, August 1993.

Methods for the Determination of Organic Compounds in Drinking Water, EPA/600/4-88/039, December 1998.

Methods for the Determination of Organic Compounds in Drinking Water – Supplement I, EPA/600/4-90/020, July 1990.

Methods for the Determination of Organic Compounds in Drinking Water – Supplement II, EPA/600/R-92/129, August 1992.

NELAC Chapter 5: Quality System Standard, 2003 or most current version approved by Florida and Texas NELAC Accreditation program.

NELAP, National Environmental Laboratory Accreditation Program http://www.nelac-institute.org/newnelap.php

Standard Methods for the Examination of Water and Wastewater; 18th, 20th, 21st and 22nd Editions, APHA.

Technical Notes on Drinking Water Methods, EPA/600/R-94/173, October 1994.

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW846), Environmental Protection Agency. http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm

TNI Standard, Volume 1 (EL-V1-2009), The NELAP Institute.

CHAPTER 16 – GLOSSARY OF TERMS

Accuracy - The degree of agreement between an observed value and an accepted reference value.

Analyst - The designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.

Analytical Sample - Any solution or media introduced into an instrument on which an analysis is performed, excluding instrument calibration, initial calibration verification, initial calibration blank, continuing calibration verification, and continuing calibration blank.

Audit or Assessment- A systematic evaluation to determine the conformance to quantitative specifications of some operational function or activity.

Batch - Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A preparation batch is composed of one to twenty environmental samples of the same matrix, meeting the criteria above. An analytical batch is composed of prepared environmental samples, extracts, digestates, or concentrates, which are analyzed together as a group.

Blank (BLK) - A sample of clean water that accompanies the samples through different aspects of sampling and/or sample preparation. It is used to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value. There are various types of blanks: equipment blank, field blank, instrument blank, method blank, and reagent blank.

Blank Spike - See Laboratory Fortified Blank.

Blind QC Check Samples - Samples whose analyte concentrations are not known to the analyst. That the sample is a QC check sample may or may not be known to the analyst.

Calibration - The set of operations that establish, under specified conditions, the relationship between values indicated by the measuring instrument and the corresponding known value of the property being measured.

Calibration Blank - A volume of reagent water fortified with the same matrix as the calibration standards, but without the analytes, internal standards, or surrogate analytes.

Calibration Check Standard - See Check Standard.

Calibration Curve – The graphical relationship between the known values and the instrument responses for a series of calibration standards.

Calibration Standard - A solution of known concentration used in the calibration of an analytical instrument.

Chain of Custody Form- A record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; collector; time of collection; and requested analyses.

Check Standard - A material of known composition that is analyzed concurrently with test samples to evaluate a measurement process.

Clean Water Act - Public Law PL 92-500. Found at 40 CFR 100-140 and 400-470. The act regulates the discharge of pollutants into surface waters.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) - The enabling legislation (42 USC 9601 - 9675 et seq., as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), 42 USC 9601 et seq.), to eliminate the health and environmental threats posed by hazardous waste sites.

Continuing Calibration Blank (CCB) – See Check Standard.

Continuing Calibration Standard - See Check Standard.

Continuing Calibration Verification (CCV) - See Check Standard.

Control Limits - A range within which specified measurement results must fall to be compliant.

Control Standard - See Check Standard.

Corrective Action (CA) - An action taken to eliminate the causes of an existing nonconformity, defect, or other undesirable situation in order to prevent recurrence.

Data Quality Objectives (DQO) - An integrated set of specifications that define data quality requirements and the intended use of the data.

Demonstration of Capability (DOC) - A procedure to establish the ability of the analyst to generate data of acceptable quality.

Detectability – For radiochemical analysis, detectability as a Lower Limit Detection (LLD) or Minimum Detection Concentration (MDC), is assessed based on the requirements of 40 CFR 141.25(c) and is a sample-specific determination. The equation is specific for each method and noted in the method SOP.

Detection Limit - See Practical Quantitation Limit and Method Detection Limit. Reporting of detection in radiochemistry is based on specific formulas identified in individual procedures. Single activity point standards are used for efficiency calibration. When required, multiple energy emitters are used for energy calibration.

Document Control - The act of ensuring that documents and revisions are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

Duplicate (DUP) - A second aliquot of a sample that is treated the same as the original sample to determine the precision of the method.

Duplicate Sample - See Duplicate.

Fortified Sample - See Matrix Spike.

Holding Times (Maximum Allowable Holding Times) - The maximum time that samples may be held prior to analysis and still be considered valid or not compromised.

Initial Calibration Verification (ICV) - A sample of known concentration, from a source other than that of the calibration standards, analyzed following calibration to demonstrate validity of the calibration.

Instrument Blank - See Calibration Blank.

Internal Standard – A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

Laboratory Control Sample (LCS) – A sample with a known concentration prepared and/or analyzed as a measure of accuracy for the method.

Laboratory Fortified Blank (LFB) – An aliquot of reagent water to which known quantities of specific compounds are added and which is analyzed as a measure of method recovery.

Laboratory Inter-comparison Sample - A performance evaluation sample analyzed by numerous laboratories. Acceptance criteria are often based statistically on the analysis results.

Limit of Detection (LOD) - For chemical analysis, the LOD is an estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte and matrix specific and may be laboratory-dependent.

Limit of Quantitation (LOQ) – For chemical analysis, the LOQ is an estimate of the minimum amount of a substance that can be reported with a specified degree of confidence. An LOQ is an evaluation of precision and bias.

LIMS - Laboratory Information Management System.

Matrix – The substrate of a test sample.

Matrix Spike - (MS) – An aliquot of a sample to which known quantities of specific compounds are added, and which is carried through the entire analytical process to determine the effect of the matrix on the methods recovery efficiency.

Matrix Spike Duplicate (MSD) – A second aliquot of a sample to which known quantities of specific compounds are added, and which is carried through the entire analytical process to determine the effect of the matrix on the method's recovery efficiency and the precision of the method.

Maximum Contaminant Level (MCL) – Regulatory action levels for a contaminant of concern.

Method Blank (MBLK)- A clean sample processed simultaneously with, and under the same conditions as, samples being tested for an analyte of interest through all steps of the analytical procedure.

Method Detection Limit (MDL) - A measure of the limit of detection for an analytical method determined according to the procedure given in 40 CFR Part 136 Appendix B.

Method Reporting Limit (MRL) – See RL.

Method Validation - The confirmation by examination and the provision of objective evidence that the particular requirements for a specific intended use are fulfilled (NELAC 2003) (MARLAP 2004 for radiochemical methods).

NELAC - National Environmental Laboratory Accreditation Conference.

NELAP - National Environmental Laboratory Accreditation Program.

NPDES - National Pollutant Discharge Elimination System- A discharge permit system authorized under the Clean Water Act.

Performance Evaluation (PE) Sample - A sample with a composition unknown to the analyst that is provided to test whether the analyst/laboratory can produce analytical results within specified limits.

Practical Quantitation Limit (PQL) – The lowest concentration or amount of the target analyte that can be identified, measured and reported with confidence that the analyte concentration is not a false positive value.

Precision - The degree to which a set of observations or measurements of the same property conform to themselves.

Preservation - Refrigeration and/or reagents added at the time of sample collection to maintain the chemical and/or biological integrity of the sample.

Proficiency Testing (PT) Sample - A sample with a composition unknown to the analyst which is provided to test whether the analyst/laboratory can produce analytical results within specified limits.

Quality Assurance – An integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.

Quality Assurance Project Plan (QAPP) - A formal document describing the detailed quality control procedures pertaining to a specific project. For environmental clean-up projects, this is typically produced by an engineering firm with references to include a laboratory's Quality Assurance Manual.

Quality Control – The overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.

Quality Control Sample – A sample used to assess the performance of all, or a portion, of the measurement system.

Raw Method Reporting Limit (RMRL) – MRL usually in the default units of the analytical instrument before any preparation or dilution factors are applied.

Raw Practical Quantitation Limit (RPQL) – PQL usually in the default units of the analytical instrument before any preparation or dilution factors are applied.

Replicate - See Duplicate.

Reporting Limit (RL) – The lowest level of concentration reported for an analyte.

Resource Conservation and Recovery Act (RCRA) - The enabling legislation under 42 USC 321 et seq. (1976) that gives EPA the authority to control hazardous waste.

Safe Drinking Water Act (SDWA) - The enabling legislation, 42 USC 300f et seq. (1974), which requires the USEPA to protect the quality of drinking water in the U.S. by setting maximum allowable contaminant levels, monitoring, and enforcing violations.

Sample (SAMP) - A portion of material to be analyzed.

Spiked Sample – See Matrix Spike.

Standardization - See Calibration.

Standard Operating Procedure (SOP) **-** A written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks.

TNI – The NELAC Institute

Traceability – The property of a result of a measurement whereby it can be related to appropriate standards.

Trip Blank - One type of Field Blank. An aliquot of analyte-free water or solvent transported to the field in a sealed container and returned to the laboratory with the sample containers.

Acronyms and Abbreviations

AA	-	Accrediting Authority
AB	-	Accrediting Body
ANSI	-	American National Standards Institute
AOAC	-	The Scientific Association Dedicated to Analytical Excellence
APHA	-	American Public Health Association
ASQC	-	American Society for Quality Control
ASTM	-	American Society for Testing and Materials
Bq	-	Becquerel
BLK	-	Blank
Bg	-	Background
°C	-	Degrees Celsius
Cal	-	Calibration
CAS	-	Chemical Abstract Service
CCB	-	Continuing Calibration Blank
CCV	-	Continuing Calibration Verification
COC	-	Chain of Custody
DOC	-	Demonstration of Capability
DO	-	Dissolved Oxygen
DQO	-	Data Quality Objectives
DMRQA	-	NPDES Discharge Monitoring Report Quality Assurance
DUP	-	Duplicate
ELI	-	Energy Laboratories, Inc.
EPA	-	Environmental Protection Agency
FDA	-	Food and Drug Administration
g/L	-	Grams per Liter
GC	-	Gas Chromatography
GC-MS	-	Gas Chromatography-Mass Spectrometry
ICP-AES	-	Inductively Coupled Plasma Atomic Emission Spectrophotometry
ICP-MS	-	Inductively Coupled Plasma-Mass Spectrometry
ICV	-	Initial Calibration Verification
ISO	-	International Organization for Standardization
LCS	-	Laboratory Control Sample
LFB	-	Laboratory Fortified Blank
LIMS	-	Laboratory Information Management System
LLD	-	Lower Limit of Detection
LOD	-	Limit of Detection
LOQ	-	Limit of Quantitation
MDC	-	Minimum Detection Concentration
MDL	-	Method Detection Limit
MBLK	-	Method Blank
MS/MSD	-	Matrix Spike/Matrix Spike Duplicate
NELAC	-	National Environmental Laboratory Accreditation Conference
NELAP	-	National Environmental Laboratory Accreditation Program
NIOSH	-	National Institute for Occupational Safety and Health
NIST	-	National Institute of Standards and Technology
NPDES	-	National Pollutant Discharge Elimination System
OSHA	-	Occupational Safety and Health Administration
pCi/L	-	Picocuries per Liter
PT	-	Proficiency Testing
QA/QC	-	Quality Assurance / Quality Control
QS	-	Quality Systems
QAM	-	Quality Assurance Manual
QAPP	-	Quality Assurance Project Plan

RDL	-	Required Detection Level
RCRA	-	Resource Conservation and Recovery Act
RL	-	Reporting Limit
RPD	-	Relative Percent Difference
RSD	-	Relative Standard Deviation
SOP	-	Standard Operating Procedure
SPK	-	Spike
Std	-	Standard
SVOC	-	Semi-Volatile Organic Compound
TNI	-	The NELAC Institute
ug/L	-	Micrograms Per Liter
UV/VIS	-	Ultraviolet/Visible Spectroscopy
VOC	-	Volatile Organic Compound
WET	-	Whole Effluent Toxicity

APPENDIX A

QUALITY ASSURANCE / QUALITY CONTROL SPECIFICATIONS

These are general QA/QC parameters. The table must be tailored for each specific method, as not all sample types, frequency or acceptance criteria may apply. Where frequency, acceptance criteria or comments have multiple options separated by "OR", please choose only one of the options. Use the verbiage and formatting of this table wherever possible. *

<u>Method QA/QC Parameters</u>
Method Name
Method Number

QA SAMPLE/ SAMP TYPE CODE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	COMMENTS
Instrument Calibration	Daily OR Monthly OR Every 6 months After maintenance or when needed due to peak shifts or QC failures.	r ≥ 0.995 Also includes visual interpretation for quadratic or higher order calibration fit types.	1) Prepare/Purchase new standards 2) Recalibrate 3) Perform instrument maintenance	Establishes calibration curve over a range of analyte concentrations to quantify analytes of interest. Minimum 3 calibration points and a blank (depending on method) required.
Linear Calibration/Dynamic Range (LCR/LDR)	Initially, then every 6 months. Or with major changes in equipment. Or as required by method.	Residuals (Percent Recovery of standards) recommended being within CCV limits.	1) Evaluate alternate non-linear calibration models, especially for lowest and highest calibration points.	LCR/LDR is the linear portion of a calibration curve. See the ELI LDR procedure on the wiki.
Linear Dynamic Range (LDR) For metals methods only.	Initially, then every 6 months.	%Rec = 90-110	1) Re-establish/verify LDR 2) Dilute samples within the calibration range.	Sets the upper limits of the calibration range. Must include at least 3 points, with one outside the upper range of the curve.
Retention Time (RT) window position establishment	Initially with instrument set up. Recommend verifying annually.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	1) For shifting retention times, adjust according to initial CCV (mid-range). 2) Follow method requirements.	Calculated for each analyte.

Method QA/QC Parameters Method Name Method Number				
QA SAMPLE/ SAMP TYPE CODE	**FREQUENCY**	**ACCEPTANCE CRITERIA**	**CORRECTIVE ACTION**	**COMMENTS**
Retention Time (RT) window width	Initially with instrument set up. Recommend verifying annually.	IC: RT width is ±3 times standard deviation for each analyte RT from the 24-hour period. GC and HPLC: RT width is ±3 times standard deviation for each analyte RT from the 72-hour period. GC/MS: RT of each reported analyte within ± 0.06 RT units.	1) For shifting retention times, adjust according to initial CCV (mid-range). 2) Follow method requirements.	Calculated for each analyte.
Initial Calibration Verification (ICV)	Immediately following calibration, daily when used as Analytical Sequence LCS for analyses without Prep.	%Rec = 90-110 (Limits may be set statistically depending on method.)	1) Re-pour and rerun. 2) Prepare fresh calibration standards and/or ICV. 3) Recalibrate and rerun.	Evaluates calibration accuracy and method performance. Must be prepared from second source standard.
Initial Calibration Blank (ICB/MBLK)	Immediately follows ICV	< Lowest reporting limit	1) Prepare fresh blank 2) Re-pour blanks, recalibrate, and rerun.	Evaluates calibration accuracy, reagent/ glassware contamination, and instrument carryover.
Continuing Calibration Verification (CCV)	Run every 10 samples and at end of run. (Methods with internal standards do not require and ending CCV.)	%Rec = 90-110 (Limits may be set statistically depending on method.)	1) Remake and rerun. 2) Recalibrate and rerun samples since last valid CCV	Evaluates instrument drift throughout analytical sequence. Typically uses midpoint calibration standard.
Continuing Calibration Blank (CCB)	Run after every CCV. (Run every 10 samples and at the end of run)	< Lowest reporting limit	1) Check for high conc. sample. 2) Prepare fresh blank. 3) Rerun samples since last valid CCB.	Evaluates baseline drift, contamination in the analytical system, and analyte carryover.

Method QA/QC Parameters
Method Name
Method Number

QA SAMPLE/ SAMP TYPE CODE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	COMMENTS
Instrument Blank	Daily prior to sample analysis.	< Lowest reporting limit	1) Re-pour and rerun. 2) Perform instrument maintenance	Evaluates baseline drift, contamination in the analytical system, and analyte carryover. The method blank may be substituted; not required for methods with CCB criteria. Generally necessary for organics methods. Not necessarily imported to Omega.
Method Blank (MBLK)	1/preparation batch	<Lowest reporting limit	1) Re-digest samples from batch, or 2) Qualify sample data	Evaluates overall method including possible contamination in reagents and glassware utilized in preparatory batch.
Laboratory Control Sample (LCS)	1/preparation batch	Reference material specified limits or laboratory statistical limits of +/- 3 standard deviations.	1) Repeat analyses once 2) Correct problem 3) Re-extract and re-analyze all samples associated with LCS	Evaluates overall method accuracy/bias for the Preparatory Batch. Must be second source. If prepared the same as MS/MSD will evaluate the spiking technique.
Laboratory Fortified Blank (LFB)	1/daily sequence	%Rec = 90-110 (Limits may be set statistically depending on method.)	1) Re-prep and rerun. 2) Recalibrate and rerun.	Evaluates spiking technique. Can be primary or secondary source depending on the method. LCS or ICV are preferred QC Types.
Duplicate Sample (DUP)	1/10 samples OR 1/20 samples	% RPD ≤ 5 OR 10 OR 20 or < PQL OR < 2X PQL (Appropriate limits must be evaluated for each method.)	1) Rerun sample pair, evaluate for sample homogeneity or 2) Report with qualifiers***	Evaluates method precision. MSD duplicate analyses preferred on some methods.

Method QA/QC Parameters
Method Name
Method Number

QA SAMPLE/ SAMP TYPE CODE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	COMMENTS
Matrix Spike (MS/MSD)	1/10 samples OR 1/20 samples	Water %Rec = 90-110, %RPD ≤ 20 Soil Statistical Limits OR Soil Post Digestion Spike %Rec= 80-120 %RPD ≤ 20	LCS OR LFB OR ICV must be passing 1) If matrix interference suspected report as found, or 2) Re-analyze and re-spike if no matrix interference suspected, or 3) Use "A" qualifier for sample amount > 4X spike level.	Evaluates effect of matrix on method performance. MSD also evaluates method precision.
Post Digestion Spike (PDS/PDSD)	1/10 samples	Soil Statistical Limits OR Soil Post Digestion Spike %Rec= 80-120 %RPD ≤ 20	LCS OR LFB OR ICV must be passing 1) If matrix interference suspected report as found, or 2) Re-analyze and re-spike if no matrix interference suspected, or 3) Use "A" qualifier for sample amount > 4X spike level.	Evaluates effect of matrix on method performance. PDSD also evaluates method precision. Use the same solution and concentration as LFB.
External PE Samples	Biannual WS and/or WP and internal blind and double blind samples.	PT sample defined acceptance limits (Must pass 2 out of last 3 PT studies.)	1) Complete corrective action report 2) Repeat with another make-up study (for failure of 2 out of 3)	External review of analytical method accuracy.
MDL Studies	Bi-annually OR Annually per method requirement or whenever method changes might affect sensitivity.	<PQL, Spike Level < 10X MDL	1) Repeat if obvious problem occurs 2) Adjust reporting limit to > MDL	Evaluates overall method detection limits in clean sample matrix. Actual samples may have higher MDL.
LOD Verification	Bi-annually OR Annually per method MDL requirement following each MDL Study	Positive Result, S/N greater than 3 (above typical Method Blank performance)	1) Examine method or preparatory steps, 2) Verify MDL study, 3) Repeat analysis 4) Consult QA	Spike at 2-3X calculated MDL for single analyte test. OR Spike at 1-4X MDL for multiple analyte tests.
Control Charting and Proof of Competency	Annual statistical review of method.	Data statistically within control limits.	1) Trend Analysis/ Method Review 2) Correct method/instrument problem.	For statistical process control.

Method QA/QC Parameters **Method Name** **Method Number**				
QA SAMPLE/ SAMP TYPE CODE	**FREQUENCY**	**ACCEPTANCE CRITERIA**	**CORRECTIVE ACTION**	**COMMENTS**
Batch Definition	Water = Each daily analytical sequence Prepped Samples = Each batch of 20 samples/matrix or when there is a change of reagents, whichever is more frequent.	Must pass all method QC criteria	Re-analyze batch or qualify results	A group of samples and associated QC

*** DUP Qualifier (Canned Comment) for use when values are low and the % RPD criteria does not apply.
Since the difference between the analytical result for the sample and its duplicate is less than the reporting limit, the RPD variance is not considered significant.

APPENDIX B

ORGANIZATIONAL CHARTS

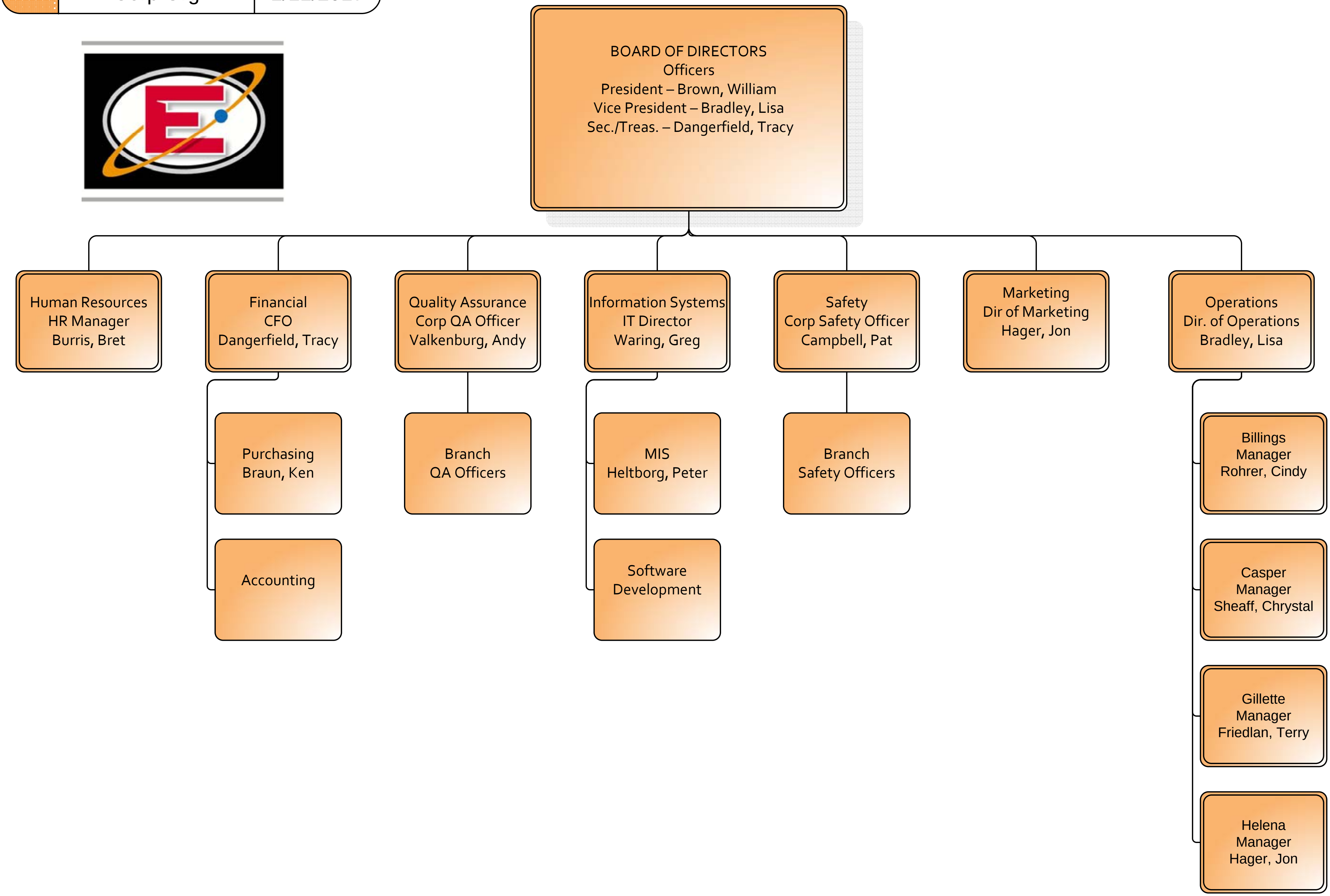
Corporate Organizational Chart

Casper Laboratory Organizational Chart

Energy Laboratories

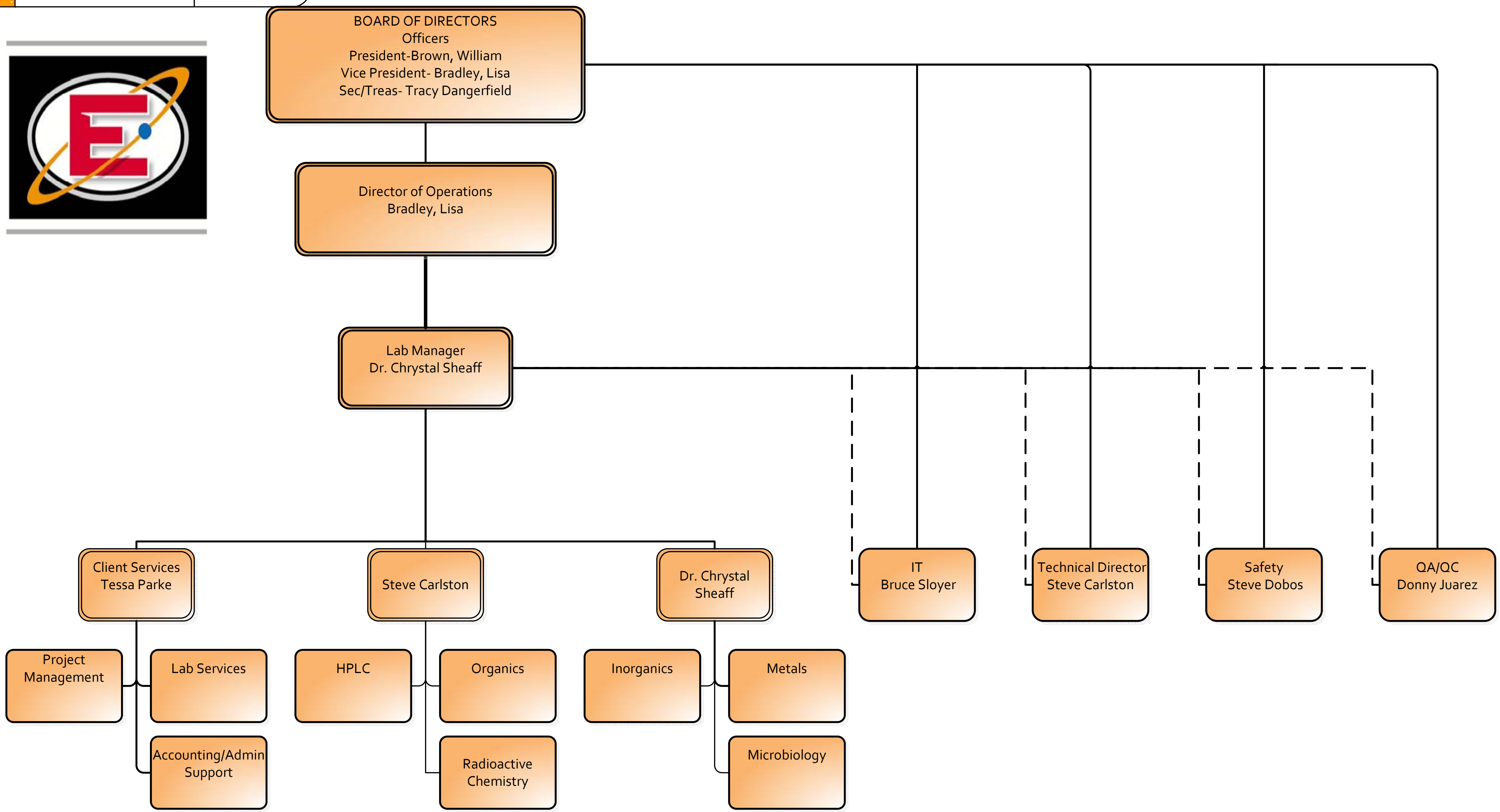
Corp Org | 1/11/2017

Energy Laboratories / Corporate Structure



Casper

Branch Structure | 5/31/2017



APPENDIX C

CURRICULA VITAE OF KEY LABORATORY PERSONNEL

WILLIAM T. BROWN

President

Responsible for corporate direction and operations of Energy Laboratories, Inc.

Experience: Thirty plus years of experience in environmental laboratory operations including lab manager, supervisor of organic analysis and senior organic chemist. Experienced in Gas Chromatography, Gas Chromatography/Mass Spectrometry (GC/MS), sample preparation and extraction, ion chromatography and chromatography data systems.

Education

Bachelor of Science in Fish and Wildlife, Montana State University, Bozeman, Montana, 1977

Professional Experience

1986 to present, President - Energy Laboratories, Inc

1981 - 1987, Manager - Energy Laboratories, Inc., Branch Laboratory, Gillette, Wyoming. Responsible for routine analysis and quality control of water, natural gas, and petroleum products. Involved in field on site sampling and testing, meter calibrations, and supervision of branch laboratory staff.

1979 - 1981, Laboratory Technician - Energy Laboratories, Inc., Billings, Montana. Responsible for the natural gas and petroleum products department of the lab including field natural gas testing. Also involved with various work in water and soil analysis including formal training in ion chromatography.

1977 - 1979, Fisheries Biologist - Water and Forests Department of the Government of Niger, Africa. While in the Peace Corps, responsible for developing fisheries management programs in a specific region including monitoring water quality by on-site testing.

LISA A BRADLEY PH.D.

Vice President/ Director of Corporate Laboratory Operations

Responsible for development and oversight of technical operations for Energy Laboratories, Inc.

Experience: Interim laboratory manager, supervisor of inorganic analysis, supervisor of elemental analysis, senior elemental analyst, research assistant, laboratory environmental technician.
Experienced in atomic absorption spectroscopy (AA), inductively coupled plasma optical emission (ICPOES), and mass spectrometry (ICP-MS).

Education
Ph.D., Analytical Chemistry, Indiana University - Bloomington, Indiana, 1996
Bachelor of Science, Chemistry, Montana State University, Bozeman, Montana, 1990

Professional Experience
2007-Present, Director of Corporate Technical Operations- Energy Laboratories, Inc., Billings, MT.
2008- Interim Laboratory Manager- Energy Laboratories, Inc., Casper, WY: Supervision of the Casper laboratory.

2005-2008, Supervisor, Inorganics Dept.- Energy Laboratories, Inc., Billings, MT: Responsible for supervision and management of inorganics laboratory.

2000-2005-Supervisor, Metals Dept- Energy Laboratories, Inc., Billings, MT: Supervised metals department; performed chemical analyses using laboratory instrumentation.

1996- 2000, Analytical Chemist - Energy Laboratories, Inc., Billings, Montana: Performed atomic absorption spectroscopy (AA), inductively coupled plasma optical emission (ICP-OES), and mass spectrometry (ICP-MS) analyses.
October 1990-1995, Research Assistant/Department of Chemistry - Indiana University, Bloomington, Indiana.
August, 1990-December, 1992, Associate Instructor of Chemistry - Indiana University, Bloomington, Indiana.

1989, Laboratory Technician - Intermountain Laboratory, Bozeman, Montana.

1986-1990, Undergraduate Research Assistant - Montana State University, Bozeman, Montana

TRACY A. DANGERFIELD, CPA, MBA

Treasurer and Chief Financial Officer

Experienced in business leadership, management and strategic development. Extensive background in accounting, finance and organizational development.

<u>Education</u>
Master of Business Administration, University of Montana, Missoula, MT 2013
Certified Public Accountant, 1992
Bachelor of Science, Business Administration, Minor in Accounting, Eastern Montana College, Billings, MT 1989

<u>Professional Experience</u>
1989-Present, Chief Financial Officer-Energy Laboratories, Inc., Billings, Montana.
Responsible for initiating, developing, and directing administrative operations including finance, human resources, taxation and marketing. Involved with growing Energy Laboratories, Inc. (ELI) from 20 employees to over 225, quadrupling revenues, and expanding to six locations throughout the Rocky Mountain Region. Steered the implementation of an Employee Stock Ownership Plan, transacted the ensuing 30% purchase of ELI, and continues to serve as Plan Trustee.

1985 -1989 Office Management-Energy Laboratories, Inc., Billings, Montana.
Responsible for daily office operations and management of staff.

CORNELIUS A. VALKENBURG PH.D.

Senior Analytical Chemist/Quality Assurance Officer

Education

Ph.D., Analytical Chemistry, Montana State University, Bozeman, Montana, 1987
Bachelor of Arts, Biology with minor in Chemistry, Carroll College, Helena, Montana, 1979

Professional Experience

1992- Present, Analytical Chemist/Quality Assurance Officer - Energy Laboratories, Inc., Billings, Montana. Corporate Quality Assurance Officer responsible for the Quality Assurance monitoring of laboratory operations. Performs method development, prepares and updates standard operating procedures, performs technical training, and involved with special projects. Manages laboratory solvent recycling program.

1989 - 1992, Senior Organic Analytical Chemist - ICF Kaiser Engineers, Las Vegas, Nevada. Provide supervisory and technical support in the design, preparation, analysis, and multi-laboratory certification of analytical method performance evaluation materials used to evaluate current and proposed EPA organic analytical procedures. Also review proposed EPA methods contracts for technical accuracy. Secondary duties as Laboratory Safety Officer.

1987 - 1989, Senior Scientist - Lockheed Engineering and Sciences Company, Environmental Programs (Organic Chemistry Section), Las Vegas, Nevada. Responsible for research and development projects as applied to improved methods for the analysis of EPA priority pollutants. Areas of study include: liquid-liquid extractions, solid-phase extraction, soil leachability modeling (TCLP), chemical derivatives for gas and liquid chromatography, production of performance evaluation materials, gas chromatographic methods, supercritical fluid chromatography and extraction, and laboratory automation.

1981 - 1987, Ph.D. Candidate, Graduate Research, Assistant - Montana State University, Department of Chemistry, Bozeman, Montana. Research in gas chromatographic detector design, modification, and characterization by computer modeling. Teaching of undergraduate laboratories in the areas of inorganic, organic, and analytical chemistry.

1981 - 1981, Research and Development Chemist - Falls Chemicals, Great Falls, Montana. Methods development for the analysis of raw materials and formulated products used or produced by Falls Chemicals. Performed optimization studies for plant chemical processes.

1980 - 1981, Research Technician - Oregon Graduate Center, Beaverton, Oregon. Synthesis and purification of polyamine dueterated analogues for their use as internal standards in mass spectrometry.

1978 - 1979, Field Technician and Student Researcher - State of Montana Water Quality Bureau and Carroll College, Helena, Montana. Evaluate the effects of subsurface drainage on saline seep areas.

Summer 1978, Lab Technician - American Chemet Corporation, East Helena, Montana. Quality control for the manufacture of CuO and CuO2, and the trace analysis of Pb. Methods used were wet chemistry, electrochemistry, and atomic absorption.

Technical Training

Technical Writing, University of Nevada, Las Vegas, Nevada, 1988
Emergency Medical Training, Hillsboro Medical Hospital, 1981
Mass Spectrometry, Oregon Graduate Center, 1981
Dale Carnegie Management Training, Billings, Montana, 1996
Dale Carnegie Graduate Assistant Training, Billings, Montana 1997

Professional Organizations

American Chemical Society

Dr. Chrystal N. Sheaff

EDUCATION	University of Idaho, Moscow, ID Ph.D., Chemistry, 2008
	Black Hills State University, Spearfish, SD B.S., Chemistry and Biology, 2004

PROFESSIONAL EXPERIENCE

2015- Present ***ENERGY LABORATORIES, INC., Casper, Wyoming***
Organics Department Manager – Supervise the daily operation and management of the volatiles, semi-volatiles, HPLC, soil, and microbiology departments. Leads staff training sessions within the department as well as across departments. Responsible for maintaining quality control/assurance compliance within the department. Technical reviewer of standard operating procedures.

2012 – 2014 ***ENERGY LABORATORIES, INC., Casper, Wyoming***
Chemist – Performed HPLC analysis for determination of pesticides and herbicides in drinking water. Performed analysis for gasoline range organics using a purge and trap system. Perform instrument maintenance and repair on HPLC and GC-PID/FID. Responsible for sample management; including, turn-around-times, sample disposal, and waste disposal. Writer, editor, and reviewer of standard operating procedures.

2008 - 2012 ***ALTURAS ANALYTICS, INC., MOSCOW, IDAHO***
Scientist – Performed sample analysis on various biological matrices using HPLC-MS/MS. Developed analytical methods to support drug discovery under regulatory criteria. Followed SOPs, method protocols, analytical test methods, and EPA regulations. Performed troubleshooting, repairs, and maintenance on HPLC-MS/MS instruments.

2004 - 2008 ***UNIVERSITY OF IDAHO, INC., MOSCOW, IDAHO***
Research Assistant – Researched fluorescent methods to detect and identify explosives, determine effectiveness of catalytic hydrogenation, and determining uranium extraction from aqueous solutions. Used synchronous spectroscopy, derivative spectroscopy and excitation-emission matrices (EEM) to identify explosives bases on their impurities and associated tagging agents.

2004 - 2006 ***UNIVERSITY OF IDAHO, INC., MOSCOW, IDAHO***
Teaching Assistant – Taught laboratory classes for General Chemistry and Quantitative Analysis. Tutored chemistry students across all disciplines. Instructed recitation classes and review sessions.

TRAINING GLPs for Study Directors-West Coast Quality Control Training-2011.
Testing Requirements in EPA Regulations, TNI Webinar, 10/9/2015

Donny Juarez

EDUCATION Casper College, Casper, Wyoming
A.S., Chemistry, 2017

PROFESSIONAL EXPERIENCE

June 2014 – Present Quality Assurance Manager, **Energy Laboratories, Inc., Casper, Wyoming**

Maintains laboratory certifications, quality assurance and control criteria. Responsible for annual employee ethics training. Maintains employees training folders. Manages Quality Systems of laboratory including annual reviews of Standard Operating Procedures, QA Manual and employee training folders. Technically reviews data and reports. Well-versed in NELAC, EPA, SW-846, Clean Water Act, and Safe Drinking Water Act regulations and guidelines.

2012 – May 2014 Quality Assurance Assistant, Energy Laboratories, Inc., Casper, Wyoming

Assisted in management of quality and client service standards, implemented and maintained quality initiatives, and assessed quality system performance. Was actively involved with peer auditing of branch laboratories and assisted with the development of internal test method assessments.

2006 – 2012 Soils and Semi-Volatile Organics Dept. Supervisor, Energy Laboratories, Inc., Casper, Wyoming

Performed supervisory duties pertaining to the Agronomic Soils and Semi Volatile Organics Departments. Responsibilities included; prioritization of sample analyses, sample scheduling, ordering, data review and report generation. Managed sample loads, maintained quality assurance and control criteria, and performed method development and improvements.

1995 – 2006 Semi-Volatile Organic and Agronomic Soils Analyst, Energy Laboratories, Inc., Casper, Wyoming

Responsibilities included analysis of samples for semi-volatile organics using Gas Chromatographs, routine maintenance, optimization of instrument performance, data documentation and review, and report generation. Instrumentation included various HP Gas Chromatographs equipped with FIDs to include automated injectors, trays, and controllers. Proficient in analytical and preparation methods including EPA 8015B DRO, 3510, 3550, 1010A, and 1664. As Soil Analyst, responsibilities included analysis, and data review for agronomic and mining samples utilizing various agronomic testing methods.

SPECIAL TRAINING Supervisor Interaction Management Training, 2009 Energy Laboratories, Inc., Lean Training, 2012 Manufacturing-Works, Environmental Laboratory Assessment - Basic Assessor Training – TNI Standard Testing Requirements in EPA Regulations, TNI Webinar, 10/9/2015

Steven E. Carlston

EDUCATION	University of Northern Colorado, Greeley, Colorado B.A., Chemistry, with Physics minor, 1980
SPECIALITIES	Gas Chromatography; Resource Conservation and Recovery Act (RCRA) and Toxic Characteristics Leaching Procedure (TCLP) Programs; Quality Assurance/Quality Control Program (QA/QC).

PROFESSIONAL EXPERIENCE

2014- Present	***ENERGY LABORATORIES, INC., Casper, Wyoming*** Senior Project Specialist – Developing and Implementing the tools and Processes for the analysis of company data streams.
2011 – 2014	***ENERGY LABORATORIES, INC., Casper, Wyoming*** Branch Manager – Responsible for collecting and analyzing data, establishing, planning and implementing business objectives, directing staff, recommending actions; tracking and evaluating results.
2008 - 2009	Interim QA Director - Responsible for Quality Assurance programs, QA/QC documentation, training records, PE studies and SOPs. Perform technical data review prior to releasing final data reports.
2005 - 2008	IT Department Supervisor - Responsible for: all programs, internal applications, commercial LIMS (Omega) system, Operating Systems, servers and PC support activities. Provided specific support to Radiochemistry Department for commercial software and hardware procurement
1988 - 2005	Organic Chemistry Department Supervisor - Responsible for: Supervision and performance of analyses for the Gas Chromatography and Hazardous Waste Departments, backup analyst for crude oil, radiochemistry, and soils analysis during peak activity periods.
1979 - 1988	***NAVY DRUG SCREENING LABORATORY, Oakland, California*** Quality Control Coordinator and Chemist - Prepared QA/QC blind samples; tracked and reported results of RIA and GC/MS analyses; trained personnel; and suggested and implemented changes to laboratory Standard Operating Procedures. As a chemist, performed extraction, derivatization, and GC/MS analysis of drugs of abuse. Responsible for the technical maintenance of nine GC/MS instruments. ***TRANSCONTEC, Golden, Colorado*** Chemist - Organized the Environmental Analysis Laboratory which specialized in the detection and remediation of radon contamination. ***NEWPARK RESOURCES, INC., Denver, Colorado*** Chemical Engineer - Prepared and presented fluid system proposals.

Field-tested and adjusted chemical properties of fluid tested and adjusted chemical properties of fluid systems. Responsible for the laboratory testing of new fluid formulations prior to and during initial field-testing.

TRAINING

Control Data Corporation, Denver, Colorado
Certificate in Computer Programming and Operations, 1987
American Chemical Society, Philadelphia, Pennsylvania
Certificate in Gas Chromatography, 1989
Testing Requirements in EPA Regulations, TNI Webinar, 10/9/2015

AFFILIATIONS

American Chemical Society
Society of Petroleum Engineers
American Petroleum Institute
Wyoming State Committee on Pesticides in Groundwater

Steven M. Dobos

EDUCATION University of Montana, Missoula, Montana
B.S., Geology, 1980

PROFESSIONAL EXPERIENCE

2011 – Present ***ENERGY LABORATORIES, INC., Casper, Wyoming***
Safety Officer and Radiation Safety Officer - This position is responsible for ensuring compliance with the Company's proactive safety, and hazardous waste management programs. The individual must provide day-to-day support and guidance to staff and management in order to ensure the laboratory is operated within Federal, State and local regulations. Presents effective employee training on safety; documents training dates.

Works as Casper Radiation Safety Officer (RSO) to assure compliance with the radiation safety plan and U.S. Nuclear Regulatory Commission (USNRC) license requirements. Conducts periodic safety audits and performs a variety of routine and complex administrative practices as they may obtain to the laboratory. Performs or assists with accident investigations as needed. Insures that processes take necessary corrective action to prevent future incidents. Communicates recommendations to all concerned parties promptly. Workers Compensation reporting, administration and handling of work place injuries.

2011 – 2012 Technical Director/Senior Project Manager – Responsible for client reporting and data quality review of water analyses. Developed test methods and trained laboratory staff.

2010 – 2012 Senior Project Manager/Client Services Supervisor – Responsible for client reporting and review of results. Supervisor of Project Managers.

1986 – 2010 Inorganic and trace metals Laboratory Supervisor - Primary responsibilities include trace metal analysis and hazardous waste consultation. Project management and administrative input for special projects and operations.

1985 - 1986 ***WESTERN ENVIRONMENTAL SERVICES AND TESTING, Casper, Wyoming***
Laboratory Technician - Soil analysis and air quality stack testing.

CORE LABORATORIES, INC., Casper, Wyoming
Crude oil analysis and gas chromatography.

PROJECT MANAGEMENT EXPERIENCE

Texas Water Development Board (TWDB)

Nevada Mining Clientele
- Newmont Mining Company
- Queenstake Resources USA Inc
- Placer Dome US Inc / Bald Mountain Mine
- Anglo Gold Nevada Corp

Drinking water clients

TRAINING

2012 OSHA Hazardous Material
2012 MSHA Mine Hazardous Training
2012 Radiation Safety Officer Training 40 hours
Perkin Elmer School - ICP Operations
OSHA 8 Hour Hazardous Materials, Annual Refresher
American Chemical Society, Short Course on *Effective Management of Scientists and the Technical Staff*.
Wyoming Association of Municipalities *Current Water Policy Issues, Subtitle D*, Regulations Workshop
Spiegel and McDiarmid Municipal Environmental Compliance Course
Testing Requirements in EPA Regulations, TNI Webinar, 10/9/2015

AFFILIATIONS

American Society of Mining Engineers
American Water Works Association
Wyoming Solid Waste Management Association
Wyoming Non-point Source Organization
Casper Public Utilities Advisory Board Member

Tessa J Parke

EDUCATION Associates in Business Adminstration, Casper College, 2003

SPECIALITIES Accounts receivable, report preparation, and customer service.

PROFESSIONAL EXPERIENCE

2004 - Present **_ENERGY LABORATORIES, INC., Casper, Wyoming_**
Project Manager - Responsible for the preparation of reports, accounts receivable, customer service, telephone management, archives, research, and training. Distribute work and provide back up to the Administrative Assistant during absences and heavy peak periods. Utilize Smart and orders (Database Accounting Library) programs for reporting purposes.

2002 to 2004 **_Dahle's, Casper, Wyoming_**
Retail – Making sales, handling money and credit cards transactions, making bank deposits, and ordering clothing.

2000-2002 **_Hometown Buffet, Casper, Wyoming_**
Cashier – Responsible for handling money, balancing the cash register, answering customer questions, and opening or closing the restaurant.

TRAINING

Bacteriological Training, 2013
LEAN Training, 2012
Supervisory Training, 2011
Radiochemistry Training, 2008
Testing Requirements in EPA Regulations, TNI Webinar, 10/9/2015

APPENDIX D

EQUIPMENT AND METHODS LIST

ENERGY LABORATORIES, INC – CASPER, WYOMING

Equipment	Quantity	Methods
Gas Chromatograph-FID with auto sampler	3	EPA 8015 DRO
Gas Chromatograph-PID/FID with purge and trap & auto sampler	2	EPA 8015 GRO
Gas Chromatograph-Dual ECD with auto sampler	1	EPA 504.1, EPA 552.2
Gas Chromatograph-Mass Spectrometer with purge and trap & auto sampler	2	EPA 524.2, EPA 624, EPA 8260
Closed Cup Flashpoint Analyzer	2	EPA 1010
Atomic Absorption Fluorescence Spectrophotometer with cold vapor apparatus	1	EPA 245.7
Inductively Coupled Argon Plasma Spectrophotometer	1	EPA 200.7, EPA 6010
Inductively Coupled Argon Plasma Spectrophotometer-Mass Spectrometer	2	EPA 200.8, EPA 6020
Quick Trace Mercury Analyzer - Cold Vapor Atomic Absorption Analyzer	1	EPA 245.1, EPA 7470, SM 3112B,
Ion Chromatograph	3	EPA 300.0
Conductivity and pH	1	SM 2510 B, SM 4500-H+- B
Turbidimeter	2	SM 2130 B
Auto Titrator / ISE	1	SM 2320B, SM 4500-F C
Manual Solid-Phase Extractor	1	EPA 1664 A
Spectrophotometer	2	Hach 8000, SM 4500-NO2 B
Autoanalyzer (FIA)	1	EPA 351.2, EPA 353.2, EPA 365.1, SM 4500-NH3 G
TOC Analyzer	2	SM 5310 C
Liquid Chromatography (HPLC)	2	EPA 549.2, EPA 531.1, EPA 547
Liquid Scintillation Counter	2	EPA 906.0, EPA 909.0, ASTM D5072 92
Alpha / Beta Gas Proportional Counters Detectors	4 64	EPA 900.0, EPA 903.0, EPA 905.0, EPA Ra-05
Gamma Ray Spectrometers (1 HPGe, 3 NaI(TI))	4	EPA 901.1
Alpha Spectrometers Detectors	6 48	EPA 908.0, SM 7500-U C
BOD/DO Analyzer	1	SM 5210 B
TCLP Extractor/Rotator	2	EPA 1311
Serial numbers and associated support equipment are located in the ELI-Casper's LIMS database.		
Additional Methods: SM 2340 B, SM 2540 C, SM 2540 D		

RECORD OF REVIEW/REVISION
CASPER, WYOMING

Date of Review/ Revision	Revision Number	Performed By	QA Officer Approval Initials/Date	Action (Review with no changes/ Detailed modifications)
5/15/2015	5/15/2015	D Juarez	D Juarez 5/15/2015	Updated Laboratory Manager and Quality Assurance Officer Changed all reference to "Branch Manager" to "Laboratory Manager" Removed all reference to the Laboratory Policy SOP Removed all reference to the Roles and Responsibilities SOP Removed reference to Rapid City Lab Updated the Table of Contents Removed Appendix A and renamed Appendix B, C, D, E and F to A, B, C, D and E Updated the Introduction Section Updated Chapter 4 Updated Chapter 6 Updated Chapter 7 Updated Chapter 8 Updated Chapter 11 Major update Chapter 12 moved equipment list the Appendix E Updated Chapter 15 Updated all Appendices Removed Attachment 2 Multiple grammatical corrections See redline document for all changes Added Management of Change Chapter
7/29/2015	July 29, 2015	D. Juarez	D. Juarez 7/29/15	Removed Dr. Vien as Technical Director from the title page. Added Acting Technical Director to Daniel Lashbrook's title on the title page. Replaced Appendix C (Casper Organization Chart) with current version indicating Daniel Lashbrook as Acting Technical Director. Removed Dr. Vien from Appendix D (Curricula Vitae). Fixed minor typographical errors.
1/29/2016	January 29, 2016	D. Juarez	D. Juarez 1/29/16	Fixed minor typographical errors and format irregularities. Removed all reference to the Qualifications Manual Removed reference to Peer Audits Chapter 1 – Quality Control Program Updated Quality Assurance Program Section Chapter 2 – Quality Assessment Program Updated Quality Assurance Audits Section Chapter 4 – Personnel Requirements and Laboratory Organization Updated Laboratory Organization Section Chapter 5 – Sampling Procedures Removed reference to sample condition report

Date of Review/ Revision	Revision Number	Performed By	QA Officer Approval Initials/Date	Action (Review with no changes/ Detailed modifications)
				Removed reference to preservation check at log in and added reference to the *Bench Level pH Preservation Verification, Documentation and Communication* SOP Chapter 6 – Sample Handling Updated Sample Receipt Section Chapter 9 – General Laboratory Practices Updated Chemicals and Reagents Section Updated Employee Training Section Updated Standard Operating Procedures Section Chapter 11 – Corrective Action Clarified required re-analysis in the event that an instrument has been determined to be out of control Chapter 13 – Major Equipment and Methods Clarified contents of Appendix E Updated Appendix A – Quality Systems Controlled Documents Updated Appendix C – Organizational Charts Updated Appendix D – Curricula Vitae of Key Laboratory Personnel Updated Appendix E – Equipment and Methods List See "redline" (tracked changes) word file for detailed information on all changes
3/3/2016	March 3, 2016	D. Juarez	D. Juarez 3/3/2016	Changed title page; Laboratory Manager from Daniel Lashbrook Dr. Chrystal Sheaff and Technical Director to Steven E. Carlston. Updated Chapter 14 Preventive Maintenance; ICP-Mass Spectrometer maintenance items Updated Attachment C Organizational Charts; Current Organization Updated Attachment D Curricula Vitae of Key Personnel; Removed Daniel Lashbrook
1/11/2017	January 11, 2017	D. Juarez	D. Juarez 1/11/2017	Changed title page; Updated page numbers in Table of Contents; Fixed minor typographical and grammatical errors; Removed reference to College Station Lab; Removed Attachment A and renamed all subsequent Attachments, changed all relevant references to all Attachments; Added ANSI N13.30-2011 to References Section; Updated Attachment B Organizational Charts; Update Attachment C *Curricula Vitae*; See "redline" (tracked changes) word file for detailed information on all changes.
6/1/2017	June 1, 2017	D. Juarez	D. Juarez 6/1/2017	Removed all reference to the Safety Manual & Chemical Hygiene Plan; Removed all reference to "branch" were appropriate; Changed all reference to the Technical Services and Fee Schedule to the Professional Services Guide; Changed all Chapter references to numerical; Removed stipulation that SOPs are not allowed to be removed; Added website reference to facility description (Chapter 3); Changed all reference to Quality Assurance Manager to Quality Assurance Officer; Changed wording to the analyst

Date of Review/ Revision	Revision Number	Performed By	QA Officer Approval Initials/Date	Action (Review with no changes/ Detailed modifications)
				training section (Chapter 4); Removed reference to 40 CFR 141.25 (c) from MDL determination (Chapter 7); Re-defined approved documents (Chapter 8); Changed SOP review to annually (Chapter 10); Updated example preventative maintenance table (Chapter 14); Added definitions (Chapter 16); Incorporated example QA/QC Parameters into .doc (Appendix A); Updated organizational chart (Appendix B); Updated Curricula Vitae (Appendix C); Updated and incorporated equipment and methods list (Appendix D).
7/27/2017	July 27, 2017	D. Juarez	D. Juarez 7/27/2017	Introduction – Added reference to USNRC License and adherence to Reg. Guide 4.15.

ATTACHMENT 3
Data Management Plan

Attachment 3 - Data Management Plan

October 23, 2017

TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS/ABBREVIATIONS

CSC	Construction Supervising Contractor
DEM	Digital Elevation Model
DMP	Data Management Plan
EDD	Electronic Data Deliverable
ERT	Environmental Response Team
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
GIS	Geographic information system
GPS	Global positioning system
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NAD27	North American Datum of 1927
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NGS	National Geodetic Survey
NGVD29	National Geodetic Vertical Datum of 1929
PM	Project Manager
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SPCS	State Plan Coordinate System
SQL	Structured Query Language
USEPA	US Environmental Protection Agency
WGS84	World Geodetic System 1984

1 INTRODUCTION

This Data Management Plan (DMP) describes the intended procedures and responsibilities pertinent to project data collection, data management flow, quality assurance/quality control (QA/QC), storage and data export in support of the Removal Action for excavation control (Appendix T-1 of the 95% Design Report) and for the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Final Status Surveys (Appendix T-2 of the 95% Design Report).

The project data sources will comprise data from laboratory analysis of samples from soil and water (from equipment decontamination), field forms, radiological survey data, site photographs, global positioning system (GPS) data, and Geographic Information System (GIS) data. Stantec will maintain the project data in an integrated data management system consisting of an Oracle structured query language (SQL) database, GIS database, U.S. Environmental Protection Agency (USEPA) Scribe database deliverable, and project file management system.

1.1 Data Management Objectives

Successful data management results from coordinating data collection, quality control, storage, access, reduction, evaluation and reporting. This DMP documents the methods to be employed during project execution to link the various data management elements to confirm systematic collection and management of the various data and information types. Specific objectives of this DMP are:

1. Standardize and facilitate the collection, formatting, and transfer of project data into the data management system and its components
2. Provide a structured data system to support data end uses, including planning, decision-making and reporting
3. Minimize uncertainties associated with the data, data-derived products, and interpretation of results through defined QA/QC measures and documented processes, assumptions and practices
4. Provide data adequately documented with descriptive information for technical defensibility and legal admissibility of the data

1.2 Data Management Team Organization

The project data management team will work together to properly execute this DMP such that the project objectives and scope are met. The team is composed of specialists in each related discipline and technical resource. The Construction Supervising Contractor (CSC) Project Manager (PM) and QA Manager are integral to the data management team, having overall responsibility for assuring compliance with the Design Report and Quality Assurance Project Plan (QAPP). The roles and responsibilities of the data management team shown are in Table 1. One or more persons may hold one or more of the roles. The CSC PM and Data Manager will determine assignments as appropriate to assure the best workflow.

Table 1
Data Management Roles and Responsibilities

Team Member	Roles and Responsibilities
CSC PM and QA Manager	• Responsible for preparing the work plans, schedule and milestones • Coordinates efforts with the project stakeholders and project team • Determines the needs and objectives for tasks • Assigns appropriate personnel to complete the project • Ultimately responsible for the completion of the project • Oversee quality control and quality assurance
Data Manager	• Coordinates, documents and reports to the CSC PM on data management activities • Oversees or performs field data transcription for database entry • Acts as a liaison between the data users and the data holders, providing to users in the appropriate format • Reviews field data, and notifies the field teams of data gaps • Archives/transcribes field data
Field Team Leader	• Responsible for collection and documentation of field-generated data • Conducts QC checks between the planned collection and actual collection of data, and the accuracy of documentation submitted by the field teams
CSC Project Chemist	• Works with the subcontracts manager to develop the scope of work for laboratory subcontracts • Assists in defining regulatory criteria and threshold values, and maintains the regulatory criteria in the database • Provides assistance to the CSC PM and technical staff in interpreting analytical results • Performs data validation, or reviews third-party validation, if used
Project Data Coordinator	• Responsible for tracking samples from collection through analysis to inclusion in the database through maintenance of a data tracking matrix • Communicates with laboratories and data validators as needed • Coordinates the QC process for validated data
Database Administrator	• Overall responsibility for the operation and maintenance of the project database • Ensures that the electronic data deliverable (EDD) provided by the subcontractor laboratory meets subcontract requirements • Responsible for loading field and laboratory data to the database • Responsible for the implementation and evaluation of standard operating procedures to ensure integrity of the database system • Final delivery of a project Scribe database
GIS Manager	• Manages the Project Environmental Systems Research Institute (ESRI) ArcGIS File GeoDatabase (File GeoDatabase) • Responsible for version control, quality control and quality assurance of GIS data sent from multiple sources • Produces project maps

2 PROJECT DATA TYPES

2.1 Field-Collected Data

Field-collected data include field notes, field forms, and other data collected during field activities. Project database entry of field-collected data first requires QA/QC and transcription to electronic format, performed by the Field Team Leader, Data Manager or qualified persons they delegate.

2.2 Radiological Survey Data

Radiological survey data will be collected using GPS-based radiological detectors/meters, as described in Appendix T-2. The radiological field team is responsible for the calibration and correct operation of their equipment, and for initial QA/QC prior to delivering their radiological survey data. The radiological contractor delivers both the radiological survey reports and the native survey GIS data that will be entered into project files and File GeoDatabase.

2.3 Laboratory Sample Data

Laboratory-analyzed sample data include the analytical results and quality control results (e.g., duplicate samples and matrix spike samples) provided by the analytical laboratory. Field personnel will deliver collected samples to the analytical laboratory in accordance with Appendix T-2 of the 95% Design Report and the QAPP. The analytical laboratory will be responsible for instrument calibration and holding times, and will deliver data analysis packages and electronic data deliverables (EDDs) to the Analytical Laboratory Manager within the timeframe specified in the QAPP.

2.4 GIS Data

GIS data include aerial imagery; digital elevation models (DEMs); and points, lines, and polygons obtained in the field using a hand-held GPS or otherwise provided to the project. A unique name and description accompany each point, line and polygon feature surveyed, in addition to the spatial data recorded by the GPS. The GIS Manager is responsible for accuracy and input of the GIS data from any source into the File GeoDatabase in accordance with Project GIS procedures.

2.5 Site Photographs

Project site photographs from field reconnaissance activities may include photos of sample locations, project elements, and geomorphic features. The File GeoDatabase features may have links to some feature photographs, and the project file system houses selected photographs, organized by site.

3 PROJECT DATA STORAGE

The CSC will manage all project data as presented in this DMP. A data flowchart in Figure 1 depicts the inputs, transfer, storage and outputs of the data management system. In summary, project data are stored via one, or a combination of: 1) an Oracle SQL relational database; 2) an ESRI File GeoDatabase; and 3) the project file system.

3.1 Project Database

The primary repository for field-collected and laboratory analytical data will be a project-dedicated relational database, such as Oracle SQL database. The database shall have a schema developed to increase data handling efficiency and include data entry, validation, and reporting tools. The project database will be used to export project data for various uses, including exporting to the USEPA Scribe database format, as discussed in Section 4.

The project database contains a series of related tables to store project data. In a relational database, primary key columns ensure that there are no duplicate records in the table, and foreign key columns ensure that values in that column of a table match with values in the corresponding column in a related table. The overall effect of this approach ensures data quality, consistency and facilitates data interoperability with other systems.

3.1.1 Project Database Input

Data input to the project database will occur via two primary pathways: 1) transcription and subsequent entry of field-collected data from field forms, field notes and GPS point coordinates; and 2) uploading laboratory-delivered EDDs. The Data Manager/Database Administrator or their delegate(s) will perform data entry via either of these pathways into the project database.

3.1.2 Project Database Output

The project database serves as the primary storage location for QA/QC-approved project data, and therefore is the primary source of information included in report tables, report figures, and used to perform statistical and other analyses. Common outputs include data summary tables, graphs, data summary figures/maps, data verification reports, and input destined for statistical analysis software or other programs. The project database also exports project data, via a “crosswalk” procedure, to the USEPA Scribe database format, as discussed in Section 4 below.

3.2 Project GIS Database

A dedicated File GeoDatabase houses project GIS data of record. The File GeoDatabase approach enforces data integrity, version control, file size compression, and ease of sharing to preserve GIS output quality. Periodic File GeoDatabase backup also ensures no corruption or loss of data.

3.2.1 GIS Data Sources

GIS data come from multiple sources including GPS field-acquired features, commercially available aerial photography, DEMs, digitized historical map features, and raw GIS data provided by subcontractors (e.g., radiological survey data). Data from any source must undergo verification overseen by the GIS Manager to ensure consistency within the project file GeoDatabase. Typical verification includes checking feature location accuracy, coordinate system, and metadata.

3.2.2 Coordinate Systems

Data contained in the project file GeoDatabase are in the North American Datum 1983 (NAD83), and State Plane Coordinate System (SPCS), New Mexico West (feet). The vertical datum for the project is North American Vertical Datum of 1988 (NAVD88) using Geoid09.

3.2.3 Coordinate System Conversions

It is possible that some GIS data sources will not be in the desired datum or coordinate system and will require transformation before being stored in the File GeoDatabase. Two common datums requiring transformation are the World Geodetic System 1984 (WGS84) and the North American Datum 1927 (NAD27). The recommended ArcGIS transformations are:

- WGS_1984_(IITRF00) to NAD_1983 transformation for horizontal datum transformations from WGS84.
- NAD_1927 to NAD_1983_NADCON transformation for horizontal datum transformations from NAD27.

Should a vertical datum transformation be necessary, the recommended method is the National Geodetic Survey (NGS) software program VERTCON. This software computes the modeled difference in orthometric height between the NAVD88 and the National Geodetic Vertical Datum of 1929 (NGVD29) for a given location.

3.2.4 GIS Metadata

Basic GIS metadata accompany project GIS features within the File GeoDatabase. Metadata content must adhere to Federal Geographic Data Committee Content Standards for Digital Geospatial Metadata STD-001-1998 (FGDG, 1988) and its USEPA profile, and the USEPA's Geospatial Metadata Technical Specification, Version 1.0 (USEPA, 2007). At a minimum, project GIS metadata comprise the feature originating organization, creation date, collection and accuracy information, project identification, and a description.

3.3 Project Files

Project data forms, field notes, photographs, cultural/natural resource findings, laboratory reports, and EDDs, following QA/QC, are stored within the project files. A secure server must be used to provide storage for project files. Project files are available for use in reports, or delivered otherwise upon request. Project files remain archived for the duration of the project and a period after project completion.

4 DATA REPORTING/SCRIBE

The primary means for disseminating project analytical chemistry data and field-measured data is via compiled reports, data tables, and figures output from the project database and File GeoDatabase. In addition, data from the project database will be exported to Microsoft Access (.accdb file) containing a USEPA Scribe database.

4.1 USEPA Scribe Database

Scribe is a software tool developed by the USEPA's Environmental Response Team (ERT) to assist in the process of managing environmental data. The Scribe tool itself contains many features enabling it for use as a primary data management tool. However, data-handling efficiency is highest using the previously developed data entry, validation and reporting tools within the proprietary project database. Therefore, Scribe will remain as a final, additional output destination from the project database and not the primary data management tool.

The Data Manager/Data Administrator is responsible for meeting the project data transfer requirements from the project database to Scribe. The project Data Manager/Data Administrator will maintain custom data queries and "crosswalk" export routines built into the project database to facilitate data export to the Scribe database as required.

5 REFERENCES

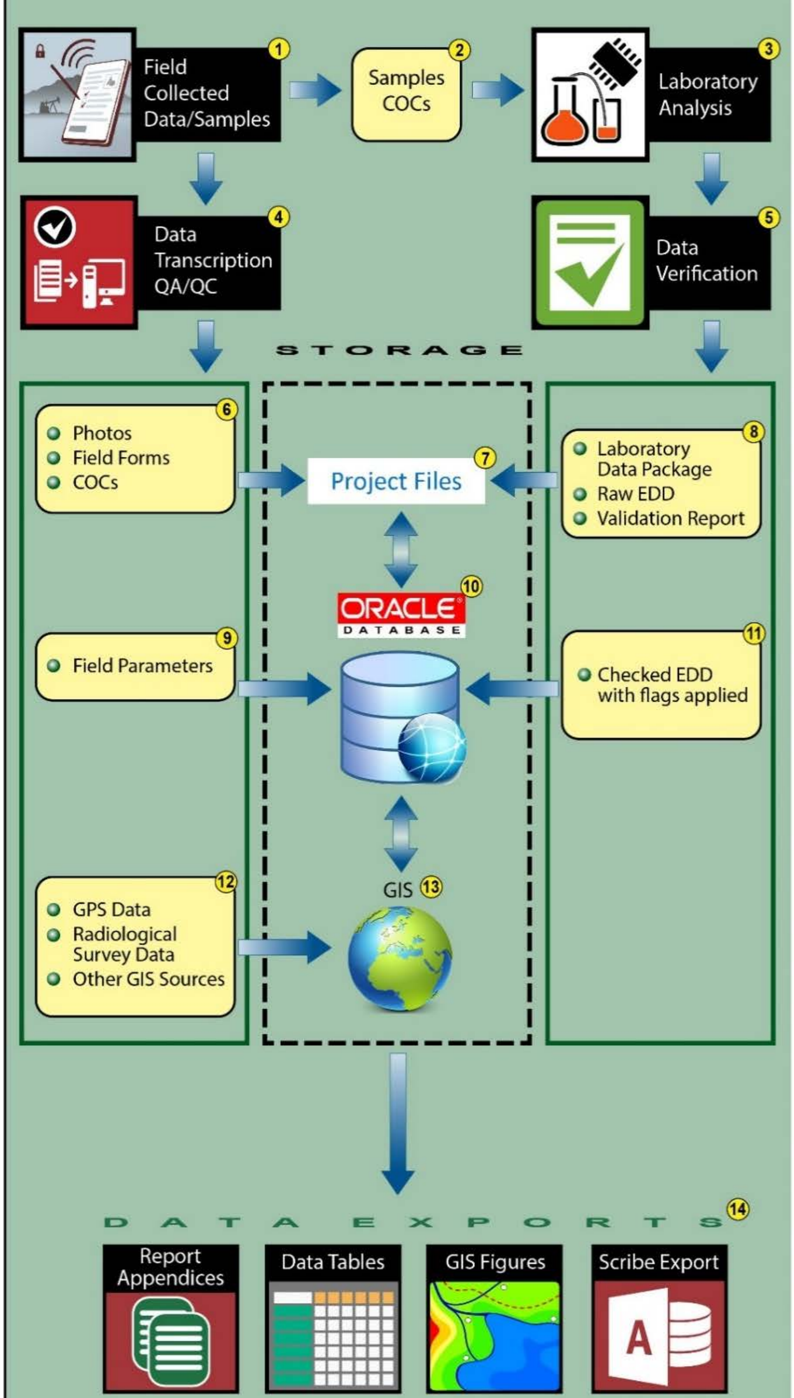
Federal Geographic Data Committee (FGDC), 1988. Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998).

United States Environmental Protection Agency (USEPA), 2007. EPA's Geospatial Metadata Technical Specification, Version 1.0. November 2.

FIGURE

Figure 1 - Data Management Plan Flowchart

Figure 1 Data Management Plan



1. Field Data include samples, measurements, photographs, survey data, and quality control samples such as field duplicates and blanks.
2. Preserved, cooled samples and chain of custody forms go to the laboratory for analysis in accordance with the project QAPP.
3. Laboratories perform the analyses, calibration, and quality control in accordance with the QAPP and contractual agreement. They produce electronic data deliverables (EDDs) and laboratory data packages for delivery and further review.
4. Hand-written field data are transcribed/-converted to electronic format for upload into the Project Files and the Oracle SQL database. Transcribed data undergo QA/QC procedures to ensure data correctness.
5. All laboratory data undergo data verification in accordance with the project QAPP producing EDDs, data package, and data flags.
6. Following QA/QC, scanned copies of all field-collected data are uploaded to the Project Files.
7. The Project Files serve as a repository for all project-related documents. Project Files allow the entire project team ready access to all relevant documents.
8. All data received from the laboratory and relevant data validation reports will be uploaded to the Project Files.
9. Transcribed field measurements such as water levels, DO, pH, etc. are uploaded to the Oracle SQL database.
10. The Oracle database contains all the results from field measurements and analytical data from the laboratory. This allows for the retrieval of data used in the production of report appendices, data tables, GIS figures, input for software packages, and export to the USEPA Scribe database.
11. The project chemist applies data quality flags to the laboratory EDD. The data are checked electronically for consistency and uploaded to the Oracle SQL database.
12. Data collected using GPS devices and from other sources are uploaded to the File GeoDatabse. These data may include location coordinates, aerial imagery, DEMs, and radiological survey data.
13. The File GeoDatabase contains all location coordinate data, lines, polygons, aerial imagery, and DEMs. Data are shared, as needed, between the File GeoDatabase and Oracle SQL database.
14. The centralization of data in the Project Files, Oracle SQL, and File GeoDatabase supports generation of reports and other data exports. Because of upstream QA/QC, the data are correct, centralized, and consistent between reports and other data exports.

ATTACHMENT T.4

Standard Operating Procedures

95% Design

Standard Operating Procedures

Excavation Control and Final Status Survey

Northeast Church Rock Mine Site Removal Action

Prepared by

AVM Environmental Services, Inc.

Grants, New Mexico

July 2018

Table of Content

SOP-1
AVM Environmental Services, Inc.
Calibration of Gamma Radiation Survey Instruments
NECR Removal Action

1. SCOPE

1.1 Purpose

To provide a standard procedure for calibration of the Ludlum Scaler/Ratemeter, model 2221 with a 2”x2” NaI Scintillation Detector (the Ludlum 44-10 or Eberline SPA-3) for gamma radiation surveys during NECR removal action.

The Ludlum 2221 is a portable, battery operated, self-contained counting instrument designed for operation with scintillation, proportional or G-M detectors. When combined with a 2”x2” NaI scintillation detector, the Ludlum 2221 is used for the detection and measurement of gamma radiations. This instrument configuration is used for detection of the soil Ra-226 gamma radioactivity.

1.2 Applicability

This instrument will be calibrated every twelve months, after repairs, or when the instrument function check fails. This method can be used with any Scaler/Ratemeter with a 2”x2” NaI scintillation detector configuration.

2. REFERENCES

2.1 Technical Manual for Scaler Ratemeter, Model 2221

3. REQUIREMENTS

3.1 Tools, Material, Equipment

3.1.1 Small flat head screwdriver.

3.1.2 Ludlum Model 500 Pulser or equivalent.

3.1.3 A source of sufficient gamma radiation activity to allow a response For high voltage plateau and function check. A 1% uranium ore in a sealed can is used.

3.1.4 Detector response factor for Ra-226 gamma survey is performed as described in Section 7

3.2 Precautions, Limit

3.2.1 The detector to Scaler/Ratemeter connector cable could easily be damaged if the weight of the 2”x2” NaI detector is suspended with it.

3.2.2 The NaI scintillation crystal is fragile. Shock to the crystal could cause a fracture or a crack, which could impact operation.

3.2.3 Do not leave the reading lamp on for any length of time as it will rapidly drain the battery voltage.

3.2.4 The meter firmware affects the measurements outputted via the RS-232 communication port. Based on the selected integrated count output for specific scan survey, verify appropriate firmware version installed for the Model L2221. The L2221 should have firmware version 261-02-N11 for one second integrated count output, and the firmware version 26106n03 two second integrated count output. The firmware version will appear on the L2221 display after turning it ON.

3.3 Acceptance Criteria

The instrument response to the calibration source should be within ± 20%.

4. LUDLUM 2221 OPERATION CALIBRATION

If the Ludlum 2221 has been calibrated by the vendor within 12 months, skip this procedure in this section and start with detector calibration in Section 5. Record Scaler/Ratemeter information (model and serial number, and calibration date) on the Scaler/Ratemeter Calibration Form. Record information about the calibration source (Pulser and/or source, 1% uranium ore standard).

4.1 Check the battery condition by pressing the “BAT” button with instrument switched on.
If the meter does not indicate the battery charge above 5.3 volts, replace the four (4) D-
cell batteries.

4.2 Set the threshold value as follows:

4.2.1 With the instrument turned on, press the threshold button. Read the displayed reading. If necessary, adjust the **“**THR**”** adjustment screw until the threshold reads 100.

NOTE: The "THR” adjustment screw is located under the calibration cover

4.3 Set the WIN (window) IN/OUT to OUT.

4.4 Connect the Ludlum 500 Pulser to the 2221.

4.5 Switch SCALER/DIG RATEMETER switch to DIG RATEMETER.

4.6 Select 400 CPM on the Pulser (multiplier switch to 1 and count rate adjusted to 400 cpm).

4.7 Adjust the pulser amplitude above the set threshold (100 mV) until a steady count rate is observed.

4.8 Record the meter rate count response in AS FOUND column on the calibration form. If the meter response is not within 10% of the Pulser set count rate of

400 cpm, adjust the R40 Meter Cal (Labeled MCAL) on the processor board for 400 cpm on the meter.

4.9 Repeat steps 4.6 to 4.8 for 4000, 40,000 and 400,000 cpm pulses.

4.10 Switch the SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

4.11 Select 400 counts on the pulser (multiplier switch to 1 and count rate adjusted to 400)

4.12 Count the pulses on the meter for one minute by pressing COUNT switch.

4.13 Record the meter response counts in AS FOUND column on the calibration form. If the meter count is not within 10% of the pulser set counts of 400 cpm, adjust the R40 Meter Cal (Labeled MCAL) on the processor board and repeat step 5.12 until a count of 400 is observed on the meter.

4.14 Repeat steps 4.11 to 4.13 for 4000, 40,000 and 400,000 pulses.

If the meter reading could not be set within 10% of the pulses generated by the pulser, the meter requires repair and calibration prior to use.

The Ludlum 2221 is ready for detector calibration and operation.

5. DETECTOR HIGH VOLTAGE AND BACKGROUND CALIBRATION

Record Scaler/Ratemeter (Ludlum 2221) and 2”x2” NaI detector (Eberline SPA-3 or Ludlum 44-10) information (model and serial number, and calibration date) on the Scaler/Detector Calibration Form. Record information about the radiation source (1% uranium ore standard).

5.1 Connect the calibrated Ludlum 2221 to the 2”x2” NaI detector.

5.2 Turn the Ludlum 2221 ON. Set WIN ON/OFF to OFF.

5.3 Check Threshold setting. Should be at 100 mV.

5.4 Switch SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

5.5 Set HV to 500 VDC.

5.6 Expose the detector to the 1% uranium ore can by placing directly under the detector.

5.7 Obtain one-minute counts with the detector exposed to the source at every 50-volt increment until voltage plateau is passed and sudden increase in the counts is observed. (Usually for the 2”x2” NaI detector, the high voltage plateau maximum voltage is about 1300 to 1400 VDC.). Record the counts under the

READING CPM SOURCE in the calibration form.

5.8 Return HV setting back to 500 VDC.

5.9 Remove the calibration source away from the detector. Obtain one-minute background counts with the detector shielded from the source at every 50-volt increment until similar voltage to the source high voltage plateau reading. Record the counts under the READING CPM BACKGROUND in the calibration form.

5.10 Plot voltage versus cpm reading for both the source and background high voltage data.
From the plot, select the optimum operating high voltage, which is usually at least about 50 volts above the knee of the source response plateau curve for greater counting stability. The optimum high voltage should be also within 50 volts of the background plateau curve for background counting stability.

5.11 Set the Ludlum HV at the optimum operating voltage determined above.

5.12 Record the HV voltage setting on the Scaler/Detector Calibration Form.

The Ludlum 2221 and the 2”x2” NaI detector configuration are ready for determining the detector response factor and establishing the operating background and source function check.

6. OPERATING BACKGROUND AND SOURCE FUNCTION CHECK DETERMINATION

6.1 Set the Ludlum 2221 to Scaler mode, Count Time at 1 minute, with WIN OUT and THR at 100.

6.2 Remove any type of sources of radioactivity from the detector. Obtain five one-minute background counts. Record the background counts in the calibration form. Average the five one-minute background counts. Record the average background counts in the calibration form. The daily function check background counts should be within 20% of this average.

6.3 Expose the 1% uranium ore source (in the sealed can). Note the exact location of the source to the detector. Obtain five one-minute background counts with the detector exposed to the source. Record the source counts in the calibration form. Average the five one-minute source counts. Record the average source counts in the calibration form. The source position to the detector for the function check should be exactly the same as this calibration, and the source counts for the daily source function check counts should be within 20% of this average.

7. DETECTOR RESPONSE FACTOR AND FIELD OF VIEW

7.1 Filed View

A detector field of view (FOV) is used for determining observation interval of gamma scan survey for scan MDC calculations, and for transects spacing calculations for scan gamma survey coverage. Detection range of a photon from a particular source by a detector is related to FOV for that detector. The detection range is dependent on the energy of radiation (photon) being detected since it is a characteristic of photon energy, not a detector. Detection range will be longer for a photon with higher energy than a photon of lower energy. FOV is a circular area with the detection range as radius. A conservative FOV of 6.0 feet for bare and 3.0 feet for collimated 2x2 NaI detectors for Ra-226 (uranium ore) photons will be used for observation interval for MDC calculations. If a different FOV is used, it will be verified by conducting a FOV test.

7.2 Detector Response Factor

For the calculation of minimum detectable concentrations (MDCs), the detector response factor, a.k.a detector efficiency, which is a conversion constant in units of cpm per pCi/g is required. There are several methods for determining the detector response factor, such as using calibration pads, source modeling or a concentration to gamma radiation level correlation study. Since final gamma radiation level to Ra-226 surface soil concentration correlations for bare and collimated detectors are established for the NECR site, the appropriate detector response factor from these correlations will be used for MDC calculations for gamma surveys during the NECR removal action. The correlations were developed for the ground surface assumptions similar to what is expected following removal action, i.e. fairly homogeneous and distribution of Ra-226 concentration in surface soils by using sampling data from appropriate conditions. These correlations meet the statistical acceptance criteria and the project data quality objectives.

The slope of the regression represents the relationship between the field gamma measurement in cpm and the Ra-226 surface soil concentration in pCi/g. Thus, the slope is in units of pCi/g/cpm. The derivations of the correlations are described in the Attachment 1 to the Attachment T.1 to Appendix T of the Design Report, Excavation Control Plan. The final correlations yielded a regression slope of 0.0005 pCi/gm/cpm (or 2000 cpm/pCi/g) for bare 2x2 NaI Detectors, and 0.0013 pCi/gm/cpm (or 970 cpm/pCi/g) for 0.5-inch lead collimated 2x2 NaI detectors.

Response factor for all 2x2 NaI scintillation detectors are fairly comparable. However, if a detector is repaired, replaced or new one is used, the comparability of the response factor should be verified by cross measurement against the original calibrated detector using a constant uranium ore source with sufficient activity, or preferably at the DOE uranium ore calibration pad. The response should be within ±10%.

8. DETECTOR MINIMUM DETECTABLE CONCENTRATION CALCULATION

8.1 MDC for Static Gamma Radiation Measurement (for 0.05 probability for both false positive and false negative errors)

The calculation below is an example for illustrative purposes and the static MDC will be calculated in the field based on actual field background measurements from function checks. It is important to note that these MDC calculations necessarily depend on several assumptions of consistent conditions in the field such as homogeneous distributions of contamination in soil, infinite plane geometry, consistent thickness of the contaminated layer of material, and consistent detector to soil surface relationship. Those conditions will not be ideal when field measurements are performed, and the MDC will likely be greater than the value calculated below.

$$MDC = C \times [3 + 4.65\sqrt{B}]$$

Where,

C = Detector response factor, cpm/pCi/g

B = Background count rate in cpm.

Example:

- o For the bare 2x2 NaI detector, estimated background count rate of 10,000 cpm from previous function checks at NECR, detector response of 0.0005 pCi/g/cpm from Section 7.2 above, then the MDC for a one minute static measurement would be:

$$MDC = 0.0005 \text{ pCi/g/cpm} \times [3 + 4.65\sqrt{}\ (10{,}000 \text{ cpm})] = 0.23 \text{ pCi/gm}$$

- o For the 0.5-inch lead collimated 2x2 detector, estimated background count rate of 3,000 cpm from previous function checks at NECR, detector response of 0.0013 pCi/g/cpm from Section 7.2 above, then the MDC for a one minute static measurement would be:

$$MDC = 0.0013 \text{ pCi/g/cpm} \times [3 + 4.65\sqrt{}\ (3{,}000 \text{ cpm})] = 0.33 \text{ pCi/gm}$$

The integration count time for static measurement may be changed to attain MDCs to required levels. Tolerable maximum instrument background count rate to attain a specified MDC can be calculated by solving the above equation using other accepted parameters (integration time and detector response factor). A daily function check must be performed prior to use.

The total propagated uncertainty will be calculated for the static survey measurement and reported with the static MDC values in all reports, tables, and figures.

8.2 MDC for Scan Gamma Radiation survey

The scan MDC is assumed for a scan rate of about 3 feet per second and a 2 second interval with an For a single component scan, such as gamma scan for final status survey during NECR removal action, the scan CPM is recorded using DGPS and Data logger for later evaluation of data with no pausing for stationary survey investigation needed in the field during the scan, and variability in the actual scan speed due to human inconsistencies in scan rate and detector height, a surveyor efficiency (p) of 0.8 is appropriate. For a dual component where a surveyor may pause during a scan survey for investigation, a surveyor efficiency of 0.5 will be used. The calculation below is an example for illustrative purposes and the scan MDC will be calculated in the field based on actual field conditions (based on the actual detector response factor, surveyor efficiency, field of view, scan rate to meet the scan MDC requirements, and background; d' is fixed as indicated below).

First calculate the Minimum Detectable Count Rate (MDCR) as follows:

$$MDCR = (d' \times \sqrt{bi}) \times (60/i)$$

Where:

d' = value for true positive and false positive proportion. A value of 1.38

(MARSSIM Table 6.5) will be used for 95% true and 60% false positive proportion.

bi = number of background counts in the interval i [(background rate in cpm/60 sec/min) x 2 for two second interval].

Example: For the bare 2x2 NaI detector background count of 10,000 cpm estimated from previous function checks at NECR, the MDCR for two second observation interval (6.0 feet FOV/3.0 feet per second scan rate) would be:

bi (2 sec) = (10,000 cpm) x (1 min/60 sec) x (2 sec) = 333 counts

MDCR cpm = (1.38) x √[333 counts] x (60 sec/min)/(2 sec) = 756 cpm.

The MDCR $_{surveyor}$ using surveyor efficiency (p) of 0.8 would be:

MDCR $_{surveyor}$ = MDCR/√p = 756 cpm/√0.8 = 845 cpm.

From the MDCR $_{surveyor}$, calculate the scan MDC using the following:

Scan MDC = MDCR $_{surveyor}$, cpm x C, cpm/pCi/gm

Where: C = Detector response factor, 0.0005 pCi/g/cpm (from Section 7.2 above)

Scan MDC = 756 cpm x 0.0005 pCi/g/cpm = 0.42 pCi/gm

For the 0.5-inch lead collimated detector with a background of 3,000 cpm, C of 0.0013 pCi/g/cpm, observation interval of one second (3.0 feet FOV/3.0 feet per second scan rate), the scan MDC would be 0.85 pCi/g.

A daily function check must be performed prior to use. The scan rate for radiation scan survey may be changed to attain MDCs to required levels. The tolerable maximum instrument background count rate to attain a specified scan MDC can be calculated by solving the above equation using the other approved instrument and survey parameter values, such as survey sensitivity (d'); detector response factor; scan rate; observation interval; and surveyor efficiency. Likewise, maximum scan rate for scan survey to attain a specified scan MDCs can be calculated by solving the above equation with using other instrument and survey parameter values, such as survey sensitivity (d'); instrument background count rate; detector response factor; detector FOV for Ra-226; and surveyor efficiency factor.

Attachment A

Scaler/Ratemeter Calibration Form

Model___________________________ S/N ___________________

Calibration Source____

Threshold (input sensitivity), Found at_______________ mV Left or Set at _________ mV

Window, In/Out_________ Window _______________ mV

Pulser Amplitude Set @___________________________mV

Range/Mode	Calibration Point (Pulser Setting) cpm x multiplier	As Found Reading	Left or Set Reading

HV Set @_______________ VDC

____

____

____

____

____

____

____

Date ________________________ Calibrated By ______________________________________

Attachment B

AVM Environmental Services Inc.
Scaler/Ratemeter - Detector Calibration Form

Scaler/Ratemeter : Ludlum 2221, SR #
Detector: 0.5 Inch Lead Collimated SPA-3, #

Source: ____________________________ Strength: ________________

Scaler/Ratemeter Threshhold set @ 100 (10mV); Window IN/OUT: OUT; Window: N/A mV

HV	Reading, CPM (Source)	Reading, CPM (Background)
500		
550		
600		
650		
700		
750		
800		
850		
900		
950		
1000		
1050		
1100		
1150		
1200		
1250		
1300		
1350		
1400		

at designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

Count Readings with 1 percent U_3O_8 can directly under collimated detector on designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

HV Set @ ______________________ VDC (Instrument) _________________ VDC (DVM Fluke 8020B)

Input Sensitivity (THR), mV ________________

Function Check with 1 percent U_3O_8 ore in can. Can Directly under the detector.
Acceptable Function check range is: ______________________ to ___________________ CPM

Count Readings for Calibration Pad GPL (87.78 pCi/gm Ra-226)

#1 ______________ cpm
#2 ______________ cpm Average ______________ cpm
#3 ______________ cpm
#4 ______________ cpm Efficiency ______________ cpm/pCi/gm
#5 ______________ cpm Efficiency ______________ pCi/gm/cpm (1/cpm/pCi/gm)

Date ____________________________ By ____________________________________

SOP-2
AVM Environnemental Services, Inc.
Direct Gamma Radiation Level to Ra-226 Soil Concentration Correlation Update
NECR Mine Site Removal Action

1.0 Purpose

The purpose of this procedure is to update the Site specific Ra-226 concentrations in surface soil to direct gamma radiation level correlations for NECR removal action. Site specific correlations were initially developed for both bare and collimated 2x2 NaI detectors during the 2006 RSE as discussed in Attachment 1 to Appendix T.1. The correlation for a collimated detector was updated during various phases of investigation and 2009 Interim Removal Actions and the 2013 East Drainage Removal Action. The correlation data and updates were provided in the appropriate reports (MWH 2006b, MWH 2007, MWH 2009, MWH 2011 and MWH 2013). Although these correlations meet or exceed the appropriate acceptable statistical criteria (correlation coefficient, p-value and low MSEs), the correlations may be updated to improve the statistical parameters.

2.0 Scope

The Ra-226 levels in soil could be measured as a surrogate by measuring Pb-214 and Bi-214 gamma radiation levels, as to the measurement described in Section 4.3.2 of the MARSSIM. Pb-214 and Bi-214 are decay products of Ra-226 through radon-222 (Rn-222), a gaseous form, some of which emanates from soil. This process results in activity disequilibrium between Ra-226 and PB-214/Bi-214 in the soil. The Rn-222 gas emanation fraction from the soil varies with different characteristics of a particular soil. Therefore, a site-specific calibration of the detector is necessary. Studies at the Site have shown that about 20 percent of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant percentage (about 80 percent) of Ra-226 will decay into Pb-214 and Bi-214 in the soil matrix. If the soil characteristics and other parameters (such as moisture, radon emanation fraction, contamination distribution profile, gamma ray shine from nearby sources, and land topography) are consistent, the ratio of Pb-214/Bi-214 to Ra-226 will be consistent. This results in a direct correlation between Pb-214/Bi-214 gross gamma radiation levels and Ra-226 concentrations in the soil. The gamma radiation from other naturally occurring isotopes in soil, such as Th-232 decay products and K^{40}, may contribute to gross gamma radiation intensity. In addition, background gamma radiation from cosmic rays also contributes to gross gamma radiation intensity. However, the gamma radiation level from such naturally occurring isotopes and sources are generally at a constant level. A linear regression would identify such a constant to correct for and minimize interference with the gamma radiation level and Ra-226 soil concentration correlation.

The site specific correlations for both the bare and collimated 2x2 NaI detectors were developed with primary assumption of contamination distribution in surface soil. Any lateral gamma radiation shine from the nearby elevated areas would skew gamma radiation level. A collimator detector mitigates the lateral shine interference. The collimated detector correlation was updated with sampling data from locations that fit this assumption during previous investigations and removal actions. A correlation with this assumption is most appropriate for excavation control and final status surveys during removal actions because the contamination distribution is expected to be fairly homogeneous in surface soils following the removal action. Only gamma radiation level measurements and soil sample Ra-226 data from corresponding locations with this correlation assumption will be used to update the correlations.

3.0 Instrumentation

Instrumentation to collect gamma radiation level measurements will be the same as used during the development of previous correlations. A 2"x2" NaI Scintillation detector (an Eberline SPA-3 or Ludlum 44-10 detector) and a Scaler/Ratemeter, (Ludlum Model 2221 or 2241) will be used for field gamma radiation level measurements and to select sampling locations. A 2x2 NaI detector with 0.5-inch thick lead collimator will also be used for gamma radiation level measurement for the collimated detector correlation update. The Scaler/Ratemeter will be calibrated consistent with SOP-1 to assure that it properly counts the electronic pulses generated and sent by the 2x2 NaI detector. An optimum operating high voltage for the detector will be established by performing a high voltage plateau on the detector using SOP -1a. The input sensitivity (threshold) of the Scaler/Ratemeter will be set @ 100 mV to avoid interference from low level background radiation. The pulses generated by the detector for Ra-226 gamma radiations (primarily from the Pb-124 and Bi-214 decay products) are significantly higher than 100 mV, as verified by using 1% uranium ore standard.

4.0 Gamma Radiation Level Measurements and Soil Sample Collection for Updating Correlation

If any surface soil sampling is performed during excavation control with a co-located static gamma radiation level measurement, the data may be used to update the correlation. One minute static gamma radiation level measurements will be performed consistent SOP-1. The co-located surface soil sample will be collected consistent with SOP-5, and will be analyzed for Ra-226 by an offsite vendor laboratory using EPA Method 901.1.

5.0 Linear Regression Analysis

The relationship between gamma radiations from Ra-226 to detector response is linear. To determine the correlation between gamma radiation level counts and corresponding Ra-226 concentration in surface soil, i.e. to determine a calibration equation, a liner regression analysis will be performed on the sample Ra-226 concentration in pCi/gm, Y, and the associated gamma radiation level count rate, cpm at X, from all the sample locations using a least-square liner regression and plotting the results. A linear regression is the only statistical approach determined to be appropriate because the 2x2 NaI detector response to gamma radiation detection is linear, specifically at the levels emanating from uranium ore and tailings impacted soil. The liner regression will be performed by augmenting the appropriate correlation data included in Attachment 1 of Appendix T.1. Prior to augmenting and updating the correlation, review the data to make sure that the data meets appropriate QA/QC requirements and the collected data fits the correlation assumption, i.e. fairly homogeneous Ra-226 distribution in only surface soil for bare detector, and in area with any lateral shine is mitigated with collimated detector.

Linear regression data will be summarized by the generalized equation:

$$Y = mX + b$$

where,

Y = soil concentration in pCi/gm,
m = slope, pCi/gm/cpm
X = count rate (the mean) in cpm
b = constant, y intercept

This correlation will provide a site specific calibration factor (m) in pCi/gm/cpm for the 2”x2” NaI detector, with a constant (b) to correct for any interference, specifically at lower range. The purpose of the update is to increase correlation sample numbers to improve statistical parameters (correlation coefficient, confidence level, p-value and low MSEs). If the update does not improve the statistical parameters, investigate the data to see if they meet the correlation assumptions or are outliers.

SOP-3
AVM Environnemental Services, Inc.
Field Gamma Radiation Survey for Ra-226 Concentration in Soil
NECR Mine Site Removal Action

1.0 SCOPE

1.1 Purpose

This procedure will be used for direct gamma radiation surveys to detect Ra-226 in surface soil for performing investigation surveys, excavation control (Remedial Action Support) surveys, and as a component of the Final Status Survey (FSS) at the NECR uranium mine site during removal action.

2.0 EQUIPMENT AND MATERIALS

2.1 A Ludlum model 2221 or 2241 Scaler/Ratemeter coupled with a Ludlum 44-10 or an Eberline SPA-3 2”x2” NaI crystal scintillation detector for direct gamma radiation detection. (SPA-3 and Ludlum 44-10 are both similar 2”x2” NaI crystal scintillation detectors).

2.2 A global positioning system (GPS) with real time differential correction and data logging capability

2.3 A 0.5 inch lead Collimator for use with 2”x2” NaI detectors, if needed to mitigate nearby lateral gamma-ray shine interference and focus on the area of interest under detector. The 0.5-inch thick collimator, which surrounds the NaI crystal, is contained within a protective marlex housing.

2.4 A vendor calibrated Exposure Rate (uR/hr) meter.

2.5 Map of survey areas with marked points, grid nodes and transects. Ink pen and appropriate Field Survey Forms to record survey readings and notes.

2.6 Measuring tape, pin flags, area markers and marking paint.

3.0 INSTRUMENT CONFIGURATION & OPERATIONS

Prior to any instrument function check or operation, the technician will read the Technical Manual for the instrument operations (Ludlum 2221) and the correlation Method (SOP-2) for the rationale behind the gamma radiation surveys.

The field gamma radiation level surveys for Ra-226 in surface soil will be performed using a Ludlum 2221 Scaler/Ratemeter connected to a 2”x2” NaI crystal scintillation detector (SPA-3 or Ludlum 44-10) which detects gamma radiation emitted from radium-226 decay products (primarily Pb-214 and Bi-214) in the soil. The detector will be held at approximately 12 inches from the ground surface. The bare (uncollimated) detector should be sensitive to an area at least six feet in diameter under the detector. The Model 2221 Scaler/Ratemeter with external RS232 connector can be coupled to a DGPS/data logger where the gamma radiation count rate in CPM would be logged with its corresponding location coordinates.

For gamma radiation surveys where significant shine interference is present from nearby areas, the 2”x2” NaI crystal scintillation detector will be installed in a 0.5 inch thick lead collimator to reduce gamma shine interference. During the survey, the detector will be held approximately 12 inches above ground level, which should focus and be most sensitive to an approximate 36 inch diameter area under the detector.

The instrumentation must be calibrated consistent with SOP-1 prior to use.

3.1 Instrument Function Check

An operational function check will be performed on the Scaler/Ratemeter (L2221) and the detector (SPA-3 or Ludlum 44-10) configuration each day prior to any field surveys. The operator will verify calibration validity for the Scaler/Ratemeter and the detector. The calibration date for the instruments must be within one year. If not, the instrument must be removed from service and calibrated with a certificate in file. The function check will be performed in the field office. The following function check procedures will be used, and the pertinent information recorded on the Scaler/Ratemeter-Detector Function Check Form (Attachment A).

3.1.1 Visual Inspection

Perform a visual inspection checking for signs of any damage on the instrument, cables, detector and the shield. Test for possible electrical shorts in the cable with the instrument in the audio on mode, move the cable and note for any sudden increase in audible “clicks” and also and sudden increase in counts on the Scaler/Ratemeter display.

3.1.2 Calibration Due

Verify calibration validity for the Scaler/Ratemeter and the detector. Calibration date for the instruments must be within one year and have a current Calibration Certificate on file.

3.1.3 Battery Charge

Assure that the Scaler/Ratemeter battery is functional. For ESP Scaler/Ratemeter it should not be indicating a “Low BAT” signal. For Ludlum 2221, the battery voltage digital readout must be at least 5.3 volts.

3.1.4 High Voltage

The detector high voltage must match that determined during high voltage calibration (HV Plateau) for that detector.

3.1.5 Threshold (input sensitivity)

Check and make sure that the Scaler/Ratemeter threshold is set at 100 mV. If not, set the threshold to 100 as all gross gamma measurements are performed with 10 mV (equivalent to 100 setting on instrument) threshold. Ludlum 2221 Threshold can be set by the instrument digital read out display.

3.1.6 Window

If Ludlum 2221 Scaler/Ratemeter is used for instrument configuration, the WIN (window) toggle switch must be in the OUT position for gross gamma measurements.

3.1.7 Background Counts

The background counts will be determined for the same time interval as the field static survey count time, generally one minute. The background counts will be performed at the designated location in the field office. A location will be designated in the field office for obtaining the required daily background counts. Keep all beta/gamma radiation sources away from the detector while performing the background check. The background function check counts at the field office must be within 20% or lower than the background counts obtained during the detector high voltage calibration.

3.1.8 Source Function Counts

Obtain the gamma radiation function check source, (1% U_3O_8 ore standard sealed in a can marked "Function Check Source"). The 1% ore standard was used to determine the acceptable count range for the detector following calibration. Place the source at the same location on the detector used to obtain the source function check counts during calibration. Count the source for one minute and note the counts in CPM. The source function check counts must be within 20% of the source counts obtained during the detector and Scaler/Ratemeter calibration.

3.1.9 Instrument Tolerance

The Scaler/Ratemeter and detector counting and detecting tolerance are expressed as percent deviation from the mean of the acceptable count range. The background counts and the source function check counts must be within 20% of the mean established following instrument calibration. If the source count is outside this range, pull the instrument from service. The instrument must be repaired and/or re-calibrated prior to use.

3.1.10 Technician

After completing the function check, initial in the column marked TECH of the function check form.

3.2 Instrument Minimum Detectable Concentration Calculations

When required, calculate Minimum Detectable Concentration (MDC) for the instrumentation using the function check background readings as described in SOP-1 (Instrument MDC Calculation). Acceptable MDCs are below the specified investigation or Action Levels. The acceptable Ra-226 MDC limit for NECR RA for static gamma survey is 1.1 pCi/g (50% of the 2.24 pCi/g RAL) and scan MDC limit for scan gamma survey is 2.04 pCi/g (50% of the 3.09 pCi/g DCGLemc plus 1.0 pCi/g background level) for Class 1 survey units, and 1.1 pCi/g (50% of the 2.24 pCi/g DCGLw plus 1.0 pCi/g background level) for Class 2 survey units. Calculate MDC for appropriate survey, i.e. Direct Measurement MDC for static (stationary) gamma radiation survey and scan MDC for scan or walkthrough gamma radiation survey instrument background information. Record in the Function Check Form (Attachment A) if the instrument MDC is less than the acceptable limit.

The integration count time for static measurement and the scan rate for scan survey may be changed to attain MDCs at acceptable levels

4.0 FIELD GAMMA RADIATION SURVEYS

The direct gamma radiation level survey for Ra-226 in surface soil will be conducted as either scan survey (walkthrough) or static survey (stationary) measurements.

4.1 Scan Gamma Radiation Survey

Scan gamma radiation surveys (walkthrough surveys) will be performed by walking with the detector at about 12 inches from the ground surface with the scaler/Ratemeter in count RATE MODE. Scan surveys will be performed to identify and locate any hot spots and contaminated area boundaries for investigations and excavation control during the NECR removal action Scan surveys will also be performed as a component of the FSS. A 0.5 inch lead collimator for 2"x2" NaI detectors will be used if needed to reduce lateral gamma-ray shine interference and focus on an area of interest under the detector. The scan rate and walking speed depends on the desired scan MDC for the survey. For the collimated detector instrument configuration, a scan walking rate of 3 feet per second (fps), FOV of 3 feet and detector background at 3000 CPM, detector response factor of 0.0013 pCi/g/cpm, and surveyor efficiency of 0.5 results in a Ra-226 scan MDC of 1.1 pCi/g. For a different scan MDC, the scan walking rate may be modified.

A GPS based gamma radiation scan survey can be performed to log a gamma radiation rate with corresponding point location coordinates in a data logger. A GPS based scan survey paired with a scaler/ratemeter and a bare 2"x2" detector will be used for FSS scan surveys. This scan survey can be performed by walking along the specified transects in the areas using a 2x2 NaI detector with a ratemeter coupled with a DGPS/data logger unit. The GPS-gamma scan survey system will consist of a Ludlum 2221 Scaler/Ratemeter/ with SPA-3 2x2 NaI Detector coupled to a DGPS/data logger system. Where terrain allows, the FSS scan survey may also be performed using an all terrain vehicle (ATV) mounted scan survey system. The Ludlum 2221 will be operated in Ratemeter mode, allowing a gamma count rate (cpm) to be logged with its corresponding coordinates in one or two second intervals. Appropriate walk-over transect spacing based on the scan coverage rate and the detector FOV for Ra-226 will be used for this survey, as discussed in SOP-1.

The logging process can be partially automated by logging points by interval. You can log points after a specified time period has elapsed. The procedure for using the Log By Interval function in Solo Field mapping software is described below:

1. Select **Log** > **Log by Interval** or tap the **Log by Interval** button in the Mode Toolbar. This will open the **Select Feature to Log** screen.
2. You will be prompted to select a feature and to complete the attribute entry. When you tap on the **OK** button in the **Attributes** screen, the **Log by Interval** screen will be displayed.
3. Select **Log by TIME interval.**
4. Enter the **2.00 Seconds** log interval in the **Log every** field.
5. Tap the **Start** button to begin logging by interval.

The first point will be logged at your current position. Once you have waited the specified time another point will be logged. This will continue until you tap the **Pause** button or close the screen. At the end of each survey day, the field data will be downloaded into a computer and processed for tabularization and mapping. Download the survey file as follow:

Select **File** > **More** > **Export** to open the **File Export** screen.

You may select the **Export Format** by tapping on the down arrow to the right of the selection box. choose Text, All exported files are stored in \My\Documents\SOLO\Export by default, otherwise. If **Prompt for filename** is selected, you can customize the names as each file is created.

Depending upon the export format selected, you may choose to export your features in two ways; a unique file for each feature layer, or one file.

With **Text *.txt** selected as the **Export Format**, tap **Options** to display the text options. You may turn these options on/off using the checkbox next to each option.

When you are satisfied with your selections, tap the **Export** button to create the file(s) in the selected format

4.2 Static Gamma Radiation Survey

Static gamma radiation surveys will be performed at any point or location of interest during surface soil characterization surveys, excavation control surveys, and at specified grid nodes within survey units for the FSS. The detector will be held at about 12 inches from the ground surface. The Scaler/Ratemeter will be set in the count SCALER MODE. A one-minute integrated count (CPM) of gamma radiation level will be obtained at each location for a static gamma radiation survey. A DGPS integrated with a data logger may be used to log the gamma counts and location for static surveys. A 0.5 inch lead collimator for the 2”x2” NaI detectors will be used if needed to reduce lateral gamma-ray shine interference and focus on the area of interest under detector. Static surveys for the FSS will be conducted using a collimated detector. For this instrument configuration, a one-minute integrated count results into a Ra-226 MDC of about 0.3 pCi/g for bare detectors and 0.4 pCi/g for collimated detectors. For a different MDC, the integrated count period may be modified.

4.3 Remedial Action Support (Excavation Control) Survey

Excavation control surveys will be performed to guide the excavation of contaminated soil exceeding the Ra-226 RAL of 2.24 pCi/g during the NECR removal action. Obtain field action level in CPM (for either bare or collimated detector) for the site soil cleanup level concentration (pCi/g) based on the site specific correlation. This direct radiation cleanup level may change as cleanup progresses and the correlation is updated; therefore, contact the Radiation Safety Officer (RSO) to obtain the current direct radiation cleanup level. Excavation control surveys will be performed using a combination of scan gamma radiation surveys and static radiation level measurements as follow:

IT IS IMPORTANT TO COORDINATE WITH THE EXCAVATION CREW THE EXCAVATION AND SURVEY SEQUENCE FOR YOUR SAFETY. ESTABLISH NECESSARY SAFETY COORDINATION WITH THE EXCAVATION CREW. ALWAYS WEAR AN ORANGE SAFETY VEST WHILE PERFORMING SURVEY IN THE FIELD.

1. Perform the function check as indicated in Section 4.1 of this procedure. In area where

gamma radiation shine is expected, use the collimated detector.

2. Insure that the Scaler/Ratemeter is set in RATE mode. Turn the Scaler/Ratemeter audio speaker to the ON position. For Ludlum 2221 Scaler/Ratemeter, set the RESP (response) toggle switch to F (fast) position. Set the audio rate toggle switch to x1, x10 or x100 position based on radiation level of the area and familiarize yourself to the audio rate at the action level count rate. The audio toggle rate set at x10 or x100 is appropriate for the field survey.

3. Using appropriate maps, area boundary location coordinates and a DGPS if needed, field locate and mark any area exceeding the cleanup level with pin flags. Radiation scanning may be necessary to delineate the contaminated area boundaries. Coordinate the marked area with the excavation crew. The area may be divided into smaller subareas such as 100 square meter areas, or 10 feet strips to help efficiently control excavation based on the type of excavation equipment used for excavation. The excavation fleet will remove the contaminated soil in necessary thickness lifts initially based on vertical extent of contamination.

4. Following the initial excavation lift, assure that the excavation equipment is out of the way and the area is clear and safe, perform a radiation scan with the detector at approximately 12 inches from the ground surface by walking in a serpentine pattern along a transect or within the subdivided areas with the audio speaker ON to identify any locations that exceed the site action level count rate by audio response and digital count rate display. The scan survey for the excavation control will be performed for 100% coverage within the area. Note that the collimated detector at about 12 inches from ground is most sensitive within an area of about three feet diameter under the detector, and about six feet diameter under the bare detector. The scan gamma radiation survey form (Attachment B) may be used to note any comments.

   If no point or a location exceeding the action level is identified within the area by the scan, the removal action in the area would be considered complete, and the area will be ready for the final status survey.

5. If the radiation scan following the initial soil excavation lift shows portions the area above the cleanup level, or any static measurement point is above the cleanup level, mark out those areas with pin flags or marking paint and coordinate with the excavation crew for the additional excavation of contaminated soil as necessary until the scan survey shows no points or locations above the cleanup level, and repeat step 5 at those locations.

6. If the radiation scan following the initial soil excavation lift still shows most or all of the area above the cleanup level, the contamination in entire area is deeper than the initial lift. Coordinate with the excavation crew for additional soil excavation and repeat steps 5 and 6 until the area is clean.

4.4 Investigation Survey

Gamma radiation surveys for Ra-226 contamination investigations will be used to identify hot spots and contamination boundaries. Static gamma radiation surveys will be conducted at any points of interest that are above the appropriate investigation level of an area. Obtain appropriate investigation level in CPM since they are different for different class areas as described in the FSS Plan. Follow the scan and static survey procedure as described in

Section 4.1 and 4.2 above. Scan gamma radiation surveys will be performed by walking around with the detector at about 12 inches from the ground surface with the scaler/ratemeter in count RATE MODE. Scan surveys will be performed at necessary coverage rates, as specified in the FSS Plan for investigations, within areas of interest in a serpentine shape along transects. The investigation scan and static gamma survey data may be recorded in the DGPS/data logger and/or in field forms that are included in Attachments B and C.

4.5 Final Status Survey

The final Status Survey will be implemented following excavation control surveys indicating that the contaminated soil an area or a survey unit exceeding the RAL has been removed and is ready for FSS. Both, the scan and static gamma radiation surveys are components of the FSS. The scan gamma radiation survey would have already been performed at 100% coverage during the excavation control survey for remedial action support. If the excavation control scan data is used for the FSS, the excavation control scan data will be reviewed to assure compliance with the FSS DQO before accepting the data as valid for the FSS.

FSS Scan gamma radiation survey

Systematic FSS scan gamma radiation surveys with a bare detector will be conducted prior to the static gamma radiation survey in survey units. The technician will perform the static gamma radiation survey as follows:

1. The scan survey coverage in each class survey unit is different. Obtain appropriate scan coverage for the survey unit from the FSS Plan.

2. Calculate Transect spacing for the FSS systematic gamma scan using the detector field of view (FOV) for the Ra-226 gamma radiations:

   transect spacing = FOV/Required % scan coverage.

   For example, for FOV of 6.0 feet for 2x2 NaI detectors, a 100 percent scan coverage requires a transect spacing of 6.0 feet and 25 percent scan coverage will require 24 feet transect spacing.

3. Field locate and mark the specified transects in a survey unit using a GPS and appropriate marking material.

4. Conduct the FSS scan survey along transects as described in Section 4.1

5. Download the scan survey data as described in Section 4.1.

A QA/QC review of the scan data will be performed. The scan data will be reviewed to determine if the survey unit is ready for the static gamma survey.

FSS Static gamma radiation survey

The static gamma radiation survey will be implemented following the FSS scan gamma survey. One minute static direct gamma radiation survey will be performed using a 0.5 inch lead collimated detector at triangular grid nodes in each survey unit casted on a random origin. The triangular grid spacing in each class survey unit is different, e.g. 50 feet spacing for Class 1 survey units and 72 feet spacing for Class 2 survey units. The static gamma survey data points are randomly located in Class 3 survey units. The technician will perform the static gamma radiation survey as follows:

1. Place the detector in the 0.5 inch lead collimator. Perform the function check as indicated in Section 4.2 of this procedure.

2. Verify that the Scaler/Ratemeter (Ludlum 2221) is set in scaler (integration) mode and that the count time is set for one minute. Turn the Scaler/Ratemeter audio speaker to the ON position.

3. Obtain coordinates of each grid node in the survey unit.

4. Locate FSS static points (grid node) using the static survey point coordinate data, and a DGPS system.

5. Hold the detector at approximately 12 inches from the ground surface above the survey point. Obtain a one minute integrated count.

6. Log the survey point ID, coordinates and counts in the DGPS/data logger. The technician may also record the counts in CPM and appropriate corresponding survey point information (location ID and/or coordinates etc) on the Static Gamma Radiation Survey Field Form (Attachment C).

7. If any of the measurement is above the counts for RAL or RALemc based on the correlation, mark the survey point with a pin flag for investigation.

8. Repeat steps 4 to 6 for additional static radiation measurements.

9. The Ra-226 concentration in the soil will be calculated from the gamma radiation survey counts (CPM) using the linear regression equation established from the correlation for that detector. The static gamma survey data will be reviewed for QA/QC. The results from the static gamma survey will be used for demonstrating compliance with RAL.

5.0 ATTACHMENTS

Attachment A	Scaler/Ratemeter-Detector Function Check Form
Attachment B	Scan/Walkthrough Gamma Radiation Survey Field Form
Attachment C	Static Gamma Radiation Survey Field Form

Attachment A, SOP-03

Scaler/Ratemeter - 2" x 2" NaI Detector Function Check

Scaler/Ratemeter ID:_________________________________

Function Check Source ID: 1% U_3O_8 Ore in Sealed can

2" x 2" Detector ID:___________________________________

Acceptable background Count (cpm) Range (20%) _____________________ to ___________________

Acceptable Source Count (cpm) Range (20%) _____________________ to ______________________

Date	Physical Check	Cal Due	Battery[1] Volts or OK	HV Volts	Threshhold mV [2]	Window In or OUT[3]	C.C.[4]	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	MDC pCi/gm	Tech

Note: (1) Battery Voltage for Ludlum 2221 must be >5.3 volts; (2) Threshhold must be at 100 mV; (3) Window Position must be OUT; (4)

Attachment B, SOP-03

Scan/Walkthrough Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter________________________________, Detector____

Instrument Calibration Date: _____________________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Area-Transect ID/Description	Gamma Radiation Reading Range CPM	Comments/Notes

Technician Signature __________________________________, Reviewed by _____________________________________

Attachment C, SOP-03
Static Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter___________________________, Detector ______________________________________

Instrument Calibration Date: ______________________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Point ID/Description	Survey Point Coordinate		Gamma Radiation Reading, CPM	Comments/Notes
		Northing	Easting		

Technician Signature __________________________________, Reviewed by _______________________________________

SOP-4
AVM Environmental Services, Inc.
Field Soil Gamma Radiation Screening Procedure
NECR Removal Action

1.0 Introduction

This field soil screening procedure for Ra-226 consists of measuring 609 KeV gamma radiations of Bi-214, a decay product of Ra-226 through Rn-222. The 609 KeV gamma radiation counts of the sample soil are compared to a reference soil from the Site with a known Ra-226 concentration for field screening. Although the Rn-222 is a gas and the soil is not sealed, the soil retains over 80 % of Rn-222 gas within the soil matrix, resulting in a significant amount of Bi-214 decay product and its gamma radiations. Bi-214 609 KeV gamma radiation is at fairly high intensity (46%) and isolated, which mitigates interference from other energy gamma radiations. A single channel analyzer (SCA), such as Ludlum L221 integrated with Ludlum 44-20 3x3 NaI scintillation detector will be used to measure radiation of a particular energy of Bi-214. The heavily shielded counting chamber lowers the background counts without lowering the counting efficiency for that geometry and sample size, thus lowers the detectable concentration. For a quick estimate of Ra-226 in soil, a reference soil with a known Ra-226 concentration (similar to screening level), which is not previously sealed, the 609 KeV gamma radiation level of Bi-214 can be measured (pulse height analysis) for field screening. The sample in a plastic bag is placed in a counting chamber (1.5 inch thick x 7.5 Inch ID x 12 inch tall lead ring collimator with a 1.5 inch thick lead bottom shield) around the 3x3 NaI detector and 609 KeV gamma radiation counts are obtained and compared to the reference soil and sample soil for field screening. The soil screening results are estimated for confirmation of gamma survey results during excavation control and are not used for FSS confirmation of removal actions at specified limits. If the soil screening result is used for confirmation of FSS survey and indicate that the sample concentration is at or below the RAL, the sample must be sent off site vendor laboratory analysis for confirmation.

2.0 L2221/44-20 Window Operation and Energy Calibration Procedure

The following procedure calibrates threshold directly in keV.

1. Setup the counting chamber shield system with L 44-20 detector inside the chamber and connected to L2221 scaler/ratemeter. The L44-20 3x3 NaI detector is situated in the shielded counting chamber with the detector crystal facing up.

2. Place RATEMETER multiplier switch to LOG position.

3. Unscrew and remove CAL cover.

4. Press HV pushbutton. The HV should read out on the display directly in volts. While depressing the HV pushbutton, turn HV potentiometer maximum counterclockwise. The HV should be less than 50 volts.

5. Depress the THR pushbutton. Turn the THR potentiometer clockwise until 652 displays.

6. With WIN IN/OUT switch IN, depress the WIN pushbutton. Turn the WIN potentiometer until 20 appears on the display.

7. Switch WIN IN/OUT to OUT.

8. Connect the detector (Ludlum 44-20) and expose to Cs-137 source.

9. Increase HV (if HV potentiometer is at minimum, it will take approximately 3 turns before any change is indicated). While increasing the HV, observe the log scale of the ratemeter. Increase HV until ratemeter indication occurs.

10. Switch WIN IN/OUT switch to IN.

11. Turn the HV control until maximum reading occurs on the log scale. Increase HV until reading starts to drop off, and then decrease the HV for maximum reading.

12. Turn RATEMETER selector switch to the X1K position.

13. Press ZERO pushbutton and release. If meter does not read, switch to a lower range until a reading occurs.

14. Carefully adjust HV potentiometer until maximum reading is achieved on the range scale. The instrument is now peaked for Cs137 on both the LOG and Linear scales. Record HV for energy calibration.

NOTE: When the THR control is adjusted, the effective window width remains constant. As an example, if the THR is set at 559, the WIN at 100, a 609 KeV peak +559 (100 divided by 2) will be centered in the window. Then the threshold point is equivalent to 559 KeV with a 100 KeV window and calibrated for 100 KeV per turn. Now if the thresh hold is reduced to 250, the threshold is equivalent to 250 KeV, but the window (100) is still equal to 100 KeV. Proportionally, this represents a broader window.

15. Set THR at 559 and window at 100 for Bi-214 609 KeV (559 to 669 KeV ROI) gamma radiation measurement. Expose the detector with the 1% Uranium ore function check source and obtain a one minute counts. Remove the function check source and obtain a one minute background counts.

16. Record the energy calibration data in the L2221SCA/L44-20 Energy Calibration Form (Attachment A).

3.0 Minimum Detectable Concentration

The calculation below is an example for illustrative purposes for minimum detectable concentration (MDC), and the actual MDC will be calculated in the field based on actual field background measurements from function checks. The MDC, for 0.05 probability for both false positive and false negative errors, is calculated using equation 6-7 in Section 6.7.1 of the MARSSIM Guidance,

$MDC = C \times [3 + 4.65.\sqrt{B}]$

Where,

C = Detector response factor, pCi/g/cpm

B = Background count rate in cpm.

Example:

For the 3x3 NaI detector of the soil screening system, estimated background count rate of 80 cpm from previous function checks and the detector response of 0.0109 pCi/g/cpm (18,299 cpm for 3,000 gm reference soil @ 200 pCi/g of Ra-226) sample at NECR during the 2013 PDS, then the Ra-226 MDC for a 3,000 gm screening sample for a one minute measurement is calculated to be:

$MDC = (0.0109\ \underline{pCi/g/cpm) \times [3 + 4.65.\sqrt{}(80\ cpm]} = 0.49\ pCi/gm$

For the detector response of 0.005 pCi/g/cpm for the 3000 gm of 2.0 pCi/g reference soil (455 CPM for 3000 gms of reference soil @ 2.0 pCi/g Ra-226) during the 2013 PDS, then the Ra-226 MDC for a 3,000 gm screening sample for a one minute measurement is calculated to be:

$MDC = (0.005\ \underline{pCi/g/cpm) \times [3 + 4.65.\sqrt{}(80\ cpm]} = 0.22\ pCi/gm$

The MDC calculated using the detector response for the reference soil @ 200 pCi/g of Ra-226 appears to be conservative. Therefore, the detector response for the reference soil @ 200 pCi/g will be used for MDC calculation. The required MDC for NECR RA is <1.12 pCi/g (50% of the 2.24 pCi/g RAL). The soil screening counting system will meet the required MDC limit of 1.12 pCi/g with one minute background counts as high as 440 cpm.

Note: The MDC calculation assumes the weight of reference soil and screening soil to be same, 3000 grams, and the background and sample counting time be the same, least one minute. The measurement (integration) time of background and sample may be changed to attain desired MDC. The integration count time for measurement may be changed to attain MDCs to desired levels.

4.0 Field Soil Screening Procedure

1. Setup the L2221 parameters (HV, Threshold and Window) obtained during energy calibration above and connect the 44-20 detector. Make sure the window toggle switch is in the IN position.

2. Setup the counting chamber shield system in back of pick-up truck.

3. The L44-20 3x3 NaI detector is situated in the shielded counting chamber with the detector crystal facing up.

4. Perform background and source (1% Uranium ore) function checks and record in the Function Check Form (Attachment B).

5. Insert a clean plastic bag in the counting chamber for lining detector and counting chamber to avoid cross contamination. Obtain 3,000 grams of appropriate reference soil, not previously sealed, and place in the plastic bag so that the sample is around the detector without any void, similar to the Marinelli Beaker geometry to provide the best counting efficiency. Cover the chamber opening with lead lid.

6. Obtain an integrated count for specified time period, generally one minute, with L2221 in Scaler mode and record in the soil screening Field Form (Attachment C). The reference soil counts may be used for efficiency calculation (pCi/g/com) for MDC calculation.

7. Remove the plastic bag with soil. Insert new plastic bag in the chamber for liner. Homogenize sample in stainless steel bowl and weigh 3000 grams of sample. Repeat step 5 and 6 for next soil sample. Change counting chamber liner between every sample.

8. Compare the reference soil counts to the sample soil counts to determine the sample Ra-226 concentration at above or below the reference soil concentration.

9. Following completion of soil screening, split a sample aliquot if needed for confirmatory analysis using EPA Method 901.1 by vendor laboratory. Return the unused sample at the location collected from.

QA/QC Procedure

1. The instrumentation, L2221 must be calibrated at least annually. Although the operating HV for the 3x3 NaI detector for soil screening is established during energy calibration discussed above, an HV plateau should be performed at least annually to verify proper detector operation throughout the HV range.
2. The background and source (with uranium ore check source to verify 609 KeV ROI calibration) function checks must be performed daily prior to use.
3. The reference soil material concentration must be determined from vendor laboratory analysis or prepared using a certified reference material.
4. Duplicate measurement will be performed for 10% of the samples.
5. For PTW and final status survey soil screening, any soil sample screening result less

than RAL and PTW threshold level, respectively, will be sent to a vendor laboratory for confirmation.

AVM Environmental Services, Inc.

Ra-226 Reference Soil Preparation for NECR gamma Radiation Soil Screening

The Ra-226 reference soil was prepared in April 2011 by blending splits of the soil samples collected for excavation control during the 2009 IRA and analyzed by vendor laboratory (Energy Laboratory). Approximately 2000 grams of the excavation control soil samples were collected for screening by expedited analysis using on site gamma spectroscopy (Canberra Model 1510). If a soil sample screening results indicated that Ra-226 is below the 2.24 pCi/g screening level, split of that sample was sent to vendor laboratory for confirmation. The 1200 gram aliquots of the onsite gamma spectroscopy analysis of the samples were saved and stored at the UNC mill site office. Based on the laboratory analytical results near the 2.24 pCi/g screening level, the following four 2009 IRA samples were selected to prepare a reference soil for the ex-situ gamma radiation soil screening.

Sample ID	Sample Date	Ra-226, pCi/g	Weight, grams
Z4SSS07	10/14/2009	2.0	1000
AS04a	10/16/2009	1.8	1000
AS17a	11/02/2009	2.2	1000
AS31c	11/19/2009	2.1	1000
TOTAL (2.0 pCi/g Reference soil)		**2.0**	**4000**

The soil samples weight of 1,000 grams were weighed using an Ohaus LS2000 electronic balance. The soil was mixed in a one gallon plastic jar. The 2.0 pCi/g final concentration of the reference soil provides conservative screening for the 2.24 pCi/g screening level.

AVM Environmental Services, Inc.

Ra-226 Standards Preparation for NECR PDS PTW Soil Screening

Ra-226 standards were prepared by blending local matrix soil from borrow area and Certified Reference Material (CRM) from the Department of Energy's New Brunswick Laboratory (NBL). These standards were prepared to calibrate the gamma radiation soil screening system for NECR PDS. The gamma soil screening system will be utilized to determine if the soil sample is above or below the PTW level (200 pCi/g Ra-226). The matrix blending provides additional compensation for local background. To increase range accuracy, the higher Radium content CRM was diluted with the local matrix to bring the standard concentrations to 200 and 100 pCi/gm of Ra-226. An NBL CRM 3-B (3.90% U_3O_8 with Ra to U weight ratio of 3.38E-07 which results to 11,178 pCi/gm Ra-226) was used to prepare matrix standards.

Standard #RA1 (4000 grams)

71.2176 grams of CRM-3B @ 11,178 pCi/g = 796,070 pCi
3,930 grams of Matrix Soil (@1.0 pCi/g) = 3930 pCi
4001 grams Total = 800,000 pCi

RA1 Ra-226 concentration = 200.0 pCi/g (October 26, 2013)

Standard #RA2 (4000 grams)

35.4299 grams of CRM-3B @ 11,178 pCi/g = 396,035 pCi
3965 grams of Matrix Soil (@1.0 pCi/g) = 3965 pCi
4000 grams Total = 400,000 pCi

RA2 Ra-226 concentration = 100.0 pCi/g (October 26, 2013)

The matrix soil was weighed using the Ohaus LS2000 electronic balance. The CRM was weighed with the Mettler H5 balance, SN#58395. The soils and CRM were transferred into a gallon glass jar and mixed by rolling. The entire matrix standards were transferred into 1 gallon zip lock bags and labeled.

Attachment A

AVM Environmental Services Inc.
L2221 SCA/L44-20 Energy Calibration Form

SCA: L2221, SR #68782 Detector: Ludlum 44-20 (3x3 NaI Scintillator)

Calibration Source: Cs-137 Check Source, 5 uCi (August 2008) For 662 KeV Peak Cal

Threshold (input sensitiv **652**

Window, In/Ou___**IN**___ Window______**20**______

HV Initial ___________, At Peak _____________

Maximum CPM: ________________________ Background CPM: _________________

HV Set @______________ VDC

For Bi-214 609.2 KeV Peak (559 - 659 KeV ROI), Set Threshold @ 559, Window @ 100

CBi-214 609 KeV ROI Calibration Check: 1% U3O8 Ore Check Source: _______________ CPM
Background count (empty chamber) ____________ CPM

____
____
____
____

Date _______________________ Calibrated By ____________________________________

Attachment B

AVM Environmental Services, Inc.
Ludlum SCA L2221 - 44-20 3x3 NaI Detector Function Check
559 - 659 KeV Gamma Radiation Soil Screening

L2221 #68782

Function Check Source ID: 1% U_3O_8 Ore in Sealed can

Ludlum 44-20 3x3 NaI Detector, #PR295573

Acceptable background Count (cpm) Range (20%) ______________________ to ____________________

Acceptable Source Count (cpm) Range (20%) ______________________ to _______________________

Date	Physical Check	Cal Date	Battery(1) Volts or OK	HV Volts	Threshhold mV (2)	Window mV	Window In/Out	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	MDC pCi/gm	Tech

Note: (1) Battery Voltage for Ludlum 2221 must be >5.3 volts; (2) Threshhold must be at 220 mV; (3) Window @ 440, must be IN

Attachment C

AVM Environmental Services, Inc.
Field Soil Sample Gamma Radiation Screening Form

Instrumentation : Scaler/Ratemeter________________________, Detector __________________________________

Instrument Calibration Date: ___________________________, Instrument Function Check Performed: _________

Survey Area/Unit Decsription ____

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts	Weight Corrected Counts	CPM	Estimated Ra-226 pCi/g	Comments

Technician Signature ______________________________, Reviewed by _________________________________

SOP-5
AVM Environnemental Services, Inc.
Surface Soil Sampling
NECR Mine Site Removal Action

1.0 Introduction

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental surface soil samples for radiologic and chemical analyses. The information presented in this SOP is generally applicable to the collection of all surface soil samples, except where the analyte(s) may interact with the sampling equipment. This SOP defines sample collection procedures using hand augers and shovels/trowels samplers. This document focuses on methods and equipment that are readily available and typically applied in collecting surface soil samples. It is not intended to provide an all-inclusive discussion of sample collection methods.

The objective of surface soil sampling is to characterize radiologic and chemical properties of the soil. Details pertaining to sample locations, number of samples, and type of analyses required, are presented in the Excavation Control (Appendix T.1) and Final Status Survey Plan (Appendix T.2).

2.0 Scope

This SOP describes procedures for surface soil sampling using hand tools for Ra-226, total uranium and CPOC metals analysis during the NECR removal action.

3.0 Sample Type

Surface soil samples are typically collected from the ground surface to 6 inches below ground surface. Samples collected from greater than 6 inches below ground surface are referred to as subsurface soil samples. Soil sampling includes samples for excavation control, PTW characterization, investigation, and confirmatory samples for the final status survey. Surface soil samples may be collected as grab samples or as composite samples. The sample method is determined based on the physical characteristics of the sample location and soil matrix.

- Grab sample: A sample taken from a particular location. Grab samples are useful in determining discrete concentrations, but also provide spatial variability when multiple samples are collected. Grab samples will be collected from sampling locations for the final status survey and during excavation control.

- Composite sample: A number of samples that are individually collected then combined (homogenized) into a single sample for subsequent analysis. Composite samples are useful when averaged or normalized concentration estimates of a waste stream or an area are desired. Composite samples include five-point composite samples from PTW stockpiles for characterization. Also, multi-point composite samples may be collected from an area for excavation control surveys.

4.0 Sampling Equipment and Technique

The following materials will be available, as required, during soil sampling activities:

- Personal protective equipment (PPE), as specified by the site HASP
- Stainless steel bowls
- Stainless steel spoons
- Stainless steel spatulas
- Stainless steel trowel
- Stainless steel spades
- Stainless steel hand augers
- Rock pick
- Permanent Indelible ink pens
- Tape measure or a ruler
- Sealable plastic bags (e.g., Ziploc®)
- Appropriate sample location coordinates and/or area maps or figures
- Equipment decontamination materials
- Transport container such as cooler (if sampling for laboratory analysis)
- Appropriate Field Sampling Data forms

A grab surface soil sample may consist of a single scoop or core, or the sample may be a composite of several individual samples. Surface soil samples shall be obtained using hand augers, shovels/trowels, or soil core samplers.

Hand Auger: A hand auger consists of a stainless steel tube with two sharpened spiral wings at the tip. The auger typically cuts a 2-inch to 3-inch diameter boring and works better in consolidated or slightly moist soils. Because the auger is hand-driven, penetration in dense or rocky/gravelly soil may be difficult. For surface soil sample collection, the procedures outlined below shall be followed.

1. Advance the auger by hand into the soil, to the desired depth (6 inches or less for surface soil samples), by turning in a clockwise direction with down force applied.

2. Retrieve the auger by pulling straight up until completely out of the hole, preferably without any rotation.

3. Fill the sample container, generally a Ziploc bag for Ra-226 and/or a wide mouth glass jar for metals as specified in the QAPP, using clean stainless steel spatulas or spoons. Repeat step 1 and 2 until a sufficient amount of sample is collected for specified analysis. For Ra-226 analysis by Method 901.1, about 400 grams in a quart size Ziploc bag is sufficient. For on-site ex-situ soil screening, about 3500 grams in a gallon size Ziploc bag will be required. Affix label on the sample container with appropriate sample information.

<u>Shovel/Trowel:</u> Various shovel/trowel designs and sizes are commercially available for a variety of sampling applications. These devices are hand-driven and are typically used for sampling relatively soft, unconsolidated surface soils. Some designs (e.g., the sharpshooter TM) can be driven into hard, rocky soil by opening a deep, narrow hole. All shovels or trowels used for surface soil sampling shall be made of stainless steel. The procedures outlined below shall be followed while collecting samples with shovels or trowels.

1. Drive the shovel/trowel into the soil six inches deep.

2. Retrieve the shovel/trowel being careful to not spill sample.

3. Fill the sample container, generally a Ziploc bag for Ra-226 and/or wide mouth glass jar for metals as specified in the QAPP, using clean stainless steel spatulas or spoons. Repeat step 1 and 2 until sufficient amount of sample is collected for specified analysis. For Ra-226 analysis by Method 901.1, about 400 grams in a quart size Ziploc bag is sufficient. For on-site ex-situ soil screening, about 3500 grams in a gallon size Ziploc bag will be required. Affix label on the sample container with appropriate sample information.

Any soil sample collected for on-site ex-situ gamma screening may require sending to off-site vendor laboratory for Ra-226 analysis based on the ex-situ soil screening results. Split an aliquot for the off-site vendor laboratory from the ex-situ sample, which would had been already homogenized and of ample quantity.

5.0 Sample Equipment Decontamination

All sampling tool and equipment used for soil sampling will be clean prior to any soil sample collection. Sampling tools and equipment that are reusable will be decontaminated in between sample collection at different locations to avoid sample cross contamination. Hand tools, such as trowels, shovels, spoons, mixing bowls, etc. will be decontaminated at the sample locations. Any large equipment may be decontaminated at the designated decontamination pad at the Site to collect residual soil and rinsate. Since the sampling involves soil that may be potentially impacted by the COCs, Ra-226, uranium, and the COPC metals from uranium ore, which are mostly insoluble, the following procedure will be used to decontaminate soil sampling tools and equipment:

1. Brush off any loose soil from the sampling tool.
2. Wash the sampling tool with water and a residue free detergent, such as Alconox, in a bucket using a brush.
3. Rinse the sampling tool in a bucket with fresh water.
4. Rinse the sample tool with de-ionized water.

Collect a rinsate sample for each type of sampling tool once at start of soil sampling during the project in order to verify the adequacy of sampling tool decontamination. Rinse the decontaminated tool with DI/distilled water and collecting the rinsate in a sample container pre-preserved with nitric acid for analysis of the constituents similar to the sample analysis.

6.0 Investigation Derived Waste

The surface soil sampling is not expected to generate any Investigation Derived Waste (IDW) other than PPE (disposable gloves) and paper towels. Any excess soil from soil sample will be backfilled into the hole created from sample collection. Sampling tool decontamination rinse water will be poured on top of the backfilled sample hole for compaction. This method does not create any additional contamination or waste. If it is not feasible to put the excess sample back in the sample location, the excess soil will be contained and disposed of in the repository. The disposable PPE will be disposed of in the repository along with any mine waste.

7.0 Sampling Data Recording, Handling and

Field sampling documentation will be completed to provide sample information. Fill out sample information in the Field Soil Sample Log Form, included in Attachment A. Any additional information may be included in the log book. Sample handling requirements, such as storage, shipping and chain of custody, are specified in the QAPP, Appendix T.3. The soil samples collected for the COCs and CPOC metals do not require any specific preservatives. Complete sample chain of custody provided by laboratory. The field supervisor will retain all site documentation while in the field and add to project files when the field mobilization is complete.

8.0 QA/QC Requirements

Quality assurance quality control (QA/QC) includes following the SOP as discussed above, which includes proper decontamination to avoid cross contamination and sampling data recording and handling. Field QA/QC samples will be collected at the frequency specified in the Excavation Control Plan and the Final Status Survey Plan as listed below:

- Sampling equipment rinsate sample as discussed above in the section 5.0.
- Field QA/QC soil sample duplicate at a frequency of 10% of the samples collected.

Other applicable QA/QC requirements for laboratory, such as blanks, duplicate analyses, matrix spike are specified in the Quality Assurance Project Plan (QAPP), Appendix T.3.

Attachment A

Field Soil Sample Log Form
NECR Mine Site Removal Action

Sample ID	Sample Date and Time	Sample Location (Coordinates)	Sample collection method/container/preservative	Analyses	Sample Type/Description	Comments/Notes	Sample Tech

Please include other applicable information, such as sampling activity/event, COC#, sampling depth, soil description, sample sub-location, etc in sample description or comments/notes

Northeast Church Rock

95% Design Report

Appendix U:

Revegetation Plans

This page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
ARAR	Applicable or Relevant and Appropriate Requirements
CFR	Code of Federal Regulations
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NECR	Northeast Church Rock
NRC	US Nuclear Regulatory Commission
RAO	Remedial Action Objective or Removal Action Objective
ROD	Record of Decision
SOW	Statement of Work
TDA	Tailings Disposal Area
UNC	United Nuclear Corporation
USEPA	US Environmental Protection Agency

U.1 INTRODUCTION

This appendix presents the Revegetation Plans for the Northeast Church Rock Mine Site (Mine Site) and Church Rock Mill Site (Mill Site) (Attachment U.1) and the Repository on Mill Site Tailings Disposal Area (TDA) (Attachment U.2). These plans were prepared by Cedar Creek Associates, Inc., a subcontractor to Stantec.

U.2 PERFORMANCE STANDARDS

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

Table U.2-1: Performance Standards Applicable to the Revegetation Plans

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
95	2011 Action Memo, Section V.A.1, Bullet 8 – Site Restoration	Site Restoration	Restoration activities will include the backfilling and regrading of excavation areas for erosion and storm water control. These areas will also be re-vegetated with native species.	Restoration activities for the excavated areas at the Mine Site and for borrow areas are discussed in appendices C, F, and H. Disturbed areas will be revegetated in accordance with the Revegetation Plan. The Revegetation Plan for the Northeast Mine Site and Mill Site is included here as Attachment U.1, and native species are included in the selected seed mixes.
46	2013 ROD, Table 1	Closure	10 CFR 61.52(a)(9) Technical Requirements for Land Disposal Facilities. Refer to www.ecfr,gov.	The technical specifications for closure and stabilization of the Repository are discussed in Appendix J. The Revegetation Plan for the Repository on Mill Site TDA is attached as Attachment U.2.
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 Processed Primarily for Their Source Material Content - Criterion 4.	The cover system is designed to be erosionally stable without vegetation and includes establishment of a self-sustaining vegetative cover. See Appendix G, Attachment G.7. The Revegetation Plan for the Repository on Mill Site TDA is included here as Attachment U.2.
37	2013 ROD, Section 2.9.5, Cap Design Criteria, Bullet 5	Repository Design	Although the final design may vary, the major elements of the structure are not expected to be significantly different than those presented here. The cap design will be based on comprehensive planning, site-specific risk analysis, and ARARs. Cap design and cost estimates for Alternative 2 are	The Revegetation Plan for the Repository on Mill Site TDA is included as Attachment U.2. The revegetation plan includes the use of amendments, such as composted cow or green manure, or composted biosolids to promote vegetation growth.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
			based on the following elements: …use of biosolids or top soil to facilitate vegetation growth	
38	2013 ROD, Section 2.9.5, Cap Design Criteria, Bullet 6	Repository Design	Although the final design may vary, the major elements of the structure are not expected to be significantly different than those presented here. The cap design will be based on comprehensive planning, site-specific risk analysis, and ARARs. Cap design and cost estimates for Alternative 2 are based on the following elements: …the use of vegetation to emulate the structure, function, diversity, and dynamics of the native community to maximize resilience and sustainability;	The Revegetation Plan for the Repository on the Mill Site TDA is included as Attachment U.2. The revegetation plan includes a seeding mix which emulates the native vegetation community to maximize resilience and sustainability.
12	2015 AOC SOW, Paragraph 27 – Site Restoration	Site Restoration	In the Design, Respondents shall include detailed plans and specifications for restoration of the Tailings Disposal Area and borrow areas on the UNC Site and for restoration of the NECR Site. Respondents shall also include plans and specifications for contouring to promote drainage, and for re-vegetation of the Tailings Disposal Area, borrow pits and NECR Site with native species. Respondents shall include plans and specifications for backfilling and regrading of disturbed (e.g., excavated) areas in the NECR Site and the UNC Site for erosion and storm water control, including re-vegetation of those areas with native species.	Detailed design plans and specifications will be prepared for restoration of disturbed areas on the UNC and NECR Sites. See appendices C, F, H, I, and J. Disturbed areas will be revegetated in accordance with the revegetation plans. The revegetation plans for the Mine Site and Mill Site and the Repository on Mill Site TDA are included as Attachment U.1 and Attachment U.2, respectively.
20	2015 AOC SOW, Paragraph 43 – Pre-Final NECR Mine Cleanup Verification and Revegetation Plan	Pre-Final NECR Mine Cleanup Verification and Revegetation Plan	Respondents shall submit a Pre-Final NECR Mine Cleanup Verification and Revegetation Plan for the NECR Site that shall be a continuation and expansion of the Preliminary NECR Mine Cleanup Verification and Revegetation Plan, and any Intermediate Design.	The Revegetation Plan for the Mine Site and Mill Site is included as Attachment U.1. The Cleanup Verification Plan is provided as Appendix T.

*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)

U.3 ENGINEERING DESIGN DRAWINGS

The relevant engineering design drawings are contained in Volume II – Design Drawings (Section 10). Drawings related to the revegetation plans are listed in Table U.3-1. The drawings show the approximate locations where the proposed seed mixes listed in the revegetation plans will be applied.

Table U.3-1: Engineering Design Drawings

Drawing No.	Drawing Title
10-01	Mine Site Revegetation Plan*
10-02	Mill Site Revegetation Plan

* Drawing excluded from LAR submittal.

U.4 REFERENCES

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

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

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

ATTACHMENT U.1

Revegetation Plan for Northeast Church Rock Mine Site and Church Rock Mill Site

Revegetation Plan

Northeast Church Rock Mine Site and Church Rock Mill Site

UNITED NUCLEAR CORPORATION

JULY 2018

CEDAR CREEK ASSOCIATES, INC.
5586 Overhill Dr.
Fort Collins, Colorado 80526
(970) 223-0775
www.cedarcreekassociatesinc.com

Table of Contents

1.0 INTRODUCTION

Cedar Creek Associates, Inc. (Cedar Creek) has been retained by Stantec to develop and then implement a work plan specific to revegetation for facilities associated with the General Electric Company and United Nuclear Corporation (GE/UNC) Northeast Church Rock Mine Site (Mine Site) and the Church Rock Mill Site (Mill Site). This plan has been prepared to fulfill the requirement to provide a revegetation plan for restoration of the Mine Site and disturbed areas on the Mill Site as described in Paragraph 27 of the Statement of Work (SOW; Appendix D to USEPA, 2015) and is one of the many 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 (AOC; USEPA, 2015). The areas addressed by this revegetation plan are presented on Map 1. In general, this plan applies to lands within the project area that are subject to revegetation, except for the repository on the Church Rock Mill Site Tailings Disposal Area (Repository), which is addressed in a separate plan. The areas subject to revegetation include portions of Step Out Area #1 which were previously revegetated and will be disturbed during construction. Revegetation protocols and performance criteria presented in this plan are responsive to the rules, regulations, and guidelines of the New Mexico Mining and Minerals Division (NMAC 19.10.5).

This work plan identifies and defines reclamation protocols (Section 2.0), monitoring methods (Section 3.0), and success criteria (Section 4.0) to be utilized for revegetation of the Mine and Mill Sites. In addition, Section 5.0 provides potential corrective actions to facilitate performance expectations.

Revegetation planning of each distinct disturbance area will consider 1.) baseline vegetation communities, 2.) post-mining (or post-disturbance) land use (PMLU), 3.) specific considerations pursuant to desired post-disturbance management of both public and private lands, and 4.) the most scientifically sound methods and state-of-the-art techniques related to revegetation, soil amendments, seedbed preparation, seeding, mulching, and general reclamation science. In addition, quality assurance and quality control procedures in the form of monitoring surveys will be undertaken to confirm that revegetation efforts are implemented correctly and the results of the process meet predetermined expectations and general liability success criteria.

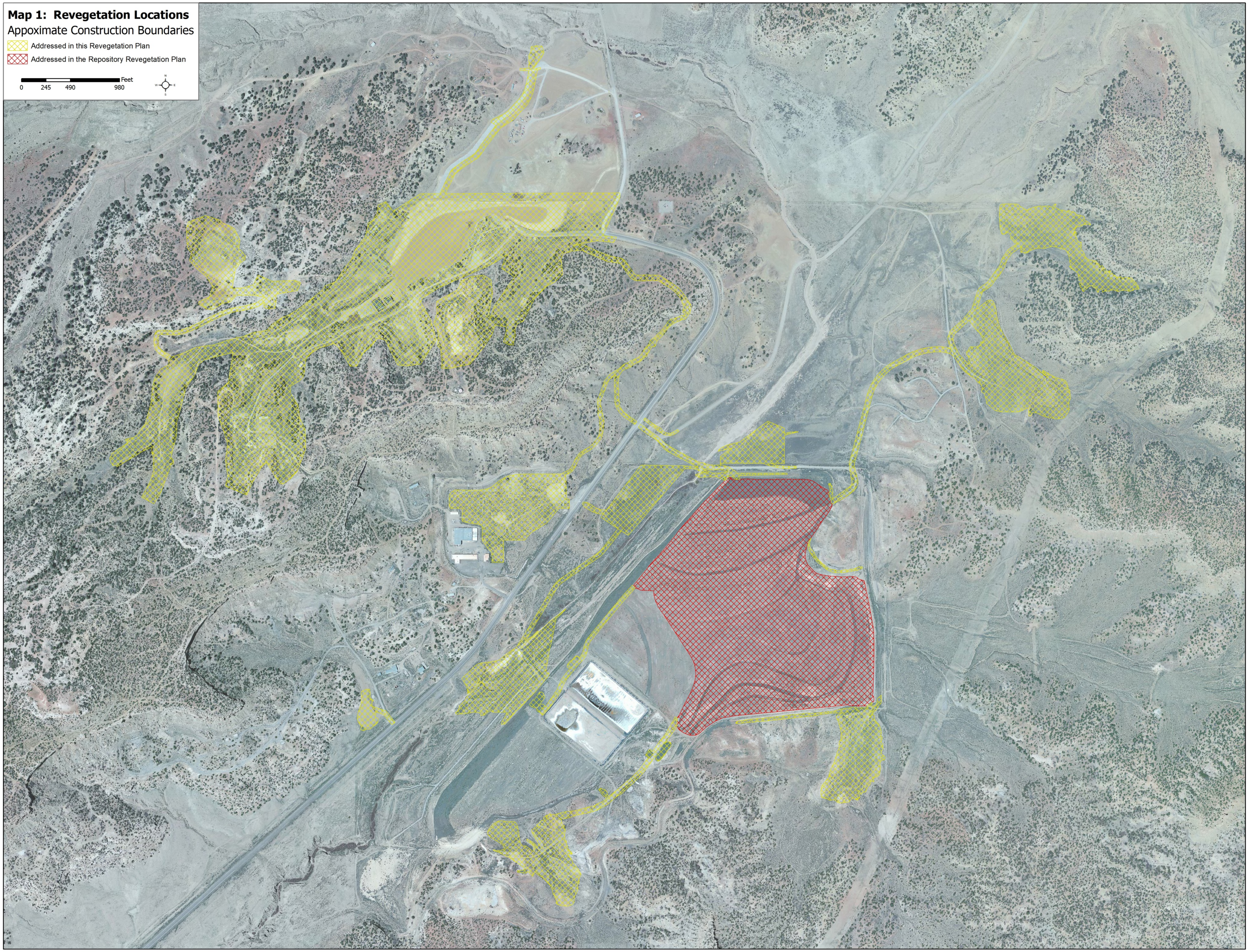
Four baseline evaluations of biological resources have been conducted at the Mine and Mill Sites. The evaluations were made in support of the 2009 Interim Removal Action (Cedar Creek, 2010), the 2012 Interim Removal Action (Cedar Creek, 2012a), Repository design (Cedar Creek, 2014), and the Environmental Data Gap Report (INTERA, 2017). Annual revegetation monitoring reports have been generated since 2010, presenting performance results from the revegetation implemented on and around the Mine Site. The baseline evaluations provide information on the biological resources prior to construction activities. This information is useful when designing revegetation protocols and seed mixes. Annual monitoring results are used to ensure the revegetation is meeting performance expectations and allow for adaptive management of future revegetation efforts. The process in which previous revegetation plans have been developed (through community coordination), as well as previous baseline evaluations and revegetation monitoring results inform the development of this plan. This plan aims to build upon these previous efforts implemented on site.

The Mine and Mill Sites are approximately 16 miles Northeast of Gallup, New Mexico and comprise of mine features (including removal areas), the Repository and associated facilities, as well as borrow areas and travel corridors. The sites are on private lands and lands administered by the Bureau of Indian Affairs on behalf of the Navajo Nation. The area is mainly grassland/shrubland and pinion juniper woodland within the Colorado Plateau physiographic province. It is characterized by rough, broken terrain, including steep mountainous areas, plateaus, cuestas, and mesas intermingled with steep canyon walls, escarpments, and valleys, with soils derived mainly from marine sandstones, mudstones, and shales. The area has very little surface water.

The weather station at Gallup Municipal Airport, New Mexico is sufficiently near the site (approximately 19 miles southwest) to provide a good comparison of long-term trends in precipitation in the area. Annual precipitation in the region is approximately 11 inches/year, with a majority delivered as summer monsoonal, convective thunderstorms. This precipitation pattern favors the growth of warm season perennial grasses and shrubs in deep and moderately deep soils, respectively, and pinion juniper woodland on hillslopes and areas of shallow soils. The mean annual temperature is about 49 degrees F.

The Mine Site exists within a Piñon – Juniper (PJ) Woodland community with occasional small pockets of mixed shrubland and ruderal shrubland (around disturbance sites) at an elevation ranging between 7,000 and 7,200 feet above mean sea level. The Mill Site is on arid mixed grass and shrubland communities in deep alluvial soils. The proposed haul road to transport mine waste to the Repository will cross PJ and grass/shrubland communities, and will transverse the bottomland ecosystem.

Previous reclamation efforts have been carried out within and adjacent to the Mine Site, and surrounding Navajo lands in PJ and mixed shrub/grassland communities, achieving extremely successful grass/shrubland revegetation has been demonstrated in the region with proper techniques and methods, and suitable growth media.


Map 1: Revegetation Locations
Appoximate Construction Boundaries
Addressed in this Revegetation Plan
Addressed in the Repository Revegetation Plan
Feet
0
245
490
980
N
W
E
S

2.0 REVEGETATION PROTOCOLS

A basic framework for all reclamation including soil/growth media considerations, seeding considerations, and proposed amendments can be established for the entirety of the project. Site-specific considerations in addition to this framework can be applied or adjusted in the future to meet site specific requirements. Revegetation protocols and performance criteria for the Mine and Mill Sites are guided by the rules and regulations of the New Mexico Mining and Minerals Division (NMAC 19.10.5). Specifically, the Mining Act Reclamation Program regulates hard rock mining reclamation activities for uranium properties. Closeout Plan Guidelines (NMMMD, 1996) provide a framework for the revegetation protocols and performance criteria to be applied to the Mine and Mill Sites.

2.1 Soil/Growth Media Physical Considerations

Handling of growth media should be done prudently as to avoid excessive disruption to soil structure. Desirable textures of proposed growth media should be a blend of sand, silt, and clay, while textures of pure sand, pure silt, or pure clay (indicated in red on Figure 1) are considered unsuitable growth media and should not be used as surficial growth media. Handling of materials immediately following precipitation events should be avoided, when possible, to limit issues associated with compaction. Any localized or unforeseen matters relating to soil physical attributes would be identified through a site visit by a soil scientist and laboratory analysis of texture by hydrometer.

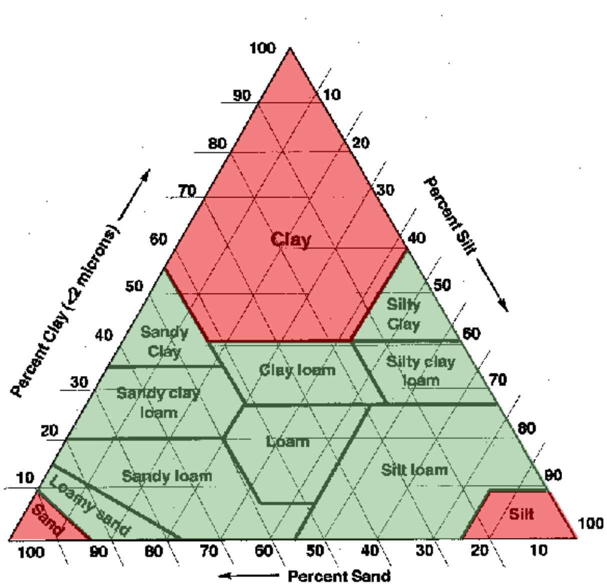


Figure 1: Suitable Growth Media Textures

2.2 Soil/Growth Media Chemical Considerations

Agronomic testing was conducted on the Step Out #1 soils during the 2009 IRA. Agronomic testing was also conducted on the proposed borrow materials for the Repository construction (INTERA, 2017). Results from both studies suggest that soils found onsite, throughout the profile, are suitable to support plant growth. Soils encountered in Step Out #1 and the borrow sites associated with the Repository are similar to those found throughout the Mine and Mill Sites. Therefore, results and recommendations stemming from those assessments can reasonably be applied to the Mine and Mill Sites soils. Table 1 presents acceptable average values for relevant soil parameters to be considered a suitable growth media. Average soils results from both studies exhibited slightly elevated salts (EC) and slightly diminished organic matter (%), when compared with typical A horizon soils in the area. However, reported results were still within acceptable ranges to be considered suitable growth media (INTERA, 2017).

Table 1 Suitable Growth Media Results

Paramater	Acceptable Average Values	Units
pH (paste)	6 - 8.3	N/A
Electrical Conductivity	< 6	mmhos/cm
Organic Matter	< 10	% of Total Soil
NO_3-N	> 0.1+	ppm
Phosphorus (P)	> 1+	ppm
Potassium (K)	> 20+	ppm
Zinc (Zn)	> 0.25+	ppm
Iron (Fe)	> 1.0+	ppm
Manganese (Mn)	> 0.1+	ppm
Copper (Cu)	> 0.1+	ppm
Calcium (Ca)	Addressed as SAR	ppm
Magnesium (Mg)	Addressed as SAR	ppm
Sodium (Na)	Addressed as SAR	ppm
Calcium Carbonate Equivalent	< 10	% by Weight
Texture by hydrometer	No Textural Extremes	% Size Fraction
Sodium Adsorption Ratio	< 15	N/A
Cation Exchange Capacity	For Information Purposes+	meq/100g

+ Values Can Be Increased Through OM Additions

2.3 Soil/Growth Media Amendments and Fertility

With the reported soils testing results from previous sampling efforts within suitable ranges, no amendments are required. However, it was decided to incorporate compost to improve germination conditions, which appears to have been effective to establishing revegetation in Step Out #1. Native arid vegetation is ecologically adapted to low fertility systems, and using standard agronomic fertility ranges designed for intensively managed, often heavily irrigated, and annually harvested agricultural systems is misrepresentative of the requirements for arid grassland and shrub systems in New Mexico.

When materials are disturbed (plowed, harvested, tilled), organic matter and associated fertility can be released (volatilized) by a subsequent increase in microbial activity. A general application rate of 2 tons/acre (dry weight) incorporated to 3 inches depth of composted cow or green manure, or composted biosolids, should be sufficient for reclamation. Composted cow manure has been used to effect successful in reclamation within the Mine Site in the past. Moisture content, salinity, and organic matter, of organic amendments need to be tested by a certified laboratory. The testing of organic matter and moisture content is to ensure the application rate (which is based on dry weight) is met. The moisture content and degree of composting significantly affect the weight of the product and adjustments in the tonnage applied per acre must be made to adjust for moisture content. Salinity results for the organic amendments should be below 5mmhos/cm on average. All testing should be conducted on representative samples from the same batch intended to be purchased. Moisture and organic matter results are used to accurately calculate target application rates. Given the potential for elevated salts in the soils, only low salt amendments should be used. Composted biosolids will be tested to ensure sufficiently low radium activity concentrations prior to use. In specific instances, such as harvesting growth media from very deep in the soil profile or using material stockpiled for more than a year, increased quantities of manure may be beneficial, and will be addressed on an “as needed” basis.

Composted manures and/or composted biosolids are more desirable than inorganic fertilizers and industrial byproducts such as Biosol, because they are significantly lower in inorganic and total nitrogen. Nitrogen preferentially stimulates the growth of undesirable weedy annual species, which reduces available water and nutrients for desirable perennial vegetation. In addition to the low nitrogen levels, the physical structure of the compost increases localized water holding capacity, and creates islands of fertility to aid germination. Plant germination and establishment in the first few years is critical, as native seed sources then begin to supplement the initial seeding, and stabilize the soil medium. Organic amendment application should occur immediately prior to seeding, and be incorporated as soon as possible, preferably by disk harrow. Composted manure and/or biosolids left on the soil surface, exposed to warm temperatures and potential precipitation, will readily decompose, thus making it less beneficial.

2.4 Erosion Control and Seedbed Preparation

The principal means to obtain erosional stability is use of stability enhancing metrics and the construction of a stable physical landscape that can then support the establishment and persistence of a reasonable herbaceous ground cover (that also provides enhanced protection against erosion). Once such a stable condition is achieved, natural successional processes are enabled leading to advancement along the successional continuum and eventually to a condition that fully supports the revegetation effort. Such progression should occur in a relatively short period of time, perhaps as few as 3 to 5 years.

Once the project area is regraded to approximate final configuration and overlaid with the native borrow material, areas of steeper slopes (greater than 3:1) should be deeply ripped, where possible, with a single or double-toothed chisel plow pulled by a D8 or equivalent dozer. Deep ripping should occur along the contour, creating contour ridges to help preclude erosion. Ripping should occur at nominal intervals of 4 feet (but no more than 6 feet) between the ripper teeth. On flatter slopes between 3:1 and 5:1, drill seeding must occur on the contour to create the small ridges associated with drill seeding as an erosion control. Ripping and/or discing may be used if site conditions warrant the need for further erosion protection. Flat areas (less than 5:1 slopes) do not require ripping or discing, unless site conditions dictate the need. However, drill seeding should still be implemented on the contour.

A field level risk assessment of erosion risk should be implemented to determine the appropriate temporary erosion control, if needed. The risk assessment should consider slope gradient, slope length, and contributing area. Areas with high consequences of erosion should receive permanent rock mulches and mixed into the growth media, or a combination of rock and wood shreds. Mulch can help conserve soil moisture for seed germination and aid initial plant establishment as well as provide additional soil erosion protection from both wind and water until a plant cover is established. Areas with lower consequences of erosion should receive certified weed-free wood shred mulch, wood chip mulch, or crimped straw mulch.

2.5 Seeding Considerations

The reclamation site conditions at the Mine and Mill Sites can generally be characterized in three ways, steep slopes and benches with thin soil (juniper woodland), alluvial valleys with deep soils (grassland/shrubland), and wetter alluvial valleys with deep soils (bottomland). Therefore, seed mixes are designed to facilitate growth of appropriate and sustainable species in each community. Seed mixes are completely comprised of native species. Drawing 10-02 shows where each seed mix will be applied. Effort will be made to implement seeding at optimal times for site conditions (October or November / March). However, if a unit must be seeded during inopportune months, a field level risk assessment will determine whether temporary erosion control measures (such as crimped hay, wood shreds, wattles, etc.) are needed to stabilize the surface prior to anticipated vegetation establishment.

Seeding can be accomplished using both broadcasting and drilling techniques, following final contouring and compost application/incorporation. If seed is broadcast, a light disc harrowing perpendicular to the flow of energy (wind and/or water) should immediately follow seeding to increase seed to soil contact and provide some protection from wind or water erosion and granivory. Certain field conditions (such as broad, steep slopes) sometimes preclude the use of broadcast and drilling methods, and in these situations hydroseeding may be considered as an alternative. If hydroseeding is selected, a tackifier should be combined with the mulch slurry to improve adhesion.

The proposed seed mixes are comprised of native species and application rates are presented on Tables 2, 3, and 4 for Juniper Woodland, Grassland / Shrubland, and Bottomland targeted communities, respectively. The Grassland / Shrubland mix was developed with community input during the 2009 and 2012 Interim Removal Actions (Cedar Creek, 2010 and Cedar Creek, 2012b). Seed mixes will be obtained from reputable commercial sources and information regarding the percent purity, percent weed seed, and percent germination will be reported on the seed tag. A seed tag is a legal document describing the contents of the seed you are purchasing. Besides being very useful information to the consumer, State and Federal laws require seed companies to provide a description of the seed being sold. The information on the tag comes from tests that have been performed on the seed by a seed testing laboratory. Species proposed in these mixes are suitable for use, as demonstrated by their establishment on nearby revegetation at the Mine Site. Volunteer vegetation (non-seeded species) are encouraged to establish on the revegetation parcel as long as species are not noxious weeds and do not impact the ability to achieve a sustainable perennial vegetative community.

2.6 Noxious Weed Considerations

Prior to construction activities, listed noxious weed species (excluding Russian thistle and burning bush) found within the project area should be treated to limit the spread of noxious weeds. Baseline vegetation surveys in the mine and mill site have identified the presence of Bull thistle, Musk thistle, Scotch thistle, Field bindweed, and Tamarisk in the project area (INTERA, 2017). Treatment recommendations are presented in Section 5.2. Russian thistle and burning bush are commonly found in the arid west and decrease as perennial plant communities establish and disturbance diminishes. The planting of competitive native species should be sufficient to prevent the establishment of both species, so no treatment prior to construction activities is recommended.

2.7 Climate Change Considerations

Climate change modeling results provide general indications of how the climate may shift in New Mexico over the next several decades and into the next century, albeit with a significant degree of uncertainty, spatially, temporally, and degree of magnitude. In general, modeling results from the Nature Conservancy and the Southwest Climate Change Network indicate a general warming and drying trend (with localized instances of cooling and increases in precipitation), with increased variation in timing, intensity, and form of precipitation from typical averages. The species selected for revegetation are well suited to the current arid climate of this region, yet have a relatively wide tolerance to climatic conditions, particularly regarding the predicted result of climate change (warmer and drier). In other words, if precipitation decreases, drought increases, or temperatures and subsequent evaporation rates rise, these species will still be suitable for and tolerant of future climates projected in the region. The anticipated circumstances of climate change may actually select for more efficient, later seral species (as is a desired outcome for the project), over short-lived annuals and less efficient cool season grasses. Supplemental watering is not warranted to aid revegetation establishment at this site, based upon previous revegetation activities at the Mine Site.

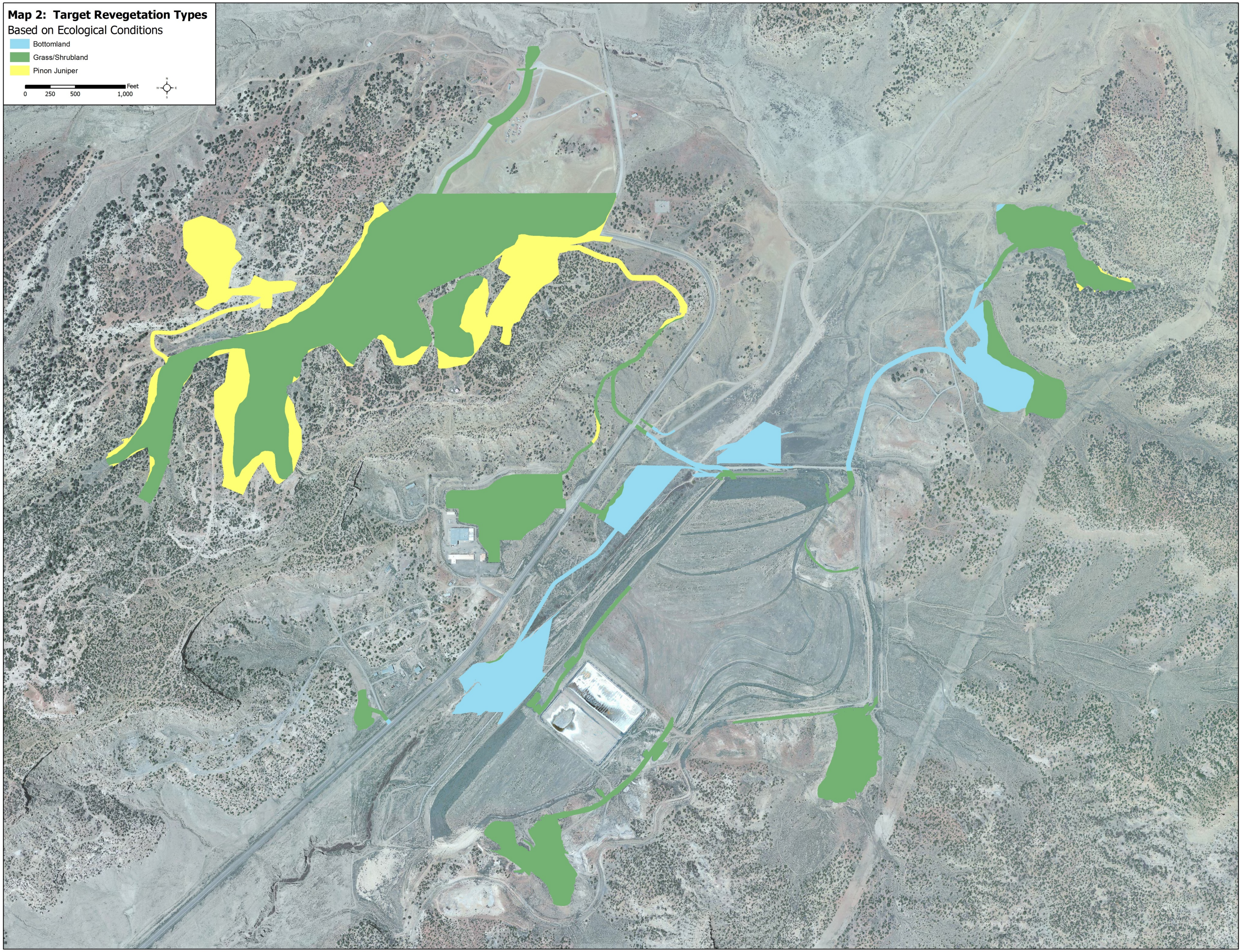

Map 2: Target Revegetation Types
Based on Ecological Conditions
Bottomland
Grass/Shrubland
Pinon Juniper
Feet
0
250
500
1,000
N
W
E
S

Table 2 Seed Mix for the Pinyon / Juniper Targeted Communities

No.	Obs. On Site	Common Name	Scientific Nomenclature	Recommendations: PLS / lb.*	Recommd. PLS lbs/ac	PLS / ft^2	% of Seeds in Mix	Preferred Method of Seeding **	This entire mix can be drill seeded very shallow. Comment (Based on Site-specific Findings or Professional Judgment)
1	**Yes**	Western wheatgrass	*Agropyron smithii*	110,000	1.50	3.8	4.1%	Drill	NRCS indicated climax species
2	**Yes**	Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.25	10.1	10.9%	Drill	NRCS indicated climax species
3	**Yes**	Blue Grama	*Bouteloua gracilis*	825,000	0.50	9.5	10.3%	Drill	Stong component of native community
4	**Yes**	Galleta	*Hiliaria jamesii*	159,000	0.50	1.8	2.0%	Drill	Stong component of native community
5	**Yes**	Purple Three-awn	*Aristida purpurea*	250,000	1.00	5.7	6.2%	B-cast/Harrow	
6	**Yes**	Indian Ricegrass	*Oryzopsis hymenoides*	141,000	1.00	3.2	3.5%	Drill	Should do well in areas of sandy texture
7	**Yes**	Sideoats Grama	*Bouteloua curtipendula*	191,000	1.00	4.4	4.8%	Drill	Good performer - Offers diversity
8	**Yes**	Spike Muhly	*Muhlenbergia wrightii*	1,600,000	0.25	9.2	10.0%	Drill	
			Subtotal		**6.00**	**47.7**	**51.7%**		
9	**Yes**	Desert Globemallow	*Sphaeralcea ambigua*	500,000	0.75	8.6	9.3%	B-cast/Harrow	Sufficient performer for diversity
10		Blanket Flower	*Gaillardia aristata*	132,000	1.00	3.0	3.3%	B-cast/Harrow	Good performer - Offers diversity
11	**Yes**	Rocky Mtn. Bee Plant	*Cleome serrulata*	65,900	1.00	1.5	1.6%	B-cast/Harrow	
12		Lewis Flax	*Linum lewisii*	293,000	1.00	6.7	7.3%	B-cast/Harrow	Good performer - Offers diversity
			Subtotal		**3.75**	**19.9**	**21.6%**		
14	**Yes**	Wyoming Big Sagebrush	*Artemisia tridentata wyo.*	2,500,000	0.25	14.3	15.6%	B-cast/Harrow	Occasional performer - Offers diversity
15	**Yes**	Douglas Rabbitbrush	*Chrysothamnus viscidiflorus*	782,000	0.50	9.0	9.7%	B-cast/Harrow	
16	**Yes**	Winterfat	*Ceratoides lanata*	56,700	1.00	1.3	1.4%	Drill	Good performer - good forage value
15	**Yes**	One Seed Juniper	*Juniperus monosperma*		If seed can be commercially sourced				
16	**Yes**	Pinon Pine	*Pinus edulis*		If seed can be commercially sourced				
			Subtotal		**1.75**	**24.6**	**26.7%**		
			Total		**11.50**	**92.2**			

* PLS = Pure Live Seed. Note: This entire mix may be drill seeded, but depth bands must be set to very shallow seed placement (e.g. 1/8 inch). If hydroseeding occurs, seed must not be mixed with a mulch for application. They must be applied in two passes: first pass seed, second pass mulch.
** The 12 lb/ac mix is designed for drill seeding of grasses and certain shrubs. If broadcast and harrow methods are used for grass seed distribution, the rate should be increased 1.5 times. When hydroseeding methods are to be used, the rate should be raised to 1.5 times when using two passes.

Table 3 Seed Mix for Shrubland / Grassland Targeted Communities

No.	Obs. On Site	Common Name	Scientific Nomenclature	Recommendations: PLS / lb.*	Recommendations: Recommd. PLS lbs/ac	Recommendations: PLS / ft^2	Recommendations: % of Seeds in Mix	Recommendations: Preferred Method of Seeding **	This entire mix can be drill seeded very shallow — Comment (Based on Site-specific Findings or Professional Judgment)
1	**Yes**	Western wheatgrass	*Agropyron smithii*	110,000	1.50	3.8	3.6%	Drill	NRCS indicated climax species
2	**Yes**	Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.75	30.3	29.1%	Drill	NRCS indicated climax species
3	**Yes**	Blue Grama	*Bouteloua gracilis*	825,000	0.50	9.5	9.1%	Drill	Stong component of native community
4	**Yes**	Galleta	*Hiliaria jamesii*	159,000	0.50	1.8	1.8%	Drill	Stong component of native community
5		Thickspike Wheatgrass	*Agropyron dasystachyum*	154,000	0.75	2.7	2.5%	Drill	Fair performer - Offers diversity
6	**Yes**	Indian Ricegrass	*Oryzopsis hymenoides*	141,000	1.00	3.2	3.1%	Drill	Should do well in areas of sandy texture
7	**Yes**	Sideoats Grama	*Bouteloua curtipendula*	191,000	1.00	4.4	4.2%	Drill	Good performer - Offers diversity
8	**Yes**	Bottlebrush Squirreltail	*Sitanion hystrix*	192,000	0.25	1.1	1.1%	Drill	Fair performer - Offers diversity
			Subtotal		**6.25**	**56.7**	**54.5%**		
9	**Yes**	Desert Globemallow	*Sphaeralcea ambigua*	500,000	0.75	8.6	8.3%	B-cast/Harrow	Sufficient performer for diversity
10		Firecracker Penstemon	*Penstemon eatonii*	900,000	0.50	10.3	9.9%	B-cast/Harrow	Good performer - Offers diversity
11	**Yes**	Rocky Mountain Penstemon	*Penstemon strictus*	592,000	0.25	3.4	3.3%	B-cast/Harrow	Fair performer - Offers diversity
12		Lewis Flax	*Linum lewisii*	293,000	1.00	6.7	6.5%	B-cast/Harrow	Good performer - Offers diversity
			Subtotal		**2.50**	**29.1**	**27.9%**		
13	**Yes**	Fourwing Saltbush	*Atriplex canescens*	52,000	1.00	1.2	1.1%	Drill	NRCS indicated climax species - good forage value
14	**Yes**	Wyoming Big Sagebrush	*Artemisia tridentata wyo.*	2,500,000	0.25	14.3	13.8%	B-cast/Harrow	Occasional performer - Offers diversity
15	**Yes**	Cliffrose	*Purshia mexicana*	64,600	1.00	1.5	1.4%	B-cast/Harrow	Fair performer - Offers diversity
16	**Yes**	Winterfat	*Ceratoides lanata*	56,700	1.00	1.3	1.3%	Drill	Good performer - good forage value
			Subtotal		**3.25**	**18.3**	**17.6%**		
			Total		**12.00**	**104.1**			

* PLS = Pure Live Seed. Note: This entire mix may be drill seeded, but depth bands must be set to very shallow seed placement (e.g. 1/8 inch). If hydroseeding occurs, seed must not be mixed with a mulch for application. They must be applied in two passes: first pass seed, second pass mulch.

** The 12 lb/ac mix is designed for drill seeding of grasses and certain shrubs. If broadcast and harrow methods are used for grass seed distribution, the rate should be increased 1.5 times. When hydroseeding methods are to be used, the rate should be raised to 1.5 times when using two passes.

Table 4 Seed Mix for Bottomland Targeted Communities

No.	Obs. On Site	Common Name	Scientific Nomenclature	Specifications / Recommendations PLS / lb.**	Recommd. PLS lbs/ac	PLS / ft^2	% of Seeds in Mix	Preferred Method of Seeding	This entire mix can be drill seeded very shallow Comment (Based on Site-specific Findings or Professional Judgment)
1	Yes	Western Wheatgrass	*Agropyron smithii*	110,000	2.00	5.1	7.3%	Drill	NRCS indicated climax species - Obs. On site.
2	Yes	Blue Grama	*Bouteloua gracilis*	825,000	0.50	9.5	13.8%	Drill	NRCS indicated climax species
3	Yes	Galleta	*Hiliaria jamesii*	159,000	0.50	1.8	2.7%	Drill	Fair performer - Obs. On site.
4	Yes	Indian Ricegrass	*Oryzopsis hymenoides*	141,000	0.50	1.6	2.4%	Drill	Fair performer - Obs. On site.
5	Yes	Bottlebrush Squirreltail	*Sitanion hystrix*	192,000	1.00	4.4	6.4%	Drill	Fair performer - Obs. On site.
6	Yes	Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.25	10.1	14.7%	B-cast/Harrow	NRCS indicated climax species
7	Yes	Sand Dropseed	*Sporobolus cryptandrus*	5,298,000	0.10	12.2	17.7%	B-cast/Harrow	Fair performer - Offers diversity
		Grass Subtotal			**4.85**	**44.6**	**64.9%**		
8		Rocky Mtn. Bee Plant	*Cleome serrulata*	65,900	1.50	2.3	3.3%	B-cast/Harrow	Requested species - Culturally Significant
9		Lewis Flax	*Linum lewisii*	293,000	1.00	6.7	9.8%	B-cast/Harrow	Good performer - Offers diversity
10	Yes	Rocky Mtn. Penstemon	*Penstemon strictus*	592,000	0.25	3.4	4.9%	B-cast/Harrow	Fair performer - Offers diversity
11	Yes	Scarlet Globemallow	*Sphaeralcea coccinea*	500,000	0.25	2.9	4.2%	B-cast/Harrow	Fair performer - Obs. On site.
		Forb Subtotal			**3.00**	**15.3**	**22.2%**		
12	Yes	Fourwing Saltbush	*Atriplex canescens*	52,000	2.50	3.0	4.3%	B-cast/Harrow	NRCS indicated climax species
13	Yes	Winterfat	*Ceratoides lanata*	56,700	1.00	1.3	1.9%	B-cast/Harrow	Good performer - good forage value
14	Yes	Rubber Rabbitbrush	*Chrysothamnus naseousus*	400,000	0.50	4.6	6.7%	B-cast/Harrow	NRCS indicated climax species
		Shrub Subtotal			**4.00**	**8.9**	**12.9%**		
		Total			**11.85**	**68.8**			

* The 12 lb/ac mix is designed for drill seeding of grasses. If broadcast and harrow methods are used for grass seed distribution, the rate should be increased 1.5 times. When hydroseeding methods are to be used, the rate should be raised to 1.5 times when using two passes. ** PLS = Pure Live Seed. Note: This entire mix may be drill seeded, but depth bands must be set to very shallow seed placement (e.g. 1/8 inch). If hydroseeding occurs, seed must not be mixed with a mulch for application. They must be applied in two passes: first pass seed, second pass mulch.

3.0 VEGETATION SAMPLING METHODS

Cedar Creek's vegetation sampling protocols involve an emphasis on ground cover to facilitate repeatable statistical comparisons among treatment areas (or unique revegetation units). Concentration on a single variable of plant ecology facilitates improved comprehension and comparability over time and among treatment scenarios. Ground cover data, especially when determined using a very precise method such as the point-intercept procedure, provides some of the most important information regarding community variability that ecologists can evaluate. Such data facilitate the determination of true species composition, relative health (condition), and successional status of the sampled area. Furthermore, the same data can be utilized to develop the "sister" variables of frequency and species composition if desired. In addition, strong inferences can be developed with other reasonably correlated variables such as production when species composition is factored into the analysis. Also, ground cover is a preferred variable for revegetation monitoring because cover data can be readily obtained in a statistically adequate and cost-effective manner (using the proper procedures), has broad application for evaluation (including erosion control modeling), precisely reflects species' dominance of a given area, and when collected using bias-free techniques such as the point-intercept procedure, is one of the most repeatable variables among independent observers.

Deficiencies in vegetation, both general and localized, and other pertinent information relative to the reclamation are also recorded while traversing monitoring units during vegetation evaluations. During these traverses, the observer is vigilant for: 1) areas of poor establishment/growth, 2) pervasively weak or stressed plants, 3) indicators of soil fertility problems (e.g., certain anthocyanine colorations), 4) noxious weeds or invasive plant infestation, 5) evidence of unintended livestock grazing, 6) excessive erosion, 7) pockets of the aforementioned, and 8) any other similar revegetation / reclamation related issues.

3.1 Sample Site Selection / Location

The primary field efforts call for sampling revegetation and corresponding reference area(s). The systematic procedure for the determination of sample locations occurs in the following stepwise manner. First, a fixed point of reference is selected for the entire area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions (i.e., 200 ft X 200 ft) is selected by Cedar Creek to provide a minimum number of coordinate intersections; reclaimed areas are conducted to a minimum of 20 (for areas greater than 1 acre) or 5 (for areas less than 1 acre) initial transects whereas reference area sampling is conducted to a minimum of 15 initial transects. Third, a scaled representation of the grid is overlain on field maps extending parallel to major compass points to facilitate field location. Fourth, unbiased placement of this grid is controlled by selection of two random numbers between 0 and

200 (used as coordinates). Fifth, utilizing a handheld GPS, all of the initial sample points are located in the field.

3.2 Determination of Ground Cover

Ground cover at each sampling site is determined utilizing the point-intercept method (Bonham 1989) as illustrated on Figure 1. This method has been utilized for range studies for over eighty years, however, Cedar Creek utilizes state-of-the-art instrumentation that it has pioneered to facilitate much more rapid and accurate collection of data. Implementation of the technique for the sampling effort occurs as follows: First, a transect of 10 meters length is extended from the starting point of each sample site toward the direction of the next site to be sampled. Then, at each one-meter interval along the transect, a laser point bar is situated vertically above the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species), litter, rock (greater than 2mm), or bare soil. Hits are determined at each meter interval by activating a battery of 10 specialized lasers situated along the bar at 10 centimeter intervals and recording the variable intercepted by each of the narrow (0.02 inch) focused beams (see Figure 1). In this manner, a total of 100 intercepts per transect are recorded resulting in 1 percent cover per intercept. The point-intercept procedure has been widely accepted in the scientific community as the protocol of choice for vegetation monitoring and is used extensively within the mining industry in connection with bond release determinations.

3.3 Determination of Woody Plant Density

At each sample site, a 2-meter wide by 50-meter long belt transect is established parallel to the ground cover transect and in the direction of the next sampling point (in a cardinal compass direction – Figure 1). Occasionally 4 x 25 meter transects are employed where distance between points necessitates shorter belts. Then within each belt, all woody plants (shrubs, trees, and succulents) are enumerated by species and age class. Determination of whether or not a plant could be counted depends on the location of its main stem or root collar where it exited the ground surface with regard to belt limits. Sample adequacy is determined for informational purposes only.

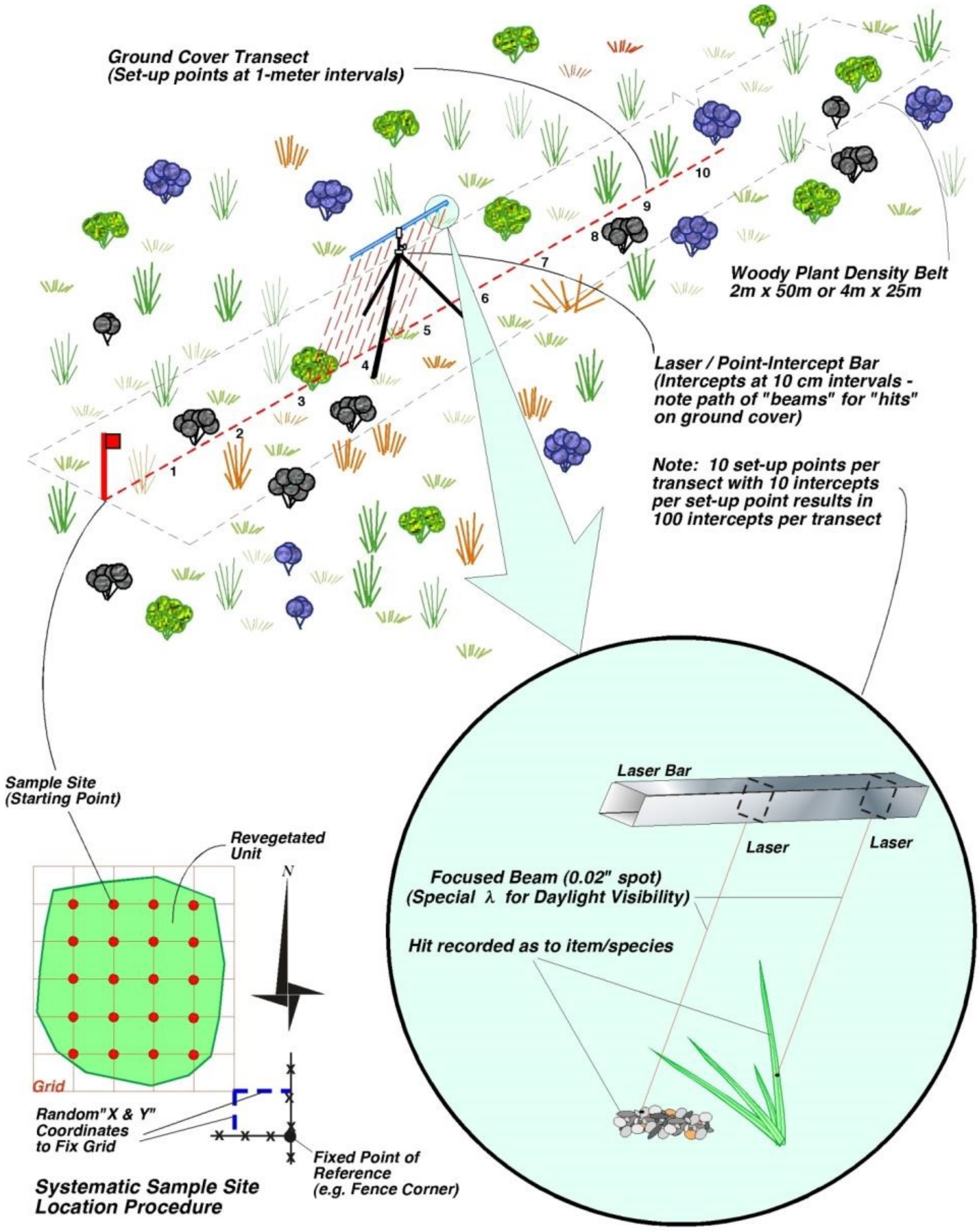


Figure 2: Systematic Sampling Procedure at Each Sampling Point

3.4 Photo Monitoring

Permanent photo-points (marked in the field with wood lathe and GPS coordinates) are established within revegetation areas to visually catalog vegetation progress. At each point, four photos are exposed, one each in a cardinal compass direction (N-E-S-W) using a photo board to indicate photo-point and direction visible in each frame. Photos are exposed in portrait orientation (as opposed to landscape) with the horizon at the very top of each photo. In this manner, all vegetation from very close to very far is observable. A map of the photo points will be provided in the revegetation monitoring reports.

3.5 Year 1 - Emergent Density Methodology

Following the first growing season after seeding, each reclaimed unit is subjected to a relatively brief one-time evaluation to document plant establishment as well as record other pertinent reclamation considerations. The purpose of this survey is to identify revegetation issues early on so that the appropriate adaptive management actions can be applied. This semi-subjective evaluation consists of a qualified observer traversing the reclamation areas and assessing vegetation establishment and related physical and biotic conditions. During these traverses, the observer is vigilant for: 1) areas of poor seedling emergence, 2) pervasively weak or stressed seedlings, 3) indicators of soil fertility problems (e.g. certain anthocyanine colorations), 4) noxious weeds or invasive plant infestation, 5) evidence of unintended livestock grazing, 6) excessive erosion (e.g. rills, large gullies, mass wasting), 7) pockets of the aforementioned, and 8) any other similar revegetation / reclamation related issues.

In addition to the physical and biotic attributes evaluation, the surveying observer collects semi-quantitative samples to document the emergent density of seeded species. In this regard, between 5-15 samples are collected from each of the reclaimed units. Each sample consists of a cluster of five 1.0 ft^2 quadrats distributed in an unbiased manner. Following a random toss of each quadrat, the number of emergent plants rooted within the frame's perimeter is recorded accordingly into one of five classes: perennial grass, perennial forb, shrub/tree (by species), annual grass, or annual forb. This procedure typically takes only 2-3 minutes per sample point (five quadrats) yet yields valuable information on the success of the seeding effort. Typically, efforts that result in an average of fewer than one perennial emergent per ft^2 should be considered to be poor and a possible candidate for remediation. Efforts with 1 – 2 perennial emergents per ft^2 are considered to be fair, 2 - 3 perennial emergents per ft^2 are considered moderately good, 3 – 4 perennial emergents per ft^2 are considered to be good and 4 – 5 perennial emergents per ft^2 are considered to be very good. Finally, greater than five perennial emergents per ft^2 are considered to be excellent. Barring overly adverse events (grazing, drought, etc.), the number of observed emergents following the first growing season provides both an indication of the quality of eventual revegetation as well as the expected time necessary for the new community to reach maturity.

4.0 REVEGETATION MONITORING SCHEDULE AND SUCCESS EVALUATIONS

The monitoring program and success criteria will follow the framework from the New Mexico Mining and Minerals Division (NMMMD). In this regard, a qualified revegetation specialist will review the revegetated areas on an annual basis (during the peak of the growing season in September or shortly thereafter) to capture developing problems early in the process.

4.1 Revegetation Monitoring Schedule - NMMMD Framework

The NMMMD framework differs from the revegetation success criteria that are currently employed at the Mine Site. Under this framework, the revegetation liability period (period of time that the owner is responsible for revegetation performance) is 12 years with monitoring every three years. The annual site visits for the revegetation will be as follows:

Year 1 – Emergent Density Evaluation
Year 3 – Qualitative and quantitative evaluations (managerial information only).
Year 6 – Qualitative and quantitative evaluations (managerial information only).
Year 9 – Qualitative and quantitative evaluations (managerial information only).

Year 11 – Qualitative and quantitative evaluations (final success evaluation).
Year 12 – Qualitative and quantitative evaluations (final success evaluation).

As indicated, the final efforts, during year 11 and 12, would be an evaluation for success determination. Years 11 and 12 information will be collected in such a manner as to provide defensible verification that success has been achieved. If it is determined that vegetation needs additional time to mature, monitoring will continue once every 3 years, thereafter, until success evaluations are positive. Other than first year efforts, annual monitoring would be a combination of both qualitative and quantitative efforts to facilitate tracking and progress toward revegetation success standards.

4.2 Revegetation Success Criteria

Success criteria will also differ depending on which framework is chosen. Regardless of the framework, a determination of revegetation success will take into account the following three factors:

- Comparison will be to an established reference area representative of the adjacent vegetation community and/or desirable ecological conditions (for the variables of ground cover and diversity);
- Plant species present in the approved (and planted) seed mixes; and
- For the mine and mill site (excluding the Repository), post-reclamation land use (e.g., livestock grazing with coincidental wildlife habitat) has been established and the vegetation is capable of being grazed at proper grazing intensity.

- Reference areas were selected during baseline evaluations, which quantify ecological resources. In 2009, the Pinon Juniper Reference Area was established during the baseline evaluation for the 2009 IRA. In 2012, the Grassland Reference Area was established during the baseline evaluation for the 2012 IRA. In 2016, the Bottomland Reference Area was established during the baseline evaluation for the final closure activities. In general, vegetation results for the areas to be disturbed must show comparability to the reference area for the reference area to be considered a suitable target for revegetation success.

When utilizing reference areas (that are late seral by definition) for determinations of revegetation success, certain allowances must be made when comparing them to early seral revegetated communities; otherwise comparisons would be scientifically invalid. Furthermore, precedent has been set in this regard in both the coal and hard-rock industry’s reclamation regulatory mandates. These allowances are a reduction in the amount of ground cover and diversity from late-seral values.

Revegetation success in revegetated units targeting livestock grazing land uses with coincidental wildlife habitats will concentrate on two performance standards (1) vegetative ground cover, and 2) woody plant density. Therefore, revegetation efforts will be considered successful when the following criteria have been met following at least 12 years of growth and development.

1. <u>Vegetative Ground Cover Criterion</u>

   The perennial vegetative ground cover (exclusive of listed noxious species) below breast height (1.25 meters) in the target revegetated unit equals or exceeds <u>70 percent</u> of the appropriate reference area's (Juniper, Grassland/Shrubland or Bottomland) perennial vegetative ground cover, with 90 percent statistical confidence.

   The success criterion was developed based on the New Mexico Mining and Minerals Division’s precedents. The NMMMD has accepted 70% ground cover comparison on legacy mine sites which existed prior to the establishment of the Mining Act Reclamation Program.

2. <u>Woody Plant Density Standard:</u>

   Woody Plant Density, as indicated by number of stems per acre in each revegetated unit equals or exceeds 60% of the stems per acre found in the appropriate reference area (Juniper, Grassland/Shrubland or Bottomland).

   <u>OR</u>

   The density of live shrubs, trees, and woody cacti rooted within the boundaries of the revegetated unit equals or exceeds a success criterion of <u>200 plants per acre</u>.

   The success criterion was developed based on the New Mexico Mining and Minerals Division’s precedents. The NMMMD has accepted 60% woody plant density comparison on legacy mine sites which existed prior to the establishment of the Mining Act Reclamation Program. Additional information used to develop this success criterion is data from Hoenes and Bender (2012) for measured native shrub density on grassland communities of New Mexico with results of approximately 200 shrubs per acre on average.

4.3 Sample Adequacy Determination

Ground cover sampling within reclaimed areas is conducted to a minimum of 20 initial transects whereas reference area sampling is conducted to a minimum of 15 initial transects. From these preliminary efforts, sample means and standard deviations for total non-overlapping vegetation ground cover are calculated. The procedure is such that sampling continues until an adequate sample, $\mathbf{n_{min}}$, has been collected in accordance with the Cochran formula (below) for determining sample adequacy, whereby the population is estimated to within 10% of the true mean (μ) with 90% confidence. These limits facilitate a very strong estimate of the target population.

When the inequality ($\mathbf{n_{min}} \leq \mathbf{n}$) is true, sampling is adequate and $\mathbf{n_{min}}$ is determined as follows:

$$\boxed{\mathbf{n_{min}} = (t^2 s^2) \;/\; (0.1\,\bar{x})^2}$$

where: n = the number of actual samples collected

t = the value from the one-tailed t distribution for 90% confidence with n-1 degrees of freedom

s^2 = the variance of the estimate as calculated from the initial samples

$\bar{x}$ = the mean of the estimate as calculated from the initial samples

If sampling is designed for a formal success evaluation and the initial samples do not provide a suitable estimate of the mean (i.e., had the inequality been false), additional samples will be collected until the inequality ($\mathbf{n_{min}} \leq \mathbf{n}$) became true or until a maximum of 40 samples are collected. If sample adequacy is not achieved after 40 samples are collected, a reverse null approach will be used to demonstrate success. The demonstration of success will utilize the central limit theorem which assumes approximate normality when a sufficiently large number of samples are collected (greater than 30). A one-sided, one-sample, reverse–null t-test is considered appropriate. Since sampling adequacy is not required (nor recommended) for woody plant density, one density belt will be co-located with each ground cover transect, but adequacy shall not be tested for this variable. Resulting data can then be considered reasonable for the evaluation purposes intended.

5.0 CORRECTIVE ACTIONS / CONTINGENCY

After the initial seeding occurs and monitoring has begun, circumstances may require additional management actions to facilitate revegetation parcels toward the desired outcomes. The management actions presented below are normal land management activities. However, prior to implementing any remedial action, a plan will be submitted to the oversight agencies for approval. This plan will outline the issue(s) needing corrective action, proposed remedial activities, and a timeline for implementation. The list of remedial actions presented below may not represent an exhaustive list of potential options, as additional management alternatives may be needed to address site specific issues that arise. Renegotiation of success criteria may be required if unforeseen circumstances occur.

5.1 Inter-seeding

If undesirable precipitation, wind events, or any other factors contribute to poor seed germination, additional seed can be broadcast or drilled (if topography allows) into the required parcels as required without restarting the liability period.

5.2 Weed Control

Weed management will be implemented if noxious weeds identified during annual vegetation surveys present an obstacle to achieving performance criteria. Noxious weed patches deemed detrimental to revegetation success will be identified by a trained ecologist and delineated with a GPS during the annual vegetation survey. Data regarding the species and density of the population will be recorded, and then an informal control plan will be formulated and implemented. The effectiveness of control methods will be documented during the following annual vegetation survey.

Vegetation surveys conducted in 2017 and 2018 indicate the presence of noxious weeds found on the New Mexico Noxious Weed List (September 2016) and the Integrated Weed Management Plan (January 2013). These observations include Russian thistle, burning bush, bull thistle, scotch thistle, musk thistle, field bindweed, and tamarisk in the project area (INTERA, 2017). These noxious weeds should be treated in the following manner:

- Thistles (Bull, Scotch, and Musk Thistle)
  - Biennial weeds complete their life cycle in two years.
  - These plants come up from seed, produce a rosette the first year, grow through the winter (overwinter) as a rosette. During the second growing season, the plant produces a stem, flowers, seed, and then dies.
  - The key to control: <u>Do not allow the plant to set seed</u>!

  - Thistle species should be chemically treated with the appropriate herbicide [Milestone / Transline / Banvel,Vanquish,Clarity], in fall (September through mid-October) or spring (late April through mid-June) when weeds are rosettes and actively growing.

- Field Bindweed
  - Perennial weeds come back year after year from the same vegetative reproductive root systems.
  - Application of appropriate herbicides, which reduce bindweed growth and kill germinating seedlings, should also be part of an integrated pest management program.
  - Treat the bindweed plants before they are drought stressed. Use a translocated herbicide, such as glyphosate, or a combination of glyphosate and dicamba, when the plant is actively growing. Re-treatments will be necessary to control both established plants and seedlings. Reseeding should occur to provide desirable species to compete with field bindweed.

- Weedy Annuals (Russian thistle and burning bush)
  - Annual weeds germinate from seed and flower in a single year.
  - Cultural approaches are the best control methods for Russian thistle and burning bush.
  - Cultural approaches include seeding desirable species to compete with existing annual weed patches and limiting land disturbances. Russian thistle and burning bush are commonly found in the arid west and decrease as perennial plant communities establish and disturbance diminishes.

- Tamarisk
  - Woody plants found along riparian corridors or around desert springs can seriously reduce underground water tables and surface water availability, drying up wetlands, and reducing flows.
  - Biological control [saltcedar leaf beetle] will not eradicate tamarisk but it has the potential to suppress tamarisk populations by 75 to 85%.
  - Due to the proximity to surface water, herbicide should only be applied by a qualified applicator.

Noxious weeds located on borrow sites should be treated with herbicide or controlled in a manner to limit risk of spreading these weeds to reclamation. Observations of tamarisk and bull thistle were recorded in the Jetty area during 2018 surveys. If chemical control is not feasible, stripping and disposing of the top 6 inches of surface material prior to borrow should be considered. This layer contains the seed source for the spread of noxious weeds.

In the event that a patch of a previously unidentified noxious weed species is found, an informal weed control plan will be developed at that time.

5.3 Range Fencing

Range fencing, cattle guards, and gates should be installed around areas deemed necessary to exclude grazing livestock from revegetated areas. Residents will be notified that grazing of the restored area will not be permitted until approved by a qualified revegetation specialist (biologist or ecologist).

5.4 Mulching

If revegetation parcels are eroding at an unforeseen rate while vegetation is still establishing, mulch can be used to provide rainsplash and wind protection, reduce evaporation, and stabilize the seedbed. Preferably, a wood fiber or wood shred mulch would be used, as it is more robust than hay or straw and more likely to provide wind protection.

If used, wood fiber mulch or wood shred mulch will consist of specially prepared wood fibers and will not be produced from recycled material such as sawdust, paper, cardboard, or residue from pulp and paper plants. If necessary, such as on a steep slope or an area deemed a high wind erosion risk area, a tackifier can be used with the wood-fiber mulch to improve adhesion. If erosion areas are localized, small, or well-sheltered, simple straw mulch should suffice in providing rainsplash protection. Interseeding will most likely be necessary if erosion is sufficient enough to require post-revegetation corrective mulching.

5.5 Supplemental Irrigation

Supplemental irrigation is not considered a suitable treatment mitigation alternative for the Mine and Mill Sites, even in instances of extreme drought. Underperforming areas will be remediated using common techniques, such as reseeding and applying mulch or other amendments to improve vegetative growing conditions. Previous revegetation efforts at the Mine Site demonstrate that successful revegetation can be established without supplemental irrigation.

6.0 STEP OUT AREA #1

Step Out Area #1 was disturbed during the 2009 Removal Action and has been revegetated. The Step Out Area #1 has met the final performance criteria for revegetation and gained acceptance from the EPA, with the exception of the tree agreement. Portions of Step Out Area #1 that will be disturbed during the upcoming Northeast Church Rock Mine Site Removal Action will require revegetation including tree replacement. Based on tree population surveys occurring before (2009) and after (2014) the removal action, 551 Juniper trees (*Juniperus monosperma*) and 315 Pinon pines (*Pinus edulis*) were removed during the excavations.

6.1 Tree Planting Recommendations

Only those areas that exhibited piñon-juniper woodland prior to reclamation activities are candidates for transplants. Areas exhibiting alluvial habitats are not conducive to a population of trees given the deeper soils that encourage grasses that compete heavily (and detrimentally) with young trees. Map 3 displays the tree planting area. A typical expected loss rate for transplanted stock is 50%; therefore, twice the target number of replacement trees should be initially planted into areas targeted for tree restoration.

Seedling stock should be obtained from a reputable nursery. Tree seedlings usually are described as a 1-0, 2-0 or 3-0 stock. The first number refers to the number of years grown in a nursery seedling bed or in a greenhouse (plug) and the second to the number of years in a transplant bed. It is best to use 2/0 stock because older plants have a better, more strongly developed root system with greater reserves and can therefore handle more of the stress of transplanting, however, older stock is more expensive to obtain. Overall cost-effectiveness can be obtained with 1/0 stock if appropriate care is taken during planting. Such care would include the following activities and recommendations (whether 1/0 or 2/0 stock is used). Transplanting should occur as follows:

- An auger should be used to excavate a hole somewhat larger in diameter than the stock pots and sufficiently deep so that when the plant is placed in the hole (after supplements are added), the top of the root collar is approximately one/half to one inch below ground surface.

- One or two controlled-release tree fertilizer tablets (depending upon manufacturer recommendations) should be dropped into the hole before the seedling is planted. The tablets should have an NPK of 20-10-5.

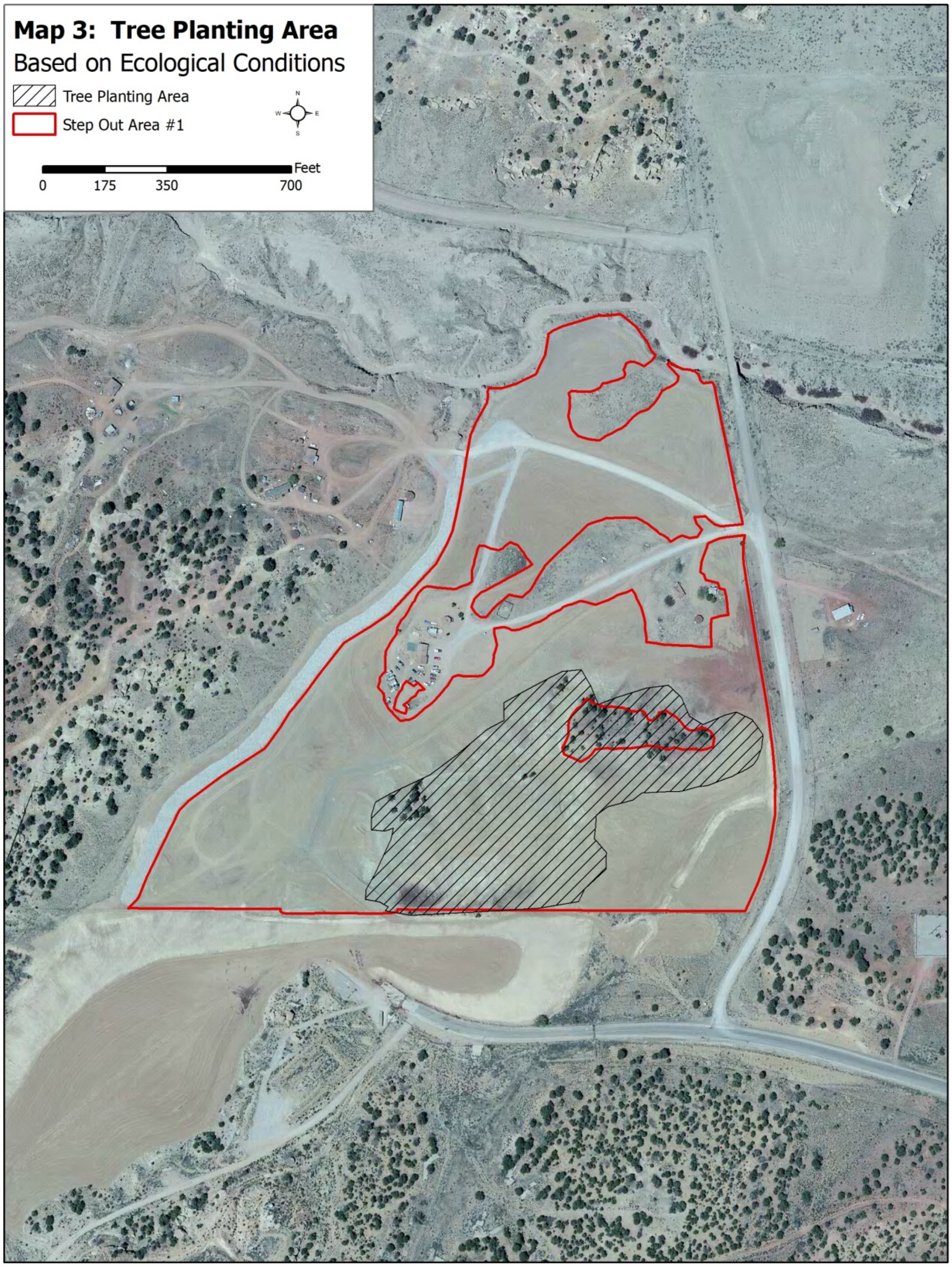
- Optionally, a cup (for 1/0 stock) or pint (for 2/0 stock) of DriWaterTM or DriWater PlusTM irrigation gel supplement should be placed along (or crushed into) the margins of the open hole, or within a separate but adjacent chamber. This gel should be flattened / crushed so that no air spaces remain once the root ball is seated. This material supplies supplemental water/nutrients for several days/weeks following planting which is then helpful for root damage repair. (www.driwater.com)

- The seedling container must be carefully removed so as not to overly disturb the root and soil ball. This is often best accomplished by placing the stem of the seedling between the middle and ring finger and inverting the tree while simultaneously working the pot loose and off the root ball. Loss of container soil due to rough handling destroys the established root hairs that will take a young plant several days/weeks to replace, over which time and depending on the level of damage, may cause the death of the plant.

- Following careful placement of the root ball into the receiving hole, approximately one quart of water should be poured over the root collar of the transplant and the edges of the hole stepped down and/or tamped with the heel to compact the surrounding soil and force out any remaining air pockets.

- Depending on topographic location a berm should be constructed with hand shovel (spade) and/or concrete rake that will collect rainwater and direct it to the new transplant. The wings of the berm should be about 3 feet on either side of the transplant and should form a shallow "V" pattern with the transplant just inside the point of the "V". The basin should be able to hold at least 2 gallons of water without down-gradient spillage. If the area is flat, a circular basin (donut) should be constructed with a radius of between 18 and 24 inches. Following completion of the berm, an additional gallon (for 1/0 stock) or two gallons (for 2/0 stock) of water should be carefully poured around the new transplant. This watering will moisten the surrounding soil and help the new transplant recover from the shock of transplanting.

- If the optional use of DriWater is not selected, then supplemental watering should be initiated. An ideal program of supplemental watering would involve about one gallon of water being provided to each transplant once per month for the first 4 months following transplanting, once every 2 months for the next 8 months, and then 3 times (on a random basis) over the following growing season. Scheduled watering can be skipped / delayed during the coldest part of the winter and if significant rain (e.g., ½ inch or more) occurred in the previous two weeks.



Map 3: Tree Planting Area
Based on Ecological Conditions
Tree Planting Area
Step Out Area #1
N
W
E
S
Feet
0
175
350
700

- Transplanting is best for plant health if it occurs early in the Spring just after the ground thaws but before the buds begin to swell. The second best time is in the Fall after leaf drop but well before the ground freezes. There must be sufficient time before the soil freezes for new root hair development (typically about 4-6 weeks). The worst time for transplanting is late Spring / early Summer when transplants are exhibiting maximum shoot growth.

- If livestock (especially goats) are expected in the area, the acreage receiving transplants should be fenced to preclude access. Certain individual animals can gain an affinity for young transplants and devastate the effort.

- The final recommendation would be the use of personnel well experienced with transplanting nursery stock. Proper adherence to the aforementioned recommendations by trained personnel will significantly improve the probability for survival of transplants.

6.2 Step Out #1 Tree Replacement Success Criteria

Based on tree population surveys occurring before (2009) and after (2014) the Removal Action, 551 Juniper trees and 315 Pinon pines were removed during the excavations. A typical expected loss rate for transplanted stock is 50%; therefore, twice the target number of replacement trees should be initially planted into areas targeted for tree restoration. In Year 6, a survey will be implemented to determine the number of surviving transplanted trees. If more than the target number of trees remain alive, no additional transplanting will be required. If less than the target number of trees remains, supplemental transplanting will occur to bring the number of live trees to the target. The effort will be deemed successful if 866 live transplanted trees are found in Step Out #1 during the Year 12 revegetation evaluation.

7.0 REFERENCES

Bonham, Charles D. *Measurements for Terrestrial Vegetation*. John Wiley & Sons. 338 pp. 1989.

Bureau of Indian Affairs. *Integrated Weed Management Plan for the Navajo Nation*. April 2013.

Cedar Creek Associates, Inc. *Northeast Church Rock Mine, Vegetation & Wildlife Evaluations / Revegetation Recommendations, 2009 Evaluations and Planning*. February, 2010.

Cedar Creek Associates, Inc. *Northeast Church Rock Mine, 2012 Eastern Drainage Baseline Vegetation Evaluation*. November, 2012a.

Cedar Creek Associates, Inc. *Northeast Church Rock Mine, 2012 Eastern Drainage Revegetation Plan*. November, 2012b.

Cedar Creek Associates, Inc. *Northeast Church Rock Mill Site, Baseline Vegetation and Wildlife Surveys.* July, 2014.

Hoenes, B. D. and L. C. Bender. *Factors influencing foraging habitats of mule deer (Odocoileus hemionus) in the San Andres Mountains, New Mexico*. The Southwestern Naturalist, Vol. 57, No. 4 pp. 370-379. 2012.

INTERA. *Environmental Data Report for the Northeast Church Rock Site Removal Action and the United Nuclear Corporation Site Remedial Action*. October 2, 2017.

New Mexico Department of Agriculture. *New Mexico Noxious Weed Update.* October 19, 2016.

New Mexico Mining and Minerals Division. *Closeout Plan Guidelines for Existing Mines*. April 30, 1996.

New Mexico Mining and Minerals Division. Rules and Regulations for Existing Mining Operations, Non-Coal Mining, Natural Resources and Wildlife. 19.10.5 NMAC. May 15, 2001.

U.S. Environmental Protection Agency (USEPA), Region 6 and Region 9. *Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery*. April 27, 2015.

ATTACHMENT U.2

Revegetation Plan for Repository on Church Rock Mill Site Tailings Disposal Area

Revegetation Plan

Repository on Church Rock Mill Site Tailings Disposal Area

UNITED NUCLEAR CORPORATION

JULY 2018

CEDAR CREEK ASSOCIATES, INC.

5586 Overhill Dr.
Fort Collins, Colorado 80526
(970) 223-0775
www.cedarcreekassociatesinc.com

Table of Contents

1.0 INTRODUCTION

Cedar Creek Associates, Inc. (Cedar Creek) was retained by Stantec to develop a revegetation plan for the repository to be located on the Church Rock Mill Site Tailings Disposal Area (Repository). This plan has been prepared to fulfill the requirement to provide a revegetation plan for the Repository as described in Paragraph 27 of the Statement of Work (SOW; Appendix D to USEPA, 2015) and is one of the many 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 (AOC; USEPA, 2015). The area addressed by this revegetation plan is presented on Map 1. In general, this plan applies to the Repository and the rest of the project area is addressed within the Mine and Mill Site Revegetation Plan.

This plan identifies and defines revegetation protocols (Section 2.0), vegetation sampling methods (Section 3.0), and the monitoring schedule and success criteria (Section 4.0) to be utilized for revegetation of the Repository. Section 5.0 provides a potential list of post revegetation management actions.

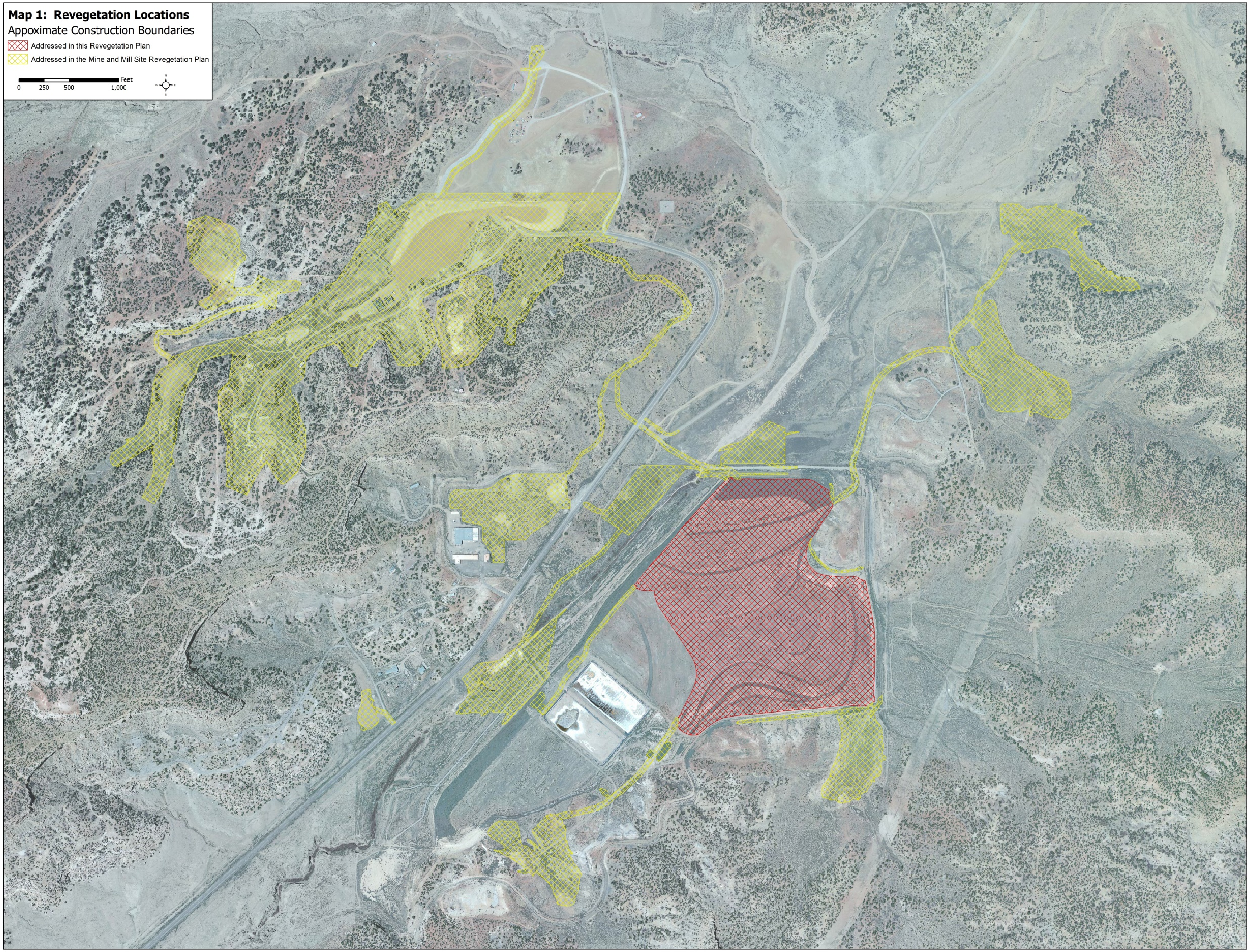
Revegetation planning of each distinct disturbance area will consider 1) baseline vegetation communities, 2) post-revegetation objectives (PMLU), 3) specific considerations pursuant to desired post-disturbance management, and 4) the most scientifically sound methods and state-of-the-art techniques related to revegetation, soil amendments, seedbed preparation, seeding, mulching, and general reclamation science. In addition, quality assurance and quality control procedures in the form of annual monitoring surveys will be undertaken to ensure that revegetation efforts meet predetermined performance expectations.

Four baseline evaluations of biological resources have been previously conducted at the Mine and Mill Sites. The evaluations were made in support of the 2009 Interim Removal Action (Cedar Creek, 2010), the 2012 Interim Removal Action (Cedar Creek, 2012), Repository design (Cedar Creek, 2014a), and the Environmental Data Report for the Northeast Church Rock Site Removal Action and the United Nuclear Corporation Site Remedial Action (INTERA, 2017). Annual revegetation monitoring reports have been generated since 2010, presenting performance results from the revegetation implemented on and around the mine site. The baseline evaluations provide information on the biological resources prior to construction activities. This information is useful when designing revegetation protocols and seed mixes. Annual monitoring results are used to ensure the revegetation is meeting performance expectations and allow for adaptive management of future revegetation efforts. The process in which previous revegetation plans have been developed (through community coordination), as well as previous baseline evaluations and revegetation monitoring results inform the development of this plan. This plan aims to build upon these previous efforts implemented on site.

In addition, vegetation data were collected on representative analog sites to provide necessary information for evapotranspiration (ET) cover modeling. The results of these surveys are presented in Cedar Creek's *Vegetation Characterization and Biointrusion Surveys* report from 2014 (Cedar Creek, 2014b).

The site is located approximately 16 miles Northeast of Gallup, New Mexico. This site is on private lands, although associated ancillary disturbances (addressed in the *NECR Mine Site and Church Rock Mill Site Revegetation Plan* in Appendix U) will affect land administered by the Bureau of Indian Affairs on behalf of the Navajo Nation. The geographic area is mainly rangeland and pinion juniper woodland within the Colorado Plateau physiographic province. It is characterized by rough, broken terrain, including steep mountainous areas, plateaus, cuestas, and mesas intermingled with steep canyon walls, escarpments, and valleys, with soils derived mainly from marine sandstones, mudstones, and shales.

The weather station at Gallup Municipal Airport, New Mexico is sufficiently near the site (approximately 19 miles southwest) to provide a good comparison of long-term trends in precipitation in the area. Annual precipitation in the region is approximately 11 inches/year, with a majority delivered as summer monsoonal, convective thunderstorms. This precipitation pattern favors the growth of warm season perennial grasses and shrubs in deep and moderately deep soils, respectively, and pinion juniper woodland on hillslopes and areas of shallow soils. The mean annual temperature is about 49 degrees F. The Repository exists within an arid mixed grass and shrubland community in deep alluvial soils at an elevation ranging between 7,000 and 7,200 feet above mean sea level. Previous reclamation efforts on the Mine Site have demonstrated that extremely successful revegetation can be achieved in the region with proper techniques and methods, and suitable growth media (see Cedar Creek's annual revegetation monitoring reports for the Mine Site).


Map 1: Revegetation Locations
Appoximate Construction Boundaries
Addressed in this Revegetation Plan
Addressed in the Mine and Mill Site Revegetation Plan
Feet
0 250 500 1,000

2.0 REVEGETATION PROTOCOLS

A basic framework for all reclamation including soil/growth media considerations, seeding considerations, and proposed amendments can be established for the project. Site specific considerations can be applied or adjusted in the future to meet field requirements. Revegetation protocols and performance criteria for the Repository are guided by the Uranium Mill Tailings Radiation Control Act guidance from the Department of Energy (DOE 2002, Waugh 2009, and Waugh 2004). This framework is used for the Repository because the DOE will eventually provide long-term surveillance under a general license from the NRC. The remaining portions of the project site, collectively called the Mine and Mill Sites, are subject to New Mexico Mining and Minerals Division rules, regulations, and guidelines.

The material properties of the borrow materials are provided in Appendix H and borrow materials placement is discussed in Appendix G.

2.1 Soil/Growth Media Physical Considerations

Handling of growth media should be done prudently as to avoid excessive disruption to soil structure. Desirable textures of proposed growth media should be a blend of sand, silt, and clay, while textures of pure sand, pure silt, or pure clay (indicated in red on Figure 1) are considered unsuitable growth media and should not be used as surficial growth media. . Handling of materials immediately following precipitation events should be avoided, when possible, to limit issues associated with compaction. Localized or unforeseen matters relating to soil physical attributes would be identified through a site visit by a soil scientist and laboratory analysis of texture by hydrometer.

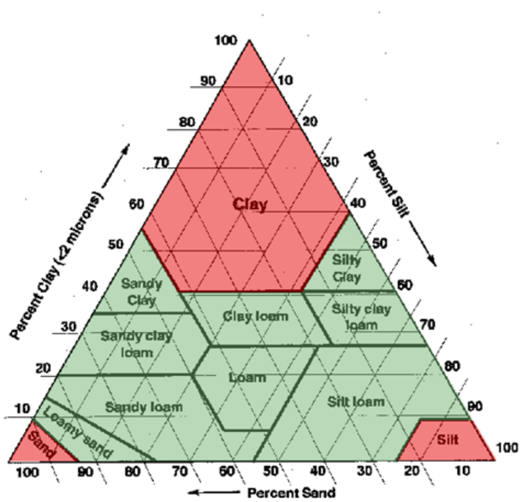


Figure 1: Suitable Growth Media Textures

2.2 Soil/Growth Media Chemical Considerations

Growth media used to reclaim the surface of the Repository will be primarily sourced from identified borrows and the Jetty excavation. Table 1 presents acceptable average values for relevant soil parameters to be considered a suitable growth media. Average soils results from the agronomic assessment of the borrows exhibited slightly elevated salts (EC) and slightly diminished organic matter (%), when compared with typical A horizon soils in the area. However, reported results were still within acceptable ranges to be considered suitable growth media (INTERA, 2017).

Table 1 Suitable Growth Media Results

Paramater	Acceptable Average Values	Units
pH (paste)	6 - 8.3	N/A
Electrical Conductivity	< 6	mmhos/cm
Organic Matter	< 10	% of Total Soil
NO_3-N	> 0.1+	ppm
Phosphorus (P)	> 1+	ppm
Potassium (K)	> 20+	ppm
Zinc (Zn)	> 0.25+	ppm
Iron (Fe)	> 1.0+	ppm
Manganese (Mn)	> 0.1+	ppm
Copper (Cu)	> 0.1+	ppm
Calcium (Ca)	Addressed as SAR	ppm
Magnesium (Mg)	Addressed as SAR	ppm
Sodium (Na)	Addressed as SAR	ppm
Calcium Carbonate Equivalent	< 10	% by Weight
Texture by hydrometer	No Textural Extremes	% Size Fraction
Sodium Adsorption Ratio	< 15	N/A
Cation Exchange Capacity	For Information Purposes+	meq/100g

+ Values Can Be Increased Through OM Additions

Table 2 presents the results of the agronomic assessment of the Jetty excavation soils. Laboratory analyses were implemented by Colorado State University Soil, Water, and Plant Testing Lab in accordance with the testing procedures presented in the Environmental Data Report (INTERA, 2017).

Table 2 Jetty Excavation Soil Agronomic Laboratory Results													
Laboratory Sample ID	Client Sample ID	Paste pH	Paste EC mmhos/cm	% CaCO3 equiv	% Organic Matter	ppm NO_3-N	ppm P	ppm K	ppm Zn	ppm Fe	ppm Mn	ppm Cu
R316	CRDB sand	7.5	2.7	3.11	1.1	16.20	2.50	35.8	0.45	4.70	0.47	1.40
R317	CRDB clay	7.7	3.2	3.21	1.5	103.40	2.80	85.5	0.34	7.30	0.48	1.80
R318	CRNN clay	7.6	3.6	4.00	1.5	96.70	1.50	54.4	0.17	3.80	0.19	1.00
R319	CRNN Sand 1	7.7	2.3	3.91	1.0	10.60	1.40	24.3	0.11	1.70	0.23	0.55
R320	CRNN Sand 2	7.6	1.3	3.56	0.8	16.00	1.90	28.6	0.14	2.70	0.37	0.69
R321	CRNN Sand 3	7.1	2.6	2.44	1.7	5.20	2.20	25.8	0.22	7.20	0.45	0.73
Average		**7.5**	**2.6**	**3.37**	**1.3**	**41.35**	**2.05**	**42.4**	**0.24**	**4.57**	**0.37**	**1.03**

Laboratory Sample ID	Client Sample ID	% Sand	% Silt	% Clay	Texture
R316	CRDB sand	61	21	18	Sandy Loam
R317	CRDB clay	52	18	30	Sandy Clay Loam
R318	CRNN clay	55	17	28	Sandy Clay Loam
R319	CRNN Sand 1	60	19	21	Sandy Clay Loam
R320	CRNN Sand 2	63	21	16	Sandy Loam
R321	CRNN Sand 3	41	24	35	Clay Loam
Average		55	20	25	Sandy Clay Loam

Six samples were analyzed for carbonate concentration, texture, and agronomic properties. Carbonate concentration, electrical conductivity, texture, organic matter, and most of the micronutrients fell within acceptable average values presented on Table 1. Zinc is slightly below the threshold with 0.24 ppm versus the threshold of 0.25 ppm. This is a marginal deficiency that is unlikely to impact revegetation and may be a result of averaging composite soil samples without accounting for volumes. In any case, the zinc deficiency will be rectified through the addition of the proposed organic amendment described in Section 2.3. Based on this laboratory testing of carbonates and agronomic properties, the Jetty excavation soils are suitable for use as reclamation growth media, for both surface and subsurface applications. No special handling of soils is warranted.

2.3 Soil/Growth Media Amendments and Fertility

With the reported soils testing results from previous sampling efforts within suitable ranges, no amendments are required. However, it was decided to incorporated compost to improve germination conditions, which appears to have been effective to establishing revegetation in Step Out #1. Native arid vegetation is ecologically adapted to low fertility systems, and using standard agronomic fertility ranges designed for intensively managed, often heavily irrigated, and annually harvested agricultural systems is misrepresentative of the requirements for arid grassland and shrub systems in New Mexico.

When materials are disturbed (plowed, harvested, tilled), organic matter and associated fertility can be released (volatilized) by a subsequent increase in microbial activity. A general application rate of 2 tons/acre (dry weight) incorporated to 3 inches depth of composted cow or green manure, or composted biosolids, should be sufficient for reclamation on the Repository. Composted cow manure has been used to effect successful in reclamation within the Mine Site in the past. Moisture content, salinity, and organic matter, of organic amendments need to be tested by a certified laboratory. The testing of organic matter and moisture content is to ensure the application rate (which is based on dry weight) is met. The moisture content and degree of composting significantly affect the weight of the product and adjustments in the tonnage applied per acre must be made to adjust for moisture content. Salinity results for the organic amendments should be below 5mmhos/cm on average. All testing should be conducted on representative samples from the same batch intended to be purchased. Moisture and organic matter are used to accurately calculate target application rates. Given the potential for elevated salts in the soils, only low salt amendments should be used. Composted biosolids will be tested to ensure sufficiently low radium activity concentrations prior to use. In specific instances, such as harvesting growth media from very deep in the soil profile or using material stockpiled for more than a year, increased quantities of manure may be beneficial, and will be addressed on an "as needed" basis.

Composted manures and composted biosolids are more desirable than inorganic fertilizers and industrial byproducts such as Biosol, because they are significantly lower in inorganic and total nitrogen. Nitrogen preferentially stimulates the growth of undesirable weedy annual species, which reduces available water and nutrients for desirable perennial vegetation. In addition to the low nitrogen levels, the physical structure of the compost increases localized water holding capacity, and creates "islands" of fertility to aid germination. Plant germination and establishment in the first few years is critical, as native seed sources then begin to supplement the initial seeding, and stabilize the soil medium. Organic amendment application should occur immediately prior to seeding, and be incorporated as soon as possible, preferably by disk harrow. Composted manure and/or biosolids left on the soil surface, exposed to warm temperatures and potential precipitation, will readily decompose, thus making it less beneficial.

2.4 Erosion Control and Seedbed Preparation

The principal means to obtain erosional stability is use of stability enhancing metrics and the construction of a stable physical landscape that can then support the establishment and persistence of a reasonable herbaceous ground cover (that also provides enhanced protection against erosion). Once such a stable condition is achieved, natural successional processes are enabled leading to advancement along the successional continuum and eventually to a condition that fully supports the interim revegetation effort. Such progression should occur in a relatively short period of time, perhaps as few as 3 to 5 years.

Mulch is not required for erosion protection on the Repository cover. The rock mixture will provide the erosion protection (see Appendix G.7).

2.5 Seeding Considerations

Seeding can be accomplished using both broadcasting and drilling techniques (as recommended on the seed mix), following final contouring and compost application/incorporation. Effort will be made to implement seeding at optimal times for site conditions (October or November / March). However, if a unit must be seeded during inopportune months, a field level risk assessment will determine whether temporary erosion control measures (such as crimped hay, wood shreds, wattles, etc.) are needed to stabilize the surface prior to anticipated vegetation establishment. Drill seeding techniques cannot be used on extremely rough surfaces (such as areas that have been contour furrowed with deep ripping equipment, or in rocky areas). If seed is broadcast, a light disc harrowing perpendicular to the flow of energy (wind and/or water) should immediately follow seeding to increase seed to soil contact and provide some protection from wind or water erosion and granivory. Certain field conditions (such as broad, steep slopes) sometimes preclude the use of broadcast and drilling methods, and in these situations hydroseeding may be considered as an alternative. If hydroseeding is selected, a tackifier should be combined with the mulch slurry to improve adhesion.

The proposed seed mix is comprised of all native species and application rates are presented in Table 3 below. This seed mix was developed with community input during the 2009 and 2012 Interim Removal Actions. Species proposed in this mix are suitable for use, as demonstrated by their establishment on nearby revegetation at the Mine Site. Volunteer vegetation (non-seeded species) are encouraged to establish on the revegetation parcel as long as species are not noxious weeds and do not impact the ability to achieve a sustainable perennial vegetative community.

2.6 Fencing

Fencing will be employed to exclude grazing livestock and wildlife from revegetated areas.

2.7 Climate Change Considerations

Climate change modeling results provide general indications of how the climate may shift in New Mexico over the next several decades and into the next century, albeit with a significant degree of uncertainty, spatially, temporally, and degree of magnitude. In general, modeling results from the Nature Conservancy and the Southwest Climate Change Network indicate a general warming and drying trend (with localized instances of cooling and increases in precipitation), with increased variation in timing, intensity, and form of precipitation from typical averages. The species selected for revegetation are well suited to the current arid climate of this region, yet have a relatively wide tolerance to climatic conditions, particularly regarding the predicted result of climate change (warmer and drier). In other words, if precipitation decreases, drought increases, or temperatures and subsequent evaporation rates rise, these species will still be suitable for and tolerant of future climates projected in the region. The anticipated circumstances of climate change may actually select for more efficient, later seral species (as is a desired outcome for the project), over short-lived annuals and less efficient cool season grasses.

Table 3 Seed Mix for the Tailings Disposal Area

No.	Obs. On Site	Common Name	Scientific Nomenclature	PLS / lb.*	Recommd. PLS lbs/ac	PLS / ft^2	% of Seeds in Mix	Preferred Method of Seeding **	Comment (Based on Site-specific Findings or Professional Judgment)
				Recommendations					This entire mix can be drill seeded very shallow
1	XX	Western wheatgrass	*Agropyron smithii*	110,000	1.50	3.8	3.6%	Drill	NRCS indicated climax species
2	XX	Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.75	30.3	29.1%	Drill	NRCS indicated climax species
3	XX	Blue Grama	*Bouteloua gracilis*	825,000	0.50	9.5	9.1%	Drill	Stong component of native community
4	XX	Galleta	*Hiliaria jamesii*	159,000	0.50	1.8	1.8%	Drill	Stong component of native community
5		Thickspike Wheatgrass	*Agropyron dasystachyum*	154,000	0.75	2.7	2.5%	Drill	Fair performer - Offers diversity
6	XX	Indian Ricegrass	*Oryzopsis hymenoides*	141,000	1.00	3.2	3.1%	Drill	Should do well in areas of sandy texture
7	XX	Sideoats Grama	*Bouteloua curtipendula*	191,000	1.00	4.4	4.2%	Drill	Good performer - Offers diversity
8	XX	Bottlebrush Squirreltail	*Sitanion hystrix*	192,000	0.25	1.1	1.1%	Drill	Fair performer - Offers diversity
			Subtotal		**6.25**	**56.7**	**54.5%**		
9	XX	Desert Globemallow	*Sphaeralcea ambigua*	500,000	0.75	8.6	8.3%	B-cast/Harrow	Sufficient performer for diversity
10		Firecracker Penstemon	*Penstemon eatonii*	900,000	0.50	10.3	9.9%	B-cast/Harrow	Good performer - Offers diversity
11	XX	Rocky Mountain Penstemoı	*Penstemon strictus*	592,000	0.25	3.4	3.3%	B-cast/Harrow	Fair performer - Offers diversity
12		Lewis Flax	*Linum lewisii*	293,000	1.00	6.7	6.5%	B-cast/Harrow	Good performer - Offers diversity
			Subtotal		**2.50**	**29.1**	**27.9%**		
13	XX	Fourwing Saltbush	*Atriplex canescens*	52,000	1.00	1.2	1.1%	Drill	NRCS indicated climax species - good forage value
14	XX	Wyoming Big Sagebrush	*Artemisia tridentata wyo.*	2,500,000	0.25	14.3	13.8%	B-cast/Harrow	Occasional performer - Offers diversity
15	XX	Cliffrose	*Purshia mexicana*	64,600	1.00	1.5	1.4%	B-cast/Harrow	Fair performer - Offers diversity
16		Winterfat	*Ceratoides lanata*	56,700	1.00	1.3	1.3%	Drill	Good performer - good forage value
			Subtotal		**3.25**	**18.3**	**17.6%**		
			Total		**12.00**	**104.1**			

* PLS = Pure Live Seed. Note: This entire mix may be drill seeded, but depth bands must be set to very shallow seed placement (e.g. 1/8 inch). If hydroseeding occurs, seed must not be mixed with a mulch for application. They must be applied in two passes: first pass seed, second pass mulch.
** The 12 lb/ac mix is designed for drill seeding of grasses and certain shrubs. If broadcast and harrow methods are used for grass seed distribution, the rate should be increased 1.5 times. When hydroseeding methods are to be used, the rate should be raised to 1.5 times when using two passes.

3.0 VEGETATION SAMPLING METHODS

Cedar Creek's vegetation sampling protocols involve an emphasis on ground cover to facilitate repeatable statistical comparisons among treatment areas (or unique revegetation units). In brief, concentration on a single variable of plant ecology facilitates improved comprehension and comparability over time and among treatment scenarios. Ground cover data, especially when determined using a very precise method such as the point-intercept procedure, provides some of the most important information regarding community variability that ecologists can evaluate. Such data facilitate the determination of true species composition, relative health (condition), and successional status of the sampled area. Furthermore, the same data can be utilized to develop the "sister" variables of frequency and species composition if desired. In addition, strong inferences can be developed with other reasonably correlated variables such as production when species composition is factored into the analysis. Also, ground cover is a preferred variable for revegetation monitoring because cover data can be readily obtained in a statistically adequate and cost-effective manner (using the proper procedures), has broad application for evaluation (including erosion control modeling), precisely reflects species' dominance of a given area, and when collected using bias-free techniques such as the point-intercept procedure, is one of the most repeatable variables among independent observers.

Any deficiencies in vegetation, both general and localized, and any other pertinent information relative to the reclamation is also recorded while traversing monitoring units during vegetation evaluations. During these traverses, the observer is vigilant for: 1) areas of poor establishment/growth, 2) pervasively weak or stressed plants, 3) indicators of soil fertility problems (e.g., certain anthocyanine colorations), 4) noxious weeds or invasive plant infestation, 5) evidence of unintended livestock grazing, 6) excessive erosion, 7) "pockets" of the aforementioned, and 8) any other similar revegetation / reclamation related issues.

3.1 Sample Site Selection / Location

The primary field efforts call for sampling revegetation and corresponding reference area(s). Analog sites were selected to represent the vegetative conditions of communities expected to inhabit the Repository (Cedar Creek, 2014b). The analog areas can serve as a reference area to assess revegetation performance. The systematic procedure for the determination of sample locations occurs in the following stepwise manner. First, a fixed point of reference is selected for the entire area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions (i.e., 200 ft X 200 ft) is selected by Cedar Creek to provide a minimum number of coordinate intersections; reclaimed areas are conducted to a minimum of 20 transects whereas reference area sampling is conducted to a minimum of 15 initial transects. Third, a scaled representation of the grid is overlain on field maps extending parallel to major compass points to facilitate field location. Fourth, unbiased placement of this grid is controlled by selection of two random numbers between 0 and 200 (used as coordinates). Fifth, utilizing a GPS, all of the initial sample points are located in the field.

3.2 Determination of Ground Cover

Ground cover at each sampling site is determined utilizing the point-intercept method (Bonham 1989) as illustrated on Figure 1. This method has been utilized for range studies for over eighty years, however, Cedar Creek utilizes state-of-the-art instrumentation that it has pioneered to facilitate much more rapid and accurate collection of data. Implementation of the technique for the sampling effort occurs as follows: First, a transect of 10 meters length is extended from the starting point of each sample site toward the direction of the next site to be sampled. Then, at each one-meter interval along the transect, a “laser point bar” is situated vertically above the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species), litter, rock (>2mm), or bare soil. Hits are determined at each meter interval by activating a battery of 10 specialized lasers situated along the bar at 10 centimeter intervals and recording the variable intercepted by each of the narrow (0.02 inch) focused beams (see Figure 1). In this manner, a total of 100 intercepts per transect are recorded resulting in 1 percent cover per intercept. The point-intercept procedure has been widely accepted in the scientific community as the protocol of choice for vegetation monitoring and is used extensively within the mining industry in connection with bond release determinations.

3.3 Determination of Woody Plant Density

At each sample site, a 2-meter wide by 50-meter long belt transect is established parallel to the ground cover transect and in the direction of the next sampling point (in a cardinal compass direction – Figure 1). Occasionally 4 x 25 meter transects are employed where distance between points necessitates shorter belts. Then within each belt, all woody plants (shrubs, trees, and succulents) are enumerated by species and age class. Determination of whether or not a plant could be counted depends on the location of its main stem or root collar where it exited the ground surface with regard to belt limits. Sample adequacy is determined for informational purposes only.

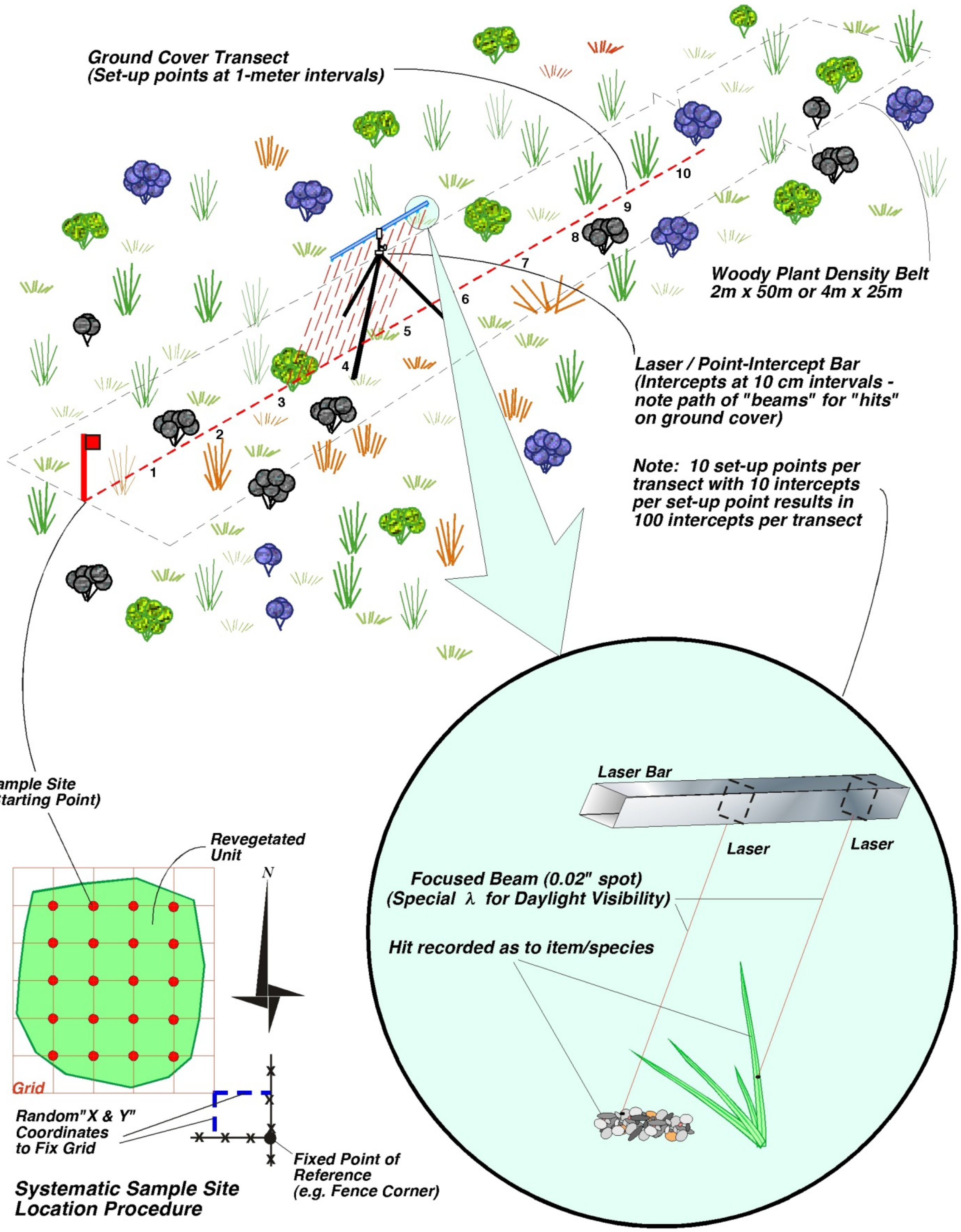


Figure 2: Systematic Sampling Procedure at Each Sampling Point

3.4 Photo Monitoring

Permanent photo-points (marked in the field with wood lathe and GPS coordinates) are established within revegetation areas to visually catalog vegetation progress. At each point, four photos are exposed, one each in a cardinal compass direction (N-E-S-W) using a photo board to indicate photo-point and direction visible in each frame. Photos were exposed in “portrait” orientation (as opposed to landscape) with the horizon at the very top of each photo. In this manner, all vegetation from very close to very far was observable.

3.5 Year 1 - Emergent Density

Following the first growing season after seeding, each reclaimed unit is subjected to a relatively brief one-time evaluation to document plant establishment as well as record other pertinent reclamation considerations. The purpose of this survey is to identify revegetation issues early on so that the appropriate adaptive management actions can be applied. This semi-subjective evaluation consists of a qualified observer traversing the reclamation areas and evaluating vegetation establishment and related physical and biotic conditions. During these traverses, the observer is vigilant for: 1) areas of poor seedling emergence, 2) pervasively weak or stressed seedlings, 3) indicators of soil fertility problems (e.g., certain anthocyanine colorations), 4) noxious weeds or invasive plant infestation, 5) evidence of unintended livestock grazing, 6) excessive erosion (e.g. rills, large gullies, mass wasting), 7) “pockets” of the aforementioned, and 8) any other similar revegetation / reclamation related issues.

In addition to the physical and biotic attributes evaluation, the surveying observer collects semi-quantitative samples to document the emergent density of seeded species. In this regard, between 5-15 samples are collected from the repository cover. Each sample consists of a cluster of five 1.0 ft^2 quadrats distributed in an unbiased manner. Following a “blind” toss of each quadrat, the number of emergent plants rooted within the frame’s perimeter is recorded accordingly into one of five classes: perennial grass, perennial forb, shrub/tree (by species), annual grass, or annual forb. This procedure typically takes only 2-3 minutes per sample point (5 quadrats) yet yields valuable information on the success of the seeding effort. Typically, efforts that result in an average of fewer than one perennial emergent per ft^2 should be considered to be poor and a possible candidate for remediation. Efforts with 1 – 2 perennial emergents per ft^2 are considered to be fair, 2 - 3 perennial emergents per ft^2 are considered moderately good, 3 – 4 perennial emergents per ft^2 are considered to be good and 4 – 5 perennial emergents per ft^2 are considered to be very good. Finally, greater than 5 perennial emergents per ft^2 are considered to be excellent. Barring overly adverse events (grazing, drought, etc.), the number of observed emergents following the first growing season provides both an indication of the quality of eventual revegetation as well as the expected time necessary for the new community to reach maturity.

4.0 REVEGETATION MONITORING SCHEDULE AND SUCCESS EVALUATIONS

The monitoring program and success criteria will follow the framework used on the Monticello Mill closure project (DOE, 2002). This framework is used for the Repository because the DOE will eventually provide long-term surveillance under a general license from the NRC. The remaining portions of the project site, collectively called the Mine and Mill Sites, are subject to New Mexico Mining and Minerals Division rules, regulations, and guidelines. A qualified revegetation specialist will review the revegetated areas on an annual basis (during the peak of the growing season in September or shortly thereafter) to capture developing problems early in the process.

4.1 Repository Monitoring Schedule

The vegetation monitoring liability period for the Repository will be defined in coordination with the NRC and as part of the NRC License Amendment Request. It is expected that annual site visits would be conducted that include qualitative and quantitative evaluations to facilitate tracking and progress toward revegetation success standards, and the final effort during the last inspection year would be an evaluation for success determination. Final year information would be collected in such a manner as to provide defensible verification that success has been achieved.

4.2 Repository Success Criteria

Due to the specific objectives and requirements of the Repository, traditional revegetation success criteria and PMLU's do not readily apply. The primary function of the Repository is to isolate contaminated materials from meteoric precipitation and aqueous transport via an ET cover. The vegetation community and supporting soil system simply needs to store and release meteoric precipitation, while remaining erosionally stable. Therefore, the vegetation and soil system objectives can be attained using the approach presented below. The revegetation process will establish a grass-forb community with a shrub component consisting primarily of native, long-lived perennial grasses, forbs, and shrubs that are highly adapted to the climatic and edaphic conditions of the site.

Revegetation success in revegetated units planted primarily as grassland or shrub steppe will concentrate on three performance standards (1) vegetative ground cover, and 2) diversity, and 3) woody plant density. Therefore, revegetation efforts will be considered successful when the following criteria have been met following at least ten years of growth and development. The primary basis for these success criteria are the reclaimed, grassland, and shrubland analog sites. The analog sites are suitable to base success criteria on because these sites were evaluated to provide vegetation parameters (leaf area index and root density) for the Repository evapotranspiration cover design (Cedar Creek, 2014b). Success criteria were developed to represent average conditions of the three vegetation communities projected to inhabit the Repository, and represent average vegetation conditions used in the evaporation cover design.

1. Vegetative Ground Cover Standard

   The target revegetated unit equals or exceeds 25% absolute perennial vegetative ground cover (exclusive of listed noxious species), with 90 percent statistical confidence.

   This success criterion was established by averaging perennial ground cover from the 2013 evaluation of the three analog sites (Cedar Creek, 2014b). The precipitation in 2013 was near average with 9.74 inches versus the 15 year average of 10.70 inches from the Gallup Airport station. The analog sites exhibited 36.6%, 31.7%, 23.0% perennial ground cover on the reclaimed, grassland, and shrubland analog sites, respectively, corresponding to an average for the three sites of 30.4%. As typical in revegetation success testing, to the measured perennial ground cover was adjusted to account for success testing in drought years. An adjustment of 80% of the average perennial ground cover was selected for this site, which is slightly higher than the typical value of 75%. The adjusted average perennial ground cover is 24.4%. This value was conservatively rounded to 25%.

   To evaluate the validity of the analog data, Grassland Reference Area data from the Mine Site was reviewed and compared to the analog sites. The Grassland Reference Area exhibited 22.3% perennial cover in a very dry year with 4.62 inches of precipitation (Cedar Creek, 2012) and 43.5% perennial cover in a very wet year with 13.75 inches of precipitation (Cedar Creek, To Be Published). The results from the Grassland Analog site indicate an average of 31.7% perennial cover for a normal average precipitation year.

2. Species Diversity Standard:

   Ground cover shall be comprised of a minimum of three perennial grass species, one perennial forb species, and one shrub species to address species diversity.

   The species diversity success criterion was developed to incorporate lifeform and species diversity. Prescriptive species diversity tests, such as this one, are used on many revegetation sites, including the Monticello repository (DOE 2002).

3. Woody Plant Density Standard:

   Woody Plant Density, as indicated by number of stems per acre in the revegetated unit equals or exceeds 200 stems per acre.

This success criteria is based on native grassland ecosystems in the vicinity of the Mine Site which have exhibited 175.4 and 165.9 shrubs per acre (Cedar Creek, 2012). Additional information used to develop this success criterion is data from Hoenes and Bender (2012) for measured native shrub density on grassland communities of New Mexico with results of approximately 200 shrubs per acre on average.

4.3 Sample Adequacy Determination

Ground cover sampling within reclaimed areas is conducted to a minimum of 20 initial transects whereas reference area sampling is conducted to a minimum of 15 initial transects. From these preliminary efforts, sample means and standard deviations for total non-overlapping vegetation ground cover are calculated. The procedure is such that sampling continues until an adequate sample, $\mathbf{n_{min}}$, has been collected in accordance with the Cochran formula (below) for determining sample adequacy, whereby the population is estimated to within 10% of the true mean (μ) with 90% confidence. These limits facilitate a very strong estimate of the target population.

When the inequality ($\mathbf{n_{min} \leq n}$) is true, sampling is adequate and $\mathbf{n_{min}}$ is determined as follows:

$$\boxed{\mathbf{n_{min} = (\mathit{t}^2 \mathit{s}^2) \; / \; (0.1 \, \bar{x})^2}}$$

where: n = the number of actual samples collected

t = the value from the one-tailed t distribution for 90% confidence with n-1 degrees of freedom

s^2 = the variance of the estimate as calculated from the initial samples

$\bar{x}$ = the mean of the estimate as calculated from the initial samples

If sampling is designed for a formal success evaluation and the initial samples do not provide a suitable estimate of the mean (i.e., had the inequality been false), additional samples will be collected until the inequality ($\mathbf{n_{min} \leq n}$) became true or until a maximum of 40 samples are collected. If sample adequacy is not achieved after 40 samples are collected, a reverse null approach will be used to demonstrate success. The demonstration of success will utilize the central limit theorem which assumes approximate normality when a sufficiently large number of samples are collected (greater than 30). A

one-sided, one-sample, reverse–null t-test is considered appropriate. Since sampling adequacy is not required (nor recommended) for woody plant density, one density belt will be co-located with each ground cover transect, but adequacy shall not be tested for this variable. Resulting data can then be considered reasonable for the evaluation purposes intended.

5.0 MANAGEMENT ACTIONS / CONTINGENCY

After the initial seeding occurs and monitoring has begun, circumstances may require additional management actions to facilitate revegetation parcels toward the desired outcomes. The management actions presented below may not represent an exhaustive list of potential options, as additional management alternatives may be needed to address site specific issues that arise.

5.1 Inter-seeding

If undesirable precipitation, wind events, or any other factors contribute to poor seed germination, additional seed may be broadcast or drilled (if topography allows) to increase vegetative cover or diversity, as required.

5.2 Weed Control

Weed management will be implemented if noxious weeds identified during annual vegetation surveys present an obstacle to achieving performance criteria for the Repository. Noxious weed patches deemed detrimental to revegetation success will be identified by a trained ecologist and delineated with a GPS during the annual vegetation survey. Data regarding the species and density of the population will be recorded, and then an informal control plan will be formulated and implemented. The effectiveness of control methods will be documented during the following annual vegetation survey.

Prevention is the highest priority weed management practice on non-infested lands; therefore, protecting weed-free plant communities is the most economical and efficient land management practice. Prevention is best accomplished by ensuring that new weed species seed or vegetative reproductive plant parts of weeds are not introduced into new areas and early detection of any new weed species before they begin to spread. Control methods may include chemical or mechanical approaches. The optimum method or methods for weed management vary depending on a number of site-specific variables such as associated vegetation, weed type, stage of growth, and severity of the weed infestation.

Vegetation surveys conducted in 2017 and 2018 indicate the presence of noxious weeds found on the New Mexico Noxious Weed List (September 2016) and the Integrated Weed Management Plan (January 2013). These observations include Russian thistle, burning bush, bull thistle, scotch thistle, musk thistle, field bindweed, and tamarisk in the project area (INTERA, 2017). These noxious weeds should be treated in the following manner:

- Thistles (Bull, Scotch, and Musk Thistle)
    - Biennial weeds complete their life cycle in two years.

- These plants come up from seed, produce a rosette the first year, grow through the winter (overwinter) as a rosette. During the second growing season, the plant produces a stem, flowers, seed, and then dies.
- The key to control: Do not allow the plant to set seed!
- Thistle species should be chemically treated with the appropriate herbicide [Milestone / Transline / Banvel,Vanquish,Clarity], in fall (September through mid-October) or spring (late April through mid-June) when weeds are rosettes and actively growing.

- Field Bindweed
    - Perennial weeds come back year after year from the same vegetative reproductive root systems.
    - Application of appropriate herbicides, which reduce bindweed growth and kill germinating seedlings, should also be part of an integrated pest management program.
    - Treat the bindweed plants before they are drought stressed. Use a translocated herbicide, such as glyphosate, or a combination of glyphosate and dicamba, when the plant is actively growing. Re-treatments will be necessary to control both established plants and seedlings. Reseeding should occur to provide desirable species to compete with field bindweed.

- Weedy Annuals (Russian thistle and burning bush)
    - Annual weeds germinate from seed and flower in a single year.
    - Cultural approaches are the best control methods for Russian thistle and burning bush.
    - Cultural approaches include seeding desirable species to compete with existing annual weed patches and limiting land disturbances. Russian thistle and burning bush are commonly found in the arid west and decrease as perennial plant communities establish and disturbance diminishes.

- Tamarisk
    - Woody plants found along riparian corridors or around desert springs can seriously reduce underground water tables and surface water availability, drying up wetlands, and reducing flows.
    - Biological control [saltcedar leaf beetle] will not eradicate tamarisk but it has the potential to suppress tamarisk populations by 75 to 85%.

- Due to the proximity to surface water, herbicide should only be applied by a qualified applicator.

Noxious weeds located on borrow sites should be treated with herbicide or controlled in a manner to limit risk of spreading these weeds to reclamation. Observations of tamarisk and bull thistle were recorded in the Jetty area during 2018 surveys. If chemical control is not feasible, stripping and disposing of the top 6 inches of surface material prior to borrow should be considered. This layer contains the seed source for the spread of noxious weeds.

In the event that a patch of a previously unidentified noxious weed species is found, an informal weed control plan will be developed at that time. As necessary, the following guidance will be used when implementing noxious weed control.

5.2.1 Chemical Control

Target noxious weed, herbicide selection, proximity to desirable plant species, timing are considerations for chemical control. The use of herbicides will be in compliance with all Federal and State laws on proper use, storage, and disposal. The chemical application will be done by a licensed contractor in accordance with all applicable laws and regulations and all label instructions will be strictly followed.

5.2.2 Mechanical Control

Mechanical control is the physical removal of weeds and includes tilling, mowing, and pulling undesirable plant species. Treatment options and efficacy depend on the noxious weed targeted and method used.

5.3 Mulching

If revegetation parcels are eroding at an unforeseen rate while vegetation is still establishing, mulch can be used to provide rainsplash and wind protection, reduce evaporation, and stabilize the seedbed. Preferably, a wood fiber or wood shred mulch would be used, as it is more robust than hay or straw and more likely to provide wind protection.

If used, wood fiber mulch or wood shred mulch will consist of specially prepared wood fibers and will not be produced from recycled material such as sawdust, paper, cardboard, or residue from pulp and paper plants. If necessary, such as on a steep slope or an area deemed a high wind erosion risk area, a tackifier can be used with the wood-fiber mulch to improve adhesion. If erosion areas are localized, small, or well sheltered, a simple straw mulch should suffice in providing rainsplash protection. Interseeding will most likely be necessary if erosion is sufficient enough to require post-revegetation corrective mulching.

5.4 Supplemental Irrigation

Seed mixes proposed in this project are comprised of species adapted to the local climactic conditions and supplemental irrigation is not likely required to establish vegetation. Irrigation typically causes an artificial climactic regime that overly encourages annual weeds versus the desired seeded species. Also, under the influence of irrigation, the adapted plants that do germinate will develop above ground biomass at the expense of below ground biomass. Once the irrigation stops, those plants have essentially become "accustomed" to artificial circumstances and will typically die during a normally tolerated drought. Over approximately the last 20 years, practical applications of arid land reclamation science have abandoned the use of irrigation.

However, within high risk reclamation areas, such as the Repository, a prolonged drought during the plant establishment period could become detrimental to the project. In this specific circumstance, supplemental irrigation may be used to facilitate germination, but procedures for implementing irrigation need to be highly managed and not exceed 120% of any monthly precipitation average. Soil moisture sensors and unsaturated flow modeling should accompany the planning and implementation of irrigation events to facilitate vegetation establishment and growth, while maintaining the primary function of isolating the buried materials from the water balance.

In order to encourage and sustain perennial growth, particularly of warm season grasses and shrubs, and discourage annual weedy species, irrigation needs to occur as infrequent pulses of relatively substantial quantities of water, in an attempt to mimic the natural monsoonal precipitation experienced in mid to late summer. These irrigation events, mimicking high intensity, short duration convective thunderstorms will increase the amount of plant available water, facilitating the robust and extensive root systems needed for survival of perennial vegetation beyond irrigation. In contrast, frequent and shallow irrigation events will benefit the shallow rooted annual species and facilitate perennial root growth near the surface, which during periods of drought will desiccate, and result in the senescence of all shallow rooted vegetation.

It is anticipated that a sprinkler irrigation system would be used if it is determined that irrigation is needed to establish vegetation. A detailed plan describing the method and application of irrigation will be prepared for agency review, prior to implementation.

6.0 REFERENCES

Bonham, Charles D. *Measurements for Terrestrial Vegetation*. John Wiley & Sons. 338 pp. 1989.

Bureau of Indian Affairs. *Integrated Weed Management Plan for the Navajo Nation*. April 2013.

Cedar Creek Associates, Inc. *Northeast Church Rock Mine, Vegetation & Wildlife Evaluations / Revegetation Recommendations, 2009 Evaluations and Planning*. February, 2010.

Cedar Creek Associates, Inc. *Northeast Church Rock Mine, 2012 Eastern Drainage Baseline Vegetation Evaluation*. November, 2012.

Cedar Creek Associates, Inc. *Northeast Church Rock Mill Site, Baseline Vegetation and Wildlife Surveys*. July, 2014a.

Cedar Creek Associates, Inc. *Northeast Church Rock Mill Site, Vegetation Characterization And Biointrusion Surveys*. July, 2014b.

Cedar Creek Associates, Inc. *Northeast Church Rock Mine Site, 2015 Revegetation Evaluation*. To Be Published.

Hoenes, B. D. and L. C. Bender. *Factors influencing foraging habitats of mule deer (Odocoileus hemionus) in the San Andres Mountains, New Mexico*. The Southwestern Naturalist, Vol. 57, No. 4 pp. 370-379. 2012.

INTERA. *Environmental Data Report for the Northeast Church Rock Site Removal Action and the United Nuclear Corporation Site Remedial Action*. October 2, 2017.

New Mexico Department of Agriculture. *New Mexico Noxious Weed Update.* October 19, 2016.

U.S. Department of Energy, *Methodology for determining revegetation success at the Monticello Repository*, GJO–2002–325–TAR, Grand Junction, Colorado. 2002.

U.S. Environmental Protection Agency (USEPA), Region 6 and Region 9. *Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery*. April 27, 2015.

W.J. Waugh, C.H. Benson, and W. H. Albright, *Sustainable Covers for Uranium Mill Tailings, USA: Alternative Design, Performance, and Renovation*, proceedings of the 12th International Conference on Environmental Remediation and Radioactive Waste Management, Liverpool, United Kingdom, 2009.

W.J. Waugh. *Design, Performance, and Sustainability of Engineered Covers for Uranium Mill Tailin*gs. Proceedings of the Workshop on Long-Term Performance Monitoring of Metals and Radionuclides in the Subsurface: Strategies, Tools, and Case Studies. U.S. Geological Survey. Reston, Virginia. April 21 and 22, 2004.

Northeast Church Rock

95% Design Report

Appendix V:
Construction Quality Assurance Plan

This page intentionally left blank

TABLE OF CONTENTS

TABLE

FIGURE

ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CC	Construction Contractor
CM	construction management
CQA	construction quality assurance
CQAO	construction quality assurance official
CQAP	Construction Quality Assurance Plan
CQC	construction quality control
CS	Construction Superintendent
CSC	Construction Supervising Contractor
CSF	Construction Support Facility
EOR	Engineer of Record
FE	Field Engineer
FI	Field Inspector
GE	General Electric
Mill Site	UNC Mill Site
Mine Site	Northeast Church Rock Mine Site
NNEPA	Navajo Nation Environmental Protection Agency
NNC	Notice of non-compliance
NRC	US Nuclear Regulatory Commission
PM	Project Manager
RA	Removal Action (Mine Site) or Remedial Action (Mill Site)
RAO	Remedial Action Objective
RFI	request for information
ROD	Record of Decision
RPM	Remedial Project Manager
SM	Site Manager
SWA	stop work authority
QA	quality assurance
QC	quality control

QCM	Quality Control Manager
SWPPP	Stormwater Pollution Protection Plan
UNC	United Nuclear Corporation
USEPA	United States Environmental Protection Agency

V.1 INTRODUCTION

This Construction Quality Assurance Plan (CQAP) establishes the construction quality assurance (CQA) activities and processes required to demonstrate and document that construction of the Removal Action (RA) at the Northeast Church Rock Mine Site (Mine Site) and the Remedial Action (RA) at the UNC Mill Site (Mill Site) comply with the Drawings, Technical Specifications, and regulatory requirements. The final approved CQAP will be updated as necessary to incorporate major changes to the project team or CQA procedures.

This CQAP has been developed using the following Agency guidance documents:

- *Technical Guidance Document – Construction Quality Management for Remedial Action and Remedial Design Waste Containment Systems, EPA/540/R-92/073* (USEPA, 1992).

- *Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility, NUREG-1199, Rev 2* (USNRC, 1991)

- *Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility, NUREG-1200, Rev 3* (USNRC, 1994)

This CQAP includes the following information:

- Responsibility and authority of organizations and key personnel involved in the RA
- CQA Processes including:
  - Meetings
  - Inspection, testing, and verification, including hold points
  - Nonconformance, corrective action and work stoppage
  - Documentation
  - Change management

Construction quality control (CQC) requirements, which are the responsibility of the Construction Contractor (CC), are included in the Technical Specifications.

V.1.1 Key Quality Program Terms

Two related but independent processes associated with the construction quality program are CQA and CQC, defined as follows:

Construction Quality Assurance (CQA) - A planned system of activities that document that the project is constructed as specified, and that the materials used in construction are procured or manufactured according to specifications. CQA includes inspections and audits of materials and workmanship necessary to determine the quality of the construction and compliance with the design. CQA activities are the responsibility of the Construction Quality Assurance Official (CQAO, defined in Section V.3.2.5).

Construction Quality Control (CQC) –The process of a planned system of inspections and testing used directly to monitor and control work quality. CQC includes surveying, sampling, and testing to directly monitor the quality of furnished, constructed, and installed components. CQC activities are the responsibility of the CC (defined in Section V.3.1.6) in order to demonstrate and document that the work product complies with the design. CQC processes shall be prepared and submitted by the CC prior to implementation of construction.

V.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the Record of Decision, United Nuclear Corporation Site, (ROD; USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the Statement of Work attached as Appendix D to the AOC, and were developed to define attainment of the Removal Action and Remedial Action Objectives (RAOs) for the Selected Remedy. The Performance Standards include both general and specific standards applicable to the Selected Remedy work elements and associated work components. Table V.2.1 presents Performance Standards related to the CQAP and how the design accomplishes these standards.

Table V.2-1: Performance Standards Applicable to the Construction Quality Assurance Plan

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
89	2011 Action Memo, V.A.1, Bullet 3 – Construction	Construction	Construct a repository that will contain the contaminated mine waste and soil excavated and removed from the NECR Mine Site in accordance with the approved design specifications. This action is contingent on the NRC approval of a license amendment for the UNC Mill Site disposal cells, and on USEPA's decision document for the surface contamination at the UNC Mill Site.	This appendix describes the quality assurance (QA) process to document that the project is conducted in accordance with the applicable design Drawings and Technical Specifications.

*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)

V.3 RESPONSIBILITIES AND AUTHORITIES

This section presents responsibilities and authorities of organizations and key personnel involved in the RA and the structure of the CQA/CQC organization. The final approved CQAP will identify specific individuals or firms assigned to each role. A CQAP organization chart is presented in Figure V.3-1.

V.3.1 Responsibilities and Authorities of Organizations

V.3.1.1 US Environmental Protection Agency

US Environmental Protection Agency (USEPA) Region 9 is the lead agency for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) action at the Mine Site. USEPA Region 6 is the cooperating agency, and the lead agency for the CERCLA action at the Mill Site. USEPA's approval of deliverables will be provided by USEPA's Remedial Project Manager (RPM) or USEPA's Alternate RPM pursuant to the AOC (USEPA, 2015).

The Navajo Nation Environmental Protection Agency (NNEPA) is a support agency to USEPA Region 9. In its capacity as a support agency under CERCLA, the NNEPA has the opportunity to review each submittal and comment to the USEPA.

The USEPA is expected to have representatives onsite periodically during construction. Both CQA and CQC staff will make accommodation for agency personnel inspections and/or QA testing. Quality control data will be provided to the agencies upon request.

V.3.1.2 Nuclear Regulatory Commission

The US Nuclear Regulatory Commission (NRC) is a cooperating agency with jurisdiction over the licensed Mill Site and is not a party to the Construction Consent Decree between USEPA and General Electric/United Nuclear Corporation (GE/UNC). Construction of the Repository at the NRC-licensed facility would proceed following an NRC-approved license amendment. It is expected that NRC would review the design and this CQAP as part of the license amendment process. NRC inspections are anticipated during the construction.

V.3.1.3 United Nuclear Corporation/General Electric Company

GE/UNC, has responsibility for procuring consultants and contractors to perform the RA work, including budgeting and securing the necessary funds, and assuring that the requirements of the RA are met. GE/UNC is responsible for executing administrative aspects of the contract with the CC such as contract approval, claims, change orders, amendments, pay applications, and quality through the Site Manager and the CQAO (both described below).

The Mine Site was operated and is now managed by UNC, or its representatives, which is an indirect wholly-owned subsidiary of GE (referred to collectively as GE/UNC). The majority of the land encompassing the Mine Site is primarily land held in Trust for the Navajo Nation (Trust Land). A small portion of the southern end of the Mine Site and the land encompassing the Mill Site is owned by GE/UNC.

V.3.1.4 Design Supervising Contractor

The Design Supervising Contractor (DSC) is the company retained by GE/UNC to provide design and engineering services for design of the RA. The DSC coordinates development of the design with GE/UNC, EPA and NRC. Stantec (formerly MWH), is a licensed design firm retained by GE/UNC as the DSC.

V.3.1.5 Construction Supervising Contractor

The Construction Supervising Contractor (CSC) would be the company retained by GE/UNC to provide professional construction quality assurance services in connection with the RA, including its qualified personnel. The CSC would be independent of, and oversee, the CC on behalf of GE/UNC (including review of the CC's proposed means and methods) and serve as the primary point of contact with the CC with regard to construction quality. The CSC would be responsible for implementation of this CQAP. The CSC will provide CQA and monitor day-by-day CQC activities performed by the CC. The CSC will monitor and document compliance with the design plans and Technical Specifications. The DSC may also act as the CSC.

V.3.1.6 Construction Contractor

GE/UNC would retain the CC to provide labor, materials, and equipment required to construct the project in accordance with the project documents. The CC is responsible for scheduling, coordinating, and planning the construction work (e.g., the means and methods). The CC is responsible for the quality of their constructed work product as well as the necessary inspections and tests required to verify that work complies with the design drawings and technical specifications. The CC exercises authority over its workforce, including CQC personnel (described in Section V.3.2.7), subcontractors and its CQC support services. The CC and CQC staff would be identified prior to construction. As described above, the CC would establish a QC system in accordance with the Technical Specifications.

V.3.2 Responsibilities of Key Personnel

The CQA/CQC roles and responsibilities for key personnel are described in the following sections. These may vary slightly based on nomenclature used by the actual CSC and CC contracted by GE/UNC to implement the RAs. The CQA/CQC staff would be on site as needed during the RA based on the nature, volume, or complexity of the tasks being performed at any given time, and the CQA/CQC requirements associated with those tasks. Prior to the start of construction activities, the CQA personnel will review and become familiar with all construction Drawings, Technical Specifications, this CQAP, and related work plans and permits.

V.3.2.1 GE/UNC Project Manager

The GE/UNC Project Manager (PM) shall be the individual responsible for executing the RA on behalf of GE/UNC. The PM is an employee of GE/UNC and is the primary point of contact between GE/UNC and the USEPA and has financial contractual authority and final decision making authority on all matters related to the RA. The PM is not required to be on-site on a daily basis.

V.3.2.2 Engineer of Record

The Engineer of Record (EOR) is an employee of the DSC and is the Professional Engineer licensed in the State of New Mexico ultimately responsible for accepting the RA work as complete, and for approving design modifications or deviations. The EOR may assume the role of the CQAO. The EOR may also delegate authority to the Field Engineer to approve design modifications and deviations.

V.3.2.3 Site Manager

The Site Manager's (SM) primary responsibility is to administer the CC's and CSC's contracts. SM responsibilities include:

- Supervision of site operations to ensure work is completed safely, on-time and within budget, and to the required quality standards
- Management of pay applications, change orders and miscellaneous contractual issues
- Progress reporting to the GE/UNC PM.
- The SM may be granted limited financial signature authority by the PM.
- The SM is typically required to be on-site on a daily basis.

The SM would be an employee, or contract employee, of GE/UNC and the primary point of GE/UNC contact for the CC's and CSC's key personnel. The SM would report to the GE/UNC PM. The SM will, at a minimum, possess a bachelor's degree in civil or construction engineering, construction management, geotechnical engineering, engineering geology, or a closely related discipline, and have sufficient combined experience, as deemed adequate by GE/UNC, in one or more of the following positions: Project Superintendent, QC Manager, Project Manager, or Construction Manager on similar size and type construction projects.

V.3.2.4 Construction Superintendent

The Construction Superintendent (CS) is an employee of the CC and is the individual responsible for executing the RA construction activities as required by the construction contract. The CS coordinates scheduling, construction crews, procurement, and all on-site CC personnel report to the superintendent. The CS will, at a minimum, possess sufficient combined education and experience, as deemed adequate by GE/UNC in one or more of the following positions: Project Superintendent, QC Manager, Project Manager, or Construction Manager on similar size and type construction projects

V.3.2.5 Construction Quality Assurance Official

The CQAO is an employee of the CSC and will coordinate field implementation of this CQAP. The CQAO would be responsible for assembling, tracking, and storing CQA/CQC related documentation. The primary duty of the CQAO is to confirm and document that the RA is implemented in accordance with the approved design.

The CQAO has authority to institute actions necessary for the successful implementation of the CQA/CQC program to determine compliance with the plans and Technical Specifications (including stop-work authority). The CQAO would coordinate activities to provide inspection and coordination of testing firms. The CQAO will work closely with the CC CQC staff to carry out the requirements of this CQAP and the CC's QC system.

The CQAO will track and report nonconformance to CC management and CC CQC staff. The CQAO will have authority to obtain direct access to CC CQC files. Other CQAO responsibilities would include:

- Reviewing CC reports, tests, and inspection results
- Facilitating implementation of, and participating in, required inspections
- Checking that quality and testing laboratories are adequately trained and understand assignment limits and time frames
- Assist in developing a plan for process change to eliminate nonconformance trends
- Maintaining site QCA files and reporting QA results to the EOR, Site Manager, PM and/or agencies.

The CQAO will be familiar with the USEPA technical guidance document, *Quality Assurance and Quality Control for Waste Containment Facilities* (USEPA 1993). The CQAO also will be familiar with the most recent construction schedule, so that adequate resources (i.e., laboratory, field testing equipment, staff, and CQA forms), including contingencies (e.g., backup equipment, alternate laboratory, and alternate CQA staff) for CQA activities, will be commensurate with the anticipated construction productivity and work schedule.

The CQA will possess sufficient combined experience, as deemed adequate by GE/UNC in one or more of the following positions: Project Superintendent, QC Manager, Project Manager, or Project Engineer, or Construction Manager on similar size and type construction projects.

The CQAO may assume the role of the Field Engineer described below.

V.3.2.6 Field Engineer

The Field Engineer's (FE) primary responsibility is to assist the SM with administration of the CC contract and ensure the RA is performed in accordance with the design plans and Technical Specifications. The FE reviews CQC testing documentation with the CC, engineers, and inspectors. Specific responsibilities of the FE include:

- Review and document compliance with the RA design plans and Technical Specifications
- Coordinate requests for information (RFIs) and required design clarifications with the Design Supervising Contractor and distribute them to CQA/CQC team members and construction staff
- Maintain, control, and supervise required submittals between the CC, their subcontractors and suppliers, and the EOR.

V.3.2.7 CC's Quality Control Staff

Quality Control Manager (QCM). The QCM is responsible for daily on-site implementation of the CC's QC system. The QCM is responsible for:

- Confirming all required QC tests and inspections are performed in accordance with the Technical Specifications
- Reviewing CQC reports, tests, and inspection results to determine compliance with design plans and Technical Specifications, and other contractual documents
- Documenting CQC activities, and supplying this documentation to the CQA team
- Rectifying nonconformance in a timely fashion
- Ensuring that CC and subcontractor CQC personnel conducting inspections are adequately trained and understand assignment limits and time frames
- Providing the required notifications of upcoming QC activities to the CQA team

QC Technicians. CC staff may include QC Technicians to support the QCM. The QCM may assume the role of the QC Technician, which includes the following functions:

- Inspect materials, construction, and equipment for conformance with the Technical Specifications
- Perform CQC tests, as required by the Technical Specifications

V.4 CONSTRUCTION QUALITY CONTROL

The CC shall establish a QC system to perform sufficient inspection and tests of all work, including that of subcontractors, to ensure conformance with the design. This includes inspection, sampling and testing. The CC's QC system shall be established for all construction except where the Technical Specification provide for specific compliance tests by laboratories employed by GE/UNC. The CC's QC system shall specifically include all testing required by the various section of the Technical Specifications. Contractor QC requirements are included in the Technical Specifications as follows:

Specification Section 01400 – Quality Control: Specifies the CC QC requirements for the RA, including personnel, documentation, and inspection.

Division 2 through 16 Technical Specifications: Specifies the QC inspections, tests, and test frequencies for the work identified in each section, if applicable.

A summary of quality control test requirements and quality assurance activities are included in Table V.1, attached to this document.

The CC shall be responsible for establishing a system of daily test reports that will document all CQC test results. Test results from each day's work period shall be submitted to the FE prior to the start of the next day's period. The CC's responsible technician and the CC CQM shall sign the daily test reports. The FE will review test results daily and identify any non-conforming test results for discussion with the CC regarding potential corrective action.

V.5 CONSTRUCTION QUALITY ASSURANCE

V.5.1 Project Meetings

V.5.1.1 Pre-construction Meetings

The FE will plan, and participate in, a pre-construction meeting prior to initiating major RA work components. The purpose of pre-construction meetings is to resolve uncertainties following award of the construction contract, but prior to the start of construction. At a minimum, the meeting will be attended in person or via telephone by GE/UNC (or GE/UNC's representative), the EOR, the CQAO (Supervising Contractor), the FE, and CC Project Manager or superintendents and QCM.

Topics covered in this meeting will include the following:

- Responsibilities of each organization
- Lines of authority and communication for each organization
- Work area security and safety protocols
- CQA/CQC processes including:
  - Procedures and/or protocols for observations, inspections, and tests
  - Procedures and/or protocols for handling construction deficiencies
  - Procedures for location and protection of stockpiled or stored construction materials
  - Documentation and documentation control
  - Supporting CQA/CQC plans and references
- Submittal requirements
- RFIs and design change process
- Methods for distributing and storing documents and reports
- Work area security and health and safety protocols
- Project schedule

The FE will document the meeting and distribute minutes to all attendees within seven working days of the meeting.

V.5.1.2 Weekly Construction Coordination Meetings

The FE will plan, and participate in, weekly construction coordination meetings held at the site during the RA. Additional coordination meetings may be scheduled by either the SM or CC staff. The FE will document the meeting and distribute minutes to all attendees within three working days of the meeting. At a minimum, progress meetings will be attended by the FE, the CC QCM, and the CC superintendent. Topics covered in the progress meetings will include:

- Activities and accomplishments
- Planned work locations and activities
- Personnel and equipment assignments
- New test data
- Resolution of previously identified problems

- Potential construction problems, deficiencies, or nonconformance
- Changes or delays to the construction schedule
- Claims, change orders, and similar item

V.5.1.3 Ad-Hoc Daily Meetings

The Field Engineer will preside over ad-hoc quality meetings that may be required to review specifications or QC requirements with the CC, CQC or CQA staff for specific work tasks. Such informal meetings shall be documented in the FE's daily reports.

V.5.2 CQA Monitoring and Testing Activities

This section presents the CQA monitoring and testing activities and processes, including the general inspection process for the CQA staff, to verify and document compliance with the Drawings and Technical Specifications. The organization of this section aligns with the organization of the RA design Drawings, presenting the CQA requirements for each of the following drawing sections:

- Section 2: Early Works and Construction Support Facilities
- Section 3: Mine Waste Excavation
- Section 4: Haul Routes
- Section 5: Construction Stormwater Management
- Sections 6 and 9: Permanent Stormwater Controls
- Section 7: Waste Repository
- Section 8: Borrow Areas
- Section 10: Revegetation

V.5.2.1 Hold Points

Mandatory hold points will be established in the Technical Specifications for certain key construction activities. At these points, the CC will notify the CQA staff that the construction activity, or portion of an activity, is ready for inspection. The hold points anticipated for RA would be at completion or partial completion of each of the following components:

- Mine site excavation between phases
- Mine site grading prior to revegetation
- Completion of subgrade preparation for rock, fill, or structure placement
- Radon barrier conditioning and compaction prior to waste placement
- Waste layer surface preparation prior to cover placement
- Soil cover placement prior to erosion protection layer placement
- Final cover grading prior to seeding
- Subgrade prior to riprap filter layers
- Filter layers prior to riprap placement
- Regrading of borrow areas prior to revegetation

- Rebar placement, prior to concrete placement

At each hold point noted above, the FE must review the item and provide approval that the completed activity meets specifications. This will include:

- Review of applicable QC testing data to confirm correct densities, gradations, moisture or other specified properties
- Inspection of the completed item for correct grade, alignment, placement, and/or completion of excavation
- Inspection of graded surfaces for uniformity and compliance with grading plans

Approval shall be verbally given to the CS and noted in the FE's daily report. If an item is found to be deficient, the procedures of Section V5.3 shall be followed. A summary of quality control test requirements and quality assurance activities, including hold points, is included as Table V.1, attached to this document.

V.5.2.2 Material Handling, Storage, Packaging, Preservation and Delivery

The CQA staff will review CC activities to document technical compliance in identification, handling, storage, packaging, preservation, and delivery of materials, parts, assemblies, and end products with either the Technical Specifications, manufacturers' recommendations, or generally accepted practices. Related quality records and documents will be maintained and controlled in accordance with the procedures provided in Section V.5.4.

V.5.2.3 Material Identification and Management

CQA staff will monitor the CC to confirm that material identification and management requirements are met. Products and materials shall be traced from receipt through installation. Documentation such as project control checklists, material receipts, sample and test documentation, and reports will verify that the applicable material/item is received and installed. Technical specifications and/or procedures define product identification and management requirements, which generally include the following:

- Construction materials or equipment intended for project use are identified and segregated until inspection confirms that they conform to technical and quality requirements
- Materials or equipment are traceable to documents attesting to their conformance with technical requirements that are stated in Technical Specifications or Construction Drawings

V.5.2.4 Construction Support Facilities (Section 2 Drawings)

The CQAO personnel will document the following:

- Layout is in compliance with the CCs construction support facility (CSF) submittal including:
    - Zone delineation and controls (fencing, gates, security shacks, etc.)
    - Decontamination facilities (type, configuration and location)
    - Personnel facilities (type, configuration and location)
    - Water storage tanks (type, configuration and location)
    - Access roads and laydown yards (configuration, location and grading)
- Grading is conducted in accordance with the CC's CSF submittal.
- Subgrade and compacted fill materials meet the requirements of the Technical Specifications as determined by the test methods and frequencies specified within the Technical Specifications

- Drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications
- Gravel surfacing, asphalt and concrete is placed in accordance with the Technical Specifications and in the specified locations

V.5.2.5 Mine Waste Excavation (Section 3 Drawings)

The CQAO personnel will verify and document the following:

- Haul and access roads are constructed to the general elevations and grades shown in the Drawings
- Drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications
- Contamination control features are in place prior to operation
- Excavation sequence is in accordance with the Technical Specifications and Construction Drawings

V.5.2.6 Haul Routes (Section 4 Drawings)

The CQAO personnel will review and document the following:

- Haul and access roads are constructed to the elevations and grades shown in the Drawings
- Subgrade and compacted fill materials meet the requirements of the Technical Specifications as determined by the test methods and frequencies specified within this CQAP
- Drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications
- Gravel surfacing is placed in accordance with the Technical Specifications and in the specified locations
- Contamination control features are in place prior to operation

V.5.2.7 Construction Stormwater Management (Section 5 Drawings)

The CQAO personnel will review and document the following:

- Construction stormwater control items are constructed in the locations shown on the Drawings
- Construction stormwater controls are constructed and maintained in accordance with the CC's Stormwater Pollution Prevention Plan (SWPPP).

V.5.2.8 Permanent Stormwater Controls (Section 6 & 9 Drawings)

The CQAO personnel will review and document the following:

- Excavation is conducted to the lines and grades shown in the Drawings
- Subgrade and compacted fill materials meet the requirements of the Technical Specifications
- Riprap and filter materials placement meets the requirements of the Technical Specifications
- Concrete and rebar meets the requirements of the Technical Specifications
- Drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications

V.5.2.9 Waste Repository (Section 7 Drawings)

The CQAO personnel will review and document the following:

- Channel and cover stripping, processing and stockpiling is conducted in accordance with the Technical Specifications
- Radon barrier moisture conditioning and compaction meets the requirements of the Technical Specifications
- Debris processing is in compliance with the Technical Specifications and placement location is in compliance with the Drawings
- Mine waste moisture conditioning, lift thickness, and compaction are in compliance with the Technical Specifications
- Mine waste final grade and elevation is in accordance with the Drawings
- Cover system moisture conditioning, lift thickness, gradations, and compaction are in compliance with the Technical Specifications
- Drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications
- Repository haul route restrictions are enforced and subsequent cover system repairs are conducted in compliance with the Technical Specifications

V.5.2.10 Borrow Areas (Section 8 Drawings)

The CQAO personnel will verify and document the following:

- Haul and access roads are constructed to the elevations and grades shown in the Drawings
- Drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications
- Borrow excavation is conducted in accordance with the Drawings
- Borrow materials meet the requirements of the Technical Specifications
- Reclamation grading is conducted in accordance with the Drawings

V.5.2.11 Revegetation (Section 10 Drawings)

The CQAO personnel will review and document the following:

- Revegetation is conducted in accordance with the Technical Specifications
- Seed mixes and other revegetation materials are in compliance with the Technical Specifications
- Watering and other maintenance work is conducted in accordance with the Technical Specifications

V.5.2.12 CQA Monitoring

During construction, FIs will perform the following tasks for the RA element under observation:

- Observe completion of clearing and grubbing
- Observe completion of excavation and subgrade compaction prior to fill placement
- Monitor the subgrade prior to placement of structural fill to:

  - Document that the surface of the subgrade is free of unsuitable material, wet and soft areas, standing water, vegetation, mud, ice, or frozen material
  - Identify areas of weak or excessively weathered subgrade materials
  - Identify areas that exhibit excessive rutting, heaving, or softening
- Observe excavation and backfilling operations associated with unsuitable material found in the prepared subgrade
- Document the location and volume of any unsuitable material removed from the prepared subgrade
- Document that a survey has been conducted in accordance with the Technical Specifications
- Document that embankment fill material meets the requirements of the Technical Specifications
- Document that aggregate surfacing materials meet the requirements of the Technical Specifications
- Verify that sampling points in the prepared subgrade are plugged or backfilled so that the prepared subgrade meets the Technical Specifications
- Document that the lift thickness of compacted materials is in accordance with the requirements of the Technical Specifications
- Document that the dry unit weight of compacted materials meets specifications
- Document materials testing in accordance with Section V.5.4.2.
- Report any nonconformance with the Technical Specifications in accordance with the nonconformance reporting procedures in Section V.5.3

V.5.2.13 CQA Testing

Independent testing to verify the adequacy of CQC testing shall be at the discretion of the CQAO, except where specifically prescribed by the Technical Specifications. When conducted, the following materials testing procedures shall be observed by the FE, or the FE's designee.

- Material properties will be determined from samples collected either immediately after placement or from stockpiles. This may include the following tests:
  - Proctor tests
  - Laboratory moisture content
  - Particle-size distributions
  - Atterberg limits
  - Organic content tests (LOI)
- In-place density and water content will be determined by nuclear methods.
  - Standard count calibrations will be conducted to monitor the aging of the nuclear density gauge sources in accordance with ASTM standards.
  - Oven moisture content tests will be conducted and compared to field moisture content results to determine a field correction factor for moisture, if necessary.
- Concrete sampling and testing (temperature, slump, air content, and compressive strength) shall be conducted by an independent laboratory according to ASTM standards. Field sampling and testing shall be observed by the FIs.

V.5.2.14 Acceptance Criteria

The CC will be required to notify the FE when a hold point is reached (refer to Section V.5.2.1) and the preceding work has been completed. The CC may proceed with the overlying layer, or subsequent work item, upon acceptance of the preceding work by the FE. The FE may, at his/her discretion, delegate this authority to the FIs. The FE shall document acceptance of prepared subgrade in the field book.

If an in-place CQC density test result fails to meet specifications, a confirmatory test will be performed immediately adjacent to the failed test. If the confirmatory test meets or exceeds specifications, a second confirmatory test will be performed at a second location immediately next to the failed test. If the second confirmatory test also meets or exceeds specifications, the area will be declared as meeting project specifications and the confirmatory tests will be reported. In the event that either confirmatory test fails to meet specifications, the FE will determine the extent and nature of the defect by observations and/or additional testing, as necessary, to identify the limits of the area that does not meet project specifications.

If a defective area is discovered in the fill related to adverse site conditions, such as excessively wet soils or surface desiccation, the CQA representative will define the limits and nature of the defect by testing or observation. After the extent and nature of a defect is determined and remedied by the CC, the FI will verify that the deficiency has been corrected by re-testing repaired areas before any additional work is performed by the CC in the area of the deficiency. All confirmatory tests, failing tests, and retests will be documented in accordance with Section V.5.4.2.

V.5.3 Corrective Action and Work Stoppage

This section provides procedures for tracking construction deficiencies (non-compliance) from identification through acceptable corrective action. It defines the controls and related responsibilities and authorities for dealing with noncompliant work products, including stop work criteria and authority.

V.5.3.1 Stop Work Authority

The following individuals shall be authorized to stop work when there is a nonconformance with the Drawings and Technical Specifications:

- GE/UNC Project Manager and/or Safety Manager
- EOR
- FE
- CC CQM

Upon issuance of a Stop Work Order by any of the above personnel, the CC shall immediately cease the activity indicated until an acceptable resolution has been approved by the party issuing the Stop Work Order.

V.5.3.2 Deficiency Definition

A deficiency occurs when a material, performed work, or installation does not conform to the Drawings, Technical Specifications, and/or intended use for the project. A deficiency can be identified by anyone on the CC or CQAO project team.

V.5.3.3 Deficiency Identification and Control

When material, performed work, or installation is found deficient, the FE (or designee) shall ensure that the non-conforming material, work, or installation is identified and controlled to prevent unintended use or delivery. The FE will notify the CC of nonconformance in accordance with this section. The CC shall, after receipt of such notice, immediately take corrective action.

V.5.3.3.1 Deficiency Notification

Deficiencies noted by the CQA staff during testing or inspection will be verbally reported to the CC's representative and noted on the Daily Construction Report (see Section V.5.4.1). Ideally, deficiencies would be corrected on the spot by agreement with the CC's Supervisor. Failure by the CC to correct a deficiency after having been put on verbal notice will result in a nonconformance (discussed below).

V.5.3.4 Nonconformance

Nonconformance shall be formally documented by the FE on a Notice of Non-Compliance (NNC; see example contained in Attachment V-1). The NNC is a formal notification to the CC that work does not meet the design plans or the Technical Specifications for the project. Nonconformance reports will be included on a nonconformance log and tracked through verification that the nonconformance has been corrected.

Nonconformance may occur when:

- The CC has not made efforts to correct a reported deficiency within 5 working days of notification.
- The CC has covered or advanced the deficient work without correction. An example of this would be placing mine waste material over radon barrier that has not been sufficiently conditioned.
- The CC has tried but is unable to correct a deficiency.

The NNC shall provide a description of the nonconformance and the required corrective action.

V.5.3.5 Deficiency Correction

When material, performed work, or installation is found deficient and/or does not meet the project Technical Specifications, the FE will assure deficiency correction is implemented. The FE shall confirm that the non-conforming material, work or installation is identified and controlled to prevent unintended use or delivery. The non-conforming material or work product shall be tagged and segregated by the CC, when practical, from conforming material or items to preclude their inadvertent use. If needed, the FE is responsible for documenting nonconformance (as described above) in an NNC form.

The CC will implement corrective actions to remedy work that is not in accordance with the Drawings and Technical Specifications. Corrective actions will include removal and replacement of deficient work using methods approved by the FE. Removal must be done in a manner that does not disturb existing work and that meets CQA/CQC criteria; otherwise, the disturbed work must also be removed and replaced. Replacement must be done in accordance with the corresponding design plans, and Technical Specifications. Replacement will be subjected to the same scope of CQA/CQC inspection and testing as the original work. If the replacement work is not in accordance with the Drawings and Technical Specifications, the replacement work will be removed, replaced, re-inspected, and re-tested.

V.5.3.6 Preventative Actions

The CC and CQA/CQC team shall take preventative actions to eliminate the causes of potential deficiencies so as to prevent their occurrence. The FE will monitor, inspect, and audit processes used to prevent erroneous information or construction products from being passed to UNC/GE. The FE has the authority to implement, verify, and review the project's preventative and corrective action effectiveness. The FE is empowered to improve the project's work processes to eliminate the causes of potential nonconformities.

V.5.4 Documentation

A major function of CQA is to properly and adequately document and certify the work. This section describes the minimum required documentation.

V.5.4.1 Daily Recordkeeping

Daily reports will be completed by the FIs when they are onsite. All FIs will be assigned field books or tablets by the FE that will be labeled with a unique number. The FIs, including the FE, will record all field observations and the results of field tests in their assigned field book or tablet. When not in use, all field books will be kept in the FE field office. After each field book is filled (or at the end of the project), the field books will be returned to the FE.

Each daily report or page of the field book will be numbered, dated, and initialed by the FI. At the start of a new work shift, the FI will list the following information at the top of the page:

- Date
- Name
- Weather conditions
- Page number (if pages are not pre-numbered)

The remaining individual entries will be prefaced by an indication of the time at which they occurred. If the results of test data are being recorded on separate sheets, this will be noted. Entries will include, but not be limited to, the following information:

- Reports on any meetings held and their results
- CC's equipment and personnel being used in each location
- Descriptions of areas being observed and documented
- Descriptions of materials delivered to the site, including any quality verification (vendor certification) documentation
- Descriptions of materials incorporated into construction
- Calibrations, or recalibrations, of test equipment, including actions taken as a result of recalibration
- Decisions made regarding use of material and/or corrective actions to be taken in instances of substandard quality.

Unique identifying sheet numbers of inspection data sheets and/or problem reporting and corrective measures reports used to substantiate the decisions described in the preceding item.

V.5.4.2 Materials Testing Documentation

Field test results will be provided to the FE and other specified representatives of the CQAO team, electronically in spreadsheet format (MS Excel), within 24 hours of the tests being completed. Test results are an important component of the as-built record for the project and because of this, the specific locations and elevations where all field tests are performed is vital. All test locations will require horizontal coordinates to identify where the tests were conducted along with elevation detail to the nearest whole foot. Test results without the proper accompanying horizontal and vertical location information will be considered invalid.

Laboratory test results will be also provided to the FE and other specified representatives of the CQAO team, electronically in spreadsheet format (MS Excel), within 24 hours of the tests completion.

V.5.4.3 Daily Construction Report

The FE will prepare and sign a daily construction report. The report will include a summary of the CC's daily construction activities. Supporting inspection data sheets will be attached to the daily report where needed. An example Daily Construction Report form is included in Attachment V-2.

At a minimum, the daily construction report will include the following information:

- Date, project name, location, and other identification
- Description of weather conditions, including temperature, cloud cover, and precipitation
- Reports on meetings held and their results
- Record of visitors to the construction site
- Locations of construction activities during that day
- Equipment and personnel working in each activity, including subcontractors
- Descriptions of work being inspected
- Decisions made regarding approval of units of material or of work, and corrective actions to be taken
- Description of problems or delays and resolution
- Communications with CC staff
- Construction activities completed and/or in progress
- Progress photos, where applicable
- CC Daily Report from the previous day
- Signature of the report preparer

The daily construction reports will be filed on a daily basis in the project CQA/CQC files and will be maintained by the FE as part of the permanent project record.

V.5.4.4 Record Drawings

The CC will be responsible for red-lining design Drawings in the field to prepare Record Drawings. The red-lined design Drawings will document actual field conditions upon completion of the work. Where there was a change to a specified material, dimension, location, or other feature, the red-lined design Drawings will indicate the actual work performed.

The FE working with the CC will be responsible for assuring that red-lined design Drawings are maintained daily throughout the construction process. These red-lined design Drawings will be used to update the design Drawings to Record Drawings at the completion of the work.

The CC will submit draft red-lined design Drawings to the FE for review and will prepare final red-lined design Drawings based on CQA staff comments. The FE will provide the red-lined design Drawings to the EOR who will incorporate the red lines and issue the final Record Drawings to UNC/GE.

V.5.4.5 Documentation Control

The CC shall provide an electronic or paper copy (suitable for scanning) of CQC documentation associated with the work to the FE within five working days of the generation of such documents per Specification Section 01400 – Quality Control. The CC's documentation shall contain all inspection reports, test records, project, and daily field reports.

The FE is responsible for verifying CQA record accuracy and maintains copies of all quality-related documentation in the project files.

V.5.4.6 Agency Review

The CQAO will make project CQA/CQC files available for on-site, or electronic, review by agency personnel upon request. UNC/GE will provide USEPA with as-built construction documentation as required by the Construction Consent Decree, which has not yet been finalized.

V.5.5 Quality System Change Management

V.5.5.1 CQA System Changes

UNC/GE, CQAO, EOR, or the FE may initiate revisions to this CQAP. The CQAP may be revised when it becomes apparent that the CQAP procedures or controls are inadequate to support work being produced in conformance with the specified quality requirements, or are deemed to be more excessive than required to support work being produced in conformance with the specified quality requirements. Updates to CQAP staffing will be made by UNC/GE with notification to USEPA without submission of a fully revised CQAP. Updates the CQA procedures or controls shall be subject to UNC/GE and EOR acceptance. USEPA will be notified of any revisions to CQA procedure or controls. Absent an objection by USEPA, changes to CQA procedures implemented upon approval by the EOR.

V.5.5.2 CQC System Changes

The CC's QC system may require revisions to correct unsatisfactory performance. At any time, the FE, UNC/GE, CQAO, or EOR may require the CC to make changes to their QC system, including personnel changes, as necessary to obtain the quality specified. The CC may self-initiate system changes to correct CQC process problems, and is required to notify the FE in writing of any desired changes. All changes are subject to UNC/GE and EOR acceptance. USEPA will be notified of any revisions to CQC procedure or controls. Absent an objection by USEPA, changes to CQC procedures implemented upon approval by the EOR.

V.6 REFERENCES

US Environmental Protection Agency (USEPA), 1992. Technical Guidance Document – Construction Quality Management for Remedial Action and Remedial Design Waste Containment Systems. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R-92/073. October.

US Environmental Protection Agency (USEPA), 1993. Technical Guidance Document –Quality Assurance and Quality Control for Waste Containment Facilities. Risk Reduction Engineering Laboratory, Office of research and Development, Cincinnati, Ohio. EPA/600/R-93/182. September.

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

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

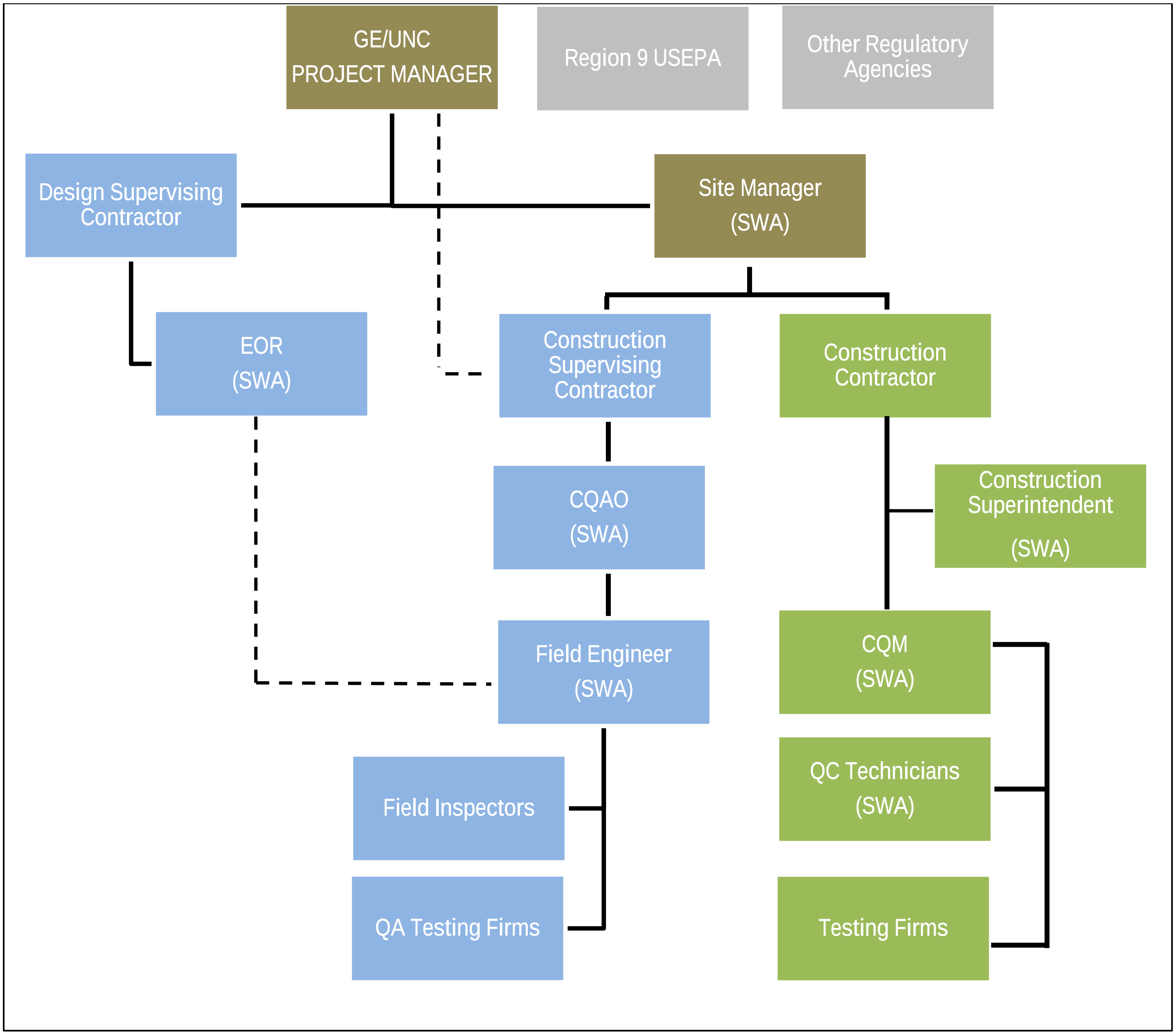
US Environmental Protection Agency (USEPA), Region 6 and Region 9, 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery. April 27

US Nuclear Regulatory Commission (USNRC), 1991. Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility, NUREG-1199, Rev 2. January.

US Nuclear Regulatory Commission (USNRC), 1994. Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility, NUREG-1200, Rev 2. April.

.

FIGURE



Color Key: Brown indicates owner management; Green indicates QC management; Blue indicates QA management.
(SWA) = stop work authority

Figure V.3-1 95% CQAP Organizational Chart

ATTACHMENTS

V.1 Summary of Construction Quality Control and Quality Assurance Requirements

Table V.1 Summary of Construction Quality Control and Quality Assurance Requirements

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Construction Support Facilities	CSF facilities	Refer to CC's QC System for QC inspections	N/A	Layout conforms to construction support CSF submittal including: zone delineation, fencing, gates, security, facilities, water storage, road and yard locations.	N/A	
	Cultural resources sites		N/A	Site boundaries identified and temporarily fenced under the direction of a qualified archeologist prior to ground disturbing activities. Proper work perimeter, 50-foot defined.	N/A	No ground disturbance in the vicinity of the sites until FE approves the temporary fencing.
	Grading		N/A	Verify grading is conducted in accordance with the CSF submittal.	N/A	
	Fencing		N/A	Verify fencing meets specifications and conforms to CSF submittal locations	N/A	
	Subgrade preparation for appurtenances		Proctor (ASTM D698): 1/10,000 CY General Fill/Gravel 95% Density, +2% to -5% Moisture, Compacted General Fill (D6938): 1/500 SF/Lift 95% Density, Crushed Gravel (D6938): 1/500 SF/Lift	Observe QC testing, review results	At the discretion of the FE	Do not place vault until gravel subgrade has been approved by FE.
	Gravel surfacing		Gradation (ASTM C136): 1/10,000 CY Proctor (ASTM D698): 1/10,000 CY 95% Density (D6938): 1/10,000 SF	Observe QC testing, review results	At the discretion of the FE	Do not place gravel until grading has been approved by FE.
	Asphalt		Mix Density: Per submittal 95% Density, (D2726) 2 tests per lift on decon pad	Observe QC testing, review results. Observe 2-lift placement	At the discretion of the FE	Do not place asphalt until gravel subgrade has been approved by FE.
	Drainage and erosion control		Proctor (ASTM D698): 1/10,000 CY 95% Density, +2% to -5% Moisture, Trench Backfill Density (D6938): 1/Lift/Culvert 90% Density, +5% to -5% Moisture, Pipe Zone Density (D6938): 1/Lift/Culvert	Verify drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications.	At the discretion of the FE	
	Decontamination pad sump		N/A	Verify vault has been properly installed, level, with watertight joints, at the correct elevations and orientations.	N/A	
	Fuel farm		N/A	Verify configuration and containment meets SPCCP	N/A	

Table V.1 Summary of Construction Quality Control and Quality Assurance Requirements

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Mine Waste Excavation	Clearing and excavation limits	Refer to CC's QC System for QC inspections	N/A	Verify Contractor has staked clearing and excavation areas and check against Drawings for consistency.	N/A	
	Clearing and grubbing		N/A	Verify correct stockpile location, tree removal, no grubbing.	N/A	
	Tree disposal		N/A	Observe chip placement, verify 6-inch lifts	N/A	
	Drainage and erosion control		Proctor (ASTM D698): 1/10,000 CY 95% Density, +2% to -5% Moisture, Trench Backfill Density (D6938): 1/Lift/Culvert 90% Density, +5% to -5% Moisture, Pipe Zone Density (D6938): 1/Lift/Culvert	Verify drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications	At the discretion of the FE	
	Contamination control facilities		N/A	Verify contamination control facilities are in place and in conformance with CSF submittals, or as otherwise modified in field with FE approval.	N/A	
	Mine waste excavation and Placement		N/A	Verify excavation sequence	N/A	After each phase. Contractor not to begin next phase until authorized by FE.

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Haul and Access Roads	Clearing and excavation limits	Refer to CC's QC System for QC inspections	N/A	Inspect construction staking for excessive cut or fills, or alignments that do not appear to match design.	N/A	
	Clearing and grubbing		N/A	Verify correct stockpile location(s), tree removal, adequate grubbing	N/A	Do not place fill until FE has approved site preparation.
	Road embankments		Proctor (ASTM D698): 1/10,000 CY 95% Density, +0 to -5% Moisture, Compacted General Fill (D6938): 1/500 LF/Lift	Observe QC testing, review results	At the discretion of the FE	Do not place gravel until FE has approved road fill.
	Gravel surfacing		Gradation (ASTM C136): 1/10,000 CY Proctor (ASTM D698): 1/10,000 CY 95% Density (D6938): 1/10,000 SF	Observe QC testing, review results	At the discretion of the FE	
	Drainage and erosion control		Proctor (ASTM D698): 1/10,000 CY 95% Density, +2% to -5% Moisture, Trench Backfill Density (D6938): 1/Lift/Culvert 90% Density, +5% to -5% Moisture, Pipe Zone Density (D6938): 1/Lift/Culvert	Verify drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications.	At the discretion of the FE	
	Contamination control facilities		N/A	Verify contamination control facilities are in place and in conformance with CSF submittals, or as otherwise modified in field with FE approval.	N/A	

Table V.1 Summary of Construction Quality Control and Quality Assurance Requirements

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Construction Stormwater Controls	Drainage and erosion control	Refer to CC's QC System for QC inspections	Proctor (ASTM D698): 1/10,000 CY 95% Density, +2% to -5% Moisture, Trench Backfill Density (D6938): 1/Lift/Culvert 90% Density, +5% to -5% Moisture, Pipe Zone Density (D6938): 1/Lift/Culvert	Verify drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications.	At the discretion of the FE	
	SWPPP		N/A	Verify the Contractor is conducting SWPPP inspections, maintenance and keeping all SWPPP documentation up to date.	N/A	

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Mine Site and Mill Site Permanent Stormwater Controls	Clearing and excavation limits	Refer to CC's QC System for QC inspections	N/A	Inspect construction staking for excessive cut or fills, or alignments that do not appear to match design.	N/A	
	Excavation		N/A	Excavation is conducted to the lines and grades shown in the Drawings.	N/A	
	Subgrade and fill for appurtenances		Proctor (ASTM D698): 1/10,000 CY General Fill/Gravel 95% Density, +2% to -5% Moisture, Compacted General Fill (D6938): 1/500 SF/Lift 95% Density, Crushed Gravel (D6938): 1/500SF/Lift	Observe QC testing, review results.	At the discretion of the FE	Do not place fill or gabions until FE has approved site preparation.
	Riprap filter		Gradation (D6913): 1/5,000 CY Proctor (ASTM D698): 1/5,000 CY 95% Density, +3% to -3% Moisture, (D6938): 1/2,000 CY	Filter materials placement meets the requirements of the Technical Specifications.	At the discretion of the FE	Do not place riprap until filter is approved by FE
	Riprap		Durability testing and petrography prior to production for Mill Site Riprap. Durability testing regularly during production of Mill Site riprap. Gradations approved by FE at source location during production.	Riprap placement meets the requirements of the Technical Specifications.	At the discretion of the FE	FE to approve durability tests and rock gradations.
	Concrete forming and rebar		N/A	Inspect forms. Inspect rebar placement and verify against final rebar submittals and requirements of the specifications.	N/A	Do not place concrete until rebar has been approved by FE
	Drainage and erosion control		Proctor (ASTM D698): 1/10,000 CY 95% Density, +2% to -5% Moisture, Trench Backfill Density (D6938): 1/Lift/Culvert 90% Density, +5% to -5% Moisture, Pipe Zone Density (D6938): 1/Lift/Culvert	Drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications.	At the discretion of the FE	
	Gabions		N/A	Observe gabion construction. Verify geotextiles are placed correctly. Verify baskets are constructed correctly, and in the correct configuration.	N/A	

Table V.1 Summary of Construction Quality Control and Quality Assurance Requirements

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Waste Repository	Rock and rock mulch stripping, screening and stockpiling	Refer to CC's QC System for QC inspections	N/A	Verify channel riprap and cover rock mulch stripping is conducted in a manner that does not overexcavate or leave rock in place. Water is used for dust control during screening.	N/A	
	Exposed tailings		N/A	RSO notified. Scan and remove tailings.	N/A	
	Radon barrier conditioning		Proctor (ASTM D698): 1/150,000 SF 95% Density, Dry of Optimum Moisture, (D6938): 1/30,000 SF	Observe conditioning, observe QC testing, review QC test results.	At the discretion of the FE	Do not place mine waste until radon barrier is approved by FE.
	Mine debris disposal		N/A	Observe that debris is crushed and sized properly, verify placement restrictions are observed.	N/A	
	Mine waste placement		Proctor (ASTM D698): 1/100,000 CY 90% Density, Dry of Optimum Moisture (D6938): 1/100,000 SF	Observe mine waste moisture conditioning, lift thickness, and compaction. Review test results.	At the discretion of the FE	Do not place cover until mine waste surface is approved by FE
	Waste grading		N/A	Review staking and survey data to verify waste final grade and elevation is in accordance with the Drawings.	N/A	
	Cover soil		Proctor (ASTM D698): 3/Borrow Source 88-93% Density, Dry of Optimum Moisture, (D6938): 1/100,000 SF	Observe cover system moisture conditioning and lift thickness. Observe QC testing. Review QC testing results.	At the discretion of the FE	Survey to confirm thickness and grades of completed surface.
	Cover soil admixture		Proctor (ASTM D698): 3/cover mixture with rock corrections 88-93% Density, Dry of Optimum Moisture, (D6938): 1/30,000 SF Volume Mixture: 1/ 1 AC Cover, plus 1/6,000 CY if mixed off-site	Observe cover system moisture conditioning, rock mixing, and lift thickness. Observe QC testing. Review QC testing results.	At the discretion of the FE	If mixing in-place hold until survey thicknesses of layers in admixture are confirmed. Hold until test pits are approved by FE for rock volumes.
	Repository haul roads		N/A	Observe repository haul route restrictions are enforced. Notify FE if haul routes are not enforced.	N/A	

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Borrow Areas	Clearing and excavation limits	Refer to CC's QC System for QC inspections	N/A	Verify Contractor has staked clearing and excavation areas and check against Drawings for consistency.	N/A	
	Clearing and grubbing		N/A	Verify correct stockpile location, tree removal, adequate grubbing.	N/A	
	Drainage and erosion control		Proctor (ASTM D698): 1/10,000 CY 95% Density, +2% to -5% Moisture, Trench Backfill Density (D6938): 1/Lift/Culvert 90% Density, +5% to -5% Moisture, Pipe Zone Density (D6938): 1/Lift/Culvert	Verify drainage and erosion control features are constructed at the locations shown on the Drawings, or as modified by the FE, and in conformance with the Technical Specifications.	N/A	
	Final grading		N/A	Review staking and survey data to verify final grades and elevations are in accordance with the Drawings.	N/A	FE to approve final reclaimed grading prior to reseeding.

	Construction Item	QC Inspections	CQC Testing	CQA Inspections	CQA Testing	Hold Point
Revegetation	Seed Mix	Refer to CC's QC System for QC inspections	N/A	Verify supplied seed conforms to submittals and specified mix. Check bag tags, reject if tags are not available.	N/A	
	Seed Placement		N/A	Observe seeding for compliance with revegetation plan.	N/A	
	Maintenance		N/A	Observe maintenance for compliance with revegetation plan.	N/A	

V.2 Non-conformance Form

NOTICE OF NON-COMPLIANCE (NNC)

Date: ____________ NNC No. ____________ 1

To: ____________ 2

Company Name: From: ____________ 3

Address CQAO: ____________ 4

City, State, Zip Project no: ____________ 5

Phone Project name: ____________ 6

Date Deficiencies Corrected and 7

NNC Closed: ____________ 8

(See line 18 below)

Deficiencies and Corrective Actions:

9

Outstanding Items:

10

Attachments:

11

CQAO Signature: ____________ Date: ____________ 12

SUBCONTRACTOR'S COMPLIANCE

Corrective Action: 13

Outstanding Items: 14

Attachments: 15

Date Deficiencies Corrected: ______________________ 16

Subcontractor's Signature: ______________________ 17

Name: ______________________ 18

To be completed by CQAO Only:

Date Deficiencies Corrected and

NNC Closed: ______________________ CQAO Signature: ______________________ 18

(Write this date on line 8 above)

V.3 Daily Report Form

Daily Construction Report

Date ______________________

PROJECT: ______________________

JOB NO: ______________________

CLIENT: ______________________

CONTRACTOR: ______________________

PROJECT MANAGER: ______________________

Weather		
Temp. °F		Report No.
Wind		

Personnel, Subcontractors, and Visitors			
Time	Name	Representing	Remarks

Equipment Used:
Construction Activities:
Quality Assurance/Quality Control Activities (including field calibrations):
Health and Safety Levels and Activities:
Preparatory Control Issues:
Initial and Follow-up Control Activities:
Summary of Inspections and Test Results:
Conversations with Client:
Conversations with Contractors:
Potential Causes for Delays or Change Orders:

Daily Construction Report (continued)

Photos:

Distribution: 1. Proj. Mgr.
2. Field Office
3. File
4. Client

Page 1 of X Pages

By ______________________ Title ______________________

Northeast Church Rock
95% Design Report

Appendix W:
Operations, Monitoring, and Maintenance Plan

MWH® now part of Stantec

This page intentionally left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
ARAR	Applicable or Relevant and Appropriate Requirements
DOE	US Department of Energy
EDD	Electronic Data Deliverable
EME	Metadata Editor
EOR	Engineer of Record
FGDC	Federal Geographic Data Committee
HASP	Health and Safety Plan
JSA	Job Safety Analysis
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
MSOC	Mine Site Outlet Channel
NECR	Northeast Church Rock
NMAC	New Mexico Mining and Minerals Division
NRC	US Nuclear Regulatory Commission
OM&M	Operation, Monitoring and Maintenance
RA	Removal Action
RAO	Remedial Action Objective
ROD	Record of Decision
SOW	Statement of Work
USEPA	US Environmental Protection Agency

W.1 INTRODUCTION

This document outlines the Operations, Monitoring, and Maintenance Plan (OM&M Plan), following completion of the Removal Action (RA) at the Northeast Church Rock (NECR) Mine Site (Mine Site). This plan refers exclusively to this RA. The RA does not require active operation after completion, thus there are no operational procedures required for this plan. However, the Site elements included herein are to be monitored or inspected following completion of the RA.

This OM&M plan specifies the activities required to maintain the effectiveness of the RA at the Mine Site. This plan provides the requirements for monitoring to identify any areas of the Mine Site and Church Rock Mill Site (Mill Site) which require repair to restore the intended functionality of the RA. This plan identifies the Mill Site and Mine Site elements to be monitored or inspected, the inspection schedule, inspection and reporting requirements, and repair and notification procedures in the event that a repair is required at the Mill Site or Mine Site. OM&M requirements are divided into the two areas as follows:

- Area 1: Repository
- Area 2: Mine Site and Mill Site Disturbed Areas

These areas are identified on Figure W.1-1 – Limits of OM&M Division Areas. The number of years that monitoring is required varies by area. This OM&M plan includes the initial minimum timeframe of 12 years as noted in Section 4 for the Mine and Mill Site, excluding the Repository. The OM&M liability period for the Repository will be defined in coordination with the NRC and as part of the NRC License Amendment Request. Monitoring and maintenance beyond this timeframe would be addressed in future revisions. The inspections of the individual Site elements are discussed in Sections W.3 and W.4. Reporting requirements are outlined in Section W.6. Inspection checklists are provided in Attachment W.1.

W.2 PERFORMANCE STANDARDS

The Performance Standards presented here are defined in the Action Memorandum: Request for a Non-Time-Critical Removal Action at the Northeast Church Rock Site (2011 Action Memo; USEPA, 2011), the ROD, United Nuclear Corporation Site (USEPA, 2013), and the Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery (AOC; USEPA, 2015) including the SOW attached as Appendix D to the AOC, and were developed to define attainment of the 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 W.1-1 presents Performance Standards related to the Mine Site Removal Action and how the design accomplishes these standards.

Table W.1-1: Performance Standards Applicable to the Operation, Maintenance and Monitoring Plan

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
54	2013 ROD, Table 1	Monitoring and Maintenance	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 12. Refer to www.ecfr.gov.	Inspections and repairs are conducted as described in this appendix to confirm that the functionality of all aspects of the RA are maintained as intended.
57	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 6. Refer to www.ecfr.gov.	As noted above.
56	2013 ROD, Table 1	Radiation Protection	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 6A. Refer to www.ecfr.gov.	As noted above.
53	2013 ROD, Table 1	Monitoring	10 CFR 40, Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content, Criterion 7. Refer to www.ecfr.gov.	As noted above.
48	2013 ROD, Table 1	Environmental Monitoring	10 CFR 61.53(b), Environmental Monitoring. Refer to www.ecfr.gov.	As noted above.
50	2013 ROD, Table 1	Environmental Monitoring	10 CFR 61.53(d), Environmental Monitoring. Refer to www.ecfr.gov.	As noted above.
26	2013 ROD, Section 2.9.1, Bullet 3	Repository Design	Prevent the migration of concentrations of contaminants located in the soil, mine waste, and tailings contained within the Tailings Disposal Area to ground water where the migration of those contaminants would result in ground water concentrations that exceed remediation goals established in USEPA's 1988 ROD for the Ground	As noted above.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
			Water Operable Unit (including any amendment), and, through this action, prevent human and ecological receptors from being exposed to ground water with concentrations of contaminants that exceed remediation goals established in the 1988 ROD, including any amendment.	
72	2013 ROD, Table 1 and Section 2.9.5, Cap Design Criteria Bullets 1, 3, and 4	Closure	40 CFR 264.111(a), Closure Performance Standard. Refer to www.ecfr.gov.	As noted above.
73	2013 ROD, Table 1 and Section 2.9.5, Cap Design Criteria Bullets 3 and 4	Closure	40 CFR 264.228(b)(1), Closure and Post-Closure Care. Refer to www.ecfr.gov.	As noted above.
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.	As noted above.
15	2015 AOC SOW, Paragraph 30 – Data Submission	Data Submission	Respondents shall submit data under this SOW, according to the following technical specifications for those submissions: Respondents shall submit sampling and monitoring data in the standard USEPA regional Electronic Data Deliverable (EDD) format that USEPA identifies. USEPA may change this EDD format upon written notice to the Respondents. USEPA may allow Respondents to use other non-EDD Format data delivery methods upon Respondents' showing that the EDD Format presents a significant burden to Respondents or upon Respondents showing that technological improvements make the EDD Format outdated. Respondents shall submit spatial data, including spatially-referenced data and geospatial data, in the ESRI File Geodatabase, and as unprojected geographic coordinates in decimal degree format using North American Datum 1983 (NAD83) or World Geodetic System 1984 (WGS84) as the datum. If applicable as determined by USEPA, Respondents shall include descriptions of their data collection methods in their data submissions. At USEPA's discretion, Respondents shall	Inspection and monitoring data will be submitted in the appropriate EDD format.

Identifying Number*	Location of Performance Standard Requirement	Topic	Performance Standard	Comments
			include projected coordinates with documentation. Respondents shall include metadata with all spatial data submissions. Respondents shall ensure that all metadata that they submit is compliant with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata and its USEPA profile, and the USEPA Geospatial Metadata Technical Specification. An add-on metadata editor for ESRI software, the USEPA Metadata Editor (EME), complies with these FGDC and USEPA metadata requirements and is available at https://edg.epa.gov/EME/. Respondents shall ensure that each data file that Respondents submit includes an attribute name for each SA Site unit, including the NECR and UNC Sites for which data is submitted. Respondents shall consult and use the information published by USEPA at http://www.epa.gov/geospatial/policies.html, as Respondents identify and name data attributes. Respondents understand and agree that spatial data submitted by Respondents will not, and is not intended to, define the boundaries of the SA Site.	

*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)

W.3 AREA 1 – REPOSITORY OM&M REQUIREMENTS

Area 1 includes the Mill Site Repository and the permanent stormwater controls associated with the Repository, as delineated on Figure W.1-1. These are the components of the design specifically related to the tailings facility.

The RA elements included in Area 1 OM&M are:

- Repository cover and cover vegetation
- Repository access controls
- Repository stormwater controls:
  - North Diversion Channel
  - East Repository Channel and related sediment controls on Dilco Hill
  - Repository South and West Side Drainage
  - North Cell Drainage Channel
  - Pipeline Arroyo Stabilization (Rock Jetty)

W.3.1 Revegetation Monitoring

A revegetation monitoring program for the Repository is presented in Appendix U – Revegetation Plans, Attachment U.2. Revegetation protocols and performance criteria for the Repository are guided by the Uranium Mill Tailings Radiation Control Act guidance from the Department of Energy (DOE 2002, Waugh 2009, and Waugh 2004). This framework is used for the repository because the DOE will eventually provide long-term surveillance under a general license from the NRC. A separate revegetation monitoring program guided by the rules and regulations of the New Mexico Mining and Minerals Division (NMAC 19.10.5) is required for Area 2 disturbed areas (Section W.5).

The vegetation monitoring liability period for the Repository will be defined in coordination with the NRC and as part of the NRC License Amendment Request. It is expected that annual site visits would be conducted that include qualitative and quantitative evaluations to facilitate tracking and progress toward revegetation success standards, and the final effort during the last inspection year would be an evaluation for success determination. Final year information would be collected in such a manner as to provide defensible verification that success has been achieved.

A qualified vegetation specialist will review the revegetated areas of the Repository cover (during the peak of the growing season; in September or shortly thereafter) to assess success. This review includes the following elements:

- Specific success criteria including:
  - Vegetation ground cover standard
  - Species diversity standard
  - Woody plant density standard
  - Absence of noxious weeds that are detrimental to revegetation success
- Sample adequacy determination
- Management actions and contingency

W.3.2 Engineering Inspections

W.3.2.1 Inspections

Engineering inspections are independent of vegetation inspections and shall be performed by a New Mexico Professional Engineer with expertise in reclamation cover systems and stormwater controls. The frequency and duration of engineering inspections for the Repository will be defined in coordination with the NRC and as part of the NRC License Amendment Request.

The Repository Cover will be subject to the following inspections and monitoring requirements during the monitoring period:

- Settlement:
  - The Repository surface will be inspected for visual evidence of localized areas of settlement, including evidence of ponding.
  - The cover surface (and/or select settlement monuments installed during construction) will be surveyed according to the criteria outlined in Section W.3.2.2.
- Stormwater erosion/damage: the Repository surface will be inspected for evidence of erosion/damage such as rilling or gullying.
- Veneer stability: Soil surface conditions will be observed to determine if there has been mass movement of the soil surface, areas of subsidence, cracking, or other signs of slope instability.
- Vehicle damage: Vehicle traffic will be prohibited from the completed cover unless approved for a specific maintenance function. The Repository Cover surface will be visually inspected to determine if there is evidence of damage from vehicles or equipment.
- Animal damage: Small mammal burrows, dens, or other damage.
- Fencing and access controls: Fencing and other controls for the Repository will be visually inspected for damage and functionality.
- Permanent Stormwater controls:
  - Repository channels, aprons and transitions shall be inspected for evidence of riprap degradation, erosion, subsidence, sediment accumulation, undercutting, obstructions, slope instability and other disturbances.
  - Natural drainages shall be inspected for excessive sedimentation or erosion, and vegetation growth. The natural channels need to be inspected to verify that the runoff from the Repository Cover and surrounding areas is draining in the intended direction.

Inspections will be documented in a report that will include a summary of the areas inspected, along with observations, and photos documenting the condition of the sites.

W.3.2.2 Settlement Monitoring

Settlement will be monitored during construction as described in Appendix G – Mine Waste Repository Design. Upon construction completion, the Engineer of Record (EOR, defined in Appendix V) will review survey data collected during construction. The EOR will use this data to determine the appropriate extent of future surveys. Criteria for determination of future survey will include:

- Settlement observed during construction that has not stabilized
- As-built waste material placement during construction that may be expected to experience long-term consolidation, such as fine-grained materials
- As-built topography including permanent stormwater controls.

The settlement monitoring plan will be updated as needed by the EOR and included as long as required by the NRC as part of the engineering inspections until the site is transferred.

W.3.2.3 Non-Routine Inspection

In addition to engineering inspections, non-routine inspections of the Repository for stormwater erosion/damage and veneer stability shall commence within seven days and be completed within fourteen days after a 25-year, 24-hour storm event (2.3 inches). These inspections will include:

- Stormwater erosion/damage: the Repository surface will be inspected for evidence of erosion/damage such as rilling or gullying.
- Veneer stability: Soil surface conditions will be observed to determine if there has been mass movement of the soil surface, areas of subsidence, cracking, or other signs of slope instability.
- Pipeline Arroyo: Pipeline Arroyo will be inspected for evidence of scouring or erosion that may undermine or damage the jetty.

W.3.3 Maintenance and Repairs

The purpose of the maintenance procedures is to verify that these areas perform as designed and that maintenance activities do not affect the long-term integrity of the cover and vegetation. This is accomplished by confirming the materials and maintenance practices are consistent with the final design and specifications. All repairs and/or reconstruction shall be conducted in a manner that maintains the final cover system surface grading integrity.

Corrective action repairs and maintenance for identified problems will be prioritized and scheduled within 30 days. The scheduled repairs will be completed within the same field season unless any of the observed damages could present an immediate threat to the Repository cover integrity, in which case the repair will be addressed immediately.

W.3.3.1 Revegetation Maintenance and Repairs

Refer to Attachment U.2 of Appendix U for detailed information regarding Repository revegetation OM&M.

W.3.3.2 Settlement

The following conditions shall require repair:

- Observed or recorded settlement that results in ponding (observed standing water, or evidence of standing water) on the surface of the repository cover.

Repair procedures for settlement damage may include localized regrading and/or cover soil placement followed by re-establishment of vegetation. The Contractor will be required to stockpile additional volumes of the cover mixtures for the 2-inch and 1.5-inch cover mixtures to fill settled areas of the cover, during OM&M, if necessary. Placement of these materials will follow the project specifications for Earthwork. The Revegetation Plan (Appendix U) has procedures for establishment of vegetation on the soil covered surfaces, including the applicable seed mixes and planting techniques. All OM&M repairs to the cover will be reseeded with the specified seed mix used for Construction.

W.3.3.3 Erosion and Vehicle Damage

The following conditions shall require repair:

- Erosion damage greater than 6 inches in depth and 20 feet in length
- Vegetation destroyed due to erosion

- EOR determines that repairs are required to maintain the effectiveness of the RA

Repair procedures for damage from erosion or vehicles may include scarifying, regrading, cover soil placement, or placement of erosion matting, followed by re-establishment of vegetation. The Revegetation Plan (Appendix U) contains procedures for establishment of vegetation on the soil covered surfaces, including the applicable seed mixes and planting techniques. Erosion repairs made to the cover must be completed with materials (soil and rock) and placement procedures, as described in the project specifications for Earthwork. OM&M repairs to the cover will be reseeded with the specified seed mix used for Construction.

W.3.3.4 Veneer Slope Instability

The following conditions shall require repair:

- Longitudinal cracks in soil surface greater than 10 feet in length, and greater than 3-inches in width.
- Bulged toe area
- EOR determines repairs are required to maintain the effectiveness of the RA

Repairing slope stability may entail simple regrading to correct surface drainage issues, or in some cases a partial reconstruction of cover slopes. Veneer slope instability repairs made to the cover must be completed with materials (soil and rock) and placement procedures, as described in the project specifications for Earthwork. All OM&M repairs to the cover will be reseeded with the specified seed mix used for Construction. Modified design specifications for the reconstruction activities in areas exhibiting persistent slope movement shall be submitted to the NRC for review and approval within 90 days upon discovery of persistently unstable conditions.

W.3.3.5 Stormwater Controls

The following conditions shall require repair:

- Damage or displacement of riprap and/or filter material
- Structural damage to concrete structures
- Sediment/debris buildup within channels and structures
- Signs of ponding water to indicate damage or plugging of channels or structures
- Engineer determines repairs are required

Repairs may entail regrading to correct surface drainage, excavation of debris or sediments, repair or replacement of riprap, and repair of concrete structures.

W.3.3.6 Access Controls

The following conditions shall require repair:

- Damaged or non-functioning infrastructure, including but not limited to:
    - Broken or missing fencing and gates
    - Missing, damaged (i.e., bullet holes), or unreadable signage

Corrective actions may entail minor repairs and maintenance for damaged items, or replacement if necessary.

W.4 AREA 2 - MINE SITE AND MILL SITE RECLAIMED AREA

Area 2 is delineated on Figure W.1-1 and applies to all disturbed areas that are subject to reclamation and revegetation, except for the Repository cover and permanent stormwater controls at the Tailings Disposal Area. Area 2 OM&M requirements are guided by the rules and regulations of the New Mexico Mining and Minerals Division (NMAC 19.10.5). Area 2 includes:

- Mine Site excavation areas
- Reclaimed borrow areas at the Mill Site
- Reclaimed haul and access road corridors
- Reclaimed lay down yards and support facility areas

Area 2 also includes the Mine Site Outlet Channel (MSOC) which has the following components:

- MSOC inlet structure
- Box culvert
- Containment berm
- Riprap channel
- Rock chute and chute toe protection

W.4.1 Revegetation Monitoring

A revegetation monitoring program for the Mine and Mill Site disturbed areas is presented in Appendix U – Revegetation Plans, Attachment U.1. Revegetation protocols and performance criteria for this area are guided by NMAC 19.10.5 and the monitoring timeframe differs from the DOE monitoring timeframe used for Area 1.

A qualified vegetation specialist will review the revegetated areas of the affected locations during the peak of the growing season (in September or shortly thereafter) to assess success. Monitoring would include a minimum 12-year vegetation monitoring liability period which includes the following inspection schedule:

- Year 1 – Emergent Density Evaluation
- Year 3, 6, 9 – Qualitative and quantitative evaluations (managerial information only)
- Year 11, 12 – Qualitative and quantitative evaluations (final success evaluation)

This annual review includes the following elements:

- Specific success criteria including:
  - Vegetation ground cover standard
  - Species diversity standard
  - Woody plant density standard
  - Sample adequacy determination
  - Management actions and contingency

W.4.2 Engineering Inspections

W.4.2.1 Annual Inspections

Engineering inspections are independent of vegetation inspections and shall be performed by a New Mexico Professional Engineer with expertise in mine reclamation design for a monitoring period of 5 years. The reclaimed areas will be subject to the following annual inspections and monitoring requirements:

- Stormwater erosion/damage: Area 2 will be inspected for evidence of erosion/damage such as rilling or gullying.
- Fencing and access controls: Fencing and other access controls for Mine and Mill Site disturbed areas, except for the Repository, will be visually inspected for damage and functionality.
- Natural drainages shall be inspected for excessive sedimentation or erosion. The natural channels need to be inspected to verify that runoff in surrounding areas is draining in the intended direction.
- MSOC:
    - MSOC channel, rock chute, chute toe protection and transitions shall be inspected for evidence of riprap degradation, erosion, subsidence, sediment accumulation, undercutting, obstructions, slope instability and other disturbances.
    - Natural drainages shall be inspected for excessive sedimentation or erosion, and vegetation growth.
    - MSOC box culvert shall be inspected for structural damage, evidence of upstream and downstream scouring, sediment accumulation and other disturbances.

W.4.2.2 Non-Routine Inspection

In addition to annual engineering inspections, non-routine inspections of the Mine Site and Mill Site Disturbed Areas for stormwater erosion/damage shall commence within seven days and completed within fourteen days after a 25-year, 24-hour storm event (2.3 inches). Non-routine inspections shall include:

- Stormwater erosion/damage: Area 2 areas will be inspected for evidence of erosion/damage such as rilling or gullying.

W.4.3 Maintenance and Repairs

W.4.3.1 Revegetation Maintenance and Repairs

Refer to Attachment U.1 of Appendix U (Revegetation Plans) for detailed information regarding Mine Site and Mill Site Disturbed Areas revegetation OM&M.

W.4.3.2 Engineering Maintenance and Repairs

The purpose of the maintenance procedures is to confirm that these areas perform as designed and that maintenance activities do not affect the long-term integrity of vegetation. This is accomplished by verifying the materials and maintenance practices are consistent with the final design and specifications.

Corrective action repairs and maintenance of identified problems will be prioritized and scheduled within 30 days. The scheduled repairs will be completed within the same field season.

W.4.3.3 Revegetation Maintenance and Repairs

Refer to Attachment U.1 of Appendix U (Revegetation Plans) for information regarding Mine Site and Mill Site Disturbed Areas revegetation OM&M.

W.4.3.4 Erosion and Vehicle Damage

The following conditions shall require repair:

- Erosion damage greater than 6 inches in depth and 20 feet in length
- Vegetation destroyed due to erosion
- EOR determines repairs are required

Repair procedures for damage from erosion or vehicles may include scarifying, regrading, soil placement, or placement of erosion matting followed by re-establishment of vegetation. Attachment U. 1 of Appendix U contains procedures for establishment of vegetation on the soil covered surfaces, including the applicable seed mixes and planting techniques.

W.4.3.5 Stormwater Controls

The following conditions shall require repair:

- Damage or displacement of riprap and/or filter material
- Structural damage to concrete structures
- Sediment/debris buildup within channels and structures that impedes more than 25 percent of the flow capacity
- Signs of ponding water to indicate damage or plugging of channels or structures
- Engineer determines repairs are required

Corrective actions may entail regrading to correct surface drainage, excavation of debris or sediments, repair or replacement of riprap, and repair of concrete structures.

W.4.3.6 Access Controls

The following conditions shall require repair:

- Damaged or non-functioning infrastructure

Corrective action may entail minor repairs and maintenance for damaged items, or replacement, if necessary.

W.5 INSPECTION SAFETY

Prior to the start of each inspection, the Company conducting the inspection shall prepare a Health and Safety Plan (HASP), which shall be specific to the inspection activities. The HASP shall include:

- A job safety analysis (JSA) for inspection works that present any health or safety risks. Each JSA will detail the task, identify the task-specific hazards and the measures to eliminate or control those hazards, including but not limited to:
  - Physical hazards and mitigation
  - Weather hazards and mitigation
  - Communication and emergency evacuation procedures.

W.6 REPORTING AND DOCUMENTATION

An annual summary of monitoring and maintenance activities shall be submitted to the USEPA during the Operations and Maintenance Phase of the RA for the Mine and Mill Site (unrestricted area). This yearly summary report will be transmitted to the USEPA by March 31. The report will contain the following (at a minimum):

- A description of the annual inspection
- Annotated photographs of the site features and maintenance work
- Summaries of all findings during the reporting period
- Summaries of all changes or repairs made, indicating consultation with USEPA and approval of those changes by the USEPA, when necessary
- Summaries of all contacts with representatives of the local community, public interest groups or government agencies during the reporting period
- Summaries of actions taken to achieve and maintain performance standards
- Changes in project personnel
- Projected work for the next reporting period
- Copies of inspection reports and any other relevant records

For the Repository, UNC is obligated under the Source Materials License to prepare routine reports and documentation.

W.7 REFERENCES

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

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

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

FIGURES

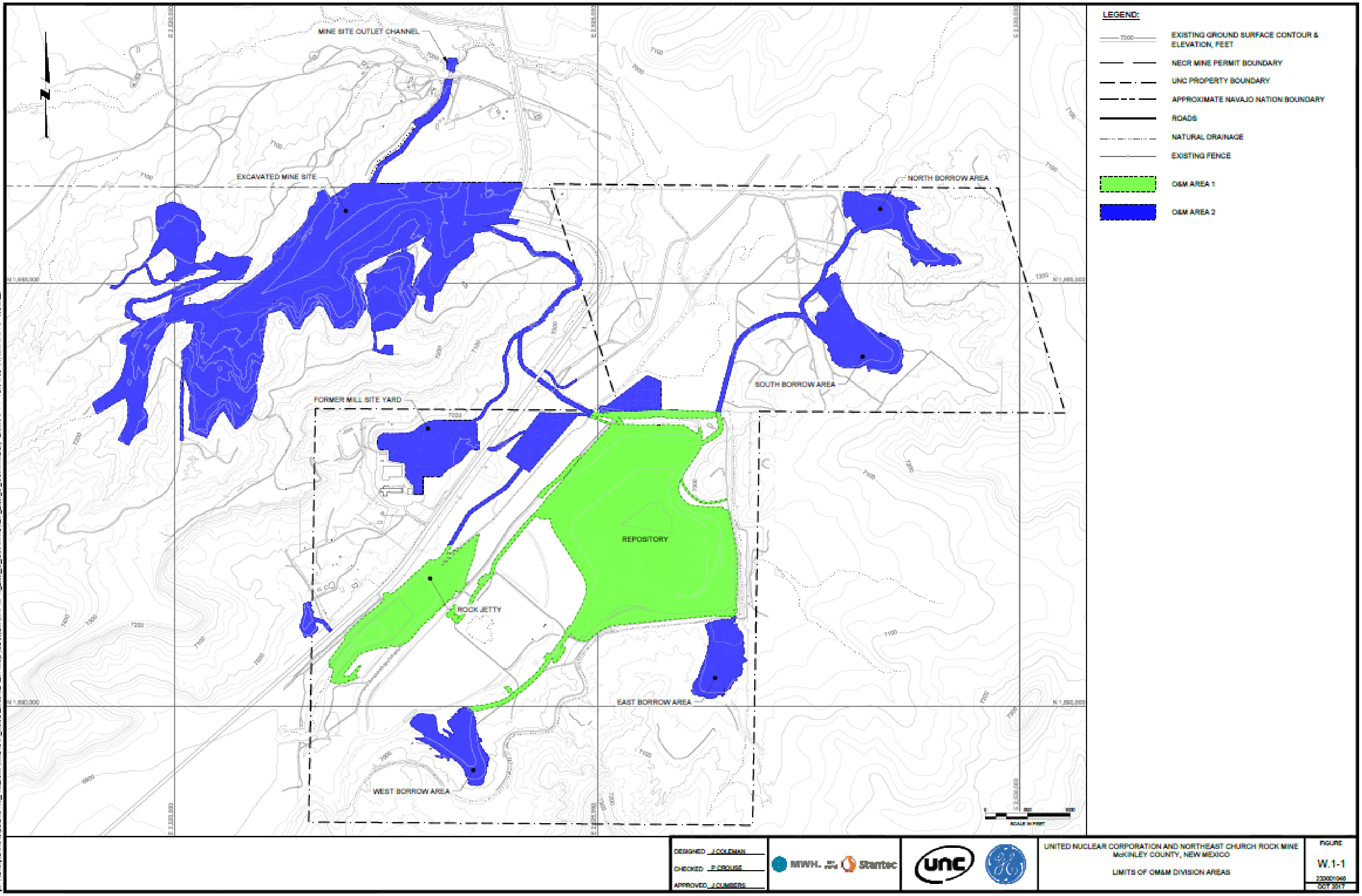


Figure W.1-1: Limits of OM&M Division Areas

ATTACHMENT W.1
OM&M Inspection Checklists

DIVISION 1 -
OPERATION, MAINTENANCE, AND MONITORING CHECKLIST

AREA 1 - REPOSITORY INSPECTION CHECKLIST

Post-Remedial Monitoring Element[1]	Measurement/Inspection	Inspection Completed	Action Trigger/Unacceptable Condition	Response Action
Inspections	Settlement Surveys		Evaluation of settlement in excess of parameters determined by EOR	Repairs / maintenance will be prioritized and scheduled within 30 days then completed within the field season unless any of the observed damages could present an immediate threat to the repository cover integrity.
	Visual Settlement Observed		Signs of depressions or ponding on the repository cover.	As Above
	Signs of Erosion/Damage: Repository		Signs of excessive run-on/runoff erosion or other damage to the repository cover, including sediment buildup. Erosion damage greater than 6 inches in depth and 20 feet in length or if vegetation has been destroyed due to erosion.	As Above
	Signs of Erosion/Damage: Stormwater Controls		Signs of excessive run-on/runoff erosion or other damage to stormwater controls, including sediment buildup, riprap damage, and scouring.	As Above
	Veneer Stability		Visual observations of cracks in soil surface, bulged toe area, or other signs indicating soil movement downslope.	As Above
	Vegetation		Refer to Appendix U	
	Wildlife Damage		Excessive wildlife activity causing damage to the cover.	As Above
	Stormwater Diversion Controls		Signs of structural damage to or sediment/debris buildup within bench channels and downdrains. Signs of ponding water to indicate damage or plugging of drainage bench subsurface collectors.	As Above
25-Year, 24-Hour Storm Event Inspections (2.3 inches of rain in 24 hours)	Signs of Stormwater Erosion		Signs of excessive cover erosion or other damage, or sediment buildup. Erosion damage greater than 6 inches in depth and 20 feet in length or if vegetation has been destroyed due to erosion.	As above
	Stormwater Diversion Controls		Damage to or sediment / debris buildup within diversion control infrastructure.	As above
Inspections	Security Systems		Damaged or non-functioning security infrastructure (e.g., fences, signs, gates, etc.)	Repairs / maintenance will be prioritize and scheduled within 30 days then completed within the field season.

DIVISION 2 -
OPERATION, MAINTENANCE, AND MONITORING CHECKLIST

AREA 2 - MINE AND MILL SITE DISTURBED AREAS INSPECTION CHECKLIST

Post-Remedial Monitoring Element[1]	Measurement/Inspection	Inspection Completed	Action Trigger/Unacceptable Condition	Response Action
Inspections	Visual Settlement Observed		Signs of depressions or ponding on the repository cover.	As Above
	Signs of Erosion/Damage: Mine and Borrow Areas		Signs of excessive run-on/runoff erosion or other damage to the repository cover, including sediment buildup. Erosion damage greater than 6 inches in depth and 20 feet in length or if vegetation has been destroyed due to erosion.	As Above
	Signs of Erosion/Damage: Stormwater Controls		Signs of excessive run-on/runoff erosion or other damage to stormwater controls, including sediment buildup, riprap damage, and scouring.	As Above
	Vegetation		Refer to Appendix U	
	Wildlife Damage		Excessive wildlife activity causing damage to the cover.	As Above
25-Year, 24-Hour Storm Event Inspections (2.3 inches of rain in 24 hours)	Signs of Stormwater Erosion		Signs of excessive cover erosion or other damage, or sediment buildup. Erosion damage greater than 6 inches in depth and 20 feet in length or if vegetation has been destroyed due to erosion.	As above
	Stormwater Diversion Controls		Damage to or sediment / debris buildup within diversion control infrastructure.	As above
Inspections	Security Systems		Damaged or non-functioning security infrastructure (e.g., fences, signs, gates, etc.)	Repairs / maintenance will be prioritize and scheduled within 30 days then completed within the field season.

Northeast Church Rock

95% Design Report

Appendix Y:

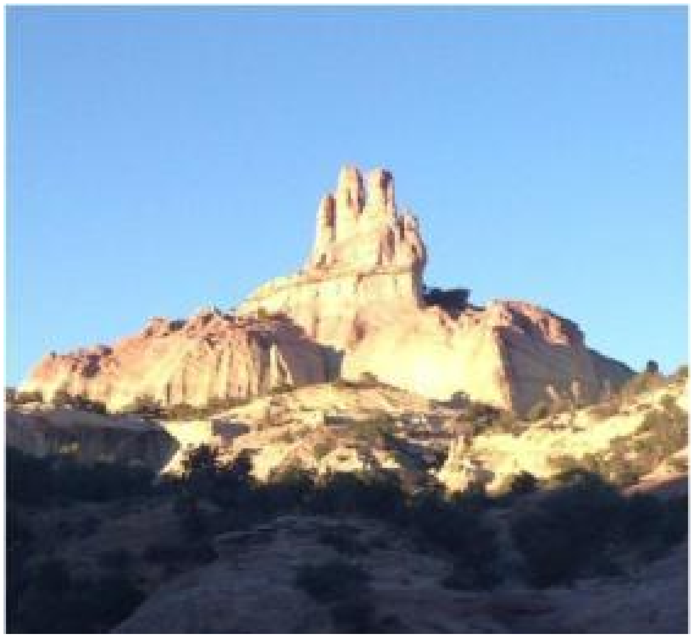
Consolidation and Groundwater Evaluation Report

(Dwyer Engineering, LLC)

MWH® now part of Stantec

95% DRAFT

CONSOLIDATION AND GROUNDWATER EVALUATION REPORT



July 2018

Northeast Church Rock Site Closure

Prepared by:
Dwyer Engineering LLC
Stephen F Dwyer, PhD, PE
1813 Stagecoach Rd. SE
Albuquerque, NM 87123

Prepared for:
United Nuclear Corporation
475 Creamery Way
Exton, PA 19341

EXECUTIVE SUMMARY

The Remedial Action (RA) referenced in the Administrative Settlement Agreement and Order on Consent (AOC) for the United Nuclear Corporation Superfund Site and Northeast Church Rock Mine Removal Site (AOC; USEPA, 2015) as described in the 2011 Action Memorandum (USEPA, 2011) and 2013 Record of Decision (ROD) (USEPA, 2013) calls for the excavation of approximately 1,000,000 cubic yards (cy) of mine waste from the Mine Site and placement at the Mill Site. Mine waste will be disposed of in a repository designed within the footprint of the existing tailings impoundment at the Mill Site. An Evapotranspiration (ET) cover composed of compacted soil overlain by a rock/soil admixture will then be placed over the mine waste (Dwyer 2017).

Placement of the mine spoils and subsequent ET Cover will place added weight and thus stress on the existing tailings material originally placed within the existing impoundment. This report presents an overview of the potential effect of this added weight on these tailings and subsequently on the underlying groundwater. That is, the report summarizes findings comparing the impact on groundwater before mine spoil placement and ET Cover versus after materials placement on the existing impoundment.

The results of the evaluation showed that there is a small amount of consolidation and thus reduction in porosity in the tailings due to the added weight from placement of the mine spoils and ET Cover on the existing impoundment. However, there is no drainage impact into the underlying groundwater. That is, there is no increase in flux into the underlying groundwater from the tailings impoundment.

Findings from the analyses show that the new ET Cover prevents flux while the existing cover potentially allows small amounts of percolation. Consequently, the addition of the mine spoils and new ET Cover should help reduce potential future groundwater impacts from the impoundment.

Table of Contents

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent
ASTM	American Society for Testing and Materials
BGS	below ground surface
cm	centimeter
cy	cubic yards
DWYER	Dwyer Engineering, LLC
EP	evaporation
ET	evapotranspiration
LAI	leaf area index
MDD	maximum dry density
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
MWH	Montgomery Watson Harza
NECR	Northeast Church Rock
PET	potential evapotranspiration
PODR	Point of Diminishing Returns
RA	Removal Action
ROD	Record of Decision
RLD	root length density
SWCC	soil water characteristic curve
Tp	transpiration
UNC	United Nuclear Corporation
USEPA	United States Environmental Protection Agency

1.0 PURPOSE

United Nuclear Corporation (UNC) is evaluating the possibility of placing soils removed during the Mine Site Removal Action (RA) on the existing mill site tailings impoundments as per an Administrative Settlement Agreement Order on Consent for Design and Cost Recovery (AOC, USEPA, 2015). The purpose of this consolidation and modeling analysis on the UNC NECR mine tailings was to evaluate any potential impact on groundwater due to deposition of mine spoils and a new ET Cover on the existing impoundment. The weight from placement of these materials on the existing impoundment will add stress and some consolidation to the existing near saturated tailings. The designed ET Cover has adequate performance for 1,000-years to include limiting meteoric flux into the underlying mine waste, minimize erosion, provide a rooting medium for native vegetation, and attenuate emanation of radon-222 from the mine waste (Dwyer 2017).

1.1 Site Background

The existing ground surface and tailings thickness is shown on Figure 1. Figure 1 also shows the geometry of the proposed mine spoils placement and the boring locations for a geotechnical field investigation performed at the site (MWH 2014). This analysis evaluated the worst case areas; if these areas pose no significant impact to groundwater, it can be inferred that the rest of the repository poses no risk to groundwater.

1.2 Methods

The analysis evaluated the water balance and moisture status of the four profiles described in Section 2. Existing conditions ('before' condition) were compared to the same profiles with the proposed mine spoils and ET Cover placed on the impoundment (the 'after' condition) whereby the tailings experienced consolidation from the added weight of the placed materials. The consolidation and modeling analysis was performed to evaluate potential impact on groundwater from deposition of mine spoils and a new ET Cover on the existing mill tailings impoundment. The analysis described is composed of computations including consolidation and unsaturated flow modeling. The surcharge loading due to the weight of the mine spoils and new cover is expected to impact the existing tailings by consolidating the near saturated (greater than 90 percent of saturation) fine-grained materials. This consolidation will then impact the hydraulic properties of the tailings by reducing the porosity of the soil, albeit very small. Finally, the potential impact to groundwater was evaluated due to the potential increase in drainage from wet fine-grained tailings (tailings of particular concern are generally greater than 90 percent degree of saturation).

The hydraulic properties of the existing materials (identified in a 2014 site investigation) were utilized as input parameters in unsaturated modeling to estimate the water balance of the profiles prior to placement of any additional materials on the existing repository. These soils hydraulic properties were then altered based on the reduction in porosity of the fine-grained tailings due to consolidation. The changed soil hydraulic properties were utilized as input parameters in the subsequent analysis of the same four profiles 'after' placement of the mine spoils and ET Cover. The results for the 'before' and 'after' conditions were compared to verify if an increase in drainage from the alluvium beneath the tailings could impact groundwater due to placement of the mine spoils and ET cover on the existing impoundment.

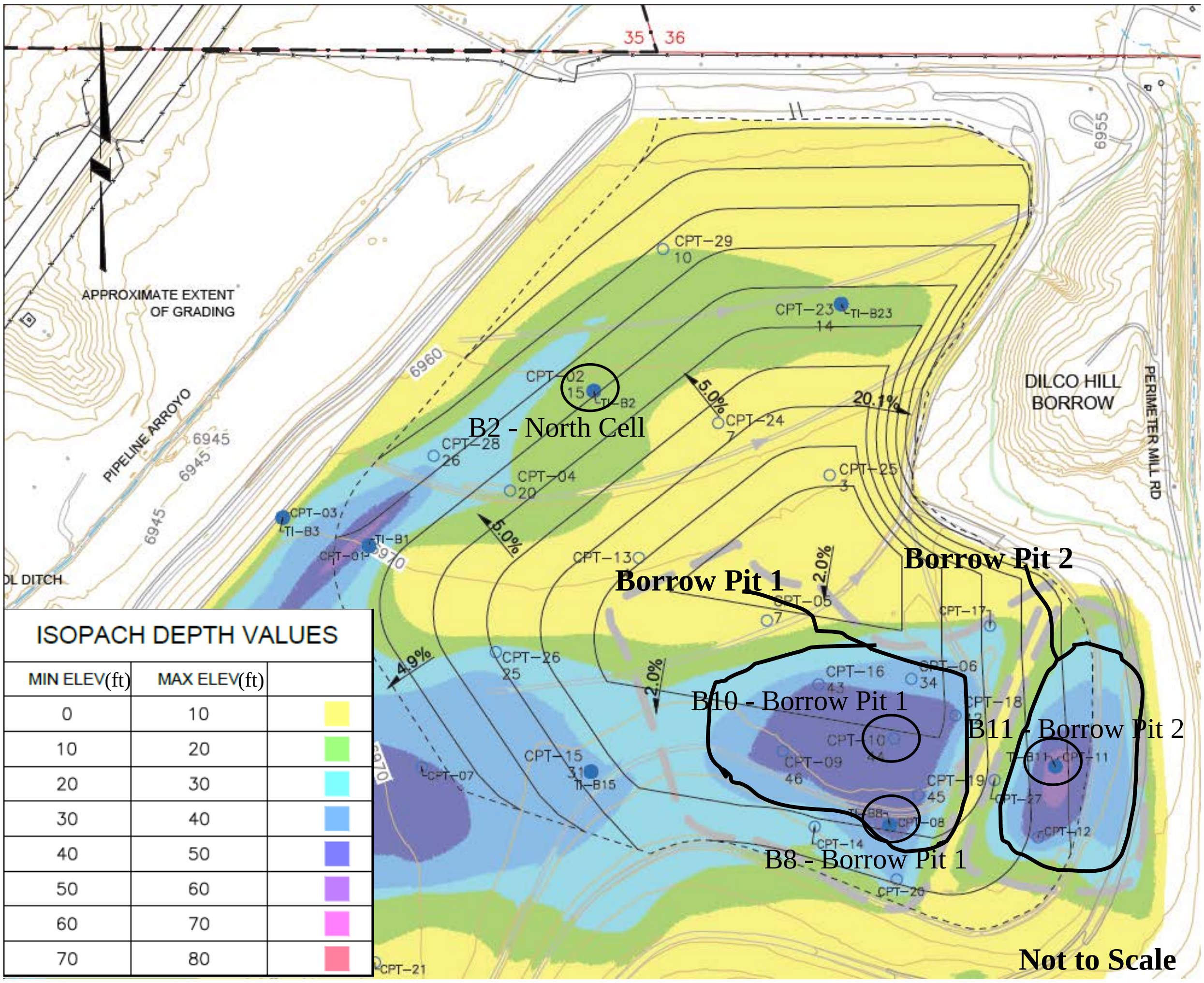


Figure 1. Existing Ground Surface and Tailings Thickness with Boring Locations and Repository Plan

2.0 PROFILES EVALUATED

According to historical documents (Canonie, 1987), the upper seven-feet (minimum) of the impoundment in the vicinity of the repository footprint consists of an existing cover and either fill or coarse-grained tailings. Beneath these layers is the fine-grained tailings layer (if any) (MWH 2014). Deep fine-grained tailings beneath the proposed repository are associated with Borrow Pits 1 and 2 (Figure 1).

A geotechnical investigation at the site (MWH 2014) assessed the volume, location, and properties of tailings (Figures 1 and 3). Results identified the presence of fine-grained tailings within the impoundment that have relatively high moisture content and a very low saturated hydraulic conductivity (about 10^{-8} cm/sec), which lessens their ability to drain the moisture. The overlying coarse-grained tailings were relatively dry compared to the fine-grained tailings. The saturated hydraulic conductivity of the coarse-materials is several orders of magnitude higher (about 10^{-4} cm/sec) than the fine-grained tailings.

The alluvium beneath the fine-grained tailings was much drier than the fine-grained tailings with a saturated hydraulic conductivity several orders of magnitude higher than the fine-grained tailings. The higher hydraulic conductivity of the alluvium allowed this material to drain after operations much faster than the fine-grained tailings. Thus, the very low saturated hydraulic conductivity of the fine-grained tailings is controlling the drainage of the profile (Figure 2).

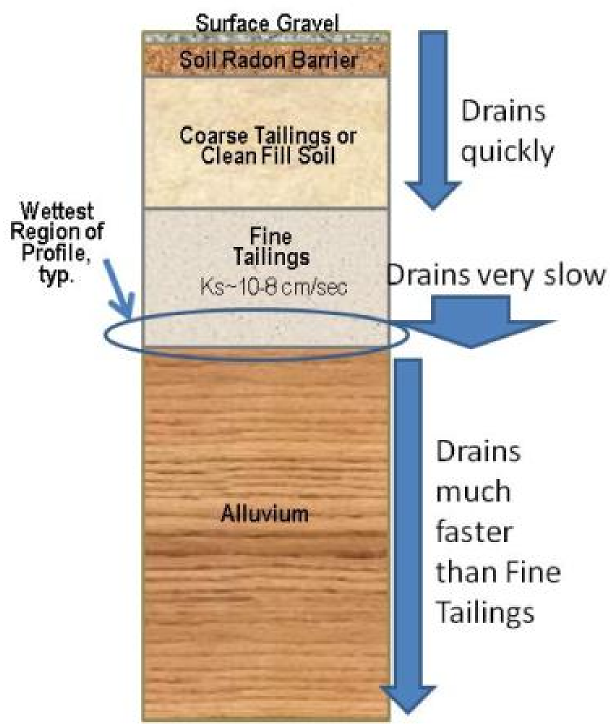


Figure 2. Typical Cross Section of Existing Impoundment

The profiles evaluated were chosen based on (1) general representativeness of the areas of most concern, and (2) completeness of field data available for those locations. These areas include the borrow pits where the deepest fine-grained tailings or slimes exist as well as other areas as described in MWH (2014). The areas evaluated include fine-grained tailings near to or exceeding

90 percent saturation. Cone penetrometer testing (CPT) was performed at these locations along with physical sampling and laboratory measurements of soil textures and hydraulic properties.

This analysis evaluated the worst case areas: Borrow Pit 1 (Borings B8 and B10) and Borrow Pit 2 (Boring B11). A typical cross section in the North Cell (Boring B2) was also analyzed because it has fine-grained tailings near saturation.

The analysis evaluated the water balance and moisture status of the four profiles (B2, B8, B10, and B11). Figure 3 shows the depth from the top of the planned finished grade after placement of mine spoils and ET Cover to the base of the existing tailings. Deep tailings beneath the proposed repository are associated with Borrow Pit 1 and 2 (Figure 3).

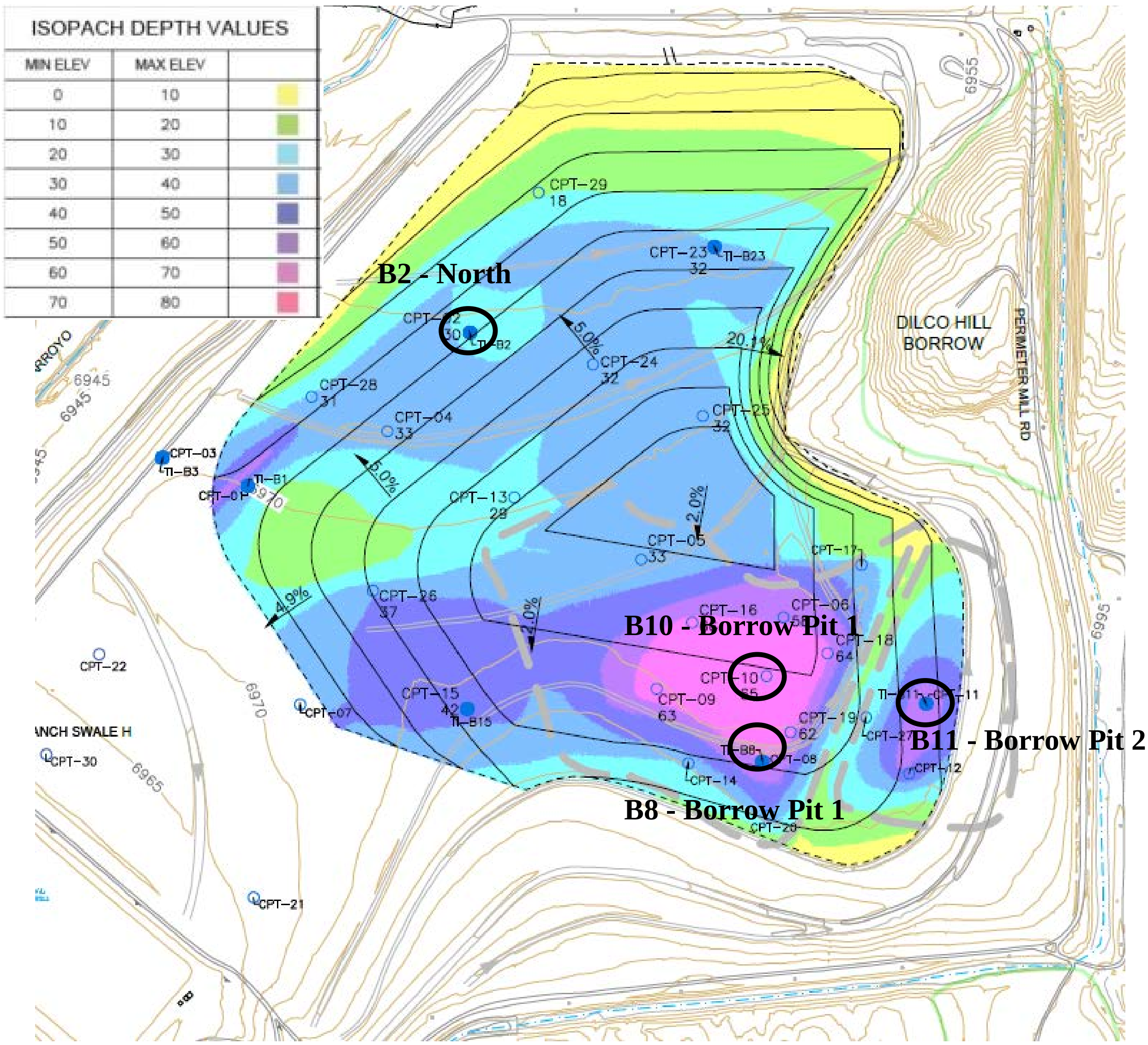


Figure 3. Repository Plan: Depth of Planned Finished Grade to Base of Tailings

3.0 CONSOLIDATION OF TAILINGS

Consolidation of the fine-grained tailings was performed to assess the potential impact on groundwater due to the addition of mine spoils on the existing impoundment at the NECR site. Consolidation is a concern because the fine-grained tailings are at or near saturation and consolidation will more strongly affect the hydraulic properties of these soils. The other materials within the profile are relatively dry and any consolidation should not force excess pore water from them.

Consolidation of soil occurs in three stages:

a. Immediate –takes place as the soil is placed

b. Primary – occurs after soil placement and impacts relatively fine-grained soils (such as the fine-grained tailings or slimes); involves the removal of excess pore water from the soil

c. Secondary – this stage is time dependent and occurs following primary consolidation

Immediate consolidation occurs as the load is applied or within about 7 days and is defined as elastic deformation of soils. Immediate consolidation was not considered relevant to this analysis because it is associated with consolidation that takes place **without change to soil moisture content** and it predominates in cohesion-less soils and unsaturated clay. Additionally, immediate consolidation analyses apply to fine-grained soils including silts and clays with a degree of saturation less than 90% and for coarse grained soils with a large coefficient of permeability (i.e. greater than $10x10^{-3}$ m/s) (Bowles 1996). The analysis summarized in this report focuses on the fine-grained tailings that generally have a degree of saturation greater than 90%.

Primary consolidation typically includes the largest volume change and dominates in saturated/nearly saturated fine-grained soils where consolidation theory applies (Figure 4). It is caused by a reduction in void space and subsequent squeezing of excess pore water from the materials. This analysis calculated the primary consolidation to quantify the impact on near-saturated fine-grained tailings given the placement of mine spoils and ET Cover on the existing impoundment. Canonie (1990 and 1992) stated primary consolidation completed within a few months for the fine-grained tailings when the existing cover was placed.

Secondary consolidation occurs after primary consolidation where excess pore water pressures have dissipated in the soil. Secondary consolidation was not considered in the analysis because it is time dependent and occurs under constant effective stress from continuous rearrangement of clay particles into a more stable configuration. Secondary consolidation is generally a significantly smaller amount of total deformation than primary consolation and occurs more slowly than primary consolidation (Figure 4).

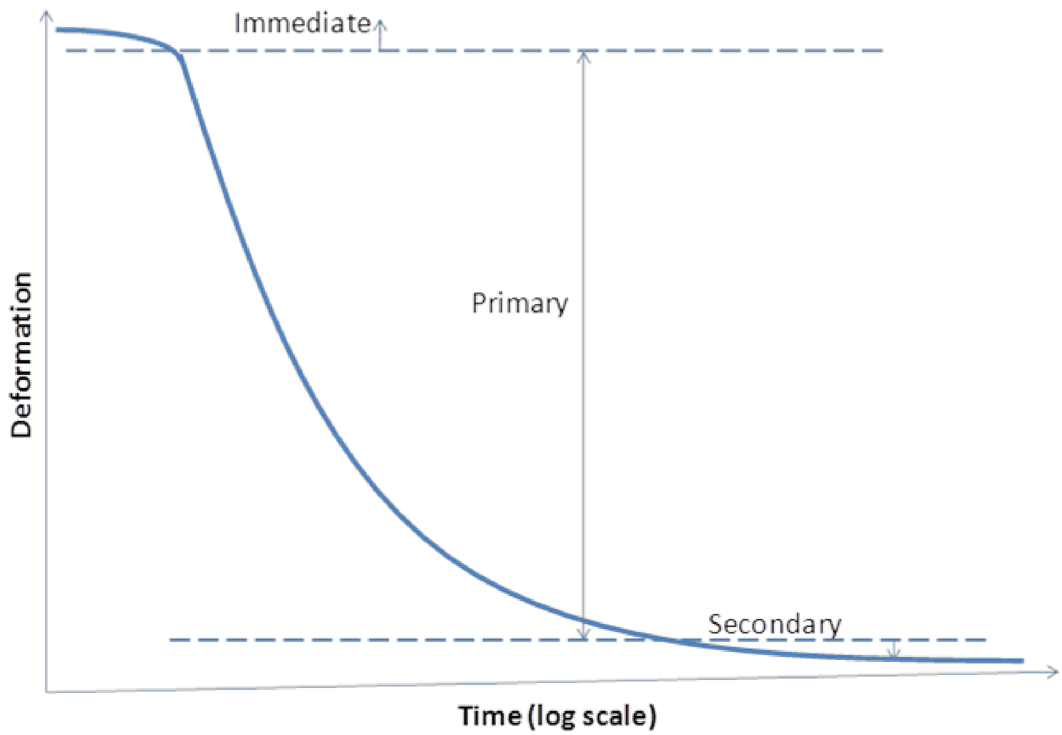


Figure 4. Consolidation Stages

3.1 CONSOLIDATION THEORY

Vanapalli and Oh (2010) showed that the use of saturated soil properties is appropriate for estimation of settlement in unsaturated fine-grained soils including the theory of consolidation by Terzaghi (1943).

Terzaghi's theory of consolidation is a common engineering concept utilized to compute primary consolidation in fine-grained soils. According to Karl Terzaghi "…consolidation is any process which involves a decrease in water content of saturated soil without replacement of water by air." Consolidation is the process in which reduction in volume takes place by reduction in void space under long-term static loads. It occurs when stress is applied to a soil and the soil particles pack together more tightly, reducing the bulk volume. When this occurs in saturated conditions, water will be squeezed out of the soil. The magnitude of consolidation can be predicted by many different methods. In the classical method, developed by Terzaghi, soils are tested in the laboratory to determine their one-dimensional compression index under vertical load. This was performed on soil samples from the tailings (MWH 2014). This change in void space can be used to predict the amount of consolidation that would occur under similar loading in the field. This is the method of consolidation analysis utilized for the tailings materials in this analysis.

Terzaghi's theory of 1-D consolidation makes the following simplifying assumptions:

1. The soil is homogeneous
2. The soil is fully saturated
3. The solid particles and the pore water are incompressible

4. The flow of water and compression of soil is one-dimensional (vertical)
5. Strains are small
6. Darcy’s law is valid at all hydraulic gradients
7. The coefficient of permeability and the coefficient of volume compressibility remain constant throughout the consolidation process
8. There is a unique relationship, independent of time, between void ratio and effective stress

Assumptions 1 to 5 are straightforward and generally pose no difficulties in applying Terzaghi’s theory to practical problems. The analysis performed evaluated each relatively homogenous tailings layer independently while analyzing the profile as a whole thus satisfying assumption 1. Typical consolidation analyses assume a single compression index for the total fine-grained tailings thus treating all fine-grained tailings as a single layer. This analysis utilized a measured compression index for each soil texture change measured in each respective profile (MWH 2014) of the fine-grained tailings and thus evaluated each specific layer individually in calculating consolidation for that respective layer. Furthermore, each homogeneous layer within the fine-grained tailings had its respective hydraulic properties adjusted as input parameters for the subsequent unsaturated flow modeling performed for the cross section. This allowed for heterogeneity within the vertical profile to be evaluated in the modeling. Assumption 2 lends conservatism to the analysis given most of the tailings are unsaturated.

At very low hydraulic gradients, there is evidence that pore water flow doesn’t take place according to Darcy’s law as stated in Assumption 6. However, for most fine-grained soils, the hydraulic gradient is sufficiently high and therefore, this assumption is acceptable.

A limitation of Terzaghi’s theory specific to this analysis is generally found in assumption 7. The coefficient of permeability and the coefficient volume compressibility generally decrease with increasing effective stress. That is, the coefficient of permeability is not constant through the consolidation process; rather the saturated permeability of soil generally decreases as density increases. The analysis presented here assumes a constant permeability in the tailings under consideration even after consolidation; the saturated hydraulic conductivity of the tailings at 'before' density in both the 'before' and 'after' scenarios. The modeling performed assumed a constant saturated hydraulic conductivity for tailings materials even though each layers' moisture retention or unsaturated hydraulic properties were adjusted to reduce the storage capacity. This adds conservatism to the analysis because as the tailings are compacted, typically the saturated hydraulic conductivity would also be reduced which would slow water movement and ultimately reduce the predicted annual flux through the base of the unsaturated alluvium.

Another limitation of Terzaghi’s theory originates from Assumption 8. Experimental results have shown that the relationship between the void ratio and effective stress is not independent of time. Most fine-grained soils undergo a decrease in void ratio with time (called secondary consolidation or creep) at constant effective stress. Therefore, Terzaghi’s theory is good only for the estimation of primary consolidation.

Terzaghi's theory of primary consolidation is represented by the following equation:

$$S_p = C_c \times \left(\frac{H}{1+e}\right) log\left(\frac{\sigma+\Delta\sigma}{\sigma}\right) \qquad \textbf{Equation 3-1}$$

where:

S_p = primary settlement

C_c = primary consolidation coefficient

H = fine tailings layer thickness before settlement

e = void ratio

σ = initial stress

Δσ = change in stress (additional weight due to spoils and ET Cover)

The use of this theory is intended to provide a conservative value of consolidation. This would in turn produce a conservatively high reduction in storage capacity of each tailings layer considered as well as a conservatively higher degree of saturation after loading. The use of the primary consolidation estimation is appropriate because the soils are fine-grained and are generally near saturation (90 percent saturated or higher) [Vanapalli and Oh 2010]. Saturated soils are generally more compressible than unsaturated soils under the same loading conditions and the approach is intended to account for the settlement that would occur under saturated loading.

3.2 CONSOLIDATION RESULTS

The settlement calculated in a fine-grained tailings layer allowed for respective reduction of the layer thickness when comparing existing conditions to the expected conditions after placement of the mine spoils and ET Cover. For example, the geometry representing the geologic cross-section of Profile B2 modeled for the existing conditions of the fine-grained tailings was 2.5-ft thick. The weight of the mine spoils and ET Cover placed on the impoundment directly above this profile caused the fine-grained tailings to settle 0.18 ft. Thus, the geometry for the comparative profile modeled included this layer reduced to 2.32-ft thick.

Based on the consolidation estimated in the fine-grained tailings, the final void ratio and thus porosity of the respective layer was computed. Assuming the porosity and saturated moisture content are the same, the reduced porosity was used to adjust the saturated moisture content and moisture retention curve (Figure 6). Finally, the final degree of saturation of the fine-grained tailings layer(s) was calculated to allow for an adjustment to the initial suction value(s) for each respective layer based on the adjusted moisture characteristic curve for the soil layer similar to that seen in Figure 6 (refer to Section 4).

The ET Cover and mine spoils soil weight was calculated as follows (weights of soil for ET Cover and Mine Spoils derived in Appendix G, Attachment G.3 of the 95% Design Report):

1. Maximum dry density of cover soil [average value based on MWH (2014)] is 115 pounds per cubic foot (pcf). The moisture content of the soil is estimated at 10.8 percent (the average of the optimum moisture content less 3 percent) and is used to be consistent with MWH (2014). This is the likely moisture content of the soil installed. Thus, the moist unit weight of the cover soil at 90 percent relative density is 114.68 pcf. Similarly, the soil/rock admixture unit weight is 130 pcf with 33 percent rock by volume. The moisture content taking into account the rock is 6.3 percent. This yields a moist unit weight of 129.64 pcf

for the rock/soil admixture. Assuming the worst case or heaviest cover combination that would yield the most consolidation of underlying materials; the admixture consisting of 3-inch rock at a depth of 27 inches is used to quantify the consolidation. Given the cover is 4-ft thick and the admixture is 27-inches thick, the moist weight of the cover soil for the full cover thickness is then 492.4 psf.

2. Maximum dry density of mine spoils [average value based on MWH (2014)] is 118.3 pcf. The moisture content of the soil is 9.3 percent. This is the average of the optimum moisture content less 3 percent and used to be consistent with MWH (2014). This is the likely moisture content of the soil installed. The moist unit weight of the mine spoils soil at 90 percent relative density is 116.37 pcf. This unit weight was then multiplied by the respective depth of mine spoils in each profile evaluated.

The input data utilized to quantify the settlement in the wet/finer-grained tailings, the final void ratio, and the final degrees of saturation are summarized in Tables 1 to 4. These input data were measured values obtained during the pre-design study (MWH 2014). Results of the CPT (MWH 2014) for boring profiles B2, B8, B10, and B11 are included in Appendix B. Appendix B and MWH (2014) contain details on the measured values shown in Tables 1 to 4 for each layer or textural change in the geologic cross section and layer thicknesses of the existing materials at the impoundment. Other values shown in these tables were computed.

A spreadsheet was prepared to compute the settlement, final void ratio, and final degree of saturation after application of the mine spoils and new ET Cover. The total settlement of the fine-grained tailings estimated for Profile B2 was 0.18 ft with a final degree of saturation of 92.3 percent (Table 1). This profile is in the north cell where the fine-grained tailings are relatively thin; most areas of the north cell contain no fine-grained tailings (Figures 1, 3, and 8). There were no saturated tailings in this profile 'before' or 'after' placement of the mine spoils and ET Cover.

Profile B10 is in Borrow Pit 1 where the tailings of concern are 25.5 ft thick located from 37.1 ft below ground surface (BGS) to a depth beyond 62.6-ft BGS (Figure 10). The CPT instrumentation experienced refusal at this depth. The total settlement of the fine-grained tailings (and coarser-grained tailings sandwiched within them) estimated for Profile B10 was 0.93 ft (Table 3). Each unsaturated layer's moisture retention curve and the final degrees of saturation (degree of saturation was higher after consolidation) were adjusted and used to compute a revised *initial* suction value for the fine-grained tailings layers in the *'after'* condition. Any water 'squeezed' from a fine-grained layer within the profile was added to an adjacent tailings layer. This resulted in saturation of most of the fine-grained tailings in Profile B10 and thus an initial suction value of zero in the 'after' condition (Table 3).

The total settlement of the fine-grained tailings (and coarser-grained tailings sandwiched among them) estimated for Profile B11 was 0.1 ft (Table 4). There were no saturated tailings in this profile 'before' or 'after' placement of the mine spoils and ET Cover. Since each layer of the fine-grained tailings was unsaturated, each layer's moisture status was computed individually similarly to that described in the paragraph above. That is, each unsaturated individual layer's moisture retention curve and the final degree of saturation (degree of saturation was higher after consolidation) was adjusted and used to compute a revised *initial* suction value for the fine-grained tailings layers in the *'after'* condition. This profile is in Borrow Pit 2 where the tailings of concern are 11.5 ft thick located from 41.3 ft BGS to a depth of about 52.8-ft BGS (Figure 11).

Since Profiles B2, B10, and B11 each had at least one unsaturated layer within the tailings 'after' consolidation, each unsaturated layer's adjusted suction value was computed accounting for the adjusted soil water characteristic curve (SWCC) with the reduced saturated moisture content from the estimated consolidation (Figure 6). Any saturated layer 'after' consolidation had an initial suction value of zero assigned to it. Soil suction at saturation is zero. Refer to Section 4.2.5 and Tables 11, 13, and 14 for these values.

The total settlement of the fine-grained tailings (and coarser-grained tailings sandwiched within them) estimated for Profile B8 was 0.65 ft with a final degree of saturation of 100 percent [weighted average] (Table 2). Any water 'squeezed' from a fine-grained layer within the profile was added to an adjacent tailings layer. Since the weighted average of these fine-grained tailings was saturated, all layers of fine-grained tailings and coarse-grained tailings sandwiched within them were assigned an initial soil suction of zero (Table 12). This profile is in Borrow Pit 1 where the tailings of concern are 18.5 ft thick located from 35.2 ft BGS to a depth of about 53.7 ft BGS (Figure 9). This was the only profile where the moisture status of fine-grained tailings after consolidation was calculated to be fully saturated due to placement of the mine spoils and ET Cover on the impoundment. The SWCC was adjusted similarly to the other profiles (Figure 6), but the new soil suction value for the tailings of concern used in the 'after' condition where the full profile included the mine spoils and ET cover along with consolidated tailings thicknesses was zero for all tailings of concern.

Table 1. B2: Soil Properties to Determine Fine-Grained Tailings Consolidation[b]

Layer	Layer Thickness (ft)	Dry Bulk Density (pcf)	Water Content (g/g)	Bulk Density (pcf)	Weight of Layer (lbs)	SG	Initial Saturation	Initial Void Ratio	Initial Stress (psf)	Change in stress (psf)	Cc	Settlement (ft)	Final Void Ratio	Final Saturation
ET Cover	4				492.4									
Mine Spoils	10.8			116.4	1257									
Fill	0.5	100.4	7.7%	108.1	54.1	2.68	31.0%	0.67	27.0	1749.2				
Fill	5.5	75.9	24.5%	94.5	519.7	2.73	53.7%	1.25	313.9	1749.2				
Fine Tailings	2.5	73.4	39.6%	100.8	251.97	2.78	80.7%[a]	1.36	699.8	1749.2	0.315	0.18	1.19	92.3% [a]

[a]The initial degree of saturation is less than 90 percent. However, it is the wettest soil in the profile and was conservatively treated as though it was wetter and that the Terzaghi consolidation theory applies. When applying the theory, the final degree of saturation after consolidation is wetter than 90 percent.

[b]The soil properties are taken from MWH (2014).

Table 2. B8: Soil Properties to Determine Fine-Grained Tailings Consolidation[c]

Layer	Layer Thickness (ft)	Dry Bulk Density (pcf)	Water Content (g/g)	Bulk Density (pcf)	Weight of Layer (lbs)	SG	Initial Saturation	Initial Void Ratio	Initial Stress (psf)	Change in stress (psf)	Cc	Settlement (ft)	Final Void Ratio	Final Saturation
ET Cover	4				492.4									
Mine Spoils	11.7				1361.5									
Coarse Tailings	18.5	103.7	9.0%	113.0	2091.1	2.72	38.4%	0.64	1045.6	1853.9				
Coarse Tailings	0.5	99.6	6.2%	105.8	52.9	2.72	23.9%	0.70	2117.6	1853.9				
Coarse Tailings	0.5	91.7	16.8%	107.1	53.6	2.72	53.7%	0.85	2170.8	1853.9				
Fine Tailings	4.5	62.7	61.8%	101.5	456.9	2.8	96.9%	1.79	2426.0	1853.9	0.426	0.17	1.68	Saturated
Fine Tailings	4	74.8	41.4%	105.7	423.0	2.6	92.0%	1.17	2865.9	1853.9	0.426	0.17	1.08	Saturated[a,b]
Coarse Tailings	0.5	90.9	14.3%	103.9	51.9	2.66	46.0% [a]	0.83	3103.4	1853.9	0.094	0.01	0.81	Saturated[a,b]
Coarse Tailings	0.5	89.6	16.5%	104.3	52.2	2.67	51.2% [a]	0.86	3155.5	1853.9	0.094	0.01	0.84	Saturated[a,b]
Fine Tailings	5.5	80.4	39.7%	112.30	617.7	2.63	Saturated	1.04	3490.4	1853.9	0.426	0.21	0.96	Saturated
Coarse/Fine Tailings	0.5	83.6	34.3%	112.3	56.1	2.72	90.5%	1.03	3827.3	1853.9	0.262	0.01	0.99	Saturated[a,b]
Coarse/Fine Tailings	2.5	92.3	29.3%	119.3	298.4	2.72	94.9%	0.84	4004.6	1853.9	0.262	0.06	0.80	Saturated
Fine Tailings	0.5	74.8	43.3%	107.2	53.6	2.6	96.2%	1.17	4180.5	1853.9	0.426	0.02	1.10	Saturated

[a]The initial degree of saturation is less than 90 percent. However, the layers are sandwiched between saturated or near saturated soils consequently these layers were treated as though they were wetter and that the Terzaghi consolidation theory applies. When applying the theory, the final degree of saturation after consolidation is wetter than 90 percent.

[b]The calculated value for this layer is less than saturation, but the calculated value for the entire fine-grained tailings layer inclusive of the sandwiched coarse-grained tailings layer was saturated. Water that is presumed to be squeezed from a previous saturated layer or near- saturated layer was included in an adjacent layer that was not saturated.

[c]The soil properties are taken from MWH (2014)

Table 3. B10: Soil Properties to Determine Fine-Grained Tailings Consolidation[c]

Layer	Layer Thickness (ft)	Dry Bulk Density (pcf)	Water Content (g/g)	Bulk Density (pcf)	Weight of Layer (lbs)	SG	Initial Saturation	Initial Void Ratio	Initial Stress (psf)	Change in stress (psf)	Cc	Settlement (ft)	Final Void Ratio	Final Saturation
ET Cover	4				492.4									
Mine Spoils	11.7				1361.5									
Coarse Tailings	5	96.8	9.0%	105.512	527.6	2.63	34.0%	0.70	263.8	3122.4				
Coarse Tailings	5.5	99.1	7.5%	106.5325	585.9	2.61	30.4%	0.64	820.5	3122.4				
Coarse/Fine Tailings	7.5	92.9	26.7%	117.7239	882.9	2.72	87.7% [a]	0.83	1555.0	3122.4	0.111	0.22	0.77	95.0% [a]
Fine Tailings	1	73.4	41.0%	103.4835	103.5	2.78	83.5% [a]	1.36	2048.2	3122.4	0.315	0.05	1.24	Saturated [a, b]
Fine Tailings	2	64.3	57.4%	101.2124	202.4	2.8	93.5%	1.72	2201.1	3122.4	0.315	0.09	1.60	Saturated
Fine Tailings	4	73.4	45.3%	106.6394	426.6	2.78	92.3%	1.36	2515.6	3122.4	0.315	0.19	1.25	Saturated
Coarse Tailings	1	100.1	15.4%	115.5154	115.5	2.67	61.8% [a]	0.67	2786.6	3122.4	0.094	0.02	0.63	Saturated [a,b]
Fine Tailings	2.5	72.5	47.7%	107.0926	267.7	2.78	95.2%	1.39	2978.3	3122.4	0.315	0.10	1.29	Saturated[b]
Fine Tailings	0.5	64.3	51.4%	97.36704	48.7	2.80	83.8% [a]	1.72	3136.5	3122.4	0.315	0.02	1.62	Saturated [a,b]
Coarse/Fine Tailings	1	87.8	32.2%	116.0913	116.1	2.72	93.8%	0.93	3218.9	3122.4	0.111	0.02	0.90	Saturated [b]
Fine Tailings	4	73.7	45.7%	107.3809	429.5	2.56	Saturated	1.17	3491.7	3122.4	0.315	0.16	1.08	Saturated
Fine Tailings	2	74.5	47.2%	109.7301	219.5	2.78	98.8%	1.33	3816.2	3122.4	0.315	0.07	1.25	Saturated

[a]The initial degree of saturation is less than 90 percent. However, the layers are relatively fine-grained and near 90 percent saturation or sandwiched between saturated or near saturated soils consequently treated as though it was wetter and that the Terzaghi consolidation theory applies. Water presumed to be squeezed from a previous saturated layer or near- saturated layer was included in an adjacent layer that was not saturated.

[b]The calculated value for this layer is less than saturation, but the calculated value for the entire fine-grained tailings layer inclusive of the sandwiched coarse-grained tailings was saturated. Water presumed to be squeezed from a previous saturated layer or near- saturated layer was included in an adjacent layer that was not saturated.

[c]The soil properties are taken from MWH (2014).

[b]The calculated value for this layer is less than saturation, but the calculated value for the entire fine-grained tailings layer inclusive of the sandwiched coarse-grained tailings was saturated. Water presumed to be squeezed from a previous saturated layer or near- saturated layer was included in an adjacent layer that was not saturated.

[c]The soil properties are taken from MWH (2014).

Table 4. B11: Soil Properties to Determine Fine-Grained Tailings Consolidation[a]

Layer	Layer Thickness (ft)	Dry Bulk Density (pcf)	Water Content (g/g)	Bulk Density (pcf)	Weight of Layer (lbs)	SG	Initial Saturation	Initial Void Ratio	Initial Stress (psf)	Change in stress (psf)	Cc	Settlement (ft)	Final Void Ratio	Final Saturation
ET Cover	4				492.4									
Mine Spoils	0.8				1361.5									
Fine Tailings	3.5	63.73087	59.9%	101.9	356.5625	2.84	95.3%	1.78	4495.2	585.5	0.482	0.03	1.76	96.7%
Fine Tailings	8	63.7	59.9%	101.9	815	2.84	95.3%	1.78	5081.0	585.5	0.482	0.07	1.76	96.6%

[a]The soil properties are taken from MWH (2014)

4.0 UNSATURATED MODELING OF PROFILES

Unsaturated soil is comprised of liquid, solid, and gas (Figure 5). That is, in an unsaturated volume of soil, there will be some air-filled voids, water-filled voids, and solid material. An unsaturated soil has a lower hydraulic conductivity than a saturated soil. In a saturated volume of soil (θ_s), the air-filled voids are replaced with water-filled voids. The driest a soil volume can be is referred to as its residual moisture content (θ_r) where only adsorbed water remains. At this state, the hydraulic conductivity of the soil is at its lowest.

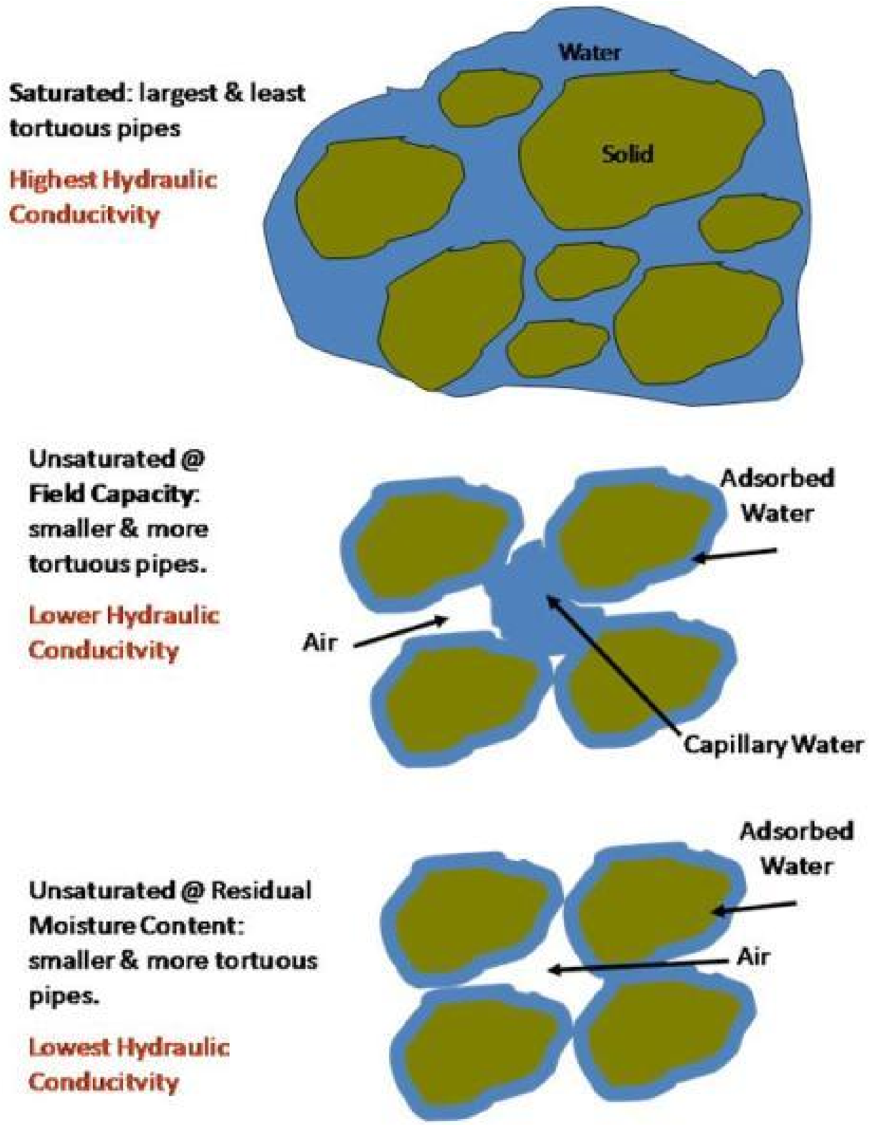


Figure 5. Components of Soil (Water, Air and Solid)

The texture and density define the moisture characteristics of a given soil and influence the storage capacity of that soil and the ability of moisture to move within the soil. These characteristics can be represented by the relationship of soil suction or matric potential to soil moisture content (Figure 6).

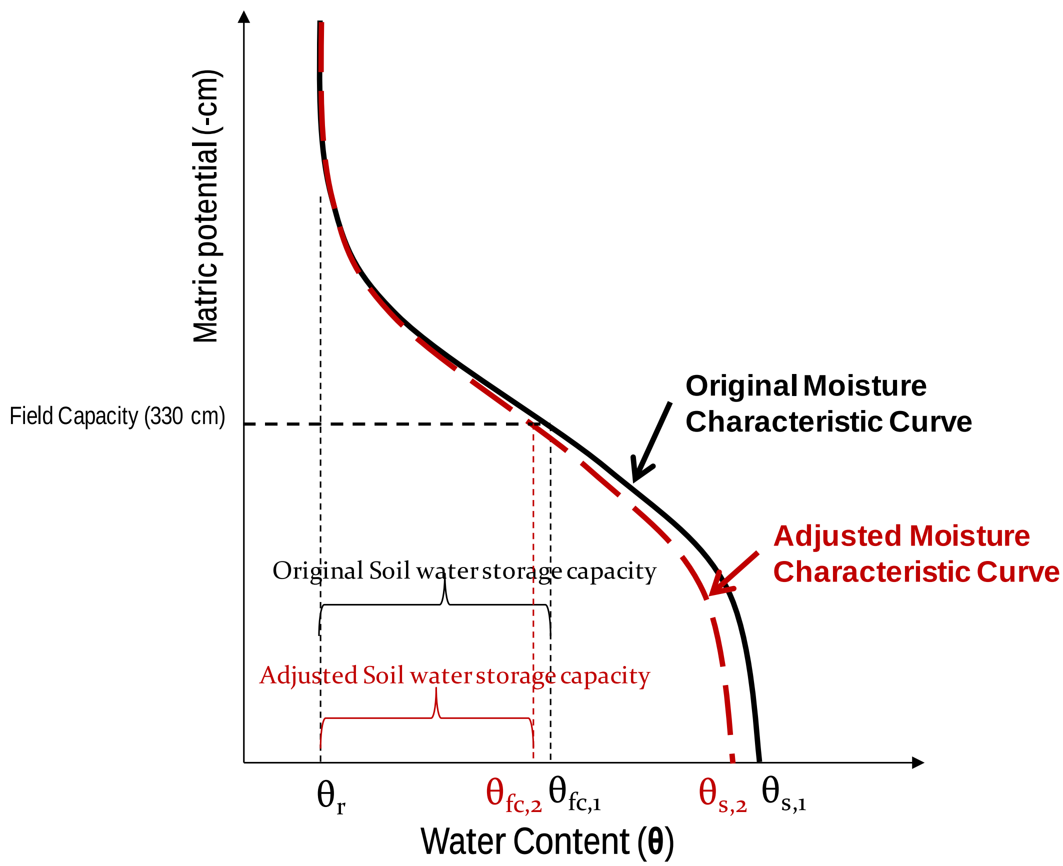


Figure 6. Change in Soil Hydraulic Properties due to Consolidation

The consolidation/modeling analysis is performed on the mill tailings to evaluate the potential change to groundwater quality due to the additional tailings seepage that might result from deposition of mine spoils and a new ET Cover on the existing impoundment. The surcharge loading due to the weight of the mine spoils and new ET Cover would compact the existing tailings by consolidating the underlying fine-grained materials. This consolidation would subsequently alter the hydraulic properties of these fine-grained tailings by reducing the storage capacity of the soil (Figure 5). Because the fine-grained tailings are wet (tailings of particular concern are generally wetter than 90 percent degree of saturation) the consolidation could potentially squeeze water from them. The hydraulic property changes affect the flow of water within each respective profile analyzed.

After consolidation of the tailings was computed (Section 3), the hydraulic properties of each fine-grained tailings layer were adjusted similar to that shown in Figure 6. The four selected profiles were then modeled to determine the annual flux at the base of the unsaturated alluvium.

4.1 OVERVIEW OF UNSAT-H

Historically, HELP (Schroeder et al, 1994) software was utilized to calculate the water balance in landfill systems. However, it is now recognized that this software has its limitations (ITRC 2003). Software more applicable for the analyses of water flow within an alternative earthen cover system is based on the Richard's Equation (ITRC 2003). A common software package in current use that is based on the Richard's equation is UNSAT-H (Fayer 2000). This unsaturated flow modeling software was designed specifically for earthen covers and is recommended for use on alternative earthen covers in the ITRC (2003) design guidance documents. Consequently, UNSAT-H was used on this project.

UNSAT-H has been used for many recent alternative earthen cover designs (Dwyer 2003). UNSAT-H is a one-dimensional, finite-difference computer program developed at the Pacific Northwest National Laboratory by Fayer and Jones (1990). UNSAT-H can simulate the water balance of soil profiles as well as soil heat flow (Fayer 2000). UNSAT-H simulates water flow through soils by solving Richards' equation and simulates heat flow by solving Fourier's heat conduction equation.

An illustration showing how UNSAT-H computes the water balance is shown in Figure 7. UNSAT-H separates precipitation falling on an earthen cover into infiltration and overland flow. The quantity of water that infiltrates depends on the infiltration capacity of the soil profile immediately prior to rainfall (e.g., total available porosity). Thus, the fraction of precipitation shed as overland flow depends on the saturated and unsaturated hydraulic conductivities of the final cover soil. If the rate of precipitation exceeds the soil's infiltration capacity, the extra water is shed as surface runoff. UNSAT-H does not consider absorption and interception of water by the plant canopy, or the effect of slope and slope-length when computing surface runoff. This allows for conservative infiltration and percolation estimates since landfill cover systems are generally sloped to encourage runoff.

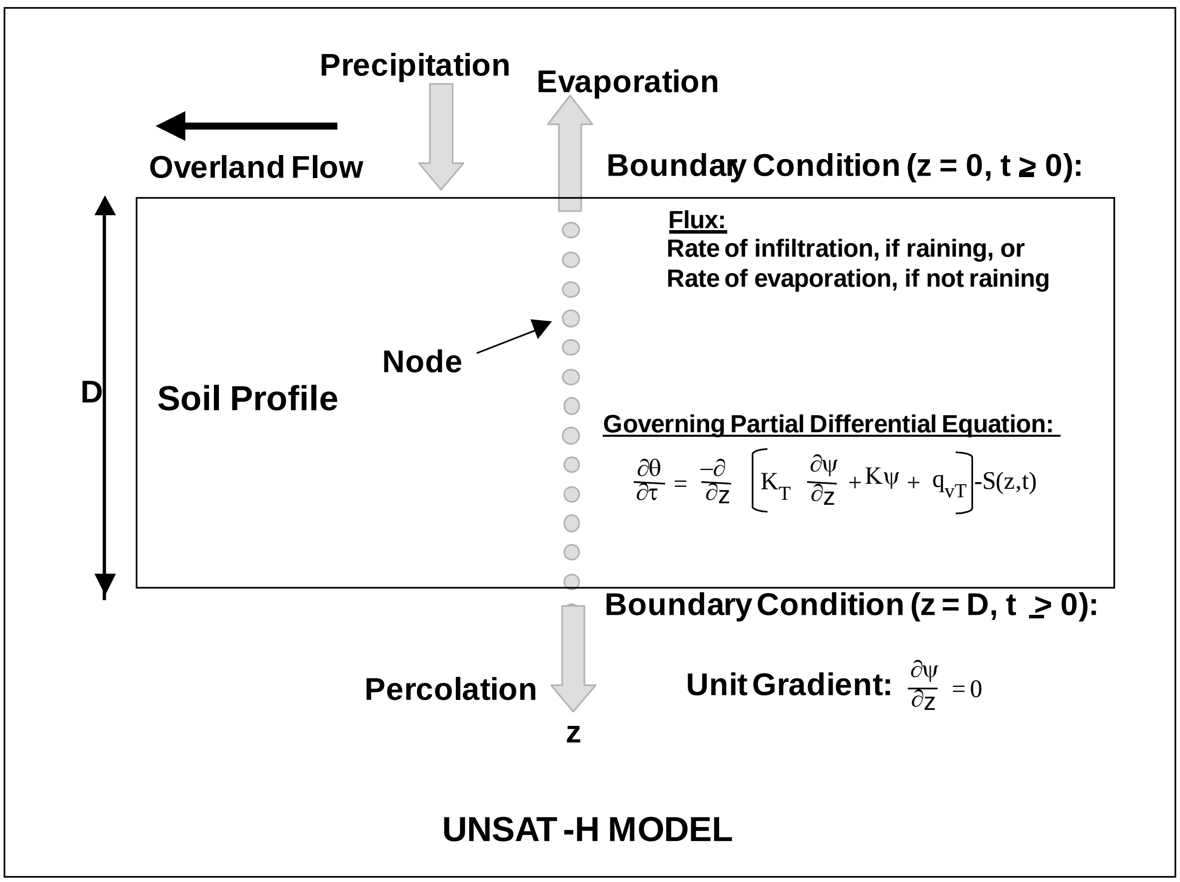


Figure 7. Schematic Representation of Water Balance Computation by UNSAT-H

Water that infiltrated a soil profile during an UNSAT-H simulation moves upward or downward as a consequence of gravity and matric potential gradients. Evaporation from the cover surface is computed using Fick's law. Water removal by transpiration of plants is treated as a sink term in Richards' equation. Potential evapotranspiration (PET) is computed from the daily wind speed, relative humidity, net solar radiation, and daily minimum and maximum air temperatures using a modified form of Penman's equation given by Doorenbos and Pruitt (1977). Soil water storage is the water stored within the entire profile modeled. Flux from the lower boundary is via percolation. UNSAT-H, being a one-dimensional program, does not compute lateral drainage.

4.2 INPUT PARAMETERS

This section provides an overview of the parameters and boundary conditions used in water balance modeling of each respective profile 'before' and 'after' consolidation of the tailings was computed for addition of mine spoils and an ET Cover.

The input parameters include the cover soil properties (MWH 2014), vegetation (Cedar Creek 2014), and profile geometry. The upper boundary condition or climate was also evaluated from typical to extreme wet conditions.

The heaviest ET Cover profile that included the 3-inch rock mixed with cover soil to a depth of 27 inches with the remaining 4-ft thickness being the similar cover soil was used in the consolidation analysis. This cover profile is heavier than the admixture with the 1.5-inch (14 inches deep) or 2-inch rock (18 inches deep) because the admixture layer is thicker. Using the heaviest cover profile added conservatism to the analyses because additional weight increased consolidation.

Based on results of the cover design sensitivity analysis performed (Dwyer 2017), the most conservative profile for unsaturated flow is the cover profile utilizing the 1.5-inch rock mixed with soil to a depth of 14 inches, with the remainder of the cover being the similar cover soil. Consequently, this profile was used in the unsaturated flow modeling to add conservatism to the analyses. That is, the thinner 14-inch-thick admixture layer allowed a quicker infiltration than that with the 3-inch rock because the rock-adjusted effective saturated hydraulic conductivity of the 1.5-inch rock admixture is greater than that for the 3-inch rock admixture. The 3-inch rock is thicker and thus the reduced saturated hydraulic conductivity applies to a thicker region. The results from the design sensitivity analysis (Dwyer 2017) showed all profiles that included the new vegetated ET Cover produced no downward flux, thus the final cover system geometry has no significant sensitivity to the modeling results of the profiles inclusive of the mine spoils and ET Cover.

4.2.1 MODEL GEOMETRY

The model geometry for existing conditions was based on measured layer thicknesses as determined via the exploratory drilling program (MWH 2014). The four profiles evaluated are well defined based on both CPT and borehole investigations at each respective location. CPT results for boring profiles B2, B8, B10, and B11 are included in Appendix B.

The geometry for the subsequent analysis of 'after' conditions included a reduction in overall thickness of the wet tailings due to consolidation induced by the weight of the mine spoils and ET Cover. The profiles modeled also include the mine spoils and new ET Cover while removing the rock within the existing cover (this rock will be scavenged for inclusion in the final closure of the site).

The nodal spacing was set at a range narrow enough to accurately represent the modeled cover profile. For the profiles with the mine spoils and ET Cover, the total cover thickness is 4 feet. The surface admixture is 14 inches thick in the ET Cover. A general summary of the profiles modeled is included in Sections 4.2.1.1 through 4.2.1.4.

4.2.1.1 PROFILE B2

Profile B2 represents an area within the north cell with wet, fine-grained tailings (Figures 1 and 2). Much of the north cell has no fine-grained tailings (MWH 2014). Figure 8 summarizes the 'before' and 'after' profiles for B2 for potential impact on the underlying groundwater. The figure shows the profile for current conditions and the post- construction profile, taking into account the respective consolidation in the fine-grained tailings.

The borehole at location B2 stopped at 32 ft BGS. No saturated condition was encountered in this borehole.

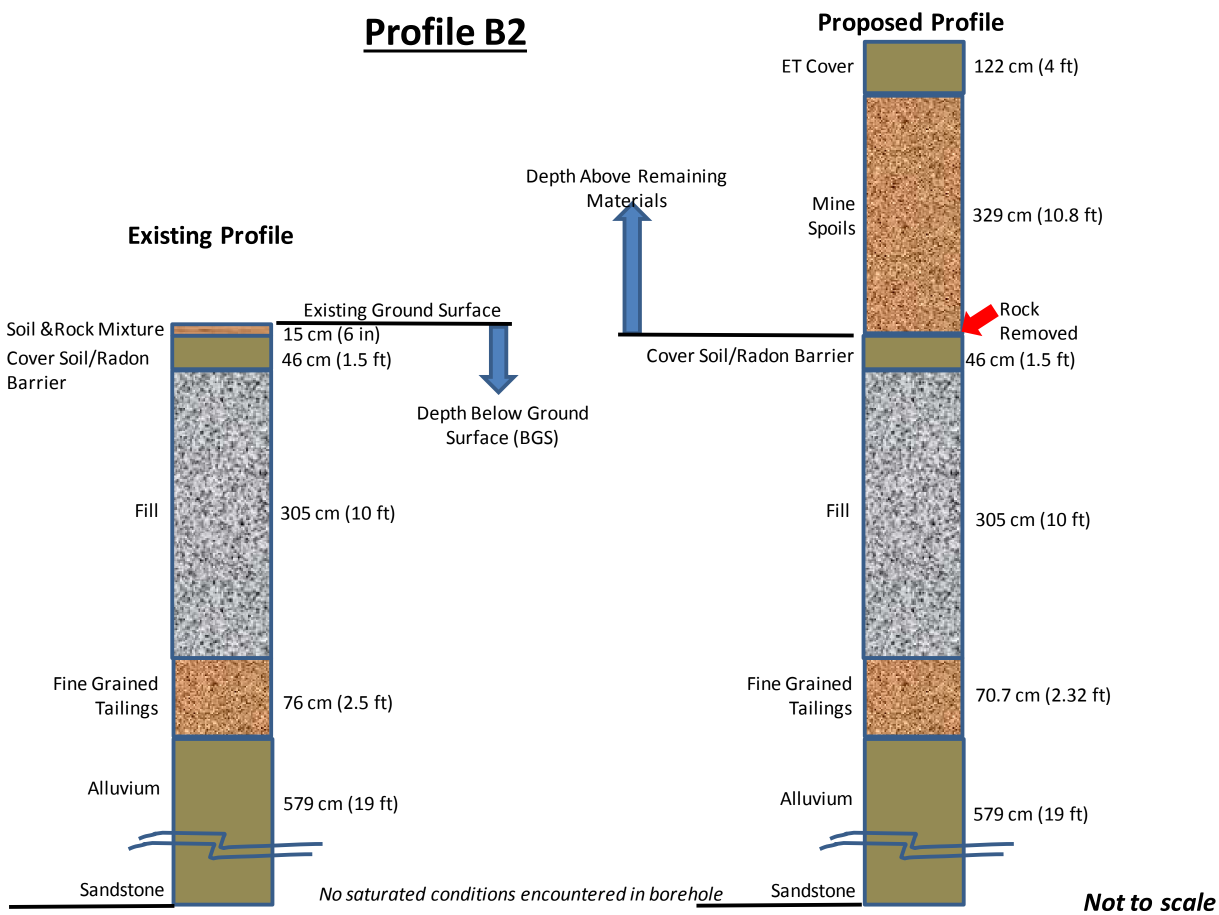


Figure 8. Profile B2

4.2.1.2 PROFILE B8

Profile B8 represents an area within Borrow Pit 1 where the fine-grained tailings are relatively thick and wet (Figures 1 and 2). Figure 9 summarizes the 'before' and 'after' profiles evaluated to assess the area for potential impact on the underlying groundwater, with the ‘after’ profile taking into account the respective consolidation in the fine-grained tailings. The coarse tailings, fine-grained tailings and coarse/fine-grained tailings layers have thinner distinctive layers within them that each had its own set of input parameters.

The borehole at location B10 stopped at 61 ft BGS. There was no saturated condition encountered in this borehole.

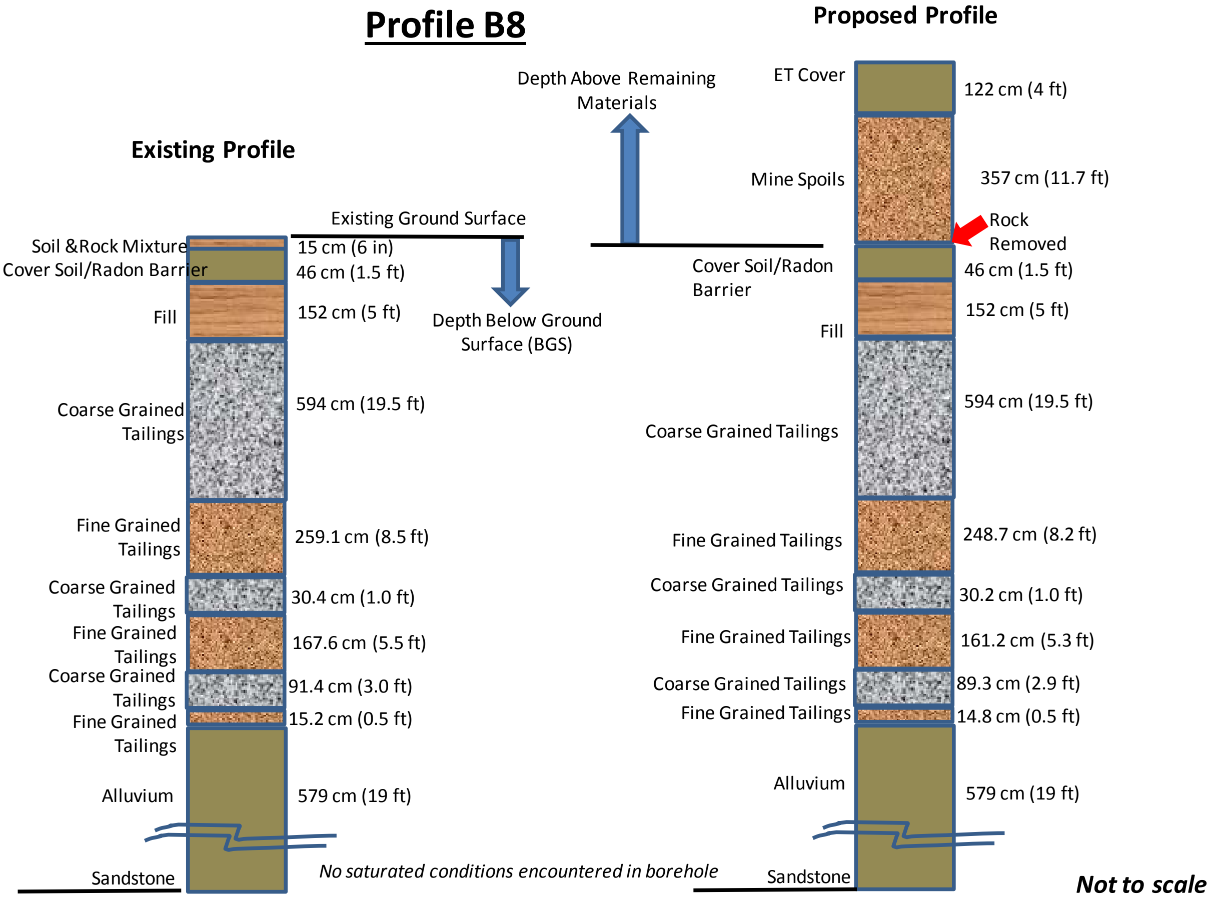


Figure 9. Profile B8

4.2.1.3 PROFILE B10

Profile B10 represents another area within Borrow Pit 1 where the fine-grained tailings are relatively thick and wet (Figures 1 and 2). Figure 10 summarizes the 'before' and 'after' profiles evaluated to assess the area for its potential impact on the underlying groundwater, with the ‘after’ profile taking into account the respective consolidation in the fine-grained tailings. The coarse tailings, fine-grained tailings and coarse/fine-grained tailings layers have thinner distinctive layers within them that each had its own set of input parameters.

The borehole at location B10 stopped at 105 ft BGS. The CPT penetration encountered refusal at a depth of 63 ft. Water was encountered in the borehole at a depth of 90 ft BGS (elevation 6883').

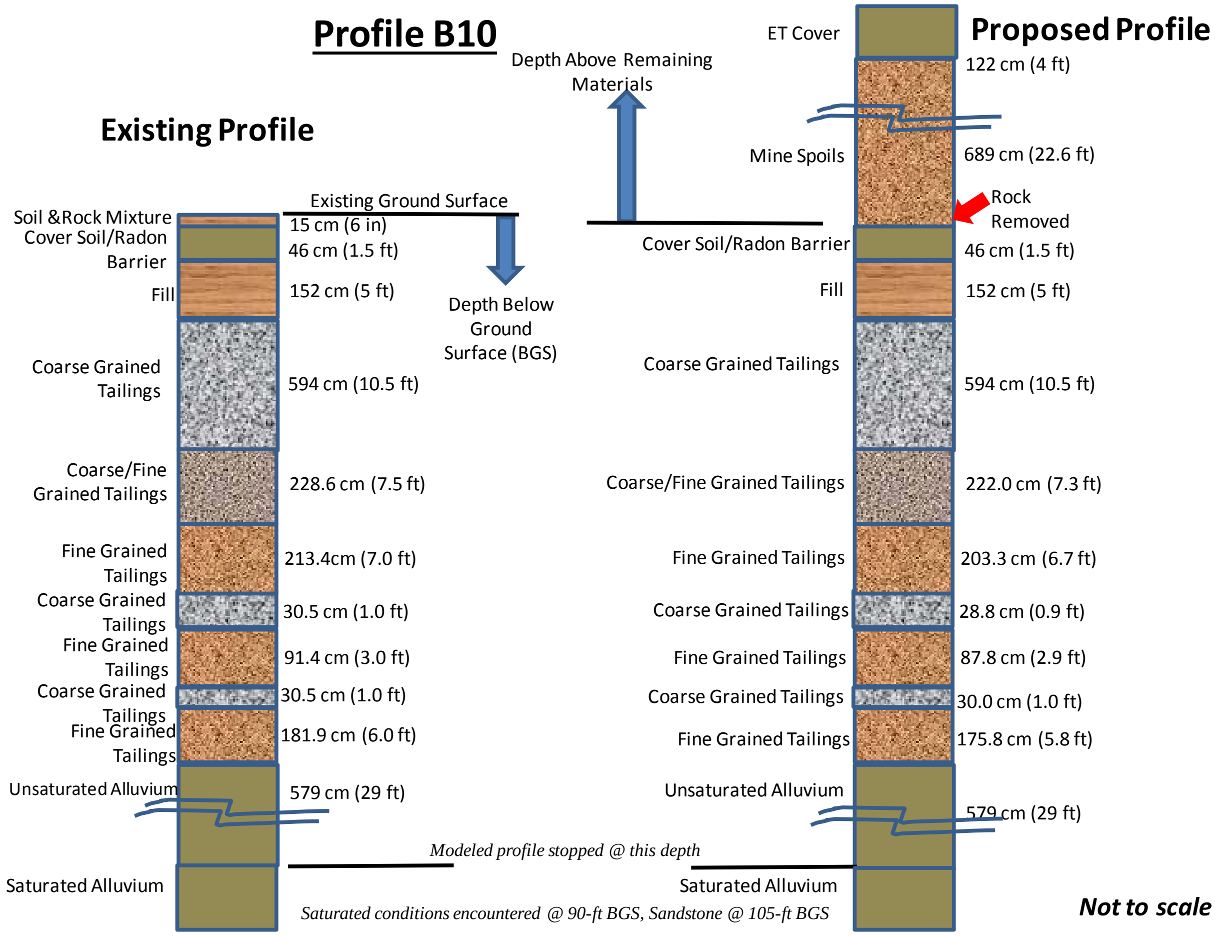


Figure 10. Profile B10

4.2.1.4 PROFILE B11

Profile B11 represents an area within Borrow Pit 2 where the fine-grained tailings are thick and wet (Figures 1 and 2). Figure 11 summarizes the 'before' and 'after' profiles evaluated to assess the area for its potential impact on the underlying groundwater. The ‘after’ profile takes into account the respective consolidation in the fine-grained tailings. The fine-grained tailings layers had thinner distinctive layers within them that each had its own set of input parameters.

The borehole at location B11 stopped at 97 ft BGS. Water was encountered in the borehole at a depth of 90 ft BGS (elevation 6887').

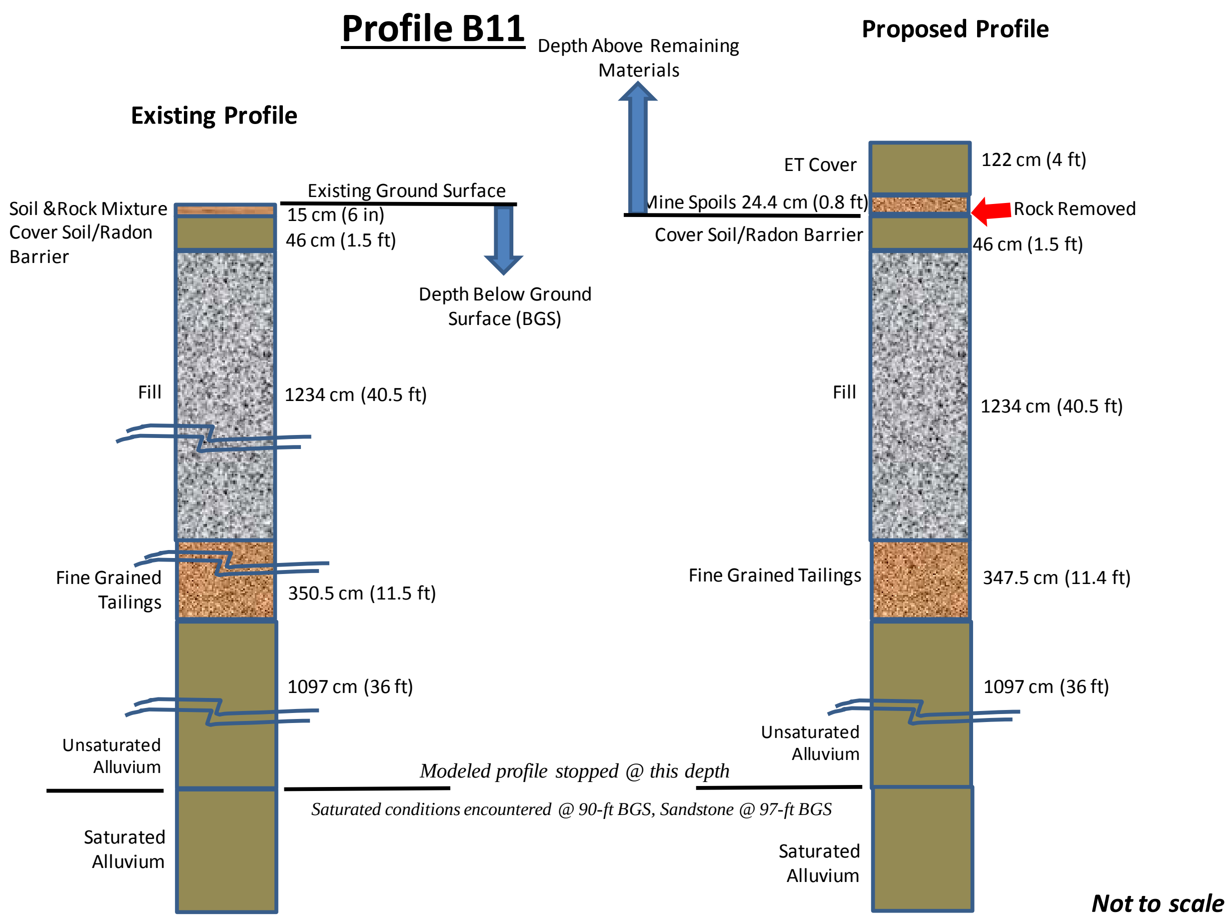


Figure 11. Profile B11

4.2.2 BOUNDARY CONDITIONS

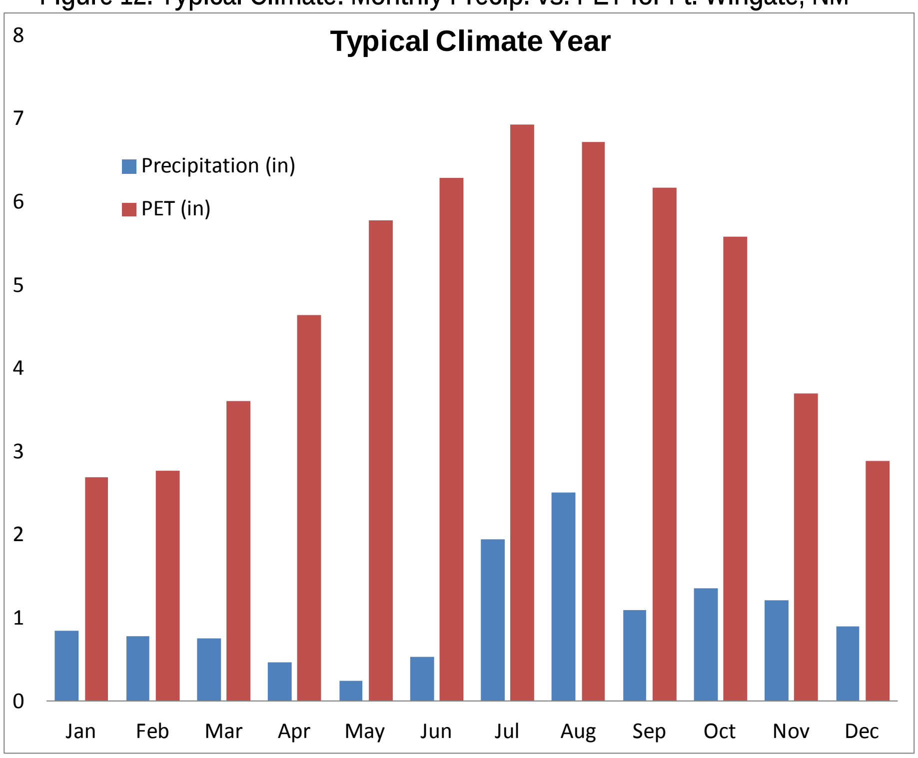
The upper boundary condition for the UNSAT-H computer simulations used 20 years of local climate data. The 20 years consisted of 10 consecutive years of average or typical climate followed by the wettest year on record run consecutively for two years, followed by eight more years of typical climate conditions. This twenty-year time frame was chosen because it includes both average and extreme climate conditions; was significantly longer than the estimated time for completion of primary consolidation, and allowed adequate time to evaluate the sensitivity of the assigned initial conditions (including initial suction values). The 20-year period allows for an evaluation of the change in moisture status of the profile over multiple years to see if trends are established or annual flux is variable. The 20-year time-frame was hypothesized to be adequate to establish and evaluate long-term trends. Verification of this hypothesis is described in Section 6. The 20-year period did not include any dry years since this analysis was intended to evaluate whether liquid flux would increase with the addition of soil on the existing impoundment. Dry years would not provide a stress of the profiles. Refer to Section 6 for longer-term simulations.

The water balance results from these 20-year simulations reveal that after a couple of years of typical climate conditions, there is no significant year-to-year change to the annual water balance variables (Appendix A; also refer to Figures 16 to 19). Furthermore, the evaluation showed that the existing cover (rock over soil radon barrier) allows for percolation and thus an increase of moisture within the profile; whereas the profile with mine spoils and an ET Cover allows no percolation and thus the profile is undergoing a drying trend. Based on this finding, the long-term drainage aspects from the tailings impoundment are improved by the addition of the mine spoils and ET Cover.

All available historical weather data for the Gallup, NM area and surrounding weather stations were evaluated. Ft. Wingate had historical weather data dating back to 1897 and the most complete set of data in the Gallup, NM area. Weather from Ft. Wingate, NM was utilized for the upper boundary condition due to its proximity to and similar elevation as the mill site repository. For the typical climate year; the weather from 1949 was utilized with an annual precipitation volume of 11.71 inches (29.74 cm) that was distributed as seen in Figure 12. For this year, it can be seen that for every month of the year, the demand for water referred to as potential evapotranspiration (PET) far exceeds the actual supply of water (precipitation). The annual PET is 83.4-inches (211.74 cm) or about 6.5 times more than the actual supply of water (precipitation). Consequently a "store and release" cover designed to take advantage of variances between the water demand and water supply (such as an ET Cover) is well suited for this climate.

It should be noted that the monthly values shown in Figures 12 and 13 are presented for the benefit of the reader and were not used in the actual analyses. Daily values are used in the boundary files for PET while hourly values are provided for precipitation. The daily precipitation total was spread through the day thus decreasing the precipitation rate to increase infiltration and reduce runoff to add conservatism to the analysis. The computer simulation is performed on an hourly basis.

Figure 12. Typical Climate: Monthly Precip. vs. PET for Ft. Wingate, NM



Extreme climatic conditions were also evaluated. The Ft. Wingate weather data set contained the wettest year on record (1906), having an annual precipitation volume of 23.8 inches (84.8 cm). Much of the precipitation came in as snow from January to April and October to December. This is a period when PET is low and transpiration of moisture through vegetation is minimized or completely ceased in the modeling. The monthly precipitation and PET are presented in Figure 13 for the wettest year on record.

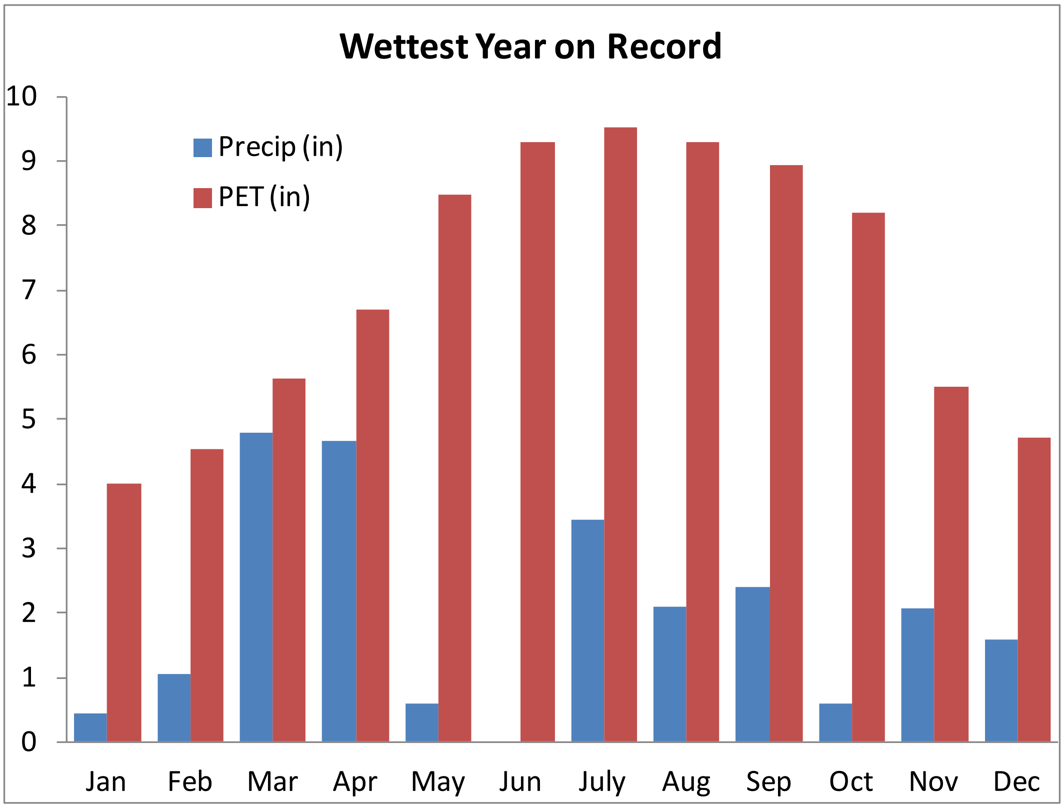


Figure 13. Wettest Year on Record: Monthly Precip. vs. PET for Ft. Wingate, NM

The water flow across the surface and lower boundary of the cover profile is determined by boundary condition specifications. For infiltration events, the upper boundary used in the simulation was conservatively set to a maximum hourly flux of 0.4 inches (1 cm) per hour. This value minimized runoff while maximizing infiltration. This is conservative because it is expected that, given the designed slopes at the site, a significant percentage of precipitation will run off without infiltrating into the cover profile.

The UNSAT-H program partitions PET into potential evaporation (Ep) and potential transpiration (Tp). Potential evaporation is estimated or derived from daily weather parameters (Fayer 2000). Potential transpiration is calculated using a function (Equation 4-1) based on the value of the assigned leaf area index (LAI) and an equation developed by Ritchie and Burnett (1971) as follows:

$T_p = PET\,[a + b(LAI)^c]$ where $d \leq LAI \leq e$ **Equation 4-1**

where:

a,b,c,d, and e are fitting parameters

a = 0.0, b = 0.52, and c = 0.5, d = 0.1, and e = 2.7 (Fayer 2000)

The maximum and minimum daily temperatures, daily precipitation value, and site latitude were input parameters used to calculate PET (Samani and Pessarkli, 1986). The Samani method used to calculate PET correlates with the Penman method utilized within UNSAT-H (Samani and Pessarkli, 1986). The UNSAT-H program then partitioned the daily PET values into Ep and Tp. Tp was calculated using a function developed by Equation 4-1. Two separate files were written for each year modeled: one file represented the daily PET values and the other file consisted of the daily precipitation values.

The lower boundary condition (at base of profile evaluated - in these cases the base of the unsaturated alluvium) was a unit gradient. With the unit gradient, the calculated drainage flux depended on the hydraulic conductivity of the lower boundary node. The unit gradient corresponded to gravity-induced drainage and was most appropriate when drainage was not impeded. The base of the modeled profile was well below any significant transient activity. The large depth between the deepest roots and the lower boundary condition allowed for the assumption that the lower boundary was subject only to the drainage process (Fayer and Walter 1995). Therefore, the lower boundary condition was specified with a unit gradient condition (i.e. free drainage).

4.2.3 VEGETATION DATA

Vegetation will generally increase ET from the cover because a plant's matric potential or suction can be orders of magnitude higher than that of the soil (Figure 14).

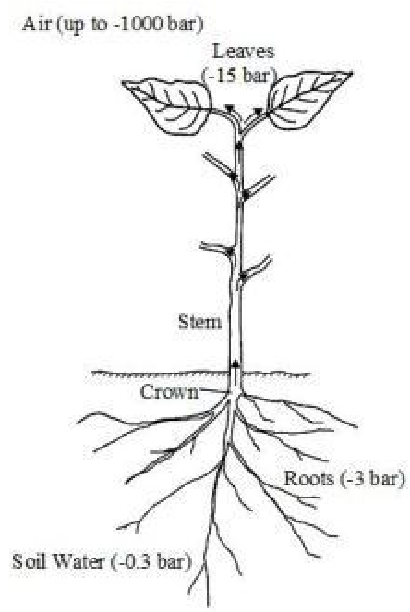


Figure 14. Typical Soil-Plant-Atmosphere Water Potential Variation (Hillel 1998)

The input parameters representing vegetation include the LAI, rooting depth and density, root growth rate, the suction head values that correspond to the soil's field capacity, wilting point, and water content above which plants do not transpire because of anaerobic conditions. The onset and termination of the growing season for the site are defined in terms of Julian days. The maximum rooting depth is based on expected vegetation characteristics. The root length density (RLD) is assumed to follow an exponential function such as that defined in Equation 4-2 (Fayer 2000):

$$RLD = a \exp(-bz) + c \qquad \textbf{Equation 4-2}$$

where:

a,b, and c are fitting parameters

z = depth below surface

The cover profiles (Figures 8 to 11) were modeled with vegetation on the surface. The computer simulations of the various profiles evaluated for the existing conditions featured shrub land vegetation (Cedar Creek 2014). This best matched the current vegetation of the existing cover. The computer simulations for the profiles with mine spoils and ET Cover features reclaimed vegetation (Cedar Creek 2014). The reclaimed vegetation is the short-term condition (within the 20 years modeled) of vegetation after a site has been disturbed (Cedar Creek 2014). Canonie (1990 and 1992) stated the primary consolidation occurred within a few months. The 20-year modeling period allowed for an evaluation of the site after consolidation takes place to assess potential changes in subsurface moisture movement due to the consolidated tailings.

Cedar Creek performed an analog study of the native vegetation at the site both in a disturbed setting and undisturbed settings (Cedar Creek 2014). Results from this study were utilized in the modeling to develop input parameters for vegetation. The following vegetation parameters (Table 5) related to rooting were utilized in the model (Cedar Creek 2014).

Table 5. Rooting Parameters (Cedar Creek 2014)

Parameter	Reclaimed Analog **(Profile with Mine Spoils and ET Cover)**	Shrub Analog **(Existing Condition Profile)**
a	556.28266872	0.42851959
b	-0.00000543	-0.03407481
c	-555.91871302	0.07781172

The LAI, percent bare area utilized, and maximum rooting depths for the respective vegetation used in a computer simulation are summarized in Table 6.

Table 6. Vegetation Parameters (Cedar Creek 2014)

Parameter	Reclaimed Analog **(Profile with Mine Spoils and ET Cover)**	Shrub Analog **(Existing Condition Profile)**
LAI	0.91	0.52
% Bare Area	52.3%	75.2%
Root Length	147 cm	155 cm

In the modeling simulations, the onset and termination of the growing season for the site were Julian days 63 and 343, respectively. This is based on the typical climate conditions for the site and the respective growing degree days computed and presented in Figure 15. The LAI was transitioned from 0 to the full LAI starting with Julian day 63 to 170. Day 171 through 266, the full LAI was utilized. The LAI was then transitioned down from the full LAI to 0 from Julian day 267 to 343.

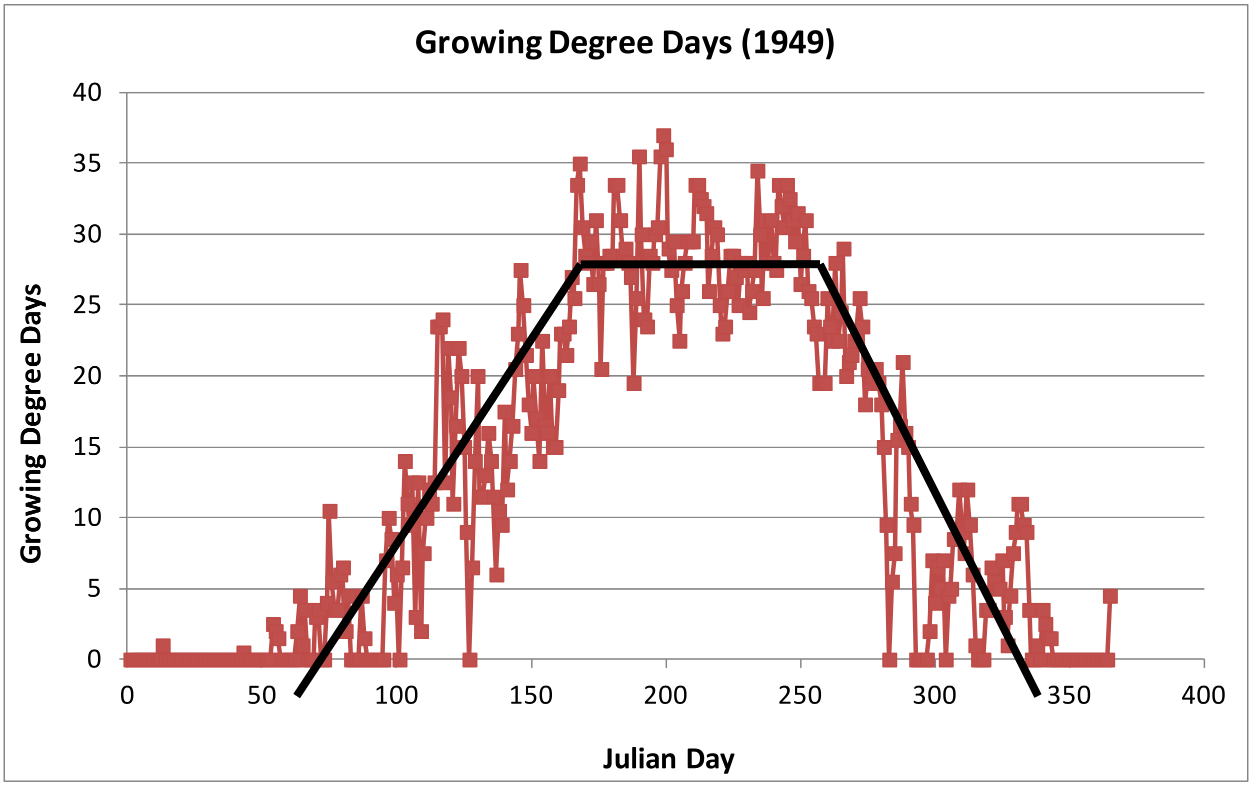


Figure 15. Leaf Area Index Transition During the Year

The UNSAT-H model adjusts the full LAI based on the percent bare area of vegetation. For example, for Shrub vegetation with an LAI of 0.52 and a percent bare area of 75.2 percent, the LAI is reduced to 0.752 * 0.52 = 0.39.

4.2.4 SOIL PROPERTIES RELATED TO VEGETATION

Soil properties related to vegetation utilized as model input parameters include suction head values corresponding to the wilting point, head corresponding to the water content below which plant transpiration starts to decrease, and a head value corresponding to the water content above which plants do not transpire because of anaerobic conditions were defined.

Not all water stored in the soil can be removed via transpiration. Vegetation is generally assumed to reduce the soil moisture content to the permanent wilting point. The suction head value for the wilting point for these simulations was set at 40,000 cm[1] for reclaimed vegetation (Fayer and Walters 1995) and 70,000 (Fayer and Walters 1995) for shrubland vegetation. These wilting point values are conservative given that nearby vegetation could remove water from the soil to a suction value of 100,000 cm (Hillel 1998). Evaporation from the soil surface can further reduce the soil moisture below the wilting point toward the residual saturation, which is the water content at an infinite matric potential. The head corresponding to the water content below which plant transpiration starts to decrease was defined as 32 ft (1000 cm) (Fayer and Walters 1995, Fayer

[1] Matric potential or suction heads are generally written as positive numbers, but in reality are negative values. Consequently, the higher the value - the greater the soil suction.

2000). The head value corresponding to the water content above which plants do not transpire because of anaerobic conditions was defined at 12 inches (30 cm) (Fayer and Walters 1995).

4.2.5 SOIL PROPERTIES

Soil mechanical and hydraulic properties were obtained from laboratory testing of soil samples collected on-site (MWH 2014). The soil input parameters for existing condition profiles are presented in Tables 7 to 10. The initial soil suction values were calculated based on the initial degree of saturation and moisture retention properties (van Genuchten 1978) and are also presented in Tables 7 to 10. The Mualem conductivity function (Mualem 1976) was calculated to describe the unsaturated hydraulic conductivity of the soils (van Genuchten et al. 1991). The van Genuchten 'm' parameter for this function is assumed to be'1-1/n'; 'n' being one of the established van Genuchten parameters. The initial soil conditions were expressed in terms of suction head or matric potential values calculated from the respective moisture content of each soil layer (van Genuchten et al. 1991). The moisture retention properties (van Genuchten parameters) were developed from the laboratory soil measurements (soil suction versus moisture content) using the RETC software (van Genuchten et al. 1991).

The input parameters summarized in Tables 7 to 10 are the best data available from measurements made during an extensive on-site drilling and laboratory measurements of existing conditions. Not all data for each layer was available via the MWH (2014) report to complete the analysis. Consequently, missing data were filled in with measured data from similar soils/tailings (MWH 2014). Engineering judgment was utilized to evaluate all of the available data and best fit the missing data with available data from MWH (2014).

The initial moisture content was calculated as follows:

$$\theta_i = S \times \theta_s \qquad \textbf{Equation 4-3}$$

where:

$\theta_i = inital\ moisture\ content\ (vol.)$

$S = \ degree\ of\ saturation$

$\theta_s \ = \ saturated\ moisture\ content\ (vol.)$

The initial soil suction or matric potential value (h_i) is computed from the following equation (van Genuchten 1978):

$$\frac{\theta_i-\theta_r}{\theta_s-\theta_r} = [1 + (\propto h_i)^n]^{-m}$$ **Equation 4-4**

where:

$\theta_i = inital\ moisture\ content\ (vol.)$

$\theta_r\ =\ residual\ moisture\ content\ (vol.)$

$\theta_s\ =\ saturated\ moisture\ content\ (vol.)$

$\propto, m, n\ =\ van\ Genuchten\ et\ al$ (1991) $fitted\ parameters$

$h_i =\ inital\ soil\ suction\ or\ matric\ potential$ (cm)

$m =\ 1 - {}^{1}/_{n}$ (Mualem 1976)

Table 7. Profile B2 Existing Conditions: Soil Layer Input Parameters

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	S_0	van Genuchten parameters				Initial Suction[a] (-cm)
					θ_s	θ_r	α	n	
Cover – rock/soil	0 to 0.5’	Loamy sand (Carsel & Parrish 1998)	4.10x10^{-3}	30%	0.41	0.057	0.124	2.28	29.2
Cover - soil	0.5’ –2’	EB-B6-03	3.60x10^{-5}	30%	0.50926	0	0.01399	1.26891	6272.7
Fill	2’ – 6.5’	Use B11-03	2.50x10^{-5}	31%	0.30331	0	0.01632	1.06655	2692958106.4[b]
	6.5’ – 12’			53.70%	0.30331	0	0.01632	1.06655	699434.4
Fine Tailings	12’ – 14.5’	Use B10-14	2.90x10^{-8}	80.70%	0.58891	0	0.0011	1.16727	2636.5
Alluvium	14.5’ – 33.5’	Use B11-10	5.60x10^{-4}	22%	0.45752	0.06145	0.13956	1.31247	11741.6

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).

[b]It appears large, but this value was calculated from its degree of saturation.

Table 8. Profile B8 Existing Conditions: Soil Layer Input Parameters

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	S_0	van Genuchten parameters				Initial Suction[a] (-cm)
					θs	θr	α	n	
Cover – rock/soil	0 to 0.5’	Loamy sand (Carsel & Parrish 1998)	4.10x10^{-3}	30%	0.41	0.057	0.124	2.28	29.2
Cover - soil	0.5’ –2’	EB-B6-03	3.60 x10^{-5}	30%	0.50926	0	0.01399	1.26891	6272.7
Fill	2’ – 7’	Use B11-03	2.50 x10^{-5}	30%	0.30331	0	0.01632	1.06655	4407686039.0[b]
Coarse Tailings	7’ – 26.5’	B8-02	3.60 x10^{-4}	38.4%	0.41023	0	0.47787	1.16163	779.9
Fine Tailings	26.5’ – 31’	Use B8-9	3.00 x10^{-8}	96.9%	0.56534	0	0.00446	1.15784	70.0
Fine Tailings	31’ – 35’	Use B8-9	3.00 x10^{-8}	92%	0.56534	0	0.00446	1.15784	193.6
Coarse/Fine Tailings	35’ - 35.5’	B8-06	1.60 x10^{-5}	46%	0.48373	0	0.0009	1.37788	8299.9
Coarse/Fine Tailings	35.5’ – 36’	B8-06	1.60E^{-5}	51.20%	0.48373	0	0.0009	1.37788	6115.2
Fine Tailings	36’ – 41.5’	Use B8-9	3.00E^{-8}	Saturated	0.56534	0	0.00446	1.15784	0.0

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	S_0	van Genuchten parameters				Initial Suction[a] (-cm)
					θs	θr	α	n	
Coarse/Fine Tailings	41.5' – 42'	B8-08	1.30 x10^{-7}	90.5%	0.4272	0	1.87772	1.16882	0.5
Coarse/Fine Tailings	42' – 44.5'	B8-08	1.30 x10^{-7}	94.9%	0.4272	0	1.87772	1.16882	0.3
Fine Tailings	44.5' – 45'	Use B8-9	3.00 x10^{-8}	96.2%	0.56534	0	0.00446	1.15784	85.8
Alluvium	45' – 63'	Use B1-13A	1.70 x10^{-6}	50.6%	0.4951	0.0398	0.43246	1.20486	98.5

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).
[b]It appears large, but this value was calculated from its degree of saturation.

Table 9. Profile B10 Existing Conditions: Soil Layer Input Parameters

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	S_0	van Genuchten parameters				Initial Suction[a] (-cm)
					θ_s	θ_r	α	n	
Cover – rock/soil	0 to 0.5'	Loamy sand (Carsel & Parrish 1998)	4.10 x10^{-3}	30%	0.41	0.057	0.124	2.28	29.2
Cover - soil	0.5' – 2.0'	EB-B6-03	3.60 x10^{-5}	30%	0.50926	0	0.01399	1.26891	6272.7
Fill	2' – 7'	Use B11-03	2.50 x10^{-5}	30%	0.30331	0	0.01632	1.06655	4407686039.0[b]
Coarse Tailings	7' – 12'	B10-02	4.30 x10^{-4}	34%	0.3481	0	0.67277	1.13662	3994.5
Coarse Tailings	12' – 17.5'	B10-03	6.70 x10^{-5}	30.40%	0.4272	0	1.87772	1.16882	615.8
Coarse/Fine Tailings	17.5' – 25'	Use B8-08	1.30 x10^{-7}	87.70%	0.44786	0	0.00129	1.29116	645.6
Fine Tailing	25' – 26'	Use B10	3.00 x10^{-8}	83.50%	0.58891	0	0.0011	1.16727	2006.5
Fine Tailing	26' – 28'	Use B10	3.00 x10^{-8}	93.50%	0.58891	0	0.0011	1.16727	585.5
Fine Tailing	28' - 32'	Use B10	3.00 x10^{-8}	92.30%	0.58891	0	0.0011	1.16727	709.8
Coarse Tailings	32' – 33'	B8-08	6.70 x10^{-5}	61.80%	0.4272	0	1.87772	1.16882	8.9
Fine Tailings	33' – 35.5'	B8-08	3.00 x10^{-8}	95.20%	0.58891	0	0.0011	1.16727	423.1
Fine Tailings	35.5' – 36'	Use B8-9	3.00 x10^{-8}	83.80%	0.58891	0	0.0011	1.16727	1947.0
Coarse/Fine Tailings	36' – 37'	B10-03	1.30 x10^{-7}	93.80%	0.44786	0	0.00129	1.29116	327.1
Fine Tailings	37' – 41'	Use B10	3.00 x10^{-8}	100.10%	0.58891	0	0.0011	1.16727	0.0

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	S_0	van Genuchten parameters				Initial Suction[a] (-cm)
					θ_s	θ_r	α	n	
Fine Tailings	41' – 43'	Use B10	3.00×10^{-8}	98.80%	0.58891	0	0.0011	1.16727	113.2
Alluvium	43' – 62'	B10-18	2.40×10^{-5}	48.86%	0.40301	0.00829	0.54078	1.1191	911.3

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).
[b]It appears large, but this value was calculated from its degree of saturation.

Table 10. Profile B11 Existing Conditions: Soil Layer Input Parameters

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	S_0	van Genuchten parameters				Initial Suction[a] (-cm)
					θ_s	θ_r	α	n	
Cover – rock/soil	0 to 0.5'	Loamy sand (Carsel & Parrish 1998)	4.10×10^{-3}	30%	0.41	0.057	0.124	2.28	29.2
Cover - soil	0.5' –2'	EB-B6-03	3.60×10^{-5}	30%	0.50926	0	0.01399	1.26891	6272.7
Fill	2' – 15'	Use B11-03	2.50×10^{-5}	29.30%	0.30331	0	0.01632	1.06655	6284703564.2[b]
	15' – 20'			42.90%	0.30331	0	0.01632	1.06655	20421368.8[b]
	20' – 30'			59.80%	0.30331	0	0.01632	1.06655	138843.8[2]
	30' – 42.5'			75.70%	0.30331	0	0.01632	1.06655	3974.6
Fine Tailings	42.5' – 54'	B8-09	3.00×10^{-8}	95.30%	0.56534	0	0.00446	1.15784	106.8
Alluvium	54' - 90'	B11-10	5.60×10^{-4}	50.10%	0.45752	0.06145	0.13956	1.31247	109.7

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).
[b]It appears large, but this value was calculated from its degree of saturation.

The input parameters for the respective profiles 'after' placement of mine spoils and new ET Cover are presented in Tables 11 to 14. The top layer or rock/soil admixture of the cover profile is composed of the mixture of rock (1.5-inch diameter for these simulations) mixed with soil. The admixture depth is 14 inches. The cover soil directly below the upper rock/soil admixture is composed of soil from the same borrow source. The cover soil properties are those from the south drainage area borrow (the largest borrow source). Results presented in Dwyer (2017) revealed that since no percolation is computed through the new ET Cover profile, the cover borrow source is insensitive to these modeling analyses results.

The hydraulic properties of the cover borrow soil modeled were obtained from laboratory testing (MWH 2014) of the various soil textures at a prescribed density of 90 percent of the maximum dry density (ASTM D698). This density approximately equates to the natural density of the borrow soils in their undisturbed setting. Because the density of the soil will migrate towards this natural density setting, it is warranted to install it as close to this density as possible. Therefore, the construction specifications for installation of the cover soil will require the installed density of the cover soil to be 90 percent of its maximum dry density (MDD) with a small tolerance allowance (+/- 5 pcf of MDD). The remolded samples are assumed to represent the soil as it is installed in the field.

The top admixture layer has rock mixed into it at a volumetric ratio of 33 percent rock to 67 percent soil. The mixture of rock into the soil alters its hydraulic properties. Consequently, the hydraulic properties were calculated for the admixture layer per ASTM D4718. Equation 4-5 was used to calculate the rock adjusted saturated hydraulic conductivity based on the addition of rock (Peck and Watson 1979).

$$K_b = [K_s * 2(1 - V_r)]/(2 + V_r) \qquad \textbf{Equation 4-5}$$

$$where: K_b = saturated\ hydraulic\ conductivty, bulk$$

$$K_s = saturated\ hydraulic\ conductivty, soil$$

$$V_r = volume\ of\ rock$$

The natural analog study performed on the cover borrow sources (Dwyer 2014) revealed that the upper foot of the undisturbed soil profile at each had a saturated hydraulic conductivity about one order of magnitude higher than the remaining of the soil profile evaluated. Consequently, the calculated bulk saturated hydraulic conductivity of the admixture layer was increased an order of magnitude from the calculated value to account for dynamic processes such as freeze/thaw cycles, wet/dry cycles, and biointrusion. Because the admixture depth is 14 inches thick, the entire depth of the admixture's saturated hydraulic conductivity was increased by an order of magnitude.

The moisture retention data for the cover soil was also altered to reflect the addition of the rock in the surface admixture layer and the subsequent loss of water storage capacity in the soil. The actual volumetric moisture content versus soil suction measurements made in the laboratory was utilized as the basis. Each respective measured volumetric moisture content used to determine the layer's moisture characteristic curve was reduced per Equation 4-6 [ASTM (2015) and Bouwer & Rice (1984)].

$$\theta_b = (1 - V_r)\theta_s$$ **Equation 4-6**

$where\text{: } \theta_b = bulk\ volumetric\ moisture\ content$

$\theta_s = \text{satuarated}\ volumetric\ moisture\ content$

$V_r = volume\ of\ rock$

The initial soil suction or matric potential value (h_i) for the fine-grained tailings (and coarser-grained tailings sandwiched within the fine-grained tailings) after consolidation is computed utilizing Equation 4-4 (van Genuchten 1978) with a modified (reduced) saturated moisture content (Figure 6) based on the computed final void ratio. The saturated moisture content is reduced because the void ratio was decreased due to consolidation of the layer, resulting in reduced storage capacity of the layer. The initial soil suction for the fine-grained tailings is therefore reduced. For Profile B8, all initial soil suction values for the fine-grained tailings layers were reduced to zero due to the saturated conditions created from their consolidation (refer to Tables 11 to 14).

Table 11. Profile B2 with Mine Spoils and ET Cover: Soil Layer Input Parameters

Soil Layer	Thickness (ft)	Data Sample (MWH 2014)	Ks (cm/sec)	van Genuchten parameters				Initial Suction[a] (-cm)
				θs	θr	α	n	
Cover Rock/Soil Admixture	1.17	SB-B4-01	$4.26x10^{-4}$	0.3478	0	0.0373	1.2243	2200.0
ET Cover	2.83	SB-B4-01	$7.40\ x10^{-5}$	0.5191	0	0.0373	1.2243	2200.0
Mine Spoils	10.8	Use TT-205-GT1	$2.20\ x10^{-4}$	0.3774	0	0.0525	1.2338	3278.4
Cover soil - Radon Barrier	1.5	EB-B6-03	$3.60\ x10^{-5}$	0.50926	0	0.01399	1.26891	6272.7
Fill	4.5	Use B11-03	$2.50\ x10^{-5}$	0.30331	0	0.01632	1.06655	2692958106.4[c]
	5.5			0.30331	0	0.01632	1.06655	699434.4
Fine Tailings	2.32[b]	Use B10-14	$2.90\ x10^{-8}$	0.555174	0	0.0011	1.16727	1617.0
Alluvium	19	Use B11-10	$5.60\ x10^{-4}$	0.45752	0.06145	0.13956	1.31247	11741.6

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).

[b]Thickness adjusted for consolidation, refer to Table 1

[c]It appears large, but this value was calculated from its degree of saturation.

Table 12. Profile B8 with Mine Spoils and ET Cover: Soil Layer Input Parameters

Soil Layer	Thickness (ft)	Data Sample (MWH 2014)	Ks (cm/sec)	van Genuchten parameters				Initial Suction[a] (-cm)
				θs	θr	α	n	
Cover Rock/Soil Admixture	1.17	SB-B4-01	$4.26x10^{-4}$	0.3478	0	0.0373	1.2243	2200.0
ET Cover	2.83	SB-B4-01	$7.40\ x10^{-5}$	0.5191	0	0.0373	1.2243	2200.0
Mine Spoils	11.7	Use TT-205-GT1	$2.20\ x10^{-4}$	0.3774	0	0.0525	1.2338	3278.4
Cover soil - Radon Barrier	1.5	EB-B6-03	$3.60x10^{-5}$	0.50926	0	0.014	1.26891	6272.7
Fill	5	Use B11-03	$2.50\ x10^{-5}$	0.30331	0	0.0163	1.06655	4407686039.0[c]
Coarse Tailings	19.50	B8-02	$3.60\ x10^{-4}$	0.41023	0	0.4779	1.16163	779.9
Fine Tailings	4.33[b]	Use B8-9	$3.00x10^{-8}$	0.54754	0	0.0045	1.15784	0
Fine Tailings	3.83[b]	Use B8-9	$3.00x10^{-8}$	0.54754	0	0.0045	1.15784	0
Coarse/Fine Tailings	0.49[b]	B8-06	$1.60x10^{-5}$	0.47776	0	0.0009	1.37788	0
Coarse/Fine Tailings	0.49[b]	B8-06	$1.60x10^{-5}$	0.47776	0	0.0009	1.37788	0

Soil Layer	Thickness (ft)	Data Sample (MWH 2014)	Ks (cm/sec)	van Genuchten parameters				Initial Suction[a] (-cm)
				θs	θr	α	n	
Fine Tailings	5.29[b]	Use B8-09	3.00×10^{-8}	0.54754	0	0.0045	1.15784	0
Coarse/Fine Tailings	0.49[b]	B8-08	1.30×10^{-7}	0.41638	0	1.8777	1.16882	0
Coarse/Fine Tailings	2.44[b]	B8-08	1.30×10^{-7}	0.41638	0	1.8777	1.16882	0
Fine Tailings	0.48[b]	Use B8-09	3.00×10^{-8}	0.54754	0	0.0045	1.15784	0
Alluvium	18	Use B1-13A	1.70×10^{-6}	0.4951	0.0398	0.4325	1.20486	98.5

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).

[b]Thickness adjusted for consolidation, refer to Table 2

[c]It appears large, but this value was calculated from its degree of saturation.

Table 13. Profile B10 with Mine Spoils and ET Cover: Soil Layer Input Parameters

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	van Genuchten parameters				Initial Suction[a] (-cm)
				θs	θr	α	n	
Cover Rock/Soil Admixture	1.17	SB-B4-01	4.26×10^{-4}	0.3478	0	0.0373	1.2243	2200.0
ET Cover Soil	2.83	SB-B4-01	7.40×10^{-5}	0.5191	0	0.0373	1.2243	2200.0
Mine Spoils	22.6	Use TT-205-GT1	2.20×10^{-4}	0.3774	0	0.0525	1.2338	3278.4
Cover soil - Radon Barrier	1.5	EB-B6-03	3.60×10^{-5}	0.50926	0	0.01399	1.26891	6272.7
Fill	5	Use B11-03	2.50×10^{-5}	0.30331	0	0.01632	1.06655	4407686039.0[c]
Coarse Tailings	5	B10-02	4.30×10^{-4}	0.3481	0	0.67277	1.13662	3662.8
Coarse Tailings	5.5	B10-03	6.70×10^{-5}	0.4272	0	1.87772	1.16882	583.2
Coarse/Fine Tailings	7.28[b]	Use B8-08	1.30×10^{-7}	0.43563	0	0.00129	1.29116	140.6
Fine Tailings	0.95[b]	Use B10-14	3.00×10^{-8}	0.57044	0	0.0011	1.16727	0
Fine Tailings	1.91[b]		3.00×10^{-8}	0.57044	0	0.0011	1.16727	0
Fine Tailings	3.81[b]		3.00×10^{-8}	0.57044	0	0.0011	1.16727	0
Coarse Tailings	0.98[b]	B10-03	6.70x10-7	0.41514	0	1.87772	1.16882	0
Fine Tailings	2.40[b]	Use B10-14	3.00×10^{-8}	0.57044	0	0.0011	1.16727	0
Fine Tailings	0.48[b]		3.00×10^{-8}	0.57044	0	0.0011	1.16727	0

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	van Genuchten parameters				Initial Suction[a] (-cm)
				θs	θr	α	n	
Coarse Tailings	0.98[b]	Use B8-08	1.30×10^{-7}	0.43563	0	0.00129	1.29116	0
Fine Tailings	3.84[b]	Use B10-14	3.00×10^{-8}	0.57044	0	0.0011	1.16727	0
Fine Tailings	1.93[b]		3.00×10^{-8}	0.57044	0	0.0011	1.16727	0
Alluvium	19	B10-18	2.40×10^{-5}	0.40301	0.00829	0.54078	1.1191	911.3

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).
[b]Thickness adjusted for consolidation, refer to Table 3
[c]It appears large, but this value was calculated from its degree of saturation.

Table 14. Profile B11 with Mine Spoils and ET Cover: Soil Layer Input Parameters

Soil Layer	Depth BGS	Data Sample (MWH 2014)	Ks (cm/sec)	van Genuchten parameters				Initial Suction[a] (-cm)
				θs	θr	α	n	
Cover Rock/Soil Admixture	1.1666667	SB-B4-01	4.26×10^{-4}	0.3478	0	0.0373	1.2243	2200.0
ET Cover Soil	2.8333333	SB-B4-01	7.40×10^{-5}	0.5191	0	0.0373	1.2243	2200.0
Mine Spoils	0.8	Use TT-205-GT1	2.20×10^{-4}	0.3774	0	0.0525	1.2338	3278.4
Cover soil - Radon Barrier	1.5	EB-B6-03	3.60×10^{-5}	0.50926	0	0.014	1.26891	6272.7
Fill	13	Use B11-03	2.50×10^{-5}	0.30331	0	0.0163	1.06655	6284703564.2[c]
	5			0.30331	0	0.0163	1.06655	20421368.8[c]
	10			0.30331	0	0.0163	1.06655	138843.8[c]
	12.5			0.30331	0	0.0163	1.06655	3974.6
Fine Tailings	11.40[b]	B8-09	3.00×10^{-8}	0.56256	0	0.0045	1.15784	95.7
Alluvium	36	B11-10	5.6×10^{-4}	0.45752	0.0615	0.1396	1.31247	109.7

[a]Initial suction values for each soil layer were computed utilizing the acquired van Genuchten parameters and measured moisture content (MWH 2014).
[b]Thickness adjusted for consolidation, refer to Table 4
[c]It appears large, but this value was calculated from its degree of saturation.

5.0 COMPUTER SIMULATION RESULTS

This section presents the modeling output from the profiles. Each respective profile was modeled in its existing condition and then again with the assumed mine spoils and new ET Cover based on the proposed design (Figures 8 to 11). The profiles were modeled for a period of 20 years consisting of typical climate for the first 10 years followed by the two wettest years on record, followed by eight more typical climate years. The results are intended to present a direct comparison of the difference between 'before' conditions and 'after' conditions. It is important to understand that the results are not intended to evaluate the flux which actually occurs for the existing condition, but rather to determine what the relative change in flux would be by conducting the proposed removal action.

The water balance results from these 20-year simulations reveal that after a few years of typical climate conditions, there is no significant year-to-year change to the annual water balance variables (Appendix A and Figures 16-19). This observation verifies that the 20-year timeframe is sufficient to determine if water movement through the profiles could reach the zone of saturation. Furthermore, the evaluation showed that the existing cover (rock over soil radon barrier) allows for percolation and thus an increase of moisture within the profile, whereas the profile with mine spoils and an ET Cover allows no percolation and thus the profile is undergoing a drying trend. Based on this finding, the long-term drainage aspects from the tailings of the impoundment are improved by the addition of the mine spoils and ET Cover.

The difference in flux (cumulative and average annual) between the existing cover and the ET Cover is shown in Table 15. Unsaturated alluvium is the bottom layer of each profile modeled. These analyses assumed that drainage though the base of the unsaturated alluvium is free to enter the underlying groundwater. Appendix A contains year-by-year water balance results for each profile evaluated. An important result of the evaluation is that the potential long-term drainage from the tailings to the base of the unsaturated alluvium is reduced by the addition of the mine spoils and ET Cover versus the existing cover.

The computer simulations revealed no difference in drainage through the base of the alluvium modeled for the 'before' and 'after' condition of profiles B2, B8, and B10. In these borings, the underlying alluvium was relatively dry compared to the overlying fine-grained tailings and had significant water storage capacity available compared to the volume of drainage. Thus, any drainage from the tailings will be captured and held within the alluvium. It is important to note that the drainage from the alluvium calculated in the modeling is likely due to the unit gradient condition applied to the base of each profile forcing drainage based on steady state conditions at the bottom node. It does not necessarily mean there is actually drainage from the alluvium.

There was a de minims difference between the simulations for Profile B11 in Borrow Pit 2. However, there are no mine spoils to be placed over B11, only a thin layer of clean fill.

Table 15. Cumulative and Average Annual Difference in Flux (cm/yr) between Existing Conditions Profiles and Proposed New Profiles with Mine Spoils and ET Cover

Profile		Layer Base	Difference (cm) for 20-year period	Average Annual Difference (cm)
B2	North Cell	Cover	+158	+7.89
		Base of Unsaturated Alluvium	0	0
B8	Borrow Pit 1	Cover	+136	+6.79
		Base of Unsaturated Alluvium	0	0
B10	Borrow Pit 1	Cover	+115	+5.75
		Base of Unsaturated Alluvium	0	0
B11	Borrow Pit 2	Cover	+127	+6.35
		Base of Unsaturated Alluvium	negligible[1]	negligible[1]

+ denotes the drainage in the existing condition profile is greater than that with the mine spoils and ET Cover.

- denotes the drainage in the existing condition profile is less than that with the mine spoils and ET Cover.

[1] Modeled values of -0.00004 and -0.000002 for the difference for 20 year period and average annual difference, respectively, are considered negligible values.

5.1 North Cell: Profile B2

Profile B2 represents an area in the North Cell with about 2.5 ft of fine-grained tailings or slimes and is representative of the majority of the area where mine spoils are to be placed. The area is proposed to have about 10.8-ft of mine spoils placed on it in addition to a 4-ft ET Cover. About 6 inches of rock from the existing cover will be removed for later use prior to placement of the mine spoils (refer to Figures 1, 2 and 8).

Both the existing profile B2 and the profile with the mine spoils and new ET Cover added have an average annual drainage rate of $1.15\text{x}10^{-6}$ cm/year or a hydraulic conductivity at the base of the profile of $3.65\text{x}10^{-14}$ cm/sec given the steady state conditions assumed. Relative to the existing condition, the ET Cover allows for drying of the profile and reduces any theoretical recharge to groundwater via the conservative assumptions used in the calculations. In conclusion, there is no increase in drainage to the underlying groundwater over the existing condition due to the addition of mine spoils and new ET Cover in Profile B2. There is projected to be no release to groundwater associated with the proposed removal action.

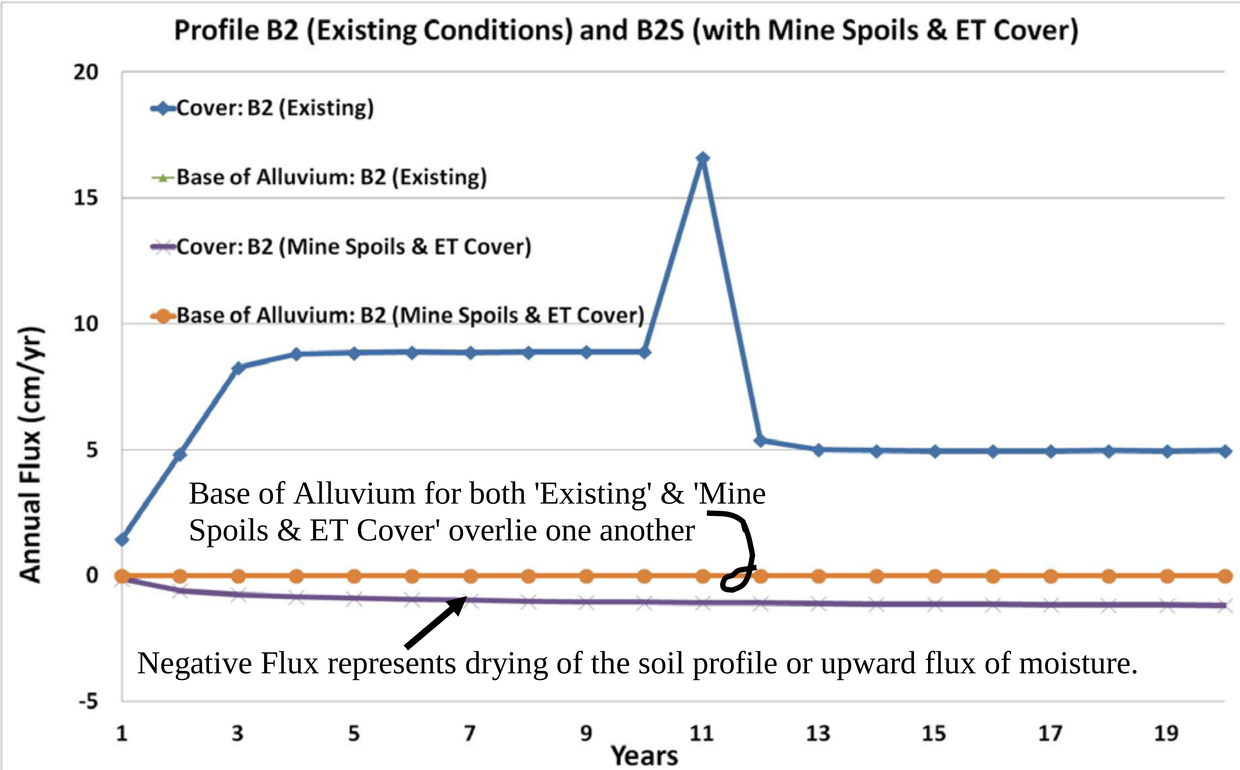


Figure 16. Profile B2 Computer Simulation Results

5.2 Borrow Pit 1: Profiles B8 and B10

Profile B8 represents an area in Borrow Pit 1 that has about 38 ft of combined coarse- and fine-grained tailings. This area is proposed to have about 11.7 ft of mine spoils placed on it in addition to a 4-ft ET Cover. About 6 inches of rock from the existing cover will be removed for later use prior to placement of the mine spoils (refer to Figures 1, 2 and 9).

Both the existing profile B8 and that with the mine spoils and new ET Cover added have an average annual drainage rate of 1.23×10^{-4} cm/year or a hydraulic conductivity given the steady state conditions assumed at the base of the profile of 3.91×10^{-12} cm/sec (Table 15, Figure 17). Relative to the existing condition, the ET Cover allows for drying of the profile and reduces any theoretical recharge to groundwater via the conservative assumptions used in the calculations. In conclusion, there is no increase in drainage to the underlying groundwater over the existing condition from the addition of mine spoils and new ET Cover in Profile B8.

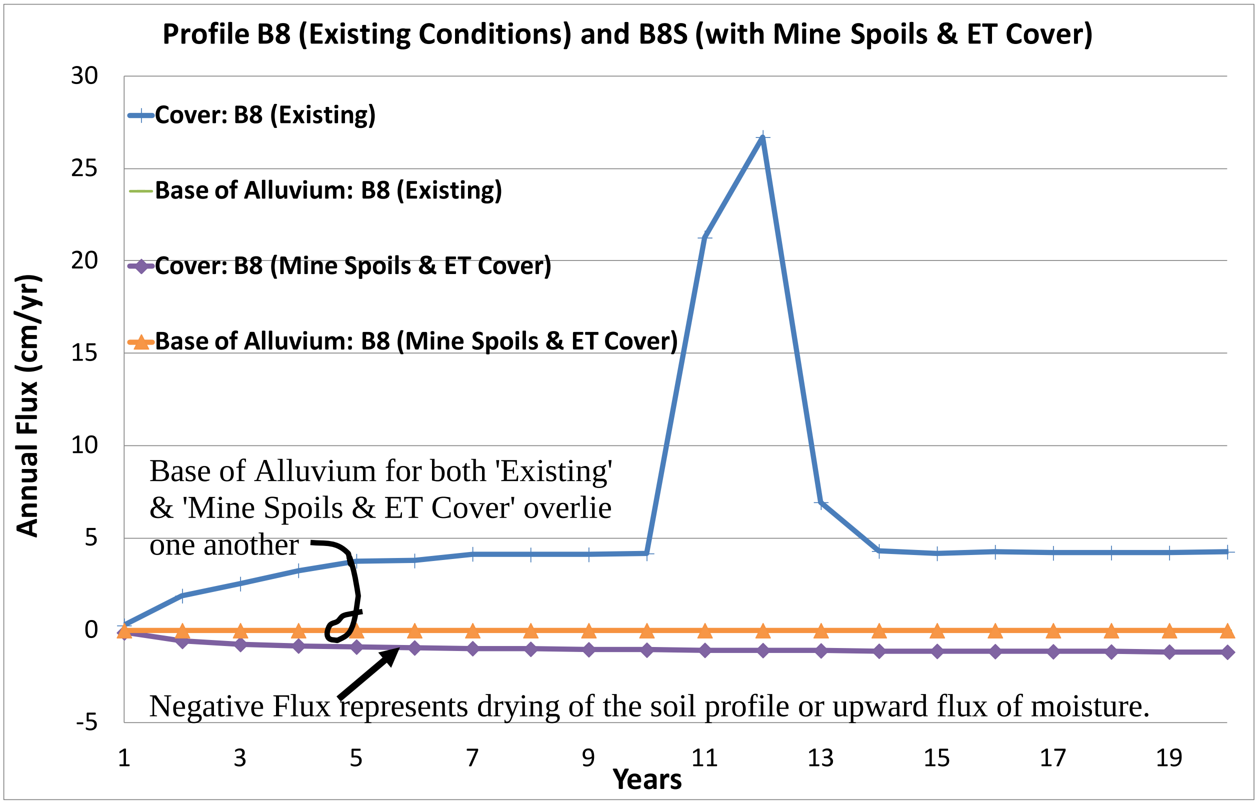


Figure 17. Profile B8 Computer Simulation Results

Profile B10 represents an area in Borrow Pit 1 that has about 36 ft of combined coarse- and fine-grained tailings. The area is proposed to have about 22.6 ft of mine spoils placed on it in addition to a 4-ft ET Cover. About 6 inches of rock from the existing cover will be removed for later use prior to placement of the mine spoils (refer to Figures 1, 2 and 10).

Both the existing and 'after' profile of B10 have an average annual drainage rate of 5.57×10^{-6} cm/year or a hydraulic conductivity given the steady state conditions assumed at the base of the profile of 1.77×10^{-13} cm/sec (Table 15, Figure 18).

Relative to the existing condition, the ET Cover allows for drying of the profile and reduces any theoretical recharge to groundwater via the conservative assumptions used in the calculations. In conclusion, there is no increase in drainage to the underlying groundwater over the existing condition due to the addition of mine spoils and new ET Cover in Profile B10.

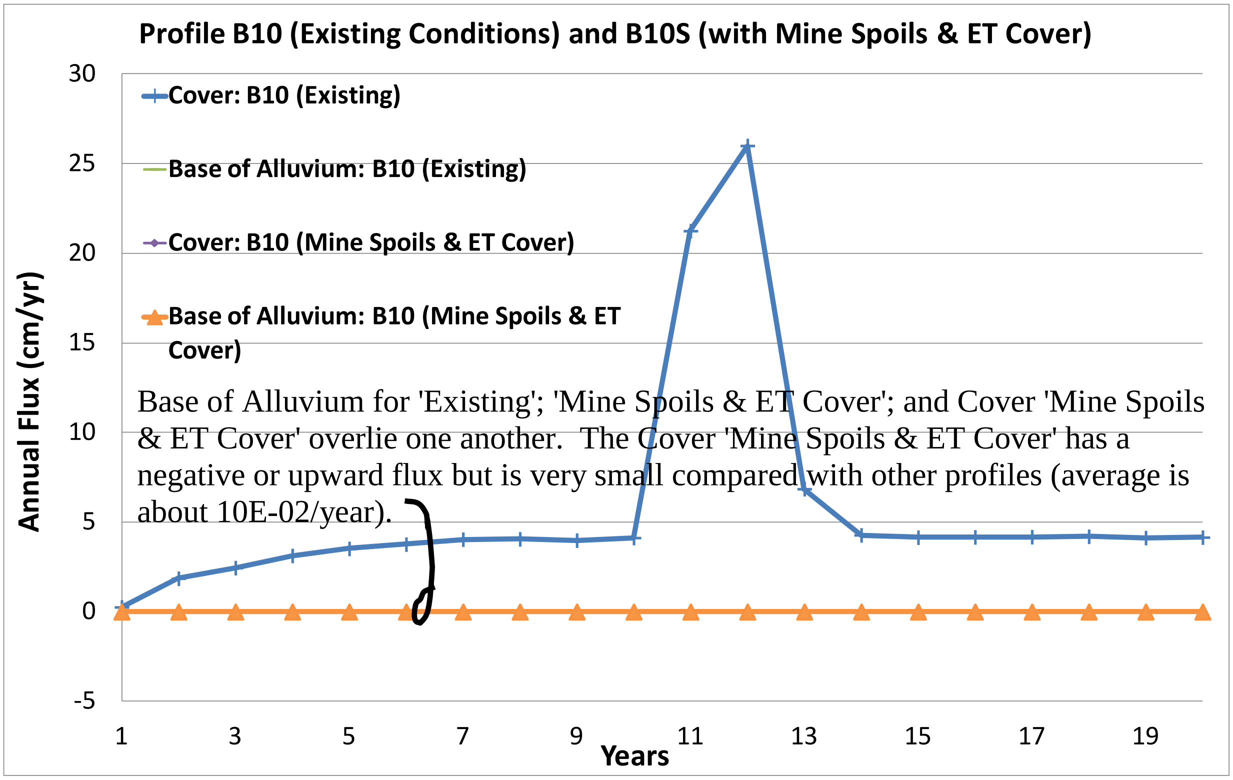


Figure 18. Profile B10 Computer Simulation Results

5.3 Borrow Pit 2: Profile B11

Profile B11 represents an area in Borrow Pit 2 that has about 36 ft of combined coarse- and fine-grained tailings. No mine spoils placement is planned for this area, just a thin layer of clean fill in addition to a 4-ft ET Cover. About 6 inches of rock from the existing cover will be removed for later use prior to placement of the mine spoils (refer to Figures 1, 2 and 11).

The existing profile B11 has an average annual drainage rate of 0.488508 cm/year or a hydraulic conductivity given the steady state conditions assumed at the base of the profile of 1.549×10^{-8} cm/sec. The profile B11 after placement of fill and new ET Cover has an average annual drainage rate of 0.488510 cm/year or a hydraulic conductivity given the steady state conditions assumed at the base of the profile of 1.549×10^{-8} cm/sec (Table 15, Figure 19).

Relative to the existing condition, the ET Cover allows for drying of the profile and reduces any theoretical recharge to groundwater via the conservative assumptions used in the calculations. In conclusion, there is no increase in drainage to the underlying groundwater over the existing condition due to the addition of soil over Profile B11.

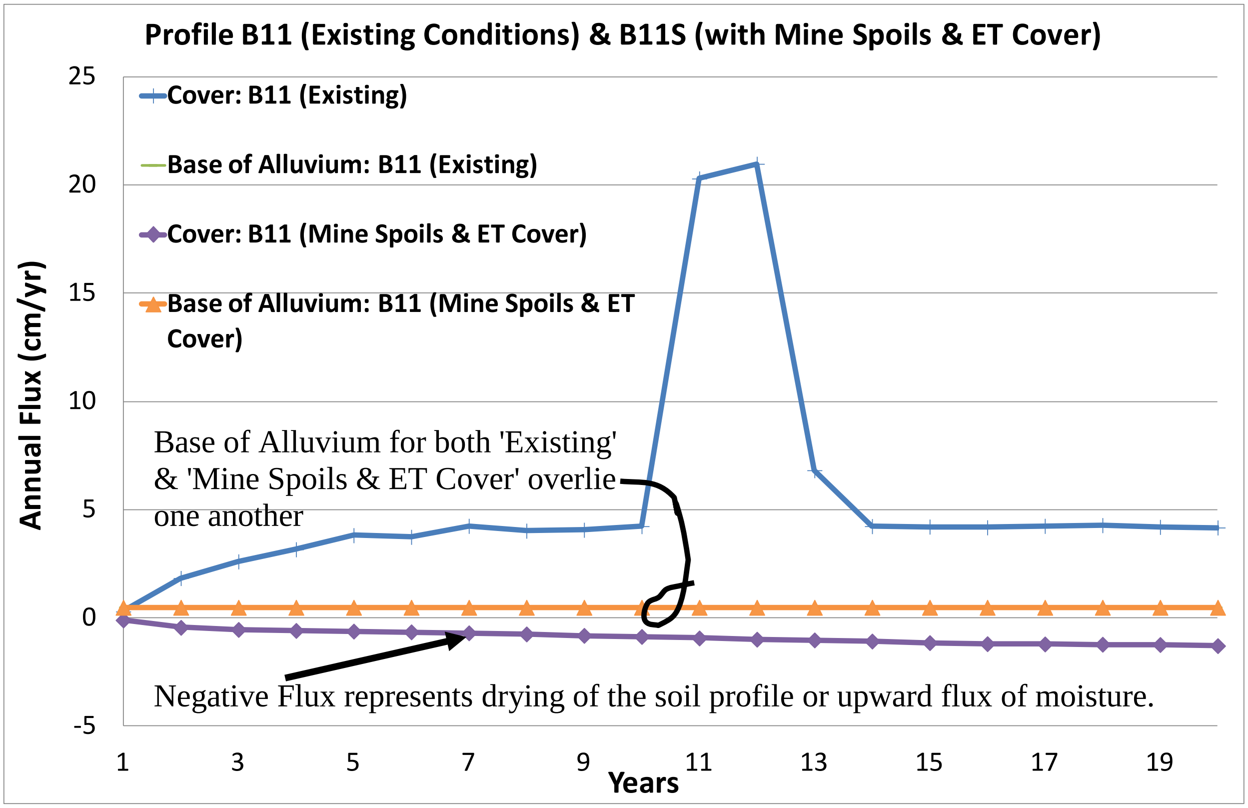


Figure 19. Profile B11 Computer Simulation Results

6.0 LONG-TERM SIMULATIONS: BORROW PIT 1: PROFILE B8

6.1 Overview of Long-Term Simulations

The profile analyses summarized in Section 5 were modeled for a 20-year period. These results each revealed no increased impact to groundwater due to the placement of the mine spoils and ET cover on the existing impoundment. The consolidation results (Section 3) of the four profiles analyzed estimated that only the fine-grained tailings in Profile B8 would actually reach full saturation after consolidation. Because Profile B8 after placement of the mine spoils is the only profile with fully saturated tailings, it is considered the worst case of the four profiles evaluated. An additional set of simulations was performed on this worst case profile to evaluate the long-term effects (Figure 9).

This long-term analysis is intended to evaluate the water balance of the entire profile and potential flux to groundwater over an extended period of time, accounting for the time-dependent variation in the input parameters (climate, soil, and vegetation). It is also meant to evaluate the potential for water accumulation above the existing radon barrier, and thereby, increase the risk of future side seeps. This long-term simulation used the wettest initial conditions resulting from the most allowable construction water placed in the mine spoils and ET Cover. The construction specifications for the installation of both the mine spoils and ET Cover shall limit the moisture content during installation to the optimum moisture content per ASTM D698. That is, each lift of soil placed of both the mine spoils and ET Cover on the impoundment shall be at or dry of its respective optimum moisture content prior to the installation of a subsequent lift of soil. Consequently, this set of simulations assumed the moisture content for ***all*** of the mine spoils and ET Cover were installed at the ***optimum moisture content***.

The UNSAT-H software cannot alter input parameters after the initiation of a given simulation. Consequently, running the long-term evaluation of Profile B8 involved multiple stages. That is, for the long-term evaluation, the initial simulation with an initial set of input parameters was performed for a specified time period and set of climatic upper boundary conditions. The last day of the last year of that initial simulation output - specifically, the matric potential values for each node from the previous simulation - was then used as the initial soil conditions for each node in the subsequent simulation with the altered input parameters. For example, the *final* soil suction values for each node in the model geometry for the ‘initial’ stage were used as the starting conditions for the next 'short-term' stage. There was no vegetation included in the 'initial' stage, but vegetation was included in subsequent stages (Cedar Creek 2014). The long-term simulations were performed in four sequential stages: 'initial', 'short-term', 'intermediate', and 'long-term' (Figure 20).

Time	Initial	Short-Term	Intermediate	Long-Term
Vegetation	None	Disturbed (Reclaimed)	Grassland	Shrubland
Soil	Remolded (Lab Measured)	Remolded (Lab Measured)	Remolded (Lab Measured)	Undisturbed (In Situ Measured)
Climate	Typical	Typical and Extreme	Typical and Extreme	Typical and Extreme

Figure 20. Input Based on Design Life for Computer Simulations

The first stage of the long-term simulations for Profile B8 assumed no vegetation for the first year. The soil from the south drainage borrow area was used for the ET Cover since it is the largest borrow source. The soil hydraulic input parameters from different borrow sources showed minimal variation in the predicted point of diminishing returns (PODR) for the cover profiles from the sensitivity analyses described in Dwyer (2017). THE PODR is defined as the depth of cover whereby additional cover thickness no longer reduces flux. The remolded values for the soil hydraulic properties based on laboratory measurements (Section 4) were used in the 'initial' stage. The input parameters are summarized in Table 12 with the exception of the initial suction values for the mine spoils and ET Cover. The initial soil suction values were revised to correlate with the optimum moisture content.

The initial suction values for the mine spoils and ET Cover were computed utilizing Equation 4-4 and the optimum moisture content (ASTM D698) for the respective soils. The optimum moisture content for the ET Cover (soil sample SB-B4-01) is 19.6 percent (vol.) (MWH 2014). The corresponding soil suction or matric potential is 2053.1 cm. The optimum moisture content for the mine spoils (soil sample TT-205-GT1) is 22.2 percent (vol.) (MWH 2014). The corresponding soil suction or matric potential is 175.2 cm.

Other soil input parameters for this set of simulations are contained in Table 12. These soil properties were also the soil input parameters used for the short- to intermediate- time periods. No vegetation is assumed for the 'initial' stage with average weather conditions. Average weather conditions were assumed because dry conditions would yield no flux while wet conditions would yield vegetation. The moisture condition (matric potential for each node in the model geometry) at the end of the initial year, was then taken and used as the initial moisture conditions (matric potential for each node in the modeled geometry) for the next 'short-term' stage.

The second stage of the long-term simulation included vegetation from the reclaimed vegetation analog (Cedar Creek 2014; refer to Section 4 for specifics on the input parameters). Tables 16 and 17 contain rooting vegetation input parameters used in this set of simulations. The reclaimed community of vegetation represents disturbed vegetation and generally considered from a time period shortly after seeding the installed ET Cover up to about 50 years (Cedar Creek 2014). The soil input parameters and geometries from the first stage of simulations were consistent with this stage of simulations. Typical climate conditions were used for ten consecutive years followed by the wettest year on record two years in a row, followed by eight more years of typical climate conditions. This is conservative to apply the wettest year on record in two consecutive years every twenty years and include no dry years in the analysis. Applying two consecutive wettest years on record is assumed to be beyond the worst case infiltration event. The moisture condition (matric potential for each node in the model geometry) at the end of the last year of the respective 'short-term' stage for each admixture design, was then taken and used as the initial moisture conditions (matric potential for each node in the new model geometry) for the next 'intermediate' stage.

Table 16. Rooting Parameters (Cedar Creek 2014)

Parameter	Reclaimed Analog	Grass Analog	Shrub Analog
a	556.28266872	0.34471705	0.42851959
b	-0.00000543	-0.07151063	-0.03407481
c	-555.91871302	0.13639067	0.07781172

Table 17. Vegetation Parameters (Cedar Creek 2014)

Parameter	Reclaim Analog	Grass Analog	Shrub Analog
LAI	0.91	0.64	0.52
% Bare Area	52.3%	64.9%	75.2%
Root Length	147 cm	142 cm	155 cm

The third stage of the long-term simulation included vegetation from the grassland vegetation analog (Cedar Creek 2014; refer to Section 4 for specifics on the input parameters). The grassland community represents undisturbed vegetation and is assumed to represents the vegetation on the cover from about 25 to 100 years after construction (Cedar Creek 2014). The soil input parameters and geometries from the 'short-term' stage were consistent with this 'intermediate' stage. Typical climate conditions were used for ten consecutive years followed by the wettest year on record two years in a row, followed by eight more years of typical climate conditions. The wettest years run consecutively is assumed to be beyond the worst case infiltration event. The moisture condition (matric potential for each node in the model geometry) at the end of the last year of each respective 'intermediate' stage for each admixture design, was then taken and used as the initial moisture conditions (matric potential for each node in the new model geometry) for the next 'long-term' stage.

The fourth stage of the long-term simulation included vegetation from the shrubland vegetation analog (Cedar Creek 2014; refer to Section 4 for specifics on the input parameters). The shrubland community represents vegetation in an undisturbed setting and is assumed to represent vegetation on the cover from about 50 to 1,000 years following construction (Cedar Creek 2014). The geometries from the 'intermediate' stage were consistent with this 'long-term' stage. The soil input parameters were changed to the soil analog data obtained from the south drainage borrow area that represent an undisturbed soil structure or the long-term status of the soil (Dwyer 2014). Typical climate conditions were used for ten consecutive years followed by the wettest year on record two years in a row, followed by eight more years of typical climate conditions. The wettest years run consecutively is assumed to be the worst case infiltration event.

6.2 Long-Term Simulations Results with Respect to Groundwater

The first objective of the long-term analyses is to evaluate the water balance of the entire profile and potential effect on groundwater over an extended time period taking into account the time-dependent variation in the input parameters (climate, soil, and vegetation). The results of the analysis demonstrated that the de minims amount of water flux through the alluvium at Borrow Pit 2 (worst case profile) will not increase over time. The results indicate the soil profile has more than sufficient storage capacity in the existing fill and in the alluvium to contain any existing moisture or added moisture for the long-term. Although, this analysis only focused on the worst case location, its results can be transferred to the entire repository to demonstrate that addition of the mine waster and ET cover will not adversely impact groundwater over the long-term.

The soil suction values versus depth from the surface over a 63-year period was plotted for the entire Profile B8 in the 'before' and ‘after’ scenarios [refer to Figures 21 and 22]. It can be seen that the soils, including the tailings, are moving toward an equilibrium moisture status under both scenarios. The deepest and wetter fine-grained tailings are drying under both scenarios. That is, the suction values are increasing. Whereas the suction values of the coarser-grained tailings above these wetter tailings are moving to the left or decreasing. Wet tailings are drying while tailings materials that are drier are pulling moisture from the wetter soils.

It can also be seen that some moisture has moved down from the fine-grained tailings into the upper portion of the unsaturated alluvium under both scenarios. The moisture movement downward is controlled by the very low saturated hydraulic conductivity of the fine-grained tailings (about 10^{-8} cm/sec). There was no downward moisture movement after about 40 years for both the 'before' and 'after’ scenarios. That is, the base of the moisture movement into the alluvium or decrease in soil suction did not change from model years 2043 to 2062. Because the moisture is no longer moving downward, the moisture in the tailings is not a threat to the underlying groundwater.

The movement of water into the top of the alluvium from the fine tailings is identical in both the ‘before’ and ‘after’ scenarios. This movement is likely the consequence of the applied unit gradient condition in the modeling. A unit gradient bottom boundary forces water to be removed. This drainage from the base of the unsaturated alluvium albeit very small pulls moisture from the tailings into the alluvium. During the drilling program, two improvised piezometers that extended through the fine-grained tailings were installed in open CPT holes at locations B10 and B18. These piezometers experienced no seepage nor did the open holes experience any creep during the several weeks they were monitored (MWH 2014). This is consistent with the notion that *actual* drainage from the tailings is unlikely.

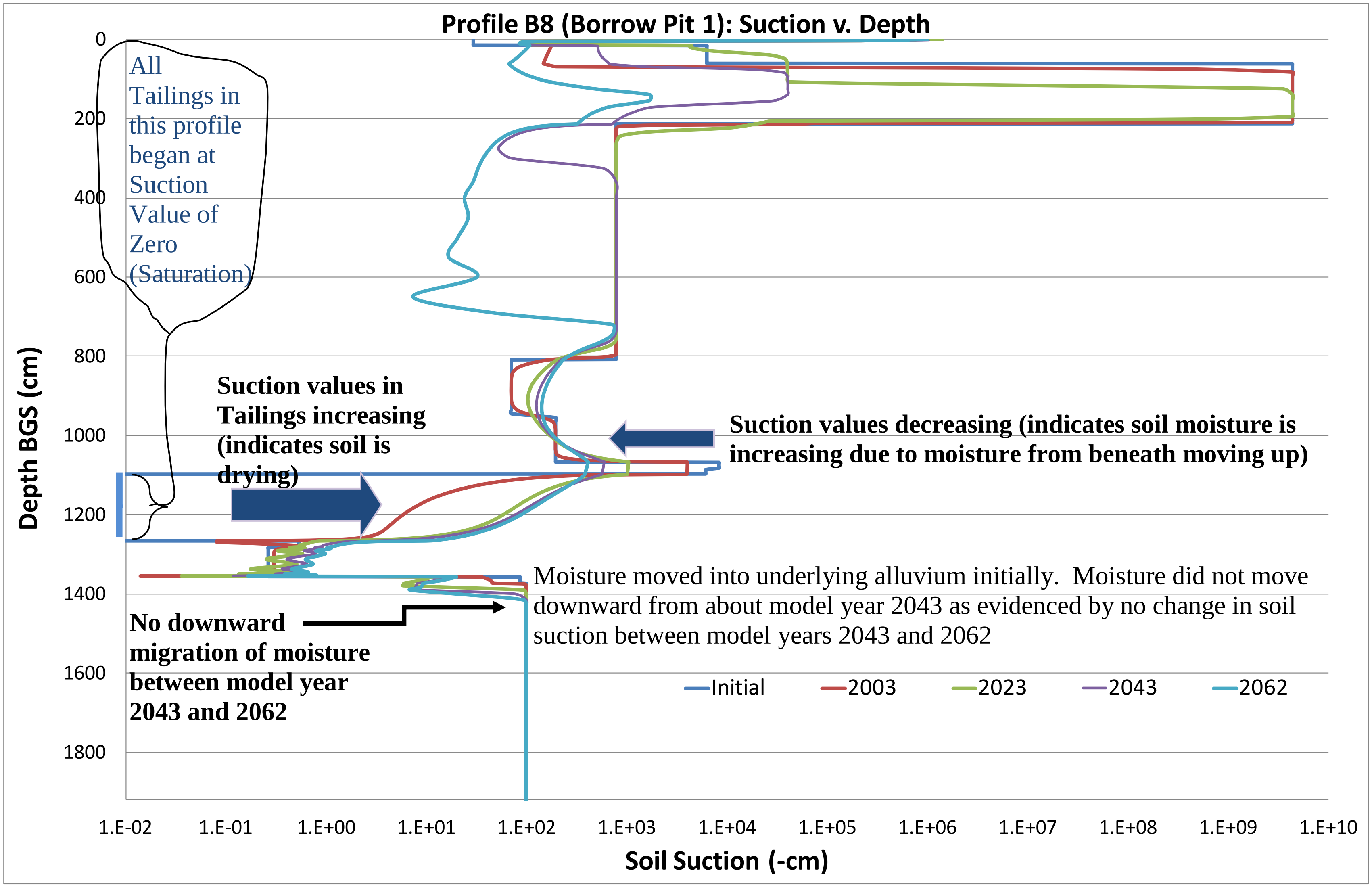


Figure 21. Profile B8 'Before' Condition: Soil Suction v. Depth

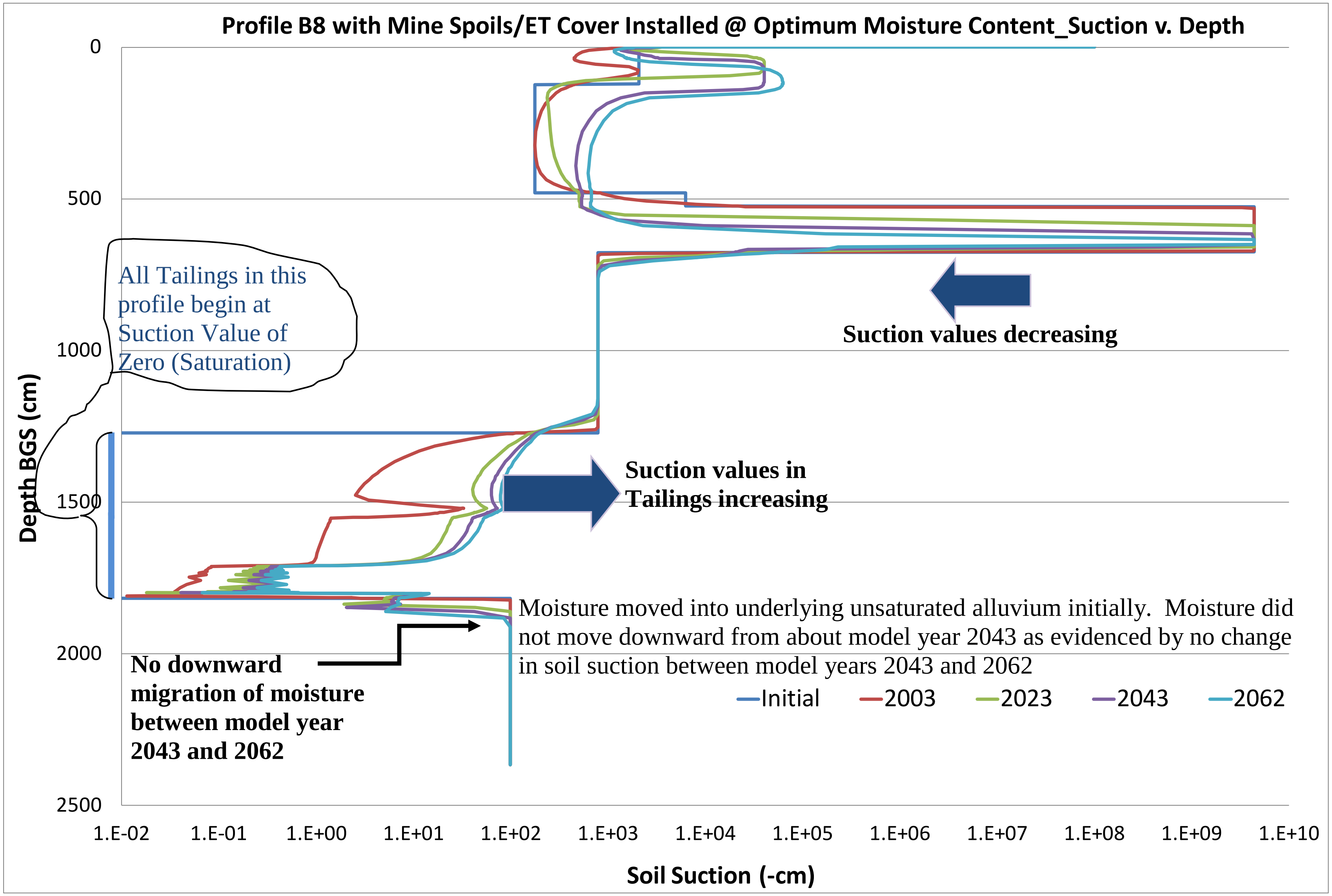


Figure 22. Profile B8 'After' Placement of Mine Spoils and ET Cover Installed @ Optimum Moisture Content

It has been noted that the initial suction values for the fill soil appear high even though these values were computed based on the field measured moisture content and corresponding laboratory measured moisture retention characteristics (MWH 2014). Figures 21 and 22 for profile B8 show that the higher initial soil suction in the *fill layers* actually makes the analysis more conservative. That is, the 'before' condition (Figure 21) shows that as percolation comes through the existing cover it moves into the fill soil and reduces the soil suction (increases the moisture content). Thus, the initial condition for the 'before' condition provides more initial storage capacity for percolation through the existing cover. Eventually, this moisture works its way down the profile as can be seen with the suction graphic for the year 2063 where the suction has moved significantly to the left. This shows that moving forward past 2063, the percolation occurring in the existing cover may actually allow moisture into the tailings thus increasing the potential for future groundwater impacts. Conversely, Figure 22 indicates that the soil suction over time has little change other than to very slowly move toward steady state. There is no percolation coming from the new ET Cover and thus there is no potential future impact on groundwater. In other words, the impoundment has been improved by the installation of the new ET Cover and is evidenced by these two figures.

6.3 Long-Term Simulations Results with Respect to Lateral Seepage

The long-term modeling was also used to address the concern for potential water accumulation on the existing radon barrier, and thereby, increase the risk of future side seeps. The concern is that water from the placement of the mine waste will migrate vertically downward to the barrier, accumulate, and eventually travel laterally along the layer to cause side seeps at the perimeter of the repository. This modeling exercise was also used to address the concern regarding the sensitivity of moisture during placement of the mine spoils and ET Cover during construction.

To address these concerns, the long-term model focused on the matric potential of the soil profile as a function of time. The output features the base of the mine spoils and middle of the radon barrier. Two sets of long-term simulations performed considered different placement water contents for the mine spoils and ET Cover. The first water content used was the installed moisture condition of all of the mine spoils and ET Cover at the suction value corresponding to the respective optimum moisture content (ASTM D698). The optimum moisture content is the wettest condition that the materials can be installed. Per the design specifications, any wetter condition will require removal of the material and drying it or reworking the soil to dry it in place. However, no material will be allowed to be placed on top of a wet layer of soil until that underlying soil lift meets the specified conditions. The mine spoils are placed directly on the existing cover/radon barrier less the removal of the existing surface riprap that will be utilized elsewhere in the project. The next simulation set used an increased moisture in the mine spoils and ET Cover whereby they were ***entirely*** installed ***3 percent wet of the optimum moisture*** content per ASTM D698. This moisture content is higher than will be allowed during actual placement, but was modeled as a sensitivity analysis.

The initial suction values for the mine spoils and ET Cover in these simulations were computed utilizing Equation 4-4 and either the optimum moisture content or 3 percent wet of the optimum moisture content per ASTM D698 for the mine spoils and cover soil. The optimum moisture content (ASTM D 698) for the ET Cover (Soil sample SB-B4-01) is 19.6 percent (vol.); therefore, 3 percent wet of optimum for the cover soil the moisture content is 22.6 percent (vol.). The corresponding soil suction or matric potential is 1083.0 cm. The optimum moisture content for the mine spoils is (soil sample TT-205-GT1) is 22.2 percent (vol.); therefore, 3 percent wet of optimum for the cover soil the moisture content is 25.2 percent (vol.). The corresponding soil suction or matric potential is 96.8 cm. Other soil input parameters for this set of simulations is contained in Table 12. The vegetation input parameters are those contained in Tables 16 and 17.

Under the optimum moisture content placement scenario, the model results indicated the mine spoils began drying immediately after installation. There is no flux that moves beneath the ET Cover (Dwyer 2017) and thus the net flux from Profile B8 is actually negative or upward with moisture from underlying wet soils moving upward and out of the profile. This trend will continue until a relative steady state is achieved. The adjacent soils of the mine spoils placed directly on the existing radon barrier soil have different soil textures and varied initial moisture contents. These adjacent soils are shown in Figure 23 moving toward equilibrium with respect to moisture as the soil suctions from each equilibrate about twenty to thirty years after installation of the wetter mine spoils. After the two soils equilibrate, both layers begin to dry. This drying trend will continue similarly to the mine spoils until a relative steady state condition is achieved at a suction value greater than that shown at the end of this set of simulations in the year 2062. The drying trend is assured given no recharge through the ET Cover (Dwyer 2017).

The results of this computer simulation for Profile B8 with all of the mine spoils and ET cover installed 3 percent wet of optimum (Figure 24) are similar to the previous analysis with the mine spoils and ET Cover installed at optimum moisture content (Figure 23). That is, the soil suction (Figure 24) and thus moisture content of the installed mine spoils and ET Cover will not cause any moisture build-up on the underlying radon barrier/liner while the radon barrier/liner continues to dry similar to that shown in Figure 23.

Even though the mine spoils initial suction value is very wet at 3 percent above optimum moisture content, it quickly dries and continues to dry during the full simulation (middle of mine spoils). The base of the mine spoils and adjacent radon barrier suction values move toward equilibrium (equal suction values) and then eventually all layers show a drying trend for the duration of the long-term simulation. This drying trend will continue until a steady state condition is reached, presumably at a suction value greater than the values shown for the base of the mine spoils or middle of the radon barrier. This is largely due to no recharge through the ET Cover system (Dwyer 2017) and the initial conditions are the wettest conditions; thus the profile will continue to dry as time passes while approaching steady state conditions.

Figure 24 also illustrates that there is no moisture buildup on the existing radon/barrier and thus no potential for future seepage from the impoundment even for mine spoils and cover material placed at 3 percent wet of optimum moisture content. Additionally, the moisture content of the mine spoils and cover soil is not a concern for future seepage form the impoundment.

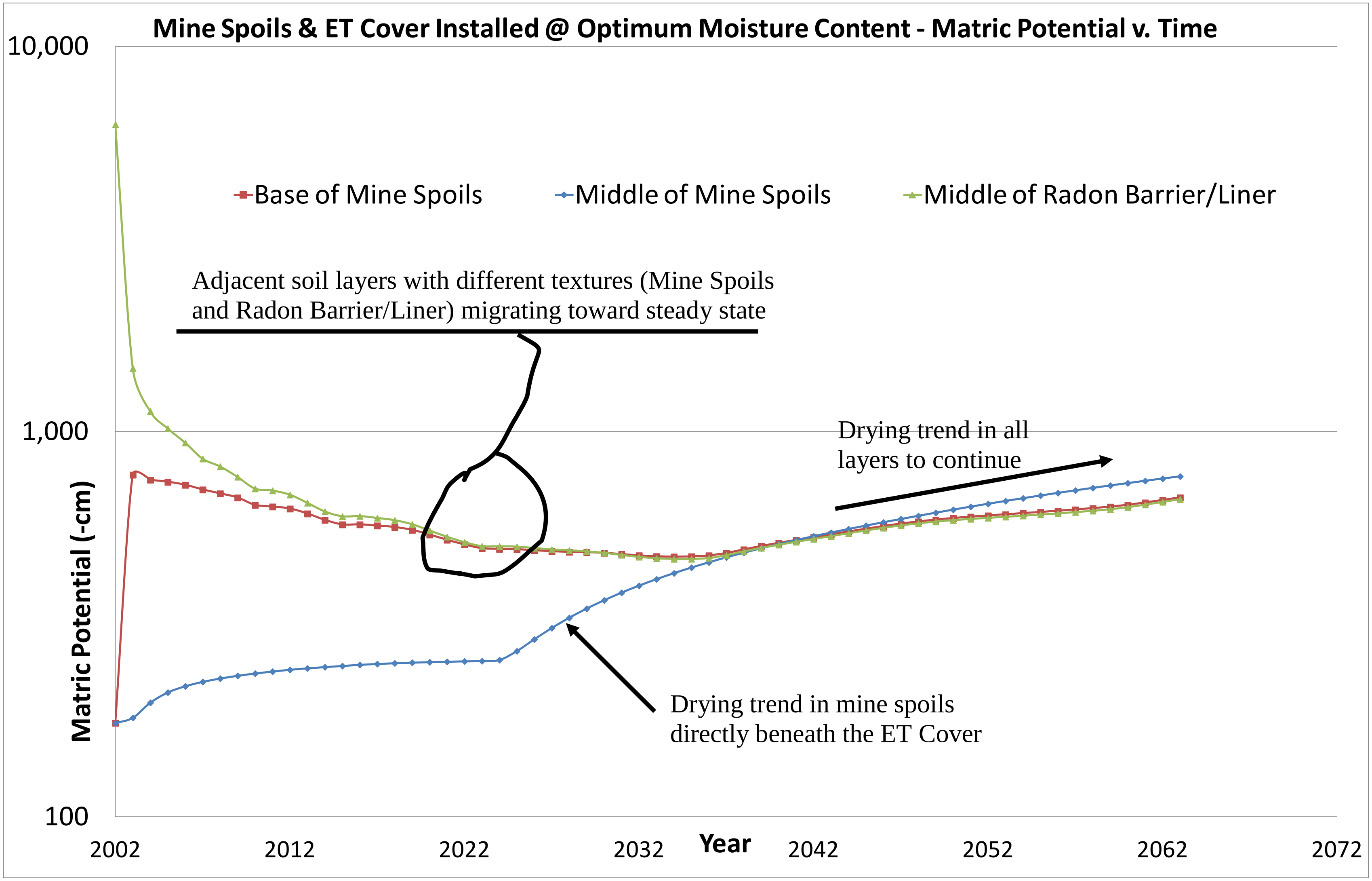


Figure 23. Suction Values with Respect to Depth vs. Time for Profile B with Mine Spoils & ET Cover Installed @ Optimum Moisture Content

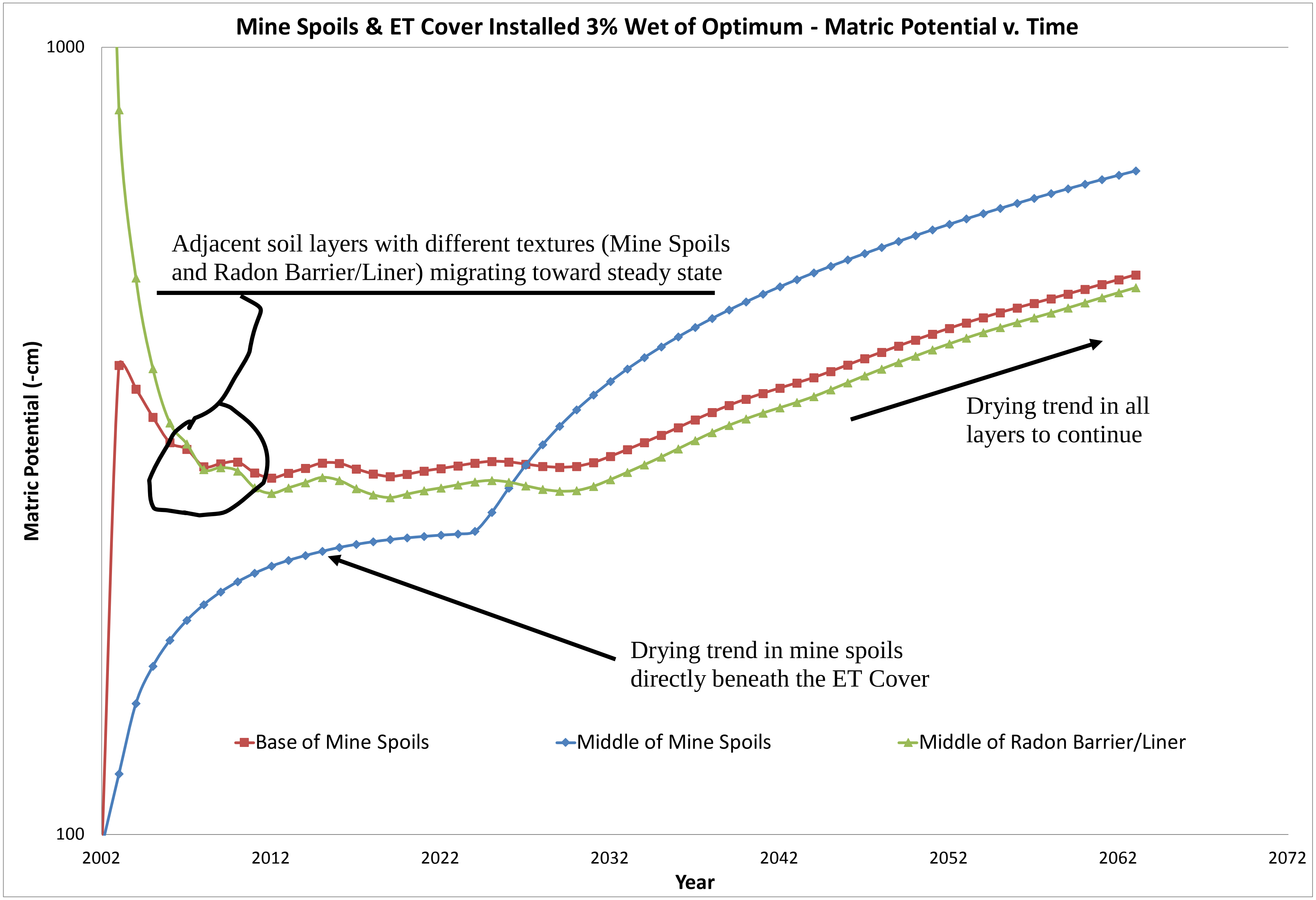


Figure 24. Suction Values with Respect to Depth vs. Time for Profile B with Mine Spoils & ET Cover Installed @ 3% Wet of Optimum Moisture Content

7.0 DISCUSSION OF RESULTS

Placement of the mine spoils and subsequent ET Cover will add weight and thus stress on the existing tailings placed within the current impoundment. Of particular interest is the consolidation on the fine-grained tailings with high water content. The purpose of the analysis was to evaluate if water currently stored in the fine-tailings would be ‘squeezed’ out with the additional weight and impact the underlying groundwater. Analyses presented in this report demonstrate that this added weight on these tailings will not adversely affect the quality of the underlying groundwater relative to current conditions. The modeling results demonstrate that the ET cover is better able to reduce tailings liquid fluxes at the base of the unsaturated alluvium than the existing condition. This is not to say that there is ongoing tailings seepage currently, rather whatever the current condition is, the proposed removal action would improve on it.

The analysis included computation of consolidation in the fine-grained tailings serving as input into subsequent model simulations using UNSAT-H. The analysis focused on two areas (the two borrow pits) with the highest potential for a release of water from the fine-tailings; and therefore, represents a conservative test case. These two areas have the thickest layers of near saturation (greater than 90 percent of saturation) fine-grained materials throughout the proposed repository footprint. In addition, they represent less than about 25 percent of the total proposed repository area (Figure 1). The remaining area has either no fine-grained tailings or a thinner layer of fine-grained tailings. Nonetheless, a representative boring in the North Cell was included to analyze potential to impact groundwater for the majority of the proposed repository area.

Consolidation was calculated for each fine-tailings layer in each profile, and a subsequent final saturation to represent saturation after placement of mine waste and the new ET cover was calculated. The hydraulic properties of the existing materials, identified in the field drilling and sampling project (MWH 2014), as well as the initial saturation values were utilized as input parameters in modeling to estimate the water balance of the profiles prior to placement of any additional materials on the existing repository. Subsequent simulations used the final saturation, which included any water squeezed from one tailings layer to an adjacent layer, to estimate the water balance of the profiles after placement of any additional materials on the existing repository.

The first set of computer simulations were for a 20-year period and looked at the calculated flux at the base of the cover and at the base of the unsaturated alluvium, both 'before' and 'after' implementing the proposed removal action. The simulations revealed no difference in drainage through the base of the unsaturated alluvium modeled for the 'before' and 'after' condition for the majority of the repository area, specifically any area outside Borrow Pit 2. Under the Borrow Pit 2 scenario, there was a de minims amount of additional flux calculated at the base of the unsaturated alluvium. With regard to Borrow Pit 2, there will be no mine spoils placed over the Borehole B11 area, just a thin layer of clean fill soil. The underlying alluvium in these areas was relatively dry compared to the overlying fine-grained tailings and had significant water storage capacity still available. Thus, any drainage from the tailings was captured within the alluvium. It should be noted that drainage from the alluvium calculated in the modeling is likely due to the unit gradient condition applied to the base of each profile forcing drainage based on steady state conditions at the bottom node and does not necessarily mean there is actually drainage from the alluvium. Given that the repository area will see no change in flux, it can be concluded that there will be no impact to water quality with the addition of the mine spoils and ET cover.

The second set of computer simulations focused on the worst case area, Borrow Pit 1, for a longer duration. Specially, Boring B8 which was the only profile computed to be at full saturation within the fine-grained tailings layer after consolidation. This long-term analysis was intended to evaluate the water balance over the entire thickness of the profile for an extended time period that accounted for the time-dependent variation in the input parameters (climate, soil, and vegetation). The results of the analysis demonstrated that drainage will not increase over time, i.e. there is no new 'slug' of water 'squeezed out' of the fine-tailings moving towards the underlying groundwater. The results also demonstrated that the wettest condition is the initial condition and that the long-term trend for the profile is drying. This analysis only focused on the worst case location, and so it has been demonstrated that the performance of the proposed removal action cannot adversely impact groundwater quality relative to the existing condition.

It is important to prevent the risk of future side seeps as well as the potential for recharge to groundwater. Therefore, the long-term simulations were also used to address a concern for water to accumulate on the radon barrier (see Section 6.3). The computer simulation results in these cases focused on the base of the mine waste and the middle of the radon barrier under two water contents for the mine waste. The first was at the maximum water content of the mine spoils as specified in the design and the second simulation used a wetter moisture content (3 percent wet of the optimum water content). The results of the computer simulation were similar. The soil suction and thus moisture content of the installed mine spoils and ET Cover will not cause moisture build-up on the underlying radon barrier while the radon barrier continues to dry. Thus, there is no potential for seeps emerging from the impoundment.

8.0 REFERENCES

1. American Society for Testing and Materials (ASTM), 2012 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. ASTM 698-12.
2. American Society for Testing and Materials (ASTM), 2015. Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles. ASTM D4718.
3. Bouwer H. and R. Rice, 1984. Hydraulic Properties of Stony Vadose Zones. Ground Water, 22 (6) (1984), pp. 696–705.
4. Bowles, Joseph E. 1996. Foundation Analysis and Design. 5th Edition. McGraw-Hill Companies, Inc.
5. Canonie Environmental. 1987. North Cell Final Reclamation, As-Built Report. November.
6. Canonie Environmental. 1990. North Cell Interim Stabilization, As-Built Report. January.
7. Canonie Environmental. 1992. Central Cell Interim Stabilization, As-Built Report Addendum. April.
8. Carsel, R. F., and R. S. Parrish. 1988. Developing joint probability distributions of soil water retention characteristics. Water Resources Research, 24(5):755-769. May.
9. Cedar Creek Associates. 2014. Vegetation Characterization and Biointrusion Surveys Church Rock Mill Site. July.
10. Doorenbos, J. and W.O. Pruitt. 1977. Guidelines for prediction crop water requirements. FAO Irrig. and Drain. Paper No. 24, 2nd ed., FAO Rome, Italy.
11. Dwyer, SF. 2003. Water Balance Measurements and Computer Simulations of Landfill Closures. PhD Dissertation. University of New Mexico, Albuquerque, NM.
12. Dwyer, SF. 2014. Natural Analog Study of Cover Soil Borrow Sources Using a Tension Infiltrometer. Northeast Churchrock Mine, Gallup, NM. August 20.
13. Dwyer, SF. 2017. Cover System Design Report - 95% Design Draft. October.
14. Fayer, M. J., and T. L. Jones. 1990. UNSAT-H version 2.0: Unsaturated soil water and heat flow model. PNL-6779, Pacific Northwest Laboratory, Richland, WA.
15. Fayer, M.J. 2000. UNSAT-H Version 3.0: Unsaturated Soil Water and Heat Flow Model, Theory, User Manual, and Examples. Pacific Northwest Laboratory, Richland, WA.
16. Fayer, MJ and TB Walters. 1995. Estimated Recharge Rates at the Hanford Site. PNL-10285, Pacific Northwest Laboratory, Richland, WA.
17. Hillel, D. 1998. Environmental Soil Physics. Academic Press, San Diego, CA.
18. ITRC. 2003. Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers. Interstate Technology and Regulatory Council, Alternative Landfill Technologies Team, Washington DC.
19. Mualem Y. 1976. “A new model for predicting the hydraulic conductivity of unsaturated porous media.” Water Resour. Res. 12(3):513-522.

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

21. Peck, A.J., and J.D. Watson. 1979. Hydraulic Conductivity and Flow in Non-uniform Soil. In Workshop on Soil Physics and Field Heterogeneity. CSIRO Division of Environmental Mechanics, Canberra, Australia.

22. Ritchie, J.T., and E. Burnett. (1971). Dryland Evaporative Flux in a Semi-humid Climate, 2, Plant Influences. Agron. J. 63:56-62.

23. Samani, Z. A. and M. Pessarakli, 1986: Estimating Potential Crop Evapotranspiration with Minimum Data in Arizona, Transactions of the ASAE Vol. 29, No. 2, pp. 522-524.

24. Schroeder, P., C. Lloyd and P. Zappi. 1994. The Hydrologic Evaluation of Landfill Performance (HELP) Model User's Guide for Version 3.0. U.S. Environmental Protection Agency, EPA/600/R-94/168a, Cincinnati, OH.

25. Terzaghi, K., Theoretical Soil Mechanics, John Wiley & Sons, New York, NY, USA, 1943.

26. U.S. Environmental Protection Agency (USEPA), Region 6 and Region 9. 2015. Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery. April 27.

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

28. U.S. Environmental Protection Agency (USEPA), Region 6. 2013. Record of Decision, United Nuclear Corporation Site, McKinley County, New Mexico. March 29.

29. van Genuchten R. 1978. Calculating the unsaturated hydraulic conductivity with a new closed-form analytical model. Water Resource Program, Department of Civil Engineering, Princeton University, Princeton, New Jersey.

30. van Genuchten, M.Th., F.J. Leij, and S.R. Yates. 1991. The RETC code for quantifying the hydraulic functions of unsaturated soils.

31. Vanapalli, S.K. and Oh, W.T. 2010. Mechanics of unsaturated soils for the design of foundation structures. Plenary Address, *In* Proc. 3rd WSEAS Int. Conf. on Engineering Mechanics, Structures, Engineering Geology, 20-24 July 2010, Corfu Island, Greece: 363-377.

APPENDIX A

WATER BALANCE RESULTS

Appendix A contains water balance results for each simulation for all twenty years. The water balance variables included are annual values, with each value having the units in 'cm'. The water balance variables included are applied upper boundary conditions including precipitation and potential evapotranspiration (PET) applied, as well as, calculated output: evaporation, transpiration, runoff, and drainage. Evaporation, transpiration, and runoff are all surface values while drainage is the value at the base of the profile modeled.

Table A1. Profile B2 (Existing Condition) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	8.42	11.98	0	1.14910E-06
2	29.743	211.744	10.049	11.809	0	1.15220E-06
3	29.743	211.744	11.263	11.871	0	1.14910E-06
4	29.743	211.744	12.499	11.918	0	1.14910E-06
5	29.743	211.744	13.416	11.926	0	1.14910E-06
6	29.743	211.744	13.407	11.932	0	1.15220E-06
7	29.743	211.744	13.398	11.929	0	1.14910E-06
8	29.743	211.744	13.378	11.931	0	1.14910E-06
9	29.743	211.744	13.374	11.922	0	1.14910E-06
10	29.743	211.744	13.373	11.938	0	1.15220E-06
11	60.35	215.456	5.136	34.1	0.634	1.14910E-06
12	60.35	215.456	3.998	45.512	5.371	1.14910E-06
13	29.743	211.744	6.067	21.059	0	1.14910E-06
14	29.743	211.744	6.169	18.683	0	1.15220E-06
15	29.743	211.744	6.171	18.671	0	1.14910E-06
16	29.743	211.744	6.166	18.683	0	1.14910E-06
17	29.743	211.744	6.166	18.686	0	1.14910E-06
18	29.743	211.744	6.161	18.691	0	1.15220E-06
19	29.743	211.744	6.164	18.675	0	1.14910E-06
20	29.743	211.744	6.17	18.685	0	1.15220E-06

Table A2. Profile B2 (Mine Spoils & ET Cover) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	16.147	18.937	0.097	1.14910E-06
2	29.743	211.744	10.691	18.819	0.091	1.15220E-06
3	29.743	211.744	10.201	18.857	0.093	1.14910E-06
4	29.743	211.744	10.318	18.946	0.088	1.14910E-06
5	29.743	211.744	10.288	18.862	0.095	1.14910E-06
6	29.743	211.744	10.26	18.763	0.095	1.15220E-06
7	29.743	211.744	10.359	18.778	0.092	1.14910E-06
8	29.743	211.744	10.397	18.753	0.099	1.14910E-06
9	29.743	211.744	10.662	18.927	0.091	1.14910E-06
10	29.743	211.744	10.459	18.729	0.094	1.15220E-06
11	60.35	215.456	19.82	35.552	0.735	1.14910E-06
12	60.35	215.456	21.741	37.68	0.345	1.14910E-06
13	29.743	211.744	13.548	20.349	0.087	1.14910E-06
14	29.743	211.744	10.755	18.843	0.09	1.15220E-06
15	29.743	211.744	10.551	18.733	0.087	1.14910E-06
16	29.743	211.744	10.641	18.793	0.085	1.14910E-06
17	29.743	211.744	10.875	18.955	0.101	1.14910E-06
18	29.743	211.744	10.78	18.882	0.092	1.15220E-06
19	29.743	211.744	10.642	18.767	0.091	1.14910E-06
20	29.743	211.744	10.668	18.781	0.09	1.15220E-06

Table A3. Profile B8 (Existing Condition) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	6.688	17.647	0.306	1.23350E-04
2	29.743	211.744	8.005	17.514	0.37	1.23690E-04
3	29.743	211.744	8.563	17.508	0.317	1.23350E-04
4	29.743	211.744	9.179	17.528	0.351	1.23350E-04
5	29.743	211.744	9.567	17.519	0.312	1.23350E-04
6	29.743	211.744	10.17	17.573	0.287	1.23690E-04
7	29.743	211.744	10.54	17.54	0.352	1.23350E-04
8	29.743	211.744	11.015	17.544	0.3	1.23350E-04
9	29.743	211.744	11.016	17.58	0.332	1.23350E-04
10	29.743	211.744	11.316	17.573	0.335	1.23690E-04
11	60.35	215.456	11.181	27.932	0.029	1.23350E-04
12	60.35	215.456	11.239	25.795	0.241	1.23350E-04
13	29.743	211.744	13.124	17.848	0.316	1.23350E-04
14	29.743	211.744	13.133	17.617	0.341	1.23690E-04
15	29.743	211.744	13.15	17.598	0.336	1.23350E-04
16	29.743	211.744	13.138	17.573	0.302	1.23350E-04
17	29.743	211.744	13.054	17.582	0.332	1.23350E-04
18	29.743	211.744	12.835	17.583	0.341	1.23690E-04
19	29.743	211.744	12.624	17.561	0.345	1.23350E-04
20	29.743	211.744	12.474	17.554	0.336	1.23690E-04

Table A4. Profile B8 (Mine Spoils & ET Cover) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	16.169	18.953	0.088	1.23350E-04
2	29.743	211.744	10.602	18.746	0.09	1.23690E-04
3	29.743	211.744	10.148	18.811	0.086	1.23350E-04
4	29.743	211.744	10.122	18.793	0.087	1.23350E-04
5	29.743	211.744	10.334	18.897	0.087	1.23350E-04
6	29.743	211.744	10.516	18.962	0.09	1.23690E-04
7	29.743	211.744	10.477	18.87	0.093	1.23350E-04
8	29.743	211.744	10.551	18.884	0.087	1.23350E-04
9	29.743	211.744	10.468	18.769	0.096	1.23350E-04
10	29.743	211.744	10.732	18.956	0.088	1.23690E-04
11	60.35	215.456	19.789	35.604	0.728	1.23350E-04
12	60.35	215.456	21.769	37.682	0.344	1.23350E-04
13	29.743	211.744	13.443	20.277	0.092	1.23350E-04
14	29.743	211.744	10.692	18.797	0.089	1.23690E-04
15	29.743	211.744	10.635	18.796	0.091	1.23350E-04
16	29.743	211.744	10.653	18.797	0.093	1.23350E-04
17	29.743	211.744	10.686	18.822	0.093	1.23350E-04
18	29.743	211.744	10.747	18.873	0.091	1.23690E-04
19	29.743	211.744	10.877	18.956	0.088	1.23350E-04
20	29.743	211.744	10.569	18.694	0.089	1.23690E-04

Table A5. Profile B10 (Existing Condition) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	6.682	17.624	0.379	5.56550E-06
2	29.743	211.744	7.998	17.505	0.397	5.58080E-06
3	29.743	211.744	8.54	17.518	0.343	5.56550E-06
4	29.743	211.744	9.102	17.533	0.328	5.56550E-06
5	29.743	211.744	9.479	17.517	0.352	5.56550E-06
6	29.743	211.744	10.156	17.533	0.405	5.58080E-06
7	29.743	211.744	10.345	17.541	0.344	5.56550E-06
8	29.743	211.744	11.005	17.546	0.313	5.56550E-06
9	29.743	211.744	11.011	17.556	0.341	5.56550E-06
10	29.743	211.744	11.113	17.555	0.406	5.58080E-06
11	60.35	215.456	11.166	27.874	0.053	5.56550E-06
12	60.35	215.456	11.191	26.454	0.233	5.56550E-06
13	29.743	211.744	13.111	17.835	0.376	5.56550E-06
14	29.743	211.744	13.128	17.589	0.32	5.58080E-06
15	29.743	211.744	13.149	17.566	0.351	5.56550E-06
16	29.743	211.744	13.138	17.575	0.359	5.56550E-06
17	29.743	211.744	13.003	17.577	0.368	5.56550E-06
18	29.743	211.744	12.761	17.552	0.344	5.58080E-06
19	29.743	211.744	12.562	17.545	0.352	5.56550E-06
20	29.743	211.744	12.395	17.554	0.394	5.58080E-06

Table A6. Profile B10 (Mine Spoils & ET Cover) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	17.365	19.187	0.091	5.56550E-06
2	29.743	211.744	12.161	18.996	0.087	5.58080E-06
3	29.743	211.744	11.513	19.02	0.088	5.56550E-06
4	29.743	211.744	11.105	18.829	0.089	5.56550E-06
5	29.743	211.744	11.208	18.964	0.095	5.56550E-06
6	29.743	211.744	11.152	18.953	0.093	5.58080E-06
7	29.743	211.744	11.081	18.908	0.088	5.56550E-06
8	29.743	211.744	11.079	18.914	0.09	5.56550E-06
9	29.743	211.744	11.256	19.066	0.088	5.56550E-06
10	29.743	211.744	11.231	19.046	0.089	5.58080E-06
11	60.35	215.456	20.229	35.861	0.685	5.56550E-06
12	60.35	215.456	22.04	37.873	0.335	5.56550E-06
13	29.743	211.744	13.968	20.434	0.092	5.56550E-06
14	29.743	211.744	11.239	18.998	0.09	5.58080E-06
15	29.743	211.744	11.025	18.889	0.09	5.56550E-06
16	29.743	211.744	11.034	18.904	0.09	5.56550E-06
17	29.743	211.744	11.059	18.925	0.091	5.56550E-06
18	29.743	211.744	10.984	18.867	0.09	5.58080E-06
19	29.743	211.744	11.125	18.99	0.089	5.56550E-06
20	29.743	211.744	11.112	18.978	0.09	5.58080E-06

Table A7. Profile B11 (Existing Condition) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	6.634	17.619	0.336	0.488
2	29.743	211.744	7.946	17.475	0.352	0.49
3	29.743	211.744	8.572	17.507	0.365	0.488
4	29.743	211.744	9.138	17.516	0.361	0.488
5	29.743	211.744	9.599	17.517	0.352	0.488
6	29.743	211.744	9.943	17.523	0.323	0.49
7	29.743	211.744	10.544	17.547	0.363	0.488
8	29.743	211.744	10.855	17.55	0.364	0.488
9	29.743	211.744	10.855	17.563	0.361	0.488
10	29.743	211.744	10.899	17.59	0.38	0.49
11	60.35	215.456	10.76	29.121	0.039	0.488
12	60.35	215.456	10.416	30.582	1.412	0.488
13	29.743	211.744	13.14	17.848	0.332	0.488
14	29.743	211.744	13.156	17.587	0.326	0.49
15	29.743	211.744	13.138	17.566	0.355	0.488
16	29.743	211.744	12.951	17.574	0.364	0.488
17	29.743	211.744	12.656	17.559	0.307	0.488
18	29.743	211.744	12.467	17.548	0.358	0.489
19	29.743	211.744	12.358	17.56	0.331	0.488
20	29.743	211.744	12.255	17.564	0.344	0.489

Table A8. Profile B11 (Mine Spoils & ET Cover) - all units are cm

Year	Precip	PET	Transp	Evap	Runoff	Drain
1	29.743	211.744	16.16	19.004	0.088	0.488
2	29.743	211.744	10.531	18.888	0.086	0.49
3	29.743	211.744	9.723	18.739	0.088	0.488
4	29.743	211.744	9.635	18.725	0.086	0.488
5	29.743	211.744	9.894	18.919	0.086	0.488
6	29.743	211.744	9.842	18.834	0.086	0.49
7	29.743	211.744	9.968	18.904	0.087	0.488
8	29.743	211.744	10.016	18.905	0.089	0.488
9	29.743	211.744	10.067	18.899	0.086	0.488
10	29.743	211.744	9.918	18.732	0.088	0.49
11	60.35	215.456	19.25	35.433	0.745	0.488
12	60.35	215.456	21.21	37.538	0.356	0.488
13	29.743	211.744	12.829	20.157	0.092	0.488
14	29.743	211.744	10.264	18.764	0.089	0.49
15	29.743	211.744	10.357	18.863	0.09	0.488
16	29.743	211.744	10.308	18.775	0.085	0.488
17	29.743	211.744	10.471	18.868	0.086	0.488
18	29.743	211.744	10.427	18.798	0.085	0.489
19	29.743	211.744	10.395	18.755	0.088	0.488
20	29.743	211.744	10.543	18.859	0.091	0.489

APPENDIX B

Cone Penetrometer Results for Applicable Borings (from MWH 2014)

The following are graphical summaries of results for applicable borings (Profiles B2, B8, B10, and B11) from the on-site field drilling performed of the existing impoundment. Specifically, they are graphical summaries of the cone penetrometer findings for the full depth drilled in each profile. These findings are part of the full suite of data presented in MWH (2014).

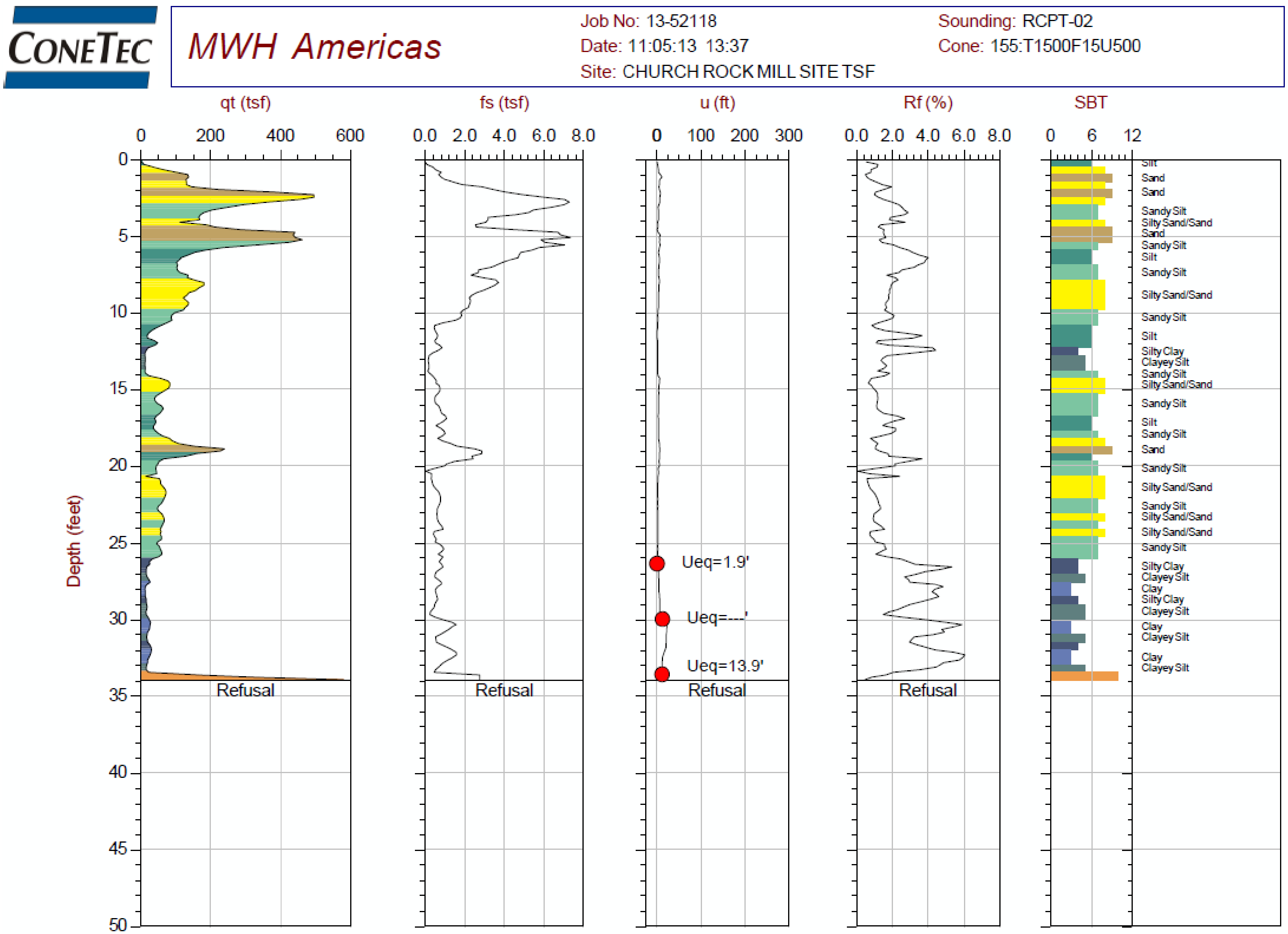


Figure B1 CPT for Boring B2

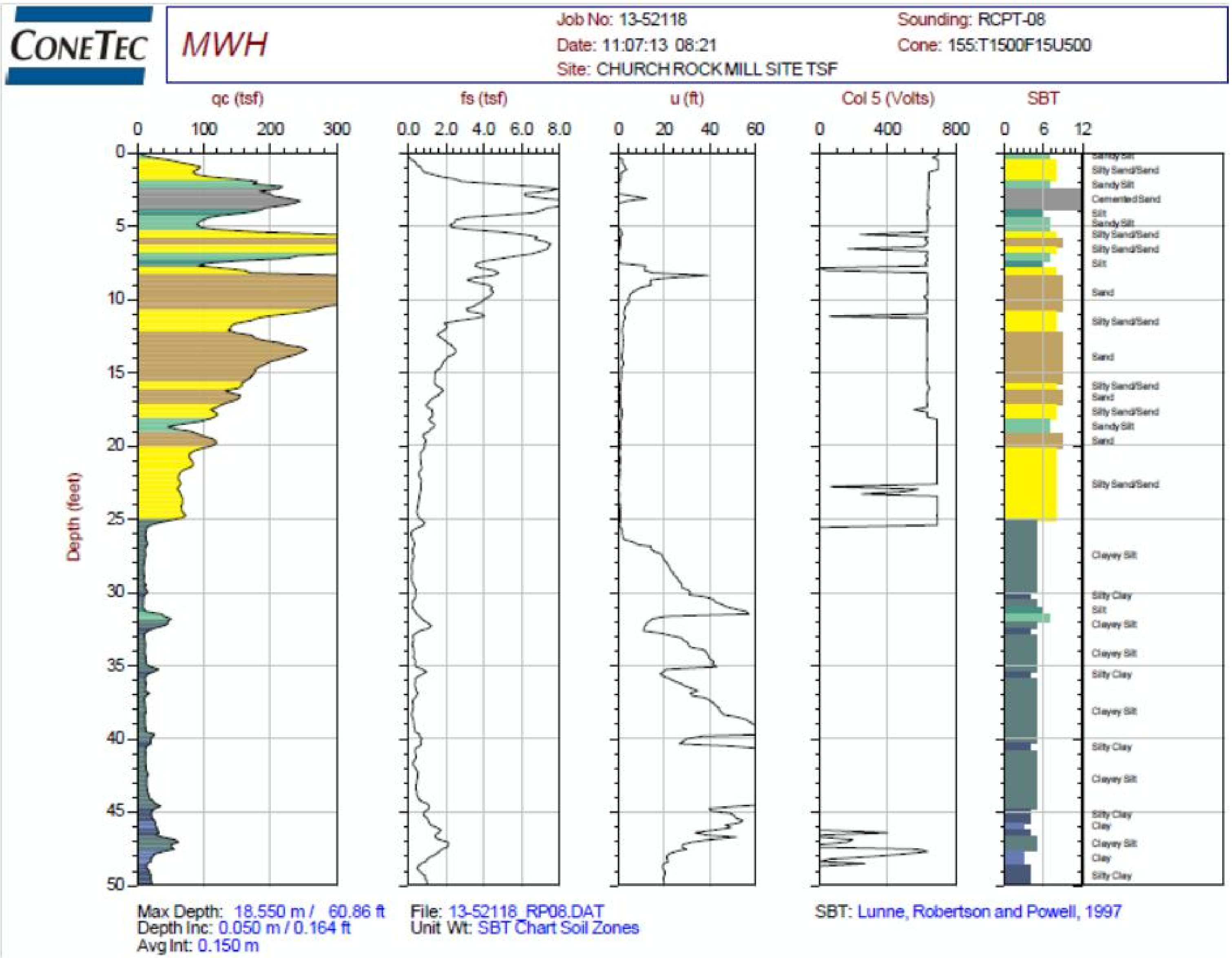


Figure B2 CPT for Boring B8

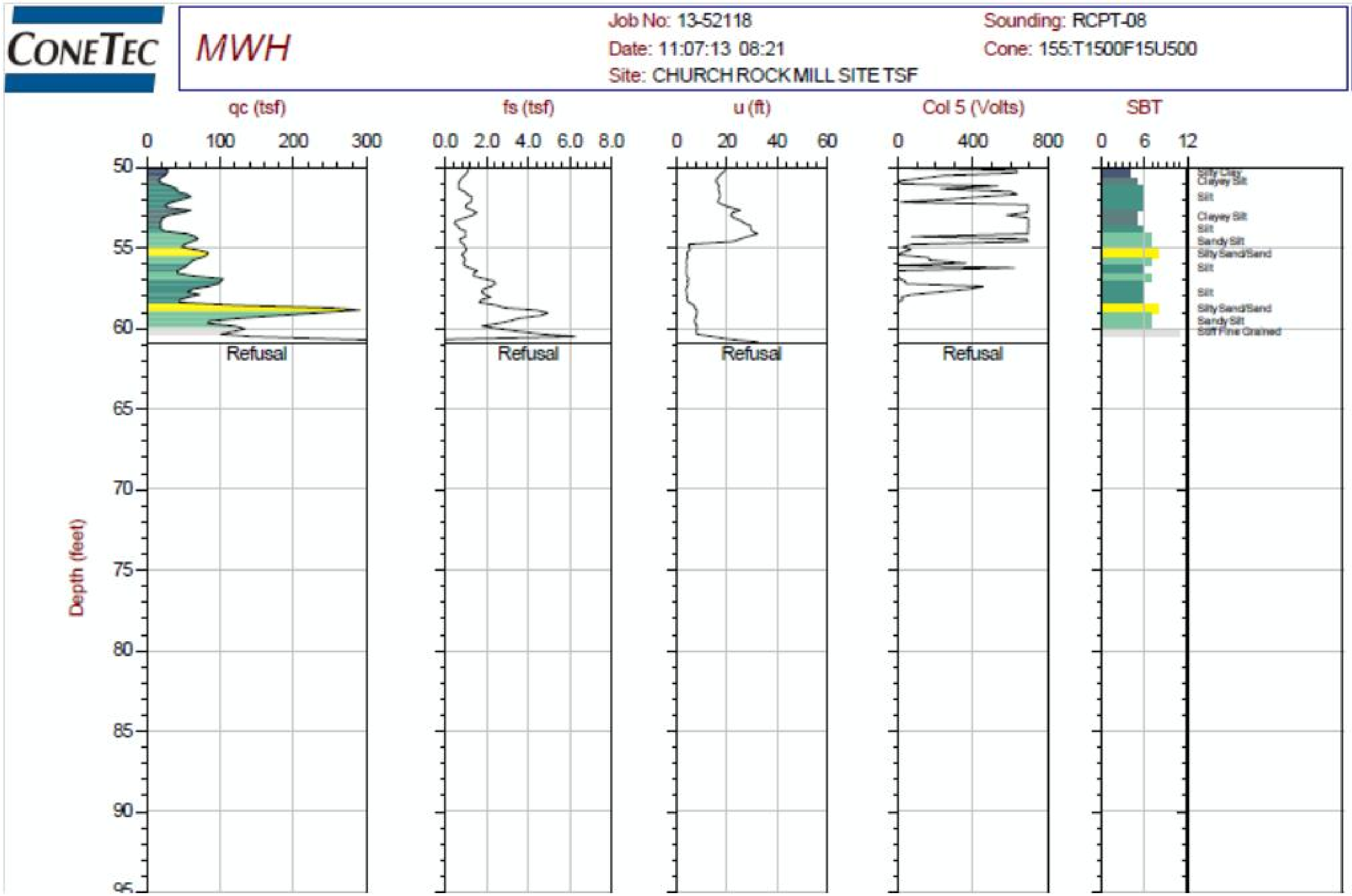


Figure B3. CPT for Boring B8 (continued)

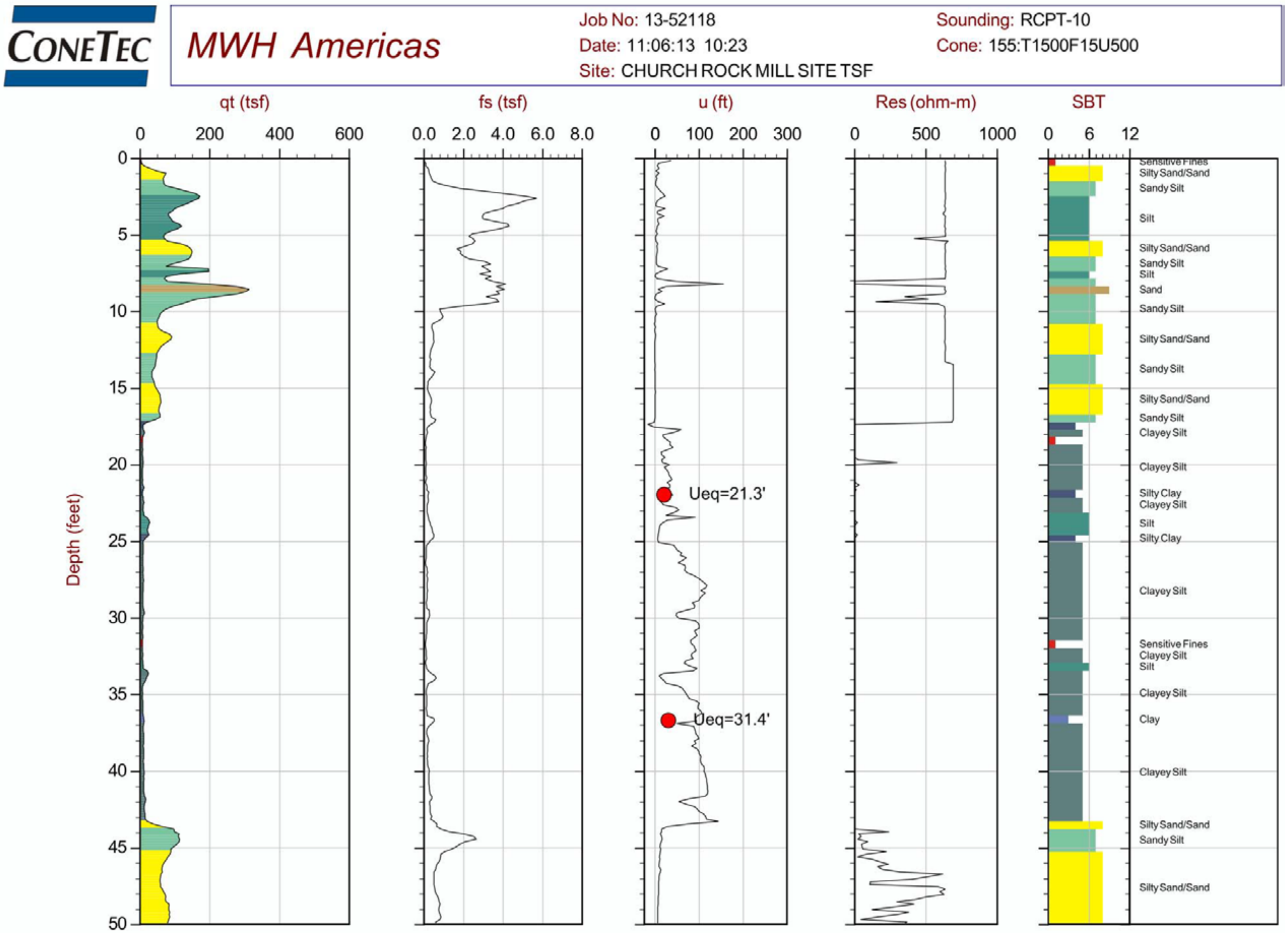


Figure B4 CPT for Boring B10

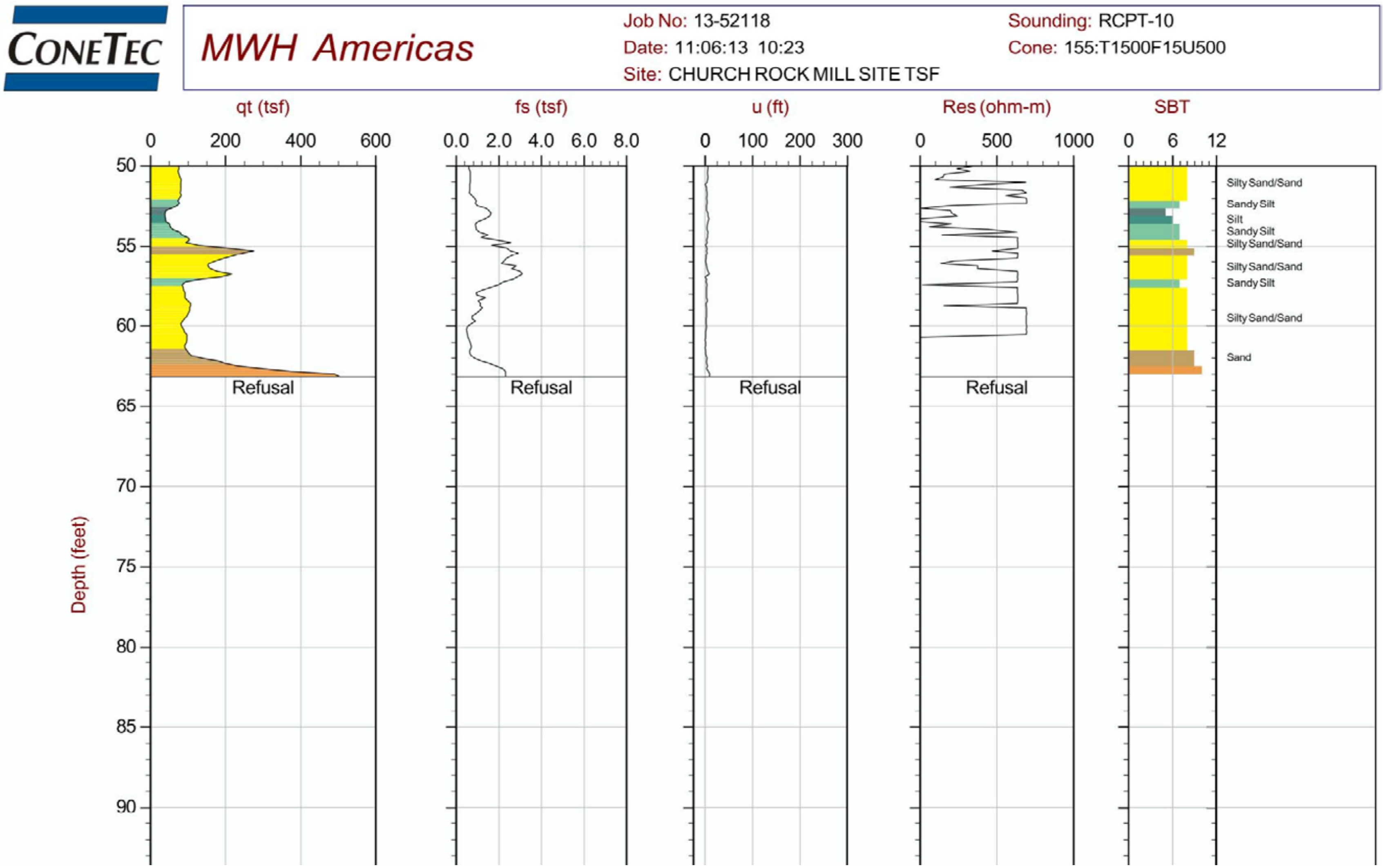


Figure B5. CPT for Boring B10 (continued)

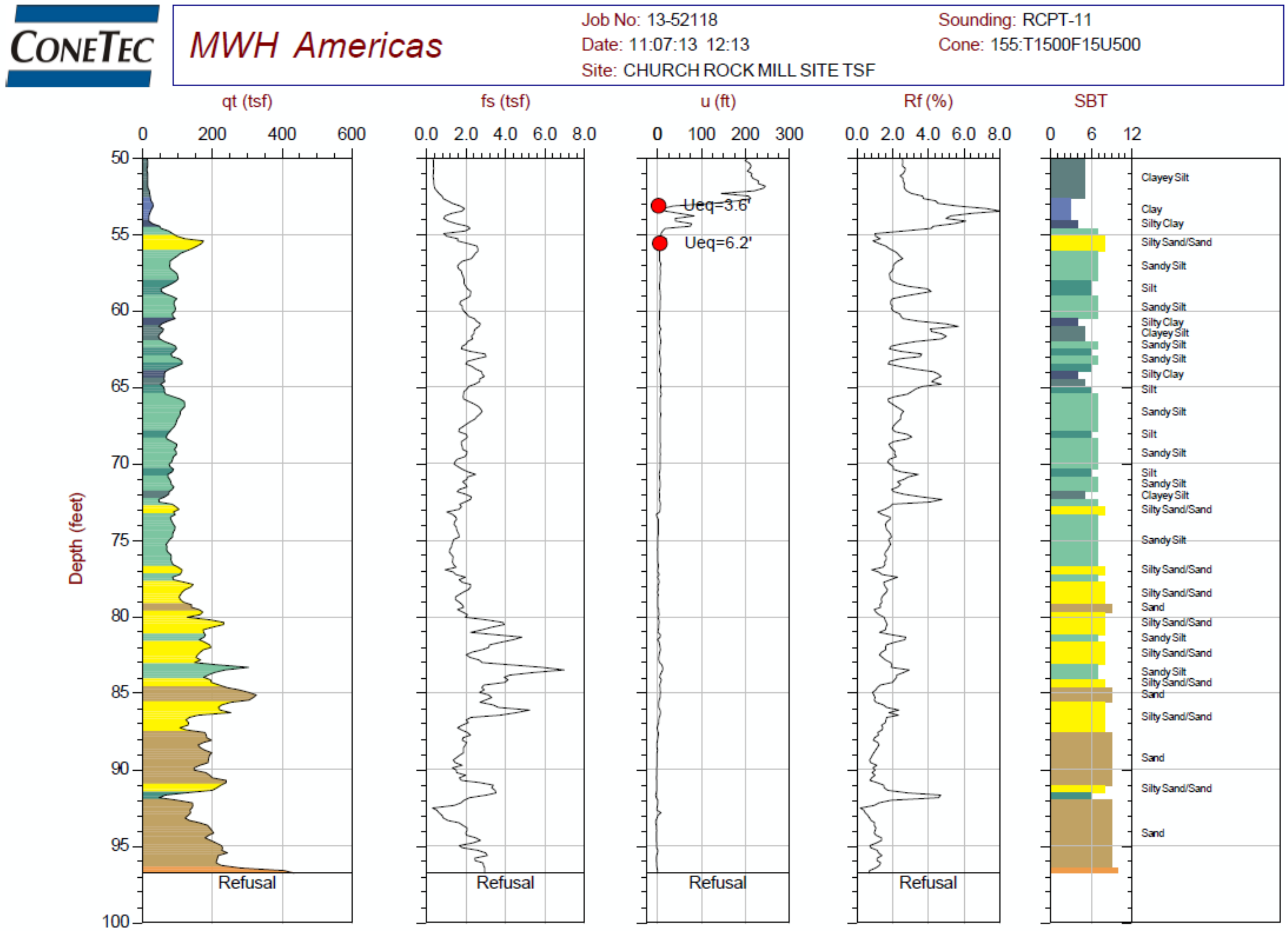


Figure B6. CPT for Boring B11