Attachment 1.
Procedures and Work Instructions

Moab UMTRA Project Remedial Action Plan Addendum E
Remedial Action Inspection Plan (DOE-EM/GJ1547)

Moab UMTRA Project Remedial Action Plan Addendum B
Final Design Specifications (DOE-EM/GJ1547)

ADDENDUM B

Final Remedial Action Plan
DOE-EM/GJ1547
February 2019

Final Design Specifications

Number	Title
31-00-00 R5	Earthwork
31-00-20 R5	Placement and Compaction of Tailings and Interim Cover
31-00-30 R8	Placement and Compaction of Final Cap Layers
31-32-11 R2	Surface Water Management and Erosion Control
32-11-23 R9	Aggregate and Riprap

Design Change Notice

(Ref. FONQAWI 105 Design Change Control with NQA-1 QA Requirements)

Project No:	**5NGA7200**	**Discipline Lead:**	**Butch Parton**
Change No:	**027**	**Date:**	**9/11/20**
		Discipline:	**Civil**

1st Issue - Engineering To: Project Manager .....Project Secretary: .....

DESCRIPTION OF CHANGES: Revised Specifications

Specification 31-00-00 Earthwork – Revise specification requirements to remove references stating, "moisture content shall be modified to bring fill to optimum moisture plus or minus 5%" and replace with the following statement, "Moisture content shall be maintained within a range needed to achieve specified compaction requirements."

SOURCE OF CHANGES: Receipt of CID 073

DISCIPLINE AFFECTED	YES	NO		INITIAL ASSESSMENT	YES	NO
PROCESS		X		REVISION NOTE REQUIRED		X
SAFETY		X		HAZOP REVIEW REQUIED		X
CIVIL/STRUCT/ARCH	X			MAJOR SCHEDULE IMPACT		X
PIPING		X				
INSTRUMENTS		X				
MECHANICAL		X				
ELECTRICAL		X				
VALIDATION/cGMP		X				
CONSTRUCTION		X				

2nd Issue - Project Authorization To: Project Secretary: .....

Proceed with Change	YES	NO	Hold Change	YES	NO	Raise Variation Note	YES	NO
	✓				✓			✓

Signed: Frank Parton **Date: 9/14/2020**

3rd Issue - Project Authorization To: Project Secretary: .....

Hold Release proceed with Change	YES	NO	Raise Variation Note	YES	NO
	~~YES~~				~~NO~~

Signed: Frank Parton **Date: 9/14/2020**

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MOAB UMTRA PROJECT **MOAB, UTAH** **PROJECT NO: 35DJ2600**	DOCUMENT NO.: 35DJ2600-056-SPEC-31-00-00
	SECTION NO.: 31-00-00
	EARTHWORK

This title sheet is the first page of the specification and a record of each issue or revision. The pages revised and the description of the revision should be noted under remarks.

REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
0	12/17/07	WDB	FMP	W. Barton	ALL	ISSUED FOR CONSTRUCTION
1	1/30/08	WDB	FMP	W. Barton	ALL	Page 16: Added Section 3.11.1.2 Pages 18-19, revised soil testing frequencies
2	2/27/08	WDB	FMP	W. Barton	ALL	Revised per DOE & Golder Comments Page 6 Section 1.2.7: revised to reference Section 32 11 23, AGGREGATE AND RIPRAP Page 7, Section 1.5: revised to include topsoil. Page 10, Section 3.1.5: revised to include additional requirements for safe trench excavation. Page 12, Section 3.4: revised to add sediment/erosion control to stockpile areas. Page 13, Section 3.6.2: revised to delete word muddy. Page 14, Section 3.9.1.3: revised to include sand (SW). Page 19, Section 3.14.2: revised frequency of check tests.
3	4/14/08	WDB	FMP	W. Barton	ALL	Page 8, Section 1.7: Added section about NQA-1 and Quality Levels. Page 16, Section 3.11.1: Revised from 10" loose lift thickness to 12" loose lift thickness. Page 16, Section 3.11.1.1, Item 2): Revised wording to clarify, fill placed in lifts not to exceed 12" loose. Page 16, Section 3.11.1.2, Item 2): Revised wording to clarify, fill placed in lifts not to exceed 12" loose.
4	06/01/08	WDB	FMP	W. Barton	ALL	Revised per NRC Comments Page 5, Section 1.2 Revised Definitions. Page 17, Section 3.11: Revised Embankments Section, corrected misspelled words, and

REGISTERED PROFESSIONAL ENGINEER
No. 178541
FRANKLIN M. PARTON JR.
STATE OF UTAH

7/1/19

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REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
						deleted sentence describing compaction of cohesionless material. Pages 17 - 20, Sections 3.11-3.14: Revised testing requirements to describe testing by others and the Contractor's role in compaction of material. Page 14, Section 3.7.1: Added moisture range of "optimum moisture content plus or minus 5%" Page 21, Section 3.14.4: Added moisture range of "optimum moisture content plus or minus 5%"
5	1/23/19	FMP	WDB	W. Barton	ALL	Section 1.2.2: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 1.3: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 1.5.3: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 1.5.4: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.1.5.5: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.1.6: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.1.7: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.3.2: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.6.1: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.11.1.2: Revised Computer Aided Earthmoving

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REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
						System to Computer Based Compaction System, Revised CAES to Computer Based Compaction System Section 3.11.3: Deleted "contracted by Energy Solutions" Section 3.12.1: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.14.4: revised Energy Solutions to RAC Section 3.14.4: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.15: Revised Construction Manager to Crescent Junction Operations/Site Manager

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DIVISION 31 - EARTHWORK

SECTION 31 00 00

EARTHWORK

End of Section Table of Contents --

SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

This Earthwork Specification covers most of the earthwork in support of the Moab UMTRA Project, including work at the Moab site, at Crescent Junction, and for the Green River to Crescent Junction Water Line. Earthwork not covered by this specification (covered under separate specifications) includes the Haul Road work at Moab, Placement and Compaction of Tailings and Interim Cover, and Placement and Compaction of Final Cap Layers.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 99 (2001; R 2004) Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in) Drop

AASHTO T 180 (2001; R 2004) Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in) Drop

AASHTO T 224 (2001; R 2004) Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

ASTM A 139 (2004) Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)

ASTM C 136 (2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C 33 (2003) Standard Specification for Concrete Aggregates

ASTM D 698 (2000ael) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu ft)

ASTM D 1140 (2000) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve

ASTM D 1556 (2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D 1557 (2002el) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (56,000 ft-lbf/cu ft)

ASTM D 1883 (2005) CBR (California Bearing Ratio) of Laboratory-Compacted Soils

ASTM D 2487 (2006) Soils for Engineering Purposes Unified Soil Classification System)

ASTM D 422 (1963; R 2002el) Particle-Size Analysis of Soils

ASTM D 4318 (2005) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D 6938 (2007b) In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM D 2216 (2005) Laboratory Determination of Water Moisture) Content of Soil and Rock by Mass (Oven Moisture)

ASTM D 4643 (2000) Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

ASTM D 4944 (2004) Field Determination of Water Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester

ASTM D 4643 (2000) Determination of Water (Moisture) Content of Soil by Direct Heating

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1 (2004) Structural Welding Code - Steel

1.2 DEFINITIONS

1.2.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D 2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC,CL, ML, and CL-ML. Satisfactory materials for grading comprise stones less than 4 inches, except for fill material for pavements and railroads which comprise stones less than 3 inches in any dimension.

1.2.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Crescent Junction Operations / Site Manager when encountering any contaminated materials.

1.2.3 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 698 or ASTM D 1557 abbreviated as a percent of laboratory maximum density. Since ASTM D 698 and ASTM D 1557 apply only to soils that have 30 percent or less by weight of their

particles retained on the 3/4 inch sieve, degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve shall be as a percentage of the maximum density in accordance with AASHTO T 99 or AASHTO T 180 and corrected with AASHTO T 224.

1.2.4 Rock

Solid homogeneous material with firmly cemented, laminated, or foliated masses or conglomerate deposits, none of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume.

1.2.5 Unstable Material

Unstable materials are materials that are too soft or unstable to properly support the utility pipe, conduit, or structure.

1.2.6 Select Granular Material

Select granular materials are materials classified as GW, GP, SW, or SP, or by ASTM D 2487 where indicated. Not more than 30 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D 1140.

1.2.7 California Bearing Ratio

California Bearing Ratio (CBR) tests are tests to evaluate the strength of pavement subgrade. If required, perform CBR tests on select granular material in accordance with ASTM D 1883

1.2.8 Pipe Bedding Material

Pipe bedding material shall consist of select granular material in accordance with Section 32 11 23, AGGREGATE AND RIPRAP.

1.2.9 Expansive Soils

Expansive soils are defined as soils that have a soil Activity number greater than 1.25, where Activity (Ac) = Plasticity Index/ percent finer than 0.02 mm.

1.2.10 Non Frost-Susceptible (NFS) Material

Non Frost-Susceptible material is a uniformly graded gravel or washed sand with no more than 3 percent smaller than 0.02mm.

1.3 SUBMITTALS

Approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. All submittals shall be provided to the Crescent Junction Operations / Site Manager in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring; G;

Blasting; G;

Submit 15 days prior to starting work.

SD-03 Product Data

Utilization of Excavated Materials;

Rock Excavation

of any Excavation or Borrow Pit

Procedure and location for disposal of unused satisfactory material. Proposed source of borrow material. Notification of encountering unrippable rock in the project. Advance notice on the opening of excavation or borrow areas.

SD-06 Test Reports

Borrow/Fill Material Testing

Compaction Testing

Within 24 hours of conclusion of physical tests, 3 copies of test results, including calibration curves and results of calibration tests.

SD-07 Certificates Testing

Qualifications of the testing laboratory

1.4 SUBSURFACE DATA

Subsurface soil boring logs are available for elements of this project. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.5 CLASSIFICATION OF EXCAVATION

Excavation will be designated as topsoil, common excavation, Mancos Shale, or rock excavation.

1.5.1 Topsoil

Topsoil is defined as the top one ft of natural soil at Crescent Junction.

1.5.2 Common Excavation

Common excavation includes all materials not classified as topsoil, Mancos shale or rock excavation.

1.5.3 Rock Excavation

Include rock excavation with blasting, excavating, grading, disposing of material classified as rock, and the satisfactory removal and disposal of boulders 1/2 cubic yard or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). Include the removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic yard in volume that may be encountered in the work in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, uncover such material and notify the Crescent Junction Operations / Site Manager. The Contractor shall not proceed with the excavation of this material until the Crescent Junction Operations / Site Manager has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Crescent Junction Operations / Site Manager, and allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Crescent Junction Operations / Site Manager for the areas of work in which such deposits occur.

1.5.4 Blasting

Blasting shall be limited to that required for a quarrying operation to provide rock for the Waste Cell construction at Crescent Junction. At other project locations, blasting to break rock for excavating shall be performed only if no other method of rock removal will work, and only with prior written approval of a blasting plan. The Contractor shall submit a Blasting Plan in conformance with Federal, State, and local safety regulations, prepared and sealed by a registered professional engineer that includes calculations for overpressure and debris hazard. Provide blasting mats and use the non-electric blasting caps. Obtain written approval prior to performing any blasting and notify the Crescent Junction Operations / Site Manager 24 hours prior to blasting. Include provisions for storing, handling and transporting explosives as well as for the blasting operations in the plan. The Contractor is responsible for damage caused by blasting operations.

1.6 DEWATERING

Perform dewatering of work areas in accordance with the project plans and Section 31 32 11, SURFACE-WATER MANAGEMENT AND EROSION CONTROL.

1.7 NQA-1 QUALITY LEVEL

All Earthwork activities for the Disposal Cell at Crescent Junction, including: the cell excavation, construction of the perimeter embankments, Waste Cell Spoil Material Embankment, and perimeter

ditches are designated as Quality Level 2. All other work (not on the Disposal Cell) is non-Quality related (Quality Level 3).

PART 2 PRODUCTS

2.1 BURIED WARNING AND IDENTIFICATION TAPE

Provide polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3-inch minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes

Red:	Electric
Orange:	Telephone and Other Communications
Blue:	Water Systems
Green:	Sewer Systems

2.2 MATERIAL FOR RIP-RAP

Provide filter fabric between soil and riprap in accordance with 31 05 19 GEOTEXTILE and rock conforming to RIPRAP in accordance with 32 11 23 AGGREGATE AND RIPRAP.

2.3 PIPE BEDDING MATERIAL

Provide bedding material consisting of sand, gravel, or crushed rock, open graded with a maximum particle size of 3/8 inch. Compose material of tough, durable particles. Bedding material shall be free of fines passing the No. 200 standard sieve.

2.4 CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, open graded crushed rock, crushed gravel or uncrushed gravel placed beneath a slab with or without a vapor barrier below. Conform to ASTM C 33 for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D 1140, No. 200 sieve.

2.5 PIPE CASING

2.5.1 Casing Pipe

Pipe for casing utility lines shall be ASTM A 139, Grade B or approved substitute. Match casing size to the outside diameter and wall thickness as indicated on the drawings. Protective coating is not required on casing pipe.

PART 3 EXECUTION

3.1 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated on the drawings. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Dispose of unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times.

Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas selected by the Contractor.

3.1.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown on the drawings. Do not excavate ditches and gutters below grades shown.

Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or riprap to grades shown. Dispose of excavated material as shown or as directed, except in no case allow material to be deposited a maximum 4 feet from edge of a ditch.

Maintain excavations free from detrimental quantities of brush, sticks, trash, and other debris until final acceptance of the work.

3.1.2 Drainage Structures

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed. Where pile foundations are to be used, stop the excavation of each pit at an elevation 1 foot above the base of the footing, as specified, before piles are driven. After the pile driving has been completed, remove loose and displaced material and complete excavation, leaving a smooth, solid, undisturbed surface to receive the concrete or masonry.

3.1.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages

of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.1.4 Dewatering

While the excavation is open, dewater the construction area to limit accumulation of water in the work area and to prevent damage to finished work. Operate dewatering system continuously until construction work below existing water levels is complete.

3.1.5 Trench Excavation Requirements

Excavate trenches as recommended by the manufacturer of the pipe to be installed. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls more than 4.5 feet high, cut back to a stable slope (as defined by OSHA 29 CFR 1926), or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in. Excavate trench walls which are cut back to at least the angle of repose of the soil as determined by a professional geotechnical engineer. "Safe trench excavation is at all times the responsibility of the Contractor."

3.1.5.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 1 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.1.5.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, remove such material 6 inches below the required grade and replace with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.1.5.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION.

3.1.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation. When concrete or masonry is to be placed in an excavated area, take special care not

to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.1.5.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Crescent Junction Operations / Site Manager, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.1.6 Underground Utilities

For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines until approval for backfill is granted by the Crescent Junction Operations / Site Manager. Report damage to utility lines or subsurface construction immediately to the Crescent Junction Operations / Site Manager.

3.1.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Crescent Junction Operations / Site Manager prior to concrete placement.

3.2 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material from the borrow areas within the limits of the project site, selected by the Contractor or from approved private sources. The Contractor is responsible for obtaining and delivering borrow material to the project site.

3.3 SHORING

3.3.1 General Requirements

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.3.2 Geotechnical Engineer

The Contractor is required to hire a Professional Geotechnical Engineer to design shoring, and provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The

Geotechnical Engineer is responsible for updating the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and submit an updated plan if necessary. The Crescent Junction Operations / Site Manager is responsible for arranging meetings with the Geotechnical Engineer at any time throughout the contract duration.

3.4 STOCKPILE AREAS

Keep stockpiles in a neat and well drained condition, giving due consideration to drainage and erosion control at all times. Separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material.

3.5 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

3.6 GROUND SURFACE PREPARATION

3.6.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Crescent Junction Operations / Site Manager, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 2 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.6.2 Frozen Material

Do not place material on surfaces that are frozen or contain frost.

3.7 UTILIZATION OF EXCAVATED MATERIALS

Dispose of unsatisfactory excavated materials in designated waste disposal or spoil areas. Use satisfactory material from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, and for similar purposes. Do not waste any satisfactory excavated material without specific written authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed.

3.7.1 Use of Excavated Material as Fill

Excavated material to be used as fill shall be stockpiled or hauled directly to the fill site. Prior to installation as fill, the material shall be tested to determine the maximum dry density (ASTM D 698) or (ASTM D 1557) and optimum moisture content (ASTM D 2216) of the material. The moisture content of the soil shall be adjusted to near optimum moisture content (optimum moisture content plus or minus 5%) for compaction.

Moisture shall be added to the material in a manner that results in a consistent moisture content throughout the fill. Quick tests of moisture content (ASTM D 4643, ASTM D 4944, or ASTM D 4959) shall be performed as required to maintain moisture control during fill placement.

3.8 BURIED TAPE AND DETECTION WIRE

3.8.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.9 BACKFILLING AND COMPACTION

Place backfill adjacent to any and all types of structures, and compact to at least 95 percent laboratory maximum density (ASTM D 698) for cohesive materials or 98 percent laboratory maximum density for cohesionless materials (ASTM D 698), to prevent wedging action or eccentric loading upon or against the structure. Prepare ground surface on which backfill is to be placed as specified in paragraph GROUND SURFACE PREPARATION. Compact backfill materials in conformance with the applicable portions of paragraphs GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.9.1 Trench Backfill

Backfill trenches to the grade shown. Do not backfill trenches until all specified tests are performed.

3.9.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or bedding material.

3.9.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6-inch loose thickness.

3.9.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. Place initial bedding material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the bedding backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Compact backfill to top of pipe to 95 percent of ASTM D 698 maximum density. Provide plastic piping with bedding to spring line of pipe.

Provide bedding materials as follows:

a. Clean, coarsely graded natural gravel, crushed stone or a combination thereof, having a classification of SW, GW, or GP in accordance with ASTM D 2487 for bedding. Do not exceed maximum particle size of 3/8 inch.

3.9.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, and railroads with satisfactory material. Place backfill material and compact as follows:

a. Roadways and Railroads: Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

3.9.2 Backfill for Appurtenances

After the manhole, catch basin, inlet, or similar structure has been constructed and the concrete has been allowed to cure, place backfill in such a manner that the structure will not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.10 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.10.1 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.10.2 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.10.3 Pipeline Casing

Provide new smooth wall steel pipeline casing under existing railroad by the boring and jacking method of installation. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated. Install pipeline casing by dry boring and jacking method as follows:

3.10.3.1 Bore Holes

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1. Do not use water or other fluids in connection with the boring operation.

3.10.3.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.10.3.3 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight segmented elastomeric end seals.

3.10.4 Rip-Rap Construction

Place rip-rap on filter fabric in the areas indicated. Install riprap to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.10.4.1 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above.

3.11 EMBANKMENTS

3.11.1 Earth Embankments

Construct earth embankments in accordance with the following subsections. Section 3.11.1.1 shall apply to all earth embankments at Moab and Crescent Junction except the Waste Cell Perimeter Embankments and the Waste Cell Spoil Material Embankment. Section 3.11.1.2 shall

apply to the Waste Cell Perimeter Embankments and Section 3.11.1.3 shall apply to the Waste Cell Spoil Material Embankment.

3.11.1.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 12 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise break up each layer; moisten or aerate as necessary; thoroughly mix; and compact material to at least 95 percent laboratory maximum density in accordance with ASTM D 698. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.11.1.1 Waste Cell Perimeter Embankment at Crescent Junction

The Waste Cell Perimeter Embankment forms the outside of the waste cell, and will have 2:1 interior slopes, 5:1 exterior slopes, and a 30 ft wide level top. Material from the cell excavation will be used to construct the Waste Cell Perimeter Embankment. The fill shall be tested (by others) to determine its maximum dry density in accordance with ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort, and the moisture content shall be modified to bring the fill to optimum moisture plus or minus 5%.

Construct the Waste Cell Perimeter Embankment as follows:

1) Prepare the ground beneath the proposed perimeter embankment by stripping vegetation and loose soil from the site, scarifying and compacting the top six inches of soil.
2) Dump and spread fill in lifts of nearly uniform thickness, not to exceed 12" loose. Fill shall be compacted with a minimum 45,000 lb static weight footed roller capable of kneading compaction, with feet a minimum of 6 inches in length.
3) At the Contractor's option, the compactor may be equipped with a computer based compaction system, and soil placement and compaction shall be controlled by the computer based compaction system.
4) If the computer based compaction system is used, the Contractor shall assist on-site soil testing personnel by using the computer based compaction system to determine and document compaction. If the computer based compaction system is not used, soil density tests will be performed by testing personnel in accordance with Section 3.14, below.

3.11.1.2 Waste Cell Spoil Material Embankment at Crescent Junction

The Waste Cell Spoil Material Embankment is a fill embankment to be constructed north of the waste cell. The embankment will divert storm water from the Book Cliffs around the waste cell, and shall be constructed of surplus excavated material (spoil material) from the waste cell excavation. Prior to placement, spoil material shall be

tested to determine its maximum dry density in accordance with ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort, and the moisture content shall be modified to bring the fill to optimum moisture plus or minus 5%.

Construct the Waste Cell Spoil Material Embankment as follows:

1) Prepare the ground beneath the proposed perimeter embankment by stripping vegetation and loose soil from the site.
2) Dump and spread fill in lifts of nearly uniform thickness, not to exceed 12" loose. Compact material with rollers, equipment tracks, or successive passes of scrapers. Fill shall be compacted to a density of 90% of the laboratory determined maximum density in accordance with ASTM D 698.
3) Soil density tests will be performed by testing personnel in accordance with Section 3.14, below.

3.12 SUBGRADE PREPARATION

3.12.1 Proof Rolling

Prior to the placement of fill or stone base material perform proof rolling to identify soft soil areas. Proof roll the existing subgrade with rubber-tired construction equipment, such as a loaded dump truck or loaded scraper, with a minimum weight of 45,000 lbs. Notify the Crescent Junction Operations / Site Manager a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Crescent Junction Operations / Site Manager. Undercut rutting or pumping of material as directed by the Crescent Junction Operations / Site Manager to a depth of 12 inches and replace with select material.

3.12.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified.

Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade.

Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line and grade, in accordance with project plans.

3.12.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas and railroads, compact each layer of the embankment to at least 95 percent of laboratory maximum density (ASTM D 1557).

3.12.3.1 Subgrade for Railroads

Compact subgrade for railroads to at least 95 percent laboratory maximum density for cohesive materials or 98 percent laboratory maximum density for cohesionless materials (ASTM D 1557).

3.12.3.2 Subgrade for Pavements

Compact subgrade for pavements to at least 95 percent laboratory maximum density (ASTM D 1557) for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 6 inches of subgrade.

3.13 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed from settlement or washing to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.13.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation.

The Contractor is responsible for protecting and maintaining the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.13.2 Capillary Water Barrier

Place a capillary water barrier under concrete floors and slabs directly on the subgrade and compact with a minimum of two passes of a vibratory compactor.

3.13.3 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.14 TESTING

In-place density testing of fill material will be performed by testing personnel contracted by RAC. The following sections and the Remedial Action Inspection Plan (RAIP) describe the testing that will be performed by others, so that the Contractor will be familiar with the type and frequency of tests being performed. When test results indicate that compaction is not as specified, the Contractor will be required to rework the material, replace and recompact to meet specification requirements.

The following type and number of tests are the minimum for each type operation.

3.14.1 In-Place Densities

In-place density testing will be performed using nuclear gage ASTM D 6928 and/or Sand Cone ASTM D 1556 methods. Moisture content of soil will be determined using oven ASTM D 216 or microwave ASTM D 4643 methods. For small work areas (less than 1/2 acre), in-place density tests will be performed at the following frequency:

a. One test per 5,000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

For large fill areas (greater than½ acre), in-place density tests will be performed at the following frequency:

a. For material compacted by other than hand-operated machines: One test per 50,000 square feet or 1,850 cubic yards of material placed, or fraction thereof, a minimum of one test for each lift of fill or backfill, and a minimum of two tests per day.

b. For material compacted by hand-operated machines: One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas.

3.14.1.1 In-Place Density Testing of Waste Cell Perimeter Embankment

a. For material compacted by other than hand-operated machines: One test per 50,000 square feet or 1,850 cubic yards of material placed, or fraction thereof, a minimum of one test for each lift of fill or backfill, and a minimum of two tests per day.

b. For material compacted by hand-operated machines: One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas.

3.14.1.2 In-Place Density Testing of Waste Cell Spoil Material Embankment

a. For material compacted by other than hand-operated machines: One test per 100,000 square feet or 3,700 cubic yards of material placed.

b. For material compacted by hand-operated machines: One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas.

3.14.2 Check Tests on In-Place Densities

If ASTM D 6938 is used, check in-place densities by ASTM D 1556 as follows:

a. One check test for each 20 tests per ASTM D 6938, of fill or backfill compacted by other than hand-operated machines.

b. One check test for each 10 tests per ASTM D 6938, of fill or backfill compacted by hand-operated machines.

3.14.3 Optimum Moisture and Laboratory Maximum Density

Laboratory Density and Moisture Content tests (ASTM D 698, ASTM D 1557, and ASTM D 2216) will be performed (by others) for each type of fill material to determine the optimum moisture and laboratory maximum density values. For small fill areas of 50,000 cubic yards of fill or less, one representative test per 5,000 cubic yards of fill and backfill will be performed, or when any change in material occurs that may affect the optimum moisture content or laboratory maximum density. For fill areas requiring more than 50,000 cubic yards of fill, one representative test per 20,000 cubic yards of fill and backfill will be performed, or when any change in material occurs that may affect the optimum moisture content or laboratory maximum density.

3.14.4 Moisture Control

In the stockpile, excavations, or borrow areas, moisture tests will be performed (by others) to determine in situ moisture content. The Contractor shall add moisture to fill materials as needed to bring moisture content to near optimum (optimum moisture content plus or minus 5%) for compaction. The Contractor shall control the moisture content of material being placed as fill, and may perform additional tests of moisture content or make use of tests performed by others to control moisture. Testing of moisture content may be performed by any of the following tests:

1) ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (Oven Moisture)
2) ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating
3) ASTM D 4944 - Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
4) ASTM D 4959 - Determination of Water (Moisture) Content of Soil by Direct Heating

5) During unstable weather, perform tests as dictated by local conditions and approved by the Crescent Junction Operations / Site Manager

3.15 DISPOSITION OF SURPLUS MATERIAL

Surplus material or other soil material not required or suitable for filling or backfilling, and brush and refuse, shall be removed from Government property or disposed of on site as directed by the Crescent Junction Operations / Site Manager.

-- End of Section --

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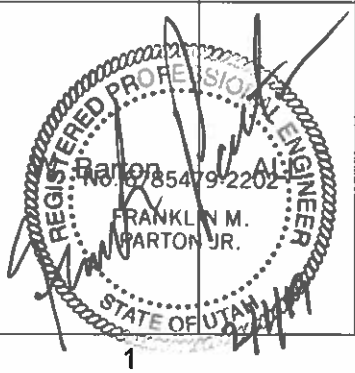
MOAB UMTRA PROJECT **MOAB, UTAH** **PROJECT NO: 35DJ2600**	DOCUMENT NO.: 35DJ2600-056-SPEC-31-00-20
	SECTION NO.: 31-00-20
	PLACEMENT AND COMPACTION OF RRM AND INTERIM COVER

This title sheet is the first page of the specification and a record of each issue or revision. The pages revised and the description of the revision should be noted under remarks.

REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
0	12/17/07	WDB	FMP	W. Barton	ALL	ISSUED FOR CONSTRUCTION
1	01/30/08	WDB	FMP	W. Barton	ALL	Page 5, Section 1.3.2: Added Dozers Page 6, Section 3.2.1: Revised Lift Thickness Page 7, Section 3.4.1: Revised Test Frequencies
2	02/27/08	WDB	FMP	W. Barton	ALL	Page 6, Section 2.2: Removed requirement to screen material.
3	04/14/08	WDB	FMP	W. Barton	ALL	Page 5, Section 1.4: Add section 1.4 NQA-1 Quality Level Page 6, Table 1, Revised gradation to limit fines. Page 6, Section 3.2.1: Revised from 10" loose lift thickness to 12" loose lift thickness.
4	06/02/08	WDB	FMP	W. Barton	ALL	General, revised "Tailings" to "RRM" Page 6, Section 2.2: Revised section on material requirements for Interim Cover. Page 6, Section 3.1.1: Revised section to clarify test requirements for Interim Cover. Page 7, Section 3.2.2: Revised moisture requirement to add "optimum plus or minus 5%. Page 7, Section 3.2.5: Added demolition debris sizing. Page 8, Section 3.4.2: Revised moisture requirement to add: for RRM - "optimum plus or minus 3%", and for Interim Cover - "optimum plus or minus 5%".
5	1/23/19	FMP	WDB			Section 1.2: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 1.3.2: Revised compaction equipment requirements Section 2.1: Revised moisture requirements Section 3.1.1: Revised Energy Solutions to Crescent Junction Operations/Site Manager, revised proctor from 5 points to 4 points, added ASTM reference

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MOAB UMTRA PROJECT **MOAB, UTAH** **PROJECT NO: 35DJ2600**	DOCUMENT NO.: 35DJ2600-056-SPEC-31-00-20
	SECTION NO.: 31-00-20
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REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
						Section 3.2.1: Revised Computer Aided Earthmoving System and CAES to Computer Based Compaction System, revised lift thickness Section 3.2.2: Revised moisture content requirement Section 3.2.4: Deleted requirement for final lift Section 3.2.5: Revised debris minimization requirements Section 3.4.1: Revised CAES to Computer Based Compaction System Section 3.4.2: Deleted section Section 3.4.3: Revised section number to 3.4.3, revised CAES to Computer Based Compaction System Section 3.5.1: added "for dust suppression" Section 3.5.2: added option to add a protective top layer over Interim Cover for erosion and root protection. Section 3.5.3: Removed "as directed from last sentence

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PLACEMENT AND COMPACTION OF RRM AND INTERIM COVER

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SECTION 31 00 20

PLACEMENT AND COMPACTION OF RRM AND INTERIM COVER

PART 1 GENERAL

This specification covers placement, compaction and testing requirements for RRM material and interim clean cover layers at Crescent Junction.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 698	(2000ael) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu ft)
ASTM D 1140	(2000) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D 1556	2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2002el) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu ft)
ASTM D 1587	(2000) Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D 2167	(1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2488	(2006) Description and Identification of Soils (Visual-Manual Procedure)
ASTM D 2922	(2005) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	(2005) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 3740	(2004a) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D 422	(1963; R 2002el) Particle-Size Analysis of Soils

ASTM D 4318 (2005) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D 4643 (2000) Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

ASTM D 4944 (2004) Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester

ASTM D 4643 (2000) Determination of Water (Moisture) Content of Soil by Direct Heating

ASTM D 6938 (2007b) In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.2 SUBMITTALS

Approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only.All submittals shall be provided to the Crescent Junction Operations / Site Manager in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Protection

Equipment

Materials Handling Plan describing the following: processing and placement of the soil; type, model number, weight and critical dimensions of equipment to be used for soil processing, compaction, scarification, and smooth rolling; method of protecting fill materials from changes in moisture content and freezing after placement.

Testing Laboratory

Name and qualifications of the proposed testing laboratory.

SD-06 Test Reports

RRM/Fill Material Testing Compaction Testing

Within 24 hours of conclusion of physical tests, 3 copies of test results, including calibration curves and results of calibration tests.

1.3 EQUIPMENT

RRM and interim cover material shall be installed with equipment capable of scarifying and preparing the ground surface to receive fill, spreading fill material in uniform lifts, and compacting it to the density required by this specification.

1.3.1 Scarification Equipment

Disks, tillers, or other approved means shall be provided to scarify the ground surface or the surface of each previous lift of fill prior to placement of the next lift. The scarification equipment shall be capable of uniformly disturbing the upper 1 inch of the underlying soil surface to provide good bonding between lifts.

1.3.2 Compaction Equipment

For 24" lifts the compaction equipment shall consist of footed rollers. Footed rollers shall have a minimum weight of 45,000 pounds and at least one tamping foot shall be provided for each 110 square inches of drum surface. The length of each tamping foot from the outside surface of the drum, shall be at least 6 inches. During compaction operations, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tamping foot rollers. For 12" and 8" lifts a dozer with a minimum ground pressure of 1650 pounds per square feet may be used or a rubber-tired piece of equipment with similar ground pressure.

1.3.3 Steel Wheeled Rollers

A smooth, non-vibratory steel-wheeled roller shall be used to produce a smooth compacted surface on the top of the completed interim cover layer, such that direct rainfall causes minimal erosion. Steel-wheeled rollers shall weigh a minimum of 20,000 pounds.

1.3.4 Hand Operated Tampers

Hand operated tampers shall consist of rammers or other impact type equipment. Vibratory type equipment will not be allowed.

1.4 NQA-1 QUALITY LEVEL

All construction and testing activities included in this specification: PLACEMENT AND COMPACTION OF RRM AND INTERIM COVER for the Disposal Cell at Crescent Junction, are designated as Quality Level 2.

PART 2 PRODUCTS

2.1 RRM MATERIAL

RRM material will consist of uranium mill tailings from the Moab Pile, off-pile contaminated soils, and demolition debris and other waste materials stored in the Pile at Moab. Most of the material will be uranium mill tailings, consisting of contaminated sands, slimes, intermediate material, and cover soil. The RRM material will be excavated, mixed and blended, dried to moisture necessary to meet required compaction specifications, loaded in containers, and shipped to Crescent Junction for disposal. Off-pile contaminated soil material will be excavated and hauled to the tailings pile and eventually mixed with the tailings. Debris and other waste materials will be excavated, placed in containers, and shipped like the RRM material. In the waste

cell, non-soil materials will be placed in the contaminated RRM fill in a manner that will not result in voids in the waste mass.

2.2 INTERIM COVER SOIL

Interim Cover Soil will be soil from the excavation of the Crescent Junction waste cell. It will be material that has been produced on site by modifying the existing overburden soil and weathered Mancos Shale excavated on site. Overburden and weathered Mancos Shale shall be excavated, pulverized, wetted, and mixed to produce a uniform fine-grained soil near optimum moisture content for compaction. Soil shall be free of roots, debris, organic or frozen material, and shall have a maximum clod size of 2 inch at the time of compaction, based on a visual inspection.

PART 3 EXECUTION

3.1 RRM AND FILL SOIL ASSESSMENT TESTS

Assessment tests shall be performed on RRM and on Stockpiled soil for the Interim Cover Layer to assure compliance with specified requirements and to develop compaction requirements for placement. A minimum of three tests for maximum dry density (ASTM D 698) and moisture content (ASTM D 2216) shall be performed for each type of RRM soil observed. A minimum of three assessment tests shall be performed on stockpiled excavated material for use as Interim Cover Soil for each type of soil observed. During placement of RRM and Interim Cover soil, quick moisture content tests (ASTM D 4643, ASTM D 4944, or ASTM D 4959) shall be performed as required to maintain moisture control.

3.1.1 Compaction Testing

In-place density testing of RRM and Interim Cover material will be performed by the Remedial Action Contractor. The following sections describe the type and frequency of tests being performed. When test results indicate that compaction is not as specified, the material will be reworked, replaced and/or recompacted to meet specification requirements.

The following type and number of tests are the minimum for each type operation:

1) RRM Testing: A representative sample from each principal type or combination of blended RRM materials shall be tested to establish compaction curves using ASTM D 698. A minimum of one set of compaction curves shall be developed per 10,000 cubic yards of RRM material. A minimum of 4 points shall be used to develop each compaction curve as per ASTM D 698.
2) Interim Cover Testing: A representative sample from each type or combination of stockpiled excavated soil for use as Interim Cover soil shall be tested to establish compaction curves using ASTM D 698.
3) In-place density testing of RRM and Interim Cover material shall be performed in accordance with Section 3.4 of this specification.

3.2 INSTALLATION

3.2.1 RRM and Interim Cover Soil Placement

RRM and Interim Cover soil shall be placed to the lines and grades shown on the drawings. A GPS guided Computer Based Compaction System can be used to direct fill placement such that RRM and Interim Cover Soil are placed in lifts of nearly uniform thickness which will not exceed an average uncompacted thickness of 12 inches for 1-foot lifts and 24 inches for 2-foot lifts. In areas where hand operated tampers must be used, the loose lift thickness should not exceed 4 inches.

3.2.2 Moisture Control

RRM and Interim Cover shall be placed and compacted within the moisture content range needed to achieve 90% of the laboratory determined maximum dry density of each type of material. The range in moisture content shall be maintained uniform throughout each lift as necessary to achieve 90% compaction and dust control. The moisture content shall be maintained uniform throughout each lift.

3.2.3 Compaction

RRM and Interim Cover soil shall be compacted to meet the following density requirements:

1) RRM - 90 percent of the laboratory determined maximum dry density as determined by ASTM D 698.
2) Interim Cover Layer - 90 percent of the laboratory determined maximum dry density as determined by ASTM D 698.

3.2.4 Scarification

Scarification shall be performed on all areas of the upper surface of each lift prior to placement of the next lift. Scarification shall be accomplished with approved equipment. The final lift of Interim Cover soil shall not be scarified.

3.2.5 Placement of Demolition Debris

Demolition debris will be placed in the waste cell along with RRM material.

Debris shall not contain free liquids. Debris shall be sized to minimize voids. Pipes and ducts that are 6 inches or greater in diameter shall be crushed or, if crushing is impractical, shall be cut in half longitudinally or filled. Rubber tires shall be cut and placed in order to minimize void space. Debris shall be spread and/or oriented in a manner that results in a minimum of voids.

Debris may be placed as a sacrificial lift at the bottom of the disposal cell in a 2-foot lift. Debris in sacrificial lifts shall contain no free liquids, and oriented in a manner that minimizes voids and contained within the 2-foot lift profile. Sacrificial debris lifts are not subject to moisture and compaction criteria.

3.3 CONSTRUCTION TOLERANCES

The top surface of the RRM and Interim Cover Layer shall be no greater than 2 inches above the lines and grades shown on the drawings. No minus tolerance will be permitted.

3.4 CONSTRUCTION TESTS

3.4.1 RRM and Interim Cover Layer Tests

Compaction can be verified by the computer based compaction system. When compaction of a lift of RRM or Interim Cover soil is achieved, the computer based compaction system will produce a map of the location and thickness of the completed lift. Computer records for each layer of soil placed will constitute documentation of completed lifts and be compiled as construction records.

Perform compaction Verification Tests, in-place density and moisture content tests on compacted fill material, in accordance with the following requirements:

1) Verification tests of in-place density shall be performed on the initial layer of RRM, on the first 5,000 cubic yards of Interim Cover, and on any layers in which the Computer Based Compaction System indicates that problems occurred obtaining compaction.

2) When verification in-place density and moisture content tests are performed on a soil layer, a minimum of two tests shall be performed per 5,000 cubic yards of fill material placed.

3) Compaction and moisture content tests shall be performed in accordance with the following methods:

   - ASTM D 1556 - Density and Unit Weight of Soil in Place by the Sand-Cone Method
   - ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (Oven Moisture)
   - ASTM D 6938 - In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Note: Companion sand cone tests and oven moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

3.4.2 Test Results

Where the computer based compaction system indicates acceptable compaction, the computer output for that lift (lift thickness, location, and compaction), shall be considered proof of satisfactory lift placement. If the computer based compaction system indicates that adequate compaction is not achieved, the lift shall be reworked until an acceptable result is achieved. Verification test results of ASTM D 6938, In-Place Density and Water Content of Soil and Soil-Aggregate by

Nuclear Methods (Shallow Depth), shall be used to confirm the acceptability of the computer based compaction system results.

3.5 PROTECTION

3.5.1 Moisture Content

After lift placement, moisture content shall be maintained for dust suppression until the next lift is placed.

3.5.2 Erosion

Erosion that occurs in the RRM or Interim Cover layers shall be repaired and grades re-established. If the Radon Barrier is not placed immediately after completion of the Interim Cover it is acceptable to use a Best Management Practice of placing a protective layer of 0.8' (minimum) on the Interim Cover. The BMP will protect the Interim Cover from damaged caused by erosion and roots and self-sown vegetation. The vegetation does not have to be removed until the Radon Barrier placement. The protective layer can be cleared of vegetation and re-used as a part of the Radon Barrier.

3.5.3 Freezing and Desiccation

Freezing and desiccation of the RRM and Interim Cover soil shall be prevented. If freezing or desiccation occurs, the affected soil shall be reconditioned.

3.5.4 Retests

Areas that have been repaired shall be retested as directed. Repairs to the RRM or Interim Cover layers shall be documented including location and volume of soil affected, corrective action taken, and results of retests.

-- End of Section --

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MOAB UMTRA PROJECT **MOAB, UTAH** **PROJECT NO: 35DJ2600**	DOCUMENT NO.: 35DJ2600-056-SPEC-31-00-30
	SECTION NO.: 31-00-30
	PLACEMENT AND COMPACTION OF FINAL CAP LAYERS

This title sheet is the first page of the specification and a record of each issue or revision. The pages revised and the description of the revision should be noted under remarks.

REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
0	12/17/07	WDB	FMP	W. Barton	ALL	ISSUED FOR CONSTRUCTION
1	1/30/08	WDB	FMP	W. Barton	ALL	Page 7, Section 3.2.2: Revised lift thickness Page 8, Section 3.2.6: Added bentonite Page 8, Section 3.3.2: Revised lift thickness Page 9, Section 3.3.6: Added bentonite Page 9, Section 3.4.1: Revised final sentence.
2	4/14/08	WDB	FMP	W. Barton	ALL	Page 6, Section 1.5: Add section 1.5, NQA-1 Quality Level. Page 8, Section 3.2.2: Revised from 10" loose lift thickness to 12" loose lift thickness. Page 9, Section 3.3.2: Revised from 10" loose lift thickness to 12" loose lift thickness.
3	06/02/08	WDB	FMP	W. Barton	ALL	Page 5, Section 1.3: Deleted "Relative" Page 7, Section 2.2: Added reference to Aggregate Spec. Page 8, Section 3.2.1: Added grain size distribution to list of tests on Radon Barrier Material. Page 9, Section 3.2.5: Added reference to ASTM D698. Page 9, Section 3.2.3: Revised moisture requirement to add "optimum plus or minus 3%. Page 9, Section 3.3.3: Revised moisture requirement to add "optimum plus or minus 5%.
4	08/03/10	WDB	FMP	W. Barton	ALL	Page 6, Section 2.1: Change maximum clod size from 1 inch to 3 – 4 inches. Page 7, Table 1: Change maximum particle size from 1 inch to 3 – 4 inches.
5	09/02/10	WDB	FMP	W. Barton	ALL	Page 6, Section 2.1: Change word "clod" to "particle". Page 6, Section 2.1: Add new 3rd paragraph about placement and inspection of Mancos shale.

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REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
6	09/08/10	WDB	FMP	W. Barton	ALL	Page 8, Section 2.1, Table 1: Revised the minimum Liquid Limit from 35 to 30 and added a maximum Liquid Limit of 50. Page 12, Section 3.6.1: Added a paragraph describing sampling and testing of in-place aggregate. The paragraph includes criteria for evaluating results of testing and any deviation from the specified range of aggregate.
7	08/18/11	WDB	FMP	W. Barton	ALL	Page 12, Section 3.5: Added Section 3.5.1 Tolerance of RRM and Interim Layers Added Section 3.5.2 Tolerances of Cover Layers New sections revise the tolerances of each layer of material placed.
8	1/23/19	FMP	WDB	W. Barton	ALL	Section 1.3: Revised Construction Manager to Crescent Junction Operations/Site Manager, revised CAES to Computer Based Compaction System, revised Energy Solution Construction Quality Control Manager to Quality Assurance Manager Section 1.4.1: Added rubber-wheeled equipment Section 3.1: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 3.2.5: Revised Computer Aided Earthmoving System to Computer Based Compaction System Section 3.3.3: Revised moisture content Section 3.3.5: Revised Computer Aided Earthmoving System to Computer Based Compaction System Section 3.4.1: Revised Computer Aided Earthmoving System to GPS, revised vibratory steel

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	PLACEMENT AND COMPACTION OF FINAL CAP LAYERS

This title sheet is the first page of the specification and a record of each issue or revision. The pages revised and the description of the revision should be noted under remarks.

REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
						drum to smooth drum Section 3.6.1: Revised "shall" to "should", Revised Computer Aided Earthmoving System to Computer Based Compaction System, revised CAES to Computer Based Compaction System Section 3.6.1: Revised CAES to Computer Based Compaction System

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DIVISION 31 - EARTHWORK

SECTION 31 00 30

PLACEMENT AND COMPACTION OF FINAL CAP LAYERS

-- End of Section Table of Contents --

SECTION 31 00 30

PLACEMENT AND COMPACTION OF FINAL CAP LAYERS

PART 1 GENERAL

1.1 SCOPE

This specification covers material characteristics, placement, compaction, and testing of final cap layers, including:

a. Radon barrier layer;

b. Stone infiltration and bio-barrier;

c. Frost protection layer; and

d. Rock armoring.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 1140 (2000) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve

ASTM D 1556 (2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D 698 (2002e1) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu ft)

ASTM D 2167 (1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D 2216 (2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

ASTM D 2488 (2006) Description and Identification of Soils (Visual-Manual Procedure)

ASTM D 6938 (2007b) In-place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM D 3740 (2004a) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

ASTM D 422 (1963; R 2002e1) Particle-Size Analysis of Soils

ASTM D 4220 (1995; R 2000) Preserving and Transporting Soil Samples

ASTM D 4318 (2005) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D 4643 (2000) Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

ASTM D 4944 (2004) Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester

ASTM D 4643 (2000) Determination of Water (Moisture) Content of Soil by Direct Heating

1.3 SUBMITTALS

Approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. All submittals shall be provided to the Crescent Junction Operations / Site Manager in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Equipment

Submit specifications for equipment for the processing, scarification, placement, compaction, and smooth rolling of fill, including type, model number, weight and critical dimensions of equipment.

SD-06 Test Reports

Moisture Content and Density Tests of Fill Materials, G;

Moisture Content Tests of Soil Fill, G;

Moisture Content and In-Place Density Tests of Soil Fill (Verification Testing), G;

COMPUTER BASED COMPACTION SYSTEM Soil Placement and Compaction Records, G;

Test reports shall be submitted to the Quality Assurance Manager within 48 hours of the completion of soil placement and field testing.

1.4 EQUIPMENT

Equipment used to place and compact the Radon Barrier material and Frost Protection common fill shall not brake suddenly, turn sharply, or be operated at excessive speeds.

1.4.1 Compaction Equipment

Compaction equipment shall consist of rubber-wheeled equipment or footed rollers which have a minimum weight of 45,000 pounds and at least one foot for each 110 square inches of drum surface. The length of each tamping foot shall be at least 6 inches from the outside

surface of the drum. During compaction operations, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tamping foot rollers.

1.4.2 Scarification Equipment

Disks, rotor tillers, or other approved means shall be provided to scarify the surface of each lift of soil prior to placement of the next lift. The scarification equipment shall be capable of uniformly disturbing the upper 1 to 2 inches of the soil surface to provide good bonding between lifts.

1.4.3 Steel Wheeled Rollers

A smooth, non-vibratory steel wheeled roller shall be used to produce a smooth compacted surface on finished compacted soil layers. Steel wheeled rollers shall weigh a minimum of 20,000 pounds.

1.4.4 Hand Operated Tampers

Hand operated tampers shall consist of rammers or other impact type equipment. Vibratory type equipment will not be allowed.

1.5 NQA-1 QUALITY LEVEL

All construction and testing activities included in this specification: PLACEMENT AND COMPACTION OF FINAL CAP LAYERS for the Disposal Cell at Crescent Junction, are designated as Quality Level 2.

PART 2 PRODUCTS

2.1 RADON BARRIER LAYER

Radon Barrier is the layer constructed on top of the interim cover layer and the contaminated tailings material in the waste cell and underlying the protection layers in the final cap. The purpose of this layer is to retard the emanation of radon gas from the tailings into the atmosphere and to minimize infiltration of incident precipitation into the tailings material.

Radon Barrier Layer soil shall be produced by modifying the weathered Mancos Shale excavated on site. Weathered Mancos Shale shall be excavated, separated from other excavated materials, pulverized, wetted, and mixed to produce a uniform fine-grained fill soil at or above optimum moisture content for compaction. It shall be free of roots, debris, organic or frozen material, and shall have a maximum particle size of 3 to 4 inches at the time of compaction. Fill material shall comply with the criteria listed in Table 1. Testing of Radon Barrier soil to verify conformance with the following table is described in Section 3.2.1 Radon Barrier Material.

Placement of Mancos shale will be visually inspected to make sure there are no locations where rock type particles accumulate in a concentrated location. Particles found in a concentrated location will be removed or reworked per QC direction.

TABLE 1
REQUIRED PHYSICAL PROPERTIES OF RADON BARRIER FILL SOIL

Test Property	Test Value	Method
Max. particle size (inches)	3 to 4	ASTM D 422
Min. percent passing No. 4 sieve	80	ASTM D 422
Min. percent passing No. 200 sieve	50	ASTM D 1140
Min. liquid limit	30	ASTM D 4318
Max. liquid limit	50	ASTM D 4318
Min. plasticity index	10	ASTM D 4318
Max. plasticity index	40	ASTM D 4318

2.2 STONE FOR FINAL COVER LAYERS

Stone for the final cover layers, infiltration and bio-barrier layer and rock armoring, shall be rock material that has long-term chemical and physical durability. Rock for final cover layers shall be in accordance with Section 32 11 23 Aggregate and Riprap. Rock for final cover layers shall achieve an acceptable score for its intended use, in accordance with the following rock scoring and acceptance criteria:

TABLE 2
NRC TABLE OF SCORING CRITERIA FOR ROCK QUALITY

Laboratory Test	Weighing Factor			10	9	8	7	6	5	4	3	2	1	0
	L*	S*	I*	Good				Fair				Poor		
Specific Gravity	12	6	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.3	2.25
Absorption, percent	13	5	2	0.10	0.30	0.50	0.67	0.83	1.0	1.5	2.0	2.5	3.0	3.5
Sodium Sulfate, percent	4	3	11	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
LA Abrasion, percent	1	8	1	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
Schmdt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	0

Notes:

1) Scores were derived from Tables 6.2, 6.5, and 6.7 of NUREG/CR-2642, Long-Term Survivability of Riprap for Armoring Uranium Mill Tailings and Covers: A Literature Review, 1982.
2) Weighing Factors are derived from Table 7 of "Petrographic Investigations of Rock Durability and Comparisons of Various Test Procedures," by G.W. Dupuy, Engineering Geology, July 1965. Weighing factors are based on inverse of ranking of test methods for each rock type. Other tests may be used; weighing factors for these tests may be derived using Table 7, by counting upward from the bottom of the table.
3) Test methods should be standardized, if a standard test is available and should be those used in NUREG/CR2642, so that proper correlations can be made.

Rock Acceptance Criteria

An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the final cover, the rock must score at least 50 percent or the rock is rejected. If the rock scores between 50 percent and 80 percent the rock may be used, but a larger D50 must be provided (oversizing). If the rock score is 80 percent or greater, no oversizing is required.
- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65 percent or the rock is rejected. If the rock scores between 65 percent and 80 percent, the rock may be used, but must be oversized. If the rock score is 80 percent or greater, no oversizing is required.

Oversize rock as follows;

- Subtract the rock score from 80 percent to determine the amount of oversizing required. For example, a rock with a rating of 70 percent will require oversizing of 10 percent (80 - 70 = 10 percent).
- The D50 of the stone shall be increased by the oversizing percent. For example, a stone with a 10 percent oversizing factor and a D50 of 12 inches will increase to a D50 of 13.2 inches.
- The final thickness of the stone layer shall increase proportionately to the increased D50 rock size. For example, a layer thickness equals twice the D50, such as when the plans call for 24 inches of stone with a D50 of 12 inches, if the stone D50 increases to 13.2, the thickness of the layer of stone with a D50 of 13.2 should be increased to 26.4 inches.

2.3 FROST PROTECTION LAYER

The Frost Protection Layer is the top soil layer constructed of the waste cell cover. The purpose of this layer is to protect underlying cover layers from degradation due to environmental factors such as freeze-thaw cycles. The Frost Protection Layer shall be constructed of common fill material, which can be any soil material from the waste cell excavation.

PART 3 EXECUTION

3.1 EXCAVATION, SEGREGATION, AND STOCKPILING OF CAP MATERIALS

Cap materials shall be soil material from the waste cell excavation. Materials shall be excavated, segregated into common fill and weathered Mancos Shale, and stockpiled for use as cap materials. Stockpiles shall be at locations shown in the project plans or as directed by the Crescent Junction Operations / Site Manager.

3.2 INSTALLATION OF RADON BARRIER MATERIAL

3.2.1 Radon Barrier Material

The Radon Barrier Layer will be constructed of processed Mancos Shale soil. The soil will be produced on site by processing excavated Mancos Shale into a fine-grained soil and adding water to bring the Mancos Shale soil to near optimum moisture content for compaction. Mancos Shale soil produced for Radon Barrier fill shall be tested to determine its material properties and its maximum dry density and moisture

content. As a minimum, perform the following soil tests on each 10,000 cubic yards of soil:

ASTM D 4318, Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D 422, Particle-Size Analysis of Soils

ASTM D 1140, Amount of Material in Soils Finer than the No. 200 Sieve

ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort

ASTM D 2216, Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass and/or ASTM D 4643, Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

3.2.2 Radon Barrier Material Placement

Radon Barrier shall be placed to the lines and grades shown on the drawings. The soil shall be placed in loose lifts not to exceed 12 inches in thickness after compaction. In areas where hand operated tampers must be used, the loose lift thickness shall not exceed 4 inches.

3.2.3 Moisture Control

Radon Barrier soil shall be placed and compacted within a moisture content range that will achieve the specified compaction (optimum plus or minus 3 percent). The moisture content shall be maintained uniform throughout each lift. Water added shall be thoroughly incorporated into the soil to ensure uniformity of moisture content prior to compaction.

3.2.4 Scarification and Dressing of Final Lift Surface

Scarification shall be performed on all areas of the upper surface of each underlying soil layer prior to placement of the next lift. Scarification shall be accomplished with approved equipment. The final lift of Radon Barrier soil shall not be scarified. The final lift shall be smooth rolled with at least 3 passes of the approved smooth steel wheeled roller to provide a smooth surface.

3.2.5 Compaction

Radon Barrier soil shall be compacted to at least 95 percent of its laboratory maximum dry density determined in accordance with ASTM D 698. The Computer Based Compaction System may be used to direct fill placement, monitor compaction, and record the location and thickness of the each soil layer being placed. If the COMPUTER BASED COMPACTION SYSTEM is not used for compaction, fill shall be compacted with a minimum 45,000 pound static weight footed roller capable of kneading compaction, with feet a minimum of 6 inches in length.

3.2.6 Repair of Voids

Voids created in the Radon Barrier layer during construction (including, but not limited to, penetrations for test samples, grade

stakes, and other penetrations necessary for construction) shall be repaired by removing any unsuitable material, backfilling with soil and compacting by tamping each lift with a steel rod, or by backfilling with bentonite.

3.3 INSTALLATION OF FROST PROTECTION LAYER SOIL

3.3.1 Frost Protection Material

The Frost Protection layer will be constructed of common fill soil. The soil will be produced on site by adding water to bring the excavated and stockpiled soil to near optimum moisture content for compaction. Test soil in accordance with ASTM D 698, Laboratory Compaction Characteristics of Soil Using Standard Effort. Perform at least 3 tests on each type of material stockpiled for use as fill. Perform additional lab density tests on stockpiled material if changes in material characteristics are observed.

3.3.2 Frost Protection Layer Placement

Frost Protection soil shall be placed to the lines and grades shown on the drawings. The soil shall be placed in loose lifts not to exceed 12 inches in thickness after compaction. In areas where hand operated tampers must be used, the loose lift thickness shall not exceed 4 inches.

3.3.3 Moisture Control

Frost Protection soil shall be placed and compacted within a moisture content range that will achieve the specified compaction. The moisture content shall be maintained uniform throughout each lift. Water added shall be thoroughly incorporated into the soil to ensure uniformity of moisture content prior to compaction.

3.3.4 Scarification and Dressing of Final Lift Surface

Scarification shall be performed on all areas of the upper surface of each underlying soil layer prior to placement of the next lift. Scarification shall be accomplished with approved equipment. The final lift of soil shall not be scarified. The final lift shall be smooth rolled with at least 3 passes of the approved smooth steel wheeled roller to provide a smooth surface.

3.3.5 Compaction

Soil shall be compacted to 90 percent of the laboratory determined maximum dry density in accordance with ASTM D 698. The Computer Based Compaction System may be used to direct fill placement, monitor compaction, and record the location and thickness of each soil layer being placed.

3.3.6 Repair of Voids

Voids created in the Radon Barrier layer during construction (including, but not limited to, penetrations for test samples, grade stakes, and other penetrations necessary for construction) shall be

repaired by removing any unsuitable material, backfilling with soil and compacting by tamping each lift with a steel rod, or by backfilling with bentonite.

3.4 INSTALLATION OF ROCK LAYERS

This section describes the material and installation of rock layers for the Infiltration and Biobarrier and Rock Armoring of the final cover.

3.4.1 Rock Placement and Compaction

Rock shall be spread to the thickness indicated on the drawings or in accordance with oversizing due to scoring criteria (see Section 2.2 of this specification). Rock placement shall be guided by GPS to ensure that the appropriate thickness has been placed at all locations. Stone with a D50 of 2 inches or less shall be shall be compacted with a smooth drum.

3.5 CONSTRUCTION TOLERANCES

3.5.1 Tolerance of RRM and Interim Layers

- RRM Layer - The top surface of the RRM layer shall be no greater than 2 inches above the lines and grades shown on the drawings. No minus tolerance will be permitted.
- Interim Layer – The top surface of the Interim Layer shall be no greater than 2" above the lines and grades shown on the drawings. No minus tolerance will be permitted.

3.5.2 Tolerances of Cap Layers

The following layers shall be installed to the thicknesses indicated for each layer, no minus tolerance will be permitted. Excess soil or rock is permitted to assure that the minimum thickness is achieved, but shall be as little as practically achievable. Final layer thickness shall be uniform, smooth and continuous, without humps or thickened edges or other defects.

- Radon Barrier – Layer minimum thickness is 4 feet, no minus tolerance permitted. Confirm 4 feet minimum thickness by performing a pre and post survey.
- Infiltration and Biointrusion – Layer minimum thickness is 6 inches, no minus tolerance permitted.
- Frost Protection - Layer minimum thickness is 3 feet, no minus tolerance permitted. Confirm 3 feet minimum thickness by performing a pre and post survey.
- Cap Rock - The final thickness of the Cap Rock depend on the location in which the rock is placed and shall be in accordance with the drawings and the Aggregate and Riprap Specification 32-11-23, Table 3. No minus tolerance permitted.

3.6 CONSTRUCTION TESTS

3.6.1 Material Tests

For placement and compaction of soils, moisture content tests should be performed daily prior to placement to maintain moisture control and uniformity of soil to be used for fill. Computer Based Compaction System can be used to place, compact and document compaction of all soil layers. Computer Based Compaction System acceptance of an installed layer of soil will constitute proof of satisfactory compaction. Computer output of the Computer Based Compaction System will be acceptable documentation for location, thickness and compaction of installed layers.

Aggregate Particle Size Tests on In-Place Stone - When particle size tests are performed on in-place stone, obtain bulk samples of aggregate and perform sieve analyses in accordance with ASTM D 422 - Particle Size Analysis of Soils. Aggregate shall be considered acceptable if the result of particle size testing:

- For any sieve size >#4 sieve, is within 5 percent of the specified gradation range (Specification 32 11 23, Table 3); or
- For any sieve size <#4 sieve, is within 3 percent of the specified gradation range (Specification 32 11 23, Table 3).

Compaction Verification Tests - Perform in-place density and moisture content tests on compacted fill material in accordance with the following requirements:

- Verification tests of in-place density shall be performed on initial layer of soil placed, and on any layers in which the Computer Based Compaction System indicates that problems occurred obtaining compaction.
- When verification in-place density and moisture content tests are performed on a soil layer, a minimum of two tests shall be performed per 5,000 cubic yards of fill material placed.
- Compaction and moisture content tests shall be performed in accordance with the following methods:
    - ASTM D 1556 - Density and Unit Weight of Soil in Place by the Sand-Cone Method
    - ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
    - ASTM D 6938(2007b) - In-place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Note: Companion sand cone tests and oven moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

3.6.2 Initial and Confirmatory Surveys

Verification of the thickness of the Radon Barrier Layer will be performed by comparing before and after surveys of the Layer. Prior to placement of the Radon Barrier Layer, a survey shall be performed of the top of the Interim Cover layer. The initial survey will document

the pre-cap geometry of the site. After the Radon Barrier Layer has been installed, a post-installation survey will be performed on the top of the Radon Barrier fill to confirm that the total fill thickness is in accordance with the plans and specifications.

3.7 PROTECTION

3.7.1 Moisture Content

After placement, moisture content shall be maintained or adjusted to meet criteria.

3.7.2 Erosion

Erosion that occurs in the fill layers shall be repaired and grades re-established.

3.7.3 Freezing and Desiccation

Freezing and desiccation of the Radon Barrier layer shall be prevented. If freezing or desiccation occurs, the affected soil shall be removed or reconditioned as directed.

3.7.4 Retests

Areas that have been repaired shall be retested as directed. Repairs to the Radon Barrier layer shall be documented including location and volume of soil affected, corrective action taken, and results of retests.

-- End of Section --

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MOAB UMTRA PROJECT **MOAB, UTAH** **PROJECT NO: 35DJ2600**	DOCUMENT NO.: 35DJ2600-056-SPEC-31-32-11
	SECTION NO.: 31-32-11
	SURFACE WATER MANAGEMENT AND EROSION CONTROL

This title sheet is the first page of the specification and a record of each issue or revision. The pages revised and the description of the revision should be noted under remarks.

REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
0	12/17/07	WDB	FMP	W. Barton	ALL	ISSUED FOR CONSTRUCTION
1	1/30/08	WDB	FMP	W.Barton	ALL	Page 4, Sections 2.3 and 3.1: Added a tackifier or crusting agent for erosion control.
2	1/23/19	FMP	WDB	W.Barton	ALL	Section 1.2: Revised Construction Manager to Crescent Junction Operations/Site Manager, Section 2.3: Revised Construction Manager to Crescent Junction Operations/Site Manager, Section 3.2: Revised Construction Manager to Crescent Junction Operations/Site Manager, Section 3.4: Revised Construction Manager to Crescent Junction Operations/Site Manager

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SECTION 31 32 11

SURFACE-WATER MANAGEMENT AND EROSION CONTROL

-- End of Section Table of Contents --

SECTION 31 32 11

SURFACE-WATER MANAGEMENT AND EROSION CONTROL

PART 1 GENERAL

1.1 SCOPE

This section includes materials and placement of silt fence, erosion mat, check dams, construction entrances, diversions, ditches, channels, berms, and stabilization; and maintenance of sedimentation basins and surface-water management and erosion control measures.

1.2 SUBMITTALS

Approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. All submittals shall be provided to the Crescent Junction Operations / Site Manager in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's data on silt fence;

Manufacturer's data on erosion control matting;

SD-08 Manufacturer's Instructions

Manufacturer's installation and maintenance instructions;

PART 2 PRODUCTS

2.1 SILT FENCE

Furnish silt fence with either woven or nonwoven geotextile. Silt fence shall be:

a. Woven geotextile consisting of slit films of polypropylene treated with ultraviolet light stabilizers, or nonwoven geotextile consisting of long chain polymeric filaments or polyester yarns, inert to chemicals commonly found in soils and to hydrocarbons, and resistant to mildew, rot, insects, and rodent attack.

b. Reinforcement Backing: Shall be minimum 14-gauge steel wire and maximum mesh spacing of 6 inches or synthetic netting of equal strength. Use reinforcement backing can be eliminated if post spacing is a maximum of 6 feet and the geotextile tensile strength is at least 200 pounds.

c. Posts: Shall be either wood or steel with minimum length of 4 feet. Wood posts shall be at least 2 inches by 2 inches of oak or similar hardwood. Steel posts shall be round or shaped as a "U", "T", or "C". Steel posts shall have a minimum weight of 1.33 pounds per linear foot and shall have projections for fastening reinforcement to silt fence.

d. Wire Staples: Shall be at least 9-gauge thickness with a minimum length of 1 inch.

e. A preassembled silt fence meeting the material requirements may be used instead of a field constructed silt fence.

2.2 EROSION MAT

Furnish erosion mat that shall be a woven blanket-like fabric made of biodegradable yarn with the following material properties:

a. Material Content: Coir Yarn: 100 percent; containing 45 percent Lignin, 55 percent Cellulose (approximately)

b. Weight: Minimum 22.7 ounces per square yard;

c. Open Area: 38 percent (approximately); and

d. Average Mesh Opening: 0.4" X 0.5"

Furnish erosion mat that will resist degradation for a minimum 6-month period after installation.

Furnish erosion mat having a permissible velocity of 7 feet per second.

2.3 OTHER MATERIALS

a. Culverts shall be in accordance with Section 33 40 01 STORM DRAINAGE.

b. Construction entrances shall be in accordance with design plans and details.

c. Tackifiers or crusting agents shall be used to reduce soil erosion as directed by the Crescent Junction Operations / Site Manager.

d. Materials for other surface-water management and erosion controls shall be in accordance with design plans and details.

2.4 EQUIPMENT

Furnish equipment to perform work specified in this section.

PART 3 EXECUTION

3.1 INSTALLATION

a. Install silt fence in accordance with Manufacturer's Instructions.

b. Install check dams in ditches and channels in accordance with project plans and details.

c. Tackifiers or crusting agents shall be applied in accordance with manufacturer's application instructions.

d. Construct channels, ditches, and other earthwork as shown on the construction drawings and in accordance with the Contractor's Surface-Water Management and Erosion Control Work Plan. Earthwork for channels, ditches, and berms shall be in accordance with Section 31 00 00, EARTHWORK.

3.2 ADDITIONAL REQUIREMENTS

Prevent the runoff of polluting substances such as silt, clay, fuels, oils, and contaminated soils from migrating into water supplies and surface waters.

Remove accumulated silt and debris from behind the face of the silt fence when the silt deposits reach approximately one half the height of the fence. Replace silt fence geotextile damaged during maintenance operations. Removed silt and debris shall be placed in locations approved by the Crescent Junction Operations / Site Manager.

3.3 MAINTENANCE

Clean, maintain, repair, and replace surface-water management and erosion controls for the duration of the contract in accordance with the Contractor's Surface-Water Management and Erosion Control Work Plan.

3.4 INSPECTIONS

Inspect surface-water management and erosion control measures and sedimentation basins to evaluate their effectiveness and need for maintenance. Any required repairs to the surface-water management and erosion control measures and sedimentation basins shall be initiated upon discovery, but no later than 24 hours after discovery. Inspections shall occur, at a minimum, at the following frequencies:

a. Weekly.

b. Daily after each rain event exceeding 0.5 inch.

c. Daily during prolonged rainfall events.

Records of inspections shall be kept on file on site by Contractor and shall be submitted monthly to the Crescent Junction Operations / Site Manager. The records of inspection shall include the following:

a. Summary of the scope of the inspection.

b. Name of inspector.

c. Inspection date.

d. Inspection location.

e. Purpose of the inspection (e.g., regular weekly, following a storm, etc.).

f. Observations relative to performance of the surface-water management and erosion control measures.

g. Any necessary corrective actions.

h. Corrective actions completed and their performance since the previous inspection.

-- End of Section --

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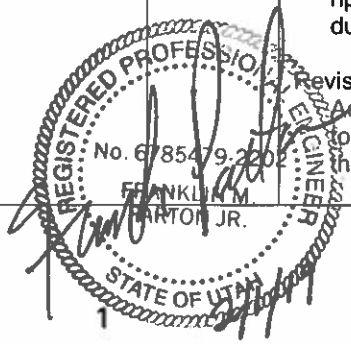
MOAB UMTRA PROJECT **MOAB, UTAH** **PROJECT NO: 35DJ2600**	DOCUMENT NO.: 35DJ2600-056-SPEC-32-11-23
	SECTION NO.: 32-11-23
	AGGREGATE AND RIPRAP

This title sheet is the first page of the specification and a record of each issue or revision. The pages revised and the description of the revision should be noted under remarks.

REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
0	12/17/07	WDB	FMP	W. Barton	ALL	ISSUED FOR CONSTRUCTION
1	1/30/08	WDB	FMP	W. Barton	ALL	Page 11, Table 3, Revised Gradations to allow small amount of fines.
2	2/27/08	WDB	FMP	W. Barton	ALL	Page 8, Section 1.5, Revised weather limitations. Page 11, Section 2.1.6.2, revised riprap thicknesses.
3	4/15/08	WDB	FMP	W. Barton	ALL	Page 8, Section 1.7: Added Section 1.7, NQA-1 Quality Levels.
4	06/03/08	WDB	FMP	W. Barton	ALL	Revised Section 1.4.2.2, deleted requirements to check Liquid Limit and Plasticity Index. Revised Section 1.4.3.1, deleted requirements to check Liquid Limit and Plasticity Index.
5	07/03/08	WDB	FMP	W. Barton	ALL	Revised Section 2.1.4, Riprap: Added sentence clarifying: TABLE 1 for non-disposal cell aggregate TABLE 3 for disposal cell aggregate/riprap Revised Section 2.1.6.1 Biobarrier: Added sentence describing the filter requirements of biobarrier material. Revised TABLE 3: Adjusted gradations to increase sizes of materials as follows: Cover Top - D50 = 2 in Cover N, E & W edge - D50 = 4 in Cover South Edge/Slope - D50 = 6 in CJ East and West Apron - D50 = 6 in CJ North Apron - D50 = 8 in CJ South Apron - D50 = 12 in Added note to TABLE 3: Contractor to limit the amount of fines associated with riprap to minimize segregation of riprap during installation. Revised Section 3.6 Installation of Riprap: Added paragraph requiring Contractor to minimize fines and install riprap such that it does not segregate.



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REV.	DATE	BY	CKD	APPROVED	PAGES	REMARKS
6	09/09/10	WDB	FMP	W. Barton	ALL	Revise Table 3, Cover Biobarrier gradation: change range for 1 ½ inch sieve from 40-50 to 40-60.
7	05/20/11	WDB	FMP	W. Barton	ALL	Revise Spec Section 2.1.6, Stone Layers for the Waste Cell Final Cover, to change riprap D50 sizes, and gradations. Table 3 was extensively revised.
8	08/18/11	WDB	FMP	W. Barton	ALL	Revise Table 3, Gradation of fines in accordance with CID 065 and CID 067.
9	1/23/19	FMP	WDB	W. Barton	ALL	Section 1.3: Revised Construction Manager to Crescent Junction Operations/Site Manager Section 1.4: Revised Contracting Officer to Crescent Junction Operations/Site Manager Section 1.4.1: Revised Contracting Officer to Crescent Junction Operations/Site Manager Section 3.3: Revised Contracting Officer to Crescent Junction Operations/Site Manager

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SECTION 32 11 23

AGGREGATE AND RIPRAP

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 11	(2005) Standard Method of Test for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T 19	(2004) Standard Method of Test for Bulk Density ("Unit Weight") and Voids in Aggregate
AASHTO T 27	(2006) Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 99	(2001; R 2004) Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in) Drop
AASHTO T 180	(2004) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in) Drop
AASHTO T 193	(2003) Standard Method of Test for The California Bearing Ratio
AASHTO T 224	(2001; R 2004) Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

ASTM C 1260	(2005a) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 127	(2004) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 128	(2004a) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C 131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

ASTM C 29/C 29M (1997; R 2003) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

ASTM C 88 (2005) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM D 698 (2000ae1) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu ft)

ASTM D 1556 (2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D 1557 (2002e1) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)

ASTM D 2167 (1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D 2487 (2006) Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D 6938 (2007b) In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM D 75 (2003) Standard Practice for Sampling Aggregates

ASTM E 11 (2004) Wire Cloth and Sieves for Testing Purposes

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Untreated Base Course

Untreated Base Course (UBC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in AASHTO T 99 or AASHTO T 180 abbreviated as a percent of laboratory maximum dry density. The degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve shall be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 99 or AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SUBMITTALS

Approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. All submittals shall be provided to the Crescent Junction Operations / Site Manager in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Sampling and Testing, G;

Field Density Tests, G;

Certified copies of test results for approval not less than 10 days before material is required for the work.

Calibration curves and related test results prior to using the device or equipment being calibrated.

Copies of field test results within 24 hours after the tests are performed.

1.4 SAMPLING AND TESTING

Sampling and testing shall be the responsibility of the Contractor. The materials shall be tested to establish compliance with the specified requirements; testing shall be performed at the specified frequency. The Crescent Junction Operations / Site Manager may specify the time and location of the tests. Copies of test results shall be furnished to the Crescent Junction Operations / Site Manager within 24 hours of completion of the tests.

1.4.1 Sampling

Samples for laboratory testing shall be taken in conformance with ASTM D 75. When deemed necessary, the sampling will be observed by the Crescent Junction Operations / Site Manager.

1.4.2 Tests

The following tests shall be performed in conformance with the applicable standards listed.

1.4.2.1 Sieve Analysis

Sieve analysis shall be made in conformance with AASHTO T 27 and AASHTO T 11. Sieves shall conform to ASTM E 11.

1.4.2.2 Moisture-Density Determinations

The laboratory maximum dry density and optimum moisture content shall be determined in accordance with AASHTO T 99 or AASHTO T 180, Method D and corrected with AASHTO T 224.

1.4.2.3 Field Density Tests

Density shall be field measured in accordance with ASTM D 1556, ASTM D 2167 or ASTM D 6938. For the method presented in ASTM D 6938 the calibration curves shall be checked and adjusted if necessary using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D 6938 result in a wet unit weight of soil and when using this method, ASTM D 938 shall be used to determine the moisture content of the soil. The

calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 6938. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration of ASTM D 6938, on each different type of material being tested at the beginning of a job.

1.4.2.4 Wear Test

Wear tests shall be made on aggregate material in conformance with ASTM C 131.

1.4.2.5 Soundness

Soundness tests shall be made on aggregate in accordance with ASTM C 88.

1.4.3 Testing Frequency

1.4.3.1 Tests on Proposed Material

To demonstrate that the proposed material meets all specified requirements, one of each of the following tests shall be performed on the proposed material prior to commencing construction, and subsequently for every 5,000 cubic yards of material. If materials from more than one source are going to be utilized, this testing shall be completed for each source.

a. Sieve Analysis.

b. Moisture-density relationship.

c. Wear.

d. Soundness.

1.4.4 Approval of Material

The source of the material shall be selected prior to the time the material will be required in the work. Approval of material will be based on test results.

1.5 WEATHER EFFECTS

Completed areas damaged by freezing, rainfall, or other weather conditions shall be corrected to meet specified requirements.

1.6 PLANT, EQUIPMENT, AND TOOLS

All plant, equipment, and tools used in the performance of the work shall be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.7 NQA-1 QUALITY LEVEL

All rock armoring activities for the Disposal Cell at Crescent Junction, including: The Cover Biobarrier, Top, Apron Riprap, Slope Riprap, and Channel Armor are designated as Quality Level 2. All other work (not on the Disposal Cell) is non-Quality related (Quality Level 3).

PART 2 PRODUCTS

2.1 AGGREGATES

Aggregate shall consist of clean, sound, durable particles of crushed stone, crushed gravel, angular sand, or other approved material. Untreated Base Course shall be free of lumps of clay, organic matter, and other objectionable materials or coatings. Gravel shall be free of silt and clay as defined by ASTM D 2487, organic matter, and other objectionable materials or coatings. Aggregates will be used for the following applications, and the material properties for each of these applications will be provided in the following section:

Application	**Name of Material**	**Gradation**
Road Base	Untreated Base Course	UDOT UBC
Pipe Bedding	Coarse sand/gravel	ASTM D 448 #9
Drainage Stone	Open graded gravel	ASTM D 448 #57
Riprap slope armor	Riprap	D50 per plans
Riprap channel armor	Riprap	D50 per plans
Cover Biobarrier	Sandy gravel	D50 2 in
Cover Top	Sandy gravel	D50 2 in
Cover Apron Riprap	Riprap, 1,000 yr	D50 per plans
Cover Slope Riprap	Riprap, 1,000 yr	D50 per plans
CJ Channel Armor	Riprap, 1,000 yr	D50 per plans

2.1.1 Road Base

Aggregate for road base beneath asphalt pavement and for unpaved gravel roads and pads shall be UDOT Untreated Base Course. The UBC coarse aggregate shall not show more than 50 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C 131. The amount of flat and elongated particles shall not exceed 30 percent. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregates shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the piece. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel for road base shall be provided in the gradation listed in Table 1. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements and shall be stockpiled separately.

2.1.2 Pipe Bedding

Pipe bedding shall be coarse sand, or fine gravel, free from deleterious materials and rocks larger than 3/8 inch. Sandy soil or excavated shaly soil may be used for pipe bedding if it is excavated or processed such that the material size is similar to the gradation listed in Table 1.

2.1.3 Drainage Stone

Drainage stone is an open graded stone material intended as a capillary break beneath concrete slabs. Drainage stone will also be used for French Drains and seepage collection drains for retaining structures and mechanically stabilized earth structures. Drainage stone shall be provided in the gradation listed in Table 1.

2.1.4 Riprap

Riprap for slope and channel protection shall be provided at locations indicated on the drawings. Riprap shall be sized in accordance with plans and as listed in Table 1. Materials listed in Table 1 are not intended for use on the Disposal Cell at Crescent Junction. Disposal Cell materials are included in Table 3, below.

TABLE 1
GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	Road Base	Pipe Bedding	Drainage Stone	Riprap Slope Armor	Riprap Channel Armor
12 inch	--	--	--	--	100
10 inch	--	--	--	100	80-100
8 inch	--	--	--	80-100	20-80
6 inch	--	--	--	20-60	0-20
4 inch	--	--	--	0-20	0
2 inch	--	--	--	0	--
1-1/2 inch	100	--	100	--	--
1 inch	90-100	--	95-100	--	--
3/4 inch	70-85	--	--	--	--
1/2 inch	65-80	--	25-60	--	--
3/8 inch	55-75	100	--	--	--
No. 4	40-65	85-100	10-20	--	--
No. 8	--	20-40	5-10	--	--
No. 16	25-40	10-20	0	--	--
No. 50	--	5-10	--	--	--
No. 200	7-11	0-5	--	--	--

2.1.5 Stone for Final Cover Layers

Stone for the final cover layers, infiltration and bio-barrier layer and rock armoring, shall be rock material that has long-term chemical and physical durability. Rock for final cover layers shall achieve an

acceptable score for its intended use, in accordance with the following rock scoring and acceptance criteria:

TABLE 2
NRC TABLE OF SCORING CRITERIA FOR ROCK QUALITY

Laboratory Test	Weighing Factor			10	9	8	7	6	5	4	3	2	1	0
	L*	S*	I*	Good				Fair				Poor		
Specific Gravity	12	6	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.3	2.25
Absorption, percent	13	5	2	0.10	0.30	0.50	0.67	0.83	1.0	1.5	2.0	2.5	3.0	3.5
Sodium Sulfate, percent	4	3	11	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
LA Abrasion, percent	1	8	1	1.0	3.0	5.0	6.7	8.3	10.0	12.5	15.0	20.0	25.0	30.0
Schmdt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	0

* L = Limestone, S = Sandstone, I = Igneous

Notes:
1) Scores were derived from Tables 6.2, 6.5, and 6.7 of NUREG/CR-2642, Long-Term Survivability of Riprap for Armoring Uranium Mill Tailings and Covers: A Literature Review, 1982.
2) Weighing Factors are derived from Table 7 of "Petrographic Investigations of Rock Durability and Comparisons of Various Test Procedures," by G.W. Dupuy, Engineering Geology, July 1965. Weighing factors are based on inverse of ranking of test methods for each rock type. Other tests may be used; weighing factors for these tests may be derived using Table 7, by counting upward from the bottom of the table.
3) Test methods should be standardized, if a standard test is available and should be those used in NUREG/CR2642, so that proper correlations can be made.

2.1.5.1 Rock Acceptance Criteria

An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the final cover, the rock must score at least 50 percent or the rock is rejected. If the rock scores between 50 percent and 80 percent the rock may be used, but a larger D50 must be provided (oversizing). If the rock score is 80 percent or greater, no oversizing is required.

- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65 percent or the rock is rejected. If the rock scores between 65 and 80 percent, the rock may be used, but must oversized. If the rock score is 80 percent or greater, no oversizing is required.

Oversize rock as follows:

- Subtract the rock score from 80 percent to determine the amount of oversizing required. For example, a rock with a rating of 70 percent

will require oversizing of 10 percent (80 - 70 percent = 10 percent).

- The D50 of the stone shall be increased by the oversizing percent. For example, a stone with a 10 percent oversizing factor and a D50 of 12 inches will increase to a D50 of 13.2 inches.

- The final thickness of the stone layer shall increase proportionately to the increased D50 rock size. For example, a layer thickness equals twice the D50, such as when the plans call for 24 inches of stone with a D50 of 12 inches, if the stone D50 increases to 13.2, the thickness of the layer of stone with a D50 of 13.2 should be increased to 26.4 inches.

2.1.6 Stone Layers for the Waste Cell Final Cover

Stone shall be provided and installed for the following Final Cover Layers:

Application	Type of Material	Material Size
Cover Biobarrier	Sandy gravel, 1,000 yr	D50 2 in
Cover Top	Sandy gravel, 1,000 yr	D50 2 in
Cover E & W Edge/Slope	Riprap, 1,000 yr	D50 2.3 in
Cover N Edge/Slope	Riprap, 1,000 yr	D50 4 in
Cover South Edge/Slope	Riprap, 1,000 yr	D50 5.8 in
CJ Apron Armoring (East & West Apron)	Riprap, 1,000 yr	D50 4.7 in
CJ Apron Armoring (North Apron)	Riprap, 1,000 yr	D50 8 in
CJ Apron Armoring (South Apron)	Riprap, 1,000 yr	D50 11.8 in

2.1.6.1 Biobarrier and Cover Top

The Biobarrier and Top of Cover Stone shall meet the 1,000-year lifespan rock scoring criteria and shall be a mix of 2 inch stone and finer materials. The Cover Biobarrier material is overlain by the Frost Protection soil layer and includes fines to act as an aggregate filter and retain the overlying soil. The gradation shall be as listed in Table 3, below.

TABLE 3
GRADATION OF FINAL COVER AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Seive Designation	Cover Biobarrier	Cover Top	Cover E & W Edge Riprap	Cover N Edge Riprap	Cover S Edge Riprap	E & W Apron Armor & Bedding	N Apron & Bedding	S Apron Armor & Bedding
D50:	2"	2	2.3	4.0"	5.8"	4.7"	8.0	11.8
Min. Thickness	6"	6"	6"	8"	12"	16"	24"	36"
Bedding Thickness	--	--	--	--	--	--	4"	4"
30 inch	--	--	--	--	--	--	--	80-100

Seive Designation	Cover Biobarrier	Cover Top	Cover E & W Edge Riprap	Cover N Edge Riprap	Cover S Edge Riprap	E & W Apron Armor & Bedding	N Apron & Bedding	S Apron Armor & Bedding
25 inch	--	--	--	--	--	--	--	55-90
22 inch	--	--	--	--	--	--	--	25-60
18 inch	--	--	--	--	--	--	--	10-40
16 inch	--	--	--	--	--	--	--	5-25
12 inch	--	--	--	--	--	--	90-100	0-15
10 inch	--	--	--	--	--	--	45-90	0-10
8 inch	--	--	--	--	90-100	90-100	35-50	--
7 inch	--	--	--	--	45-90	--	--	--
6 inch	--	--	90-100	90-100	35-55	35-90	0-30	--
5 inch	--	--	--	--	--	35-55	--	--
4 inch	100	--	35-90	35-50	10-40	--	--	--
3 inch	--	--	20-60	--	--	--	--	--
2 inch	50-100	40-50	8-45	10-36	--	--	--	--
1-1/2 inch	40-60	20-30	--	0-30	5-30	0-30	100	100
1 inch	20-40	10-20	0-30	5-30	--	--	60-100	60-100
1/2 inch	15-25	5-15	0-30	0-30	0-30	0-30	50-90	50-90
No. 4	10-20	0-5	0-5	0-5	0-5	0-5	20-70	20-70
No. 8	5-15	--	--	--	--	--	10-40	10-40
No. 16	5-10	--	--	--	--	--	0-30	0-30
No. 200	0-5	--	--	--	--	--	0-15	0-15

Note: The Contractor is not required to provide washed riprap, and the gradations shown in Table 3 allow a small percentage of fines. The Contractor shall, however, minimize the amount of fine material to prevent segregation of fines from riprap and the concentration of fine materials in any location. See Section 3.6 Installation of Riprap for more direction on placement of riprap to limit concentration of undersized material.

2.1.6.2 Final Cover Edge Riprap

The Cover Edge consists of the Waste Cell slope and a 10-foot transition zone along the top of the slope. Cover Edge stone sizes, thicknesses, and gradations shall be as listed in Table 3, above. Riprap shall be placed on the Final Cover Edges in accordance with the locations shown on the Final Cover Plans. The riprap must meet the 1,000-year lifespan rock scoring criteria. The Cover edge riprap shall contain up to 15 percent material less than 1/2 inch in size to fill in around the riprap to prevent erosion beneath the riprap.

2.1.6.3 Apron Armor Riprap

Apron armor riprap for the Waste Cell shall have stone sizes, thicknesses, and gradations as listed in Table 3, above; and riprap armoring shall be placed in accordance with locations shown in the Final Cover plans and gradations listed. The riprap must meet the 1,000-year lifespan rock scoring criteria. The apron armor riprap with D50 8 inches or larger shall be installed with a 4-inch bedding layer.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Adequate drainage shall be provided during the entire period of construction to prevent water from collecting or standing on the

working area. Line and grade stakes shall be provided as necessary for control.

3.2 OPERATION OF AGGREGATE SOURCES

Clearing, stripping, and excavating shall be the responsibility of the Contractor. The aggregate sources shall be operated to produce the quantity and quality of materials meeting these specifications requirements in the specified time limit.

3.3 STOCKPILING MATERIAL

Prior to stockpiling of material, storage sites shall be cleared and leveled by the Contractor. All materials, including approved material available from excavation and grading, shall be stockpiled in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Crescent Junction Operations / Site Manager to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.4 PREPARATION OF UNDERLYING COURSE

Prior to constructing the base course(s), the underlying course or subgrade shall be cleaned of all foreign substances. At the time of construction of the base course(s), the underlying course shall contain no frozen material. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. The underlying course shall conform to Section 31 00 00 EARTHWORK. Ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained by the Contractor in a satisfactory condition until the base course is placed.

3.5 INSTALLATION OF UNTREATED BASE COURSE

3.5.1 Placing

The material shall be placed on the prepared subgrade or subbase in layers of uniform thickness. When a compacted aggregate layer 6 inches or less in thickness is required, the material shall be placed in a single layer. When a compacted aggregate layer in excess of 6 inches is required, the material shall be placed in layers of equal thickness. No layer shall be thicker than 6 inches or thinner than 3 inches when compacted. The layers shall be so placed that when compacted they will be true to the grades shown in the plans.

3.5.2 Grade Control

The finished and completed base course shall conform to the lines, grades, and cross sections shown. Underlying material(s) shall be excavated and prepared at sufficient depth for the required base course

thickness so that the finished base course and the subsequent surface course will meet the designated grades.

3.5.3 Compaction of Untreated Base Course

Each layer of the Untreated Base Course (UBC) shall be compacted as specified with approved compaction equipment. In all places not accessible to the rollers, the mixture shall be compacted with hand-operated power tampers. Compaction of UBC shall continue until each layer has a degree of compaction that is at least 95 percent of laboratory maximum density through the full depth of the layer. The Contractor shall make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.5.4 Thickness

Compacted thickness of the base course shall be as indicated. No individual layer shall be thicker than 6 inches nor be thinner than 3 inches in compacted thickness.

3.5.5 Finishing

The surface of the top layer of base course shall be finished after final compaction by cutting any overbuild to grade and rolling with a steel-wheeled roller. Thin layers of material shall not be added to the top layer of base course to meet grade. If the elevation of the top layer of base course is 1/2 inch or more below grade, then the top layer should be scarified to a depth of at least 3 inches and new material shall be blended in and compacted to bring to grade.

3.5.6 Smoothness of Base Stone for Pavement

The surface of the top layer shall show no deviations in excess of 1/2 inch when tested with a 12 foot straightedge. Measurements shall be taken in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 50 foot intervals. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.6 INSTALLATION OF RIPRAP

Riprap shall be placed at locations, thicknesses, and sizes indicated on the drawings. At all locations except the Waste Cell at Crescent Junction, riprap shall be placed over a geotextile in accordance with Section 31 05 19 GEOTEXTILE. For the Waste Cell cover slopes, bedding aggregate shall be placed and the riprap installed over the bedding aggregate.

For the Crescent Junction Disposal Cell, the Contractor must supply and install riprap such that the riprap material does not segregate. The objective is a uniform distribution of the specified riprap gradation. If excessive fine material is present in the riprap, it may settle to the bottom of a truck during transport and segregate from the riprap when dumped. The Contractor shall minimize the fines in the riprap, and spread the stone in a manner that prevents concentration of fine materials. Visual inspection of the riprap placement will be performed by the inspection personnel and any pockets of fines observed will be required to be replaced with material containing a uniform distribution of the specified material gradation. The Contractor shall minimize segregation of materials when bedding material is placed in conjunction with the installation of riprap and when no bedding material is required.

3.7 TRAFFIC

Completed portions of the base course for pavement may be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Heavy equipment shall not be permitted except when necessary to construction, and then the area shall be protected against marring or damage to the completed work.

3.8 MAINTENANCE

The base course shall be maintained in a satisfactory condition until the full pavement section is completed and accepted. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter, shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

3.9 DISPOSAL OF UNSATISFACTORY MATERIALS

Any unsuitable materials that must be removed shall be disposed of as directed.

-- End of Section --

DOE–EM/GJ1547

Office of Environmental Management – Grand Junction

UMTRA Project

Remedial Action Plan and Site Design for Stabilization of Moab Title I Uranium Mill Residual Radioactive Material at the Crescent Junction, Utah, Disposal Site

Addendum E.
Remedial Action Inspection Plan

Revision 6

June 2020

U.S. Department of Energy

Office of Environmental Management

Prepared by the Technical Assistance Contract under contract number DE-EM0005014 and the Remedial Action Contractor under contract number DE-EM0011049 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

Moab UMTRA Project Remedial Action Plan Addendum E
Remedial Action Inspection Plan

Revision 6

Review and Approval

6/16/2020

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Statement of Policy

This Remedial Action Inspection Plan identifies the means by which the remedial action activities associated with the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project disposal cell at Crescent Junction, Utah, are controlled, verified, and documented.

This Plan has been developed within the scope of the *Moab UMTRA Project Quality Assurance Plan for the Remedial Action Contractor* (QAP) (DOE-EM/GJRAC1766) and complies with the applicable parts of American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA)-1-2008, and addenda through 2009, "Quality Assurance Program for Nuclear Facilities," Title 10 Code of Federal Regulations Part 830 Subpart A (10 CFR 830A), "Quality Assurance," and DOE Order 414.1D, "Quality Assurance."

The testing and inspection activities discussed in this Plan are performed in accordance with the following applicable sections of the QAP: Section 1.0, Organization; Section 2.0, Quality Assurance Program; Section 12.0, Control of Measuring and Testing Equipment; Section 15.0, Nonconforming Materials, Parts, or Components; Section 16.0, Corrective Action; and Section 17.0, Quality Assurance Records.

Testing and Inspection

1.0 Purpose

The purpose of this Plan is to describe the methods by which the construction activities will be tested and inspected to verify compliance with the design specification requirements.

2.0 Scope

This Plan defines the testing and inspection of remedial action construction activities at the Crescent Junction site. Types of tests, test frequencies and acceptability, and documentation and reporting requirements are contained in this Plan. Procedures for performing the individual tests shall be in accordance with the applicable ASTM International (ASTM) standards, the referenced or other approved methods, and the design specifications.

3.0 Acronyms

ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials International
CFR	Code of Federal Regulations
D_{50}	median stone diameter
DOE	U.S. Department of Energy
GPS	global positioning system
GLONASS	Global Orbiting Navigation Satellite System
GNSS	Global Navigation Satellite System

ISRM	International Society for Rock Mechanics
NQA	Nuclear Quality Assurance
QA	Quality Assurance
QAP	Quality Assurance Plan
QC	Quality Control
RAC	Remedial Action Contractor
RRM	residual radioactive material
UMTRA	Uranium Mill Tailings Remedial Action

4.0 Attachment

None.

5.0 References

10 CFR 830 (Code of Federal Regulations), "Nuclear Safety Management," Subpart A, "Quality Assurance."

ASME (American Society of Mechanical Engineers), Nuclear Quality Assurance (NQA)-1 2008 and addenda through 2009 consensus standard, "Quality Assurance Requirements for Nuclear Facility Applications (QA)."

ASTM (ASTM International) C88 – Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

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

ASTM (ASTM International) C127 – Standard Test Method for Density, Relative Density, Specific Gravity, and Absorption of Coarse Aggregates.

ASTM (ASTM International) C131 – Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

ASTM (ASTM International) C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

ASTM (ASTM International) D422 – Standard Test Method for Particle-Size Analysis of Soils.

ASTM (ASTM International) D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.

ASTM (ASTM International) D1140 – Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve.

ASTM (ASTM International) D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

ASTM (ASTM International) D2216 – Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

ASTM (ASTM International) D2922 – Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

ASTM (ASTM International) D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

ASTM (ASTM International) D4643 – Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating.

ASTM (ASTM International) D4944 – Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester.

ASTM (ASTM International) D4959 – Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.

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

DOE (U.S. Department of Energy), *Moab UMTRA Project Quality Assurance Plan for the Remedial Action Contractor* (DOE-EM/GJRAC1766).

DOE (U.S. Department of Energy), *Moab UMTRA Project Records Management Manual*

(DOE-EM/GJ1545).

DOE (U.S. Department of Energy) Order 414.1D, "Quality Assurance."

ISRM (International Society for Rock Mechanics) Method, Schmidt Rebound Hardness. ISRM (International Society for Rock Mechanics) Method, Splitting Tensile Strength.

6.0 General Requirements

6.1 General Approach to Soil Compaction and Compaction Testing

Typically, soil is tested in a laboratory to determine the maximum density that the particular soil can achieve. The maximum dry density will be achieved at the optimum moisture content for that soil type. The laboratory maximum dry density and optimum moisture content for the soil type becomes the basis of comparison for the compaction of the soil type in the field.

In the field, the soil is placed in loose layers, compacted with specialized compaction equipment, and the relative density tested to confirm the soil density falls within the specified range of the previously determined laboratory maximum dry density. A variety of field tests have been used to determine soil density, including sand cone, rubber balloon, drive cylinder, and nuclear gauge methods. Moisture content tests are also needed to determine the in-place soil density.

All of these test methods determine the density of a small quantity of soil at a single point in a large quantity of placed and compacted soil. A number of tests are required to infer that an entire layer of soil is adequately compacted. The documentation of soil compaction has typically consisted of a visual inspection report combined with a map of the compacted layer and the field moisture density test results.

6.1.1 Computer-based Compaction System

Global Navigation Satellite System (GNSS), comprised of both the U.S. Global Position System (GPS) and the Russian Global Orbiting Navigation Satellite System (GLONASS) and computer terrain modeling technology have been combined to provide a new method of performing soil compaction.

The system works as follows:

- A digital terrain model of the site receiving fill material is loaded into an on-site computer and onboard heavy equipment computer (CB-460). The on-site computer is linked to the CB-460 in the cab of the compaction equipment utilizing Trimble Vision Link. A GNSS receiver is also linked to the CB-460. When the machine moves across the site, the GNSS equipment provides an accurate position (to within 0.1 foot) and elevation of the equipment at all times.
- Soil is dumped and spread into a layer of fill. As the compactor spreads and compacts the layer of soil, the position of the machine is compared to the terrain model to determine the location and thickness of the fill layer being placed and/or compacted. The CB-460 provides real-time cut/fill information to the equipment operator so that the operator may place the material in a layer with uniform specified thickness. This lift may also be graded to uniform thickness utilizing a dozer, also equipped with GNSS and a CB-460 with the terrain model loaded into it.
- After a layer has been placed with uniform thickness, the compactor makes multiple passes over the fill to compact the fill material in place. The number of passes required to achieve the specified relative compaction is determined using an assessment test where pass count is correlated to nuclear density gage readings. Assessment tests are conducted of each material/soil type to determine the pass count/relative density correlation, or whenever a new material type is encountered. Each pass of the compactor is tracked using the computer-based compaction system. The compacted surface elevation is also tracked with the pass count and position information.
- As the compactor traverses the soil to compact it, the computer-based compaction system records the position data, comparison to previous lift/or terrain model, and pass count allowing the QA/QC personnel to generate reports and verification that the lift met the specified compaction and thickness requirements.

Visual inspection, correct placement and compaction techniques, and good moisture control are still required to ensure fill is properly placed and compacted, but the computer-based compaction system method has distinct advantages over traditional field density testing. Lift thicknesses are computer-controlled and are more uniform than when layers are installed based on visual estimates by the equipment operators.

Additionally, the computer tracks compaction over the entire surface of every layer, whereas the in-place test methods only check a few points on each layer. Soil density verification tests and independent land surveys will be performed to demonstrate the effectiveness of the computer-based compaction system.

In the following sections of this Plan, the verification testing and surveying will be described in detail for each element of the cell in which fill is placed.

6.2 Cell Excavation

Part of the proposed disposal cell will be below the ground surface in an excavation. The excavation will be constructed in phases. The overall cell floor and side slopes are described below.

6.2.1 Floor and Side Slopes

The cell floor slopes 2.3 percent from northwest to southeast. The cut slopes on the northern, western, and southern sides of the cell slope at 2:1 or 3:1.

6.2.2 Final Floor and Embankment Elevations

The cell floor coordinates and elevations are shown on the design plans. When each section of the cell is excavated to the elevations indicated on the plans, a verification survey shall be performed to confirm the excavation meets proposed lines and grades. The verification survey shall be signed and submitted to the Remedial Action Contractor (RAC) Crescent Junction Operation/Site Manager.

6.2.3 Cell Floor in Weathered Mancos Shale

The cell floor elevation has been set based on test pit, and soil boring data and is at least 2 feet below the top of the Mancos Shale at each data point. The cell floor shall be visually inspected to confirm that it is in the Mancos Shale formation. If an area is observed where the overburden soil extends below the cell floor, the area will be undercut, backfilled with prepared Mancos Shale, and compacted.

6.2.4 Inspection and Testing

The RAC QC Representative shall visually inspect the material and ground preparation and verify the cell floor is constructed in accordance with plans and specifications by checking and confirming:

- Floor and side slopes follow the design plans.
- Final floor and side slopes survey match the coordinates and elevations in the plans.
- Floor is weathered Mancos Shale, or low spots have been compacted with Mancos Shale.

6.3 Embankment Construction

Part of the proposed disposal cell will be below the existing ground surface in an excavation, and part will be above the existing ground surface within a constructed embankment. The proposed embankment will have 3:1 or 2:1 interior slopes, 5:1 exterior slopes, and a minimum 30-foot-wide, level top. Excavated material from the cell excavation will be used to construct the cell perimeter embankment.

6.3.1 Material

Excavated material from the cell excavation shall be segregated into four types of soil: topsoil, weathered Mancos Shale, common fill, and unsuitable material. Materials shall be separately stockpiled. The perimeter and spoils embankments will be constructed of common fill. The fill shall be tested to determine its maximum dry density in accordance with ASTM D698, and the moisture content shall be modified to bring the fill near (±5 percent) its optimum moisture for compaction.

6.3.2 Ground Preparation

The ground beneath the proposed perimeter and spoils embankments shall be prepared by stripping vegetation and loose soil from the site, scarifying and compacting the top 6 inches of soil.

6.3.3 Lift Placement and Thickness

The embankment shall be constructed of fill materials placed in continuous and approximately horizontal lifts. The method of dumping and spreading fill shall result in loose lifts of nearly uniform thickness, not to exceed 12 inches. At the RAC's option, the compactor may be equipped with a computer-based compaction system and soil placement, and compaction shall be controlled by the computer-based compaction system. The contractor may use the computer-based compaction system to determine and document compaction or perform soil density tests is in accordance with the Inspection and Testing section below.

6.3.4 Inspection and Testing of Cell Perimeter Embankment

QC shall visually inspect the material preparation, ground preparation, and fill placement operations. QC shall perform in-place density tests with companion moisture tests to verify at least 95 percent of the laboratory maximum dry density in accordance with ASTM D698.

QC shall verify the perimeter embankment is constructed in accordance with plans and specifications by checking and confirming:

- Interior slopes are 3:1 or 2:1, and exterior slopes are 5:1 with a minimum 30-foot-wide, level top verified once at the end of excavation.
- Fill material is properly moisture conditioned near optimum moisture.
- Fill material is placed in continuous and approximately horizontal lifts. The method of dumping and spreading material shall result in loose lifts of nearly uniform thickness, not to exceed 12 inches.
- Embankment construction soil is common fill and/or Mancos shale.
- Compaction is properly performed.
- Embankment fill shall be compacted with a minimum 45,000-pound static weight compactor. The compactor shall be a footed roller type, capable of kneading compaction, with feet a minimum of 6 inches in length.
- In-place density and moisture content tests are performed on compacted fill material in accordance with the In-Place Density Testing sections below.
- In-place density verification tests of shall be performed on initial layers of soil placed and on any specific type of material for which the computer-based compaction system is used.

Testing and verification frequencies for lifts constructed without the computer-based compaction system shall be in accordance with the following requirements.

Testing Cell Perimeter Embankment

For material compacted by other than hand-operated machines: One test per 50,000 square feet or 1,850 cubic yards of material placed (or fraction thereof), a minimum of one test for each lift of fill or backfill, and a minimum of two tests per day that fill is compacted in accordance with ASTM D6938.

One test per 500 square feet (or fraction thereof) of each lift of fill or backfill areas for material compacted by hand-operated machines.In-place density and moisture content tests shall be performed in accordance with:

- ASTM D1556
- ASTM D2216
- ASTM D4643
- ASTM D6938

Check Tests on In-Place Densities

If ASTM D6938 is used, check in-place densities by ASTM D1556 as follows:

- One check test for each 20 tests of fill or backfill compacted by other than hand-operated machines (per ASTM D698).
- One check test for each 10 tests of fill or backfill compacted by hand-operated machines (per ASTM D6938).

Optimum Moisture and Laboratory Maximum Density

Perform laboratory density and moisture content tests (ASTM D698 and ASTM D2216) for each type of fill material to determine the optimum moisture and laboratory maximum density values. Perform one representative density test per material type and every 20,000 cubic yards thereafter or when any change in material occurs that may affect the optimum moisture content or laboratory maximum dry density.

One correlation test for moistures every 10 tests per ASTM 6938 will be performed in accordance with ASTM D4643 or D2216. In the stockpile, excavations, or borrow areas, perform moisture tests to control the moisture content of material being placed as fill.

Control of moisture content of fill shall be performed by conducting routine testing of moisture content by one of the following tests:

- ASTM D2216
- ASTM D4643
- ASTM D4944
- ASTM D4959

During unstable weather, perform tests as dictated by local conditions and approved by the Crescent Junction Operations/Site Manager.

6.3.5 Disposal Cell Spoils Embankment (Wedge)

The spoils embankment is a fill embankment to be constructed north of the cell. The embankment will divert storm water from the Book Cliffs around the cell and shall be constructed of surplus excavated material (spoils material) from the cell excavation.

Before placement, spoils material shall be tested to determine its maximum dry density in accordance with ASTM D698, and the moisture content shall be modified to bring the fill to (±5 percent) optimum for compaction.

Constructing the Spoils Embankment

1. Prepare the ground beneath the proposed perimeter embankment by stripping vegetation and loose soil from the site.
2. Dump and spread fill in loose lifts of nearly uniform thickness, not to exceed 12 inches.
3. Compact material with rollers, equipment tracks, or successive passes of scrapers. Fill shall be compacted to a density of 90 percent of the laboratory-determined maximum density in accordance with ASTM D698.

QC shall verify the spoils embankment is constructed in accordance with plans and specifications by checking and confirming:

- Exterior slopes are 3:1.
- Fill material is properly moisture conditioned near (±5 percent) optimum moisture.
- Fill material is placed in continuous and approximately horizontal lifts.
- The method of dumping and spreading material shall result in loose lifts of nearly uniform thickness, not exceed 12 inches.
- Embankment construction soil is surplus excavated material.
- Compaction is properly performed.
- Embankment fill shall be compacted with rollers, equipment tracks, or successive passes of scrapers at a minimum 45,000-pound static weight.
- In-place density and moisture content compaction verification, tests are performed on compacted fill material in accordance with the In-Place Density Testing sections below.
- In-place density verification tests shall be performed on initial layers of soil placed and on any specific type of material for which the computer-based compaction system is used.

Testing and verification frequencies for lifts constructed without the computer-based compaction system shall be in accordance with the following tests.

Testing Spoils Embankment

- One test per 100,000 square feet or 3,700 cubic yards of material placed for material compacted by other than hand-operated machines.
- One test per 500 square feet (or fraction thereof) of each lift of fill or backfill areas for material compacted by hand-operated machines.

In place density and moisture content tests shall be performed in accordance with the following methods:

- ASTM D1556
- ASTM D2216
- ASTM D6938
- ASTM D4643

Check Tests on In-Place Densities

If ASTM D6938 is used, check in-place densities with ASTM D1556 as follows.

- One check test for each 20 tests of fill or backfill compacted by other than hand-operated machines (per ASTM D6938).
- One check test for each 10 tests of fill or backfill compacted by hand-operated machines (per ASTM D6938).

Optimum Moisture and Laboratory Maximum Density
Perform laboratory density and moisture content tests (ASTM D698 and D2216) for each type of fill material to determine the optimum moisture (optimum moisture content ±5 percent) and laboratory maximum density values.

Perform one representative density test per material type and every 20,000 cubic yards thereafter or when any change in material occurs that may affect the optimum moisture content or laboratory maximum dry density. One correlation test for moistures every 10 tests per ASTM D6938 will be performed in accordance with ASTM D4643 or D2216.

In the stockpile, excavations, or borrow areas, perform moisture tests to control the moisture content of material being placed as fill. Control of moisture content of fill shall be performed by conducting routine testing of moisture content by one of the following tests:

- ASTM D2216
- ASTM D4643
- ASTM D4944
- ASTM D4959

During unstable weather, perform tests as dictated by local conditions and approved by the Crescent Junction Operations/Site Manager.

6.4 Residual Radioactive Material

The objective is to place and compact the residual radioactive material (RRM) in the waste cell to create a stable waste mass. QC shall visually inspect the material preparation, ground preparation, RRM placement operations, and shall perform in-place density tests with companion moisture tests for the computer-based compaction system to verify RRM compaction meets the compaction requirements.

QC shall verify RRM placement is performed in accordance with plans and specifications and that the top of the placed waste matches the final grades identified in Section 6.4.5. RRM shall not be placed when frozen or over frozen subgrade. If rainwater ponding has occurred, placement of RRM shall only be performed after the area is dewatered, and approval of the Crescent Junction Operations/Site Manager and QC to place has been obtained.

6.4.1 Moisture Modification
RRM material should be shipped from the Moab site dried to moisture necessary to meet required compaction specifications Some RRM may require minor moisture modification when received at Crescent Junction site.

6.4.2 Residual Radioactive Material Placement
Scarify at a minimum the top 1 inch of subsoil or preceding RRM lift using a footed roller or a dozer before placing subsequent RRM layers. Fill materials shall be placed in continuous and planar lifts. The method of dumping and spreading RRM shall result in loose lifts of nearly uniform thickness, with average thickness not to exceed 24. Compaction equipment shall consist of footed rollers or dozers. Footed rollers shall have a minimum weight of 45,000 pounds and at least one tamping foot shall be provided for each 110 square inches of drum surface.

The length of each tamping foot from the outside surface of the drum shall be at least 6 inches. During compaction operations, the spaces between the tamping feet shall be maintained clear of materials that would impair the effectiveness of the tamping foot rollers. Dozers shall have a minimum ground pressure of 1,650 pounds per feet. The computer-based compaction system may be used to direct fill placement, monitor compaction, and record the location and thickness of each soil layer being placed.

6.4.3 Inspection and Testing

QC shall visually inspect the ground preparation and fill placement operations. RRM shall be compacted to meet 90 percent of the laboratory-determined maximum dry density in accordance with ASTM D698. QC shall verify the RRM placement is constructed in accordance with design plans and specifications by checking and confirming:

- Assessment tests shall be performed on RRM to ensure compliance with specified requirements and to develop compaction requirements for placement. A minimum of three tests for maximum dry density (ASTM D698) and optimum moisture content (ASTM D2216) shall be performed for each type of RRM soil observed.
- Fill material is properly moisture conditioned; one moisture content quick test will be performed each day material is placed in accordance with ASTM D4643, D4944, or D4959 until a sufficient number have been performed to demonstrate a clear correlation allowing a reduction in testing.
- Fill material is placed in continuous and planar lifts. The method of dumping and spreading RRM shall result in loose lifts of nearly uniform thickness, with average thickness of fill area not to exceed 24 inches.
- Compaction meets specifications.
- Compaction by computer-based system shall be monitored by QC by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- In-place density verification tests shall be performed on the initial layer of RRM and on any layers in which the computer-based compaction system indicates problems occurred obtaining compaction. In-place density will be taken every 6 months to verify the performance of the computer-based compaction system.

NOTE: Companion sand cone and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

If the computer-based compaction system is not used, the following testing requirements shall be followed:

- In-place density and moisture content compaction verification tests are performed on compacted fill material in accordance with the following requirements:
  - A verification representative sample from each principal type or combination of blended RRM materials shall be tested to establish compaction curves using ASTM D698.
  - A minimum of one set of compaction curves shall be developed per 10,000 cubic yards of RRM material.
  - In-place density and moisture content tests are performed on a soil layer; a minimum of two tests shall be performed per 5,000 cubic yards or 135,000 square feet of fill material placed.

- Compaction and moisture content tests shall be performed in accordance with the following methods:
  - ASTM D1556
  - ASTM D2216
  - ASTM D6938
  - ASTM D4643
- Erosion that occurs in the RRM layers shall be repaired and grades re-established before proceeding.
- Freezing and desiccation of the RRM soil shall be prevented. If freezing or desiccation occurs, the affected soil shall be reconditioned.
- Areas that have been repaired shall be retested. Repairs to the RRM layers shall be documented, including location and volume of soil affected, corrective action taken, and results of retests.

6.4.4 Demolition Debris

Demolition debris will be placed in the cell along with RRM. Debris shall not contain free liquids. Debris shall be sized to minimize voids. Pipes and ducts 6 inches or greater in diameter shall be crushed or, if crushing is impractical, shall be longitudinally cut in half or filled. Rubber tires shall be cut and placed to minimize void space. Debris shall be spread and/or oriented in a manner that results in a minimum of voids.

Debris may be placed as a sacrificial lift at the bottom of the disposal cell in a 2-foot lift. Debris in sacrificial lifts shall contain no free liquids and shall be oriented in a manner that minimizes voids, and contained within the 2-foot lift profile. Sacrificial debris lifts are not subject to moisture and compaction criteria.

6.4.5 Final RRM Geometry

The top surface of the RRM shall be no greater than 2 inches above the lines and grades shown on the drawings and verified by survey or the use of the computer-based compaction system. No minus tolerance will be permitted.

6.5 Interim Cover

After a section the RRM has been placed in the waste cell to final grade and verified by survey, an interim cover consisting of 1 foot of clean, compacted soil shall be placed over the RRM. Interim cover material will be placed and compacted directly on top of RRM to provide a buffer of uncontaminated soil before placement of the final multi-layer cap. A protective layer may be placed as mentioned in Section 6.5.5.

6.5.1 Material

Interim cover soil will be from the excavation of the Crescent Junction waste cell. It will be material that has been produced on site by modifying the existing overburden soil and weathered Mancos Shale excavated on site. Overburden and weathered Mancos Shale shall be excavated, pulverized, wetted, and mixed to produce a uniform, fine-grained soil near optimum moisture content compaction. Soil shall be free of roots, debris, and organic or frozen material.

6.5.2 Ground Preparation

The RRM beneath the proposed interim cover shall be prepared by scarifying to a minimum depth of 1 inch before placing the initial lift of interim cover soil.

6.5.3 Lift Placement and Thickness

The interim cover shall be constructed of fill materials placed in continuous lifts of uniform thickness. The method of dumping and spreading interim cover soil over the RRM shall result in loose lifts with average thickness not to exceed 14 inches.

6.5.4 Inspection and Testing

QC shall visually inspect the ground preparation and fill placement operations. The interim cover layer shall be compacted to meet 90 percent of the laboratory-determined maximum dry density in accordance with ASTM D698.

QC shall verify the interim cover is constructed in accordance with plans and specifications by checking and confirming:

- A representative sample from each type or combination of stockpiled excavated soil for use as interim cover soil shall be tested to establish a compaction curve using ASTM D698.
- Interim cover is properly moisture conditioned tested in accordance with ASTM D4643, D4944, or D4959, and moisture content shall be within the range needed to achieve a minimum of 90 percent of the laboratory-determined maximum dry density of each material type.
- Interim cover is placed in continuous and approximately horizontal lifts. The method of dumping and spreading interim cover shall result in loose lifts of nearly uniform thickness, with average uncompacted thickness not to exceed 14 inches. Compaction testing should alternate between checking compaction in the top half of each lift and the bottom half of each lift.
- Compaction is properly performed.
- Compaction by computer-based compaction system is monitored by QC by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- Verification tests of in-place density shall be performed on the first 5,000 cubic yards of interim cover and on any layers in which the computer-based compaction system indicates that problems occurred obtaining compaction.

NOTE: Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

If the computer-based compaction system is not used, the following requirements shall be followed:

- In-place density and moisture content compaction verification tests are performed on compacted fill material in accordance with the following requirements:
  - When verification, in-place density, and moisture content tests are performed on a soil layer, a minimum of two tests shall be performed per 5,000 cubic yards or 135,000 square feet of fill material placed.
  - A representative sample from each type or combination of stockpiled excavated soil for use as interim cover soil shall be tested to establish a compaction curve using ASTM D698.
  - Interim cover is properly moisture conditioned and tested in accordance with ASTM D4643, D4944, or D4959. The moisture content range needed to achieve a minimum of 90 percent of the laboratory-determined maximum dry density of each material type.

- Interim cover is placed in continuous and approximately horizontal lifts. The method of dumping and spreading interim cover shall result in loose lifts of nearly uniform thickness, with average uncompacted thickness not to exceed 14 inches.
- Compaction is properly performed.
- Compaction testing should alternate between checking compaction in the top half of each lift and the bottom half of each lift
- Compaction and moisture content tests shall be performed in accordance with the following methods:
  - ASTM D1556
  - ASTM D2216
  - ASTM D6938
  - ASTM D4643
  - ASTM D698

NOTE: Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

- After lift placement, moisture content shall be maintained until the next lift is placed.
- Erosion that occurs in the interim cover layer shall be repaired and grades re-established.
- Freezing and desiccation of the interim cover soil shall be prevented. If freezing or desiccation occurs, the affected soil shall be reconditioned.
- Areas that have been repaired shall be re-tested. Repairs to the interim cover layer shall be documented, including location and volume of soil affected, corrective action taken, and results of retests.

6.5.5 Final Interim Cover Geometry

The top surface of the interim cover shall be no greater than 2 inches above the lines and grades shown on the drawings. No minus tolerance will be permitted. If the radon barrier is not placed immediately after completion of the interim cover, it is acceptable to use a best management practice of placing a protective layer of 8 inches (minimum) on the interim cover, which will protect the interim cover from damaged caused by erosion and roots and self-sown vegetation. The vegetation does not have to be removed until the radon barrier placement. The protective layer can be cleared of vegetation and re-used as a part of the radon barrier.

6.6 Cap Construction

An UMTRA cover (a multi-layer cap) will be constructed over the RRM and interim cover. The cap materials and configuration are intended to protect the RRM from exposure due to water erosion, wind erosion, and burrowing animals for a design life of 1,000 years. The proposed cap layers are shown in the UMTRA cover design figure in Section 6.7.1.

6.7 Radon Barrier Layer

The initial cap layer is a 4-foot-thick radon barrier layer constructed of compacted clay soil. The radon barrier will be a low-permeability clay layer that limits radon emissions from the RRM and limits the infiltration of water from above.

6.7.1 Material

The radon barrier layer will be constructed of processed Mancos Shale. The clay soil will be produced on site by processing excavated Mancos Shale into a fine-grained soil and adding water to bring the Mancos Shale to near optimum moisture content for compaction.

Assessment tests shall be performed on radon barrier material to ensure compliance with specified requirements and to develop compaction requirements for placement. A minimum of three tests for maximum dry density (ASTM D698); optimum moisture content tests (ASTM D2216) shall be performed for each type of soil observed to establish the optimum moisture for radon barrier material placement.

At a minimum, perform the following soil tests on each 10,000 cubic yards of soil:

- ASTM D4318
- ASTM D1140
- ASTM D422
- ASTM D698
- ASTM D2216 or D4643

6.7.2 Ground Preparation

The interim cover layer beneath the proposed radon barrier layer shall be prepared by scarifying to a minimum depth of 1 inch before placing the initial lift of radon barrier soil. Scarification shall be performed on the upper surface of each underlying soil layer before placement of the next lift.

The final lift of radon barrier shall not be scarified; it shall be smooth-rolled with a minimum of three passes with a smooth, steel-wheeled roller with a minimum weight of 20,000 pounds to provide a smooth surface.

6.7.3 Lift Placement and Thickness

The radon barrier layer shall be constructed of fill materials placed in continuous lifts of uniform thickness. The method of dumping and spreading radon barrier shall result in loose lifts not to exceed 12 inches. Compaction equipment shall consist of rubber-tired or footed-roller compaction equipment with a minimum weight of 45,000 pounds. The in-place material may contain particles up to 4 inches.

Placement of Mancos Shale will be visually inspected to make sure there are no locations where rock-type particles accumulate in a concentrated location. Particles found in a concentrated location will be removed or reworked per QC direction.

6.7.4 Inspection and Testing

QC shall visually inspect the processing of Mancos Shale into clay soil, ground preparation, and fill-placement operations. QC shall perform in-place density tests with companion moisture tests to verify optimum moisture plus or minus 3 percent and at least 95 percent of the material's maximum dry density according to ASTM D698.

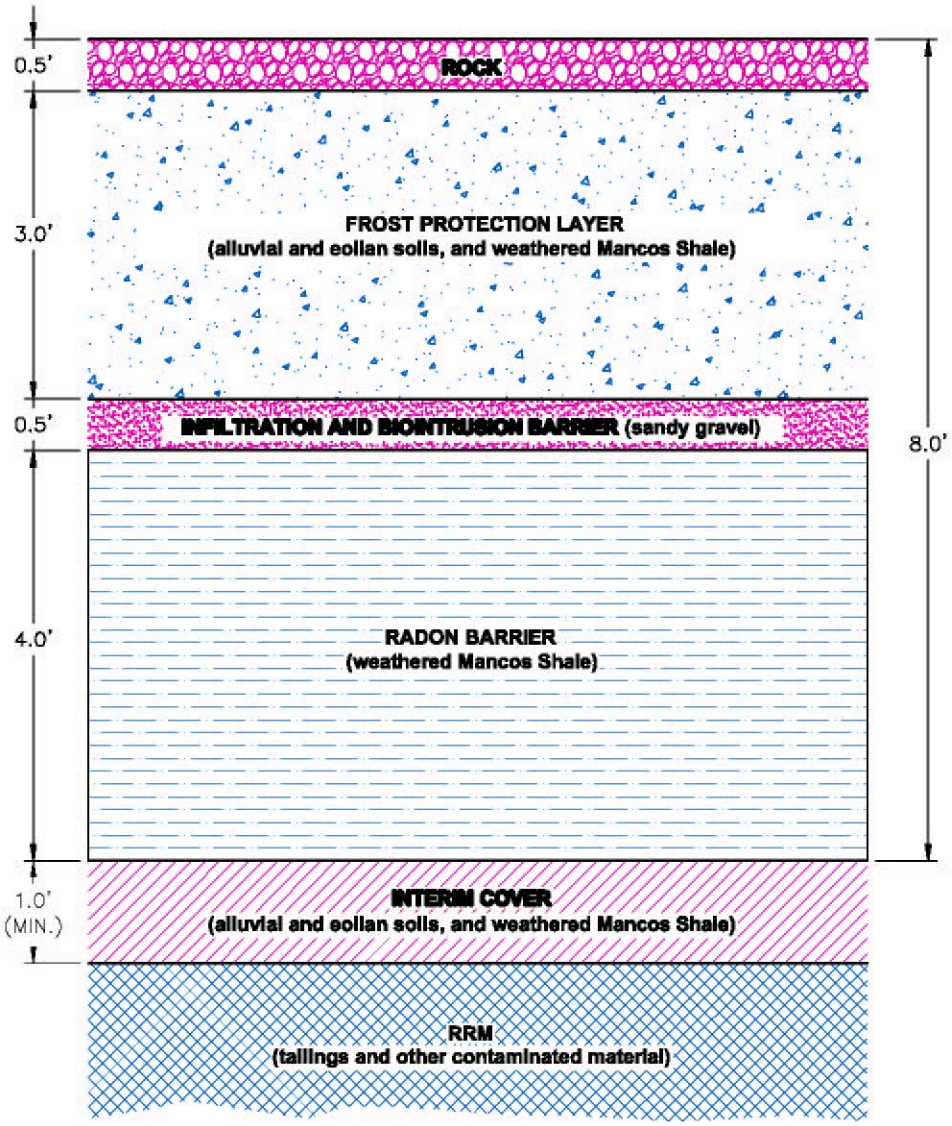
QC shall verify the radon barrier is constructed in accordance with plans and specifications by checking and confirming:

- Fill material is properly moisture conditioned; one moisture content test will be performed each day material is placed in accordance with ASTM D4643, D4944, or D4959, with moisture content plus or minus 3 percent.
- Material is placed in continuous uniform thickness lifts. The method of dumping and spreading the radon barrier shall result in loose lifts not to exceed 12 inches.
- Radon barrier soil is processed Mancos Shale.
- Tests have been performed on the processed shale soil to determine its maximum dry density and optimum moisture content.
- Radon barrier fill is compacted with rubber-tired or footed-roller compaction equipment.
- QC shall monitor the computer-based compaction system by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- Verification tests of in-place density shall be performed on the initial layer of radon barrier placed and on any layers in which the computer-based compaction system indicates problems occurred obtaining compaction.
- Maximum particle size in the fill material shall be 4 inches.
- Placement of Mancos shale will be visually inspected to make sure there are no locations where rock-type particles accumulate in a concentrated location.
- Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

NOTE: If the computer-based compaction system is not used, the following testing requirements shall be followed.

- In-place density and moisture content tests compaction verification tests are performed on compacted fill material in accordance with the following requirements:
  - A verification representative sample from each principal type or combination of blended radon barrier materials shall be tested to establish compaction curves using ASTM D698. A minimum of one set of compaction curves shall be developed per 10,000 cubic yards of radon barrier material.
  - In-place density and moisture content tests are performed on a soil layer; a minimum of two tests shall be performed per 5,000 cubic yards or 135, 000 square feet of fill material placed.
  - Fill material is properly moisture conditioned in accordance with ASTM D4643, D4944, or D4959, with moisture content plus or minus 3 percent.
  - Material is placed in continuous uniform thickness lifts. The method of dumping and spreading radon barrier shall result in loose lifts not to exceed 12 inches.
  - Radon barrier soil is processed Mancos Shale.
  - Tests have been performed on the processed shale soil to determine its maximum dry density and optimum moisture content.
  - Radon barrier fill is compacted with rubber-tired or footed-roller compaction equipment.
  - Maximum particle size in the fill material shall be 4 inches.
  - Placement of Mancos Shale will be visually inspected to make sure there are no locations where rock-type particles accumulate in a concentrated location

- Compaction and moisture content tests shall be performed in accordance with the following methods:
  - ASTM D1556
  - ASTM D2216
  - ASTM D6938
  - ASTM D4643
  - ASTM D698



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NOTE: Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

- After placement, moisture content shall be maintained or adjusted to meet criteria.
- Erosion that occurs in the fill layers shall be repaired and grades re-established.
- Freezing and desiccation of the radon barrier layer shall be prevented. If freezing or desiccation occurs, the affected soil shall be removed or reconditioned.
- Areas that have been repaired shall be retested. Repairs to the radon barrier layer shall be documented, including location and volume of soil affected, corrective action taken, and results of retests.

6.7.5 Initial and Confirmatory Surveys

Verification of the thickness of the radon barrier layer will be performed by comparing before and after surveys of the layer by surveying or using the computer-based compaction system. Before placing the radon barrier layer, an initial survey shall be performed of the section to be capped.

The initial survey will document the pre-cap geometry of the site. After the radon barrier layer has been installed, a post-installation survey will be performed on the top of the radon barrier fill to confirm that the total fill thickness is in accordance with the plans and specifications.

6.8 Infiltration and Biointrusion Barrier (Gravel)

Above the radon barrier layer, a 6-inch-thick infiltration and biointrusion layer of gravel will be placed to provide a barrier to burrowing animals and a pathway for drainage of water that has infiltrated through upper layers of the cap. The gravel will be a sandy gravel with a gradation in accordance with Project plans and specifications.

Rock shall be spread to the thickness indicated on the drawings or in accordance with oversizing due to scoring criteria. Rock placement shall be guided by GPS grade control to ensure the appropriate thickness has been placed at all locations. The biointrustion layer shall be compacted with a smooth steel drum.

6.8.1 Erosion Protection Materials Testing

Rock for the infiltration and biointrusion barrier layer shall be tested by a commercial testing laboratory during production in accordance with the following:

Test Method	Reference
SSD Specific Gravity	ASTM C127 Sodium Sulfate Soundness (5 cycles) ASTM C88
L.A. Abrasion (100 cycles)	ASTM C131
Schmidt Rebound Hardness	International Society of Rock Engineers (ISRM) Method

Test results shall be submitted to a commercial testing lab for analysis and subsequent acceptance or rejection or the material represented by the test results, based on engineering calculations.

Rock for the infiltration and biointrusion barrier layer shall be tested for gradation in accordance with ASTM C-117 and C-136 and other approved testing methods. Test results shall be in accordance with the design specifications. Rock for the final cover layers shall be tested a minimum of three times. The materials shall be tested initially before the delivery of any of the materials to the site for gradation and durability, then from the on-site stockpile at the beginning of placement for gradation. Lastly, testing shall be performed for every 5,000 square yards of material delivered.

All placed material shall be visually inspected during and after placement. The visual inspections shall verify (1) no nesting of fines, (2) no nesting of small-large aggregates in a concentrated area, and (3) all aggregate material is interlocking. Rock for the infiltration and biointrusion barrier layer shall be material that has long-term chemical and physical durability. The material shall achieve an acceptable score for its intended use in accordance with the rock scoring and acceptance criteria.

6.8.2 Rock Acceptance Criteria

An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the final cover, the rock must score at least 50 percent, or the rock is rejected. If the rock scores between 50 percent and 80 percent, the rock may be used, but a larger median stone diameter (D_{50}) must be provided (oversizing). If the rock score is 80 percent or greater, no oversizing is required.
- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65 percent, or the rock is rejected. If the rock scores between 65 and 80 percent, the rock may be used, but must be oversized. If the rock score is 80 percent or greater, no oversizing is required.

Oversizing Rock

- Subtract the rock score from 80 percent to determine the amount of oversizing required. For example, a rock with a rating of 70 percent will require oversizing of 10 percent (80 percent less 70 percent = 10 percent).
- The D_{50} of the stone shall be increased by the oversizing percent. For example, a stone with a 10 percent oversizing factor and a D_{50} of 12 inches will increase to a D_{50} of 13.2 inches.
- The final thickness of the stone layer shall increase proportionately to the increased D_{50} rock size. For example, a layer thickness equals twice the D_{50}, such as when the plans call for
- 24 inches of stone with a D_{50} of 12 inches; if the stone D_{50} increases to 13.2, the thickness of the layer of stone with a D_{50} of 13.2 should be increased to 26.4 inches.

QC shall verify the infiltration and biointrusion layer is installed in accordance with plans and specifications by checking and confirming:

- Gravel material gradation matches the gradation required in the specifications.
- Gravel material is placed and compacted to produce a continuous uniform thickness of at least 6 inches.
- Compaction is performed by a smooth steel-drum roller with a minimum of two passes over the placed gravel fill.

6.9 Frost Protection Layer

Above the infiltration and biointrusion layer a 3-foot-thick frost protection layer will be installed. This soil layer will provide protection for the low-permeability radon barrier layer beneath. The frost protection layer will consist of 3 feet of clean, compacted soil that shall be placed directly on the gravel infiltration and biointrusion layer.

6.9.1 Material

The frost protection layer will be constructed of common fill. The fill shall come from the cell excavation, tested to determine its maximum dry density, and the moisture content modified to bring the fill to optimum for compaction in accordance with ASTM D698.

6.9.2 Ground Preparation

The frost protection layer will be placed directly on the gravel infiltration and biointrusion layer.

6.9.3 Lift Placement and Thickness

The frost protection layer shall be constructed of fill materials placed in continuous lifts of uniform thickness. The method of dumping and spreading the frost protection layer shall result in loose lifts, with average thickness not to exceed 12 inches. Scarification shall be performed on all areas of the upper surface of each underlying soil layer before placing the next lift. The final lift of soil shall not be scarified. The final lift shall be smooth-rolled with at least three passes of the approved smooth, steel-wheeled roller weighing a minimum of 20,000 pounds.

6.9.4 Inspection and Testing

QC shall visually inspect the material preparation, ground preparation, and fill placement operations. QC shall perform in-place density tests with companion moisture tests. Frost protection soil shall be placed and compacted within a moisture content range that will achieve at least 90 percent of the material's maximum dry density on the initial layer according to ASTM D698.

QC shall verify the frost protection layer is constructed in accordance with plans and specifications by checking and confirming:

- Frost protection layer soil is common fill.
- Tests have been performed on the common fill to determine its maximum dry density and optimum moisture content per ASTM D698.
- Fill material is properly moisture conditioned to near optimum moisture.
- Fill material is placed in continuous and approximately horizontal lifts. The method of dumping and spreading the frost protection layer shall result in loose lifts of nearly uniform thickness, with average thickness not to exceed 12 inches.
- Compaction is properly performed.
- Frost protection fill will be compacted with rubber-tired or footed-roller compaction equipment.
- Compaction by the computer-based compaction system shall be monitored by QC by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- Verification tests of in-place density shall be performed on initial layers of soil placed and on any layers in which the computer-based compaction system indicates problems occurred obtaining compaction.

NOTE: Companion sand cone and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

If the computer-based compaction system is not used, testing requirements below shall be followed.

- Perform in-place density and moisture content compaction verification tests on compacted fill material in accordance with the following requirements:
  - When verification, in-place density, and moisture content tests are performed on a soil layer, a minimum of two tests per 5,000 cubic yards or 135,000 square feet of fill material placed.
  - Frost protection layer soil is common fill.
  - Tests have been performed on the common fill to determine its maximum dry density and optimum moisture content per ASTM D698.
  - Fill material is properly moisture conditioned.
  - Fill material is placed in continuous and approximately horizontal lifts. The method of dumping and spreading the frost protection layer shall result in loose lifts of nearly uniform thickness, with average thickness not to exceed 12 inches.
  - Compaction is properly performed.
  - Frost protection fill will be compacted with rubber-tired or footed-roller compaction equipment.
  - Compaction and moisture content tests shall be performed in accordance with the following methods:
    - ASTM D1556
    - ASTM D698
    - ASTM D2216
    - ASTM D2922
    - ASTM D6938
    - ASTM D4643

NOTE: Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

6.9.5 Initial and Confirmatory Surveys

Verification of the thickness of the frost protection layer will be performed by comparing before and after surveys of the layer. Before placing the frost protection layer, an initial survey of the section to be capped shall be performed. The initial survey will document the geometry of the top of the infiltration and biointrusion layer.

After the frost protection layer has been installed, a post-installation survey will be performed on the top of the frost protection layer to confirm the total fill thickness is in accordance with the plans and specifications.

6.10 Rock Armoring

The final cap layer is rock armoring placed over the frost protection layer. The rock armoring will vary in size and thickness at different locations on the cap and shall be installed in accordance with Project plans and specifications. Rock shall be spread to the thickness indicated on the drawings or in accordance with oversizing due to scoring criteria. Rock placement shall be guided by a GPS system to ensure the appropriate thickness has been placed at all locations. Stone shall be compacted with a smooth steel drum.

6.10.1 Erosion Protection Materials Testing

Rock for the final cover layers shall be tested by a commercial testing laboratory during production in accordance with the following:

Rock Armoring	Reference
Specific Gravity (SSD)	ASTM C127 (Absorption) Sodium Sulfate Soundness (five cycles) ASTM C88 (Coarse Aggregate)
L.A. Abrasion (100 cycles)	ASTM C131 (Abrasion)
Schmidt Rebound Hardness	ISRM Method

Test samples shall be submitted to a commercial testing lab for analysis and subsequent acceptance or rejection of the material represented by the test results, based on engineering calculations. Rock for the final cover layers shall be tested for gradation in accordance with ASTM C-117 and C-136 and other approved testing methods. Test results shall be in accordance with the design specifications.

Rock for the final cover layers shall be tested a minimum of three times. The materials shall be tested initially before the delivery of any of the materials to the site for gradation and durability, then from the on-site stockpile at the beginning of placement for gradation. Lastly, testing shall be performed for every 5,000 cubic yards of material delivered.

All placed material shall be visually inspected during and after placement. The visual inspections shall verify: (1) no nesting of fines, (2) no nesting of small to large aggregates in a concentrated area, and (3) all aggregate material interlocks.

Rock for the final cover layers shall be rock material that has long-term chemical and physical durability. Rock for final cover layers shall achieve an acceptable score for its intended use, in accordance with the rock scoring and acceptance criteria.

A geologist will periodically inspect the stockpiles at the quarry operations to ensure the percentage of other than gray basalt does not exceed 10 percent for rock for the final cover layers.

6.10.2 Rock Acceptance Criteria

An acceptable rock score depends on the intended use of the rock. A rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the final cover, the rock must score at least 50 percent, or the rock is rejected. If the rock scores between 50 and 80 percent, the rock may be used, but a larger D_{50} must be provided (oversizing). If the rock score is 80 percent or greater, no oversizing is required.
- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65 percent, or the rock is rejected. If the rock scores between 65 and 80 percent, the rock may be used, but must be oversized. If the rock score is 80 percent or greater, no oversizing is required.

Oversizing Rock

- Subtract the rock score from 80 percent to determine the amount of oversizing required. For example, a rock with a rating of 70 percent will require oversizing of 10 percent (80 percent less 70 percent = 10 percent).

- The D_{50} of the stone shall be increased by the oversizing percentage. For example, a stone with a 10 percent oversizing factor and a D_{50} of 12 inches will increase to a D_{50} of 13.2 inches.
- The final thickness of the stone layer shall increase proportionately to the increased D_{50} rock size. For example, a layer thickness equals twice the D_{50}, such as when the plans call for 20 inches of stone with a D_{50} of 12 inches; if the stone D_{50} increases to 13.2, the thickness of the layer of stone with a D_{50} of 13.2 should be increased to 26.4 inches.

QC shall verify the rock armoring is installed in accordance with plans and specifications by checking and confirming stone material is placed to produce the thickness required by the plans for each area. At a minimum, depth verification will be performed every 10,000 cubic yards.

Settlement Monitoring
A grid system shall be established for periodic surveys to monitor cell settlement. This system will be transferred to DOE Legacy Management for continued cell settlement monitoring.

Cell Construction Material Installation Summary Table

Cell Component	Material of Construction	Compaction Requirements	Lift Thickness max/approx loose/compact	Frequency of Verification Tests
Cell Excavation	NA	NA	NA	NA
Perimeter Embankment	Common Fill	95 percent	12 inches/ 10 inches	Initial layer/Section 6.3.4
RRM Placement	RRM	90 percent	Average thickness 24 inches/ 20 inches	Initial layer/Section 6.4.3
Interim Cover	Common Fill	90 percent	Average 14 inches/ 10 inches	Initial layer/Section 6.5.4
Radon Barrier	Weathered Mancos Shale	95 percent	12 inches/ 10 inches	Initial layer/Section 6.7.4
Infiltration and Biointrusion Barrier	Stone	NA	NA	NA
Frost Protection	Common Fill	90 percent	Average thickness 12 inches/ 10 inches	Initial layer/Section 6.9.4
Cap Armoring	Stone	NA	NA	NA

7.0 Records

All documentation created as a result of compliance with this Plan is considered a Project record and will be managed in accordance with the *Moab UMTRA Project Records Management Manual* (DOE-EM/GJ1545), which follows DOE orders, policies, and regulations for retention and maintenance of records.

Test and inspection records shall be reported and filed in a timely manner, consistent with the status of work performed. Inspection and test status shall be available at all times to prevent inadvertent by-passing of an inspection or test. Test and inspection records shall contain the following, at a minimum:

- Items tested or inspected
- Date of test or inspection
- Tester/inspector
- Type of test or inspection
- Results and acceptability, including the test or inspection acceptance criteria
- Identification number of instrument used in performing the test or inspection
- Action taken in connection with any deviations noted
- Person evaluating test results, if different from person named in paragraph

Test and inspection records shall be filed and maintained in accordance with the *Records Management Manual*. Surveillances shall be performed by QA of measure and test equipment used by QC. Daily Inspection Reports shall be generated, describing the adequacy, discrepancies, progress, dispositions, and details of each day's construction activities. Permanent QA/QC records shall be periodically evaluated through internal and external surveillances and audits. QC reports shall be generated daily, summarizing the volume of placed materials and the number of lifts approved. A summary of this information shall be included in the RAC's weekly Project status report submitted to DOE.