Northeast Church Rock
30% Design Report

Appendix S:
Labor Plan

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LIST OF TABLES

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
HAZWOPER	Hazardous Waste Operations and Emergency Response Standard
OSHA	Occupational Safety and Health Administration
RAO	Remedial Action Objective
USEPA	US Environmental Protection Agency

S.1 INTRODUCTION

This appendix to the Northeast Church Rock 30% Design Report presents information related to the hiring and use of trained and experienced labor to transport and manage the Northeast Church Rock Mine Site contaminated soil and mine waste, personnel certifications and health and safety training requirements, and maintenance of such certifications and training throughout the project. For the 30% design report, this appendix contains an annotated outline, with detailed information to be included at the 95% design phase. It should be noted that much of the information contained here may also be included in the Removal Action Health and Safety Plan, the Radiation Protection Plan, or other compliance plans, and therefore this plan may reference those overlapping plans to avoid redundancies.

S.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 S.2-1 presents Performance Standards related to the labor plan and explains how the design accomplishes these standards.

Table S.2-1: Performance Standards Applicable to the Labor Plan

Location of Performance Standard Requirement	Performance Standard	Comments
2015 AOC SOW, Paragraph 21 – Trained and Certified Labor	In the Design, Respondents shall include detailed plans and specifications for the hiring and use of trained and experienced labor to transport and manage the NECR Site contaminated soil and mine waste. Respondents shall produce detailed plans and specifications to ensure that personnel have certifications and health and safety training requirements to comply with Occupational Safety and Health Administration, radiation, and hazardous material handling requirements. Respondents' detailed plans and specifications shall include procedures to ensure that all personnel maintain such certifications and training throughout the project.	This plan (Appendix S) is being prepared to address this requirement and detail plans for hiring and use of trained labor for the Removal Action.

S.3 LABOR MANAGEMENT PLAN

S.3.1 Construction Contractor Qualifications

This section will provide minimum experience and qualifications required for a Construction Contractor to perform the Northeast Church Rock Removal Action construction activities. Such experience and qualifications may be used by General Electric/United Nuclear Corporation to pre-qualify potential bidders and/or to evaluate bid proposals and select a contractor.

S.3.1.1 Individual Certifications, Qualifications, and Licenses

Specific certifications, qualifications, or licenses required for trade work or specialty construction tasks (such as blasting) will be included with the Technical Specifications and will not be duplicated in this document. Certifications and qualifications required for compliance with the Stormwater Pollution Prevention Plan and/or the Spill Prevention Control and Countermeasure Plan will be included with the respective plans and will not be repeated in this document.

S.3.2 Labor Force Development

Specific requirements for labor force development, if any, will be included in this section. Preference will be given to qualified local Navajo labor to the extent consistent with law.

S.3.3 OSHA Training

This section will either provide the Occupational Safety and Health Administration (OSHA) training requirements for personnel engaged in field activities within the Exclusion Zone or Decontamination Areas, or reference the Removal Action Health and Safety Plan and the Construction Contractor's Health and Safety Plan for such requirements. These are expected to include:

- *OSHA Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) initial training in compliance with 29 CFR 1910.120*
- *Annual 8-hour HAZWOPER refresher training completed within 365 days of the last completed refresher training course.*
- *Additional OSHA training that maybe required for supervisory or manager positions.*

Verification and management of training records and certifications will also be addressed.

S.3.4 Radiation Safety Training

This section will provide the radiation safety training requirements for all personnel commensurate with the level of potential exposure to radioactive materials. These are expected to include:

- *Minimum training and experience requirements for management personnel such as the Radiation Safety Officer and the Radiation Safety Technician*
- *Training requirements for employees who work in controlled areas and/or with radioactive materials*
- *Training requirements for general radiation training for employees who are not regularly working in controlled areas and/or escorted visitors*
- *Training requirements for female workers of child bearing age on the potential effects of radiation on the fetus in accordance with the guidance contained in US Nuclear Regulatory Commission Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure*
- *Worker responsibilities*

Records and documentation pertaining to radiation safety training will also be addressed in this section.

S.4 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.

Northeast Church Rock 30% Design Report

Appendix T:

Cleanup Verification Plan

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LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
Mine Site	Northeast Church Rock Mine Site
QAPP	Quality Assurance Project Plan
RAO	Remedial 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 MWH. It also includes the Quality Assurance Project Plan (QAPP) prepared by MWH. The Excavation Control Plan is attached as T.1, the Final Status Survey Plan is attached as T.2 and, the QAPP is attached as T.3. Standard operating procedures are referenced in the attachments. Standard operating procedures will be provided with the Pre-final design.

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>Location of Performance Standard Requirement</th><th>Performance Standard</th><th>Comments</th></tr>
<tr><td>2011 Action Memo, Table 4.1 – Field Screening Levels</td><td>Table 4.1 Selected Field Screening Levels
<table>
<tr><td>Contaminant of Potential Concern</td><td>Field Screening Level</td></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>2011 Action Memo, Table 4.2 – Selected Action Levels</td><td>Table 4.2 Selected Action Levels
<table>
<tr><td>Contaminant of Concern</td><td>Action Level</td></tr>
<tr><td>Ra-226</td><td>2.24 pCi/g</td></tr>
<tr><td>Uranium</td><td>230 mg/kg</td></tr>
</table></td><td>The Selected Action Levels have been used to develop the Excavation Control Plan (Attachment T.1) and the Final Status Survey Plan (Attachment T.2) for the Mine Site.</td></tr>
<tr><td>2011 Action Memo, V.A.1, Bullet 4 – Excavation</td><td>Excavation. Excavation at the NECR Site and transportation of waste with concentrations of uranium and Ra-226 that exceed Action Levels to a repository at the UNC Mill Site for co-disposal at the existing Tailings Disposal Cells. This action is contingent on the U.S.EPA decision document for the surface contamination at the UNC Mill Site, and the NRC approval of a license amendment for the UNC Mill Site disposal cells. Depth of excavation will not exceed ten feet, except in areas susceptible to erosion or where placing clean backfill to current grade is not planned, or in areas where principal threat waste will be removed. Excavation within these areas will continue until confirmation sample results are below the Action Levels per MARSSIM procedures.</td><td>Mine waste to be removed to depth where Action Levels are below 2.24 pCi/g for Ra-226 and 230 mg/kg for uranium, or to contact with bedrock, but will not exceed 10 feet in depth in areas where clean fill will be placed to final grade.

The Excavation Control Plan (Attachment T.1) and the Final Status Survey Plan (Attachment T.2) describe the procedures proposed to verify removal of the material above the action levels.</td></tr>
</table>

Location of Performance Standard Requirement	Performance Standard	Comments
2011 Action Memo, V.A.1, Bullet 7 – Confirmation Sampling	**Confirmation Sampling.** Conduct confirmation scanning, sampling and analysis to ensure that the Action Levels have been met in excavated areas.	Procedures for confirmation scanning, sampling, and analysis is described in the Final Status Survey Plan (Attachment T.2).
2011 Action Memo, V.A.2	Contribution to remedial performance This removal action would address the mine waste and soil contamination at the NECR Mine Site, to a depth of at least 10 feet. It is expected that this removal action will remove the threat of direct or indirect contact with or inhalation of hazardous substances from the mine waste and soils at the NECR Mine Site. As noted above, the soils in the area east of Red Water Pond Road will be addressed in a separate removal action. The EE/CA presented alternatives for surface and near-surface mine waste and soil to be addressed in a non-time-critical removal action only. This removal action does not address contamination that may remain at greater depths. U.S. EPA has recently worked to assess groundwater for the NECR Mine Site and surrounding facilities, including historic releases from these facilities; however, the removal action that is the subject of this memorandum does not address groundwater.	Mine waste to be removed to depth where Action Levels are below 2.24 pCi/g for Ra-226 and 230 mg/kg for uranium, or to contact with bedrock but will not exceed 10 feet in depth in areas where clean fill will be placed to final grade. The Excavation Control Plan (Attachment T.1) and the Final Status Survey Plan (Attachment T.2) describe the procedures proposed to verify removal of the material above the action levels.
2013 ROD, Section 1.4 - Receiving	**Receiving.** NECR Site waste that is transported to the UNC Site will be disposed in the Tailings Disposal Area if NRC approves a license amendment. The waste from the NECR Site will contain concentrations of uranium and radium 226 (Ra-226) that exceed Action Levels established in the 2011 NECR Site Non-Time-Critical Action Memorandum (hereinafter the 2011 NECR Site Action Memorandum). The 2011 NECR Site Action Memorandum provides that excavation at the NECR Site will not exceed ten feet, except in areas susceptible to erosion or where placing clean backfill to current grade is not planned, or in areas where principal threat waste will be removed. As stated earlier, Principal Threat Waste is not a part of this Selected Remedy and will not be brought to the UNC Site. Excavation within these areas will continue until confirmation sample results are below the Action Levels established in the 2011 NECR Site Action Memorandum as determined using Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) procedures.	Mine waste will be removed to depths where Action Levels are below 2.24 pCi/g for Ra-226 and 230 mg/kg for uranium, or to contact with bedrock, but will not exceed 10 feet in depth in areas where clean fill will be placed to final grade. The Excavation Control Plan (Attachment T.1), is based on MARSSIM procedures.
2015 AOC SOW, Paragraph 18 – Cleanup Verification	In the Design, Respondents shall include procedures for cleanup verification (including confirmation sampling and scanning for COCs and COPCs) for the NECR Site. Respondents shall include procedures to verify that the NECR Site has achieved performance standards by presenting confirmation sample results that indicate that Action Levels have been met using Multi-Agency Radiation Survey and Site	The proposed cleanup verification procedures for the Mine Site are described in the Excavation Control Plan (Attachment T.1) and the Final Status Survey Plan (Attachment T.2)

Location of Performance Standard Requirement	Performance Standard	Comments
	Investigation Manual ("MARSSIM") procedures for radiological COCs (Radium-226) and EPA-approved lab analysis for heavy metal COCs (uranium) confirmation soil samples.	
2015 AOC SOW, Paragraph 30 – 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 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. 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.	Respondents will submit cleanup and sampling data for the Mine Site in the standard USEPA regional Electronic Data Deliverable (EDD) format that USEPA identifies.
2015 AOC SOW, Paragraph 43 – Pre-Final NECR Mine	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	The Cleanup Verification Plan is presented here with the 30% Design, rather than as a

Location of Performance Standard Requirement	Performance Standard	Comments
Cleanup Verification and Revegetation Plan	NECR Mine Cleanup Verification and Revegetation Plan, and any Intermediate Design.	separate submittal. The plan will be modified and updated for the 95% Design. The Revegetation plan for the Mine Site is included as Appendix U.

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

30% Design

Excavation Control Plan

Northeast Church Rock Mine Site Removal Action

Prepared for

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Prepared by

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Grants, New Mexico

July 2016

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ACRONYMNS

AOC	Settlement Agreement and Administrative Order on Consent for Design and Cost Recovery
CPM	counts per minute
cy	cubic yard(s)
DCGL	Derived Concentration Guidance Level
DGPS	Differential Global Positioning System
DQO	Data Quality Objectives
EDRA	East Drainage Removal Action
FSS	Final Status Survey
g	gram
HASP	Health and Safety Plan
IRA	Interim Removal Action
kg	kilogram
keV	Kiloelectronvolt
L	liter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual mg milligram
MDC	Minimum Detection Concentration
mg	milligram
NaI	Sodium Iodide
NECR	Northeast Church Rock
NIST	National Institute of Standards and Technology
NUREG	U.S. Nuclear Regulatory Commission Regulation
pCi	picocuries
PDS	Pre-Design Studies
PTW	Principal threat waste
QA/QC	quality assurance/quality control
Ra-226	Radium 226
RA	Removal Action
RAL	Removal Action Level
RD	Removal Design
ROD	Record of Decision
RSE	Removal Site Evaluation
Site	Northeast Church Rock Mine Site
SOP	Standard Operating Procedure
TPH	Total Petroleum Hydrocarbon
USEPA	U.S. Environmental Protection Agency

1.0 INTRODUCTION

This Plan provides a framework for conducting excavation control surveys to support the excavation and removal of the mining-impacted soil for the Removal Action (RA) at the Northeast Church Rock Mine Site (Site) near Gallup, New Mexico. This Plan is consistent with the guidance found in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USEPA, 2000) Section 5.4, Remedial Action Support Surveys.

The objective of the excavation control survey is to support removal of soils at the Site that exceed the Removal Action Levels (RALs) established in the 2011 Action Memorandum (USEPA, 2011) and the Record of Decision (ROD) (USEPA, 2013). The lateral and vertical extent of the soils impacted above the RALs have been characterized and established by the Removal Site Evaluations (RSEs) (MWH, 2007and 2011) and Pre-Design Studies (PDS) (MWH, 2014a and 2014b). The characterization identified surface and subsurface soils above the RALs and some debris from mining activities within 17 areas totaling approximately 130 acres as shown in Figure 1. A summary of the nature and extent of contamination is provided in the RSEs, PDS, Interim Removal Actions (IRAs), 2011 Action Memo (USEPA, 2011) and the ROD.

The RA referenced in the Settlement Agreement and Administrative Order on Consent for Design and Cost Recovery (AOC) and described in the 2011 Action Memo and the ROD, calls for the excavation of approximately 1,000,000 cy of mine waste exceeding the Ra-226 and total uranium RALs from the Site and disposed of in a repository designed within the footprint of the existing Tailings Disposal Area at the Church Rock Mill Site. The mine waste exceeding the radium 226 (Ra-226) and total uranium Principal Threat Waste (PTW) performance standard, as described in the 2011 Action Memo will be removed and transported from the Site to an alternate offsite disposal facility.

This Plan is based on available information from the RSEs, IRAs (MWH, 2009 and MWH, 2013) areas and PDS (MWH 2014a and 2014b). Excavation control surveys will be conducted at the Site to support mine waste excavation and removal, determine when a survey area is ready for the Final Status Survey (FSS), and provide updated estimates of site-specific parameters to use for planning the FSS. The excavation control survey will rely on direct gamma radiation levels near the surface as an indicator of effectiveness. The excavation control level below which there is an acceptable level of assurance that the RAL for Ra-226 has been attained will be determined and will be used for immediate, in-field decisions. The direct gamma radiation surveys will also be used for PTW segregation.

2.0 SITE DESCRIPTION

The Site is located approximately 16 miles northeast of Gallup, in McKinley County, New Mexico. The primary ore mineral that was mined at the Site was coffinite which was placed in small temporary stockpiles before it was transported to the Mill Site. Active mining operations at the Site took place between 1968 and 1982 at which time the mine was placed on stand-by status. The RSEs 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 description and information can be found in the Final Removal Site Evaluation Report (MWH 2007).

3.0 DATA QUALITY OBJECTIVES

The objective of the excavation control survey is to detect the presence of residual radionuclides at levels at or below the RALs. The Data Quality Objectives (DQOs) for this Plan are to establish a procedure for defining the criteria that must be met for the excavation control survey design to be satisfied. The DQO process includes a description of when to perform the survey, where to perform the survey, and the extent of the excavation control survey.

4.0 SURVEY DESIGN

The excavation control survey will be used to support excavation of soils exceeding the Ra-226 and total uranium RALs. The Site ROD specifies that waste from the Mine Site that contains concentrations of uranium and Ra-226 in excess of RALs established in the 2011 Action Memorandum will be excavated and removed. Excavation at the Site will continue until confirmation gamma survey and/or soil sample results from any excavated areas are below the RALs.

4.1 Removal Action Levels and Performance Standards

The ROD selected remedy addresses removal of surface and subsurface soil exceeding the Ra-226 and total uranium RALs. The mine waste consisting of soil and debris with Ra-226 concentration exceeding the RAL but below the PTW performance standard of 200 pCi/g Ra-226 and/or 500 mg/kg of total uranium will be excavated, removed and disposed of in the repository. The PTW material, surface soils and subsurface soils removed from the Site exceeding the PTW performance standard of 200 pCi/gm of Ra-226 and/or 500 mg/kg of total uranium will be transported from the Site to an alternate offsite disposal facility.

The 1.24 pCi/g Ra-226 Derived Concentration Guidance Level for the nonparametric statistical test (DCGLw) for the Site soil was established by the U.S. Environmental Protection Agency (USEPA) based on the acceptable risk to human health and the environment. A background value of 1.0 pCi/g for Ra-226 from the background reference area was determined during the RSE (MWH 2006). The 2.24 pCi/g Ra-226 RAL, which will also be referred as RALw, specified in the 2011 Action Memorandum and the ROD is based on the 1.24 pCi/g DCGLw plus 1.0 pCi/g background value. Based on the 80-foot triangular grid spacing (515 m^2 bounded area), a DCGL for elevated measurement comparison (DCGLemc) of 2.0 pCi/g was calculated and provided by USEPA during the

RSE consistent with the MARSSIM guidance for the Site. The elevated measurement comparison RAL, referred to as RALemc herein, was established at 3.0 pCi/g (2.0 pCi/g DCGLemc plus 1.0 pCi/g background value). The 230 mg/kg RAL for total uranium specified in the 2011 Action Memo and the ROD, is based on its chemical toxicity, and is not based on its radioactivity.

4.2 Gamma Radiation Survey Concept

The excavation control survey relies on a simple radiological parameter, such as direct radiation near the surface, as an indicator of effectiveness. The excavation and removal of soil is most efficient when the information for excavation control is available in real-time. In-situ direct gamma radiation surveys will provide real time information and enable excavation control for efficient removal of impacted soil to the RALs, as compared to soil sampling. Ra-226 in soil will be detected by direct gamma radiation level measurements. Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 KeV at about 4% intensity. Direct field measurement of alpha radiation is not feasible. The low energy and intensity of the Ra-226 gamma radiation emission makes it impractical to determine Ra-226 in the field by direct gamma radiation measurement. However, Pb-214 and Bi-214, Ra-226 decay products, emits high energy gamma radiations at high intensities. The high energy gamma radiations of Pb-214 and Bi-214 can be easily measured in the field utilizing a Sodium Iodide (NaI) scintillation detector, such as 2x2 NaI scintillation detector, having a high gamma radiation sensitivity.

The Ra-226 levels in soil could be measured as a surrogate by gamma radiation measurement of 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. Previous studies at the Site have shown that about 20% of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant percentage (about 80%) of this 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 soils at the Site are impacted by uranium ore; therefore, uranium will be in secular equilibrium with associated decay products, including Ra-226. The 230 mg/kg total uranium RAL will be equivalent to about 76 pCi/g of Ra-226. Therefore, removal of soils exceeding the 2.24 pCi/g Ra-226 RAL will also assure that uranium ore impacted soils exceeding about 7 mg/kg total uranium are removed, far below the 230 mg/kg total uranium RAL. The PTW performance standard for the RA is Ra-226 at 200 pCi/g and/or total uranium at 500 mg/kg. In secular equilibrium, the 500 mg/kg total uranium will be equivalent to about 165 pCi/g of Ra-226. Therefore, excavation and segregation of soils exceeding the 165 pCi/g Ra-226 level will also assure that uranium ore impacted soils above the total uranium performance standard of 500 mg/kg for PTW are segregated and removed. Therefore, excavation control for Ra-226 by gamma survey will be used for excavation control for total uranium also. 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 offsite laboratory will be used to confirm compliance with the total uranium RAL.

4.3 Gamma Survey Instrumentation

Similar to the instrumentation used for the RSEs, IRAs and PDS, the instrumentation configuration for direct gamma radiation level measurement for the excavation control survey consists of a 2x2 NaI scintillation detector (Eberline SPA-3 and/or 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. When necessary, the Scaler/Rate meter will be interfaced with a sub-meter accurate Differential Global Positioning System (DGPS) with data logger/controller for electronically recording the gamma radiation levels to the corresponding coordinates corrected in real time.

For radiation surveys where significant shine interference is present, the 2”x2” NaI crystal scintillation detector will be installed in a 0.5 inch thick lead collimator. The collimator will reduce lateral gamma shine interference and will focus on an observational area with approximately a 36-inch diameter under the detector at 12 inches from the ground surface.

4.4 Gamma Survey Minimum Detection Concentration

The selected instrumentation will meet the Minimum Detection Concentration (MDC) for both the static and gamma scan radiation surveys. The MDCs will be calculated as discussed in the Standard Operating Procedure (SOP)-1, which is consistent with Sections 6.7.1 and 6.7.2 of MARSSIM. More detail on signal detection theory and instrument response is provided in U.S. Nuclear Regulatory Commission Regulation (NUREG)-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, NUREG- 1507, June 1998. (NRC 1998). Based on gamma surveys conducted using this instrumentation during the RSEs, PDS, IRA and EDRA surveys, the instrument MDC is expected to be below 50% of the DCGLw (1.24 pCi/gm) for static survey and 50% of the DCGLemc (2.0 pCi/gm) for the scan survey during the excavation control.

4.5 Site Specific Gamma Radiation to Ra-226 Correlation

The 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 RAL in pCi/g. The counts per unit time for a given radioactivity depend on the efficiency of the detector. For comparison of gamma survey results to the Ra-226 RAL, a gamma radiation level for the detectors equivalent to the Ra-226 RAL will be determined by using liner regression analysis from the most recently updated site specific correlation as discussed below.

The direct gamma radiation level in detector counts per minute (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. A site-specific correlation (Ra-226 pCi/g = 0.0005CPM - 6.0697) with an R^2 value of 0.85 was used during the 2006 RSE for less than 10 pCi/g level Ra-226 surface soil concentrations. This correlation was described in Appendix B of the Final Removal Site Evaluation Report (MWH, 2007). The April 2011 East Drainage Area supplemental RSE correlation for the collimated 2x2 NaI detector consisting of 87 sampling locations was updated using data from soil sampling and direct gamma radiation measurements at 15 locations collected during the post-EDRA Status Survey to convert direct gamma radiation level measurements to an equivalent Ra-226 concentration (MWH 2013). The EDRA updated correlation resulted in a regression equation, Ra-226 pCi/g = (0.0013 x gamma radiation level CPM) – 4.4308, with an R^2 value of 0.92. These correlations will be used for the excavation control surveys for the RA.

4.6 Gamma Radiation Levels for RALs and PTW Performance Standards

The correlations for the direct gamma radiation level in CPM are for Ra-226 distribution in surface soil. Any lateral gamma radiation shine from the nearby elevated areas skew gamma radiation level measurement and overestimate Ra-226 concentration at a survey location. Therefore, a 0.5-inch thick lead collimator will be used to mitigate the lateral shine interference. Vertical gamma radiation shine from subsurface soils with elevated Ra-226 levels will also skew the gamma radiation level measurements and overestimate the surface soil Ra-226 concentration at those locations. Eliminating the vertical shine is not practical in the field. For excavation control, this provides a conservative approach and facilitates detecting elevated subsurface soils under the low level surface soils.

The radiation detection measurements have associated inherent uncertainties due to the random nature of radioactive disintegration. The gamma radiation screening levels in CPM for the Ra-226 RAL and the PTW screening levels are adjusted by 1.96 sigma, below which there is an acceptable level of assurance that the established RAL has been attained. Followings are the Ra-226 RAL and PTW screening level equivalent gamma radiation CPM:

1. The regression analysis from the 2x2 NaI bare detector correlation discussed above (Ra-226 pCi/g = 0.0005CPM - 6.0697) results in a direct gamma radiation level of 16,620 CPM equivalent to the 2.24 pCi/g Ra-226 RAL. Subtracting 250 CPM counting uncertainty (1.96σ of 16,620 CPM) results in a rounded gamma count rate of 16,300 for the 2.24 pCi/g Ra-226 RAL for the excavation control survey.

2. The regression analysis from the 2x2 NaI collimated detector correlation (Ra-226 pCi/g = 0.0013CPM - 4.4308) results in a direct gamma radiation level of 5,130 CPM equivalent to the 2.24 pCi/g Ra-226 RAL. Subtracting 140 CPM counting uncertainty (1.96σ of 5,130 CPM) results in a rounded gamma count rate of 5,000 for the 2.24 pCi/g Ra-226 RAL for the excavation control survey.

3. The regression analysis from the 2x2 NaI bare detector correlation (Ra-226 pCi/g = 0.0005CPM - 6.0697) results in a direct gamma radiation level of 342,140 CPM equivalent to the 165 pCi/g Ra-226 PTW screening level. Subtracting 1,150 CPM counting uncertainty (1.96σ of 342,140 CPM) results in a rounded gamma count rate of 341,000 CPM for PTW excavation and segregation control.

4. The regression analysis from the 2x2 NaI collimated detector correlation (Ra-226 pCi/g = 0.0013CPM - 4.4308) results in a direct gamma radiation level of 130,330 CPM equivalent to the 165 pCi/g Ra-226 PTW screening level. Subtracting 700 CPM counting uncertainty (1.96σ of 130,331 CPM) results in a rounded gamma count rate of 129,600 CPM for PTW excavation and segregation control.

Table 1 summarizes the RAL gamma counts for the soil excavation control based on the correlations.

Table 1: Soil Excavation and Removal RAL Gamma Count Rates

Soil Excavation RAL & PTW Screening Level	2x2 NaI Bare Detector Gamma Count Rate (CPM)	0.5-inch Lead Collimated 2x2 NaI Detector Gamma Count Rate (CPM)
2.24 pCi/g Ra-226 RAL	16,300	5,000
165 pCi/g PTW Screening Level	341,000	129,600

4.7 Excavation Control Surveys

Gamma radiation surveys will primarily be used for soil removal excavation control during the RA. Gamma scan survey in combination with gamma static measurements will be used for excavation control until the impacted soil exceeding the RALs has been removed. Soil sampling and ex-situ gamma radiation soil screening will also be used as necessary for excavation control. Excavation control surveys will be performed primarily with collimated detectors to mitigate any lateral gamma radiation shine interferences and focus on area of interest under the detector, specifically at the early stages of soil removal when lateral shine is expected due to variable contamination distribution observed during the RSE. An uncollimated detector may be used when the lateral contamination distribution is fairly homogeneous. The excavation control will also utilize soil sampling and ex-situ gamma radiation soil screening as needed.

4.7.1 Gamma scan Radiation Survey

Gamma scan radiation surveys (walk over surveys) will be performed by walking in a serpentine pattern at a scan rate of up to three feet per second along transects to identify and locate any elevated areas with the detector held at about 12 inches from the ground surface with the scaler/Rate meter in count RATE MODE. The scan surveys will be performed for a 100% coverage to detect any residual Ra-226 activity in surface soil. The transect spacing for the scan coverage will be calculated based on the detector field of view for Ra-226 decay products gamma radiations. Details of the gamma scan survey are described in SOP-3.

A GPS-based gamma radiation scan survey may be performed to log gamma radiation count rates with corresponding point location coordinates in a data logger/controller. This scan survey can be performed by walking the area with a 2x2 NaI detector and rate meter coupled with a DGPS/data logger unit. The GPS-gamma scan survey system will consist of a Ludlum 2221 Rate meter/Scaler with SPA-3 2x2 NaI Detector coupled to a DGPS/Data collector, such as Magellan Mobile Mapper CX (MMCX). The MMCX is a real-time DGPS with a controller and data logging capabilities using a surveying software. The Ludlum 2221 will be operated in rate meter mode, allowing a gamma count rate (CPM) to be logged with its corresponding coordinates in 1 or 2 second intervals. Appropriate walk-over transect spacing will be based on the 100% scan coverage rate.

4.7.2 Gamma Static Survey

Gamma static radiation surveys will be performed for confirmation of the scan survey results at any point or location of interest during excavation control, such as any questionable measurements, measurements near the Ra-226 RAL or small areas of elevated activity during the scan survey. The detector will be held at about 12 inches from the ground surface. The scaler/Rate meter will be set in the count SCALER MODE and a one-minute count of gamma radiation levels will be conducted at each location for gamma static radiation survey. Details of the gamma static survey are described in SOP-3.

4.7.3 Soil Sampling and Ex-Situ Gamma Radiation Soil Screening

Judgmental soil sampling and ex-situ gamma radiation soil screening will be performed for excavation control, as necessary. If the gamma static survey does not provide an acceptable level of assurance that the RALs have been attained for any questionable measurements, measurements near the Ra-226 RAL or small areas of elevated activity, ex-situ soil screening will be used. Also, on-site ex-situ soil screening will be used to facilitate PTW segregation control, similar to the method used for PTW characterization during the Site PDS. This screening method will allow corrective actions (e.g., expedited confirmation, additional removal and re-sampling) to be taken immediately before committing resources to off-site laboratory analyses.

The on-site ex-situ soil screening method consists of measuring 609 KeV gamma radiations of Bi-214, a decay product of Ra-226 (see SOP-4). This method, which is more reliable than the in-situ direct gamma survey, was successfully implemented during the RSEs, PDS, and IRAs for expedited estimates of Ra-226 in soil. A single channel analyzer, such as Ludlum L2221 integrated with a Ludlum 44-20 3x3 NaI scintillation detector will be used to measure the 609 keV energy peak region of Bi-214. The sample is placed around the plastic lined detector in a heavily shielded counting chamber. The shielded counting chamber lowers the system background counts, improving the system MDC. For an expedited estimate of Ra-226 in soil, a reference soil with a known Ra-226 concentration (2.0 pCi/g Ra-226, below the 2.24 pCi/g RAL for conservative approach) will be used. The 609 KeV gamma radiation counts will be obtained and compared to the sample soil for field screening during excavation control.

For PTW segregation control, a PTW screening reference soil at 165 pCi/g Ra-226 concentration will be prepared by blending local matrix soil and Certified Reference Material (CRM-3B, 3.90% U_3O_8 with Ra to U weight ratio of 3.38E-07) from the Department of Energy's New Brunswick Laboratory to calibrate the gamma radiation soil screening system. The matrix blending provides additional compensation for local background. The gamma soil screening system will be utilized to determine if the soil sample is above or below the PTW screening level. The 609 KeV gamma radiation counts will be obtained for sample will be compared to the PTW reference soil for field screening during PTW segregation.

4.8 PTW Soil Sampling

As discussed above, PTW segregation control will be conducted using ex-situ gamma radiation soil screening. If the onsite soil screening results show the gamma radiation counts at +/-20% of the PTW screening level, the soil sample will be sent to an offsite vendor laboratory for Ra-226 analysis using USEPA Method 901.1 and total uranium analysis using USEPA Method 6020 for confirmation of the material as PTW.

5.0 EXCAVATION CONTROL IMPLEMENTATION

The excavation control and removal of the mine waste will consist of two components as described below:

1. The soils exceeding the Ra-226 RAL, but below the PTW performance standard will be excavated, removed and consolidated into the repository for disposal. Also, mine debris will be excavated, removed and consolidated into the repository.

2. Mine waste material, including soils removed from the mine site exceeding the PTW performance standard will be segregated for off-site disposal.

Excavation control will be conducted to isolate PTW from the mine waste removed from the Site that exceeds the Ra-226 RAL for offsite disposal. Appendix C of the 30% Design Report describes the mine site removal excavation and demolition. The 30% Design Report Section 3 Drawings show removal excavation areas and debris locations. The removal excavation will be performed in a five-phase sequence as discussed in Appendix C and shown in Section 3 of the 30% Design Report Drawings. The PTW characterization activities for the PDS identified the lateral and vertical extent of PTW within four areas: NECR-1, Pond 1, Pond 3 and Sediment Pad, as shown in these drawings.

The excavated soils from the 2009 home site and the 2013 EDRA IRAs are stockpiled in Area 11 (TPH Soil Storage Area) and in Area 8 (NECR-1 Area). These stockpiled soils will be removed and hauled to the repository for disposal. Excavation control for removing these stockpiled soils will not be necessary.

5.1 Excavation Control for Mine Waste Exceeding the RAL

This section describes the excavation control for mine waste exceeding the Ra-226 RAL, but below the PTW performance standard. The excavation control will begin with field delineation of the soil excavation and removal areas shown in the 30% Design Report Section 3 Drawings. Prior to soil excavation, the RAL boundaries of the excavation areas, shown in Figure 1, will be marked using pin flags. A gamma scan will be performed for field locating of the outer RAL boundary by walking in a serpentine shape along the outer boundary to confirm that no changes have occurred since the boundary was last delineated during the 2013 PDS. If the gamma scan shows that the outer boundary has expanded, the RAL boundary will be revised and used to guide soil excavation. If identified PTW areas are within the area of excavation during this phase, the PTW areas will be field located and marked prior to any excavation and removal activities from these areas. A gamma scan with a collimated detector will be performed by walking in a serpentine shape along the PTW area boundary to confirm that the PTW area is bounded. The excavation control for isolating the PTW, which will be performed as described in the following section, will be coordinated with the excavation and removal fleet to avoid hauling the PTW to the repository.

The excavation areas may be divided into smaller subareas for excavation control surveys (narrow strips or small blocks) to more efficiently control excavation, depending on the equipment used for excavation. In addition to the lateral extent (RAL boundary), the RSE and PDS defined the vertical extent of impacted subsurface soils. The 30% Design Section 3 Drawings show the excavation cut contours based on the vertical extent of subsurface soils exceeding the RAL in each area.

The excavation control survey procedure is described in detail in SOP-3. A gamma scan survey in combination with gamma static measurements will be performed to guide excavation in lifts until the impacted soil exceeding the RAL has been removed. All identified mine debris will be excavated and disposed of in the repository. The mine debris from the areas shown in Section 3 of the 30% Design Report Drawings will be excavated and removed first and hauled to the repository for disposal.

The excavation fleet will excavate and remove the impacted soils at the depth based on the excavation cut specified within an area as shown in Drawing 3-02. The excavation fleet may excavate the soils in smaller lifts, such as one foot lifts if the excavation depth is greater than one foot in that area. For this case, a gamma scan survey may be performed during the smaller excavation lifts for excavation control to avoid either over excavation of soils below the Ra-226 RAL or to locate any unexpected PTW.

Following excavation of impacted soil at the specified excavation cut depths, a gamma scan will be performed with the collimated detector to identify any locations that exceed the RAL count rate. The gamma scan survey will be conducted for 100% coverage of the area. If no location exceeding the RAL count rate is identified within the area by the scan, the excavation will be considered complete. Judgmental gamma static survey at various locations within the area may be performed to confirm excavation of soils exceeding the RAL count rate.

If the gamma scans following the initial soil excavation lift show portions of the area above the RAL count rate or any static measurement point is above the RAL count rate, the area will be field marked with pin flags or marking paint. The excavation fleet will then be informed that the area needs additional excavation at those locations. The results observed during the gamma scan survey will be documented on a field form and on excavation area maps for excavation control coordination and documentation. The excavation will be repeated in lifts as necessary until the gamma scan survey indicates that soil exceeding appropriate RAL count rates, as specified in Table 1, has been excavated and removed or the excavation reaches bedrock.

5.2 PTW Excavation and Segregation

As discussed above, the RSEs and PDS identified lateral and vertical extent of PTW within four areas: NECR-1, Pond 1, Pond 3 and Sediment Pad as shown on the Section 3 Drawings of the 30% Design Report. PTW was identified at the ground surface in one area within Pond 3 and two isolated areas within the NECR-1 Area. PTW from the ground surface to a depth of 10 feet was identified in one area within the Sediment Pad Area, and from the ground surface to a depth of 15 feet in one area within the Pond 1 Area. PTW areas within the areas of excavation will be field located and marked prior to any excavation and removal activities.

The excavation and segregation of the PTW will be performed using a combination of in-situ gamma surveys and ex-situ gamma soil screening. Excavation control for the PTW will be similar to the excavation control for the soils exceeding the RALs, as follows:

1. In the areas where the PTW is at the ground surface in Pond 3 and NECR-1, the excavation of the PTW will be conducted in one lift and stockpiled near the excavation. Following the excavation lift of the PTW soil, a gamma scan will be performed with the collimated detector to identify any locations that exceed the PTW count rate by audio response and digital count rate display. If no point or a location exceeding the PTW count rate is identified within the area by the scan, the excavation of the PTW will be considered complete. Several surface soil samples will be collected from the PTW excavated area for onsite ex-situ gamma radiation soil screening to confirm if the PTW excavation is complete.

2. A five-point composite soil sample from the excavated and stockpiled PTW soil will be collected and screened by ex-situ gamma radiation soil screening for confirmation.

   The following PTW decisions will be made based on the soil screening results:

   - If the soil screening results show the gamma radiation counts higher than 20% above the screening level counts, the soils will be considered PTW, and will be hauled to the PTW staging area for offsite disposal.

   - If the soil screening results show the gamma radiation counts at +/- 20% of the PTW screening level, the soil may be a PTW and the soil sample will be sent to an offsite vendor laboratory for Ra-226 analysis using USEPA Method 901.1 and total uranium analysis using USEPA Method 6020 for confirmation. If the laboratory results indicate that the material is PTW, the soil will be hauled to the PTW staging area for offsite disposal; otherwise the soils will be hauled to the repository for disposal.

   - If the soil screening results show the gamma radiation counts less than 20% below the screening level counts, the soils will be considered not to be PTW, and will be hauled to the repository for disposal.

3. In areas where PTW is present from the ground surface to a depth greater than one foot (Sediment Pond Area and Pond 1 Area), the excavation of the PTW will be conducted in lifts, such as one foot lifts. Following each lift, a gamma scan will be conducted on the surface of the excavation and ex-situ soil screening as described in Step 1. Based on the results of the surveys, the excavation of the PTW may be continued by repeating Steps 1 to 3 above until the soil exceeding the PTW standard has been excavated and segregated.

Following the PTW excavation and removal, the soil in PTW excavated areas may be above the Ra-226 RAL. Excavation control described in Section 5.1 for waste exceeding the RAL will be conducted for excavation and removal of the soils exceeding the RAL.

5.3 Soil Sampling and Analysis

Excavation control soil samples for ex-situ gamma radiation soil screening and confirmatory soil samples for offsite vendor laboratory analysis will be collected during the soil excavation and removal. The soil 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 and labeled as discussed in SOP-5. The excavation control confirmatory surface soil samples will be shipped to an off-site laboratory for analysis of Ra-226 with a reporting limit of 0.5 pCi/g using USEPA Method 901.1, and total uranium with 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. All laboratory instrumentation will be calibrated by using National Institute of Standards and Technology (NIST) traceable standards.

5.4 Documentation

All excavation control surveys and sampling results will be recorded in the field forms included with the SOPs. The scam gamma survey results will be summarized on area maps and updated as excavation progresses for review, excavation control and coordination of the excavation activities with the excavation fleet.

5.5 Instrument Calibration and Function Checks

All instruments and equipment used during the excavation control will be operated, calibrated, and maintained according to SOP-1 and/or manufacturer's guidelines and recommendations. All instruments will be calibrated annually. Daily operational and functional checks will be performed for all radiological instruments before first use, with a mid-day check performed if necessary. Equipment that fails calibration or becomes otherwise inoperable during the excavation control surveys will be removed from service and segregated to prevent inadvertent use. Potentially affected data acquired on such equipment will be identified and evaluated for usability and potential impact on data quality. Such equipment will be tagged to indicate that it should not be used until the problem is corrected. Equipment requiring repair or recalibration must be approved for use by the Radiation Safety Officer or designee before being placed back into service. Equipment that cannot be repaired or recalibrated will be replaced.

5.6 Safety and Radiation Protection

The excavation control will require working around heavy equipment, which poses an elevated potential safety risk. Safety and radiation protection during excavation control will be addressed in the Health and Safety Plan (HASP) during the Pre-final design.

5.7 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.

Field decontamination will be conducted in a designated area near the field equipment staging area. Decontamination activities will be conducted so that all solid and liquid wastes generated can be containerized and disposed of appropriately.

8.0 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

Quality Assurance/Quality Control (QA/QC) measures will be employed throughout the excavation control process to ensure that decisions are made on the basis of data of acceptable quality. A Quality Assurance Project Plan that covers project QA/QC requirements and activities, including replicate surveys, sample recounts, instrument calibrations and function checks, and soil sample logs are included in Appendix T.3

9.0 REFERENCES

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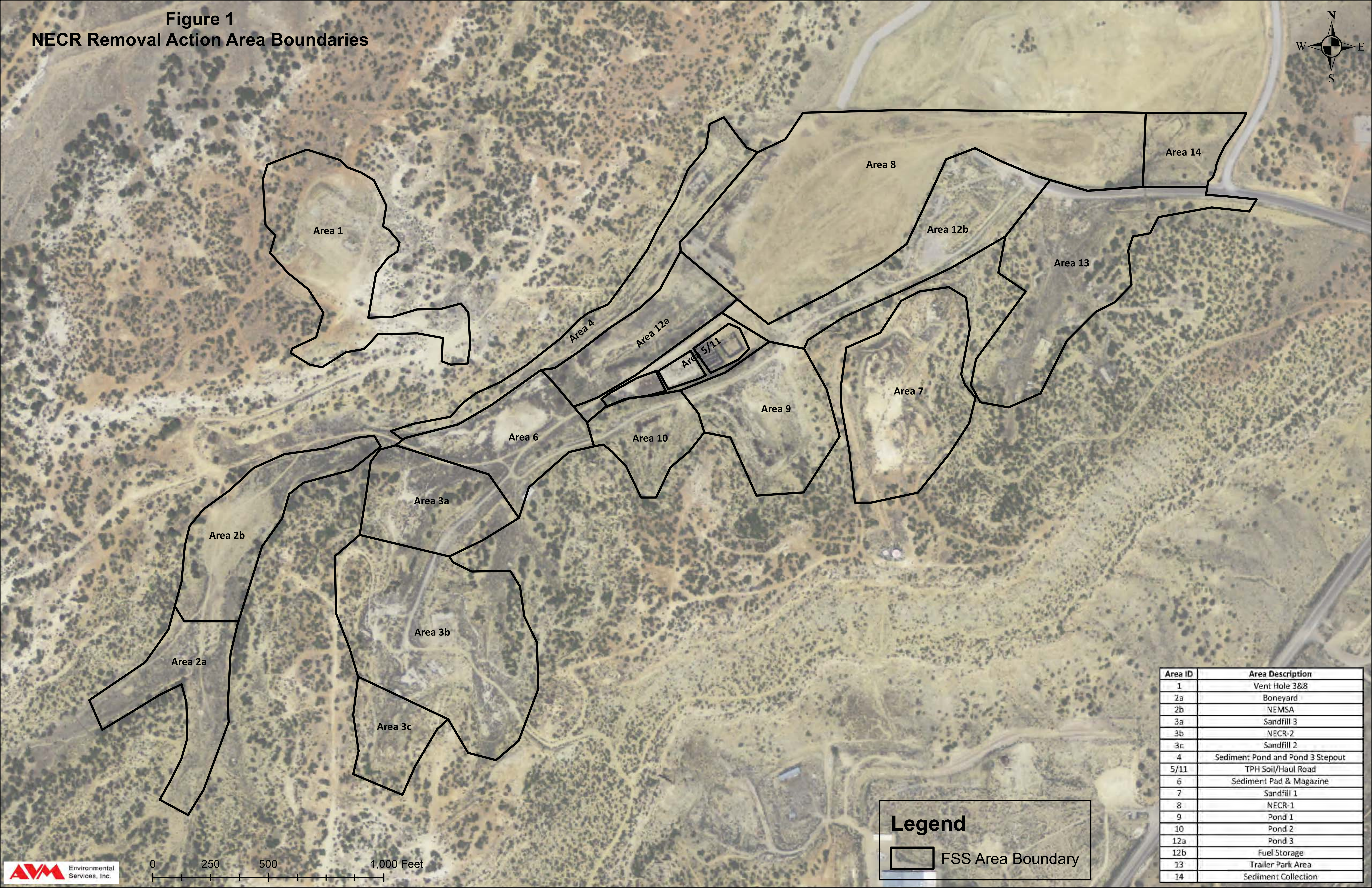
USEPA, 2006, Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, EPA/240/B-06/001, Office of Environmental Information, Washington, D.C., February.

USEPA, 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.

USEPA, Region 6, 2013. Record of Decision, United Nuclear Corporation Site, McKinley County, New Mexico. March 29.

Figures

Figure 1
NECR Removal Action Area Boundaries



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

ATTACHMENT T.2
Final Status Survey Plan

30% Design
Final Status Survey Plan

Northeast Church Rock Mine Site Removal Action

Prepared for

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TABLES

FIGURES

ACRONYMNS

AOC	Administrative Order on Consent
CPM	counts per minute
cy	Cubic Yards
DCGL	Derived Concentration Guidance Level
DGPS	Differential Global Positioning System
DQA	data quality assessment
DQO	Data Quality Objective
FSS	Final Status Survey
Ho	null hypothesis
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
ROD	Record of Decision
RSE	Removal Site Evaluation
RSO	Radiation Safety Officer
Site	Northeast Church Rock Mine Site
SOP	standard operating procedure
USEPA	U.S. Environmental Protection Agency
VSP	Visual Sampling Plan
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 (the Site) near Gallup, New Mexico. The objective of the FSS is to demonstrate that the residual radioactivity of radium 226 (Ra-226) and total uranium concentrations in the excavated areas at the Site following removal of mine waste meet the pre-determined Removal Action Levels (RALs) for release for appropriate use. 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 of mine waste impacted with uranium ore from mining activities within 17 areas as shown in Figure1, totaling approximately 130 acres. 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), Removal Action in the East Drainage Area (NECR-1 Step-out 2) (EDRA) (MWH 2013) and PDS. A summary of the nature and extent of contamination is provided in the 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 RALs specified in the 2011 Action Memo. Upon completion of this soil RA, as indicated by the excavation control surveys that the RA was effective to achieve residual soil radioactivity to RALs, a FSS will be performed to demonstrate that the residual radioactivity in the excavated areas at the Site following removal of mine waste meet 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 by 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 that was mined at the Site was coffinite which was placed in small temporary stockpiles before it was transported to the Mill Site. Active mining operations at the Site took place 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 and PDS Reports.

3.0 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQOs) for the FSS are provided below to establish a systematic procedure for defining the 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:

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

This FSS Plan will be used to determine whether residual Ra-226 and total uranium concentrations in soils at the Site comply with RALs specified in the 2011 Action Memorandum and the ROD for the Site, which is the Derived Concentration Guidance Level (DCGL) plus background concentration. This FSS Plan is consistent with MARSSIM, which 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 are consistent with the acceptable risk for the Site.

3.2 Identify the Goals of the Study

The intent of this plan is to use the FSS data to determine whether Ra-226 and total uranium are present at concentrations above or below RALs in the ROD.

Compliance with the RALs will be demonstrated by using guidance found in MARSSIM. Specifically, compliance will be demonstrated 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 judgmental soil samples (i.e., samples targeting specific areas of concern) consistent with MARSSIM guidance.

3.3 Identify Input Information

A DCGLw of 1.24 pCi/g of Ra-226 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. Based on the 80-foot triangular grid survey (515 m^2 area) static survey, similar to survey grid used during the Site RSE and IRAs, a DCGLemc of 2.0 pCi/g was calculated by USEPA consistent with the MARSSIM guidance. A background value of 1.0 pCi/g for Ra-226 from the reference area was determined during the 2006 RSE. The 2.24 pCi/g Ra-226 RAL in the 2011 Action Memorandum and the ROD is based on the 1.24 pCi/g DCGLw plus 1.0 pCi/g background value. The elevated measurement comparison RAL was established at 3.0 pCi/g (2.0 pCi/g DCGLemc plus 1.0 pCi/g background value) The RAL for total uranium of 230 mg/kg, as specified in the 2011 Action Memo and the ROD, is based on its chemical toxicity, and is not based on its radioactivity.

Guidance provided in 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).

The following information will be gathered and used as the basis for FSS decision-making:

- Historical information pertaining to 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.

- Information from excavation control surveying, also known as remedial action support survey 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 judgmental soil sampling results.

- FSS data collection, which will include scan and gamma static surveys of excavated surfaces and soil sampling combined with appropriate analytical methods.

- In addition to these quantitative methods, visual observations will also be used to determine if there is an indication of contamination or buried waste during the excavation.

The RSEs, PDS and excavation control survey data will be used primarily to confirm the appropriate FSS area classification designation for specific areas of interest. 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, PDSs 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. IRAs were previously completed and post IRA Status Survey was performed in the IRA areas (NECR-1 Step-out 1 and Step-out 2, which include the East Drainage Area). The FSS Plan will also address these two areas, as shown in Figure 3.

The footprint of the NECR Mine Site has been based on the results of the RSEs, PDS and IRA data as shown in Figure 1. Definitive FSS 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. All areas within the Site soil excavation and removal footprint will be included in the FSS.

3.5 Develop the Analytic Approach

Direct gamma radiation surveys will be used to detect the presence of 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% 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 which 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. Therefore, a site-specific correlation between direct gamma radiation levels and Ra-226 soil concentrations in pCi/g, as discussed in Section 6.6.2 of the MARSSIM (EPA, 2000), will be used to convert the counts per minute measurement to equivalent Ra-226 in soil. A site-specific correlation was developed during the RSE and updated for excavated areas during the IRAs. This correlation will be updated using the gamma static measurements and associated soil sampling during the FSS for the converting the counts per minute to soil Ra-226 concentrations in pCi/g. The gamma radiation survey will be conducted using a 2x2 NaI scintillation detector interfaced with a Scaler/Rate meter to detect presence of Ra-226 in excavated areas. EPA method 901.1 will be used for Ra-226 analysis on soil samples with required detection limit by an off-site vendor laboratory.

The soils at the Site are impacted by uranium ore; therefore uranium will be in secular equilibrium with associated decay products, including 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 at 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 offsite vendor laboratory will be used to confirm compliance with the total uranium RAL.

3.6 Specify performance or acceptance criteria

As part of the DQO process, the null hypothesis (Ho) for demonstrating compliance of data with cleanup goals must be stated. The Ho to be tested is that residual contamination exceeds the acceptance criterion (RAL). If the Ho is rejected, the alternative hypothesis 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 MARSSIM, to test the Ho for DCGLw compliance. For the DCGLemc requirements, gamma scan and static surveys and judgmental soil sample results will be compared against a DCGLemc equivalent detector counts per minute, 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. The Type I (alpha) decision error to be used in data testing is 0.025 (2.5%) which determines the minimum number of sample required for each survey area for establishing compliance with the DCGLw. The Type II (beta) decision error may range between 0.01 (1%) and 0.25 (25%). Initial Type II decision errors to be used for in-situ soil sampling is 0.05 (5%) and 0.10 (10%) for ex-situ soil sampling. The acceptable probability of a Type II error is used to determine additional sample numbers 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 percent difference of 30% or less at 50% of the DCGL values.

- Accuracy is the degree of agreement with the true or known; the objective for this parameter will be ±30% at 50% of the RAL value.

- Representativeness and comparability will be ensured through the selection and proper implementation of systematic sampling and measurement techniques.

- Completeness refers to the portion of the data that meets acceptance criteria and is therefore usable for statistical testing. The objective is 80% for this project.

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 will likely be the case during FSS work; thus, other factors should be taken into account 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 areas 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 the previous section. 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. MARSSIM defines three types of FSS units. 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 areas that were impacted and have been remediated, and are not expected to require 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.

<u>Class 1 Areas</u>

Seventeen of the 19 FSS areas at the Site are classified as Class 1 Areas since the RSEs and PDS determined that DCGLw has exceeded within these areas and are undergoing the RA. These areas are listed in Table 1 and shown in Figure 2.

Class 2 Areas

The IRA was completed in the Home Site (NECR-1 Step-out 1) Area in 2009 and RA was completed in the East Drainage Area (NECR-1 Step-out 2) in 2013. A post IRA status survey was conducted in these areas, which indicated that the areas meet the cleanup level according to the MARSSIM evaluation (MWH 2009 and 2013). Since these areas are not expected to require any RA, these two areas are classified as Class 2 Areas, and are listed in Table 1 and shown in Figure 3.

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. Background sampling consisted of a total of 25 samples at nodes of triangular grid from a reference area of approximately 4 acres from an area un-impacted by mining activities and upwind and upslope from the Site. The background sampling results showed an average Ra-226 concentration in soil of 1.0 pCi/g with a standard deviation of 0.2 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 MARSSIM as the radionuclide-specific activity concentration within a survey area corresponding to the release criterion, the RAL. DCGLs are of two types: DCGLw (wide area average criteria, applied to areas the size of survey areas) and DCGLemc (elevated area criteria, applied to areas much smaller than a survey area). 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 areas for a nonparametric Wilcoxon Rank Sum (WRS) test per MARSSIM guidance was determined during the Site RSE (MWH 2006a). A nonparametric WRS test was selected because radionuclides are present in background soil. The statistical parameters used to determine the number of data points needed to apply the nonparametric WRS test for the Site are defined in Table 2.

The statistical parameters shown in Table 2 were selected to achieve a low error rate as well as a relative shift between one and three. The relative shift is based on the lower bound of the gray region and the standard deviation. In addition, 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 resulted in a minimum of 13 data points being collected for each survey area and reference or background area. Results from a minimum of 13 gamma static survey locations in each area will be used for the FSS statistical tests and evaluation.

4.4 Sampling Spacing Grid

Although the number of samples calculated above was 13 per an area, the area will be gridded same as the grid spacing used during the Site RSE, IRA and the EDRA which will result in a higher number of systematic gamma static survey locations per area. Visual Sampling Plan (VSP) was used to determine the locations of the gamma static surveys and the surface soil samples during the RSE. The gamma static measurements and surface sample locations were located by using an 80-foot triangular grid casted on a random origin in each of the areas. A similar 80-foot grid will be used during the FSS for Class 1 areas as shown in Figure 2. One-minute gamma static surveys will be conducted at each node of the 80-foot triangular grid in each Class 1 area. Approximately 972 grid nodes are estimated for 17 Class 1 areas as shown in Figure 2 based on the excavation footprint determined by the RSE and the PDS. This may change depending on actual excavation footprint following soil excavation and removal action.

Since IRAs and RAs were completed in two Class 2 areas, the NECR-1 Step-out 1 Area and the East Drainage Area, and post IRA status surveys were conducted using 80-foot triangular grid spacing, the same post status grid points will be used for the FSS gamma static surveys, as shown in Figure 3. A total of approximately 420 gamma static survey grid nodes are estimated for the two Class 2 areas, as shown in Figure 3 and Listed in Table 1.

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. The 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 on the basis of soil sample results.

MARSSIM requires verifying that the systematic sampling densities in Class 1 areas are sufficient to also address DCGLemc concerns, given the expected scan Minimum Detection Concentration (MDC) values. A grid area of 515 m^2 is bounded by the nodes of the 80-foot triangular survey grid. Based on this gamma static survey density, a DCGLemc of 2.0 pCi/g has been established for the Site. Gamma survey techniques (i.e., surficial surveys) with a 2x2 NaI scintillation detector and soil sample analysis using EPA Method 901.1 (gamma spectroscopy) will be adequate to detect DCGLemc exceedances.

4.6 Gamma Surveys

Gamma radiation surveys will be performed for the FSS as discussed in subsections below.

4.6.1 Gamma Survey Instrumentation

As previously discussed, the Ra-226 in soil will be detected by direct gamma radiation level measurements. Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 KeV at about 4% intensity. Direct field measurement of alpha radiation is not feasible. The low energy and intensity of the Ra-226 gamma radiation emission makes it impractical to determine Ra-226 in the field by direct gamma radiation measurement. However, Pb-214 and Bi-214, a Ra-226 decay products, emits high energy gamma radiations at high intensities. The high energy gamma radiations of Pb-214 and Bi-214 can be easily measured in the field utilizing a NaI scintillation detector, such as 2x2 NaI Scintillation detector, having high gamma radiation sensitivity. The Ra-226 levels in soil could be measured as a surrogate for gamma measurement of Bi-214 gamma radiation levels, as the measurement described in Section 4.3.2 of the MARSSIM. Pb-214 and Bi-214 is a decay product 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. Therefore, a site-specific calibration is necessary. Previous studies have shown that about 20% of the Rn-222 gas decayed from Ra-226 in soil emanates out of the surface soil, indicating that a significant percentage (about 80%) 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.

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. The Scaler/Rate meter will be interfaced with a submeter accuracy and a data logger controller for electronically recording the gamma radiation levels to corresponding location coordinates. The instrumentation will be calibrated consistent with Standard Operating Procedure (SOP). MDCs for both the static and gamma scan radiation survey will be calculated as discussed in SOP-1. Based on data collected during the RSE, PDSs and IRAs surveys, the instrument MDC is expected to be below or near 50% of the DCGLw (1.24 pCi/gm) for static survey and 50% of the DCGLemc (2.0 pCi/gm) for the scan survey. The Site-specific correlation developed by performing linear regression between Ra-226 in soil and direct gamma radiation level will be updated and revised for final status survey (SOP-2) to convert the gamma survey results from counts per minutes (CPM) to equivalent Ra-226 concentration. A regression with the R^2 value of at least 0.8 will be used for determining the direct gamma radiation level equivalent Ra-226 surface soil concentration.

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.

4.6.2 Gamma scan surveys

Gamma scan survey data will be collected from all excavated soil surfaces as part of the FSS data collection process. Prior to gamma static surveys and confirmatory soil sampling, gamma scan surveys will be conducted for 100% coverage in each Class 1 area. For Class 2 areas (NECR-1 Step-out area and the East Drainage Area), judgmental gamma scan survey coverage will be performed at 10% to 100% for the FSS. As part of the FSS process, gamma scan surveys serve three primary roles: they (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, and (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. Judgmental and systematic scan surveys performed during the excavation control survey may be used for the FSS gamma scan surveys.

4.6.3 Gamma static Surveys

Following gamma scan surveys for the FSS, a one-minute gamma static survey will be conducted at each node of the 80-foot triangular grid in each area as a part of the FSS systematic sampling as discussed above. The estimated 972 gamma static survey points for the 17 Class 1 areas listed in Table 1 are shown in Figure 2. Approximately 430 gamma static survey points from the two Class 2 areas listed in Table 1 are shown in Figure 3. The FSS systematic static surveys will be used to evaluate compliance with DCGLw requirements and to confirm that DCGLemc exceedances are not an issue for the areas each systematic sample represents.

4.7 Soil Samples

Systematic confirmatory and judgmental 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 Judgmental Soil Samples

Judgmental surface soil samples will be collected to target specific locations where there are concerns about potential DCGLemc exceedances from the scan and gamma static surveys within FSS areas. Judgmental sampling locations may be selected on the basis of 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. Judgmental soil samples collected during excavation control survey will be collected consistent with 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 as confirmation samples for the FSS systematic gamma static surveys to evaluate compliance with DCGLw requirements. Confirmatory surface soil samples will be collected at 10 percent of the gamma static survey locations from each Class 1 FSS areas.

Since post-IRA status surveys with confirmatory soil samples were conducted in the two Class 2 areas which showed that the areas meet the cleanup level according to the MARSSIM evaluation (MWH 2009 and 2013), no confirmatory soil samples are proposed for this FSS. The DCGLw and DCGLemc requirement will be demonstrated with the gamma surveys only. If the gamma surveys show that a Class 2 area failed the DCGL requirements within an area, the area will be reclassified if necessary as Class 1 with appropriate systematic confirmatory soil samples.

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 judgmental sampling as necessary with evaluation of the samples by on-site ex-situ soil gamma screening or quick-turnaround off-site laboratory analysis (gamma spectroscopy) to determine if elevated area concerns (i.e., DCGLemc) exist that require additional excavation and removal;

4. Systematic one-minute gamma static surveys at nodes of 80-ft triangular grid spacing to support DCGLw evaluations; and

5. Confirmatory soil sampling with off-site laboratory analyses for systematic gamma static surveys.

A detailed 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. The direct gamma scan survey will be conducted. Gamma scan surveys will be performed in a manner that provides 100% coverage of excavated soil surfaces by walking along 6-ft spaced transects at a scan rate of 3 feet per second with the detector at 12 inches above the ground surface (see SOP-3). Based on the scan rate, detector background counting rate, detector response factor, detector field of view (at least ten 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% of the 2.0 Ra-226 DCGLemc for Site. The SOP-1 describes the scan MDC calculation in detail. 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).

The gamma scan survey measurements (initially planned at one per second) will be electronically logged with a suitable sub-meter Differential Global Positioning system (DGPS) which provides a real-time corrected location coordinates. In the event that elevated activities are encountered, one-minute static readings will be collected over the location of interest. In addition, for each location where a judgmental 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 (defined as a contamination level that exceeds the RAL for elevated measurement comparison (RALemc) will be flagged. Judgmental 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 and any bias gamma static surveys and soil sampling, a one-minute gamma static measurement will be conducted at each node of the 80-foot triangular grid in each area as a part of the FSS systematic sampling, as shown in Figure 2 for Class 1 areas and in Figure 3 for Class 2 areas. 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). Based on the detector background counting rate, detector response factor, and detector field of view, the selected instrumentation will meet the gamma static survey MDC at less than 50% of the 1.24 Ra-226 DCGLw for the Site. The gamma static surveys will be electronically logged with a suitable sub-meter accuracy DGPS which provides a 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 liner regression analysis equation from the updated 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 judgmental soil samples. 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 RSE, PDS, and IRAs for expedited estimate of Ra-226 in soil. A single channel analyzer, such as Ludlum L2221 integrated with Ludlum 44-20 3x3 NaI scintillation detector can be used to measure radiation of a particular energy of Bi-214. The sample is placed around the plastic lined detector in a heavily shielded counting chamber. The heavily shielded counting chamber lowers the system background counts thus improves the detectable concentration. The 609 KeV gamma radiation counts are obtained and compared to the reference soil and sample soil for field screening.

5.4 Judgmental 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 judgmental soil sample will be collected from that location. A one-minute static one-minute 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). The soil sample will initially be field screened for expedited Ra-226 content by onsite 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 10 percent of the gamma static survey locations in FSS Class 1 areas, as shown in Figure 2. The estimated numbers of systematic 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). The systematic soil samples will be sent to an offsite vendor laboratory for Ra-226 and total uranium analysis.

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 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. All 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 all 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. Potentially affected data acquired on such equipment will be identified and evaluated for usability and potential impact on data quality. 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.

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 30% 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 that supports the FSS field activities.

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 FSP.

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 project 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 sample holding time specified by the analytical method. During the time period between collection and shipment, all samples will be stored in a secure area.

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.

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 will be addressed and included in the Site Removal Action Health and Safety Plan (HASP) for the Pre-final design.

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, what corrective steps are required.

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 units;
- Demonstrating there are no DCGLemc exceedances through a combination of gamma scan surveys, judgmental soil sampling (as necessary), and systematic gamma static surveys and soil sampling; and
- Demonstrating compliance with DCGLw requirements through the use of 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 is evidence of 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 will be a systematic sample result near or above the DCGL values for a Class 2 area. Anomalous results do not necessarily indicate noncompliance with DCGL, but may indicate that the underlying information used as a basis for 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% 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 judgmental soil sample results will be compared against the RALemc (DCGLemc plus background level).

The generic process for demonstrating DCGLemc compliance is the same for Class 1 and Class 2 areas. Logged, spatially complete gamma survey data will be collected for each FSS area. These data will be compared to DCGLw. If the result is above the DCGLw, the individual systematic survey result will be compared to 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 (visual evidence of contamination, historical information, etc.) will be sampled on judgmental basis.

7.3 Demonstrating Compliance with DCGLw

Each survey area excavation footprint 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 80-feet triangular grid in each area. When the data clearly show that a survey area meets or exceeds the DCGLw, the systematic gamma static survey measurements are at or below the RAL, the result may be obvious without performing the formal statistical analysis. Examples of circumstances leading to specific conclusions based on a simple examination of the data for this FSS is summarized in Table 3.

Since Ra-226 is present in background, the non-parametric WRS test will be used for this FSS consistent with the 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

<u>Null Hypothesis</u>

H_0: The median concentration in the survey area exceeds that in the reference area by more than the $DCGL_W$

versus

Alternative Hypothesis

H_a: The median concentration in the survey area exceeds that in the reference area by less than the $DCGL_W$

The Ho to be tested is that residual contamination exceeds the RAL. If the Ho is rejected, the alternative hypothesis will be accepted, and the finding of the evaluation is that the FSS area satisfies the RAL requirement.

If the survey area does not pass the WRS test, the reason why 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 associated decay products. The 230 mg/kg total uranium 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 impacted soils above 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.

8.0 QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

QA/QC measures will be employed throughout the FSS process to ensure that decisions are made on the basis of 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 the highest level of confidence in the data collected to support the survey outcome.

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 (USEPA 2000). 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; and

5. Results of the WRS test.

The last step of the DQA process will be documenting the results and drawing conclusions from them.

10.0 REFERENCES

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NRC, 1998, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, NUREG- 1507, June.

USEPA, 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016.

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.

Tables

Table 1: NECR Mine Site FSS Areas

Area ID	Area Description	Area Class	Area Approximate Size, Ft^2	No. of Gamma Static Survey	No. of Soil Samples
1	Vent Hole 3/8	1	403,250	74	8
2a	Boneyard	1	226,720	45	5
2b	NEMSA	1	309,070	49	5
3a	Sandfill 3	1	222,180	40	4
3b	NECR-2	1	629,250	105	11
3c	Sandfill 2	1	122,760	26	3
4	Sediment Pad & Pond Step-Out	1	259,920	43	5
5/11	TPS Soil Storage	1	94,070	19	2
6	Sediment Pad & Magazine	1	194,700	40	4
7	Sandfill 1	1	425,150	78	8
8	NECR-1	1	899,950	172	17
9	Pond 1	1	316,100	52	5
10	Pond 2	1	155,860	27	3
12a	Pond 3	1	192,600	35	4
12b	Fuel Storage	1	304,500	56	6
13	Trailer Park Area	1	450,400	89	9
14	Sediment Collection Area	1	112,060	22	3
15	Home site (NECR-1 Step-out) IRA Area	2	1,496,250	277	No Soil Sample
16	East Drainage Area IRA	2	749,240	143	No Soil Sample
Total			**5,330,310**	**1392**	**102**

Table 2: Statistical Parameter for Wilcoxon Rank Sum Test

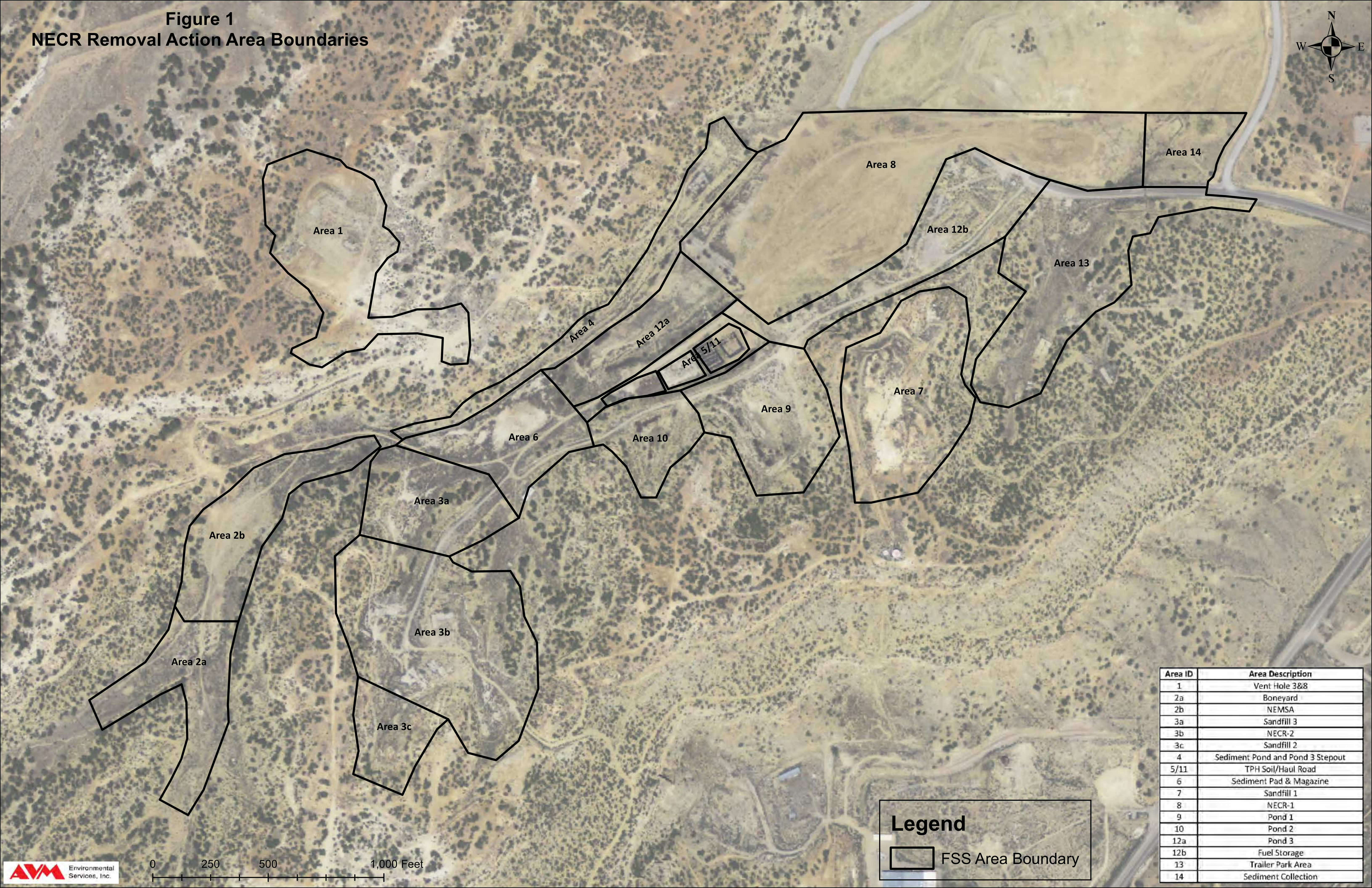
Parameter	Value
Type I Error (alpha, α)	0.05
Type II Error (beta, ß)	0.10
DCGLw	1.24 pCi/g
Shift (DCGLw - LBGR)	0.90
Standard Deviation (sigma, σ)	0.55
Relative Shift (□/σ between 1 and 3	1.6
Number of Samples (N)	13

Table 3: Summary of Statistical Test

Survey Result	Conclusion
Difference between survey area measurement and smallest reference area measurement is less than $DCGL_W$	Survey area meets RAL
Difference of survey area average and reference area average is greater than $DCGL_W$	Survey area does not meet the RAL
Difference between any survey area measurement and the reference area measurement greater than $DCGL_W$ and the difference of survey area average and reference area average is less than $DCGL_W$	Conduct WRS test and elevated measurement comparison

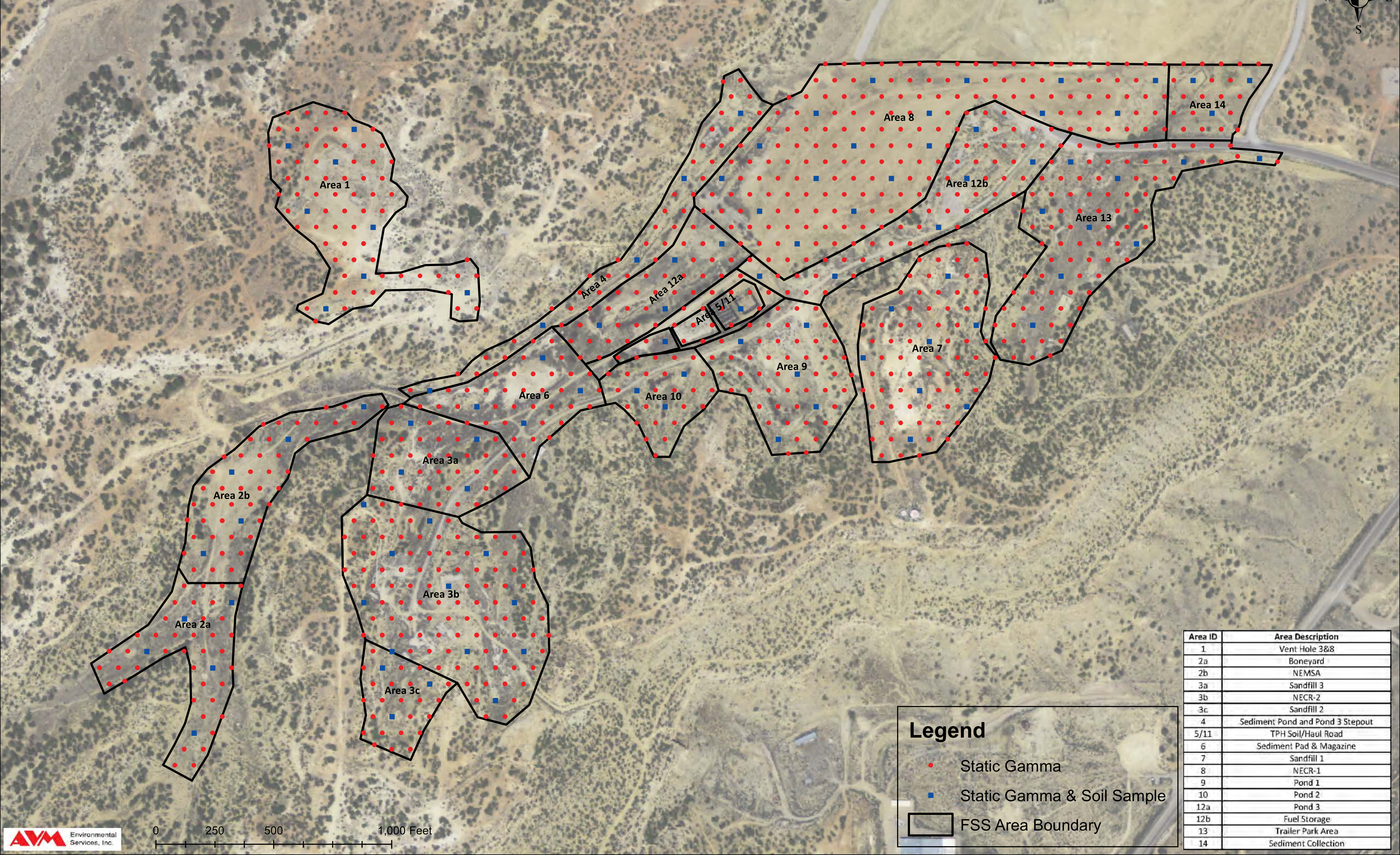
Figures

Figure 1
NECR Removal Action Area Boundaries



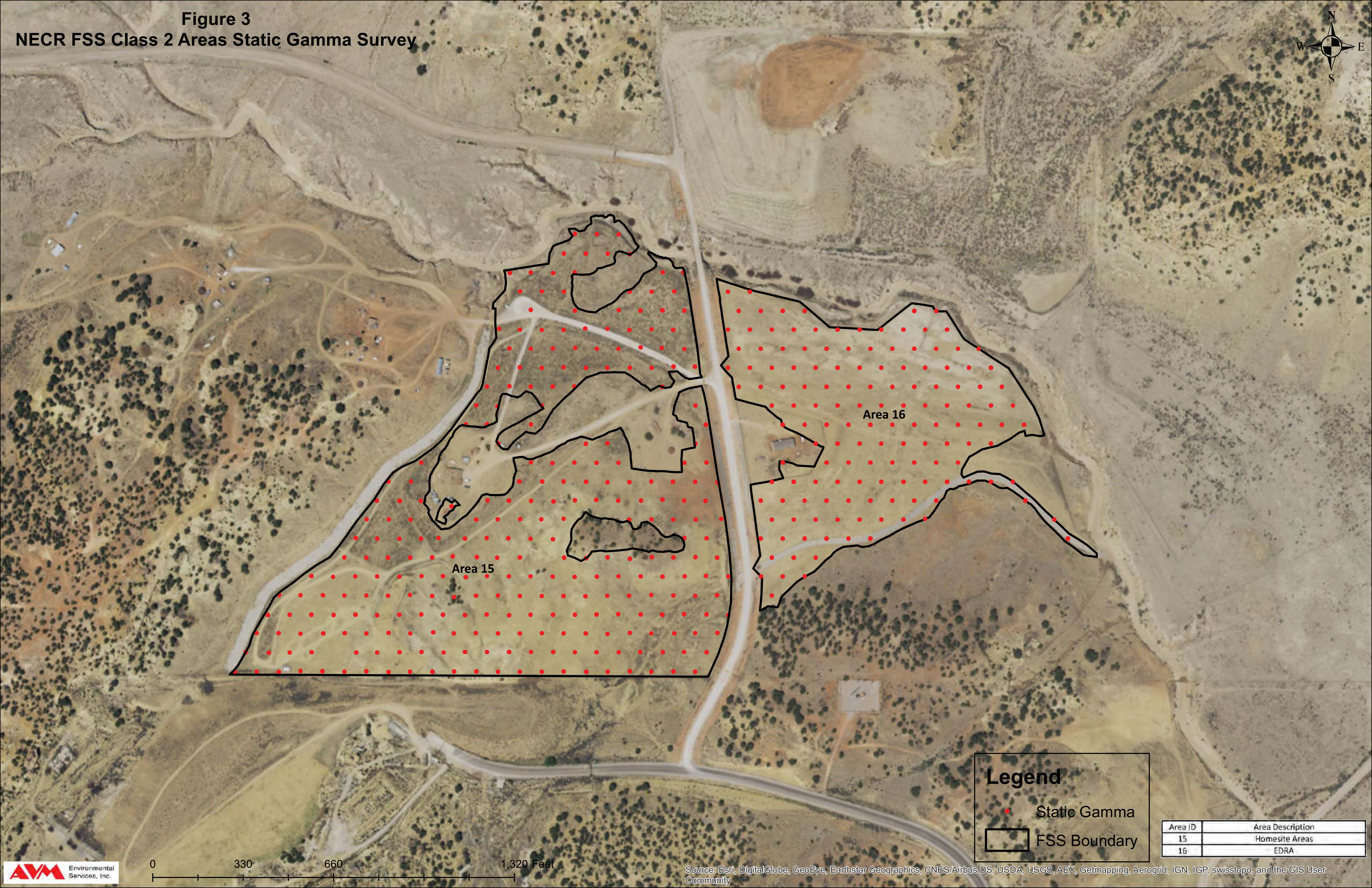
Area ID	Area Description
1	Vent Hole 3&8
2a	Boneyard
2b	NEMSA
3a	Sandfill 3
3b	NECR-2
3c	Sandfill 2
4	Sediment Pond and Pond 3 Stepout
5/11	TPH Soil/Haul Road
6	Sediment Pad & Magazine
7	Sandfill 1
8	NECR-1
9	Pond 1
10	Pond 2
12a	Pond 3
12b	Fuel Storage
13	Trailer Park Area
14	Sediment Collection

Figure 2
NECR FSS Class 1 Areas Static Gamma Survey & Soil Sample Locations



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

Figure 3
NECR FSS Class 2 Areas Static Gamma Survey



ATTACHMENT T.3
Quality Assurance Project Plan

Northeast Church Rock

30% Design Report

Attachment T.3

Quality Assurance Project Plan

MWH® now part of Stantec

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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
CVS	calibration verification standard
DQO	data quality objective
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
QAPP	Quality Assurance Project Plan

QA	quality assurance
QC	quality control
RA	Removal Action
RCA	recommendations for corrective action
RER	replicate error ratio
RL	reporting limit
RPD	relative percent difference
SOP	standard operating procedure
SSL	soil screening level
USEPA	United States Environmental Protection Agency

1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) is part of the Northeast Church Rock 30% 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 MWH 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 ensure 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 for the Data Quality Objectives Process, EPA QA/G-4 (USEPA, 2000).
- 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 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 Construction Supervising Contractor 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.** Construction Supervising Contractor 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.** Construction Supervising Contractor 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 Construction Supervising Contractor will have the overall responsibility for the implementation of this project. The Construction Supervising Contractor'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 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 Construction Supervising Contractor Project Manager 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 Construction Supervising Contractor Project Manager 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 Quality Assurance 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 Construction Supervising Contractor 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 Project Manager
- 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 Project Manager
- Day-to-day coordination with the Project Manager 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 Construction Supervising Contractor Project Manager.

2.2.4 Construction Supervising Contractor Field Team

Under the direction of the Construction Supervising Contractor 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 Quality Assurance Manager 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 Quality Assurance Manager is responsible for auditing the implementation of the QA program in reference to project-specific requirements, and report any findings to the Construction Supervising Contractor Project Manager. 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

2.2.6 Construction Supervising Contractor Project Chemist

The Construction Supervising Contractor Project Chemist like the Quality Assurance 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 Project Manager 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 Construction Supervising Contractor 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 Construction Supervising Contractor.

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 Project Manager 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, 2000). 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 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:

$$(S / \overline{X}) \text{ x } 100$$

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:

$$\%R = \frac{|X_s - X_u|}{K} \times 100\%$$

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), trip blanks, equipment rinsate blanks, source water blanks, 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 Project Manager 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 Construction Supervising Contractor 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 ensure 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 ensure 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 upon 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 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 temperature blanks, trip blanks and field replicate samples (samples that are submitted blind to the laboratory), as applicable.

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.

Equipment Rinsate Blank Samples. Equipment rinsate blank samples will be used to evaluate representativeness and will be prepared in the field (after decontamination of sampling equipment is complete) by collecting the final rinse water into the appropriate sample container. Equipment rinsate blanks will be collected on a daily basis for groundwater or surface water samples when non-dedicated equipment is used for sampling.

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.

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 Construction Supervising Contractor 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 (reagent grade water or 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 (reagent grade water or 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 and will be media specific (e.g., sediment, sludge, and groundwater). 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 $\pm$ 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 Construction Supervising Contractor 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.

Soil and air 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 Construction Supervising Contractor and will be under the custody of the Project Manager 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 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. 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 (chromatograms) 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 Construction Supervising Contractor Project Manager 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 Construction Supervising Contractor, the Contract Laboratory will perform in-house data review under the direction of the Contract Laboratory Project Manager and/or the laboratory Quality Assurance 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 Construction Supervising Contractor 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 Project Manager 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 Project Manager will also be responsible for reviewing all final data reports for proper format and reporting consistency prior to release of the reports to the Construction Supervising Contractor. 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 Project Manager and/or Quality Assurance 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 Construction Supervising Contractor. 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 Construction Supervising Contractor 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.

8.4.1 Level III Data Verification

The Construction Supervising Contractor 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 (i.e. chromatograms, quantitation reports, spectra), 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?

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.

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, and/or chromatograms 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.

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 Construction Supervising Contractor 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 Construction Supervising Contractor, at the discretion of the GE/UNC Representative, 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 Construction Supervising Contractor Project Chemist may perform magnetic tape audits of the Contract Laboratory if warranted by on-site audit results.

The Construction Supervising Contractor will forward audit results to appropriate management and the GE/UNC Representative. 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 Construction Supervising Contractor will be immediately notified and the corrective action to be taken will be determined by the Construction Supervising Contractor Project Chemist and Project Manager and GE/UNC Project Manager (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 Construction Supervising Contractor Project Manager or designee will implement corrective action only after approval. If immediate corrective action is required, approvals secured by telephone from the GE/UNC Project Manager 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 Construction Supervising Contractor Project Manager, 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 Construction Supervising Contractor 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 Construction Supervising Contractor Project Chemist, the Construction Supervising Contractor Project Manager will have responsibility for authorizing the implementation of the corrective action, including resampling and documenting the corrective action and notifying the GE/UNC Project Manager 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 Construction Supervising Contractor Project Manager. 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.

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), 2000. *Guidance for the Data Quality Objectives Process, EPA* QA/G-4. EPA/600/R-96/055.

US Environmental Protection Agency (USEPA), 2001. EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, EPA QA/R-5.

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

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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)	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 (Page 1 of 2)

Method	Analytical Procedure
MADEP APH SW-846 1312 Synthetic Precipitation Leaching Procedure	Air-phase petroleum hydrocarbons are introduced onto a 30 meter capillary column in a gas chromatograph (GC) temperature programmed to separate the analytes, which are then detected with a flame ion detector interfaced with the GC. Quantitation is accomplished by comparing response to a 5 or 6 point calibration curve. The solid phase is extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase by tumbling for 18 hours. The extraction fluid is separated from the solid phase by filtration. The extraction fluid is then analyzed as a water sample.
SW-846 1311 Toxicity Characteristic Leach Procedure	The solid phase is extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase by tumbling for 18 hours. The extraction fluid is separated from the solid phase by filtration. The extraction fluid is then analyzed as a water sample.
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.
EPA 903.0 Radium-226 by Alpha Spectrometry	Radium is collected by co-precipitation with barium sulfate. The precipitate is purified and directly deposited on a stainless steel planchet. Following a ten day in-growth period the sample is counted for alpha activity on a low background alpha/beta proportional scaler and the radium concentration is calculated from the count rate.
EPA 901.1 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 6020 Metals by ICP/Mass Spectrometer	Metals in solution is analyzed using ICP/Mass Spectrometer.
SW-846 7470A Mercury by Cold Vapor Atomic Adsorption	Mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic adsorption spectrophotometer. Absorbency (253.7 nm) is measured as a function of mercury concentration.
SW-846 8015B Total Petroleum Hydrocarbons by Gas Chromatography (GC)	Total petroleum hydrocarbons are introduced onto a 30-meter capillary column in a GC, temperature programmed to separate the analytes, which are then detected with a flame ionization detector interfaced with the GC. Quantitation is accomplished by comparing peak area to the standard 5-point calibration curve.
SW-846 8260B VOCs by Gas Chromatography/Mass Spectrometry (GC/MS)	Volatile compounds are introduced onto a 30-meter capillary column in a GC, temperature programmed to separate the analytes, which are then detected with a mass spectrometer (MS) interfaced with the GC. Quantitation is accomplished by comparing response of a major (quantitation) ion relative to an internal standard using a 5-point calibration curve.
SW-846 8270C SVOCs by GC/MS	Semi-volatile compounds (including PAHs) are introduced onto a 30-meter capillary column in a gas chromatograph (GC), temperature programmed to separate the analytes, which are then detected with a mass spectrometer (MS) interfaced with the GC. Quantitation is accomplished by comparing response of a major (quantitation) ion relative to an internal standard using a 5-point calibration curve.

Table 6-1. Analytical Method Summary (Page 2 of 2)

Method	Analytical Procedure
Agronomic Analyses	
ASA No. 9, Method 10-3.2 pH	A saturated paste is made by mixing the soil with water in a 1:1 ratio. pH is measured using a calibrated pH probe
ASA No. 9, Method 10-3.3 Electrical Conductivity	A saturated paste is made by mixing the soil with water in a 1:1 ratio. Conductivity is measured using a calibrated conductivity meter
USDA Handbook 60, Method 27A Saturation Percentage	A portion of the saturated paste is collected and dried @ 105 degrees Celsius. The loss of water weight divided by the dry weight of the soil is expressed in percent.
ASA No. 9, Method 15-5 Texture	Texture is determined by mixing a weighed portion of the sample with enough water to bring the volume to one liter. After mixing density is measured using a hydrometer at seven timed intervals as the sample settles.
ASA No. 9, Method 15-5 Rock Fragment Percentage	A weighed amount of sample is sent through a series of sieves and percentage is determined by weighing the amount of samples left on each sieve.
ASA No. 9, Method 10-3.4/SW 6010B Sodium Adsorption Ratio (SAR)	A saturated paste is made by mixing the soil with water in a 1:1 ratio. The liquid portion is then analyzed for sodium using ICP.
ASA No. 9, Method 33-3.1/EPA 353.2 Nitrate	Nitrate is extracted from soil using a 2M potassium chloride solution. Extract is then analyzed for nitrate by colorimetry.
ASA No. 9, Method 24-5.1/EPA 365.1 Phosphorus	Phosphorus is extracted from soil using a solution consisting of 0.03 N ammonium fluoride and 0.025 N hydrochloric acid. Extract is analyzed for phosphorus by colorimetry.
ASA No. 9, Method 13-3.5/SW6010B Potassium	A saturated paste is made by mixing the soil with water in a 1:1 ratio. The liquid portion is then analyzed for potassium using ICP.
ASA No. 9, Method 10-2.3.2/EPA300 Chloride	Chloride is extracted from soil using distilled water. Extract is analyzed for chloride by ion chromatography.
ASA No. 9, Method 28-5.1 Sulfate	Sulfate is extracted from soil using distilled water. Extract is analyzed for sulfate by ion chromatography
ASA No. 9, Method 29-3.5.2 (Walkley-Black) Organic Carbon	Walkley-Black was developed specifically for soils and consists of a wet oxidation method using potassium dichromate, which is back-titrated with iron^{+2}. This method targets organic matter in soil, which is the primary source of organic carbon in soil.

1. EPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), (U.S. EPA Third Edition, September 1986; Final Update III, December 1996).
2. Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA/600/4-80-032, August, 1980)
3. EPA Methods for the Determination of Inorganic Substances in Environmental Samples (EPA 100-400 Series) (EPA/600R-93/100, August 1993)
4. Massachusetts Department of Environmental Protection Methods for the Determination of Air-Phase Petroleum Hydrocarbons (APH) (MADEP, December 2009).
5. Methods of Soil Analysis, American Society of Agronomy, 1982.
6. United States Department of Agriculture(USDA), Handbook No. 60, Method 23C, USDA, 1954

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)	—Hard copy of data report
		Completed C-O-C and sample receipt and log in forms	—Hard copy of data report
		Target compound results for all samples, including field QC samples and dilution factors, reanalysis, batching information, and bracketing information	—Hard and electronic copy of data report
		Method blank results	—Hard and electronic copy of data report
		MS/MSD results (spike concentration, actual values, and percent recovery)	—Hard and electronic copy of data report
		Matrix duplicate data	—Hard and electronic copy of data report
		LCS results (spike concentration, actual values, and percent recovery)	—Hard and electronic copy of data report
		Surrogate results, organic analysis (spike concentration, actual values, and percent recovery)	—Hard and electronic copy of data report
		Initial calibration summary form	—Hard copy of data report
		Continuing calibration summary form	—Hard copy of data report
		Internal standard area and retention time summary (if applicable)	—Hard copy of data report
		Injection logs	
		Raw data for all samples where matrix interference is invoked as the reason for MS/MSD, surrogate spike, or internal standard failure	—Hard copy of data report —Hard copy of data report
		ICP interference check sample data	—Hard copy of data report
		Post digestions spike sample data	—Hard copy of data report
		Method of standard addition data (if required)	—Hard copy of data report
		Holding time summary	—Hard copy of data report
		Manually integrated data	—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).

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

[To be included in 95% Pre-final Design Report]

ATTACHMENT 2
Contract Laboratory Quality Assurance Plans
[To be included in 95% Pre-final Design Report]

Northeast Church Rock 30% Design Report

Appendix U:
Revegetation Plans

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LIST OF ATTACHMENTS

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
RAO	Remedial Action Objective
ROD	Record of Decision
SOW	Statement of Work
USEPA	US Environmental Protection Agency

U.1 INTRODUCTION

This appendix presents the Revegetation Plans for the Northeast Church Rock Mine Site and Church Rock Mill Site (Attachment U.1) and the Repository on Church Rock Mill Site Tailings Disposal Area (Attachment U.2). These plans were prepared by Cedar Creek Associates, Inc., a subcontractor to MWH.

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

Location of Performance Standard Requirement	Performance Standard	Comments
2011 Action Memo, Section V.A.1, Bullet 8 – 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 Northeast Church Rock 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 Church Rock Mine Site and Church Rock Mill Site is attached as Attachment U.1, and native species are included in the selected seed mixes.
2013 ROD, Table 1	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 Church Rock Mill Site Tailings Disposal Area is attached as Attachment U.2.
2013 ROD, Table 1	10 CFR 40, Appendix A, Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material From Ores Processed Primarily for Their Source Material Content - Criterion 4.	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 Church Rock Mill Site Tailings Disposal Area is included as Attachment U.2.
2013 ROD, Section 2.9.5, Cap Design Criteria, Bullet 5	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: …use of biosolids or top soil to facilitate vegetation growth	The Revegetation Plan for the Repository on Church Rock Mill Site Tailings Disposal Area 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.

Location of Performance Standard Requirement	Performance Standard	Comments
2013 ROD, Section 2.9.5, Cap Design Criteria, Bullet 6	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 Church Rock Mill Site Tailings Disposal Area is included as Attachment U.2. The revegetation plan includes a seeding mix which emulates the native vegetation community to maximize resilience and sustainability.
2015 AOC SOW, Paragraph 27 – Site Restoration	In the Design, Respondents shall include detailed plans and specifications for restoration of the Tailings Disposal Area and borrow areas on the UNC Site and for restoration of the NECR Site. Respondents shall also include plans and specifications for contouring to promote drainage, and for re-vegetation of the Tailings Disposal Area, borrow pits and NECR Site with native species. Respondents shall include plans and specifications for backfilling and regrading of disturbed (e.g., excavated) areas in the NECR Site and the UNC Site for erosion and storm water control, including re-vegetation of those areas with native species.	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 Northeast Church Rock Mine Site and Church Rock Mill Site and the repository on Church Rock Mill Site Tailings Disposal Area are included as Attachment U.1 and Attachment U.2, respectively.
2015 AOC SOW, Paragraph 43 – 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 Northeast Church Rock Mine Site and Church Rock Mill Site is included as Attachment U.1. The Cleanup Verification Plan is provided as Appendix T. Both plans will be updated for the 95% Design.

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

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 2016

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Table of Contents

1.0 INTRODUCTION

Cedar Creek Associates, Inc. (Cedar Creek) has been retained by MWH 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.

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.

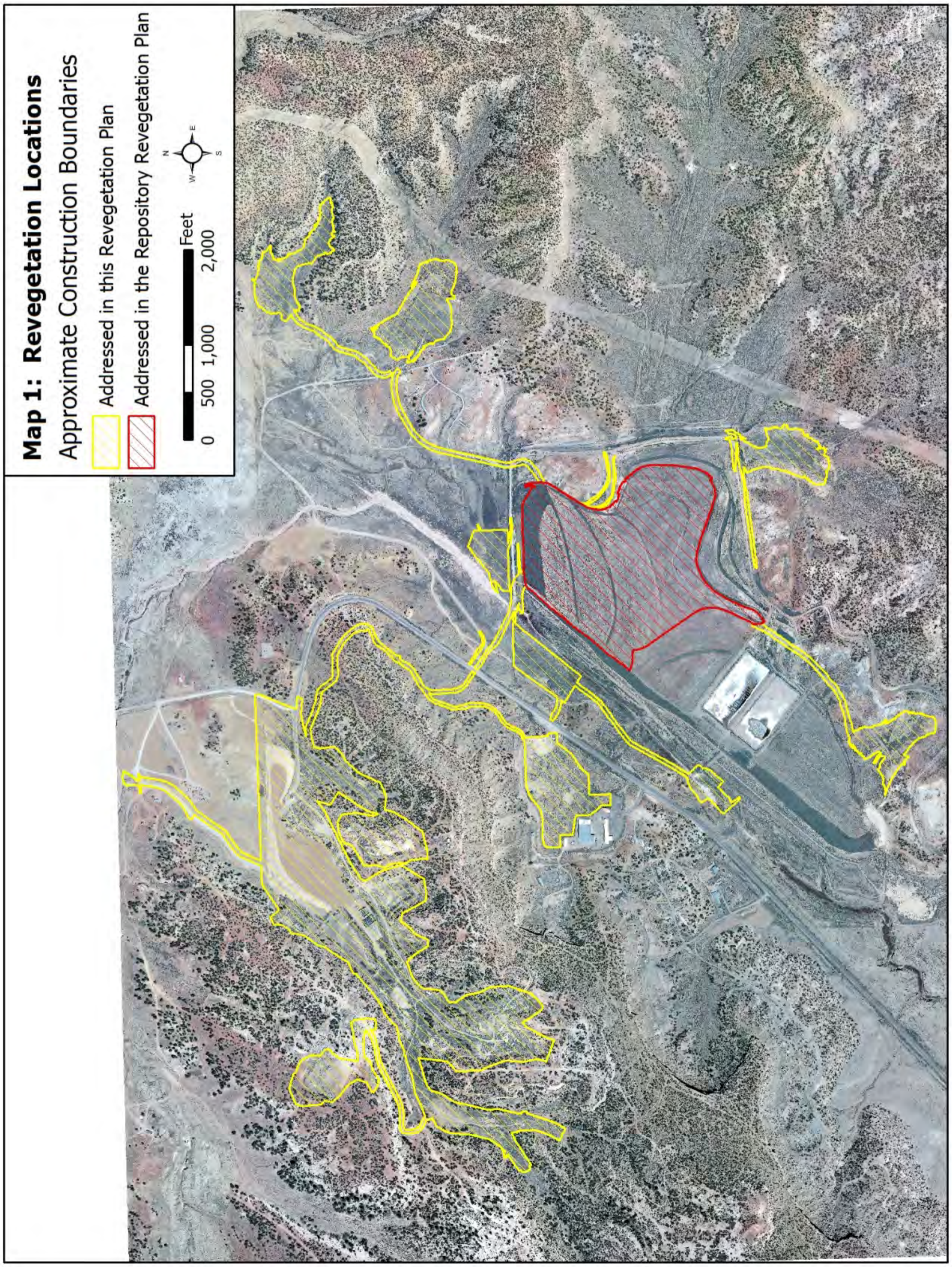
Three baseline evaluations of biological resources have been previously conducted at the Mine and Mill Sites. The evaluations were made in support of the 2009 Interim Removal Action (Cedar Creek, 2010), the 2012 Interim Removal Action (Cedar Creek, 2012a), and the Repository design (Cedar Creek, 2014). Annual revegetation monitoring reports have been generated since 2010, presenting performance results from the revegetation implemented on and around the mine site. The baseline studies 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) and associated mill 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 also could transverse a 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
Approximate Construction Boundaries
Addressed in this Revegetation Plan
Addressed in the Repository Revegetation Plan
0 500 1,000 2,000
Feet
N
E
S
W

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).

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 composed predominantly of one soil particle size fraction should be avoided (avoid the fringes of the textural triangle). 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.

2.2 Soil/Growth Media Chemical Considerations

Soil and growth media should be laboratory tested for basic macro/micro nutrients, pH, organic matter (OM), electrical conductivity (EC), and the sodium adsorption ratio (SAR) to verify that the materials can support plant growth. If material harvesting occurs deeper than what should be considered topsoil, then organic amendments will likely be needed to improve the revegetation potential. Testing soil fertility indicators, particularly pH, OM, EC, and SAR, are important facets in gaining an understanding what amendments could be beneficial toward achieving a successful revegetation.

2.3 Soil/Growth Media Amendments and Fertility

Amendments will be adjusted and applied on an "as needed" basis. Additionally, 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) of composted cow or green manure, or composted biosolids, should be sufficient for reclamation, and has been successful in reclamation within the Mine Site in the past. 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 interim 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.

If deemed necessary, a certified weed-free wood shred mulch, wood chip mulch, or crimped straw mulch can be applied at a rate of 1-2 tons/acre to areas deemed particularly susceptible to erosion following seeding. Areas with high consequences of erosion could include 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.

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. Map 2 generally shows where each seed mix will be applied. This map will be refined for the 95% Design.

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. The proposed seed mixes are comprised of native species and application rates are presented on Tables 1 and 2 for Juniper Woodland and Grassland / Shrubland targeted communities, respectively. A seed mix for the bottomland community will be developed after the baseline evaluation occurs for the 30% design environmental report. The Grassland / Shrubland mix was developed with community input during the 2009 and 2012 Interim Removal Actions (Cedar Creek, 2010 and Cedar Creek, 2012b). 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.

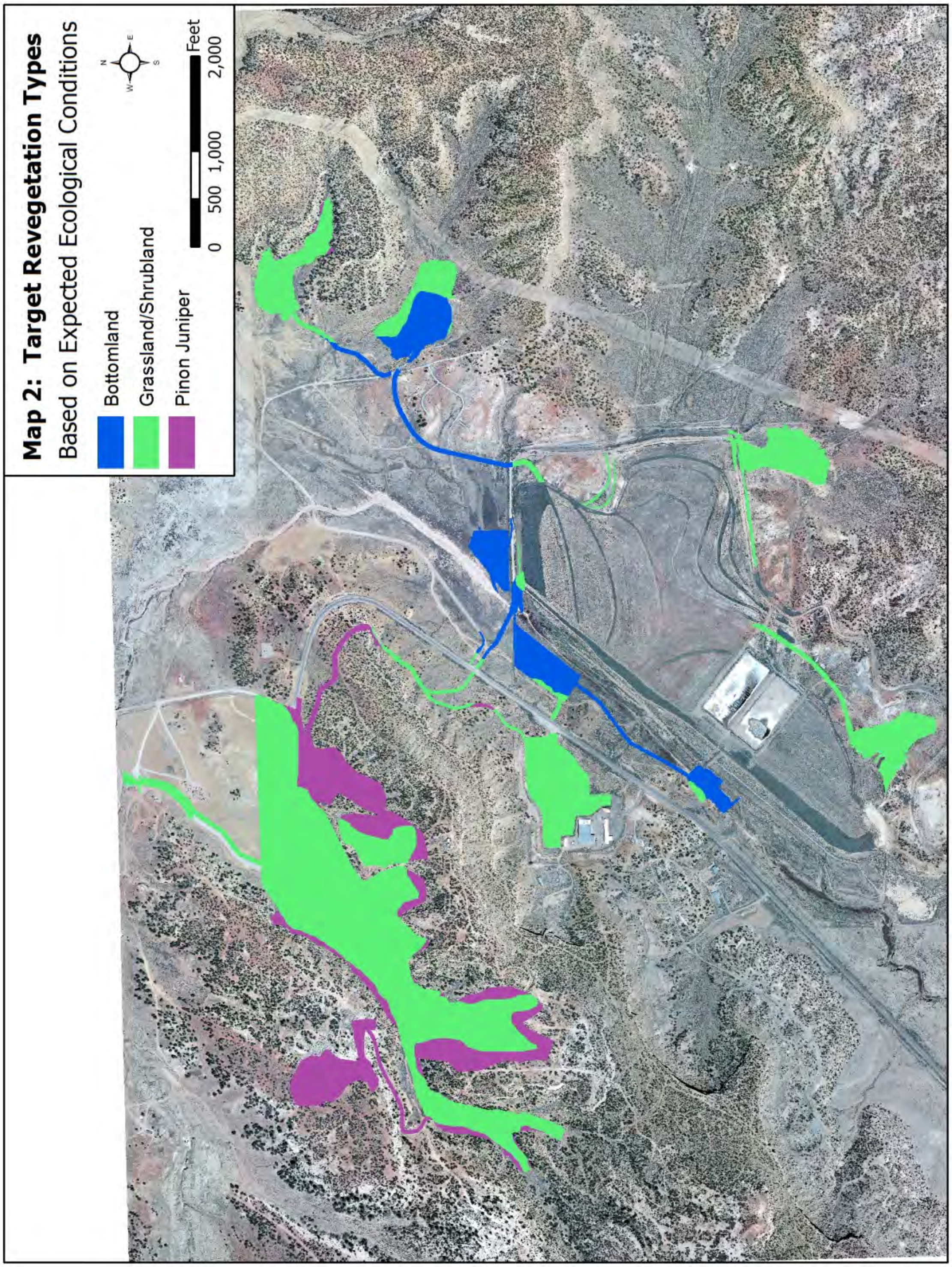

Map 2: Target Revegetation Types
Based on Expected Ecological Conditions
Bottomland
Grassland/Shrubland
Pinon Juniper
N
E
S
W
0 500 1,000 2,000
Feet

Table 1 Seed Mix for Juniper Woodland Targeted Communities

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
		Western wheatgrass	*Agropyron smithii*	110,000	1.50	3.8	4.1%	Drill	NRCS indicated climax species
		Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.25	10.1	10.9%	Drill	NRCS indicated climax species
		Blue Grama	*Bouteloua gracilis*	825,000	0.50	9.5	10.3%	Drill	Stong component of native community
		Galleta	*Hiliaria jamesii*	159,000	0.50	1.8	2.0%	Drill	Stong component of native community
		Purple Three-awn	*Aristida purpurea*	250,000	1.00	5.7	6.2%	B-cast/Harrow	
		Indian Ricegrass	*Oryzopsis hymenoides*	141,000	1.00	3.2	3.5%	Drill	Should do well in areas of sandy texture
		Sideoats Grama	*Bouteloua curtipendula*	191,000	1.00	4.4	4.8%	Drill	Good performer - Offers diversity
		Spike Muhly	*Muhlenbergia wrightii*	1,600,000	0.25	9.2	10.0%	Drill	
			Subtotal		**6.00**	**47.7**	**51.7%**		
		Desert Globemallow	*Sphaeralcea ambigua*	500,000	0.75	8.6	9.3%	B-cast/Harrow	Sufficient performer for diversity
		Blanket Flower	*Gaillardia aristata*	132,000	1.00	3.0	3.3%	B-cast/Harrow	Good performer - Offers diversity
		Rocky Mountain Beeplant	*Cleome serrulata*	65,900	1.00	1.5	1.6%	B-cast/Harrow	
		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%**		
		Wyoming Big Sagebrush	*Artemisia tridentata wyo.*	2,500,000	0.25	14.3	15.6%	B-cast/Harrow	Occasional performer - Offers diversity
		Douglas Rabbitbrush	*Chrysothamnus viscidiflorus*	782,000	0.50	9.0	9.7%	B-cast/Harrow	
		Winterfat	*Ceratoides lanata*	56,700	1.00	1.3	1.4%	Drill	Good performer - good forage value
		One Seed Juniper	*Juniperus monosperma*	If seed can be commercially sourced					
		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 2 Seed Mix for Shrubland / Grassland Targeted Communities

				Recommendations					This entire mix can be drill seeded very shallow
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)
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 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	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). 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 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). 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 or 5 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.

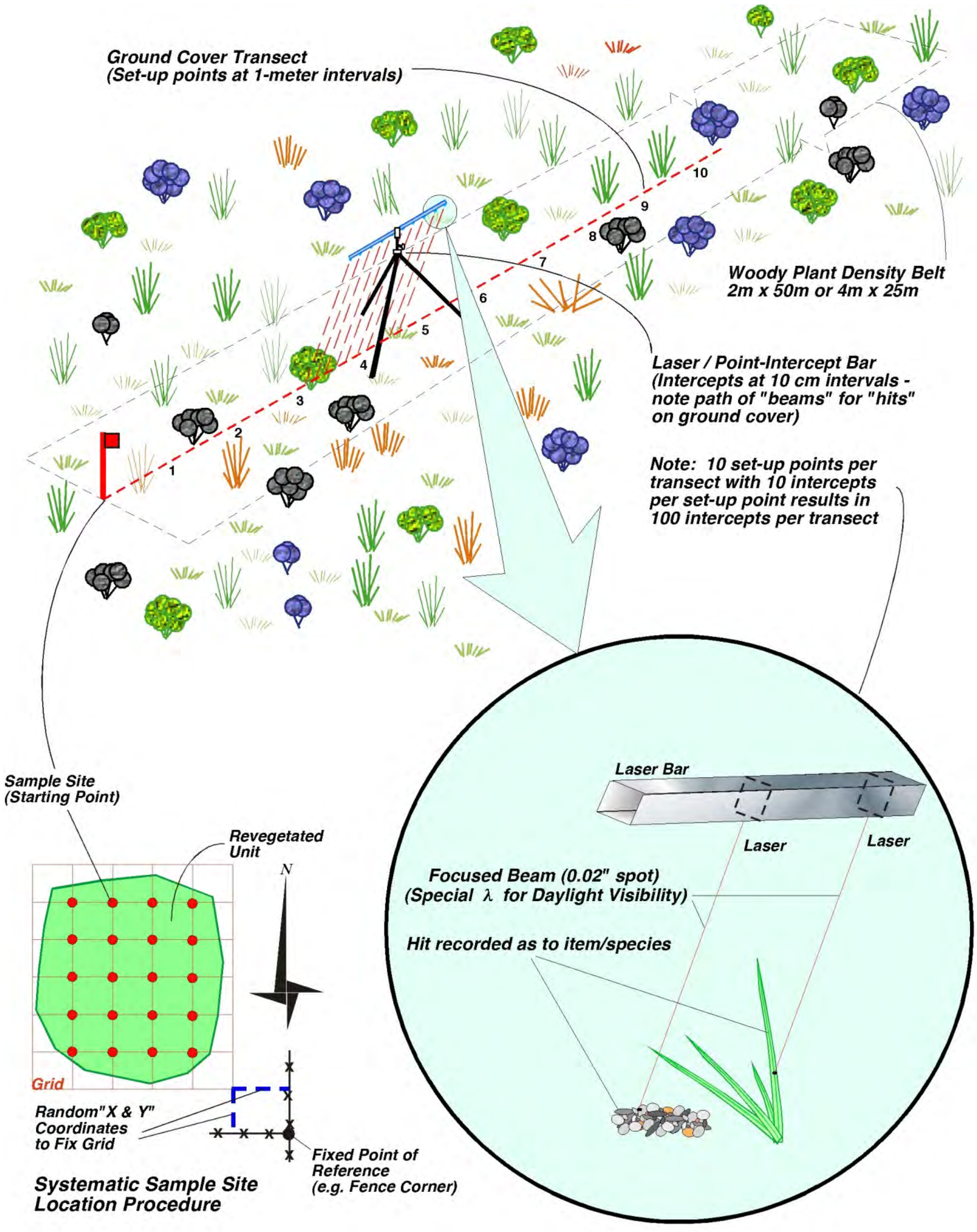


Figure 1

Sampling Procedure at a Systematic Sample Site Location

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.

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. This evaluation consists of a qualified observer traversing the reclamation areas and evaluating vegetation establishment and related physical and biotic conditions. Approximately 1 hour of review time per 20 acres is expended for qualitative efforts. 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, 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 four 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.

This semi-quantitative procedure is also implemented by Cedar Creek to provide perspective to an otherwise difficult visual circumstance. Because new seedlings are putting the vast majority of their energy into underground root systems during the first growing season, the above-ground plant parts are typically very small, obscure, and/or difficult to observe by the untrained eye. Because of this phenomenon, typical observation from a height of 5 - 6 feet (standing human) typically reveals only a small fraction of emergent plants. Oblique angle observation from a distance of more than 15 feet reveals almost zero discernible emergents. Therefore, to obtain a true reading on the success of the seeding effort, visual observation must occur below 3 feet elevation, and occasionally below 2 feet, especially if the ground surface is covered with small gravels or organic debris.

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 which are currently employed at the Mine Site. Under this framework, the vegetation liability period 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
- The post-mining land use (livestock grazing with coincidental wildlife habitat) has been established and the vegetation is capable of being grazed at proper grazing intensity.

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.

<u>4.3 Sample Adequacy Determination</u>

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 ($\mathbf{n_{min}} \le \mathbf{n}$) is true, sampling is adequate and $\mathbf{n_{min}}$ is determined as follows:

$$\mathbf{n_{min}} = (t^2 s^2) / (0.1\,\bar{x})^2$$

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 ($\mathbf{n_{min}} \le \mathbf{n}$) 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 and can be implemented without implication on the liability period. These 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 control is species-dependent and both method and timing vary from species to species. Should the need arise, noxious weed patches will be identified 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.

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, 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.

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 which will be disturbed during the upcoming Northeast Church Rock Mine Site Removal Action will require revegetation including tree replacement. A final total enumeration of lost trees will be provided after construction is complete. Replanting of trees in Step Out Area #1 will follow standard planting procedures for the area.

7.0 REFERENCES

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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.

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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 2016

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Table of Contents

1.0 INTRODUCTION

Cedar Creek Associates, Inc. (Cedar Creek) was retained by MWH 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.

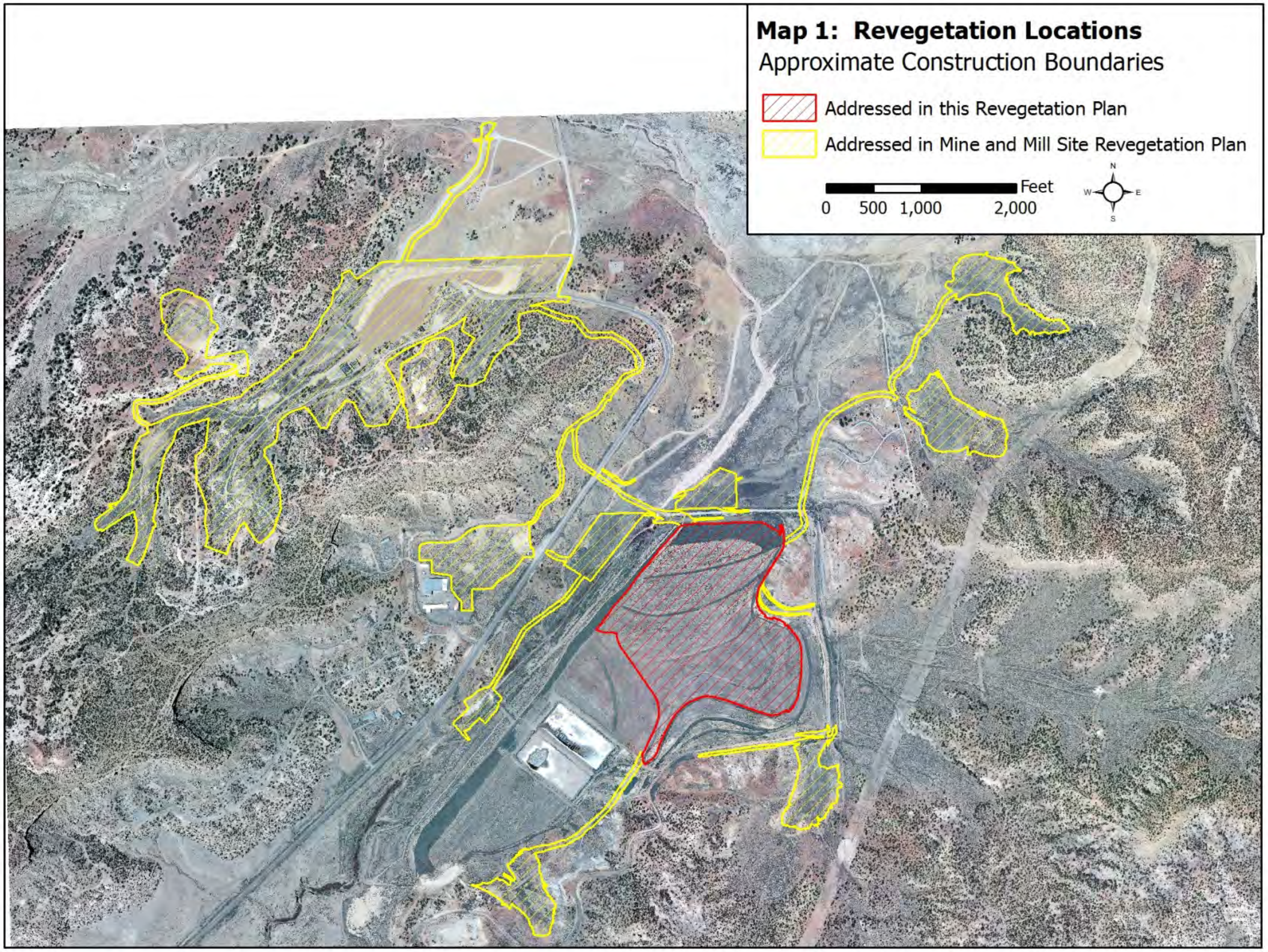
Revegetation planning of each distinct disturbance area will consider 1) baseline vegetation communities, 2) post-revegetation objectives (PMLU), 3) specific considerations pursuant to desired post-disturbance management, and 4) the most scientifically sound methods and state-of-the-art techniques related 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.

Three 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), and the Repository design (Cedar Creek, 2014a). Annual revegetation monitoring reports have been generated since 2010, presenting performance results from the revegetation implemented on and around the mine site. The baseline studies 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 nearby Northeast Church Rock (NECR) 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).


Map 1: Revegetation Locations
Approximate Construction Boundaries
Addressed in this Revegetation Plan
Addressed in Mine and Mill Site Revegetation Plan
Feet
0 500 1,000 2,000
N
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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 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).

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 composed predominantly of one soil particle size fraction should be avoided (avoid the fringes of the textural triangle). 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.

2.2 Soil/Growth Media Chemical Considerations

Soil and growth media should be laboratory tested for basic macro/micro nutrients, pH, organic matter (OM), electrical conductivity (EC), and the sodium adsorption ratio (SAR) to verify that the materials can support plant growth. If material harvesting occurs deeper than what should be considered topsoil, then organic amendments will likely be needed to improve the revegetation potential. Testing soil fertility indicators, particularly pH, OM, EC, and SAR, are important facets in gaining an understanding what amendments could be beneficial toward achieving a successful revegetation.

2.3 Soil/Growth Media Amendments and Fertility

Amendments will be adjusted and applied on an “as needed” basis. Additionally, native arid vegetation is ecologically adapted to “low” fertility systems. 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) of composted cow or green manure, or composted biosolids, should be sufficient for reclamation on the Repository, and has been successful in reclamation within the NECR mine site in the past. 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.

Once the project area is regraded to approximate final configuration, drill seeding should still be implemented on the contour. If deemed necessary, a certified weed-free wood shred mulch, wood chip mulch, or crimped straw mulch can be applied at a rate of 1-2 tons/acre to areas deemed particularly susceptible to erosion following seeding. Areas with high consequences of erosion could include permanent rock mulches 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.

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. 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. The proposed seed mix is comprised of all native species and application rates are presented in Table SM 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 NECR 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

Chain-link 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 SM Seed Mix for the Tailings Disposal Area

				Recommendations					This entire mix can be drill seeded very shallow
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)**
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 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	**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.

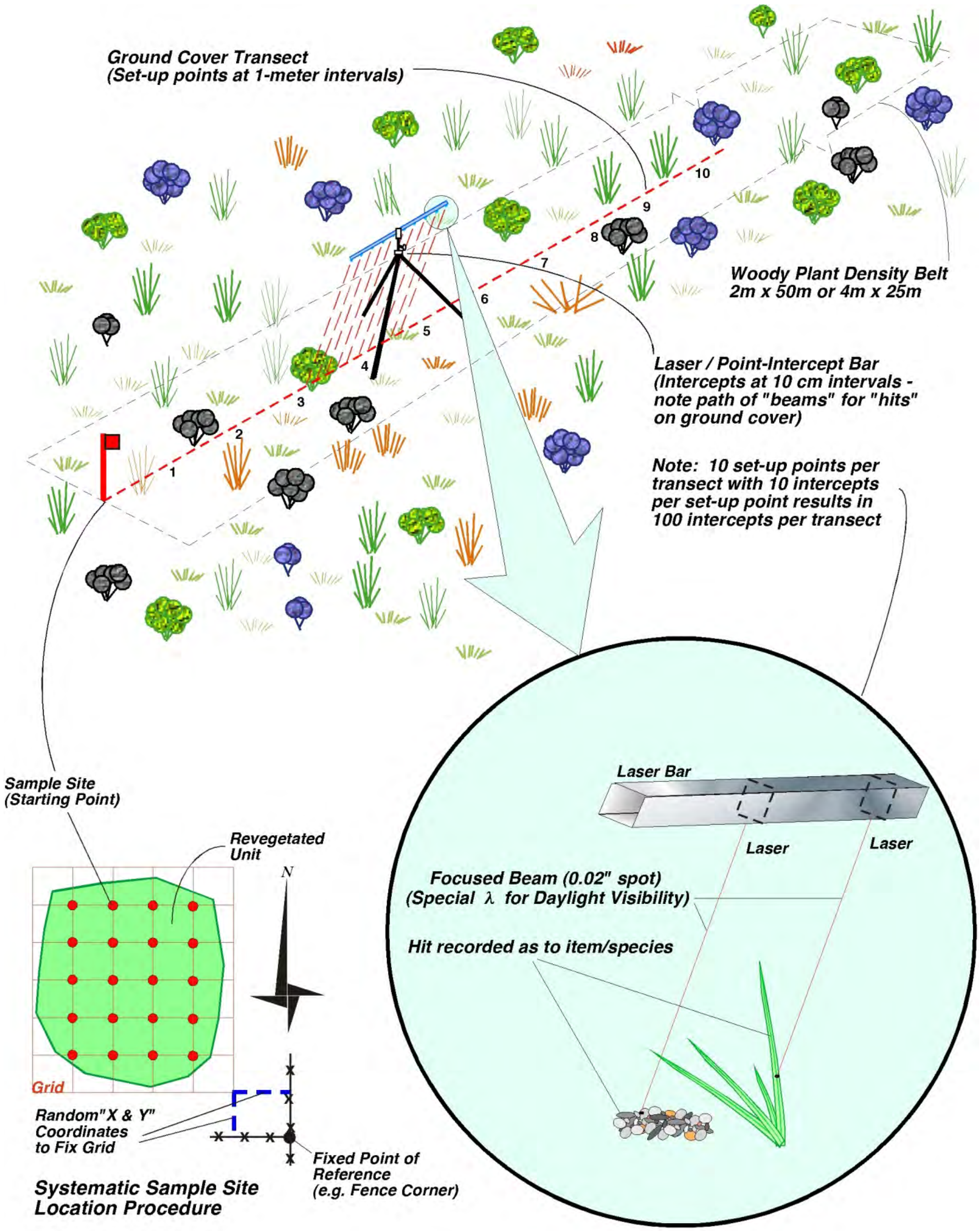

Figure 1

Sampling Procedure at a Systematic Sample Site Location

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. This evaluation consists of a qualified observer traversing the reclamation areas and evaluating vegetation establishment and related physical and biotic conditions. Approximately 1 hour of review time per 20 acres is expended for qualitative efforts. 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, 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 four reclaimed units. 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.

This semi-quantitative procedure is also implemented by Cedar Creek to provide perspective to an otherwise difficult visual circumstance. Because new seedlings are putting the vast majority of their energy into underground root systems during the first growing season, the above-ground plant parts are typically very small, obscure, and/or difficult to observe by the untrained eye. Because of this phenomenon, typical observation from a height of 5 - 6 feet (standing human) typically reveals only a small fraction of emergent plants. Oblique angle observation from a distance of more than 15 feet reveals almost zero discernible emergents. Therefore, to obtain a “true” reading on the success of the seeding effort, visual observation must occur below 3 feet elevation, and occasionally below 2 feet, especially if the ground surface is covered with small gravels or organic debris.

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). 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 Repository Monitoring Schedule

A minimum 10-year vegetation monitoring liability period will exist for the Repository. The annual site visits for the Repository will be as follows:

Year 1 – Qualitative and semi-quantitative evaluations (managerial information only).
Year 2 Through 9 – Qualitative and quantitative evaluations (managerial information only).

Year 10 – Qualitative and quantitative evaluations (final success evaluation).

As indicated, the final effort during year 10 would be an evaluation for success determination. Year 10 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 annually, 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 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 ($\mathbf{n_{min}} \leq \mathbf{n}$) is true, sampling is adequate and $\mathbf{n_{min}}$ is determined as follows:

$$\mathbf{n_{min} = (}t^{2}s^{2}\mathbf{)\ /\ (0.1\ }\bar{x}\mathbf{)^2}$$

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 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 control is species-dependent and both method and timing will vary from species to species. Should the need arise, noxious weed patches will be identified 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.

5.2.1 Chemical Control

Chemical control consists of selective and non-selective herbicides. 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.

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Northeast Church Rock 30% Design Report

Appendix V:
Construction Quality Assurance Plan

MWH® now part of Stantec

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TABLE

FIGURE

LIST OF ACRONYMS / ABBREVIATIONS

AOC	Administrative Settlement Agreement and Order on Consent for Design and Cost Recovery
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CM	construction management
CQA	construction quality assurance
CQAO	construction quality assurance official
CQAP	Construction Quality Assurance Plan
CQC	construction quality control
FE	Field Engineer
FI	Field Inspector
GE/UNC	General Electric/United Nuclear Corporation
Mill Site	Church Rock Mill Site
Mine Site	Northeast Church Rock Mine Site
NNEPA	Navajo Nation Environmental Protection Agency
NRC	US Nuclear Regulatory Commission
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
QA	quality assurance
QC	quality control
QCM	Quality Control Manager
USEPA	US Environmental Protection Agency

V.1 INTRODUCTION

This 30% Construction Quality Assurance Plan (CQAP) discusses the proposed organizational structure for implementation of construction quality assurance (CQA) during the Northeast Church Rock Removal Action (RA). The CQAP also outlines processes to be implemented to demonstrate and document that construction work elements of the RA at the Northeast Church Rock Mine Site (Mine Site) and the Remedial Action (RA) at the Church Rock Mill Site (Mill Site) comply with the Drawings, Technical Specifications, and regulatory requirements. The final approved CQAP would be updated as necessary to incorporate major changes to the project team or CQA procedures.

This CQAP has been developed using the following US Environmental Protection Agency (USEPA) guidance documents:

- *Technical Guidance Document – Construction Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182* (USEPA, 1993).

- *Technical Guidance Document – Construction Quality Management for remedial Action and Remedial Design Waste Containment Systems, EPA/540/R-92/073* (USEPA, 1992).

This CQAP includes the following information:

- Responsibility and authority – The responsibility and authority of organizations and key personnel involved in the RA.
- CQA Processes (30% outline only) including:
    - Meetings
    - Inspection and verification
    - Corrective action and work stoppage
    - Documentation
    - Change management

This CQAP is supplemented with task-specific inspection and testing requirements 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 construction quality control (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.

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 Construction Contractor in order to demonstrate and document that the work product complies with the design. CQC processes shall be prepared by the Construction Contractor and shall be an addendum to this CQAP.

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 construction quality assurance plan and how the design accomplishes these standards.

Table V.2-1: Performance Standards Applicable to the Construction Quality Assurance Plan

Location of Performance Standard Requirement	Performance Standard	Comments
2011 Action Memo, V.A.1, Bullet 3 – 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 EPA's decision document for the surface contamination at the UNC Mill Site.	This appendix describes the quality assurance process to document that the repository construction is conducted in accordance with the Drawings and Technical Specifications for the project.
2011 Action Memo Table A-1, 2013 ROD Table 1	NMAC 20.9.4.14A, 14.B(1), 14.B(2) AND 14.B(3). See http://164.64.110.239/nmac/_titles.htm.	This appendix describes the quality assurance process to document that the repository construction is conducted in accordance with the Drawings and specifications for the project. Quality control (testing) of the radon barrier and cover materials, including procedures, performance standards, and testing frequencies, will be included in the Technical Specifications (Appendix J).

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 would 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 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 provide comment to the USEPA.

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 AOC 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, defined as “the Respondent” in the AOC (EPA, 2013), 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 Construction Contractor such as contract approval, claims, change orders, amendments, pay applications, and materials through the construction quality assurance official (CQAO; described below). The CQAO would assist and advise GE/UNC with contract related matters.

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 is owned by UNC. The land encompassing the Mill Site is owned by GE/UNC.

V.3.1.4 Design Supervising Contractor and Quality Assurance Official

MWH, Inc. (now a part of Stantec; hereafter referred to as MWH), is a licensed design firm retained by GE/UNC to provide design and engineering services in connection with implementation of the RA and is the Supervising Contractor and Quality Assurance Official. MWH reports directly to GE/UNC and is responsible for identifying the tests and inspections required to demonstrate that the RA is performed as specified in the design.

V.3.1.5 Construction Quality Assurance Official

The CQAO would be the company retained by GE/UNC to provide professional construction management and CQA services in connection with the RA, including its qualified personnel. CQAO personnel (described below in Section V.3.2.1) would be responsible for implementation of this CQAP. The CQAO would oversee the Construction Contractor on behalf of GE/UNC (including review of the Construction Contractor’s proposed means and methods) and serve as the primary point of contact with the Construction Contractor with regard to construction quality. The CQAO provides CQA and monitors day-by-day CQC activities performed by the Construction Contractor to verify compliance with the design plans and Technical Specifications. The CQAO would manage, coordinate, and administer all CQA activities and requirements. Additionally, the CQAO would manage third-party CQA inspection and testing firms retained by GE/UNC.

V.3.1.6 Construction Contractor

GE/UNC would retain the Construction Contractor to provide labor, materials, and equipment required to construct the project in accordance with the contract documents. The Construction Contractor is responsible for scheduling, coordinating, and planning the construction work (e.g., the means and methods). The Construction Contractor 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 contract documents. The Construction Contractor exercises authority over its workforce, including CQC personnel (described below in Section V.3.2.2), subcontractors and its CQC support services. The Construction Contractor and CQC staff would be identified prior to construction. As described above, the Construction Contractor 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 construction management (CM) and Construction Contractor personnel are described in Section V.2.2.1 and Section V.2.2.2, respectively. These may vary slightly based on nomenclature used by the actual CM and Construction Contractor 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. A single qualified person may perform multiple CQA/CQC roles. This allows flexibility for staff only to be on site as necessary when routine or uncomplicated RA tasks are being performed. For example, a single person may assume the roles of Field Engineer (FE) and Field Inspector (FI) as discussed below. Likewise, multiple qualified persons might fill a CQA/CQC staffing role. For example, two or more qualified people may rotate on site to staff FE or FI positions.

V.3.2.1 Construction Quality Assurance Official Personnel

Field Engineer (FE). The FE would coordinate field implementation of this CQAP, including designating and delegating appropriate CQAO staff to provide CQA oversight of the RA at any given time. The FE would be responsible for assembling, tracking, and storing CQA/CQC related documentation. The primary duty of the FE is to confirm and document that the RA is implemented in accordance with the contract documents.

The FE would have authority to institute actions necessary for the successful implementation of the CQA/CQC program to verify compliance with the contract plans and Technical Specifications (including stop-work authority). The FE would coordinate activities to ensure that inspection staff and testing firms, as well as Construction Contractor CQC staff, carry out the requirements of this CQAP and the Construction Contractor's QC system.

The FE would track and report nonconformance to Construction Contractor management and Construction Contractor CQC staff. The FE would also have authority to obtain direct access to Construction Contractor CQC files. Other FE responsibilities would include:

- Reviewing Construction Contractor reports, tests, and inspection results
- Facilitating implementation of, and participating in, required inspections
- Ensuring that CQA personnel conducting inspections are adequately trained and understand assignment limits and time frames
- Review and comply 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

- Assist in developing a plan for process change to eliminate nonconformance trends
- Maintain, control, and supervise required submittals between the Construction Contractor, their subcontractors and suppliers, and the Project Engineer

The FE would be an individual with sufficient combined experience, as deemed adequate by GE/UNC in one or more of the following positions: Project Superintendent, QC Manager, Project Manager, Project Engineer, or Construction Manager on similar size and type construction contracts.

The FE also may assume the role of the FI described below.

Field Inspector (FI). CM staff may include one or more FIs to support the FE. For smaller work activities, the FE may assume the role of the FI. The FIs would monitor day-to-day activities of the Construction Contractor. This includes verifying that the Construction Contractor complies with design plans and Technical Specifications, applicable building codes, good workmanship, and CQC requirements of the contract. As part of this effort, each FI would:

- Conduct independent inspections to verify the quality of the work
- Review test and inspection reports
- Confirm that the required documentation is generated and submitted to the FE

Each FI must be alert to detecting, recording, and reporting deviations from the design and contract documents, including calling deficient items to the attention of the FE, the Construction Contractor superintendent, and/or other representative. The FIs must keep accurate and detailed records of the Construction Contractor's performance and progress, delivery of materials, and other pertinent matters, including the daily inspection report.

V.3.2.2 Construction Contractor's Quality Control Personnel

Quality Control Manager (QCM). The QCM is responsible for daily on-site implementation of the Construction Contractor's QC system and coordinating CQC activities with the CQAO. The QCM is responsible for:

- Confirming 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 CM team
- Rectifying nonconformance in a timely fashion
- Ensuring that Construction Contractor and subcontractor CQC personnel conducting inspections are adequately trained and understand assignment limits and time frames

QC Technicians. Construction Contractor staff may include quality control (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

As stated above, The CQA/CQC staff would be on site as needed during the RA activities 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. A single qualified person may perform multiple CQA roles (or a single qualified person may perform multiple CQC roles) as approved by the FE. This would allow the flexibility for staff only to be on-site as necessary when routine or uncomplicated RA tasks are being performed. Likewise, two or more qualified people may share a CQA or CQC role by rotating on site for regularly scheduled work shifts during long-duration RAs.

V.4 CONSTRUCTION QUALITY ASSURANCE (30% Outline)

V.4.1 PROJECT MEETINGS

This section would present the quality assurance objectives and performance standards of project meetings including pre-construction meetings that may be required prior to commencement of the work or work phases and periodic progress meetings. This section will contain two subsections: Pre-construction meetings and progress meetings.

V.4.2 Inspection and Verification Activities

This section would present a discussion of inspection and verification activities and processes, including the general inspection process for the CQA staff, to verify and document compliance with the Technical Specifications. The specific QA and QC tests and frequencies would be included in the Technical Specifications. Subsections may include:

V.4.2.1 CQC Testing

Standards of performance for quality control testing required by the Construction Contractor. Specific test requirements and frequencies would be included in the Technical Specifications.

V.4.2.2 Hold Points

This section would list hold points in critical construction item\s that must be inspected and accepted by the CQAO before proceeding. An example of a hold point would be the reconditioning of the radon barrier prior to placement of mine waste.

V.4.2.3 CQA Inspection and Testing

Standards of performance for quality assurance testing required by the CQAO. Specific test requirements and frequencies would be included in the Technical Specifications.

V.4.2.4 CQA Acceptance Criteria

V.4.2.5 Construction Materials Acceptance

V.4.3 CORRECTIVE ACTION AND WORK STOPPAGE

This section would provide procedures for tracking construction deficiencies (noncompliance) 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. Subsections may include:

V.4.3.1 Deficiency Definition

V.4.3.2 Deficiency Identification and Control

V.4.3.2.1 Minor Deficiencies

V.4.3.3 Nonconformance

V.4.3.4 Work Stoppage

V.4.3.5 Deficiency Correction

V.4.3.6 Preventative Actions

V.4.4 DOCUMENTATION

This section would present the performance requirements for documenting inspections and compliance with the Drawings and Technical Specifications. Subsection would include:

V.4.4.1 Daily Recordkeeping

V.4.4.2 Daily Construction Report

V.4.4.3 Record Drawings

V.4.4.4 Control of Quality Records

V.4.5 Change Management

This section would present discussion on the process for modifying the CQAP, including identification of personnel authorized to make changes and agency notification requirements. Changes discussed herein for CQA/CQC would be limited to this CQAP and the Construction Contractor's QC system. Changes to construction processes or design plans and Technical Specifications would be as governed by a change order procedure defined in the contract documents. Subsection would include:

V.4.5.1 CQAP Changes

V.4.5.2 Construction Contractor Quality Control System Changes

V.5 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.

FIGURE

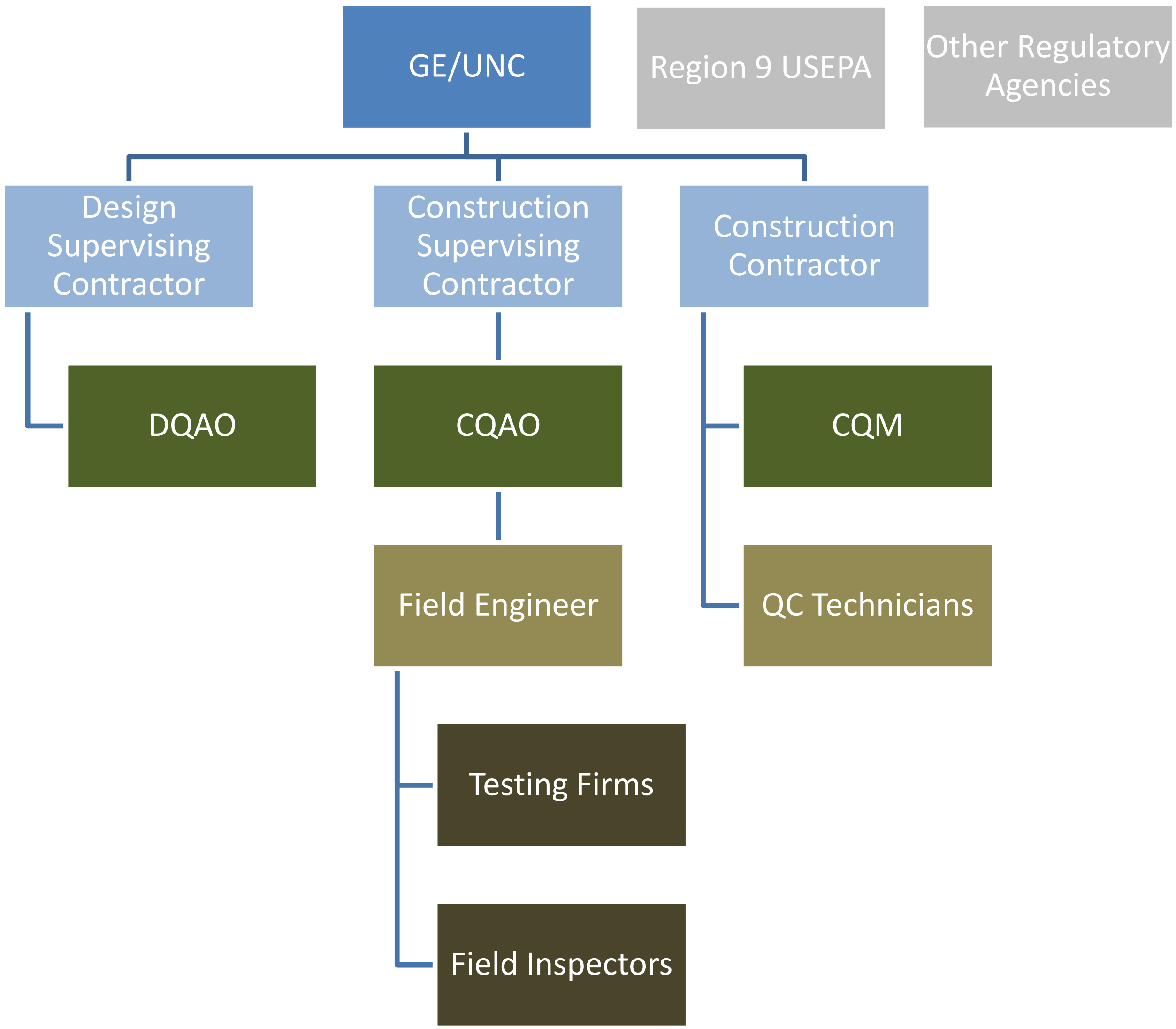

Figure V.3-1 30% CQAP Organizational Chart

APPENDIX W
Operation, Monitoring, and Maintenance Plan
(to be provided with 95% Design Report)

APPENDIX X

Institutional Control Implementation and Assurance Plan

(to be provided with 95% Design Report)